From: Samuel Hernandez-Quinones
To: Ellen Moret
Date: Fri, Jul 7, 2006 2:55 PM
Subject: RE: Vermont Yankee Documents

Ellen
Attached are the comments that we have received so far.

Also attached are the scoping meeting transcripts. An additional box containing the comments and transcripts should get to ANL today or Monday.

Sam

>>> "Moret, Ellen N." <moret@anl.gov> 07/07/2006 2:36 PM >>>
Hi Sam-

Thanks, I received the documents today. One more thing: can you please send me the transcripts of the scoping meetings? Thanks a lot.

Ellen

-----Original Message-----
From: Samuel Hernandez-Quinones [mailto:SHQ@nrc.gov]
Sent: Friday, July 07, 2006 9:12 AM
To: Moret, Ellen N.
Subject: Re: Vermont Yankee Documents

Ellen
a box with the documents should arrive at Argonne today.
I will send you and Dave a list that contains all the accession numbers for the documents located in ADAMS, I will also send you an email with all the comments received later today.

Sam

>>> "Moret, Ellen N." <moret@anl.gov> 07/07/2006 10:08 AM >>>
Hi Sam--

I was just checking up with you on the status of the documents from Vermont Yankee. Do you know when they plan on being sent to Argonne? Also Dave Miller wanted me to ask you about some comments that we being mailed to him from Massachusetts. I don't believe he has received them yet. Do you know if/when they were supposd to arrive? Thanks.

Ellen Moret

CC: AVci@anl.gov; David S. Miller; Richard Emch

Mail Envelope Properties (44AEADFC.7DB : 24 : 35376)

Subject: RE: Vermont Yankee Documents
Creation Date Fri, Jul 7, 2006 2:54 PM
From: Samuel Hernandez-Quinones

Created By: SHQ@nrc.gov

Recipients
anl.gov
avci CC (AVci@anl.gov)
david.s.miller CC (David S. Miller)
moret (Ellen Moret)

nrc.gov
OWGWPO02.HQGWDO01
RLE CC (Richard Emch)

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ANR Comments.pdf	67651	Friday, July 7, 2006 2:33 PM
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Comment 2.pdf	82021	Friday, July 7, 2006 2:34 PM
Comment 3.pdf	90261	Friday, July 7, 2006 2:34 PM
Comment 4.pdf	61393	Friday, July 7, 2006 2:35 PM
Comment 5.pdf	57659	Friday, July 7, 2006 2:35 PM
Comment 6.pdf	99124	Friday, July 7, 2006 2:35 PM
Comment 7.pdf	88653	Friday, July 7, 2006 2:36 PM
Comment 8.pdf	121180	Friday, July 7, 2006 2:36 PM
Comment 9.pdf	247442	Friday, July 7, 2006 2:37 PM
Comment 10.pdf	104269	Friday, July 7, 2006 2:37 PM
Comment 11.pdf	122450	Friday, July 7, 2006 2:37 PM
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Comment 13.pdf	89452	Friday, July 7, 2006 2:38 PM
Comment 14.pdf	41506	Friday, July 7, 2006 2:38 PM
Comment 15.pdf	260349	Friday, July 7, 2006 2:39 PM
Comment 16.pdf	502642	Friday, July 7, 2006 2:39 PM

Corrected Open House Transcript ML061840036.pdf 92469 Monday, July 3, 2006 9:14 AM
Corrected Afternoon Transcript ML061840033.pdf 268446 Monday, July 3, 2006

8:50 AM
Corrected Evening Transcript ML061840029.pdf 4180639 Monday, July 3, 2006
9:00 AM

Options
Expiration Date: None
Priority: Standard
ReplyRequested: No
Return Notification:
Send Notification when Deleted

Concealed Subject: No
Security: Standard

Junk Mail Handling Evaluation Results
Message is not eligible for Junk Mail handling
Message is from an internal sender

Junk Mail settings when this message was delivered
Junk Mail handling disabled by User
Junk Mail handling disabled by Administrator
Junk List is not enabled
Junk Mail using personal address books is not enabled
Block List is not enabled

From: "Gjessing, Catherine" <Catherine.Gjessing@state.vt.us>
To: <VermontYankeeEIS@nrc.gov>
Date: Fri, Jun 23, 2006 5:21 PM
Subject: Scoping Comments

Good afternoon,

Attached are scoping comments from the Vermont Agency of Natural Resources. Please feel free to contact Catherine Gjessing at 241-3618 or Julie Moore 241-3687 with any questions. Thank you.

CC: "Moore, Julie" <Julie.Moore@state.vt.us>, "Sayles, John" <John.Sayles@state.vt.us>

State of Vermont Agency of Natural Resources
100 South Main Street, Center Building
Waterbury, VT 05671-0301
Telephone: (802) 241-3620
Fax: (802) 241-3796

MEMORANDUM

TO: NUCLEAR REGULATORY COMMISSION

FROM: VERMONT AGENCY OF NATURAL RESOURCES

DATE: JUNE 23, 2006

SUBJECT: SCOPING COMMENTS FOR VERMONT YANKEE NUCLEAR POWER STATION LICENSE RENEWAL

The primary purpose of these scoping comments is to request site specific analysis of various issues in the context of the license renewal process for Vermont Yankee Nuclear Power Station. The Vermont Agency of Natural Resources (Agency) has referred to the list of NEPA issues for license renewal set forth in Table A-1 of NUREG-1850, *Frequently Asked Questions on License Renewal of Nuclear Power Reactors* (March 2006). It is the Agency's understanding that this comprehensive list also indicates whether the issue is subject to a generic or site specific Environmental Impact Statement. The Agency is suggesting that some of the generic issues be examined in more detail in order to determine whether a site specific environmental impact analysis should be performed. The Agency has the following comments regarding the generic environmental impact analysis:

- ***Issues 18, 20, 23, 24, and 28 through 30 (Thermal plume barrier to migrating fish, Premature emergence of aquatic insects, Losses among organisms exposed to sublethal stresses, Stimulation of nuisance organisms, Entrainment, Impingement, and Heat shock)*** As we understand it, these issues are associated with intake structures and thermal discharge issues which require a NPDES permit. The requirements of the Clean Water Act and the NPDES permit will provide assurance that the impacts of permitted intake structures and discharges meet the applicable federal and state requirements. It would be helpful, however, to have some limited site specific review of these issues. For example, have recent scientific studies regarding intake structure and thermal impacts on migrating fish species and aquatic organisms, in similar habitats or within this region, led to new knowledge applicable to these issues? Are there any organisms present in the Vernon area which are particularly susceptible to sublethal stresses or heat shock? Are there any specific study protocols recommended for determining the impacts of intake and discharges on species present in the affected regions of the Connecticut River?

- ***Issues 43 and 46 (Bird collisions).*** The Agency is interested in bird mortality rates. In particular, the Agency is interested in whether the numbers and species of birds which have experienced mortalities with the cooling towers and the power lines are an issue of concern. This concern is also applicable to the met towers on site.

- *Issue 45 (Power line right of way management).* The Agency is interested in this issue as it relates to rare, threatened and endangered species which may be present in proximity to the power lines. In addition, the Agency is interested in preserving undisturbed riparian buffers in areas of surface water or stream crossings.

- *Issue 75 (Design-basis accidents).* Is there new knowledge or technology that is applicable to this issue and should be applied in the context of the license renewal? See comments on External Design Basis Events below.

- *Issue 87 (Waste Management)* The Agency is suggesting that low level radioactive waste issue should be evaluated on a site specific basis. Title 10 Vermont Statue Annotated contains §7066 (c) states:

  > No generator of low-level radioactive waste in the state existing on the date of enactment of this section may increase its generation of waste in a year by more than 20 percent of the total annual volume of waste from all generators estimated for disposal by the secretary of natural resources, under subdivision 7065(a)(3) of this title, unless that generator receives a favorable determination from the secretary of natural resources that disposal capacity will be available as provided by section 3.04(11) of the compact agreement.

  The Agency would like to know whether Entergy Vermont Yankee will increase production of low-level radioactive waste as a consequence of the renewal and, if so, will any increase remain in compliance with the state statutory requirements regarding low level radioactive waste generation, minimization, and reporting. See also, Issue 89 below.

- *Issue 89 (Water Quality)* The Agency believes that groundwater and surface water quality are issues of great importance to Vermonters and should be subject to a site specific analysis. With respect to groundwater, it would be very useful to determine the natural background levels of radionuclides at the Entergy Vermont Yankee facility and in the vicinity of regional monitoring devices. What is the potential contribution to groundwater of constituents from land spreading of low-level constituents on site? How will both the natural and anthropogenic background levels be used when determining whether future releases from the facility exceed health standards

In addition to the issues listed above the Agency is suggesting that the scope of the NEPA review also include an inquiry about whether there is new site specific knowledge and technology or scientific knowledge which is relevant to the nuclear plant Design Basis for External Events, such as seismic or flood events. For example, how should the operating basis (OBE) and safe shutdown seismic (SSE) events be determined in 2006? It appears that accelerations for a 500-year event were used as the starting place for determining OBE and SSE in 1966. The International Building Code (IBC) standards suggest that accelerations for a 2,500-year return interval are now the base standard for design of industrial/commercial structures. Are the OBE and SSE as determined in 1966 consistent with recent advances in seismic engineering and current scientific knowledge? Is there current knowledge or technology applicable to the Design Basis for floods?

Mail Envelope Properties (449C5B3A.6EE : 1 : 59118)

Subject:	Scoping Comments
Creation Date	Fri, Jun 23, 2006 5:20 PM
From:	"Gjessing, Catherine" <Catherine.Gjessing@state.vt.us>
Created By:	Catherine.Gjessing@state.vt.us

Recipients
nrc.gov
TWGWPO03.HQGWDO01
VermontYankeeEIS

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John.Sayles CC (John Sayles)
Julie.Moore CC (Julie Moore)

Post Office	**Route**
TWGWPO03.HQGWDO01	nrc.gov
	state.vt.us

Files	**Size**	**Date & Time**
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TEXT.htm	1433	
Scoping Comments-jsm.doc	53248	
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Options

Expiration Date:	None
Priority:	Standard
ReplyRequested:	No
Return Notification:	None
Concealed Subject:	No
Security:	Standard

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HARMON, CURRAN, SPIELBERG & EISENBERG, LLP

1726 M Street, NW, Suite 600 Washington, DC 20036 (202) 328-3500 (202) 328-6918 fax

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RULES AND DIRECTIVES BRANCH USNRC

June 15, 2006

BY FEDERAL EXPRESS
Chief, Rules and Directives Branch
Division of Administrative Services
Office of Administration
Room T-6D59
Two White Flint North
11545 Rockville Pike
Rockville, MD 20952
301-415-1590

SUBJECT: *EIS Scoping Process for Vermont Yankee Nuclear Plant License Renewal, 71 Fed. Reg. 20,733 (April 21, 2006)*

Dear Madam/Sir:

On behalf of Massachusetts Attorney General Thomas F. Reilly, we are writing to submit comments on the proposed scope of the supplemental Generic Environmental Impact Statement ("Supplemental GEIS") for the renewal of the Vermont Yankee nuclear power plant operating license. The Attorney General seeks consideration in the Supplemental GEIS of the environmental impacts of a severe accident in the Vermont Yankee fuel pool, including accidents caused by equipment failures, natural disasters, and intentional malicious acts. The Attorney General also seeks consideration of a reasonable array of alternatives for avoiding or mitigating the impacts of a severe pool fire, including combined low-density pool storage and dry storage of spent fuel.

The technical grounds for the Attorney General's request are discussed in detail in the enclosed Hearing Request, submitted to the Commission on May 26, 2006.[1] The Hearing Request also discusses the basis for the Attorney General's position that the analysis he seeks is required by U.S. Nuclear Regulatory Commission ("NRC") regulations and the National Environmental Policy Act ("NEPA").

In addition, we wish to draw your attention to a recent decision by the U.S. Court of Appeals for the Ninth Circuit, in which the Court ruled that the Commission's rationale

[1] Massachusetts Attorney General's Request for a Hearing and Petition to Intervene With Respect to Entergy Nuclear Operations Inc.'s Application for Renewal of the Vermont Yankee Nuclear Plant Operating License, etc. (May 26, 2006) ("Hearing Request"). The Hearing Request is now pending before the Atomic Safety and Licensing Board.

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E-RIDS = ADM-03
Call = R.L. Emch (RLE)

for refusing to consider the environmental impacts of intentional malicious attacks against nuclear facilities, as set forth in *Private Fuel Storage* (Independent Spent Fuel Storage Installation), CLI-02-25, 56 NRC 340 (2002) (*"PFS"*), fails to meet NEPA's reasonableness standard. *San Luis Obispo Mothers for Peace v. Nuclear Regulatory Commission,* No. 03-74628 (June 2, 2006) ("*Mothers for Peace*"). A copy of the decision is enclosed. The *Mothers for Peace* decision constitutes a significant precedent that supports including the environmental impacts of intentional malicious attacks on the Vermont Yankee pool within the scope of the Supplemental EIS.

Sincerely,

Diane Curran

Matthew Brock/DC

Matthew Brock, Assistant Attorney General
Environmental Protection Division
Office of the Attorney General
One Ashburton Place
Boston, MA 02108

Enclosure: As stated

FOR PUBLICATION

UNITED STATES COURT OF APPEALS FOR THE NINTH CIRCUIT

SAN LUIS OBISPO MOTHERS FOR PEACE; SANTA LUCIA CHAPTER OF THE SIERRA CLUB; PEG PINARD, *Petitioners,* PACIFIC GAS AND ELECTRIC COMPANY, *Intervenor,* v. NUCLEAR REGULATORY COMMISSION; UNITED STATES OF AMERICA, *Respondents.*	No. 03-74628 NRC No. CLI-03-01; CLI-02-23 OPINION

On Petition for Review of an Order of the Nuclear Regulatory Commission

Argued and Submitted
October 17, 2005—San Francisco, California

Filed June 2, 2006

Before: Stephen Reinhardt and Sidney R. Thomas, Circuit Judges, and Jane A. Restani,* Chief Judge, United States Court of International Trade

Opinion by Judge Thomas

*The Honorable Jane A. Restani, Chief Judge, United States Court of International Trade, sitting by designation.

COUNSEL

Diane Curran, Harmon, Curran, Spielberg & Eisenberg, L.L.P., Washington, D.C., for the petitioners.

Charles E. Mullins, United States Nuclear Regulatory Commission, Washington, D.C., for the respondents.

David A. Repka, Winston & Strawn, L.L.P., Washington, D.C., for respondent-intervenor PG&E.

Sheldon L. Trubatch, Esq., Offices of Robert K. Temple, Esq., Chicago, Illinois, for amicus San Luis Obispo County.

Kevin James, California Department of Justice, Oakland, California, for amicus States of California, Massachusetts, Utah and Washington.

Jay E. Silberg, Shaw Pittman, L.L.P., Washington, D.C., for amicus Nuclear Energy Institute.

OPINION

THOMAS, Circuit Judge:

This case presents the question, *inter alia*, as to whether the likely environmental consequences of a potential terrorist attack on a nuclear facility must be considered in an environmental review required under the National Environmental Policy Act. The United States Nuclear Regulatory Commission ("NRC") contends that the possibility of a terrorist attack on a nuclear facility is so remote and speculative that the potential consequences of such an attack need not be considered at all in such a review. The San Luis Obispo Mothers for Peace and other groups disagree and petition for review of the NRC's approval of a proposed Interim Spent Fuel Storage Installation. We grant the petition in part and deny it in part.

I

The NRC is an independent federal agency established by the Energy Reorganization Act of 1974 to regulate the civilian use of nuclear materials. Intervenor Pacific Gas and Electric Company ("PG&E") filed an application with the NRC under 10 C.F.R. Part 72 for a license to construct and operate an Interim Spent Fuel Storage Installation ("Storage Installation" or "ISFSI") at PG&E's Diablo Canyon Power Plant ("Diablo Canyon") in San Luis Obispo, California. The NRC granted the license. The question presented by this petition for review is whether, in doing so, the NRC complied with federal statutes including the National Environmental Policy Act of 1969 ("NEPA"), 42 U.S.C. §§ 4321-4437, the Atomic Energy Act of 1954 ("AEA"), 42 U.S.C. §§ 2011-2297g, and the Administrative Procedure Act ("APA"), 5 U.S.C. §§ 551-706.

NEPA establishes a "national policy [to] encourage productive and enjoyable harmony between man and his environment," and was intended to reduce or eliminate environmental damage and to promote "the understanding of the ecological systems and natural resources important to" the United States. *Dept. of Transp. v. Pub. Citizen*, 541 U.S. 752, 756 (2004) (quoting 42 U.S.C. § 4321). The Supreme Court has identified NEPA's "twin aims" as "plac[ing] upon an agency the obligation to consider every significant aspect of the environmental impact of a proposed action[, and] ensur[ing] that the agency will inform the public that it has indeed considered environmental concerns in its decisionmaking process." *Baltimore Gas & Elec. Co. v. Natural Res. Def. Counsel, Inc.*, 462 U.S. 87, 97 (1983).

Rather than mandating particular results, NEPA imposes on federal agencies procedural requirements that force consideration of the environmental consequences of agency actions. *Pub. Citizen*, 541 U.S. at 756. At NEPA's core is the requirement that federal agencies prepare an environmental impact statement ("EIS"), or:

> include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on—(i) the environmental impact of the proposed action, (ii) any adverse environmental effects which cannot be avoided should the proposal be implemented, (iii) alternatives to the proposed action, (iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and (v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Id. at 757 (quoting 42 U.S.C. § 4332(2)(C)).

As an alternative to the EIS, an agency may prepare a more limited environmental assessment ("EA") concluding in a "Finding of No Significant Impact" ("FONSI"), briefly presenting the reasons why the action will not have a significant impact on the human environment. *Id.* at 757-58 (citing 40 C.F.R. §§ 1501.4(e), 1508.13). If, however, the EA does not lead to the conclusion that a FONSI is warranted, the agency remains obligated to prepare an EIS. *Id.* at 757.

While NEPA requires the NRC to consider environmental effects of its decisions, the AEA is primarily concerned with setting minimum safety standards for the licensing and operation of nuclear facilities. The NRC does not contest that the two statutes impose independent obligations, so that compliance with the AEA does not excuse the agency from its NEPA obligations. The AEA lays out the process for consideration of the public health and safety aspects of nuclear power plant licensing, and requires the NRC to determine whether the licensing and operation of a proposed facility is "in accord with the common defense and security and will provide adequate protection to the health and safety of the public." 42 U.S.C. § 2232(a).

The NRC is not, however, required to make this determination without assistance; federal law provides a framework for hearings on material issues that interested persons raise by specific and timely petition. 42 U.S.C. § 2239(a); 10 C.F.R. §§ 2.308-.348; 5 U.S.C. §§ 551-706. The initial hearing is held before a three-person Atomic Safety and Licensing Board ("Licensing Board"). 10 C.F.R. § 2.321. The Licensing Board's findings and decision constitute the agency's initial determination, although a party may file a petition for review with the Commission within 15 days of the Licensing Board's decision. 10 C.F.R. § 2.341. If the petition is granted, the Commission specifies the issues to be reviewed and the parties to the review proceedings, 10 C.F.R. § 2.341(c)(1), and renders a final decision. 10 C.F.R. § 2.344. A party may then petition this court for review of the Commission's final decision. 28 U.S.C. § 2344.

II

With this general statutory background, we turn to the facts underlying the petition for review. On December 21, 2001, PG&E applied to the NRC pursuant to 10 C.F.R. Part 72 for a license to construct and operate a Storage Installation at Diablo Canyon. The Storage Installation would permit the necessary and on-site storage of spent fuel, the byproduct of the two nuclear reactors at that site. PG&E expects to fill its existing spent fuel storage capacity at Diablo Canyon sometime this year. Therefore, unless additional spent fuel storage capacity is created, the Diablo Canyon reactors cannot continue to function beyond 2006.

PG&E proposes to build a dry cask storage facility. The basic unit of the storage system is the Multi-Purpose Canister ("Canister"), a stainless steel cylinder that is filled with radioactive waste materials and welded shut. The Canisters are loaded into concrete storage overpacks that are designed to permit passive cooling via the circulation of air. The storage casks, or the filled Canisters loaded into overpacks, are then placed on one of seven concrete pads. The Storage Installation would house a total of 140 storage casks, 2 more than the 138 projected to be required for storage of spent fuel generated at Diablo Canyon through 2025.

On April 22, 2002, the NRC published a Notice of Opportunity for Hearing. Under the regulatory scheme, interested parties could then request a hearing or petition for leave to intervene. 10 C.F.R. § 2.309(a). A written hearing request, which must contain the contentions the party wants litigated at the hearing, will be granted if the petitioner has standing, and has posed at least one admissible contention.[1] *Id.*

On July 19, 2002, the San Luis Obispo Mothers for Peace, a non-profit corporation concerned with Diablo Canyon's

[1]In order to be admissible, a contention must: be set forth with particularity, 10 C.F.R. § 2.309(f)(1); provide a specific statement of the disputed issue of law or fact, 10 C.F.R. § 2.309(f)(1)(i); provide the basis for the contention, 10 C.F.R. § 2.309(f)(1)(ii); demonstrate that the issue is within the scope of the proceeding, 10 C.F.R. § 2.309(f)(1)(iii); demonstrate that the issue is material to the findings the NRC must make, 10 C.F.R. § 2.309(f)(1)(iv); provide supporting references and expert opinions, 10 C.F.R. § 2.309(f)(1)(v); and provide sufficient information to show the existence of a genuine issue of law or fact, 10 C.F.R. § 2.309(f)(1)(vi).

local impact, the Sierra Club, a non-profit corporation concerned with national environmental policy, and Peg Pinard, an individual citizen, (collectively "Petitioners") submitted a hearing request and a petition to intervene, asserting contentions for admission.

In Licensing Board Proceeding LBP-02-23, 56 NRC 413 ("LBP 02-23"), the Atomic Safety and Licensing Board addressed the admissibility of the July 19 petition's five Technical and three Environmental Contentions.[2] One Technical Contention, TC-1, dealing with the state of PG&E's finances, was deemed admissible; the acceptance of at least one contention meant that the petition was granted. Although the Licensing Board deemed two Environmental Contentions, EC-1, dealing with the failure to address environmental impacts of terrorist or other acts of malice or insanity, and EC-3, dealing with the failure to evaluate environmental impacts of transportation of radioactive materials[3] inadmissible, the Licensing Board nonetheless referred the final ruling as to the admissibility of these two contentions to the NRC, "in light of the

[2]Technical Contention Number One ("TC-1") alleged Inadequate Seismic Analysis. TC-2 alleged PG&E's Financial Qualifications Are Not Demonstrated. TC-3 alleged PG&E May Not Apply for a License for a Third Party. TC-4 alleged Failure to Establish Financial Relationships Between Parties Involved in Construction and Operation of Installation. TC-5 alleged Failure to Provide Sufficient Description of Construction and Operation Costs. Environmental Contention Number One ("EC-1") alleged Failure to Address Environmental Impacts of Destructive Acts of Malice or Insanity. EC-2 alleged Failure to Fully Describe Purposes of Proposed Action or to Evaluate All Reasonably Associated Environmental Impacts and Alternatives. EC-3 alleged Failure to Evaluate Environmental Impacts of Transportation.

[3]Because the Storage Installation is not a permanent repository, this contention assumes the eventual transport of the materials stored there to a permanent site. Among the materials submitted to support the contention were some dealing with possible terrorist or other malicious attacks on the spent fuel while in transit. The ruling on the contention was "referr[ed] . . . to the Commission to the extent terrorism and sabotage matters are proffered in support of its admission." 56 NRC at 453.

Commission's ongoing 'top to bottom' review of the agency's safeguards and physical security programs." 56 NRC at 448.

In a memorandum and order, CLI-03-1, 57 NRC 1 ("CLI 03-01"), the NRC accepted the Licensing Board's referral of its decision to reject the environmental contentions related to terrorism. Although the Commission affirmed the Licensing Board's rejection of the contentions, it based its decision on a different rationale. The NRC relied on four prior decisions in which it held that the NEPA does not require a terrorism review.[4] These decisions, most particularly *Private Fuel Storage*, CLI-02-25, 56 NRC 340 (2002), outlined four reasons for this holding: (1) the possibility of terrorist attack is too far removed from the natural or expected consequences of agency action to require study under NEPA; (2) because the risk of a terrorist attack cannot be determined, the analysis is likely to be meaningless; (3) NEPA does not require a "worst-case" analysis; and (4) NEPA's public process is not an appropriate forum for sensitive security issues. The NRC concluded:

> Our decision today rests entirely on our understanding of NEPA and of what means are best suited to dealing with terrorism. Nonetheless, our conclusion comports with the practical realities of spent fuel storage and the congressional policy to encourage utilities to provide for spent fuel storage at reactor sites pending construction of a permanent repository. Storage of spent fuel at commercial reactor sites offers no unusual technological challenges. Indeed, it has been occurring at Diablo Canyon for many

[4]Those cases include: *Private Fuel Storage, L.L.C.*, CLI-02-25, 56 NRC 340 (2002) (Storage Installation); *Duke Cogema Stone & Webster* (Mixed Oxide Fuel Fabrication Facility), CLI-02-24, 56 NRC 335 (2002); *Dominion Nuclear Connecticut, Inc.* (Nuclear Power Station), CLI-02-27, 56 NRC 367 (2002); and *Duke Energy Corp.* (Nuclear Power Station), CLI-02-26, 56 NRC 358 (2002). All four cases were decided on December 18, 2002.

> years and will continue whether or not we license the proposed Installation.

57 NRC at 7.

In September of 2002, prior to the NRC's decision on the first petition, Petitioners submitted a second petition, this time requesting suspension of the Storage Installation licensing proceeding pending comprehensive review of the adequacy of Diablo Canyon's design and operation measures for protection against terrorist attack and other acts of malice or insanity. Unlike the July 19 petition, this one addressed security measures for the entire Diablo Canyon complex, not merely the Storage Installation. Petitioners explained that 10 C.F.R. § 2.335, which prohibits challenges to any NRC rule or regulation in an adjudicatory proceeding involving initial or renewal licensing, prevented the raising of contentions contesting the adequacy of NRC safety requirements protecting against terrorist or other malicious attacks on the entire complex in the July 19 Petition. Petitioners also stated that 10 C.F.R. § 72.32 prevented them from raising emergency planning contentions in the earlier petition. Thus, Petitioners insisted that the second petition "d[id] not constitute a request for rulemaking, nor . . . for enforcement action," and instead defined it, without reference to any particular hearing-granting provision of the regulations, as "a request for actions that are necessary to ensure that any licensing decision made by the Commission with respect to the proposed Diablo Canyon Installation complies with the Commission's statutory obligations under the Atomic Energy Act."

In a memorandum and order, CLI-02-23, 56 NRC 230 ("CLI 02-23"), the NRC denied the September 2002 petition. Because the petition did not, according to the NRC, "fit comfortably in any specific category, [the Commission] treat[ed] it as a general motion brought under the procedural requirements of 10 C.F.R. § 2.730."[5] In rejecting the petition, the

[5] Since renumbered as 10 C.F.R. § 2.323, this regulation provides, simply, for "motions".

Commission reasoned that by not suspending operating licenses at installations and power plants following the September 11, 2001 terrorist attacks, it had demonstrated its implicit conclusion that the continued operation of these facilities *neither posed an imminent risk to the public health, nor* was inimical to the common defense. Further, the Commission concluded that because it had already initiated a thorough review of its safeguards and physical security program, there was no reason to suspend the Diablo Canyon licensing proceeding to address the terrorism-related concerns raised by the Petitioners. It stated that "[t]here certainly is no reason to believe that any danger to public health and safety would result from mere continuation of this adjudicatory proceeding," given that the proceeding was in its initial stages, that construction was not scheduled to begin for several years, and that the Petitioners would be able to comment on any changes in the rules resulting from the Commission's ongoing review of terrorism-related matters if and when they were to occur.

In a memorandum and order, CLI-03-12, 58 NRC 185 (2003) ("CLI 03-02"), the NRC denied the petitions for agency review of the Licensing Board's decisions that "cumulatively, rejected challenges to [the PG&E] Installation application." This denial thus became a final order, reviewable by this court on petition for review. 28 U.S.C. § 2344.

In October of 2003, the Spent Fuel Project Office of the NRC's Office of Material Safety and Safeguards released its Environmental Assessment Related to the Construction and Operation of the Diablo Canyon Independent Spent Fuel Storage Installation. The 26-page document contains the NRC's conclusion "that the construction, operation, and decommissioning of the Diablo Canyon Installation will not result in significant impact to the environment," and therefore that "an [EIS] is not warranted for the proposed action, and pursuant to 10 C.F.R. [§] 51.31, a Finding of No Significant Impact is appropriate."

The EA is not devoid of discussion of terrorist attacks. Indeed, the document contains the Commission's response to a comment submitted by the California Energy Commission in response to an earlier draft that "there is no discussion in the EA of the potential destruction of the casks or blockage of air inlet ducts as the result of sabotage or a terrorist attack . . . [nor is there] a description of how decisions are being made regarding the configuration, design and spacing of the casks, the use of berms, and the location of the ISFSI to minimize the vulnerability of the ISFSI to potential attack." The NRC responded:

> In several recent cases, . . . the Commission has determined that an NRC environmental review is not the appropriate forum for the consideration of terrorist acts. The NRC staff considers the security of spent fuel as part of its safety review of each application for an ISFSI license. In addition to reviewing an ISFSI application against the requirements of 10 CFR Part 72, the NRC staff evaluates the proposed security plans and facility design features to determine whether the requirements in 10 CFR Part 73, "Physical Protection of Plants and Materials," are met. The details of specific security measures for each facility are Safeguards Information, and as such, can not be released to the public.
>
> The NRC has also initiated several actions to further ensure the safety of spent fuel in storage. Additional security measures have been put in place at nuclear facilities, including ISFSIs currently storing spent fuel. These measures include increased security patrols, augmented security forces and weapons, additional security posts, heightened coordination with law enforcement and military authorities, and additional limitations on vehicular access. Also, as part of its comprehensive review of its security program, the NRC is conducting several technical

> studies to assess potential vulnerabilities of spent fuel storage facilities to a spectrum of terrorist acts. The results of these studies will be used to determine if revisions to the current NRC security requirements are warranted.

Petitioners argue that, in denying their petitions, the NRC violated the AEA, the APA, and NEPA. Although we reject the AEA and APA claims, we agree with Petitioners that the agency has failed to comply with NEPA. We have jurisdiction over those final orders of the NRC made reviewable by 42 U.S.C. § 2239, which includes final orders entered in licensing proceedings, under 28 U.S.C. § 2342(4).

III

We turn first to Petitioners' AEA argument. Specifically, Petitioners argue that the NRC violated its regulations implementing the AEA, as well as the AEA's hearing provisions, when it denied Petitioners a hearing on whether NEPA required consideration of the environmental impact of a terrorist attack on the Storage Installation; they also argue that the NRC violated the AEA's hearing provisions in denying Petitioners a hearing on post-September 11th security measures for the entire Diablo Canyon complex. Both of these challenges fail.

A

[1] The NRC did not violate the AEA or its implementing regulations when it failed to explain its rejection of Petitioners' contentions by addressing each of their arguments. Nothing in the regulations or the AEA requires the NRC to provide such an explanation.

Section 189(a) of the AEA grants public hearing rights "upon the request of any person whose interest may be affected" by an NRC licensing proceeding. 42 U.S.C. § 2239. The

NRC public hearing regulations, at 10 C.F.R. § 2.309, "promulgated pursuant to the AEC's[6] power to make, promulgate, issue, rescind, and amend such rules and regulations as may be necessary to carry out the purposes of" the AEA, 12 U.S.C. § 2201(p), specify the procedures required of both petitioners and the NRC in making and deciding hearing petitions.

[2] Petitioners correctly observe that the NRC, in its decision, did not discuss whether Petitioners satisfied the regulatory standard. They are mistaken, however, in their unsupported contention that this omission amounts to the agency's failure to follow its own regulations and thus is "reversible error." The regulations simply do not require the NRC *to explain its decisions in any particular manner.* Although the NRC regulations are specific and demanding in what they require of petitioners, they demand far less of the NRC in responding to a petition: the regulations require only a timely "decision." *See* 10 C.F.R. § 2.714(i) ("Decision on request/petition. The presiding officer shall, within 45 days after the filing of answers and replies . . . issue a decision on each request for hearing/petition to intervene."). Because Petitioners do not claim that the NRC violated this requirement, we must reject this challenge.

B

[3] The NRC's denial of a hearing on whether NEPA requires consideration of the environmental effects of a terrorist attack on the Storage Installation did not violate the AEA's hearing provisions.

[4] Petitioners contend that the NRC relied on an improper ground in denying their request for a hearing on whether

[6]In 1974, Congress eliminated the Atomic Energy Commission ("AEC"). Regulatory functions went to the NRC, and promotional functions to the Energy Research and Development Administration. *See* Energy Reorganization Act of 1974, 42 U.S.C. § 5814.

NEPA requires the Commission to consider the environmental impacts of terrorism — namely, the ground that it had determined in earlier decisions that NEPA imposes no such obligation. Thus, Petitioners do not challenge the substantive validity or coherence of those earlier opinions in making their AEA claim, but rather the reliance upon a prior determination of the merits in order to reject a petition presenting the same issues. As such, *Sierra Club v. NRC*, 862 F.2d 222 (9th Cir. 1988), on which Petitioners rely, does not apply. In that case, the NRC rejected the petitioners' contentions as lacking in reasonable specificity, and yet went on to analyze the merits of those supposedly unacceptable contentions. *Id.* at 228. Here, however, where the agency is rejecting the contentions as contrary to a prior decision, the "merits" and the reason for the inadmissibility of the contention collapse. Put differently, the NRC did not reach the merits of the petition as much as it assessed the issues raised against issues resolved by prior decisions. We hold that in doing so, the Commission complied fully with the AEA. To hold otherwise would unduly restrict the agency's evaluation of hearing petitions, by requiring it to grant a hearing on issues it has already resolved whenever a petitioner claims to have new evidence. We can find, and Petitioners point to, nothing in the AEA that would require this result.

C

[5] The NRC's denial of a hearing on security measures for Diablo Canyon as a whole also did not violate the AEA. Petitioners argue that the AEA requires the NRC to grant petitioners a hearing on all issues of material fact, including the security of the entire Diablo Canyon complex. Petitioners therefore conclude, citing *Union of Concerned Scientists v. NRC*, 735 F.2d 1437 (D.C. Cir. 1984), that the NRC violated the AEA when it denied a hearing on that issue.

Petitioners' argument misreads *Union of Concerned Scientists*, in which the D.C. Circuit held only that the agency cannot by rule presumptively eliminate a material issue from consideration in a hearing petition. *Union of Concerned Scientists* requires the agency to consider a petition; it does not require that the agency grant it.

The NRC in CLI 02-23 did not deny that security requirements for the entire complex might need to be upgraded, but rather maintained that a licensing proceeding hearing (and one regarding an installation, not the entire complex) was not the correct forum in which to address the issue. The Commission directed Petitioners to participate in a rulemaking or to raise their concerns in a hearing then pending before the Licensing Board. Petitioners contend that these alternative fora are illusory, and that rejection of their petition amounted to the denial of any opportunity to participate in the consideration of post-9/11 security measures for the Diablo Canyon complex.

Petitioners argue "[i]f the NRC were going to resolve Petitioners' concerns that grossly inadequate security made the Diablo Canyon facility vulnerable to terrorist attacks generically, through a rulemaking, such a rulemaking would have been initiated as a result of the 'comprehensive security review' undertaken by the NRC." Thus, Petitioners argue that it would have been futile to submit a rulemaking petition. This argument must fail, as Petitioners did not use the available procedures for initiating a rulemaking. Petitioners cannot complain that NRC failed to institute a rulemaking they never requested.

[6] Given that rulemaking may have been an avenue for Petitioners' participation, had they chosen to pursue it, their argument that they had no forum in which to raise their contentions loses its force. However, even were Petitioners correct in their assertion that they were unfairly denied the opportunity to participate in a rulemaking proceeding, the argument that the Licensing Board hearing was similarly illusory would fail. In fact, Petitioners were attempting to use the present Storage Installation licensing proceeding as a means

of launching a much broader challenge to the Diablo Canyon complex. The NRC correctly observes that a petition alleging that existing NRC regulations are "grossly inadequate to protect against terrorist attack, and therefore must be supplemented by additional requirements" cannot in fact be raised before the Licensing Board, which cannot hear challenges to NRC rules. The limited scope of licensing proceedings does not, however, amount to the arbitrary denial of a forum, as Petitioners claim. While Petitioners could have raised site-specific issues "relating to the 'common defense and security' " that were not controlled by existing rules or regulations to the Licensing Board, they are not entitled to expand those proceedings to include the entire complex, and issues already covered by agency rules.

D

In short, the NRC did not violate the AEA in denying the petitions for a hearing. Neither the AEA nor its implementing regulations required the NRC to grant Petitioners a hearing on whether NEPA required a consideration of the environmental impact of a terrorist attack on the Storage Installation or the security measures adopted for the entire Diablo Canyon complex.

IV

[7] The NRC's reliance on its own prior opinions in its decision in this case does not violate the APA's notice and comment provisions. Petitioners argue that the decisions in CLI 03-01 and *PFS* amount to the announcement "of a general policy of refusing to consider the environmental impacts of terrorist attacks in Environmental Impact Statements." Petitioners rely on *Mada-Luna v. Fitzpatrick*, 813 F.2d 1006, 1014 (9th Cir. 1987) to claim that this policy depends on factual determinations not found subsequent to an evidentiary proceeding, and constitutes a "binding substantive norm," the promulgation of which, without a public hearing, violates the

APA notice and comment provisions contained in 5 U.S.C. §§ 553(b), (c).[7] The flaw in Petitioners' argument is the mistaken assertion that the NRC's decisions were factual and not legal. If the NRC's conclusion that terrorism need not be examined under NEPA were factual, then Petitioners would be correct that its determination would have to comply with APA rulemaking requirements, including notice and comment, or else the agency would have to permit petitioners to challenge it in every proceeding where it was disputed.

[8] That NEPA does not require consideration of the environmental impacts of terrorism is a legal, and not a factual, conclusion. *Cf. Greenpeace Action v. Franklin*, 14 F.3d 1324, 1331 (9th Cir. 1993) (reasoning that a challenge to the adequacy of an EA turned on factual, not legal, principles where both NEPA's applicability and the requirements it imposed were uncontested); *see also Alaska Wilderness Recreation & Tourism Ass'n v. Morrison*, 67 F.3d 723, 727 (9th Cir. 1995) (noting that although "challenges to agency actions which raise predominantly legal, rather than technical questions, are rare," the court was there required to address "just such a challenge"). Petitioners' analysis is therefore inapposite. The agency has the discretion to use adjudication to establish a binding legal norm. *See Sec. & Exch. Comm'n v. Chenery*, 332 U.S. 194, 199-203 (1947) ("[T]he choice made between proceeding by general rule or by individual, ad hoc litigation, is one that lies primarily in the informed discretion of the administrative agency."). We therefore agree with the NRC's characterization in its brief to this court: having come to the legal conclusion that NEPA does not require consideration of the environmental consequences of terrorist attacks, "[w]hen

[7]U.S.C. § 553(b) states that "[g]eneral notice of proposed rulemaking shall be published in the Federal Register," and outlines the requirements that such notice must meet. 5 U.S.C. § 553(c) states that after such notice has been given, "the agency shall give interested persons an opportunity to participate in the rulemaking through submission of written data, views, or arguments with or without opportunity for oral presentation."

petitioners in this case presented a proposed contention seeking an EIS that analyzed the impacts of possible terrorist acts at the proposed Diablo Canyon Installation, the NRC reasonably concluded that this request was sufficiently similar to the request in *PFS* to justify the application of that decision here."

V

Although we hold that the agency did not violate the APA when it relied on the prior resolution of a legal issue through adjudication, we come to a different conclusion as to that determination's compliance with NEPA. Because the issue whether NEPA requires consideration of the environmental impacts of a terrorist attack is primarily a legal one, we review the NRC's determination that it does not for reasonableness. *See Alaska Wilderness Recreation & Tourism Ass'n*, 67 F.3d at 727 (reviewing predominately legal issue for reasonableness because "it makes sense to distinguish the strong level of deference we accord an agency in deciding factual or technical matters from that to be accorded in disputes involving predominately legal questions"); *Ka Makani'o Kohala Ohana, Inc. v. Water Supply*, 295 F.3d 955, 959 n.3 (9th Cir. 2002) ("Because this case involved primarily legal issues . . . based on undisputed historical facts, we conclude that the 'reasonableness' standard should apply to this case.").

Here, the NRC decided categorically that NEPA does not require consideration of the environmental effects of potential terrorist attacks. In making this determination, the NRC relied on *PFS*, where it "consider[ed] in some detail the legal question whether NEPA requires an inquiry into the threat of terrorism at nuclear facilities." 56 NRC 340, 343 (2002). In that case, intervenor State of Utah filed a contention claiming that the September 11 terrorist attacks "had materially changed the circumstances under which the Board had rejected previously proffered terrorism contentions by showing that a terrorist attack is both more likely and potentially more dangerous than previously thought." *Id.* at 345. The NRC concluded that even following the September 11th attacks, NEPA did not impose such a requirement, reasoning:

> In our view, an EIS is not an appropriate format to address the challenges of terrorism. The purpose of an EIS is to inform the decisionmaking authority and the public of a broad range of environmental impacts that will result, with a fair degree of likelihood, from a proposed project, rather than to speculate about 'worst-case' scenarios and how to prevent them.

Id. at 347.

The NRC determined that four grounds "cut[ ] against using the NEPA framework" to consider the environmental effects of a terrorist attack: (1) the possibility of a terrorist attack is far too removed from the natural or expected consequences of agency action; (2) because the risk of a terrorist attack cannot be determined, the analysis is likely to be meaningless; (3) NEPA does not require a "worst-case" analysis; and (4) NEPA's public process is not an appropriate forum for sensitive security issues. *Id.* at 348. We review each of these four grounds for reasonableness, and conclude that these grounds, either individually or collectively, do not support the NRC's categorical refusal to consider the environmental effects of a terrorist attack.

A

[9] The Commission relied first on finding that the possibility of a terrorist attack is too far removed from the natural or expected consequences of agency action. *Id.* at 347. Section 102 of NEPA requires federal agencies to prepare "a detailed statement . . . on the environmental impact" of any proposed major federal action "significantly affecting the quality of the human environment." 42 U.S.C. § 4332(1)(C)(i). The question thus becomes whether a given action "significantly affects" the environment.

The NRC claims that the appropriate analysis of Section 102 is that employed by the Supreme Court in *Metropolitan Edison Co. v. People Against Nuclear Power*, 460 U.S. 766, 773 (1983). In *Metropolitan Edison*, the Court noted that "[t]o determine whether Section 102 requires consideration of a particular effect, we must look to the relationship between that effect and the change in the physical environment caused by the major federal action at issue," looking for "a reasonably close causal relationship . . . like the familiar doctrine of proximate cause from tort law." 460 U.S. at 774. The Commission claims that its conclusion that the environmental impacts of a possible terrorist attack on an NRC-licensed facility is beyond a "reasonably close causal relationship" was a reasonable application of this "proximate cause" analogy.

The problem with the agency's argument, however, is that *Metropolitan Edison* and its proximate cause analogy are inapplicable here. In *Metropolitan Edison*, the petitioners argued that NEPA required the NRC to consider the potential risk of psychological damage upon reopening the Three Mile Island nuclear facilities to those in the vicinity. Noting that NEPA is an environmental statute, the Supreme Court held that the essential analysis must focus on the "closeness of the relationship between the change in the environment and the 'effect' at issue." 460 U.S. at 772.

The appropriate analysis is instead that developed by this court in *NoGwen Alliance v. Aldridge*, 855 F.2d 1380 (9th Cir. 1988). In *NoGwen*, the plaintiffs argued that NEPA required the Air Force to consider the threat of nuclear war in the implementation of the Ground Wave Emergency Network ("GWEN"). We held "that the nexus between construction of GWEN and nuclear war is too attenuated to require discussion of the environmental impacts of nuclear war in an [EA] or [EIS]." 855 F.2d at 1386.

[10] The events at issue here, as well as in *Metropolitan Edison* and *NoGwen*, form a chain of three events: (1) a major

federal action; (2) a change in the physical environment; and (3) an effect. *Metropolitan Edison* was concerned with the relationship between events 2 and 3 (the change in the physical environment, or increased risk of accident resulting from the renewed operation of a nuclear reactor, and the effect, or the decline in the psychological health of the human population). The Court in *Metropolitan Edison* explicitly distinguished the case where the disputed relationship is between events 1 and 2: "we emphasize that in this case we are considering effects caused by the risk of accident. The situation where an agency is asked to consider effects that will occur if a risk is realized, for example, if an accident occurs . . . is an entirely different case." *Id.* at 775 n.9. In *NoGwen,* we followed the Court's admonition and, in addressing the relationship between events 1 and 2, we held that the *Metropolitan Edison* analysis did not apply "because it discusse[d] a different type of causation than that at issue in this case . . . [which] require[d] us to examine the relationship between the agency action and a potential impact on the environment." *Id.* at 1386. *NoGWEN* relied on our decision in *Warm Springs Dam Task Force v. Gribble,* 621 F.2d 1017, 1026 (9th Cir. 1980), which held that "an impact statement need not discuss remote and highly speculative consequences." Applying that standard to the plaintiffs' claims that the military GWEN system's installation would "increase the probability of nuclear war," and "that GWEN would be a primary target in a nuclear war," we held both propositions to be "remote and highly speculative," and, therefore, NEPA did not require their consideration.

[11] In the present case, as in *NoGwen,* the disputed relationship is between events 1 and 2 (the federal act, or the licensing of the Storage Installation, and the change in the physical environment, or the terrorist attack). The appropriate inquiry is therefore whether such attacks are so "remote and highly speculative" that NEPA's mandate does not include consideration of their potential environmental effects.

[12] The NRC responds by simply declaring without support that, as a matter of law, "the possibility of a terrorist attack . . . is speculative and simply too far removed from the natural or expected consequences of agency action to require a study under NEPA." 56 NRC at 349. In doing so, the NRC failed to address Petitioners' factual contentions that licensing the Storage Installation would lead to or increase the risk of a terrorist attack because (1) the presence of the Storage Installation would increase the probability of a terrorist attack on the Diablo Canyon nuclear facility, and (2) the Storage Installation itself would be a primary target for a terrorist attack. We conclude that it was unreasonable for the NRC to categorically dismiss the possibility of terrorist attack on the Storage Installation and on the entire Diablo Canyon facility as too "remote and highly speculative" to warrant consideration under NEPA.

[13] In so concluding, we also recognize that the NRC's position that terrorist attacks are "remote and highly speculative," as a matter of law, is inconsistent with the government's efforts and expenditures to combat this type of terrorist attack against nuclear facilities. In the PFS opinion, the NRC emphasized the agency's own post-September 11th efforts against the threat of terrorism:

> At the outset, however, we stress our determination, in the wake of the horrific September 11th terrorist attacks, to strengthen security at facilities we regulate. We currently are engaged in a comprehensive review of our security regulations and programs, acting under our AEA-rooted duty to protect "public health and safety" and the "common defense and security." We are reexamining, and in may cases have already improved, security and safeguards matters such as guard force size, physical security exercises, clearance requirements and background investigations for key employees, and fitness-for-duty requirements. More broadly, we are rethinking

> the NRC's threat assessment framework and design basis threat. We also are reviewing our own infrastructure, resources, and communications.
>
> Our comprehensive review may also yield permanent rule or policy changes that will apply to the proposed PFS facility and to other NRC-related facilities. The review process is ongoing and cumulative. It has already resulted in a number of security-related actions to address terrorism threats at both active and defunct nuclear facilities.

56 NRC at 343. Among these actions is the establishment of an Office of Nuclear Security and Incident Response, "responsible for immediate operational security and safeguards issues as well as for long-term policy development[,] work[ing] closely with law enforcement agencies and the Office of Homeland Security[,] . . . coordinat[ing] the NRC's ongoing comprehensive security review." *Id.* at 344-45.

We find it difficult to reconcile the Commission's conclusion that, as a matter of law, the possibility of a terrorist attack on a nuclear facility is "remote and speculative," with its stated efforts to undertake a "top to bottom" security review against this same threat. Under the NRC's own formulation of the rule of reasonableness, it is required to make determinations that are consistent with its policy statements and procedures. Here, it appears as though the NRC is attempting, as a matter of policy, to insist on its preparedness and the seriousness with which it is responding to the post-September 11th terrorist threat, while concluding, as a matter of law, that all terrorist threats are "remote and highly speculative" for NEPA purposes.[8]

[8]The view that a terrorist attack is too speculative to be a required part of NEPA review would seem to be inconsistent with the NRC's pre-9/11 security procedures. Since 1977, the NRC has required licensed plants to have a security plan that is designed to protect against a "design basis

[14] In sum, in considering the policy goals of NEPA and the rule of reasonableness that governs its application, the possibility of terrorist attack is not so "remote and highly speculative" as to be beyond NEPA's requirements.

B

[15] The NRC's reliance upon the second *PFS* factor, that the Risk of a Terrorist Attack Cannot be Adequately Determined, 56 NRC at 350, is also not reasonable. First, the NRC's dismissal of the risk of terrorist attacks as "unquantifiable" misses the point. The numeric probability of a specific attack is not required in order to assess likely modes of attack, weapons, and vulnerabilities of a facility, and the possible impact of each of these on the physical environment, including the assessment of various release scenarios. Indeed, this is precisely what the NRC already analyzes in different contexts. It is therefore possible to conduct a low probability-high consequence analysis without quantifying the precise probability of risk. The NRC itself has recognized that consideration of uncertain risks may take a form other than quantitative "probabilistic" assessment. In its "Proposed Policy Statement on Severe Accidents and Related Views on Nuclear Reactor Regulation," 48 Fed.Reg. 16,014 (1983), the Commission stated that:

threat" for radiological sabotage. *See* General Accounting Office, *Nuclear Regulatory Commission: Oversight of Security at Commercial Nuclear Power Plants Needs to be Strengthened*, GAO-030752 (2003) at 6. "The design basis threat characterizes the elements of a postulated attack, including the number of attackers, their training, and the weapons and tactics they are capable of using." *Id.*

Thus, the NRC—even before the terrorist attacks of 9/11—did not consider such attacks too "remote and speculative" to be considered in agency planning. To the contrary, the agency has long required analysis of means and methods of hypothetical attacks against specific facilities, with the goal of establishing effective counter-measures.

> In addressing potential accident initiators (including earthquakes, sabotage, and multiple human errors) where empirical data are limited and *residual uncertainty is large*, the use of conceptual modeling and scenario assumptions in Safety Analysis Reports will be helpful. They should be based on *the best qualified judgments of experts*, either in the form of subjective numerical probability estimates *or qualitative assessments of initiating events and casual [sic] linkages in accident sequences.*

48 Fed.Reg. at 16,020 (emphasis added).

[16] No provision of NEPA, or any other authority cited by the Commission, allows the NRC to eliminate a possible environmental consequence from analysis by labeling the risk as "unquantifiable." *See Limerick Ecology Action, Inc. v. NRC,* 869 F.2d 719, 754 (3rd Cir. 1989) (J. Scirica, dissenting) (finding no "statutory provision, no NRC regulation or policy statement, and no case law that permits the NRC to ignore any risk found to be unquantifiable"). If the risk of a terrorist attack is not insignificant, then NEPA obligates the NRC to take a "hard look" at the environmental consequences of that risk. The NRC's actions in other contexts reveal that the agency does not view the risk of terrorist attacks to be insignificant. Precise quantification is therefore beside the point.

Even if we accept the agency's argument, the agency fails to adequately show that the risk of a terrorist act is unquantifiable. The agency merely offers the following analysis as to the quantifiability of a potential terrorist attack:

> The horrors of September 11 notwithstanding, it remains true that the likelihood of a terrorist attack being directed at a particular nuclear facility is not quantifiable. Any attempt at quantification or even qualitative assessment would be highly speculative. In fact, the likelihood of attack cannot be ascertained

> with confidence by any state-of-the-art methodology. That being the case, we have no means to assess, usefully, the risks of terrorism at the PFS facility.

56 NRC at 350. The agency nonetheless has simultaneously shown the ability to conduct a "top to bottom" terrorism review. This leaves the Commission in the tenuous position of insisting on the impossibility of a meaningful, i.e. quantifiable, assessment of terrorist attacks, while claiming to have undertaken precisely such an assessment in other contexts. Further, as we have noted, the NRC has required site-specific analysis of such threats, involving numerous recognized scenarios.[9]

[17] Thus, we conclude that precise quantification of a risk is not necessary to trigger NEPA's requirements, and even if it were, the NRC has not established that the risk of a terrorist attack is unquantifiable.

C

The NRC's third ground, that it is not required to conduct a "worst-case" analysis, is a non sequitur. Although it is a true statement of the law, the agency errs in equating an assessment of the environmental impact of terrorist attack with a demand for a worst-case analysis.

The Council on Environmental Quality ("CEQ") regulations, 40 C.F.R. §§ 1500.1 - 1518.4, promulgated with the "purpose [of] tell[ing] federal agencies what they must do to comply with [NEPA] procedures and achieve the goals of

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[9]The NRC's assertion that a risk of terrorism cannot be quantified is also belied by the very existence of the Department of Homeland Security Advisory System, which provides a general assessment of the risk of terrorist attacks. *See, e.g.*, World Market Research Centre, Global Terrorism Index 2003/4 (offering a probabilistic risk assessment of terrorist activities over a 12-month period).

[NEPA]," have been interpreted by the Supreme Court as "entitled to substantial deference." *Robertson v. Methow Valley Citizens Council*, 490 U.S. 332, 355 (citing *Andrus v. Sierra Club*, 442 U.S. 347, 358 (1979)). These regulations mandated worst-case analyses until 1986, when CEQ replaced the former 40 C.F.R. § 1502.22, requiring an agency, when relevant information was either unavailable or too costly to obtain, to include in the EIS a "worst-case analysis and an indication of the probability or improbability of its occurrence," with the new and current version of the regulation, which requires an agency to instead deal with uncertainties by including within the EIS "a summary of existing credible scientific evidence which is relevant to evaluating the reasonable foreseeable significant adverse impacts on the human environment, and . . . the agency's evaluation of such impacts based upon theoretical approaches or research methods generally accepted in the scientific community." 40 C.F.R. §§ 1502.22(b)(3), (4). The current requirement applies to those events with potentially catastrophic consequences "even if their probability of occurrence is low, provided that the analysis of impacts is supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason." 40 C.F.R. § 1502.22 (b)(4). The Supreme Court held in *Robertson* that the amendment of the regulations had nullified the worst-case analysis requirement. 490 U.S. at 355; *Edwardsen v. U.S. Dep't of Interior*, 268 F.3d 781, 785 (9th Cir. 2001).

The Commission is therefore correct when it argues that NEPA does not require a worst-case analysis. It is mistaken, however, when it claims that "Petitioners' request for an analysis of [the environmental effects of] a successful terrorist attack at the Diablo Canyon ISFSI approximates a request for a 'worst-case' analysis that has long since been discarded by the CEQ regulations . . . and discredited by the Federal courts." According to the NRC, "'[m]aking the various assumptions required by [P]etitioners' scenario requires the NRC to venture into the realm of 'pure conjecture.' " We disagree.

[18] An indication of what CEQ envisioned when it imposed the worst-case analysis requirement can be gleaned from a 1981 CEQ memorandum, Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations, reprinted at 46 FR 18026-01 (March 23, 1981). CEQ answered one of those questions, "[w]hat is the purpose of a worst-case analysis? How is it formulated and what is the scope of the analysis?" with the following:

> The purpose of the analysis is to . . . cause agencies to consider th[ ]e potential consequences [of agency decisions] when acting on the basis of scientific uncertainties or gaps in available information. The analysis is formulated on the basis of available information, using reasonable projections of the worst possible consequences of a proposed action.
>
> *For example, if there are scientific uncertainty and* gaps in the available information concerning the numbers of juvenile fish that would be entrained in a cooling water facility, the responsible agency must disclose and consider the possibility of the loss of the commercial or sport fishery. In addition to an analysis of a low probability/catastrophic impact event, the worst-case analysis should also include a spectrum of events of higher probability but less drastic impact.

46 FR 18026, 18032. While it is true that the agency is not required to consider consequences that are "speculative,"[10] the

[10]Because we disagree with the agency's interpretation of worst-case analysis, we do not reach the agency's characterization of the possibility of terrorist attack as "speculative." We note, however, that this characterization stands out as contrary to the vigilant stance that Americans are encouraged to take by the Department of Homeland Security. *See* www.dhs.gov/dhspublic/display?theme=29 (urging that "[a]ll Americans should continue to be vigilant" and noting that "[t]he country remains at an elevated risk . . . for terrorist attack.")

NRC's argument wrongly labels a terrorist attack the worst-case scenario because of the low or indeterminate probability of such an attack. The CEQ memo, by including as worst-case scenarios events of both higher and lower probability, reveals that worst-case analysis is not defined solely by the low probability of the occurrence of the events analyzed, but also by the range of outcomes of those events. *See also Greater Yellowstone Coalition v. Flowers*, 321 F.3d 1250, 1260 (10th Cir. 2003) (citing a witness's testimony that the loss of bald eagle nesting sites was both "likely" and "a worst-case scenario"). Petitioners do not seek to require the NRC to analyze the most extreme (i.e., the "worst") possible environmental impacts of a terrorist attack. Instead, they seek an analysis of the range of environmental impacts likely to result in the event of a terrorist attack on the Storage Installation. We reject the Commission's characterization of this request as a demand for a worst-case analysis.

D

[19] The NRC's reliance on the fourth *PFS* factor, that it cannot comply with its NEPA mandate because of security risks, is also unreasonable. There is no support for the use of security concerns as an excuse from NEPA's requirements. While it is true, as the agency claims, that NEPA's requirements are not absolute, and are to be implemented consistent with other programs and requirements, this has never been interpreted by the Supreme Court as excusing NEPA's application to a particularly sensitive issue. *See Weinberger v. Catholic Action of Hawaii*, 454 U.S. 139 (1981) (holding that the Navy was required to perform a NEPA review and to factor its results into decisionmaking even where the sensitivity of the information involved meant that the NEPA results could not be publicized or adjudicated). *Weinberger* can support only the proposition that security considerations may permit or require modification of some of the NEPA procedures, not the Commission's argument that sensitive security issues result in some kind of NEPA waiver.

The application of NEPA's requirements, under the rule of reason relied on by the NRC, is to be considered in light of the two purposes of the statute: first, ensuring that the agency will have and will consider detailed information concerning significant environmental impacts; and, second, ensuring that the public can both contribute to that body of information, and can access the information that is made public. *Pub. Citizen,* 541 U.S. at 768. To the extent that, as the NRC argues, certain information cannot be publicized, as in *Weinberger*, other statutory purposes continue to mandate NEPA's application. For example, that the public cannot access the resulting information does not explain the NRC's determination to prevent the public from *contributing* information to the decisionmaking process. The NRC simply does not explain its unwillingness to hear and consider the information that Petitioners seek to contribute to the process, which would fulfill both the information-gathering and the public participation functions of NEPA. These arguments explain why a *Weinberger*-style limited proceeding might be appropriate, but cannot support the NRC's conclusion that NEPA does not apply. As we stated in *NoGWEN*: "There is no 'national defense' exception to NEPA . . . 'The Navy, just like any federal agency, must carry out its NEPA mandate to the fullest extent possible and this mandate includes weighing the environmental costs of the [project] even though the project has serious security implications.' " 855 F.2d at 1384 (quoting *Concerned About Trident v. Rumsfeld,* 555 F.2d 817, 823 (D.C. Cir. 1977)).

E

[20] In sum, none of the four factors upon which the NRC relies to eschew consideration of the environmental effects of a terrorist attack satisfies the standard of reasonableness. We must therefore grant the petition in part and remand for the agency to fulfill its responsibilities under NEPA.

[21] Our identification of the inadequacies in the agency's NEPA analysis should not be construed as constraining the

NRC's consideration of the merits on remand, or circumscribing the procedures that the NRC must employ in conducting its analysis. There remain open to the agency a wide variety of actions it may take on remand, consistent with its statutory and regulatory requirements. We do not prejudge those alternatives. Nor do we prejudge the merits of the inquiry. We hold only that the NRC's stated reasons for categorically refusing to consider the possibility of terrorist attacks cannot withstand appellate review based on the record before us.

We are also mindful that the issues raised by the petition may involve questions of national security, requiring sensitive treatment on remand. However, the NRC has dealt with our nation's most sensitive nuclear secrets for many decades, and is well-suited to analyze the questions raised by the petition in an appropriate manner consistent with national security.

VI

We deny the petition as to the claims under the AEA and the APA. However, because we conclude that the NRC's determination that NEPA does not require a consideration of the environmental impact of terrorist attacks does not satisfy reasonableness review, we hold that the EA prepared in reliance on that determination is inadequate and fails to comply with NEPA's mandate. We grant the petition as to that issue and remand for further proceedings consistent with this opinion.

PETITION GRANTED IN PART; DENIED IN PART; REMANDED.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
BEFORE THE COMMISSION

In the Matter of	)	
	)	
Entergy Nuclear Operations, Inc.	)	Docket No. 50-293
	)	
(Vermont Yankee Nuclear Power Station)	)	
	)	

MASSACHUSETTS ATTORNEY GENERAL'S REQUEST FOR A HEARING AND PETITION FOR LEAVE TO INTERVENE WITH RESPECT TO ENTERGY NUCLEAR OPERATIONS INC.'S APPLICATION FOR RENEWAL OF THE VERMONT YANKEE NUCLEAR POWER PLANT OPERATING LICENSE

AND

PETITION FOR BACKFIT ORDER REQUIRING NEW DESIGN FEATURES TO PROTECT AGAINST SPENT FUEL POOL ACCIDENTS

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May 26, 2006

TABLE OF CONTENTS

TABLE OF AUTHORITIES

<u>Judicial Decisions</u>

<u>NRC Decisions</u>

Federal Register Notices

Miscellaneous

I. INTRODUCTION AND EXECUTIVE SUMMARY

On behalf of the Commonwealth of Massachusetts, Attorney General Thomas F. Reilly ("Massachusetts Attorney General" or "Petitioner") petitions to intervene and requests the U.S. Nuclear Regulatory Commission ("NRC" or "Commission") to grant an adjudicatory hearing on Entergy Nuclear Operations, Inc.'s ("Entergy's") application for renewal of its license to operate the Vermont Yankee nuclear power plant. He files this petition pursuant to the notice of opportunity for a hearing published at 71 Fed. Reg. 15,222 (March 27, 2006), Section 189a of the Atomic Energy Act ("AEA") [42 U.S.C. § 2239(a)], and 10 C.F.R. § 2.309.

Through its application, Entergy seeks approval to operate the Vermont Yankee plant an additional 20 years past its expiration date of 2012. As a general matter the Attorney General does not oppose Entergy's renewal application, and he acknowledges that nuclear power provides an important component of the New England energy supply. At the same time, however, he wants to ensure that the NRC does not grant the license renewal before Entergy and the NRC address the risk of a severe accident in the Vermont Yankee spent fuel pool and comply with federal laws for the protection of public health, safety, and the environment.

As detailed below in the Petitioner's contention (*see* Section V below), Entergy's license renewal application fails to comply with the National Environmental Policy Act's ("NEPA's") requirement that it address significant new information bearing on the environmental impacts of operating the Vermont Yankee nuclear power plant during a license renewal term. That new information, not addressed in any previous Environmental Impact Statement ("EIS") for the Vermont Yankee nuclear plant or any other nuclear power plant, demonstrates that continued storage of spent fuel in high-density storage racks in the Vermont Yankee pool poses a significant and reasonably foreseeable environmental risk of a severe fire and offsite release of a large amount of radioactivity. Entergy's failure to take account of this new information is inconsistent with NEPA's major requirement that environmental decisions must take new information into account if the information shows that a proposed action will affect the quality of the human environment "in a significant manner or to a significant extent not already considered." *Marsh v. Oregon Natural Resources Council*, 490 U.S. 360, 374 (1989) ("*Marsh*").

Entergy's application also fails to satisfy the AEA's fundamental requirement to ensure safe operation of the Vermont Yankee plant during the license renewal term because it does not include adequate design measures to prevent the occurrence of a pool fire or to reduce its consequences. Therefore, pursuant to 10 C.F.R. § 50.109(a)(5), the Attorney General petitions the Commission to require that Entergy backfit the Vermont Yankee design to eliminate or substantially mitigate the risk of a pool fire. The choice of design measure for the backfit should be informed by the consideration of backfit design alternatives in an EIS.

The Attorney General's hearing request and backfit petition arise from the safety and environmental risks posed by Entergy's plan to continue to use "high-density" racks for storage of spent fuel in the Vermont Yankee fuel pool. When the Vermont Yankee plant was originally licensed in 1972, "low-density" racks were used to store spent fuel in the pool. The open construction of these racks allowed cooling fluid to flow freely all around and over the spent fuel assemblies stored in the pool. Under several license amendments granted between 1972 and 1994, the NRC has allowed Entergy to pack fuel more and more densely into the pool, using "high-density" storage racks. By the time the current license term expires in 2012, Entergy will have accumulated some three thousand fuel assemblies in the Vermont Yankee fuel pool, amounting to approximately forty million curies of radioactive isotopes. If the fuel pool were to suffer a loss of water sufficient to uncover the tops of the fuel assemblies, the dense configuration of the high-density racks would inhibit the flow of water, air or steam over the fuel assemblies, causing some of the fuel to ignite within hours. The fire could then propagate within the pool, and the burning of fuel assemblies could lead to a large atmospheric release of radioactive isotopes, contaminating a large land area for decades and at a heavy cost to public health and the economy.

While such a catastrophic accident is unlikely, its probability falls within the range that NRC considers reasonably foreseeable. Therefore it is not a speculative or worst-case event. Pool water could also be lost if the pool were the subject of an intentional attack, a risk that can no longer be ignored after the attacks of September 11, 2001. Yet, neither Entergy nor the NRC has addressed the safety and environmental impacts of a pool fire in any EIS, nor is the Vermont Yankee plant designed to avoid a pool fire accident.

Although it has long been known that high-density pool storage of spent fuel could potentially lead to a serious accident, the scientific information on such risks has continued to develop in recent years, including through technical studies by the Commission's own staff, independent expert analyses, and a study by the National Academies of Sciences. Increased appreciation for the potential for an intentional attack on nuclear facilities has also changed our consideration of that risk. Despite the NRC's acknowledgment of concern about such a risk, and despite the known vulnerability of fuel pools to fire if they are intentionally drained, the agency has not addressed the potential safety and environmental impacts of attacks involving fuel pools. *Marsh* and NRC regulations require that prior to licensing Vermont Yankee, the NRC must prepare an EIS that addresses significant new information regarding the safety and environmental impacts of a pool fire. This information was not available to the NRC when earlier EISs relevant to license renewal were prepared. Under NEPA, the EIS must also weigh reasonably available alternatives for avoiding or mitigating a pool fire, such as combined low-density pool storage and dry storage of spent fuel.

The AEA also requires the NRC to protect against the unreasonable risk of a pool fire in its license renewal decision for Vermont Yankee. *Petition for Emergency and Remedial Action*, CLI-78-6, 7 NRC 400, 404 (1978) ("*Petition for Emergency and Remedial Action*"). Therefore, the NRC must not only assess the impacts of pool fires in an EIS, it must require Entergy to change the design or operations of the plant to prevent a pool fire from occurring.

II. THE MASSACHUSETTS ATTORNEY GENERAL HAS STANDING TO INTERVENE IN THIS PROCEEDING AND REQUEST A BACKFIT ORDER.

Section 189a of the AEA, 42 U.S.C. § 2239(a)(1), provides that:

> In any proceeding under this Act, for the granting, suspending, revoking, or amending of any license . . . the Commission shall grant a hearing upon the request of any person whose interest may be affected by the proceeding, and shall admit any person as a party to such a proceeding.

As previously established, the Attorney General has standing to intervene in a proceeding involving the safety of pool storage of spent fuel at Vermont Yankee.

Vermont Yankee Nuclear Power Corporation (Vermont Yankee Nuclear Power Station), LBP-87-7, 25 NRC 116, 118 (1987) ("*Vermont Yankee*").[1]

The Attorney General is concerned that Entergy and the NRC have not adequately informed the public regarding the risks of a severe accident in the Vermont Yankee spent fuel pool during the license renewal term, nor have they implemented adequate design measures to avoid such an accident. Therefore, the Attorney General seeks enforcement of federal laws requiring the preparation of an EIS regarding the risks of storing spent fuel in the Vermont Yankee pool, as well as the imposition of design measures for avoiding those accidents. If granted, this relief would improve the level of protection of the environment and public health and safety of the residents of Massachusetts.[2]

III. STATUTORY AND REGULATORY FRAMEWORK

The two statutes that govern this hearing request and backfit petition are NEPA and the AEA. The AEA sets minimum standards for safe and secure operation of nuclear facilities, while NEPA requires NRC to consider and attempt to avoid or mitigate significant adverse environmental impacts of licensing those facilities. Although the statutes have some overlapping concerns, they establish independent requirements. *Limerick Ecology Action v. NRC*, 869 F.2d 719, 729-30 (3rd Cir. 1989). NEPA goes

1 The Attorney General satisfies the requirements of 10 C.F.R. § 2.309(d) for demonstrating standing. The Attorney General has an interest in this proceeding because the Vermont Yankee nuclear power plant lies within ten miles of the Commonwealth of Massachusetts. An accidental offsite release of radioactivity from the Vermont Yankee fuel pool during the proposed license renewal term could affect the health and well-being of Massachusetts residents, the integrity of the environment, and the economic welfare of the Commonwealth.

2 As an elected representative of the citizens of the Commonwealth of Massachusetts, the Attorney General also has the right to participate in this proceeding as a representative of an interested State. 10 C.F.R. § 2.315(c). *See also Vermont Yankee*, 25 NRC at 118.

beyond the AEA, requiring the consideration of alternatives to reduce or avoid adverse environmental impacts of NRC licensing actions. *Id.*, citing 10 C.F.R. § 51.71(d).[3]

A. Atomic Energy Act Safety Requirements

1. AEA requirements for protection of public safety

The AEA prohibits the NRC from issuing a license to operate a nuclear power plant if it would be "inimical to the common defense and security or to the health and safety of the public." 42 U.S.C. § 2133(d). Public safety is "the first, last, and a permanent consideration in any decision on the issuance of a construction permit or a license to operate a nuclear facility." *Petition for Emergency and Remedial Action,* 7 NRC at 404, citing *Power Reactor Development Corp. v. International Union of Electrical Radio and Machine Workers,* 367 U.S. 396, 402 (1961) ("*Power Reactor Development Corp.*").

2. NRC requirements for protection against design-basis accidents

NRC regulations for implementation of the AEA provide that a nuclear power plant must be designed against accidents that are "anticipated during the life of the facility." *See* 10 C.F.R. § 50.34(a)(4), which provides that a construction permit application for a nuclear power plant must include:

> a preliminary analysis and evaluation of the design and performance of structures, systems, and components of the facility with the objective of assessing the risk to public health and safety resulting from operation of the facility and including determination of the margins of safety during normal operations and transient conditions anticipated during the life of the facility, and the adequacy of

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3 As the Court observed in *Limerick,* it is "unreasonable to suppose that [environmental] risks are automatically acceptable, and may be imposed upon the public by virtue of the AEA, merely because operation of a facility will conform to the Commission's basic health and safety standards." *Id.* quoting *Citizens for Safe Power v. NRC,* 524 F.2d 1291, 1299 (D.C. Cir. 1975).

structures, systems, and components provided for the prevention of accidents and the mitigation of the consequences of accidents.

These "anticipated" accidents, against which nuclear power plants must be designed, are called "design-basis accidents." *See* NUREG-1437, Generic Environmental Impact Statement for License Renewal of Nuclear Plants at 5-1 (1996) ("License Renewal GEIS"). Design-basis accidents include low-frequency but credible events. *Id.* at 5-2.

In determining which types of accidents constitute design-basis accidents and therefore must be protected against in a nuclear plant's design, the NRC sets a "threshold" based on probability of the accident. The NRC has held that reactor core accidents with a "realistic probability" (*i.e.*, a non-conservative probability) of at least one in ten million per year (10^{-7}) must be included in the design-basis.[4]

The NRC designates accidents that are more complex and less likely than design-basis accidents as "severe accidents." License Renewal GEIS at 5-1 (severe accidents are "those involving multiple failures of equipment or function and, therefore, whose likelihood is generally lower than design-basis accidents but whose consequences may be higher"). Although severe accidents are "beyond the substantial coverage of design-basis events," they constitute "the major risk to the public associated with radioactive releases from nuclear power plant accidents." Policy Statement on Severe Accidents Regarding

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4 *Private Fuel Storage, L.L.C.* (Independent Spent Fuel Storage Installation), CLI-01-22, 54 NRC 255, 259-60 (2001) (*"PFS I"*), citing *Metropolitan Edison Co.* (Three Mile Island Nuclear Station, Unit 2), ALAB-692, 16 NRC 921 (1982); *Consumers Power Co.* (Big Rock Point Plant), LBP-84-32, 20 NRC 601, 639-52 (1984).

But see Vermont Yankee Nuclear Power Corp. (Vermont Yankee Nuclear Power Station), CLI-90-4, 31 NRC 333, 334 (1990), in which the Commission refused to rule out NEPA consideration of an accident probability of 10^{-4} per year as remote and speculative. Under the *PFS I* ruling, an accident with a probability of 10^{-4} would be well within the range of a design-basis accident. Therefore, not only should it have been considered credible for purposes of preparing an EIS, but it should have been included in the design-basis for the facility.

Future Designs and Existing Plants, 50 Fed. Reg. 32,138, 32,139 (August 8, 1985) ("Severe Accident Policy Statement").

The Commission has made a generic determination that nuclear plants can be operated safely, despite the potential for severe accidents. Severe Accident Policy Statement, 50 Fed. Reg. at 32,139-40. *See also* Final Rule, Nuclear Power Plant License Renewal, 56 Fed. Reg. 64,943, 64,948-49 (December 13, 1991). Nevertheless, the Commission has an ongoing program to address severe accidents in the context of its regulatory program for protection of public health and safety under the Atomic Energy Act, and pledges to act upon any new information that calls the safety finding into question. *Id.* As provided by the Severe Accident Policy Statement:

> Should significant new safety information become available, from whatever source, to question the conclusion of 'no undue risk,' then the technical issues thus identified would be resolved by the NRC under its backfit policy and other existing procedures, including the possibility of generic rulemaking where this is justified.

50 Fed. Reg. at 32,139.

3. Standard for license renewal

Section 2133(c) of the Atomic Energy Act allows the NRC to renew nuclear power licenses. Although the AEA does not set a safety standard for license renewal, the Commission generally interprets the AEA to require that it "must have 'reasonable assurance' that public health and safety are not endangered by its licensing actions." *Petition for Emergency and Remedial Action,* 7 NRC at 404, citing *Power Reactor Development Corp.*, 367 U.S. at 402.

In the license renewal rulemaking, the Commission made a determination that:

> With the exception of age-related degradation unique to license renewal and possibly some few other issues related to safety only during extended operation,

> the regulatory process is adequate to ensure that the licensing bases of all currently operating plants provide and maintain an acceptable level of safety for operation so that operation will not be inimical to public health and safety or common defense and security.

56 Fed. Reg. at 64,946. Thus, other than with respect to aging issues, the NRC does not inquire into safety issues in the license renewal process.

If significant new information becomes available with respect to a safety issue unrelated to the aging of the plant, the NRC does not permit it to be raised in the license renewal hearing. Preamble to Final License Renewal Rule, 56 Fed. Reg. at 64,946. Instead, the NRC requires that the issue must be addressed under the NRC policy for backfitting the design of operating reactors in 10 C.F.R. § 50.109, or under "other existing procedures, including the possibility of generic rulemaking." *Id.*[5]

B. NEPA Statutory and Regulatory Requirements

1. General NEPA requirements

a. NEPA requirement to prepare an EIS

NEPA is the "*basic charter for protection of the environment.*" 40 C.F.R. § 1500.1. Its fundamental purpose is to "help public officials make decisions that are based on understanding of environmental consequences, and take decisions that protect, restore and enhance the environment." *Id.* NEPA requires federal agencies to examine the environmental consequences of their actions *before* taking those actions, in order to ensure "that important effects will not be overlooked or underestimated only to be discovered after resources have been committed or the die otherwise cast." *Robertson v. Methow Valley Citizens Council* (*Robertson*), 490 U.S. 332, 349 (1989).

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5 Among these options the Massachusetts Attorney General has elected to request a backfit to design the Vermont Yankee plant against pool fires. *See* Section VI. below.

The primary method by which NEPA ensures that its mandate is met is the "action-forcing" requirement for preparation of an EIS, which assesses the environmental impacts of the proposed action and weighs the costs and benefits of alternative actions. *Id.*, 490 U.S. at 350-51. An EIS must be rigorous, providing a "hard look" at the environmental consequences of the proposed action. *Id.* at 349; *Marsh,* 490 U.S. at 374.

b. NEPA requirement to supplement an EIS

The completion of an EIS for a proposed action does not end an agency's responsibility to weigh the environmental impacts of a proposed action. *Marsh,* 490 U.S. at 371-72. As the Supreme Court recognized in *Marsh,* it would be incongruous with NEPA's "action-forcing" purpose to allow an agency to put on "blinders to adverse environmental effects," just because the EIS has been completed. *Id.* Accordingly, up until the point when the agency is ready to take the proposed action, it must supplement the EIS if there is new information showing that the remaining federal action will affect the quality of the human environment "in a significant manner or to a significant extent not already considered." 490 U.S. at 374.

c. NEPA requirement that an EIS must consider reasonably foreseeable impacts of nuclear accidents.

The environmental impacts that must be considered in an EIS include "reasonably foreseeable" impacts which have "catastrophic consequences, even if their probability of occurrence is low." 40 C.F.R. § 1502.22(b)(1). The Commission has held that probability is the "key" to determine whether an accident is "reasonably foreseeable" or whether it is "remote and speculative" and therefore need not be considered in an EIS.[6]

6 Vermont Yankee Nuclear Power Corp. (Vermont Yankee Nuclear Power Station), CLI-90-7, 32 NRC 129, 131 (1990). See also Limerick Ecology Action v. NRC,

In the spectrum of accidents that might be considered in an EIS for a nuclear power plant license, there is no dispute that "design-basis accidents," *i.e.*, accidents against which a nuclear plant must be designed under the AEA's requirement to protect public health and safety against "undue risk," are reasonably foreseeable and therefore must be considered. Thus, almost since the passage of NEPA the NRC has included consideration of the environmental impacts of design-basis accidents in its EISs. *Limerick Ecology Action v. NRC*, 869 F.2d 719, 726 (3rd Cir. 1989), citing 36 Fed. Reg. 22,851 (1971).

In 1980, following the Three Mile Island accident, the Commission also began to consider the environmental impacts of severe or "beyond design-basis" accidents in its EISs. *Id.*, citing Statement of Interim Policy, Nuclear Power Plant Accident Considerations Under the National Environmental Policy Act of 1969, 45 Fed. Reg. 40,101 (1980). In contested cases the Commission has required intervenors to address the quantitative probability of severe accidents for which they seek consideration in an EIS. *See, e.g., Carolina Power & Light Co.* (Shearon Harris Nuclear Power Plant), CLI-01-11, 53 NRC 370, 387 (2001) ("Harris"). While the Commission has not established a threshold for the level of accident probability considered "reasonably foreseeable," in *Harris* the Commission affirmed a decision by the ASLB approving the NRC Staff's probability estimate of 10^{-7} for a particular accident scenario and ruling that the accident was "remote and speculative." *Id.* at 388 n.8. (*But see* Section III.A.2 above.)

2. NRC's procedures for preparation of ER and EIS

NRC's NEPA procedures require the NRC to prepare an EIS for any major licensing action significantly affecting the quality of the human environment. 10 C.F.R.

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869 F.2d at 745, citing Vermont Yankee Nuclear Power Corp. v. Natural Resources Defense Council, Inc., 435 U.S. 519, 551 (1978).

§§ 51.71, 51.91. Before the EIS is prepared, however, the NRC's regulations require that the license applicant must prepare what amounts to a first draft of the EIS, *i.e.,* the environmental report ("ER"). 10 C.F.R. § 51.53(c)(2), *Duke Power Co.* (Catawba Nuclear Station, Units 1 and 2), CLI-83-19, 17 NRC 1041, 1049 (1983) (noting that "as a practical matter, much of the information in an Applicant's ER is used in the [Draft EIS]"). The ER generally must address all the same impacts, alternatives, and other environmental issues that will be addressed later in the NRC's EIS. *Compare* 10 C.F.R. § 51.53(c)(2) with 10 C.F.R. § 51.71.

3. NRC's NEPA procedures for license renewal

a. NRC reliance on License Renewal GEIS in individual license renewal proceedings

NRC regulations for the implementation of NEPA do not require the preparation of a complete ER and EIS for every nuclear power plant license renewal application. Instead, the NRC relies on the License Renewal GEIS, prepared in 1996, to evaluate most of the environmental impacts of license renewal. *See* 10 C.F.R. §§ 51.53(c)(3)(i), 51.71(d).

The License Renewal GEIS and NRC's environmental regulations for license renewal-related NEPA issues separate environmental impacts, including accidents, into two major categories: Category 1 or "generic" impacts, and Category 2 or "plant-specific" impacts. *Duke Energy Corporation* (McGuire Nuclear Station, Units 1 and 2; Catawba Nuclear Station, Units 1 and 2), CLI-02-14, 55 NRC 278, 290 (2002) ("*McGuire/Catawba*"). Environmental impacts are listed according to their category in Table B-1 of Appendix B to Subpart A of 10 C.F.R. Part 51.

For Category 1 impacts, the NRC considers the License Renewal GEIS analysis sufficient, and no further analysis is required in the Environmental Report and EIS that are prepared at the time of the license renewal application. 10 C.F.R. §§ 51.53(c)(3)(i), 51.71, 51.95(c). For Category 2 impacts, the NRC has determined that impacts and alternatives cannot be fully addressed in the Generic EIS and therefore must be addressed in the site-specific ER and EIS. *McGuire/Catawba,* 55 NRC at 290; *Florida Power & Light Co.* (Turkey Point Nuclear Generating Plant, Units 3 and 4), CLI-01-17, 54 NRC 3, 12 (2001).

b. NRC discussion of accident impacts in License Renewal GEIS

The License Renewal GEIS purports to address both design-basis accidents and severe accidents. With respect to design-basis accidents, the GEIS provides a brief statement that the impacts of design-basis accidents were considered in the original EIS for each nuclear power plant, and that the design was found adequate to "accommodate" those accidents. License Renewal GEIS at 5-11. Moreover, the GEIS asserts that the consequences of design-basis accidents are not expected to change significantly as a result of aging of the plant. *Id.* Therefore, the GEIS does not provide a further discussion of design-basis accidents. *Id.* These impacts are also classified as "Category 1 in Table B-1 of Appendix B to Subpart A of 10 C.F.R. Part 51.

With respect to severe or beyond design-basis accidents, the License Renewal GEIS discusses the potential consequences of an array of severe accidents identified in various studies, primarily the NRC's most recent and comprehensive probabilistic analysis of nuclear power plant accidents, NUREG-1150, Severe Accident Risks for Five U.S. Nuclear Power Plants (1990). While recognizing the possibility that the likelihood of some severe accidents may be so low as to be "remote and speculative" and therefore not necessary to discuss in an EIS, the License Renewal GEIS does not exclude any severe accidents on the ground of their estimated probability. Severe accidents are classified as "Category 2" impacts in Table B-1 of Appendix B to Subpart A of 10 C.F.R. Part 51.

The License Renewal GEIS does not include any discussion of how deliberate and malicious attacks on nuclear power plants may increase the likelihood or consequences of severe accidents. The NRC declines to address the topic on the grounds that (a) NRC security regulations provide reasonable assurance that the risk from sabotage is small; (b) although their probability is not quantifiable, acts of sabotage are "not reasonably expected"; and (c) even if such an event were to occur, resultant core damage and radiological releases would be "no worse than those expected from internally initiated events." License Renewal GEIS at 5-18.[7]

The License Renewal GEIS is consistent with the NRC's long-established policy of refusing to examine the environmental impacts of deliberate malicious acts on the ground that it could not make a "meaningful assessment of the risks of sabotage." *Philadelphia Electric Co.* (Limerick Generating Station, Units1 and 2), ALAB-819, 22 NRC 681, 697-701 (1985) (*"Limerick Appeal Board Decision"*), *aff'd on this ground and rev'd on other grounds, Limerick Ecology Action v. NRC,* 869 F.2d 719, 743-44 (3rd Cir. 1989). Even the attacks of September 11, 2001, did not cause the NRC to change this policy, which it reiterated in *Private Fuel Storage, L.L.C.* (Independent Spent Fuel

7 The NRC's failure to discuss impacts of deliberate and malicious acts in the License Renewal GEIS is a departure from the 1979 GEIS, in which the NRC examined the impacts of attacks on spent fuel pools, albeit not in light of significant new information about the risks of pool fires, NUREG-0575, Handling and Storage of Spent Light Water Power Reactor Fuel (1979) ("1979 GEIS"). *See* discussion in Section V.B.1.c, below.

Storage Installation, CLI-02-25, 56 NRC 340 (2002) ("*PFS II*") and *Pacific Gas & Electric Company* (Diablo Canyon ISFSI), CLI-03-12, 58 NRC 185 (2003) ("*Diablo Canyon*").[8] *Diablo Canyon* has been appealed to the U.S. Court of Appeals for the 9th Circuit, where a decision is pending. Moreover, to the extent that *PFS II* and *Diablo Canyon* are based on factual determinations that should be re-evaluated in a new EIS in light of significant new information, the policy is subject to challenge in this proceeding. 10 C.F.R. § 51.53(c)(3)(iv). *See* discussion below in Section III.B.3.c.

c. NRC requirement to supplement License Renewal GEIS

Consistent with *Marsh*, 490 U.S. at 374, NRC regulation 10 C.F.R. § 51.53(c)(3)(iv) requires that an environmental report "must contain any new and significant information regarding the environmental impacts of license renewal of which the applicant is aware." Thus, the conclusions of the License Renewal GEIS are subject to modification in individual license renewal proceedings if new and significant information, not evaluated in the License Renewal GEIS, shows that the environmental impacts of license renewal are greater than concluded in the License Renewal GEIS.

d. NRC requirement to consider alternatives in site-specific ER and EIS

For any environmental impacts that do not fall into Category 1, a license renewal applicant must consider "alternatives for reducing adverse impacts," including severe accidents. 10 C.F.R. § 51.53(c)(3)(iii), citing 10 C.F.R. § 51.45(c). This requirement

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8 For other decisions applying the NRC's policy against considering the environmental impacts of terrorism and sabotage, *see Duke Cogema Stone & Webster* (Savannah River Mixed Oxide Fuel Fabrication Facility), CLI-02-24, 56 NRC 335 (2002); *Dominion Nuclear Connecticut, Inc.* (Millstone Nuclear Power Station, Unit 1), CLI-02-27, 56 NRC 367 (2002); *Duke Energy Corp.* (McGuire Nuclear Station, Units 1 and 2), Catawba Nuclear Station, Units 1 and 2), CLI-02-26, 56 NRC 358 (2002).

also applies to the draft and final EIS for each individual license renewal application. 10 C.F.R. § 51.71(d), 51.91.

As the Commission explained in the preamble to the final rule for environmental review of license renewal applications, the alternatives that must be considered include severe accident mitigation alternatives ("SAMAs"). Final Rule, Environmental Review for Renewal of Nuclear Power Plant Operating Licenses, 61 Fed. Reg. 28,467, 28,480-81 (June 5, 1996). This requirement is:

> based on the Commission's NEPA regulations that require a review of severe [accident] mitigation alternatives in its environmental impact statements (EISs) and supplements to EISs, as well as a previous court decision that required review of severe mitigation alternatives (referred to as SAMDAs) at the operating license stage. See, Limerick Ecology Action v. NRC, 869 F.2d 719 (3d Cir. 1989).

61 Fed. Reg. at 28,481. In addition, the Commission noted that while each licensee was in the process of performing an individual plant examination ("IPE") to "look for plant vulnerabilities to internally initiated events" and a separate IPE "for externally initiated events (IPEEE)," the program had not been completed in time to include the results in an EIS or supplemental EIS. *Id.* Thus, the ER and EIS for each individual license renewal application must include consideration of SAMAs. *Id.*

C. Atomic Energy Act Public Hearing Requirements for License Renewal Decisions.

Section 189a of the AEA requires the NRC to provide interested members of the public with a prior opportunity for a hearing on any decision regarding the issuance or amendment of a nuclear facility license. 42 U.S.C. § 2239(a)(1)(A). While the AEA does not establish a specific right to a hearing for license renewal proceedings, the Commission has determined that a hearing should be granted because renewal of an operating license "is essentially the granting of a license." Proposed Rule, Nuclear Power Plant License Renewal, 55 Fed. Reg. 29,043, 29,052 (July 17, 1990).

In order to be admitted as an intervenor to an NRC adjudicatory licensing proceeding, including a license renewal proceeding, a petitioner must file "contentions" that provide "sufficient information to show that a genuine dispute exists with the applicant/licensee on a material issue of law or fact." 10 C.F.R. § 2.309(f)(vi). Contentions raising questions of compliance with NRC safety requirements must be based on the application, and contentions raising questions of compliance with NEPA must be based on the applicant's ER. 10 C.F.R. § 2.309(f).

Pursuant to 10 C.F.R. § 2.335, contentions may not challenge NRC regulations. However, factual determinations codified in NRC NEPA regulations may be challenged under regulations and judicial precedents requiring the consideration of significant new information that undermines those determinations. *See* discussion above in Sections III.B.1.b and III.B.3.c. In addition, contentions may challenge fact-based statements of NRC policy that were established without notice or opportunity for public comment. *Limerick Ecology Action v. NRC*, 869 F.2d at 733-39.[9]

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9 In the *Limerick* proceeding, which took place in the 1980s, the Intervenor submitted a contention challenging the NRC's pronouncement in an EIS that it would not consider the environmental impacts of sabotage against a proposed nuclear plant because it lacked any meaningful method of assessing the likelihood of sabotage events at a proposed nuclear power plant. 849 F.2d at 743. The Court upheld the NRC's holding that the Intervenor "failed to produce any credible evidence or theory that would 'cast any serious doubt' on the Commission's conclusion that sabotage risk analysis is beyond current probabilistic risk assessment methods and that there is no current basis by which to measure such risk." *Id.* Thus, the court recognized the Intervenor's right to challenge the NRC's policy pronouncement regarding consideration of intentional attacks on a nuclear facility in the specific licensing proceeding in which it had intervened. While the Third Circuit upheld the Commission's ruling that the *Limerick* Intervenor failed to present enough evidence to challenge the factual basis for the policy, that is not the case here. In its contention below, the Attorney General presents a significant body of evidence

IV. FACTUAL AND PROCEDURAL BACKGROUND

A. Vermont Yankee Nuclear Power Plant

1. Pool Storage of Spent Fuel at Vermont Yankee

At the Vermont Yankee nuclear power plant, electricity is generated by fission reactions in radioactive "fuel rods" in the plant's reactor. Fuel rods are grouped together in "assemblies." After a fuel assembly is "spent" in the sense that it no longer can be used to generate power, it is discharged from the reactor. However, at this point in its life the assembly is much more dangerous than when it entered the reactor. It emits heat and intense radiation, and contains a large inventory of radioactive material. Gordon Thompson, Risks and Risk-Reducing Options Associated with Pool Storage of Spent Nuclear Fuel at the Pilgrim and Vermont Yankee Nuclear Power Plants, § 2 (May 25, 2006) ("Thompson Report").[10]

The Vermont Yankee plant has a fuel storage pool through which fresh fuel assemblies pass during their placement in the reactor, and where spent fuel is stored after it is removed from the reactor core. When Vermont Yankee and other plants in the present generation of nuclear power plants first began operation in the 1970s, their spent fuel pools were equipped with low-density, open-frame racks. These racks allowed free circulation of water around the fuel assemblies. If water were lost from a pool equipped with open-frame racks, air or steam could circulate freely through the fuel assemblies, cooling the assemblies. As a result, the fuel cladding would ignite, if at all, only in rare conditions. Thompson Report, § 8.

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showing that the NRC's policy is unfounded.

10 A copy of Dr. Thompson's report is attached to the Declaration of Dr. Gordon Thompson in Support of Massachusetts Attorney General's Contention and Petition for Backfit Order (May 25, 2006, which is included as Exhibit 1 to this pleading.

Over the past three decades, spent fuel inventories have mounted because of the lack of other means of spent fuel management. Plant licensees have responded to this problem by substantially increasing the density at which fuel is stored in the existing spent fuel pools. In order to increase the density of storage, licensees have been obliged to use racks in which each fuel assembly is surrounded by solid, neutron-absorbing panels, which are needed to suppress criticality or a runaway chain reaction. The panels limit the flow of coolant (water, air or steam) to a mode of circulation in which the coolant enters each rack cell from below, rises vertically through the cell, and leaves the cell at its top.

The Vermont Yankee license has been amended several times to permit storage of an ever-increasing volume of spent fuel in high-density storage racks. Currently, all racks in the Vermont Yankee pool are high-density. During the requested period of license extension, the Vermont Yankee fuel pool will contain about 2,600 fuel assemblies with a radioactive inventory of about 39 million curies of cesium-137. Thompson Report, Table 3-4.

If water is lost from a pool equipped with high-density racks, the circulation of coolant over the fuel assemblies will be inhibited, and the fuel will ignite over a wide range of conditions. Thompson Report, § 2. *See also* discussion below in Section V.B.3. A pool fire at Vermont Yankee could release between 3.9 and 39 million curies of radioactive cesium, contaminating a large land area with radioactive cesium-137 for decades, at a cost of many billions of dollars. Thompson Report, § 5; Jan Beyea, Report to the Massachusetts Attorney General on the Potential Consequences of a Spent-fuel Pool Fire at the Pilgrim or Vermont Yankee Nuclear Plant at 21-24 (May 25, 2006)

("Beyea Report").[11]

2. Availability of dry storage as an alternative to pool storage

Dry storage is an alternative to wet storage that involves placement of the spent fuel in containers (casks or canisters) that are filled with a noncorrosive gas such as helium. Cooling is achieved by convective (*i.e.,* passive) circulation of air over the fuel containers. In comparison with high-density pool storage, dry storage is more expensive because it requires the purchase and installation of new equipment. However, dry storage eliminates the potential for a pool fire and, if properly executed, dramatically reduces the potential for other modes of release of the radioactive material in spent fuel. Thompson Report, § 8. Thus, the expense is well-justified. *Id.,* § 9; Beyea Report, Tables 4 and 5.

To this date, Entergy has not implemented dry storage at the Vermont Yankee nuclear power plant.

B. Vermont Yankee license renewal application

Entergy's license for the Vermont Yankee nuclear power plant is due to expire in 2012. On January 25, 2006, Entergy submitted an application to the NRC for renewal of its operating license for an addition 20-year term, or until 2032. Entergy License Renewal Application, Vermont Yankee Nuclear Power Station ("License Renewal Application"). As required by 10 C.F.R. § 51.53(c), the license renewal application included an ER, which purported to address the site-specific environmental impacts of the proposed operation during the renewal term and other related issues. Vermont Yankee License Renewal Application, Appendix E, Applicant's Environmental Report ("Vermont Yankee ER"). The Vermont Yankee ER addresses the environmental impacts

11 A copy of Dr. Beyea's report is attached to the Declaration of Dr. Jan Beyea in Support of Massachusetts Attorney General's Contention and Petition for Backfit Order (DATE), which is included as Exhibit 2 to this pleading.

of accidents in Section 4, relying to a significant extent on the License Renewal GEIS for the evaluation of environmental impacts. *See* ER at 4-1, 4-41. In response to its regulatory obligation to identify "new and significant" information regarding the environmental impacts of license renewal, Entergy also states that it is aware of none. ER at 5-2, citing 10 C.F.R. § 51.53(c)(3)(iv).

V. CONTENTION: THE ENVIRONMENTAL REPORT FOR RENEWAL OF THE VERMONT YANKEE NUCLEAR POWER PLANT FAILS TO SATISFY NEPA BECAUSE IT DOES NOT ADDRESS THE ENVIRONMENTAL IMPACTS OF SEVERE SPENT FUEL POOL ACCIDENTS.

A. Contention

The Vermont Yankee ER does not satisfy the requirements of 10 C.F.R. § 51.53(c)(3)(iv) and NEPA, 42 U.S.C. § 4332 *et seq.,* because it fails to address new and significant information regarding the reasonably foreseeable potential for a severe accident involving nuclear fuel stored in high-density storage racks in the Vermont Yankee fuel pool. Although an NRC-sponsored study conducted as early as 1979 raised the potential for a severe accident in a high-density fuel storage pool if water is partially lost from the pool (NUREG/CR-0649, *Spent Fuel Heatup Following Loss of Water During Storage* (March 1979) ("1979 Sandia Report")), the NRC has failed to take that risk into account in every EIS it has prepared, including the 1979 GEIS on the environmental impacts of fuel storage; the 1990 Waste Confidence rulemaking (Review and Final Revision of Waste Confidence Decision, 55 Fed. Reg. 38,474, 38,481 (September 18, 1990) ("1990 Waste Confidence Rulemaking"); and the 1996 License Renewal GEIS on which the Vermont Yankee license renewal application relies. Moreover, the environmental impacts of a pool accident were not considered in the 1972

EIS issued in support of the original operating license for the Vermont Yankee nuclear power plant (Final Environmental Statement Related to Operation of Vermont Yankee Nuclear Power Station, Boston Edison Company, Docket No. 50-293 (May 1972) ("1972 Vermont Yankee EIS")).

Significant new information now firmly establishes that (a) if the water level in a fuel storage pool drops to the point where the tops of the fuel assemblies are uncovered, the fuel will burn, (b) the fuel will burn regardless of its age, (c) the fire will propagate to other assemblies in the pool, and (c) the fire may be catastrophic. *See* Thompson Report and Beyea Report. This new information has also been confirmed by the NRC Staff in NUREG-1738, *Final Technical Study of Spent Fuel Pool Accident Risk and Decommissioning Nuclear Power Plants* (January 2001) ("NUREG-1738"), and by the National Academies of Sciences. *See* NAS Committee on the Safety and Security of Commercial Spent Nuclear Fuel Storage, *Safety and Security of Commercial Spent Nuclear Fuel Storage* at 53-54 (The National Academies Press: 2006) ("NAS Report").[12]

Moreover, significant new information, including the attacks of September 11, 2001 and the NRC's response to those attacks, shows that the environmental impacts of intentional destructive acts against the Vermont Yankee fuel pool are reasonably foreseeable. Taken together, the potential for severe pool accidents caused by intentional malicious acts and by equipment failures and natural disasters such as earthquakes is not only reasonably foreseeable, but is likely enough to qualify as a "design-basis accident," *i.e.*, an accident that must be designed against under NRC safety regulations. Thompson Report, §§ 6,7,9.

12 Relevant excerpts of NUREG-1738 and the NAS Report are attached as Exhibits 3 and 4, respectively.

The ER also fails to satisfy 10 C.F.R. § 51.53(c)(3)(iii) because it does not consider reasonable alternatives for avoiding or reducing the environmental impacts of a severe spent fuel accident, *i.e.*, SAMAs. Alternatives that should be considered include re-racking the fuel pool with low-density fuel storage racks and transferring a portion of the fuel to dry storage.

This contention is supported by the expert declarations and reports of Drs. Gordon Thompson and Jan Beyea regarding the likelihood and consequences of spent fuel pool accidents at the Vermont Yankee nuclear power plant. *See* Exhibits 1 and 2.

B. Basis for Contention

NEPA requires that new and significant information, not considered in any prior EIS for a proposed action, must be considered in a supplemental EIS if (a) the new information arises before the final action is taken, and (b) the new information shows that the environmental impacts of the proposed action would be significantly different than the impacts presented in the EIS. *Marsh, supra*; 10 C.F.R. § 51.53(c)(3)(iv). Here, significant new information, not previously considered by the NRC in any EIS, shows that the impact of high-density spent fuel pool storage at Vermont Yankee would be significantly greater than contemplated in prior EISs. Therefore the NRC must consider the environmental impacts of a pool accident in a supplemental EIS for the Vermont Yankee license renewal decision.

This contention also meets the standard established in *Harris* for pleading an admissible contention seeking consideration of a severe accident in an EIS, because it presents sufficient information to create a "genuine material dispute of fact or law adequate to warrant further inquiry" into the question of whether the likelihood of a pool fire falls within the range of probability considered reasonably foreseeable by the NRC. *Carolina Power & Light Co.* (Shearon Harris Nuclear Power Plant), LBP-00-19, 52 NRC 85, 97-98 (2000), affirmed on other grounds, CLI-01-11, 53 NRC 370 (2001).[13] In addition, it meets the standard established in *Limerick Ecology Action v. NRC,* that a party may litigate the question of whether NEPA requires consideration of the environmental impacts of intentional and malicious acts against a nuclear facility by presenting sufficient evidence to challenge the factual basis for the policy against such consideration. *See* note 9 above.

1. The potential for a pool fire has not been considered in any previous EIS.

As discussed above in the contention, new information regarding the potential for a pool fire is presented in NUREG-1738, the NAS Report, and the Thompson Report. All of these documents were written after the issuance of the License Renewal GEIS, and therefore they qualify as "new information" for purposes of requiring a supplemental EIS. As the Court recognized in *Hodges v. Abraham,* 300 F.3d 432, 447 (4th Cir. 2002), an agency may review and consider previously issued NEPA documents in determining

13 While the ASLB later ruled that the one accident scenario it selected for litigation in the *Harris* case was "remote and speculative" [LBP-01-09, 53 NRC 239, 271], that decision is not dispositive here, by virtue of significant factual differences, including differences in the plants' designs. While Harris is a pressurized water reactor ("PWR"), Vermont Yankee is a boiling water reactor ("BWR"). As a PWR, Harris has two major design features which render it less vulnerable than Vermont Yankee to a pool fire: first, the fuel pools are partially below ground, and second, the pools are in a separate building from the reactor building. In contrast, the pool at Vermont Yankee is above ground, and therefore it is more vulnerable to a breach in the pool wall or floor. NAS Report at 33. Unlike Harris, the Vermont Yankee pool is also located in the same building as the reactor. Given an early release from the Vermont Yankee reactor as part of a core-melt accident, hot gases and radioactive material from the reactor would spread throughout the building. The radiation field and the thermal environment would be more extreme than would be the case in the Harris pool building if two of the pools in that building were to suffer fires. Thompson Report, § 6.

whether to supplement an EIS. Here, the history of NRC's NEPA consideration of spent fuel storage risks shows that although the NRC has been aware of the risks of high-density fuel pool fires for many years, it has not publicly disclosed or analyzed that risk in any EIS. Nor has the NRC updated the License Renewal GEIS to address the additional information about the risks of pool fires that has accumulated over the years since publication of the License Renewal GEIS. Thus, the NRC has failed to take the "hard look" required by NEPA. *Marsh,* 490 U.S. at 374.

a. The EIS for the original Vermont Yankee license and other nuclear power plant licenses did not consider impacts of pool accidents.

Since the early 1980's, the EISs for the licensing of all U.S. nuclear plants have considered the potential for severe accidents. This consideration has been based on the findings of the Reactor Safety Study (WASH-1400) (1975). As later summarized by the NRC, the Reactor Safety Study concluded that the risks of beyond design-basis accidents in the low-density spent fuel storage pools in use at that time were "orders of magnitude" below the risks of reactor core accidents, because of the "simplicity of the spent fuel storage pool design." NUREG-1353, Regulatory Analysis for the Resolution of Generic Issue 82, "Beyond Design-basis Accidents in Spent Fuel Pools" at ES-1 (April 1989) ("NUREG-1353"). The simple features of low-density spent fuel storage were:

> (1) the coolant is at atmospheric pressure, (2) the spent fuel is always subcritical and the heat source is low, (3) there is no piping which can drain the pool and (4) there are no anticipated operational transients that could interrupt cooling or cause criticality.

Id. at ES-1. Thus, the 1972 EIS for the Vermont Yankee plant, where spent fuel initially was stored in low-density racks, had no reason to address the environmental impacts of pool accidents.

Shortly after WASH-1400 was published, then-President Carter cancelled the national program for reprocessing of spent fuel, and licensees began to use high-density racks to store an ever-increasing inventory of spent fuel at nuclear power plant sites. This decision to store an increasing volume of spent fuel onsite led to the use of high-density storage racks, which "results in a larger inventory of fission products in the pool, a greater heat load on the pool cooling system, and less distance between adjacent fuel assemblies." *NUREG-1353* at ES-1.

b. The 1979 Sandia Report showed risks of high-density pool storage.

In March of 1979, the NRC published a report by one of its contractors, Sandia National Laboratories, showing that in the case of total, instantaneous drainage of water from a pool, densely packed spent fuel, even a year after discharge, would likely heat up to the point where its zircaloy cladding would burst and then catch fire. Analysis in the report also showed that partial drainage would be a more severe condition, causing older fuel to ignite. 1979 Sandia Report. *See* Thompson Report, § 2.

c. The 1979 GEIS did not address pool fire risks.

In August of 1979, several months after publishing the 1979 Sandia Report, the NRC issued the 1979 GEIS, which constitutes the only EIS the NRC ever prepared for the specific purpose of evaluating spent fuel storage impacts. Using the assumption that all pool storage space as originally designed had been expanded by re-racking with medium-density or high-density storage racks (*see* 1979 GEIS at 3-2), the GEIS examined the impacts of fuel storage in pools and found that storage of fuel in pools "has an insignificant impact on the environment." *Id.*at 8-2.

Despite the recent publication of the 1979 Sandia Report, the GEIS made no mention of the potential for a pool fire in high-density fuel storage pools. The GEIS' only reference to the 1979 Sandia Report was to cite it as a footnote to the following statement:

> Assuming that the spent fuel stored at an independent spent fuel storage installation is at least one year old, calculations have been performed to show that loss of water should not result in fuel failure due to high temperatures *if proper rack design is employed.*[28]
>
> ---
>
> 28. "Spent Fuel Heatup Following Loss of Water During Storage," Report NUREG/CR-0649, March 1979.

1979 GEIS at 4-21 (emphasis added). But the GEIS did not mention the fact that the only rack design that could have been deemed "proper" by the authors of the 1979 Sandia Report was a low-density rack design, because Sandia had found that fuel stored in a high-density rack would burn if water were lost from the pool.

Thus, the 1979 GEIS purported to take account of the 1979 Sandia Study, but actually did not address the known, significant risk implications of the study, thereby failing to satisfy the "hard look" standard for an EIS. *Robertson,* 490 U.S. at 349; *Marsh,* 490 U.S. at 374. *See also Hughes River Watershed Conservancy v. Agriculture Dept.*, 81 F.3d 437, 446 (4th Cir. 1996) (holding that in order for an EIS to serve its functions of informing decision-makers and the public, it is "essential" that the EIS not be based on "misleading" assumptions).

d. The 1990 Waste confidence rulemaking ignored the risk of pool fires.

The NRC next addressed the environmental risks of spent fuel storage in the 1990 revision to the Waste Confidence rulemaking, where the agency examined the environmental impacts of storing spent fuel at reactor sites for an additional 30 years pending the opening of a final repository. 1990 Waste Confidence Rulemaking Notice, 55 Fed. Reg. 38474. In response to comments on the potential for spent fuel pool accidents, the Commission asserted that it had spent "several years" studying "in detail" the "catastrophic loss of reactor spent fuel pool water possibly resulting in a fuel fire in a dry pool." 55 Fed. Reg. at 38,481.[14] The NRC made no mention of the 1979 Sandia Report, however, which had found that partial loss of water from a pool posed a more serious risk than complete and instantaneous drainage.

Moreover, while the NRC cited NUREG-1353 (*id.* at 38,481), it failed to note the observation in NUREG-1353 that: "some laboratory studies have provided evidence of the possibility of fire propagation between assemblies in an air cooled environment." NUREG-1353 at ES-1. Nor did the NRC respond to the recommendation of NUREG-1353 that the NRC undertake a "re-examination" of the risks of spent fuel pool accidents. NUREG-1353 at ES-1.

Finally, the NRC asserted that BWR fuel aged over six months would not burn, although NUREG-1353 considered only low- and medium-density BWR racks, not high-density racks (see pp 4-9 to 4-11 of NUREG-1353).

c. The License Renewal GEIS merely repeated the inadequate analysis in the 1990 Waste Confidence rulemaking.

14 The NRC also cited a set of technical studies, all of which evaluated a total and instantaneous loss of water from the pool rather than partial water loss: NUREG/CR-4982, *Severe Accidents in Spent Fuel Pools in Support of Generic Issue 82* (1987); NUREG/CR-5176, *Seismic Failure and Cask Drop Analysis of the Spent Fuel Pools at Two Representative Nuclear Power Plants* (1989); NUREG/CR-5281, *Value/Impact Analysis of Accident Preventative and Mitigative Options for Spent Fuel Pools;* NUREG-1353, *Regulatory Analysis for the Resolution of Generic Issue 82, Beyond Design-basis Accidents in Spent Fuel Pools* (1989). *See* Thompson Report, § 2.

In the rulemaking notice for the license renewal rule, the Commission claimed to have generically considered the environmental impacts of on-site spent fuel storage in the context of the NRC's GEIS for license renewal. Final Rule, Environmental Review for Renewal of Nuclear Power Plant Operating Licenses, 61 Fed. Reg. 66,537, 66,538, (December 18, 1996). According to the GEIS, the environmental impacts of pool storage of spent fuel are very small. As summarized in an appendix to the NRC's regulations for implementation of NEPA:

> The expected increase in the volume of spent fuel from an additional 20 years of operation can be safely accommodated on a site with small environmental effects through dry or pool storage at all plants if a permanent repository or monitored retrievable storage area is not available.

Table B-1 of 10 CFR 51, Subpart A, Appendix B to 10 C.F.R. Part 51. *See also* License Renewal GEIS at 6-83.

The License Renewal GEIS also states that "[c]urrent and potential environmental impacts from spent-fuel storage have been studied extensively and are well understood." *Id.* at 6-8 3. But the License Renewal GEIS contains no new analysis of the potential for spent fuel pool accidents, and appears to rely entirely on the 1990 Waste Confidence rulemaking. *Id.* (referring to "generic determination of no significant environmental impact in [NRC] regulations at 10 CFR 51.23," which was promulgated in the Waste Confidence rulemaking.

2. Only the 1979 GEIS has evaluated the environmental impacts of deliberate and malicious acts against spent fuel pools.

The 1979 GEIS contains an appendix which discusses the potential impacts of a deliberate attack on a fuel pool. *Id.*, Appendix J. The GEIS postulated an attack by up to 83 adversaries, and damage to between one and 1,000 fuel assemblies by high-explosive charges. But the analysis was insufficient to address the environmental impacts of a deliberate attack on the fuel because it underestimated the potential for a pool fire if the explosives succeeded in lowering the pool's water level.

Since the 1979 GEIS was published, the NRC has declined to consider the impacts of deliberate or malicious acts against fuel pools or any other aspect of nuclear facilities in an EIS, including the License Renewal GEIS. *See* License Renewal GEIS at 5-18 and discussion above in Section III.B.3.b.

3. Significant new information shows the reasonably forceseeable potential for a pool fire, and that the consequences are high.

Significant new information, not considered by the NRC in any previous EIS, shows that the potential for a severe fire in Vermont Yankee's high-density fuel storage pool is significant and that the consequences of such a fire would be extreme.

a. Significant new information shows that fuel of any age will burn if uncovered.

Significant new information, consisting primarily of the attached Thompson Report and two government-sponsored studies -- NUREG-1738 and the NAS Report -- undermines the conclusion of the NRC's previous EISs that (1) only recently discharged fuel will burn, and (2) complete drainage of a fuel pool is a more severe case than partial drainage. *See* 1990 Waste Confidence Rulemaking Notice, 55 Fed. Reg. at 38,481. Total or partial loss of water from a fuel pool containing high-density racks will initiate either an air-zirconium reaction or a steam-zirconium exothermic reaction within hours. Thompson Report, § 2. Once initiated, this reaction could spread to nearby, previously uninvolved, fuel assemblies. A significant fraction of the pool's inventory of radioactive isotopes, notably cesium-137, could be released to the atmosphere and would then travel downwind as a plume, causing extensive environmental contamination. *See* Beyea Report.

In NUREG-1738, the NRC Staff also reached the conclusion that regardless of the age of the fuel in a pool, the fuel will burn shortly after the tops of the fuel assemblies are uncovered. *Id.* at 2-1 – 2-2. As summarized in the report, adiabatic heatup of the fuel, caused by disruption of the passive cooling process, may cause a radioactive release within 24 hours after the fuel assemblies are uncovered, even for fuel aged five years. *Id.* at 2-2.

In a subsequent study which focused on the vulnerability of fuel pools to attack, a committee of the National Academies of Sciences ("NAS"), which included former NRC official Robert Bernerno, reviewed NUREG-1738 and other more recent studies that followed on the work done in NUREG-1738. While a significant portion of the report was classified, the unclassified portion of the report reported the committee's general conclusions that:

> For some scenarios, the fuel could be air cooled within a relatively short time after its removal from the reactor. If a loss-of-coolant event took place before the fuel could be air cooled, however, a zirconium cladding fire could be initiated if no mitigative actions were taken. Such fires could release some of the fuel's radioactive material inventory to the environment in the form of aerosols.
>
> For a partial-loss-of-pool-coolant event, the analysis indicates that the potential for zirconium cladding fires would exist for an even greater time (compared to the complete-loss-of-pool-coolant event) after the spent fuel was discharged from the reactor because air circulation can be blocked by water at the bottom of the pool. Thermal coupling between circulation can be blocked by water at the bottom of the pool. However, this heat transfer model has been modeled simplistically in the MELCOR runs performed by Sandia.
>
> If the water level is above the top of the fuel racks, decay heat in the fuel could cause the pool water to boil. Once water levels fall below a certain level in the fuel assembly, the exposed portion of the fuel cladding might heat up sufficiently to ignite if no mitigative actions were taken. This could result in the release of a

> substantial fraction of the cesium inventory to the environment in the form of aerosols.

NAS Report at 53-54 (footnote omitted).

Thus, new information shows the existence of a class of severe pool accident scenarios that have not been previously evaluated or that have been evaluated improperly, either generically or for the Vermont Yankee site.

b. Significant new information shows the credibility of events leading to a fuel pool accident

Significant new information also shows that total or partial loss of water from a fuel pool, either through equipment failure or deliberate malicious acts, is not a remote or speculative event. For a variety of scenarios, including external and internal events and deliberate and malicious acts, a severe pool accident is a credible and reasonably foreseeable event. Indeed, the estimated probability for a number of scenarios is within the range considered by the NRC to constitute a design-basis accident, which must not only be discussed in an ER and EIS, but which must be designed against under NRC safety regulations. *See* Section VII. below.

i. Accidents caused by human error, equipment failure, and natural forces are credible.

As discussed in Section 6 of the attached Thompson report, a number of credible scenarios may lead to a severe accident in the Vermont Yankee fuel pool. Many reactor core melt scenarios would involve the interruption of cooling to the pool. Moreover, the high-radiation field produced by a reactor core accident could initiate or exacerbate a pool fire by precluding the presence and functioning of operating personnel. Making the reasonable assumption that the conditional probability of a pool fire accompanying an early containment release is 50%, the overall estimated likelihood of a pool fire, excluding acts of malice, is on the order of two per 100,000 years (2×10^{-5}). This level of probability is well within the range that NRC considers to qualify as a design-basis accident under the *PFS I* standard, and therefore is cognizable under NEPA.

ii. Accidents caused by intentional malicious acts are credible.

The License Renewal GEIS offers two principal bases for the NRC's refusal to consider the environmental impacts of sabotage, terrorist attacks and other intentional malicious acts in its NEPA review for license renewal: their likelihood is not quantifiable, and that in any event this type of accident is "not reasonably expected." License Renewal GEIS at 5-18. The position taken by the Commission in the GEIS is consistent with other pronouncements by the NRC. *See* discussion in Section III.B.3.b above.

Significant new information shows that the Commission's factual basis for refusing to consider the environmental impacts of deliberate and malicious acts in the License Renewal GEIS is no longer viable, and therefore may be challenged in this proceeding under 10 C.F.R. § 51.53(c)(3)(iv). Most significantly, the NRC's assertion that deliberate malicious acts are not "foreseeable" for purposes of preparing an EIS is contradicted by the agency's own response to the events of September 11, which shows not only that the NRC considers terrorist attacks on nuclear facilities to be foreseeable, but that that defending against them is an extremely high priority.

As of September 11, 2001, it is now clear that terrorists are both capable of and intent upon causing major damage to life and property in the United States. As observed by the ASLB in a 2001 decision:

> Regardless of how foreseeable terrorist attacks that could cause a beyond-design-basis accident were prior to the terrorist attacks of September 11, 2001, involving the deliberate crash of hijacked jumbo jets into the twin towers of the World Trade Center in New York City and the Pentagon in the Nation's capital, killing thousands of people, it can no longer be argued that terrorist attacks of heretofore unimagined scope and sophistication against previously unimaginable targets are not reasonably foreseeable. Indeed, the very fact that these terrorist attacks occurred demonstrates that massive and destructive terrorist acts can and do occur and closes the door, at least for the immediate future, on qualitative arguments that such terrorist attacks are always remote and speculative and not reasonably foreseeable.

Duke Cogema Stone and Webster (Savannah River Mixed Oxide Fuel Fabrication Facility), LBP-01-35, 54 NRC 403, 446 (2001), *reversed,* CLI-02-24, 56 NRC 335 (2002).[15]

Moreover, as the NRC itself has recognized, the September 11 events were by no means the first sub-national attacks on major strategic targets. Two events in 1993 -- the bombing of the World Trade Center parking garage and the intrusion into the Three Mile Island security area and turbine building by a station wagon – had already prompted the NRC to promulgate a rule protecting nuclear power plants against vehicle bombs. *See* Final Rule, Protection Against Malevolent Use of Vehicles at Nuclear Power Plants, 59 Fed. Reg. 38,889, 38,891 (August 1, 1994).[16]

15 In that case, the ASLB admitted a contention seeking NEPA consideration of the environmental impacts of a terrorist attack on a proposed factory for fabrication of plutonium-based nuclear power plant fuel. Although the Commission later reversed the ASLB's decision, the ASLB's comment remains trenchant.

16. Other events of the last two decades include the 1983 bombing of the Marine barracks in Beirut; the 1995 bombing of the Federal Courthouse in Oklahoma City; the 1993 plot to bomb the United Nations Building, FBI offices in New York City, the Lincoln Tunnel, the Holland Tunnel, and the George Washington Bridge; the 1995 release of SARIN nerve gas in the Tokyo subway; the 1998 bombing of the U.S. embassies in Tanzania and Kenya; the 2002 bombing of the U.S.S. Cole; and the 2004 bombing of commuter trains in Madrid, Spain.

Since September 11, the NRC has only increased its level of vigilance and preparedness against attacks on nuclear facilities. As summarized by the Chairman of the NRC:

> awareness, resources, and vigilance were there [before September 11], but all went to a higher level when 9/11 showed the determination of enemies of the United States to attack our people and our way of life.

Remarks by NRC Chairman Nils J. Diaz to the Joint NRC/DHS State Security Outreach Workshop (June 17, 2003). Thus, in cooperation with the Department of Homeland Security ("DHS"), the NRC established a series of graded threat levels and associated protective measures, whose purpose was to keep the government in a state of readiness to respond to a threat that was now perceived as persistent.[17]

Moreover, leaders of adversarial sub-national groups have openly admitted that nuclear power stations are near the top of their lists as targets for attacks on civilians in the United States. On October 30, 2001, for example, the Washington Post reported on an interview with a jailed disciple of Osama bin Laden who said there are "more important places, like atomic plants and reactors" that may have been more appropriate targets than the World Trade Center. William Branigan, *In Afghan Jail, a Terrorist Who Won't Surrender,* Washington Post, October 30, 2001.

17 NRC Regulatory Issue Summary 2002-12A, Power Reactors, NRC Threat Advisory and Protective Measures System (August 19, 2002). Notably, the President also has identified nuclear power plants as "key assets" that are "most critical in terms of national-level public health and safety, governance, economic and national security, and public confidence consequences." National Strategy for the Physical Protection of Critical Infrastructures and Key Assets at vii, xii (February 2003). This report can be found on the internet at http://www.whitehouse.gov/pcipb/physical.html

Other federal agencies have also acknowledged that nuclear power plants are particularly attractive targets because of the widespread health and economic damage they can cause if successfully attacked. As summarized by former FBI Director Robert S. Mueller:

> . . . America is awash in desirable targets – those that are symbolic like the U.S. Capitol and the White House – as well as the many infrastructural targets, lie nuclear power plants, mass transit systems, bridges, and tunnels, shipping and port facilities, financial centers, and airports – that if successfully hit, would cause both mass casualties and a crippling effect on our economy."

Thus, after September 11, the NRC began to treat attacks by sub-national adversaries as an inevitable and constant threat requiring perpetual vigilance and preparedness. The NRC's efforts undermine its claim that the potential for such attacks is "remote and speculative." *See PFS II*, 56 NRC at 348-350.

iii. Fuel pools are vulnerable to attack.

A range of means is available to intentionally initiate a pool fire at the Vermont Yankee plant. Thompson Report, § 7 and Table 7-1. Moreover, both the NRC Staff and the National Academies of Sciences have found that spent fuel storage pools are vulnerable to intentional damage. As the NRC Staff conceded in a 2001 memorandum to the Commissioners:

> Until recently, the staff believed that the DBT [design-basis threat] of radiological sabotage could not cause a zirconium fire. However, NUREG-1738 does not support the assertion of a lesser hazard to the public health and safety, given the possible consequences of sabotage-included uncovery of the fuel in the SFP when a zirconium-fire potential exists.

SECY-01-0100, Memorandum to the Commissioners from William D. Travers, Executive Director for Operations ("EDO") re: Policy Issues Related to Safeguards, Insurance, and Emergency Preparedness Regulations at Decommissioning Nuclear Power Plants Storing Spent Fuel in Spent Fuel Pools (WITS 200000126) (June 4, 2001), attachment at 13.[18] The memorandum went on to say that the NRC is "conducting detailed analyses of the effects of the DBT of radiological sabotage on SFPs," and that it will "use the results of these analyses to determine, on a plant-specific basis, whether

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Testimony before the Senate Committee on Intelligence of the United States Senate (February 16, 2005).

18 A zirconium-induced fire potential exists in virtually any high-density spent fuel pool that is filled with fuel, or even partially filled, as is the case at the Vermont Yankee nuclear plant. Thompson Report, § 2.

radiological sabotage can result in conditions which could lead to zirconium fires at a decommissioning plant." *Id.* Thus, by embarking on its own investigation into the vulnerability of spent fuel pools to sabotage-included fires, the Staff has effectively conceded that acts of malice against spent fuel are credible and worthy of consideration in the NRC's NEPA decision-making process.

The NAS Report also reports a similar conclusion:

> A terrorist attack that either disrupted the cooling system for the spent fuel pool or damaged or collapsed the pool itself could potentially lead to a loss-of-pool-coolant event. The cooling system could be disrupted by disabling or damaging the system that circulates water from the pool to heat exchangers to remove decay heat. This system would not likely be a primary target of a terrorist attack, but it could be damaged as the result of an attack on the spent fuel pool or other targets at the plant (e.g., the power for the pumps could be interrupted.) The loss of cooling capacity would be of much greater concern were it to occur during or shortly after a reactor offloading operation, because the pool would contain a large amount of decay heat.

NAS Report at 48. The NAS committee also evaluated studies of aircraft crashes and assaults on fuel pools using explosives, and reported that:

> . . . there are some scenarios that could lead to the partial failure of the spent fuel pool wall, thereby resulting in the partial or complete loss of pool coolant. A zirconium cladding fire could result if timely mitigative actions to cool the fuel were not taken.

NAS Report at 49. Notably, the NAS was not able to give any details in support of its conclusion, but referred instead to a classified report for that information. *Id.*

c. The NRC has adequate qualitative tools to evaluate the potential for intentional malicious acts against the Vermont Yankee plant.

In the License Renewal GEIS, the NRC asserts its inability to quantify the likelihood of sabotage as a rationale for refusing to address its impacts in an EIS. GEIS at 5-18. The fact that the risk of sabotage may not be easily quantifiable is not an excuse for failing to address it in an EIS, however. As provided in the Council on Environmental Quality's regulations implementing NEPA, 40 C.F.R. § 1502.22, the agency must make an attempt to evaluate reasonably foreseeable significant adverse effects if the costs of obtaining the information are not exorbitant. Even if the costs of obtaining the information are exorbitant, the agency must acknowledge that the information exists but is unavailable, make a statement of the relevance of the information to the evaluation of impacts in the EIS, summarize existing relevant and credible scientific evidence, and provide the agency's evaluation of the impacts based on generally accepted theoretical approaches or research methods. *See also* 10 C.F.R. § 51.71 ("To the extent that there are important qualitative considerations or factors that cannot be quantified, these considerations or factors will be discussed in qualitative terms.").

In fact, the Commission has already shown itself capable of qualitatively analyzing the potential for intentional destructive acts against nuclear facilities. By proceeding with the 1994 vehicle bomb rulemaking, which was directly responsive to the World Trade Center bombing and the Three Mile Island vehicle intrusion incident, the Commission abandoned its previous position that the difficulty of quantifying the probability of such events means that they can be ignored. While the Vehicle Bomb rule was promulgated under the AEA rather than NEPA, the rationale for the rule is relevant here because it demonstrates that the NRC has the capacity and information necessary to perform a qualitative analysis of the potential for deliberate and malicious acts. In that instance, the NRC performed a "conditional probabilistic risk analysis" to assess the vulnerability of a nuclear power plant to a vehicle bomb. Vehicle Bomb Rule, 59 Fed.

Reg. at 38,891. In using the findings of this analysis to develop the vehicle-bomb rule, the NRC took a qualitative approach to assessing the probability of a vehicle-bomb event.

In the preamble to the rule, the Commission explicitly recognized that even if the likelihood of malicious or insane acts cannot be quantified, they may not be ignored:

> Over the past several years, a number of National Intelligence Estimates have been produced addressing the likelihood of nuclear terrorism. The analyses and conclusions are not presented in terms of quantified probability but recognize the unpredictable nature of terrorist activity in terms of likelihood. The NRC continues to believe that, although in many cases considerations of probabilities can provide insight into the relative risk of an event, in some cases it is not possible, with current knowledge and methods, to usefully quantify the probability of a specific vulnerability threat.
>
> The NRC notes that, although not quantified, its regulatory analysis recognizes the importance of the perception of the likelihood of an attempt to create radiological sabotage in assessing whether to redefine adequate protection. The NRC's assessment that there is no indication of an actual vehicle threat against the domestic commercial nuclear industry was an important consideration in concluding that neither the Three Mile Island intrusion nor the World Trade Center bombing demonstrated a need to redefine adequate protection.
>
> The NRC does not agree that quantifying the probability of an actual attack is necessary to a judgment of a substantial increase in overall protection of the public health and safety (a less stringent test of the justification of for a rule change). *Inherent in the NRC's current regulations is a policy decision that the threat, although not quantified, is likely in a range that warrants protection against a violent external assault as a matter of prudence.*

59 Fed. Reg. at 38,890-9 (emphasis added). The NRC further elaborated on what it meant by it use of the term "likely," by identifying several factors that make up the "domestic threat environment" and noting the degree to which it had changed in recent years:

> The vehicle bomb attack on the World Trade Center represented a significant change to the domestic threat environment that ... eroded [our prior] basis for concluding that vehicle bombs could be excluded from any consideration of the domestic threat environment. For the first time in the United States, a conspiracy with ties to Middle East extremists clearly demonstrated the capability and motivation to organize, plan and successfully conduct a major vehicle bomb

> attack. Regardless of the motivations or connections of the conspirators, it is significant that the bombing was organized within the United States and implemented with materials obtained on the open market in the United States. Accordingly, the Commission believes that the threat characterized in the final rule is appropriate.

Id., 59 Fed. Reg. at 38891. These same considerations continue to apply in the post-September 11 environment, and indeed are all the more persuasive of a sea change in the "domestic threat environment." Thus, motive, capacity, and the pattern of past incidents are relevant to a qualitative analysis.

Thus the circumstances of this case satisfy the NRC's qualitative standard for determining that deliberate and destructive acts against the Vermont Yankee spent fuel pool are reasonably foreseeable.

d. Other GEIS grounds for refusing to address impacts of deliberate malicious acts are invalid.

As additional grounds for refusing to consider the environmental impacts of intentional destructive acts, the GEIS asserts that NRC security regulations provide reasonable assurance that the risk from sabotage is small, and that the consequences of an intentionally caused accident would be "no worse than" the consequences of internally initiated events. *Id.* at 5-18. These rationales are invalid.

First, NEPA's procedural requirements are independent of the AEA, and must be satisfied regardless of an applicant's compliance with NRC regulations for implementation of the AEA. *Limerick Ecology Action v. NRC*, 869 F.2d at 730.

Second, the radiological consequences of a pool fire would be quite different from the consequences of a reactor accident, and in some respects worse. The principal radioactive isotopes released in a severe reactor accident are generally short-lived, and thus the most important concern in avoiding or mitigating those impacts is to evacuate people as quickly as possible from the area. In contrast, the principal radioactive isotope released by a pool fire consists of cesium-137, which has a half-life of 30 years.[19] Immediate evacuation is still an important consideration, but long-term land contamination is an additional factor that must be planned for. The land area affected by a radiological release from a pool fire could be contaminated for decades, requiring permanent relocation of entire communities and their associated businesses, farms and institutions.

Moreover, the area of land contaminated by a release could be much larger for a pool fire than a reactor accident because the inventory of radioactivity that may be released from a pool is so much larger than the inventory of radioactivity that may be released from the core. As demonstrated in Table 3-3 of the Thompson Report, much more radioactive material is held in the pool than in the core.

In any event, even assuming for purposes of argument that the consequences of a reactor accident and a pool accident were the same, the SAMAs appropriate for each type of accident would be different. In considering the environmental impacts of sabotage, it is particularly important to consider SAMAs which could mitigate the impacts of sabotage. Using a combination of low-density wet storage and dry storage would virtually eliminate the vulnerability of the Vermont Yankee fuel pool to attack. *See* Thompson Report, § 8. Thus, NEPA requires a discussion of the environmental impacts of a pool fire, regardless of whether a pool fire's impacts would be bounded by the impacts of a reactor accident.

19 While the reactor core contains cesium-137, the quantity is much smaller than the quantity of cesium-137 contained in the pool. Thompson Report, § 3.

c. NRC's policy rationales in *PFS II* and *Diablo Canyon* are not supported.

In the *PFS II* and *Diablo Canyon* decisions, the Commission gave a number of policy and fact-based rationales for refusing to consider the environmental impacts of deliberate and malicious acts in its NEPA decisions. Petitioner will respond to them in this section of the contention.

In *Diablo Canyon* and *PFS II,* the Commission argued that the possibility of a terrorist attack is "too far removed from the natural or expected consequences of agency action to require a study under NEPA." *Diablo Canyon,* 57 NRC at 6-7, quoting *PFS II,* 56 NRC at 349. This argument must be rejected because it "runs counter to the evidence before the agency." *Southwest Center v. U.S. Forest Service,* 100 F.3d 1443, 1448 (9th Cir. 1996). In particular, the argument ignores the federal government's own determinations that nuclear facilities are highly attractive targets to terrorists, as well as the NRC's own actions demonstrating how seriously it takes the threat.

The Commission's ruling also is inconsistent with the agency's own long-established policy and practice of addressing the environmental impacts of external events in accident analyses conducted under NEPA. *Sierra Club v. NRC,* 862 F.2d 222, 228 (9th Cir. 1988) (reversing a decision that was "contrary to the NRC's own policy (and one that accords with common sense)"). Under its own NEPA guidance, NRC considers accidents caused or exacerbated by a range of initiating events, including internal events (such as equipment failure) and external events (such as tornados, floods, earthquakes, and explosions at adjacent facilities). NUREG-1555, Environmental Standard Review Plan for Environmental Review for Nuclear Power Plants at 7.2-3 (October 1999). None of these external events would constitute "natural" consequences of operation of the

Vermont Yankee nuclear power plant. If they were to occur while the plant is operating, however, they could cause an accidental release of radioactivity to the environment, which would not have occurred had the nuclear facility not been licensed.[20]

In *Diablo Canyon* and *PFS II*, the Commission also argued that inquiries into the environmental impacts of terrorist attacks are not "manageable." *Diablo Canyon*, 57 NRC at 6-7, and *PFS II*, 56 NRC at 349 and note 33, quoting *Metropolitan Edison Co. v. People Against Nuclear Energy*, 460 U.S. 766, 776 (1983). According to the NRC, those who seek a NEPA evaluation of the environmental impacts of terrorist attacks effectively seek an open-ended, "worst-case" analysis that has "no stopping point." *PFS II*, 56 NRC at 354.

The Commission's citation to *Metropolitan Edison Co. v. People Against Nuclear Energy* is completely inapposite. In that case, the Supreme Court ruled that psychological effects posed by the risk of an accident at the Three Mile Island nuclear power plant were "too remote from the physical environment" to warrant preparation of an EIS. 460 U.S. at 774. The Supreme Court "emphasize[d]" that it was considering, in that case, "the effects caused by the *risk* of an accident." *Id.* (emphasis added). Here, in contrast, Petitioner is concerned about actual physical environmental effects in the event

20 In a footnote to *PFS II*, the Commission attempted to distinguish "natural" events from terrorist attacks on the ground that natural events are "closely linked to the natural environment of the area within which a facility will be located, and are reasonably predictable by examining weather patterns and geological data for that region." 56 NRC at 347, note 18. Attacks on nuclear facilities, however, are also "closely linked" to those facilities, in the sense that they are desirable targets. Furthermore, the Commission's argument that natural events are "reasonably predictable" amounts to a reprise of the claim that environmental impacts must be quantifiable in order to be cognizable. *See Limerick Appeal Board Decision*, 22 NRC at 701. As discussed above in Section V.B.3.c, the Commission itself disavowed this position in the Vehicle Bomb Rule. Finally, the Commission's position is inconsistent with 10 C.F.R. § 51.71, which requires a discussion of qualitative factors that cannot be quantified.

of a terrorist attack on the Vermont Yankee fuel pool. As the Court recognized in *Metropolitan Edison,* "[t]he situation where an agency is asked to consider effects that will occur if a risk is realized, for example, if an accident occurs at TMI-1, is an entirely different case," where its holding would not apply. *Id.* at 775.

In any event, the Commission's argument is directly contradicted by the agency's own pragmatic approach to evaluating the potential for specific types of terrorist attacks, as outlined in the 1994 Vehicle Bomb Rule. The Vehicle Bomb Rule demonstrates that it is possible to evaluate the potential for and credibility of attack scenarios, and to identify a range of reasonable alternatives for avoiding or mitigating the impacts of such attacks. Here, the Attorney General seeks a hearing on whether just such an analysis is required for the Vermont Yankee license renewal decision, including a full discussion of the potential consequences of a range of credible events involving destructive intentional acts against the Vermont Yankee spent fuel pool. The Attorney General also seeks an evaluation of a range of reasonable alternatives to the proposed action, including combined low-density pool storage and dry storage. It is only common sense that the analysis requested by Petitioner is no more open-ended than the analysis the NRC performed in promulgating the Vehicle Bomb Rule.

In the *Diablo Canyon* decision, the Commission also attempted to justify its exclusion of the Petitioners' environmental contentions on the ground that "NEPA's public process is not an appropriate forum for considering sensitive security issues." CLI-03-01, 57 NRC at 7. The Commission cited no legal basis, however, that would excuse it from compliance with NEPA. Without a specific and conflicting statutory basis, the mere sensitivity of information does not provide an excuse for noncompliance with NEPA. Compliance with NEPA is required "unless specifically excluded by statute or existing law makes compliance impossible." *Limerick Ecology Action v. NRC,* 869 F.2d at 729, citing *Public Service Co. of New Hampshire v. NRC,* 582 F.2d 77, 81 (1st Cir.), *cert. denied,* 439 U.S. 1046 (1978). *See also Flint Ridge Development Corp. v. Scenic Rivers Association of Oklahoma,* 426 U.S. 776, 787-88 (1976).

Moreover, to the extent that the Commission is bound by legal requirements to protect sensitive information, the Commission has failed to demonstrate that those requirements render it "impossible" to consider the environmental impacts of deliberate and malicious against the Vermont Yankee fuel pool. In fact, the Commission's position is inconsistent with its own practice under another public participation statute, Section 189a of the AEA: 42 U.S.C. § 2239. The NRC has never denied a licensing hearing simply because sensitive, proprietary, or safeguards information may be discussed in the hearing. Instead, it implements procedures that limit access to sensitive information to parties who have signed confidentiality agreements.[21] The NRC can also use these procedures to limit access to sensitive information regarding the vulnerability of the Vermont Yankee fuel pool to the parties and interested government participants. The Commission also failed to recognize that it can *solicit* public comment, even if it does not disclose all the details of its environmental analysis. State and local governments, which have expertise in and responsibility for implementing back-up security and emergency response measures, also have valuable contributions to make to the decision-making

21 *See, e.g,* 10 C.F.R. §§ 2.744(e) (procedures for handling safeguards information in NRC hearings), 10 C.F.R. Part 2 Subpart I (procedures for handling classified information in NRC hearings); *Pacific Gas & Electric Company* (Diablo Canyon Nuclear Power Plant), ALAB-410, 5 NRC 1398, 1405 (1977) (granting intervenor's security expert access to confidential security plans during the operating license proceeding for Diablo Canyon).

process.

Finally, the NRC ignores the fact that in numerous instances, other agencies such as the U.S. Department of Energy ("DOE") have prepared EISs containing information that was not accessible to the general public.[22] In none of these instances did the DOE refuse to prepare an EIS because it would involve the discussion of sensitive information. Instead, the publicly available version of the EIS redacted sensitive information. By following appropriate procedures and obtaining appropriate clearances, interested citizens and state and local governments may gain access to the information.

Finally, in *Diablo Canyon,* the Commission asserted that its refusal to prepare an EIS on the environmental impacts of a terrorist attack "comports with the practical

22 For instance, the DOE has restricted circulation of some sensitive information, and withheld other information under the classification of "Official Use Only."For example, Appendix H of the DOE's EIS for the proposed Yucca Mountain high-level radioactive waste repository, which discusses consequences of accidents at the repository, is not in the hard copy of the EIS that was circulated to the public, nor is it on the internet. DOE/EIS-0250F, Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada at H-1 (February 2002). Instead, it was placed in Volume 4 of the Final EIS, which must be specially ordered from the DOE. *Id.,* Readers Guide at 3.

Another EIS prepared by the DOE contains an air transportation accident analysis that is not published in the publicly available version of the EIS, but is contained in an "Official Use Only document." DOE/EIS-236-S2, Draft Supplemental Programmatic Environmental Impact Statement on Stockpile Stewardship and Management for a Modern Pit Facility, Vol. II at C-15 and Tables C.4-1, C.4-2, C.4-3 (May 2003).

The DOE has also prepared EISs containing highly sensitive classified information. *See, e.g.,* DOE/EIS-0161, Final Programmatic Environmental Impact Statement for Tritium Supply and Recycling, Vol. I at 2-1 (October 1995) (evaluating environmental impacts of recycling and production of tritium for nuclear weapons); DOE/EIS-0319, Final Environmental Impact Statement for the Proposed Relocation of Technical Area 18 Capabilities and Materials at the Los Alamos National Laboratory at iii, 5-1 (August 2002) (evaluating environmental impacts of sabotage on a DOE research facility).

realities of spent fuel storage and the congressional policy to encourage utilities to provide for spent fuel storage at reactor sites pending construction of a permanent repository." CLI-03-01, 57 NRC at 7. Nothing in the Nuclear Waste Policy Act, however, exempts spent fuel storage from the requirements of NEPA. In fact, the statute specifically requires that the Commission's actions must be consistent with NEPA. 42 U.S.C. § 10152.

4. The consequences of a pool fire are different and potentially more severe than the consequences of a reactor accident.

It is important to consider the environmental impacts of a pool fire, because pool fire impacts are fundamentally different than the impacts of a reactor accident, and therefore have different implications for the consideration of alternatives. *See* discussion above in Section V.B.3.b.iv.

5. The ER and the EIS must discuss reasonable and feasible alternatives for avoiding or mitigating a pool fire.

As discussed above in Sections III.B.1.c and III.B.3.d, NEPA and the NRC's implementing regulations require the consideration of reasonable alternatives to the proposed action, including SAMAs for avoiding or mitigating the consequences of severe accidents. A range of options is available for reducing or avoiding the impacts of a pool fire, including returning the plant to its original design configuration of low-density pool storage of spent fuel and placing excess spent fuel in dry storage. Thompson Report, § 8. This option would allow the pool to survive a loss of water without damage to the fuel, thus avoiding a pool fire. *Id.* The technologies of low-density storage and dry storage are reasonable and feasible, and therefore should be considered. *Idaho Conservation League v. Mumma,* 956 F.2d 1508, 1519-20 (9th Cir. 1992).

VI. PETITION FOR IMPOSITION OF BACKFIT ORDER

As discussed above in Section III.A.1, the AEA, implementing regulations, and NRC precedents require the NRC to ensure that operation of the Vermont Yankee nuclear power plant does not pose an undue risk to public health and safety during the license renewal term. As the Commission observed in the preamble to the final license renewal rule, the purpose of the rule is to "ensure that operation during the period of extended operation is not inimical to the public health and safety." 56 Fed. Reg. at 64,945. *See also Petition for Emergency and Remedial Action,* 7 NRC at 404, citing *Power Reactor Development Corp.*, 367 U.S. at 402.

One of the NRC's key measures for ensuring adequate protection of the public is to require that its licensed facilities be designed against "design-basis accidents." *See* discussion above in section III.A.2. The NRC requires that reactor core accidents with a "realistic probability" (*i.e.*, a non-conservative probability) of at least one in ten million per year (10^{-7}) must be included in the design-basis. *PFS I,* 54 NRC at 259-60. By the reasoning of *PFS I,* the same threshold of probability should be set for pool accidents, because they also have a large source term (*i.e.*, inventory of radioactive material) that may be released by the driving force of the high heat of a fire.[23] As discussed above in

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23 In the *PFS I* decision, the Commission chose a "threshold" probability of 10^{-6} for a design-basis accident at an independent spent fuel storage installation, rather than the 10^{-7} factor used for nuclear power plants. As the Commission explained, the difference in threshold probabilities for design-basis accidents for these two types of facilities is based on the significant difference in the potential consequences of an accident:

> The Commission has previously recognized that the 'public health and safety risks posed by ISFSI storage . . . are very different from the risks posed by the safe irradiation of the fuel assemblies in a commercial nuclear reactor, which requires the adequate protection of the public . . . in the conditions of high temperature and pressures under which the reactor operates.' . . . This is because

Section V.B.3.b and as demonstrated in the Thompson Report, §§ 6, 7, and 9, the frequencies for a range of spent fuel pool accident precursors fall well above the estimated probability level considered by the NRC to establish the "threshold" for a design-basis event. *PFS I*, 54 NRC at 259-60.[24]

There was no need to design against pool fire accidents at the time of initial licensing of Vermont Yankee in 1972, when the former licensee used open low-density racks to store a much smaller quantity of spent fuel. Now that the Vermont Yankee pool has been re-designed to include high-density storage racks, the design of the Vermont Yankee plant poses an undue safety risk of a pool fire. Therefore, pursuant to 10 C.F.R. § 50.109(a)(5), the Commission should require the backfitting of the Vermont Yankee nuclear plant by returning the pool to its original low-density storage configuration and using dry storage for any excess fuel.

While current NRC regulations do not appear to provide for an adjudicatory hearing on the adequacy of any design changes ordered by the NRC, it is a subject on

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> the danger presented by irradiated fuel 'is largely determined by the presence of a driving force behind dispersion,' such as heat and pressure neither of which is present in an ISFSI. ... Moreover, the radiological source term is lower at an ISFSI than at a reactor both because the spent fuel has decayed over time prior to placement in an ISFSI and because there are fewer fuel assemblies in an individual cask than in reactor. ....

54 NRC at 265. [footnotes omitted]. As with a reactor accident, the "driving force," of the heat from a pool fire may disperse a very large amount of radioactive material into the environment. *See* Thompson Report, § 2. Thus, a pool accident is comparable to, and may in some cases be more severe than, the consequences of a reactor core melt accident.

24 . In fact, the majority of accidents analyzed in NUREG-1150 fall well within the range of probabilities considered by the NRC to qualify as design-basis accidents. *See* Figure 8.6 of NUREG-1150, for example, which shows that both the median and the average core damage frequency for internal and external events at the Peach Bottom nuclear power plant (a BWR like Vermont Yankee) fall between 10^{-3} and 10^{-5}. This core damage frequency is at least two orders of magnitude above the NRC's threshold probability for a design-basis accident at a nuclear plant.

which the NRC should take comment from the interested public because a variety of potential measures for reducing spent fuel pool fire risks are available, with varying degrees of effectiveness. *See* Thompson Report, § 8. Thus, the Attorney General seeks a discretionary hearing on the adequacy of the design modifications proposed by the Commission.[25]

The choice of design measures could also have a significant impact on the quality of the human environment if the NRC chooses a design measure that is not adequate to prevent the risk of a fire. Thus, the Commission must comply with NEPA by publishing its proposed design measures in the draft EIS for renewal of the Vermont Yankee license. Such design measures are required by the Atomic Energy Act in order to ensure that during the license renewal term operation of the Vermont Yankee nuclear plant and associated fuel pool poses no undue risk to public health and safety. 42 U. 42 U.S.C. § 2133(d).

VII. CONCLUSION

For these reasons, the Commission should grant Petitioner a hearing regarding the issues raised in his contention. In addition, the Commission should initiate a proceeding for the backfitting of the Vermont Yankee nuclear power plant to protect against a design-basis accident involving a fire in the fuel pool.

25 In contrast, the Attorney General has the statutory right under NEPA to a hearing on the environmental contention raised in Section V of this pleading.

Respectfully submitted,
COMMONWEALTH OF MASSACHUSETTS

By its Attorneys,

THOMAS F. REILLY
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May 26, 2006

CERTIFICATE OF SERVICE

I certify that on May 26, 2005, copies of the foregoing request for hearing, petition to intervene, and petition for a backfit order, were served on the following in the manner described below:

BY HAND:
Office of the Secretary
U.S. Nuclear Regultory Commission
11555 Rockville Pike
Rockville, MD 20852

Office of the General Counsel
U.S. Nuclear Regultory Commission
11555 Rockville Pike
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BY FEDERAL EXPRESS:
Terence A. Burke, Esq.
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Jackson, MS 39213

Diane Curran

EXHIBIT

1

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
BEFORE THE COMMISSION

In the Matter of	)	
	)	
Entergy Nuclear Operations, Inc.	)	Docket No. 50-271
	)	
(Vermont Yankee	)	
Nuclear Power Station)	)	
	)	

DECLARATION OF DR. GORDON THOMPSON IN SUPPORT OF MASSACHUSETTS ATTORNEY GENERAL'S CONTENTION AND PETITION FOR BACKFIT ORDER

I, Gordon Thompson, declare as follows:

1. I am the executive director of the Institute for Resource and Security Studies (IRSS), a nonprofit, tax-exempt corporation based in Massachusetts. Our office is located at 27 Ellsworth Avenue, Cambridge, MA 02139. IRSS was founded in 1984 to conduct technical and policy analysis and public education, with the objective of promoting peace and international security, efficient use of natural resources, and protection of the environment. I am also a research professor at the George Perkins Marsh Institute, Clark University, Worcester, Massachusetts.

2. In support of the Massachusetts Attorney General's request for a hearing, petition to intervene, and backfit petition with respect to the license renewal proceeding for the Vermont Yankee nuclear power plant, I have prepared a report entitled "Risks and Risk-Reducing Options Associated with Pool Storage of Spent Nuclear Fuel at the Pilgrim and Vermont Yankee Nuclear Power Plants" (25 May 2006). In preparing my report, I reviewed the 25 January 2006 license renewal application filed by Entergy Nuclear Operations, Inc. (Entergy). I have also reviewed various correspondence and technical documents relating to the proposed license amendment and to risks of spent fuel storage, which are identified in the Attorney General's contention and in my Report.

3. The technical factual statements in my report are true and correct to the best of my knowledge, and the technical opinions expressed therein are based on my best professional judgment.

4. I am an expert in the area of technical safety, security and environmental analysis related to nuclear facilities. My Curriculum Vitae is provided here as Attachment A.

5. I received an undergraduate education in science and mechanical engineering at the

University of New South Wales, in Australia. Subsequently, I pursued graduate studies at Oxford University and received from that institution a Doctorate of Philosophy in mathematics in 1973, for analyses of plasmas undergoing thermonuclear fusion. During my graduate studies I was associated with the fusion research program of the UK Atomic Energy Authority. My undergraduate and graduate work provided me with a rigorous education in the methodologies and disciplines of science, mathematics, and engineering.

6. Since 1977, a significant part of my work has consisted of technical analyses of safety, security and environmental issues related to nuclear facilities. These analyses have been sponsored by a variety of nongovernmental organizations and local, state and national governments, predominantly in North America and western Europe. Drawing upon these analyses, I have provided expert testimony in legal and regulatory proceedings, and have served on committees advising US and UK government agencies. To illustrate my expertise, I provide more detailed information on my experience below.

7. I have conducted, directed, and/or participated in a number of studies that evaluated aspects of the design and operation of nuclear power plants with respect to severe accident probabilities and consequences. These include general studies and studies of individual plants. For instance, with respect to general studies, in 1986, I participated in the preparation of a study by the Union of Concerned Scientists of the potential for escape of radioactive material during a reactor core-melt accident (Sholly and Thompson, 1986). In the late 1980s, I was part of a team of four scientists which prepared a comprehensive critique of the state of the art of probabilistic risk assessment (PRA) for Greenpeace International (Hirsch et al, 1989). I published two chapters on the relevance of PRA to emergency planning in a book entitled *Preparing for Nuclear Power Plant Accidents* (Golding, et al., 1995). All of these studies required me to be highly familiar with the design and operation of nuclear power plants, as well as the characteristics of probabilistic risk assessment.

8. I have also done considerable work on the risks posed by individual nuclear facilities. In addition to performing the studies described elsewhere in this Declaration, I have studied the risks posed by the Seabrook and Harris plants (U.S.), the La Hague facility (France), and the Darlington and Pickering Stations (Canada). All of these studies required me to become familiar with the relevant details of the design and operation of the facilities involved.

9. To a significant degree, my work has been accepted or adopted by the governmental agencies involved. During the period 1978-1979, for example, I served on an international review group commissioned by the government of Lower Saxony (a state in Germany) to evaluate a proposal for a nuclear fuel cycle center at Gorleben. I led the subgroup that examined accident and security risks and alternative options with lower risk. One of the risk issues that I identified and analyzed was the potential for an exothermic reaction of fuel cladding in a high-density fuel pool if water is lost. I identified partial loss of water as a more severe condition than total loss of water. I identified and described alternative fuel storage options with lower risk. The Lower Saxony government accepted my findings and ruled that high-density pool storage was not an acceptable option at

Gorleben. As a direct result, policy throughout Germany has been to use dry storage, rather than high-density pool storage, for away-from-reactor storage of spent fuel.

10. My work has also influenced decision making by safety officials in the U.S. Department of Energy (DOE). During the period 1986-1991, I was commissioned by environmental groups to assess the safety of the military production reactors at the Savannah River Site, and to identify and assess alternative options for the production of tritium for the US nuclear arsenal. Initially, much of the relevant information was classified or otherwise inaccessible to the public. Nevertheless, I addressed safety issues through analyses that were recognized as accurate by nuclear safety officials at DOE. I eventually concluded that the Savannah River reactors could not meet the safety objectives set for them by DOE. DOE subsequently reached the same conclusion. The current national policy for tritium production is to employ commercial reactors, an option that I had concluded was technically attractive but problematic from the perspective of nuclear weapons proliferation.

11. In 1977, and again during the period 1996-2000, I examined the safety of nuclear fuel reprocessing and liquid high-level waste management facilities at the Sellafield site in the UK. My investigation in the latter period was supported by a consortium of local governments in Ireland and the UK, and my findings were presented at briefings in the UK and Irish parliaments. I identified safety issues that were not addressed in any publicly available literature about the Sellafield site. As a direct result of my investigation, the UK Nuclear Installations Inspectorate (NII) required the operator of the Sellafield site to conduct extensive safety analyses. These analyses confirmed the significance of the safety issues that I identified, and the NII imposed a schedule for run-down of the Sellafield inventory of liquid high-level waste.

11. In 2000, the NRC Staff accepted my view that older fuel in a spent-fuel pool is more vulnerable to ignition in a state of partial drainage than in a state of total drainage, because convective heat transfer is suppressed by the presence of residual water at the base of the fuel assemblies. Although the NRC Staff previously ignored or disparaged my opinion, the Staff eventually confirmed the validity of my expert opinion on the matter.

12. I am prepared to testify as an expert witness on behalf of the Massachusetts Attorney General with respect to the facts and opinions set forth in my Report.

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I declare, under penalty of perjury, that the foregoing facts provided in my Declaration are true and correct to the best of my knowledge and belief, and that the opinions expressed herein are based on my best professional judgment.

Executed on 25 May 2006.

G. R. Thompson

Gordon Thompson

Curriculum Vitae for Gordon R. Thompson
November 2005

Professional expertise

• Technical and policy analyst in the fields of energy, environment, sustainable development, and international security.

Current appointments

• Executive director, Institute for Resource & Security Studies (IRSS), Cambridge, Massachusetts (since 1984).
• Research Professor, George Perkins Marsh Institute, Clark University, Worcester, Massachusetts (since 2002).

Education

• D.Phil., applied mathematics, Oxford University (Balliol College), 1973.
• B.E., mechanical engineering, University of New South Wales, Sydney, Australia, 1967.
• B.Sc., mathematics & physics, University of New South Wales, 1966.

Project sponsors and tasks (selected)

• California Energy Commission, 2005: conducted technical analysis and participated in expert workshop regarding safety and security of commercial nuclear facilities.
• Committee on Radioactive Waste Management (a committee appointed by the UK government), 2005: provided expert advice on safety and security of radioactive waste management.
• Legal Resources Centre, Cape Town, South Africa, 2004-2005: conducted technical analysis regarding the proposed South African pebble bed modular reactor.
• STAR Foundation, New York, 2002-2004: reviewed planning and actions for decommissioning of research reactors at Brookhaven National Laboratory.
• Attorney General of Utah, 2003: conducted technical analysis and prepared expert testimony regarding a proposed national storage facility for spent nuclear fuel.
• Mothers for Peace, California, 2002-2004: analyzed risk issues and prepared expert testimony associated with the Diablo Canyon nuclear power plant.
• Citizens Awareness Network, Massachusetts, 2002-2003: conducted analysis on robust storage of spent nuclear fuel.
• Tides Center, California, 2002-2004: conducted analysis for the Santa Susana Field Laboratory (SSFL) Advisory Panel regarding the history of releases of radioactive material from the SSFL.

• Orange County, North Carolina, 1999-2002: assessed risk issues associated with the Harris nuclear power plant, identified risk-reduction options, and prepared expert testimony.
• William and Flora Hewlett Foundation and other sponsors, 1999-2005: performed research and project development for conflict-management projects, through IRSS's International Conflict Management Program.
• STAR Foundation, New York, 2000-2001: assessed risk issues associated with the Millstone nuclear power plant, identified risk-reduction options, and prepared expert testimony.
• Massachusetts Water Resources Authority, 2000: evaluated risks associated with water supply and wastewater systems that serve greater Boston.
• Canadian Senate, Energy & Environment Committee, 2000: reviewed risk issues associated with the Pickering Nuclear Generating Station.
• Greenpeace International, Amsterdam, 2000: reviewed impacts associated with the La Hague nuclear complex in France.
• Government of Ireland, 1998-2001: developed framework for assessment of impacts and alternative options associated with the Sellafield nuclear complex in the UK.
• Clark University, Worcester, Massachusetts, 1998-1999: participated in confidential review of outcomes of a major foundation's grants related to climate change.
• UN High Commissioner for Refugees, 1998: developed a strategy for conflict management in the CIS region.
• General Council of County Councils (Ireland), W. Alton Jones Foundation (USA), and Nuclear Free Local Authorities (UK), 1996-2000: assessed safety and economic issues of nuclear fuel reprocessing in the UK; assessed alternative options.
• Environmental School, Clark University, Worcester, Massachusetts, 1996: session leader at the Summer Institute, "Local Perspectives on a Global Environment".
• Greenpeace Germany, Hamburg, 1995-1996: a study on war, terrorism and nuclear power plants.
• HKH Foundation, New York, and Winston Foundation for World Peace, Washington, DC, 1994-1996: studies and workshops on preventive action and its role in US national security planning.
• Carnegie Corporation of New York, Winston Foundation for World Peace, Washington, DC, and others, 1995: collaboration with the Organization for Security and Cooperation in Europe to facilitate improved coordination of activities and exchange of knowledge in the field of conflict management.
• World Bank, 1993-1994: a study on management of data describing the performance of projects funded by the Global Environment Facility (joint project of IRSS and Clark University).
• International Physicians for the Prevention of Nuclear War, 1993-1994: a study on the international control of weapons-usable fissile material.
• Government of Lower Saxony, Hannover, Germany, 1993: analysis of standards for radioactive waste disposal.
• University of Vienna (using funds supplied by the Austrian government), 1992: review of radioactive waste management at the Dukovany nuclear power plant, Czech Republic.

• Sandia National Laboratories, 1992-1993: advice to the US Department of Energy's Office of Foreign Intelligence.
• US Department of Energy and Battelle Pacific Northwest Laboratories, 1991-1992: advice for the Intergovernmental Panel on Climate Change regarding the design of an information system on technologies that can limit greenhouse gas emissions (joint project of IRSS, Clark University and the Center for Strategic and International Studies).
• Winston Foundation for World Peace, Boston, Massachusetts, and other funding sources, 1992-1993: development and publication of recommendations for strengthening the International Atomic Energy Agency.
• MacArthur Foundation, Chicago, Illinois, W. Alton Jones Foundation, Charlottesville, Virginia, and other funding sources, 1984-1993: policy analysis and public education on a "global approach" to arms control and disarmament.
• Energy Research Foundation, Columbia, South Carolina, and Peace Development Fund, Amherst, Massachusetts, 1988-1992: review of the US government's tritium production (for nuclear weapons) and its implications.
• Coalition of Environmental Groups, Toronto, Ontario (using funds supplied by Ontario Hydro under the direction of the Ontario government), 1990-1993: coordination and conduct of analysis and preparation of testimony on accident risk of nuclear power plants.
• Greenpeace International, Amsterdam, Netherlands, 1988-1990: review of probabilistic risk assessment for nuclear power plants.
• Bellerive Foundation, Geneva, Switzerland, 1989-1990: planning for a June 1990 colloquium on disarmament and editing of proceedings.
• Iler Research Institute, Harrow, Ontario, 1989-1990: analysis of regulatory response to boiling-water reactor accident potential.
• Winston Foundation for World Peace, Boston, Massachusetts, and other funding sources, 1988-1989: analysis of future options for NATO (joint project of IRSS and the Institute for Peace and International Security).
• Nevada Nuclear Waste Project Office, Carson City, Nevada (via Clark University), 1989-1990: analyses of risk aspects of radioactive waste management and disposal.
• Ontario Nuclear Safety Review (conducted by the Ontario government), Toronto, Ontario, 1987: review of safety aspects of CANDU reactors.
• Washington Department of Ecology, Olympia, Washington, 1987: analyses of risk aspects of a proposed radioactive waste repository at Hanford.
• Natural Resources Defense Council, Washington, DC, 1986-1987: preparation of expert testimony on hazards of the Savannah River Plant, South Carolina.
• Lakes Environmental Association, Bridgton, Maine, 1986: analysis of federal regulations for disposal of radioactive waste.
• Greenpeace Germany, Hamburg, 1986: participation in an international study on the hazards of nuclear power plants.
• Three Mile Island Public Health Fund, Philadelphia, Pennsylvania, 1983-1989: studies related to the Three Mile Island nuclear power plant and emergency response planning.
• Attorney General, Commonwealth of Massachusetts, 1984-1989: analyses of the safety of the Seabrook nuclear power plant, preparation of expert testimony.
• Union of Concerned Scientists, Cambridge, Massachusetts, 1980-1985: studies on energy demand and supply, nuclear arms control, and the safety of nuclear installations.

• Conservation Law Foundation of New England, Boston, Massachusetts, 1985: preparation of expert testimony on cogeneration potential at a Maine paper mill.
• Town & Country Planning Association, London, UK, 1982-1984: coordination and conduct of a study on safety and radioactive waste implications of the proposed Sizewell nuclear power plant, testimony to the Sizewell Public Inquiry.
• US Environmental Protection Agency, Washington, DC, 1980-1981: assessment of the cleanup of Three Mile Island Unit 2 nuclear power plant.
• Center for Energy & Environmental Studies, Princeton University, Princeton, New Jersey, and Solar Energy Research Institute, Golden, Colorado, 1979-1980: studies on the potentials of renewable energy sources.
• Government of Lower Saxony, Hannover, Federal Republic of Germany, 1978-1979: coordination and conduct of studies on safety and security aspects of the proposed Gorleben nuclear fuel cycle center.

Other experience (selected)

• Principal investigator, project on "Exploring the Role of 'Sustainable Cities' in Preventing Climate Disruption", involving IRSS and three other organizations, 1990-1991.
• Visiting fellow, Peace Research Centre, Australian National University, 1989.
• Principal investigator, Three Mile Island emergency planning study, involving IRSS, Clark University and other partners, 1987-1989.
• Co-leadership (with Paul Walker) of a study group on nuclear weapons proliferation, Institute of Politics, Harvard University, 1981.
• Foundation (with others) of an ecological political movement in Oxford, UK, which contested the 1979 Parliamentary election.
• Conduct of cross-examination and presentation of expert testimony, on behalf of the Political Ecology Research Group, at the 1977 Public Inquiry into proposed expansion of reprocessing capacity at Windscale, UK.
• Conduct of research on plasma theory (while a D.Phil candidate), as an associate staff member, Culham Laboratory, UK Atomic Energy Authority, 1969-1973.
• Service as a design engineer on coal-fired power plants, New South Wales Electricity Commission, Sydney, Australia, 1968.

Publications (selected)

• *Reasonably Foreseeable Security Events: Potential threats to options for long-term management of UK radioactive waste*, a report for the UK Committee on Radioactive Waste Management, 2 November 2005.
• "Plasma, policy and progress", *The Australian Mathematical Society Gazette*, Volume 32, Number 3, 2005, pp 162-168.
• "A Psychosocial-Healing Approach to Post-Conflict Reconstruction" (with Paula Gutlove), *Mind & Human Interaction*, Volume 14, Number 1, 2005, pp 35-63.
• "Designing Infrastructure for New Goals and Constraints", Proceedings of the conference, *Working Together: R&D Partnerships in Homeland Security*, Boston,

Massachusetts, 27-28 April 2005, sponsored by the US Department of Homeland Security. (A version of this paper has also been published as CRS Discussion Paper 2005-02, Center for Risk and Security, George Perkins Marsh Institute, Clark University, Worcester, Massachusetts.)

• "Potential Radioactive Releases from Commercial Reactors and Spent Fuel", Proceedings of the conference, *Working Together: R&D Partnerships in Homeland Security*, Boston, Massachusetts, 27-28 April 2005, sponsored by the US Department of Homeland Security. (A version of this paper has also been published as CRS Discussion Paper 2005-03, Center for Risk and Security, George Perkins Marsh Institute, Clark University, Worcester, Massachusetts.)

• *Safety of the Proposed South African Pebble Bed Modular Reactor*, a report for the Legal Resources Centre, Cape Town, South Africa, 12 January 2005.

• *Decommissioning of Research Reactors at Brookhaven National Laboratory: Status, Future Options and Hazards*, a report for STAR Foundation, East Hampton, New York, April 2004.

• "Psychosocial Healing and Post-Conflict Social reconstruction in the Former Yugoslavia" (with Paula Gutlove), *Medicine, Conflict and Survival*, Volume 20, Number 2, April-June 2004, pp 136-150.

• "Reducing the Hazards from Stored Spent Power-Reactor Fuel in the United States" (with Robert Alvarez, Jan Beyea, Klaus Janberg, Jungmin Kang, Ed Lyman, Allison Macfarlane and Frank N. von Hippel), *Science and Global Security*, Volume 11, 2003, pp 1-51.

• "Health, Human Security, and Social Reconstruction in Afghanistan" (with Paula Gutlove and Jacob Hale Russell), in John D. Montgomery and Dennis A. Rondinelli (eds), *Beyond Reconstruction in Afghanistan*, Palgrave Macmillan, 2004.

• *Psychosocial Healing: A Guide for Practitioners, based on programs of the Medical Network for Social Reconstruction in the Former Yugoslavia* (with Paula Gutlove), IRSS, Cambridge, Massachusetts and OMEGA Health Care Center, Graz, Austria, May 2003.

• *A Call for Action to Protect the Nation Against Enemy Attack on Nuclear Power Plants and Spent Fuel*, and a Supporting Document, Mothers for Peace, San Luis Obispo, California, April 2003 and May 2003.

• "Human Security: Expanding the Scope of Public Health" (with Paula Gutlove), *Medicine, Conflict and Survival*, Volume 19, 2003, pp 17-34.

• *Social Reconstruction in Afghanistan through the Lens of Health and Human Security* (with Paula Gutlove and Jacob Hale Russell), IRSS, Cambridge, Massachusetts, May 2003.

• *Robust Storage of Spent Nuclear Fuel: A Neglected Issue of Homeland Security*, a report commissioned by Citizens Awareness Network, Shelburne Falls, Massachusetts, January 2003.

• *Medical Network for Social Reconstruction in the Former Yugoslavia: A Survey of Participants' Views on the Network's Goals and Achievements*, IRSS, Cambridge, Massachusetts, September 2001.

• *The Potential for a Large, Atmospheric Release of Radioactive Material from Spent Fuel Pools at the Harris Nuclear Power Plant: The Case of a Pool Release Initiated by a*

Severe Reactor Accident, a report for Orange County, North Carolina, 20 November 2000.

• *A Review of the Accident Risk Posed by the Pickering 'A' Nuclear Generating Station,* a report for the Standing Committee on Energy, Environment and Natural Resources, Canadian Senate, August 2000.

• *High-Level Radioactive Liquid Waste at Sellafield: An Updated Review,* a report for the UK Nuclear Free Local Authorities, June 2000.

• *Hazard Potential of the La Hague Site: An Initial Review,* a report for Greenpeace International, May 2000.

• *A Strategy for Conflict Management: Integrated Action in Theory and Practice* (with Paula Gutlove), IRSS, Cambridge, Massachusetts, March 1999.

• *Risks and Alternative Options Associated with Spent Fuel Storage at the Shearon Harris Nuclear Power Plant,* a report for Orange County, North Carolina, February 1999.

• *High Level Radioactive Liquid Waste at Sellafield: Risks, Alternative Options and Lessons for Policy,* IRSS, Cambridge, Massachusetts, June 1998.

• "Science, democracy and safety: why public accountability matters", in F. Barker (ed), *Management of Radioactive Wastes: Issues for local authorities,* Thomas Telford, London, 1998.

• "Conflict Management and the OSCE" (with Paula Gutlove), *OSCE/ODIHR Bulletin,* Volume 5, Number 3, Fall 1997.

• *Safety of the Storage of Liquid High-Level Waste at Sellafield* (with Peter Taylor), Nuclear Free Local Authorities, UK, November 1996.

• *Assembling Evidence on the Effectiveness of Preventive Actions, their Benefits, and their Costs: A Guide for Preparation of Evidence,* IRSS, Cambridge, Massachusetts, August 1996.

• *War, Terrorism and Nuclear Power Plants,* Peace Research Centre, Australian National University, Canberra, October 1996.

• "The Potential for Cooperation by the OSCE and Non-Governmental Actors on Conflict Management" (with Paula Gutlove), *Helsinki Monitor,* Volume 6 (1995), Number 3.

• "Potential Characteristics of Severe Reactor Accidents at Nuclear Plants", "Monitoring and Modelling Atmospheric Dispersion of Radioactivity Following a Reactor Accident" (with Richard Sclove, Ulrike Fink and Peter Taylor), "Safety Status of Nuclear Reactors and Classification of Emergency Action Levels", and "The Use of Probabilistic Risk Assessment in Emergency Response Planning for Nuclear Power Plant Accidents" (with Robert Goble), in D. Golding, J. X. Kasperson and R. E. Kasperson (eds), *Preparing for Nuclear Power Plant Accidents,* Westview Press, Boulder, Colorado, 1995.

• *A Data Manager for the Global Environment Facility* (with Robert Goble), Environment Department, The World Bank, June 1994.

• *Preventive Diplomacy and National Security* (with Paula Gutlove), Winston Foundation for World Peace, Washington, DC, May 1994.

• *Opportunities for International Control of Weapons-Usable Fissile Material,* International Physicians for the Prevention of Nuclear War, Cambridge, Massachusetts, January 1994.

• "Article III and IAEA Safeguards", in F. Barnaby and P. Ingram (eds), *Strengthening the Non-Proliferation Regime,* Oxford Research Group, Oxford, UK, December 1993.

• *Risk Implications of Potential New Nuclear Plants in Ontario* (prepared with the help of eight consultants), a report for the Coalition of Environmental Groups, Toronto, submitted to the Ontario Environmental Assessment Board, November 1992 (3 volumes).
• *Strengthening the International Atomic Energy Agency*, IRSS, Cambridge, Massachusetts, September 1992.
• *Design of an Information System on Technologies that can Limit Greenhouse Gas Emissions* (with Robert Goble and F. Scott Bush), Center for Strategic and International Studies, Washington, DC, May 1992.
• *Managing Nuclear Accidents: A Model Emergency Response Plan for Power Plants and Communities* (with six other authors), Westview Press, Boulder, CO, 1992.
• "Let's X-out the K" (with Steven C. Sholly), *Bulletin of the Atomic Scientists*, March 1992, pp 14-15.
• "A Worldwide Programme for Controlling Fissile Material", and "A Global Strategy for Nuclear Arms Control", in F. Barnaby (ed), *Plutonium and Security*, Macmillan Press, UK, 1992.
• *No Restart for K Reactor* (with Steven C. Sholly), IRSS, Cambridge, Massachusetts, October 1991.
• *Regulatory Response to the Potential for Reactor Accidents: The Example of Boiling-Water Reactors*, IRSS, Cambridge, Massachusetts, February 1991.
• *Peace by Piece: New Options for International Arms Control and Disarmament*, IRSS, Cambridge, Massachusetts, January 1991.
• *Developing Practical Measures to Prevent Climate Disruption* (with Robert Goble), CENTED Research Report No. 6, Clark University, Worcester, Massachusetts, August 1990.
• "Treaty a Useful Relic", *Bulletin of the Atomic Scientists*, July/August 1990, pp 32-33.
• "Practical Steps for the 1990s", in Sadruddin Aga Khan (ed), *Non-Proliferation in a Disarming World*, Proceedings of the Groupe de Bellerive's 6th International Colloquium, Bellerive Foundation, Geneva, Switzerland, 1990.
• *A Global Approach to Controlling Nuclear Weapons*, IRSS, Cambridge, Massachusetts, October 1989.
• *IAEA Safety Targets and Probabilistic Risk Assessment* (with three other authors), Greenpeace International, Amsterdam, August 1989.
• *New Directions for NATO* (with Paul Walker and Pam Solo), published jointly by IRSS and the Institute for Peace and International Security (both of Cambridge, Massachusetts), December 1988.
• "Verifying a Halt to the Nuclear Arms Race", in F. Barnaby (ed), *A Handbook of Verification Procedures*, Macmillan Press, UK, 1990.
• "Verification of a Cutoff in the Production of Fissile Material", in F.Barnaby (ed), *A Handbook of Verification Procedures*, Macmillan Press, UK, 1990.
• "Severe Accident Potential of CANDU Reactors," Consultant's Report in *The Safety of Ontario's Nuclear Power Reactors*, Ontario Nuclear Safety Review, Toronto, February 1988.
• *Nuclear-Free Zones* (edited with David Pitt), Croom Helm Ltd, Beckenham, UK, 1987.
• *Risk Assessment Review For the Socioeconomic Impact Assessment of the Proposed High-Level Nuclear Waste Repository at Hanford Site, Washington* (edited; written with

five other authors), prepared for the Washington Department of Ecology, December 1987.

• *The Nuclear Freeze Revisited* (with Andrew Haines), Nuclear Freeze and Arms Control Research Project, Bristol, UK, November 1986. Variants of the same paper have appeared as Working Paper No. 18, Peace Research Centre, Australian National University, Canberra, February 1987, and in *ADIU Report*, University of Sussex, Brighton, UK, Jan/Feb 1987, pp 6-9.

• *International Nuclear Reactor Hazard Study* (with fifteen other authors), Greenpeace, Hamburg, Federal Republic of Germany (2 volumes), September 1986.

• "What happened at Reactor Four" (the Chernobyl reactor accident), *Bulletin of the Atomic Scientists*, August/September 1986, pp 26-31.

• *The Source Term Debate: A Report by the Union of Concerned Scientists* (with Steven C. Sholly), Union of Concerned Scientists, Cambridge, Massachusetts, January 1986.

• "Checks on the spread" (a review of three books on nuclear proliferation), *Nature*, 14 November 1985, pp 127-128.

• Editing of *Perspectives on Proliferation*, August 1985, published by the Proliferation Reform Project, IRSS.

• "A Turning Point for the NPT ?", *ADIU Report*, University of Sussex, Brighton, UK, Nov/Dec 1984, pp 1-4.

• "Energy Economics", in J. Dennis (ed), *The Nuclear Almanac*, Addison-Wesley, Reading, Massachusetts, 1984.

• "The Genesis of Nuclear Power", in J. Tirman (ed), *The Militarization of High Technology*, Ballinger, Cambridge, Massachusetts, 1984.

• *A Second Chance: New Hampshire's Electricity Future as a Model for the Nation* (with Linzee Weld), Union of Concerned Scientists, Cambridge, Massachusetts, 1983.

• *Safety and Waste Management Implications of the Sizewell PWR* (prepared with the help of six consultants), a report to the Town & Country Planning Association, London, UK, 1983.

• *Utility-Scale Electrical Storage in the USA: The Prospects of Pumped Hydro, Compressed Air, and Batteries*, Princeton University report PU/CEES #120, 1981.

• *The Prospects for Wind and Wave Power in North America*, Princeton University report PU/CEES # 117, 1981.

• *Hydroelectric Power in the USA: Evolving to Meet New Needs*, Princeton University report PU/CEES # 115, 1981.

• Editing and part authorship of "Potential Accidents & Their Effects", Chapter III of *Report of the Gorleben International Review*, published in German by the Government of Lower Saxony, FRG, 1979; Chapter III published in English by the Political Ecology Research Group, Oxford, UK.

• *A Study of the Consequences to the Public of a Severe Accident at a Commercial FBR located at Kalkar, West Germany*, Political Ecology Research Group, 1978.

Expert presentations and testimony (selected)

• Presentation, "Are Nuclear Installations Terrorist Targets?", at the conference, *Nuclear Energy: Does it Have a Future?*, Drogheda, County Louth, Ireland, 10-11 March 2005.

• Presentation at the session, "UN Security Council Resolution 1244 and Final Status for Kosovo", at the conference, *Lessons Learned from the Balkan Conflicts*, Boston College, Chestnut Hill, Massachusetts, 16-17 October 2004.
• California Public Utilities Commission, 2004: testimony regarding the nature and cost of potential measures for enhanced defense of the Diablo Canyon nuclear power plant.
• European Parliament, 2003: invited presentation to EP members regarding safety and security issues at the Sellafield nuclear site in the UK, and broader implications.
• US Congress, 2002 and 2003: invited presentations at member-sponsored staff briefings on vulnerabilities of nuclear-power facilities to attack and options for improved defenses.
• Numerous public forums in the USA, 2001-2005: invited presentations to public officials and general audiences regarding vulnerabilities of nuclear-power facilities to attack and options for improved defenses.
• UK Consensus Conference on Radioactive Waste Management, 1999: invited testimony on information and decision-making.
• Joint Committee on Public Enterprise and Transport, Irish Parliament, 1999: invited testimony on nuclear fuel reprocessing and international security.
• UK and Irish Parliaments, 1998: invited presentations to members on risks and alternative options associated with nuclear fuel reprocessing in the UK.
• Center for Russian Environmental Policy, Moscow, 1996: invited presentation at a forum in parallel with the G-7 Nuclear Safety Summit.
• Lacey Township Zoning Board, New Jersey, 1995: testimony regarding radioactive waste management.
• Ontario Court of Justice, Toronto, Ontario, 1993: testimony regarding Canada's Nuclear Liability Act.
• Oxford Research Group, seminar on "The Plutonium Legacy", Rhodes House, Oxford, UK, 1993: invited presentation on nuclear safeguards.
• Defense Nuclear Facilities Safety Board, Washington, DC, 1991: testimony regarding the proposed restart of K-reactor, Savannah River Site.
• Conference to consider amending the Partial Test Ban Treaty, United Nations, New York, 1991: presentation on a global approach to arms control and disarmament.
• US Department of Energy, hearing on draft EIS for new production reactor capacity, Columbia, South Carolina, 1991: testimony on tritium need and implications of tritium production options.
• Society for Risk Analysis, 1990 annual meeting, New Orleans, special session on nuclear emergency planning: presentation on real-time techniques for anticipating emergencies.
• Parliamentarians' Global Action, 11th Annual Parliamentary Forum, United Nations, Geneva, 1990: invited presentation on the potential for multilateral nuclear arms control.
• Advisory Committee on Nuclear Facility Safety, Washington, DC, 1989: testimony on public access to information and on government accountability.
• Peace Research Centre, Australian National University, seminar on "Australia and the Fourth NPT Review Conference", Canberra, 1989: invited presentation regarding a universal nuclear weapons non-proliferation regime.

• Carnegie Endowment for International Peace, Conference on "Nuclear Non-Proliferation and the Role of Private Organizations", Washington, DC, 1989: invited presentation on options for reform of the non-proliferation regime.
• US Department of Energy, EIS scoping hearing, Columbia, South Carolina, 1988: testimony on appropriate scope of an EIS for new production reactor capacity.
• International Physicians for the Prevention of Nuclear War, 6th and 7th Annual Congresses, Koln, FRG, 1986 and Moscow, USSR, 1987: invited presentations on relationships between nuclear power and the threat of nuclear war.
• County Council, Richland County, South Carolina, 1987: testimony on implications of severe reactor accidents at the Savannah River Plant.
• Maine Land Use Regulation Commission, 1985: testimony on cogeneration potential at facilities of Great Northern Paper Company.
• Interfaith Hearings on Nuclear Issues, Toronto, Ontario, 1984: invited presentations on options for Canada's nuclear trade and Canada's involvement in nuclear arms control.
• Sizewell Public Inquiry, UK, 1984: testimony on safety and radioactive waste implications of the proposed Sizewell nuclear power plant.
• New Hampshire Public Utilities Commission, 1983: testimony on electricity demand and supply options for New Hampshire.
• Atomic Safety & Licensing Board, US Nuclear Regulatory Commission, 1983: testimony on use of filtered venting at the Indian Point nuclear power plant.
• US National Advisory Committee on Oceans and Atmosphere, 1982: testimony on implications of ocean disposal of radioactive waste.
• Environmental & Energy Study Conference, US Congress, 1982: invited presentation on implications of radioactive waste management.

Miscellaneous

• Married, two children.
• Extensive experience in public speaking and interviews by mass media.
• Author of numerous essays and letters in newspapers and magazines.

Contact information

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Risks and Risk-Reducing Options Associated with Pool Storage of Spent Nuclear Fuel at the Pilgrim and Vermont Yankee Nuclear Power Plants

by
Gordon R. Thompson

25 May 2006

A report for
Office of the Attorney General
Commonwealth of Massachusetts

Abstract

This report addresses some of the risks associated with the future operation of the Pilgrim and Vermont Yankee nuclear power plants. The risks that are addressed here arise from the storage of spent nuclear fuel in a water-filled pool adjacent to the reactor at each plant. Both pools are now equipped with high-density, closed-form storage racks. Options are available to reduce spent-fuel-pool risks. The option that would achieve the largest risk reduction at each plant, during operation within a license extension period, would be to re-equip the pool with low-density, open-frame storage racks. That option would return the plant to its original design configuration.. This report describes risks and risk-reducing options, and relevant analysis that is required from the licensee and the Nuclear Regulatory Commission in the context of license extension applications for the Pilgrim and Vermont Yankee plants.

About the Institute for Resource and Security Studies

The Institute for Resource and Security Studies (IRSS) is an independent, nonprofit, Massachusetts corporation, founded in 1984. Its objective is to promote sustainable use of natural resources and global human security. In pursuit of this mission, IRSS conducts technical and policy analysis, public education, and field programs. IRSS projects always reflect a concern for practical solutions to resource and security problems.

About the Author

Gordon R. Thompson is the executive director of IRSS and a research professor at Clark University, Worcester, Massachusetts. He studied and practiced engineering in Australia, and received a doctorate in applied mathematics from Oxford University in 1973, for analyses of plasma undergoing thermonuclear fusion. Dr. Thompson has been based in the USA since 1979. His professional interests encompass a range of technical and policy issues related to international security and protection of natural resources. He has conducted numerous studies on the environmental and security impacts of nuclear facilities and options for reducing these impacts.

Dr. Thompson independently identified the potential for a spent-fuel-pool fire, and articulated alternative options for lower-risk storage of spent fuel, during his work for the German state government of Lower Saxony in 1978-1979. His findings were accepted by that government after a public hearing. Since that time, Thompson has conducted several other studies on spent-fuel-storage risk, alone and with colleagues. Findings of these studies have been confirmed by a 2005 report by the National Academy of Sciences, prepared at the request of the US Congress.

Acknowledgements

This report was prepared by IRSS for the Office of the Attorney General, Commonwealth of Massachusetts. Gordon R. Thompson is solely responsible for the content of the report.

Contents

(See next page)

List of Tables
(Tables are located at the end of the report.)

1. Introduction

Applications have been submitted for 20-year extensions of the operating licenses of the Pilgrim and Vermont Yankee nuclear power plants. These plants began operating in 1972, and their current operating licenses expire in 2012. The designs of the two plants are broadly similar, and both are operated by Entergy Nuclear Operations Inc. (Entergy). Each plant features a boiling-water reactor (BWR) with a Mark 1 containment. The US Nuclear Regulatory Commission (NRC) has announced that interested persons can petition to intervene in the license extension proceedings for these plants. In that context, the Office of the Attorney General, Commonwealth of Massachusetts, has requested the preparation of this report.

This report addresses a particular set of risks associated with the future operation of the Pilgrim and Vermont Yankee plants. These risks arise from the storage of spent nuclear fuel in water-filled pools. Each plant's nuclear reactor periodically discharges fuel that is "spent" in the sense that the fuel is no longer suitable for power generation. The spent fuel contains a large amount of radioactive material, and is stored in a water-filled pool adjacent to the reactor. In this report, the word "risk" applies to the potential for a release of radioactive material from nuclear fuel to the atmosphere. Other risks arise from the operation of nuclear power plants, but are not addressed here. The concept of risk encompasses both the consequences and probability of an event. However, risk is not simply the arithmetic product of consequence and probability numbers, as is sometimes assumed.

Although this report focuses on the risks arising from pool storage of spent fuel, the report necessarily considers some aspects of the risks arising from operation of the reactor at each plant. Such consideration is necessary because the pool and the reactor are in close physical proximity within the same building, and some of their essential support systems are shared. Thus, an incident involving a release of radioactive material from the pool could be initiated or exacerbated by an incident at the reactor, or vice versa, or parallel incidents at the pool and the reactor could have a common cause.

Scope of this analysis

This report does not purport to provide a comprehensive assessment of the risks arising from pool storage of spent fuel at the Pilgrim and Vermont Yankee plants. As discussed in Section 10, below, preparation of such an assessment is a duty of Entergy and the NRC. Neither party has performed this duty. In the absence of a comprehensive assessment, this report provides illustrative analysis of selected issues. Assumptions of the analysis are stated, and the author would be pleased to engage in open technical debate regarding his analysis. A companion report, prepared independently by Dr. Jan Beyea, examines the offsite consequences of releases of radioactive material. Findings in that report are consistent with scientific knowledge and experience in the field of radiological consequence assessment. Questions about the analysis in that report should be directed to Dr. Beyea.

Five major purposes are pursued in this report. The focus throughout is on the Pilgrim and Vermont Yankee plants and their license extension applications, but much of the report's discussion has wider application. First, the potential for a release of radioactive material from a spent-fuel pool is described. Second, options for reducing the probability and/or consequences of such a release are described. These descriptions provide a general picture of the risks and risk-reducing options associated with pool storage of spent fuel. Third, an integrated view of these risks and risk-reducing options is provided. Fourth, the state of knowledge about these risks and risk-reducing options is reviewed. Fifth, the technical analysis required from Entergy and the NRC to improve this state of knowledge is described.

Two classes of event could lead to a release of radioactive material from a spent-fuel pool. One class of events, typically described as "accidents", includes human error, equipment failure and/or natural forces such as earthquakes. A second class encompasses deliberate, malicious acts. Some events, which involve harmful acts by insane but cognitively functioning persons, fall into both classes. This report considers the full range of initiating events, including human error, equipment failure, natural forces, malice, and/or insanity.

Protection of sensitive information

Any responsible analyst who discusses potential acts of malice at nuclear power plants is careful about making statements in public settings. The author of this report exercises such care. The author has no access to classified information, and this report contains no such information. However, a higher standard of discretion is necessary. An analyst should not publish detailed information that will assist potential attackers, even if this information is publicly available from other sources. On the other hand, if a plant's design and operation leave the plant vulnerable to attack, and the vulnerability is not being addressed appropriately, then a responsible analyst is obliged to publicly describe the vulnerability in general terms.

This report exemplifies the balance of responsibility described in the preceding paragraph. Vulnerabilities of the Pilgrim and Vermont Yankee plants are described here in general terms. Detailed information relating to those vulnerabilities is withheld here, although that information has been published elsewhere or could be re-created by many persons with technical education and/or military experience. For example, this report does not provide cross-section drawings of the Pilgrim and Vermont Yankee plants, although such drawings have been published for many years and are archived around the world. NRC license proceedings provide potential forums at which sensitive information can be discussed without concern about disclosure to potential attackers. Rules and practices are available so that the parties to a license proceeding can discuss sensitive information in a protected setting.

Structure of this report

The remainder of this report has eleven sections. Section 2 outlines the hazard posed by storage of spent fuel in a high-density configuration in pools at nuclear power plants, and describes the history of attention to this issue. The hazard arises from the potential for a self-ignited fire in a spent-fuel pool if water is lost from the pool. Technical aspects of this hazard are discussed in greater detail in subsequent sections of the report. Characteristics of the Pilgrim and Vermont Yankee plants and their spent fuel are described in Section 3. National trends in the management of spent nuclear fuel are described in Section 4, providing evidence that spent fuel is likely to remain at the Pilgrim and Vermont Yankee sites for at least several decades, and potentially for more than a century. The risks of spent-fuel storage will continue to accumulate over that period.

Section 5 reviews the state of technical knowledge about potential spent-fuel-pool fires. Scenarios for such a fire at the Pilgrim or Vermont Yankee plants are discussed in the two following sections. Section 6 discusses scenarios initiated by accidents not involving malice, while Section 7 discusses scenarios initiated by malicious action. Options to reduce the risks of spent-fuel-pool fires at the Pilgrim and Vermont Yankee plants are described in Section 8. An integrated view of risks and risk-reducing options at these plants is set forth in Section 9.

In Section 5 and elsewhere, this report discusses the state of technical knowledge about risks and risk-reducing options associated with spent-fuel pools. There are substantial deficiencies in present knowledge. Section 10 describes the technical analysis required from Entergy and the NRC to correct these deficiencies in the context of license extension applications for Pilgrim and Vermont Yankee. Conclusions are set forth in Section 11, and a bibliography is provided in Section 12. All documents cited in the text of this report are listed in the bibliography.

2. Recognition of the Spent-Fuel Hazard

From the earliest years of the nuclear-technology era, analysis and experience have shown that a nuclear reactor can undergo an accident in which the reactor's fuel is damaged. This damage can lead to a release of radioactive material within the reactor and, potentially, from the reactor to the external environment. An early illustration of this accident potential occurred in the UK in 1957, when an air-cooled reactor at Windscale caught fire and released radioactive material to the atmosphere. At that time, spent fuel was not perceived as a significant hazard.

When the Pilgrim and Vermont Yankee plants began operating in 1972, there was limited technical understanding of the potential for severe accidents at commercial reactors. In this context, "severe" means that the reactor core is severely damaged, which typically involves melting of some fraction of the core materials. The environmental impact statements (EISs) related to the operation of Pilgrim and Vermont Yankee did not consider severe reactor accidents.[1] Knowledge about the potential for such accidents was improved by completion of the Reactor Safety Study (WASH-1400) in 1975.[2] More knowledge has accumulated from analysis and experience since that time.[3]

Until 1979 it was widely assumed that stored spent fuel did not pose risks comparable to those associated with reactors. This assumption arose because a spent fuel assembly does not contain short-lived radioactivity, and therefore produces less radioactive decay heat than does a similar fuel assembly in an operating reactor. However, that factor was counteracted by the introduction of high-density, closed-form storage racks into spent-fuel pools, beginning in the 1970s. Initially, pools were designed so that each held only a small inventory of spent fuel, with the expectation that spent fuel would be stored briefly and then taken away for reprocessing. Low-density, open-frame storage racks were used. Cooling fluid can circulate freely through such a rack. When reprocessing was abandoned in the United States, spent fuel began to accumulate in the pools. Excess spent fuel could have been offloaded to other storage facilities, allowing continued use of low-density racks. Instead, as a cost-saving measure, high-density racks were introduced, allowing much larger amounts of spent fuel to be stored in the pools.

The potential for a pool fire

Unfortunately, the closed-form configuration of the high-density racks would create a major problem if water were lost from a spent-fuel pool. The flow of air through the racks would be highly constrained, and would be almost completely cut off if residual water or debris were present in the base of the pool. As a result, removal of radioactive decay heat would be ineffective. Over a broad range of water-loss scenarios, the temperature of the zirconium fuel cladding would rise to the point (approximately 1,000 degrees C) where a self-sustaining, exothermic reaction of zirconium with air or steam would begin. Fuel discharged from the reactor for 1 month could ignite in less than 2 hours, and fuel discharged for 3 months could ignite in about 3 hours.[4] Once initiated, the fire would spread to adjacent fuel assemblies, and could ultimately involve all fuel in the pool. A large, atmospheric release of radioactive material would occur. For simplicity, this potential disaster can be described as a "pool fire".

Water could be lost from a spent-fuel pool through leakage, boiling, siphoning, pumping, displacement by objects falling into the pool, or overturning of the pool. These modes of water loss could arise from events, alone or in combination, that include: (i) acts of malice by persons within or outside the plant boundary; (ii) an accidental aircraft impact; (iii) an earthquake; (iv) dropping of a fuel cask; (v) accidental fires or explosions; and (vi) a severe accident at an adjacent reactor that, through the spread of radioactive

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[1] AEC, 1972a; AEC, 1972b.
[2] NRC, 1975.
[3] Relevant experience includes the Three Mile Island reactor accident of 1979 and the Chernobyl reactor accident of 1986.
[4] This sentence assumes adiabatic conditions.

material and other influences, precludes the ongoing provision of cooling and/or water makeup to the pool.

These events have differing probabilities of occurrence. None of them is an everyday event. Nevertheless, they are similar to events that are now routinely considered in planning and policy decisions related to commercial nuclear reactors. To date, however, such events have not been given the same attention in the context of spent-fuel pools.

Some people have found it counter-intuitive that spent fuel, given its comparatively low decay heat and its storage under water, could pose a fire hazard. This perception has slowed recognition of the hazard. In this context, a simple analogy may be helpful. We all understand that a wooden house can stand safely for many years but be turned into an inferno by a match applied in an appropriate location. A spent-fuel pool equipped with high-density racks is roughly analogous, but in this case ignition would be accomplished by draining water from the pool. In both cases, a triggering event would unleash a large amount of latent chemical energy.

The sequence of studies related to pool fires

Two studies completed in March 1979 independently identified the potential for a fire in a drained spent-fuel pool equipped with high-density racks. One study was by members of a scientific panel assembled by the German state government of Lower Saxony to review a proposal for a nuclear fuel cycle center at Gorleben.[5] After a public hearing, the Lower Saxony government ruled in May 1979, as part of a broader decision, that high-density pool storage of spent fuel would not be acceptable at Gorleben. The second study was done by Sandia Laboratories for the NRC.[6] In light of knowledge that has accumulated since 1979, the Sandia report generally stands up well, provided that one reads the report in its entirety. However, the report's introduction contains an erroneous statement that complete drainage of the pool is the most severe situation. The body of the report clearly shows that partial drainage can be a more severe case, as was recognized in the Gorleben context. Unfortunately, the NRC continued, until October 2000, to employ the erroneous assumption that complete drainage is the most severe case.

The NRC has published various documents that discuss aspects of the potential for a spent-fuel-pool fire. Several of these documents are discussed in Section 5, below. Only three of the various documents are products of processes that provided an opportunity for formally structured public comment and, potentially, for in-depth analysis of risks and alternatives. One such document is the August 1979 Generic Environmental Impact Statement (GEIS) on handling and storage of spent fuel (NUREG-0575).[7] The second document is the May 1996 GEIS on license renewal (NUREG-1437).[8] These two documents purported to provide systematic analysis of the risks and relative costs and

[5] Thompson et al, 1979.
[6] Benjamin et al, 1979.
[7] NRC, 1979.
[8] NRC, 1996.

benefits of alternative options. The third document is the NRC's September 1990 review (55 FR 38474) of its Waste Confidence Decision.[9] That document did not purport to provide an analysis of risks and alternatives.

NUREG-0575 addresses the potential for a spent-fuel-pool fire in a single sentence that cites the 1979 Sandia report. The sentence reads:[10]

> Assuming that the spent fuel stored at an independent spent fuel storage installation is at least one year old, calculations have been performed to show that loss of water should not result in fuel failure due to high temperatures if proper rack design is employed.

Although this sentence refers to pool storage of spent fuel at an independent spent fuel storage installation, NUREG-0575 regards at-reactor pool storage as having the same properties. This sentence misrepresents the findings of the Sandia report. The sentence does not define "proper rack design". It does not disclose Sandia's findings that high-density racks promote overheating of exposed fuel, and that overheating can cause fuel to self-ignite and burn. The NRC has never corrected this deficiency in NUREG-0575.

NUREG-1437 also addresses the potential for a spent-fuel-pool fire in a single sentence, which in this instance states:[11]

> NRC has also found that, even, under the worst probable cause of a loss of spent-fuel pool coolant (a severe seismic-generated accident causing a catastrophic failure of the pool), the likelihood of a fuel-cladding fire is highly remote (55 FR 38474).

The parenthetic citation is to the NRC's September 1990 review of its Waste Confidence Decision. Thus, NUREG-1437's examination of pool fires is totally dependent on the September 1990 review. In turn, that review bases its opinion about pool fires on the following four NRC documents:[12] (i) NUREG/CR-4982;[13] (ii) NUREG/CR-5176;[14] (iii) NUREG-1353;[15] and (iv) NUREG/CR-5281.[16] These documents are discussed in Section 5, below. That discussion reveals substantial deficiencies in the documents' analysis of the potential for a pool fire.

Thus, neither of the two GEISs (NUREG-0575 and NUREG-1437), nor the September 1990 review of the Waste Confidence Decision, provides a technically defensible

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[9] NRC, 1990a.
[10] NRC, 1979, page 4-21.
[11] NRC, 1996, pp 6-72 to 6-75.
[12] NRC, 1990a, page 38481.
[13] Sailor et al, 1987.
[14] Prassinos et al, 1989.
[15] Throm, 1989.
[16] Jo et al, 1989.

examination of spent-fuel-pool fires and the associated risks and alternatives. The statements in each document regarding pool fires are inconsistent with the findings of subsequent, more credible studies discussed below.

The most recent published NRC technical study on the potential for a pool fire is an NRC Staff study, originally released in October 2000 but formally published in February 2001, that addresses the risk of a pool fire at a nuclear power plant undergoing decommissioning.[17] This author submitted comments on the study to the NRC Commissioners in February 2001.[18] The study was in several respects an improvement on previous NRC documents that addressed pool fires. It reversed the NRC's longstanding, erroneous position that total, instantaneous drainage of a pool is the most severe case of drainage. However, it did not consider acts of malice. Nor did it add significantly to the weak base of technical knowledge regarding the propagation of a fire from one fuel assembly to another. Its focus was on a plant undergoing decommissioning. Therefore, it did not address potential interactions between pools and operating reactors, such as the interactions discussed in Section 6, below.

In 2003, eight authors, including the present author, published a paper on the risks of spent-fuel-pool fires and the options for reducing these risks.[19] That paper aroused vigorous comment, and its findings were disputed by NRC officials and others. Critical comment was also directed to a related report by this author.[20] In an effort to resolve this controversy, the US Congress requested the National Academy of Sciences (NAS) to conduct a study on the safety and security of spent-fuel storage. The NAS submitted a classified report to Congress in July 2004, and released an unclassified version in April 2005.[21] Press reports described considerable tension between the NAS and the NRC regarding the inclusion of material in the unclassified NAS report.[22]

Since September 2001, the NRC has not published any document that contains technical analysis related to the potential for a pool fire. The NRC claims that it is conducting further analysis in a classified setting. The scope of information treated as secret by the NRC is questionable. Much of the relevant analysis would address issues such as heat transfer and fire propagation. Calculations and experiments on such subjects should be performed and reviewed in the public domain. Classification is appropriate for other information, such as specific points of vulnerability of a spent-fuel pool to attack.

3. Characteristics of the Pilgrim and Vermont Yankee Plants and their Spent Fuel

Basic data about the Pilgrim and Vermont Yankee plants are set forth in Table 3-1. Data and estimates about storage of spent fuel at these plants are set forth in Tables 3-2

[17] Collins and Hubbard, 2001
[18] Thompson, 2001a.
[19] Alvarez et al, 2003.
[20] Thompson, 2003.
[21] NAS, 2006.
[22] Wald, 2005.

through 3-5. In regard to the latter tables, publicly available information is incomplete and inconsistent. Therefore, assumptions are made at various points in the tables, as is readily evident. In addition, the estimates set forth in Tables 3-3 through 3-5 involve a number of simplifying assumptions, which are also evident from the tables.

The scope and accuracy of Tables 3-1 through 3-5 could be improved using information that is held by Entergy and the NRC. Given this information, a more sophisticated analysis could be conducted to estimate the inventories and other characteristics of the Pilgrim and Vermont Yankee spent-fuel pools during the requested period of license extension. These improvements would not alter the basic findings of this report.

At the Pilgrim plant, the present configuration of the storage racks in the spent-fuel pool reflects a license amendment approved by the NRC in 1994. A report submitted by the licensee in support of that license amendment states that the existing racks in the pool and the proposed new racks had a center-to-center distance of about 6.3 inches in both directions. The new racks would, when fully installed, fill the pool tightly, wall-to-wall.[23] Equivalent detail is not available regarding the present configuration of racks in the Vermont Yankee pool. However, from the data provided in Table 3-2 regarding the capacities, inventories and dimensions of both pools, it is evident that the Vermont Yankee pool configuration is similar to that at Pilgrim.[24]

Entergy has announced its intention to establish an independent spent fuel storage installation (ISFSI) at the Vermont Yankee site, and for this purpose has requested a Certificate of Public Good from the Vermont Public Service Board. The ISFSI would store fuel in dry-storage modules. Entergy has described its planned schedule for transferring spent fuel from the pool to the ISFSI.[25] From this schedule, it is evident that Entergy plans to use the spent-fuel pool at nearly its full capacity, storing the overflow from that capacity in the ISFSI.

Extension of the Pilgrim operating license would imply the establishment of an ISFSI at the Pilgrim site. Entergy has not yet announced a plan to establish such an ISFSI. Given the continuing accumulation of spent fuel in the Pilgrim pool, and the time required to establish an ISFSI, it can reasonably be presumed that Entergy plans to use the Pilgrim spent-fuel pool at nearly its full capacity, storing the overflow from that capacity in a future ISFSI.

Inventories of cesium-137

The radioactive isotope cesium-137 provides a useful indicator of the hazard potential of the Pilgrim and Vermont Yankee spent-fuel pools. This isotope, which has a half-life of

[23] Holtec, 1993.
[24] Hoffman, 2005, states that the present Vermont Yankee racks have a center-to-center distance of 6.2 inches.
[25] Hoffman, 2005.

30 years, is a volatile element that would be liberally released during a pool fire.[26] Table 3-4 shows the estimated inventory of cesium-137 in the Pilgrim and Vermont Yankee spent-fuel pools during the period of license extension. This table shows that the pools will hold about 1.6 million TBq (Pilgrim) and 1.4 million TBq (Vermont Yankee) of cesium-137. For comparison, Tables 3-3 and 3-5 provide licensee estimates showing that the Pilgrim and Vermont Yankee reactor cores will hold 190,000 TBq and 179,000 TBq, respectively, of cesium-137. Thus, each pool will hold about 8 times as much cesium-137 as will be present in the adjacent reactor.

4. Trends in Management of Spent Fuel

Risks arising from storage of spent fuel will accumulate over time. Thus, it is important to estimate the time period during which spent fuel will be stored at the Pilgrim or Vermont Yankee site, whether in a pool or an onsite ISFSI. In testimony before the Vermont Public Service Board, an Entergy witness has stated that the US Department of Energy (DOE) could begin accepting spent fuel from Vermont Yankee as early as 2015, for emplacement in the proposed repository in Yucca Mountain, Nevada.[27]

Some decision makers have advocated a revival of spent-fuel reprocessing as an alternative to placing intact spent fuel in a repository. Reprocessing was the national strategy for spent-fuel management when the Pilgrim and Vermont Yankee plants were built, but was abandoned in the 1970s. If reprocessing were to resume, it would provide an option for removal of spent fuel from reactor sites.

This author has testified before the Vermont Public Service Board regarding the prospects for the Yucca Mountain repository, reprocessing, and other options for removal of spent fuel from the Vermont Yankee site. He concluded that spent fuel is likely to remain at the site for at least several decades, and potentially for more than a century.[28] The same arguments apply to the Pilgrim site. Here, selected arguments are summarized, to illustrate the factors that will hinder removal of spent fuel from each site.

Current national policy for long-term management of spent fuel is to establish a repository inside Yucca Mountain. Progress with this project has been slow, and many observers believe that it will be cancelled. Even if the repository does open, there will be a delay before fuel can be shipped to Yucca Mountain and emplaced in the repository. Table 4-1 shows a schedule projection by DOE, indicating that the emplacement process could occupy five decades.

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[26] A study by the US Department of Energy (DOE, 1987) shows that cesium-137 accounts for most of the offsite radiation exposure that is attributable to the 1986 Chernobyl reactor accident, and for about half of the radiation exposure that is attributable to fallout from nuclear weapons tests in the atmosphere. Note that the particular mechanisms of the Chernobyl accident could not occur in the Pilgrim or Vermont Yankee pool.
[27] Hoffman, 2005.
[28] Thompson, 2006.

The US fleet of commercial reactors will probably produce more than 80,000 MgU of spent fuel if each reactor operates to the end of its initial 40-year license period. If each reactor received a 20-year license extension, the fleet could eventually produce a total of about 120,000 MgU of spent fuel. Yet, the capacity of Yucca Mountain is limited by federal statute to 63,000 MgU of spent fuel. DOE has investigated the option of placing 105,000 MgU of spent fuel in Yucca Mountain, which assumes a statute amendment. However, Table 4-2 shows that emplacement of 105,000 MgU of fuel could require an emplacement area of up to 3,800 acres if a lower-temperature operating mode is selected. Licensing considerations are likely to favor the selection of a lower-temperature operating mode, and there may not be enough space in the mountain to allow a total emplacement area of 3,800 acres. Thus, the physical capacity of Yucca Mountain could be less than 105,000 MgU of fuel.

As Table 4-3 shows, operation of the Yucca Mountain repository would involve a large number of spent-fuel shipments. This potential traffic poses a security concern, because there is evidence that shipping casks are more vulnerable to attack by sub-national groups than DOE has previously assumed.[29] Spent-fuel shipments could be comparatively attractive targets because they cannot be protected to the same extent as nuclear power plants.

A further impediment to shipping spent fuel to Yucca Mountain is that DOE has announced that it will receive fuel in standard canisters that are inserted, unopened, into waste packages prior to emplacement in the repository. Yet, as Table 4-4 shows, the concept of a standard canister is incompatible with the present configurations of dry-storage canisters and the proposed configurations of Yucca Mountain disposal packages. There is no clear path to resolution of this problem.

5. Technical Understanding of Spent-Fuel-Pool Fires

Section 2, above, introduces the concept of a pool fire and describes the history of analysis of pool-fire risks. There is a body of technical literature on these risks, containing documents of varying degrees of completeness and accuracy. Current opinions about the risks vary widely, but the differences of opinion may be more about the probabilities of pool-fire scenarios than about the physical characteristics of these scenarios. In turn, differing opinions about probabilities lead to differing support for risk-reducing options. This situation is captured in a comment by Allan Benjamin on a paper (Alvarez et al, 2003) by this author and seven colleagues.[30] Benjamin's comment is quoted in the unclassified NAS report as follows:[31]

[29] The term "sub-national group" is used in security analysis to describe a human group that is larger and more capable than an isolated individual, but is not an arm of a national government. This distinction has strategic significance because deterrence, a potentially effective means of influencing a national government, may not influence a sub-national group.
[30] Allan Benjamin was one of the authors of: Benjamin et al, 1979.
[31] NAS, 2006, page 45.

> In a nutshell, [Alvarez et al] correctly identify a problem that needs to be addressed, but they do not adequately demonstrate that the proposed solution is cost-effective or that it is optimal.

The "proposed solution" to which Benjamin refers is the re-equipment of spent-fuel pools with low-density, open-frame racks, transferring excess spent fuel to onsite dry storage. In fact, however, the [Alvarez et al] authors had not claimed to complete the level of analysis, especially site-specific analysis, that risk-reducing options should receive in an Environmental Report or EIS. These authors stated:[32]

> Finally, all of our proposals require further detailed analysis and some would involve risk tradeoffs that also would have to be further analyzed. Ideally, these analyses could be embedded in an open process in which both analysts and policy makers can be held accountable.

The paper by Alvarez et al is consistent with current knowledge of pool-fire phenomena, including the findings set forth in the unclassified NAS report. The same cannot be said for all of the NRC documents that were cited in the NRC's September 1990 review of its Waste Confidence Decision. As discussed in Section 2, above, four NRC documents were cited to support that review's finding regarding the risks of pool fires.[33] In turn, the May 1996 GEIS on license renewal (NUREG-1437) relied on the September 1990 review for its position on the risks of pool fires. The four NRC documents are discussed in the following paragraphs.

NUREG/CR-4982 was prepared at Brookhaven National Laboratory to provide "an assessment of the likelihood and consequences of a severe accident in a spent fuel storage pool".[34] The postulated accident involved complete, instantaneous loss of water from the pool, thereby excluding important phenomena from consideration. The Brookhaven authors employed a simplistic model to examine propagation of a fire from one fuel assembly to another. That model neglected important phenomena including slumping and burn-through of racks, slumping of fuel assemblies, and the accumulation of a debris bed at the base of the pool. Each of these neglected phenomena would promote fire propagation. The study ignored the potential for interactions between a pool fire and a reactor accident. It did not consider acts of malice. Overall, this study did not approach the completeness and quality needed to support consideration of a pool fire in an EIS.

NUREG/CR-5176 was prepared at Lawrence Livermore National Laboratory.[35] It examined the potential for earthquake-induced failure of the spent-fuel pool and the pool's support systems at the Vermont Yankee and Robinson Unit 2 plants. It also considered the effect of dropping a spent-fuel shipping cask on a pool wall. Overall, this study appears to have been a competent exercise within its stated assumptions. With

[32] Alvarez et al, 2003, page 35.
[33] NRC, 1990a, page 38481.
[34] Sailor et al, 1987.
[35] Prassinos et al, 1989.

appropriate updating, NUREG/CR-5176 could contribute to the larger body of analysis that would be needed to support consideration of a pool fire in an EIS.

NUREG-1353 was prepared by a member of the NRC Staff to support resolution of NRC Generic Issue 82.[36] It postulated a pool accident involving complete, instantaneous loss of water from the pool, thereby excluding important phenomena from consideration. It relied on the fire-propagation analysis of NUREG/CR-4982. As discussed above, that analysis is inadequate. In considering heat transfer from BWR fuel after water loss, NUREG-1353 assumed that a high-density rack configuration would involve a 5-inch open space between each row of fuel assemblies. That assumption is inappropriate and non-conservative. Modern, high-density BWR racks have a center-to-center distance of about 6 inches in both directions. Thus, NUREG-1353 under-estimated the potential for ignition of BWR fuel. Overall, NUREG-1353 did not approach the completeness and quality needed to support consideration of a pool fire in an EIS.

NUREG/CR-5281 was prepared at Brookhaven National Laboratory to evaluate options for reducing the risks of pool fires.[37] It took NUREG/CR-4982 as its starting point, and therefore shared the deficiencies of that study.

Clearly, these four NRC documents do not provide an adequate technical basis for an EIS that addresses the risks of pool fires. The knowledge that they do provide could be supplemented from other documents, including the unclassified NAS report, the paper by Alvarez et al, and the NRC Staff study (NUREG-1738) on pool-fire risk at a plant undergoing decommissioning.[38] However, this combined body of information would be inadequate to support the preparation of an EIS. For that purpose, a comprehensive, integrated study would be required, involving analysis and experiment. The depth of investigation would be similar to that involved in preparing the NRC's December 1990 study on the risks of reactor accidents (NUREG-1150).[39]

A pool-fire "source term"

The incompleteness of the present knowledge base is evident when one needs a "source term" to estimate the radiological consequences of a pool fire. The concept of a source term encompasses the magnitude, timing and other characteristics of a release of radioactive material. Present knowledge does not allow theoretical or empirically-based prediction of the source term for a postulated pool-fire scenario. Instead, informed judgment must be used.

Table 5-1 provides two versions of a source term for a pool fire at Pilgrim or Vermont Yankee. Each version assumes that a high-density pool would be almost full of spent

[36] Throm, 1989.
[37] Jo et al, 1989.
[38] Collins and Hubbard, 2001.
[39] NRC, 1990b.

fuel, which is the expected mode of operation of each plant during the period of license extension.

One version of the source term involves a release of 100 percent of the cesium-137 in a pool. That is an upper limit. In practice, the cesium-137 release fraction would be less than 100 percent, but there is no way to determine if the largest achievable release fraction would be 90 percent or 95 percent or some other number. In any event, this large source term implies that all or most of the zirconium in the pool would oxidize. Table 5-1 assumes that the oxidation occurs over a period of 5 hours. The second version of the source term involves a release of 10 percent of the cesium-137 in the pool, with oxidation of 10 percent of the zirconium over a period of 0.5 hours.

Given present knowledge, the approximately 100-percent release and the 10-percent release are equally probable for a typical pool fire. A prudent decision maker could, therefore, reasonably use the 100-percent release to assess risks and risk-reducing options.

6. Initiation of a Pool Fire by an Accident Not Involving Malice

Section 2, above, provides a general description of the potential for a spent-fuel-pool fire. Such a fire could be caused by a variety of events. Here, accidental events not involving malice are considered, with a focus on the Pilgrim and Vermont Yankee plants. Section 7, below, considers events that involve malicious action.

At Pilgrim or Vermont Yankee, non-malicious events at the plant that could lead to a pool fire include: (i) an accidental aircraft impact, with or without an accompanying fuel-air explosion or fire; (ii) an earthquake; (iii) dropping of a fuel transfer cask or shipping cask; (iv) a fire inside or outside the plant building; and (v) a severe accident at the adjacent reactor.

Given the major consequences of a pool fire, analysis should have been performed to examine pool-fire scenarios across a full range of initiating events. The NRC has devoted substantial attention and resources to the examination of reactor-core-melt scenarios, through studies such as NUREG-1150.[40] Neither the NRC nor the nuclear industry has conducted a comparable study of pool fires. In the absence of such a study, this report provides illustrative analysis.

[40] NRC, 1990b.

A pool fire accompanied by a reactor accident

As mentioned in Section 1, above, at Pilgrim and Vermont Yankee the pool and the reactor are in close physical proximity within the same building, and some of their essential support systems are shared. These plants are, therefore, comparatively likely to experience a pool fire that is accompanied by a reactor accident.

This combination of accidents is the focus of discussion here. The pool fire and the reactor accident might have a common cause. For example, a severe earthquake could cause leakage of water from the pool, while also damaging the reactor and its supporting systems to such an extent that a core-melt accident occurs. In some scenarios, the high radiation field produced by a pool fire could initiate or exacerbate an accident at the reactor by precluding the presence and functioning of operating personnel. In other scenarios, the high radiation field produced by a core-melt accident could initiate or exacerbate a pool-fire scenario, again by precluding the presence and functioning of operating personnel. Many core-melt scenarios would involve the interruption of cooling to the pool.

By focusing on a pool fire accompanied by a reactor accident, this report does not imply that other pool-fire scenarios make a smaller contribution to pool-fire risks at Pilgrim and Vermont Yankee. Such a conclusion could come only from a comprehensive assessment of pool-fire risks, and no such assessment has ever been performed.

Tables 6-1 and 6-2 provide licensee estimates of core-damage frequency (probability) and radioactive-release frequency for the Pilgrim and Vermont Yankee reactors.[41] Some of these estimates are from the Independent Plant Examination (IPE) and the Independent Plant Examination for External Events (IPEEE) that have been performed for each plant.[42] The remaining estimates are from the Environmental Report (Appendix E of the license renewal application) for each plant. In this report, the IPE and IPEEE estimates are used instead of the ER estimates, because the studies underlying the latter are not available for review.[43]

Estimates shown in Tables 6-1 and 6-2 that are of particular relevance to this report are the estimates of the probability (frequency) of an early release of radioactive material from the reactor. Table 6-3 provides a definition of "early" and other terms that are used to categorize potential radioactive releases. "High" and "medium" release scenarios, as defined in Table 6-3, are often "early" and vice versa.

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[41] For present purposes, core damage is equivalent to core melt.
[42] Boston Edison, 1992; Boston Edison, 1994; VYNPS, 1993; VYNPS, 1998.
[43] NRC Public Document Room staff informed Diane Curran that the recent reactor-accident studies referenced in the Environmental Reports for Pilgrim and Vermont Yankee could not be located within the NRC.

Lessons from a license-amendment proceeding for the Harris plant

This report assumes that the conditional probability of a spent-fuel-pool fire, given an early release from the adjacent reactor, is 50 percent. That assumption is reasonable – and not necessarily conservative – for the Pilgrim or Vermont Yankee plant because the pool and the reactor are in close physical proximity within the same building, and some of their essential support systems are shared. Support for this assumption is provided by technical studies and opinions submitted to the Atomic Safety and Licensing Board (ASLB) in a license-amendment proceeding in regard to the expansion of spent-fuel-pool capacity at the Harris nuclear power plant. All three parties to the proceeding – the NRC Staff, Carolina Power and Light (CP&L), and Orange County – reached the same conclusion on an issue that is relevant to the above-stated conditional probability of 50 percent.

The Harris plant has one reactor and four pools. The reactor – a PWR – is in a cylindrical, domed containment building. The four pools are in a separate, adjacent building that was originally intended to serve four reactors. Only one reactor was built. Two pools were in use at high density prior to the proceeding, and the proceeding addressed the activation of the two remaining pools, also at high density.

During the proceeding, the ASLB determined that the potential for a pool fire should be considered, and ordered the three parties to analyze a single scenario for such a fire.[44] In the postulated scenario, a severe accident at the Harris reactor would contaminate the Harris site with radioactive material to an extent that would preclude actions needed to supply cooling and makeup to the Harris pools. Thereafter, the pools would boil and dry out, and fuel within the pools would burn. Following the ALSB's order, Orange County submitted a report by this author.[45] The NRC Staff submitted an affidavit by members of the Staff.[46] CP&L – the licensee – submitted a document prepared by ERIN Engineering.[47]

Orange County's analysis found that the minimum value for the best estimate of a pool fire, for the ASLB's postulated scenario, is 1.6 per 100 thousand reactor-years. This estimate did not account for acts of malice, degraded standards of plant operation, or gross errors in design, construction or operation. The NRC Staff estimated, for the same scenario, that the probability of a pool fire is on the order of 2 per 10 million reactor-years. The ASLB accepted the Staff's estimate, thereby concluding that, for the particular configuration of the Harris plant, the postulated scenario is "remote and speculative"; the

[44] ASLB, 2000.
[45] Thompson, 2000.
[46] Parry et al, 2000.
[47] ERIN, 2000.

ASLB then terminated the proceeding without conducting an evidentiary hearing.[48] Elsewhere, the author has described deficiencies in the ASLB's ruling.[49]

A major reason for the difference in the probability estimates proffered by Orange County and the NRC Staff was their differing assessments of the spread of radioactive material from the reactor containment building to the separate, adjacent pool building. However, the Staff agreed with Orange County on some other matters. For example, the Staff reversed its previous position that comparatively long-discharged fuel will not ignite in the event of water loss from a high-density pool. Staff members stated that loss of water from pools containing fuel aged less than 5 years "would almost certainly result in an exothermic reaction", and also stated: "Precisely how old the fuel has to be to prevent a fire is still not resolved."[50] Moreover, the Staff assumed that a fire would be inevitable if the water level fell to the top of the racks.

Most importantly for present purposes, the technical submissions of all three parties agreed that the onset of a pool fire in two of the pools in the Harris pool building would preclude the provision of cooling and water makeup to the other two pools. This effect would arise from the spread of hot gases and radioactive material throughout the pool building, which would preclude access by operating personnel. Thus, the pools not involved in the initial fire would boil and dry out, and their fuel would burn.

The Pilgrim and Vermont Yankee plants have a different configuration than the Harris plant, because at Pilgrim and Vermont Yankee the reactor and the pool are within the same building whereas at Harris they are in different buildings. Thus, the Pilgrim and Vermont Yankee plants are analogous to the Harris pool building. Given an early release from the Pilgrim or Vermont Yankee reactor as part of a core-melt accident, hot gases and radioactive material from the reactor would spread throughout the building that encloses both. Provision of cooling and water makeup to the pool would be precluded, the radiation field and the thermal environment being even more extreme than in the Harris situation. The pool would boil and dry out, and its fuel would burn.

Thus, the three parties' agreement in the Harris proceeding implies their agreement that a pool fire would inevitably follow an early release as part of a core-melt accident at Pilgrim or Vermont Yankee. Against that background, this report's assumption of a conditional probability of 50 percent for a pool fire, given an early release, is reasonable.

7. Initiation of a Pool Fire by Malicious Action

The NRC's August 1979 Generic Environmental Impact Statement on handling and storage of spent fuel (NUREG-0575) considered potential sabotage events at a spent-fuel pool.[51] Table 7-1 describes the postulated events, which encompassed the detonation of

[48] ASLB, 2001.
[49] Thompson, 2001b.
[50] Parry et al, 2000, paragraph 29.
[51] NRC, 1979, Section 5 and Appendix J.

explosive charges in the pool, breaching of the walls of the pool building and the pool floor by explosive charges or other means, and takeover of the central control room for one half-hour. Involvement of up to 80 adversaries was implied.

NUREG-0575 did not, however, recognize the potential for an attack with these attributes to cause a fire in the pool.[52] Technically-informed attackers operating within this envelope of attributes could cause a fire in a pool at Pilgrim, Vermont Yankee or other plants. Informed attackers could use explosives, and their command of the control room for one half-hour, to drain water from the pool and release radioactive material from the reactor.[53] The radiation field from the reactor release would preclude personnel access, thus precluding recovery actions if command of the plant were returned to the operators after one half-hour.

The potential for a maliciously-induced pool fire at Pilgrim or Vermont Yankee is influenced by several factors. Here, the following factors are considered: (i) the present level of protection of nuclear power plants and spent fuel; (ii) options for providing greater protection; (iii) available means of attack; and (iv) motives for attack. In the context of an EIS, the first, third and fourth of these factors relate to the probability of a successful attack, and the second factor relates to alternatives.

The present level of protection of nuclear power plants and spent fuel

Site-security measures mandated by the NRC have made access to a nuclear power plant more difficult for attackers approaching on foot or by land vehicle than was the case in 1979.[54] Nevertheless, as discussed below, a successful attack could be mounted today using resources of the scale assumed in NUREG-0575 or employed to attack the United States on 11 September 2001. In light of information now available, the NRC could prepare a supplement to NUREG-0575 that updates its sabotage analysis. This supplement could employ a classified appendix to prevent public disclosure of sensitive information.

The consideration of sabotage events in NUREG-0575 is an exception. As a general rule, the NRC does not consider malicious acts in the context of license proceedings or environmental impact statements. The NRC's policy on this matter is illustrated by a September 1982 ruling by the Atomic Safety and Licensing Board in the operating-license proceeding for the Harris nuclear power plant. An intervenor, Wells Eddleman, had proffered a contention alleging, in part, that the plant's safety analysis was deficient because it did not consider the "consequences of terrorists commandeering a very large airplane.....and diving it into the containment." In rejecting this contention the ASLB stated:[55]

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[52] The sabotage events postulated in NUREG-0575 yielded comparatively small radioactive releases.
[53] In some areas of the Pilgrim or Vermont Yankee reactor building, one explosive charge could potentially breach the pool wall, the reactor containment, and the reactor vessel.
[54] NRC, 2004; Thompson, 2004.
[55] ASLB, 1982.

> This part of the contention is barred by 10 CFR 50.13. This rule must be read *in pari materia* with 10 CFR 73.1(a)(1), which describes the "design basis threat" against which commercial power reactors *are* required to be protected. Under that provision, a plant's security plan must be designed to cope with a violent external assault by "several persons," equipped with light, portable weapons, such as hand-held automatic weapons, explosives, incapacitating agents, and the like. Read in the light of section 73.1, the principal thrust of section 50.13 is that military style attacks with heavier weapons are not a part of the design basis threat for commercial reactors. Reactors could not be effectively protected against such attacks without turning them into virtually impregnable fortresses at much higher cost. Thus Applicants are not required to design against such things as artillery bombardments, missiles with nuclear warheads, or kamikaze dives by large airplanes, despite the fact that such attacks would damage and may well destroy a commercial reactor.

As indicated by the ASLB, the NRC's basic policy on protecting nuclear facilities from attack is laid down in the regulation 10 CFR 50.13. This regulation was promulgated in September 1967 by the US Atomic Energy Commission (AEC) – which preceded the NRC – and was upheld by the US Court of Appeals in August 1968. It states:[56]

> An applicant for a license to construct and operate a production or utilization facility, or for an amendment to such license, is not required to provide for design features or other measures for the specific purpose of protection against the effects of (a) attacks and destructive acts, including sabotage, directed against the facility by an enemy of the United States, whether a foreign government or other person, or (b) use or deployment of weapons incident to US defense activities.

Pursuant to 10 CFR 50.13, licensees are not required to design or operate nuclear facilities to resist enemy attack. However, events have obliged the NRC to progressively modify this position, so as to require greater protection against malicious or insane acts by sub-national groups. A series of events, including the 1993 bombing of the World Trade Center in New York, persuaded the NRC to introduce, in 1994, regulations requiring licensees to defend nuclear power plants against vehicle bombs. The attacks of 11 September 2001 led the NRC to require additional measures.

The NRC requires its licensees to defend against a design basis threat (DBT), a postulated attack that has become more severe over time. The present DBT was promulgated in April 2003. Prior to February 2002 the DBT was published, but not thereafter. The NRC has described the present DBT for nuclear power plants as follows:[57]

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[56] Federal Register, Vol. 32, 26 September 1967, page 13445.
[57] NRC Press Release No. 03-053, 29 April 2003.

> The Order that imposes revisions to the Design Basis Threat requires power plants to implement additional protective actions to protect against sabotage by terrorists and other adversaries. The details of the design basis threat are safeguards information pursuant to Section 147 of the Atomic Energy Act and will not be released to the public. This Order builds on the changes made by the Commission's February 25, 2002 Order. The Commission believes that this DBT represents the largest reasonable threat against which a regulated private security force should be expected to defend under existing law. It was arrived at after extensive deliberation and interaction with cleared stakeholders from other Federal agencies, State governments and industry.

From this statement, and from other published information, it is evident that the NRC requires a comparatively light defense for nuclear power plants and their spent fuel. The scope of the defense does not reflect a full spectrum of threats. Instead, it reflects a consensus about the level of threat that licensees can "reasonably" be expected to resist.[58]

A rationale for the present level of protection of nuclear facilities was articulated by the NRC chair, Richard Meserve, in 2002:[59]

> If we allow terrorist threats to determine what we build and what we operate, we will retreat into the past – back to an era without suspension bridges, harbor tunnels, stadiums, or hydroelectric dams, let alone skyscrapers, liquid-natural-gas terminals, chemical factories, or nuclear power plants. We cannot eliminate the terrorists' targets, but instead we must eliminate the terrorists themselves. A strategy of risk avoidance – the elimination of the threat by the elimination of potential targets – does not reflect a sound response.

Options for providing greater protection

Chairman Meserve's statement does not consider another approach – designing new infrastructure elements or modifying existing elements so that they are more robust against attack. It has been known for decades that nuclear power plants could be designed to be more robust against attack. For example, in the early 1980s the reactor vendor ASEA-Atom developed a preliminary design for an "intrinsically safe" commercial reactor known as the PIUS reactor. Passive-safety design principles were used. The design basis for the PIUS reactor included events such as equipment failures, operator errors and earthquakes, but also included: (i) takeover of the plant for one operating shift by knowledgeable saboteurs equipped with large amounts of explosives; (ii) aerial bombardment with 1,000-pound bombs; and (iii) abandonment of the plant by the operators for one week.[60]

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[58] Fertel, 2006; Wells, 2006; Brian, 2006.
[59] Meserve, 2002, page 22.
[60] Hannerz, 1983.

As explained in Section 8, below, the spent-fuel pools at the Pilgrim and Vermont Yankee plants would be more robust against attack if they were re-equipped with low-density, open-frame storage racks. This step would restore the pools to their original design configuration.

Available means of attack

In considering the potential for a future attack on the Pilgrim or Vermont Yankee spent-fuel pool, it is necessary to consider both means and motives. Table 7-2 provides some general information about means. This table shows that nuclear power plants are vulnerable to attack by means available to sub-national groups. For example, one of the potential instruments of attack shown in Table 7-2 is an explosive-laden smaller aircraft. In this connection, note that the US General Accounting Office (GAO) expressed concern, in September 2003 testimony to Congress, about the potential for malicious use of general-aviation aircraft. The testimony stated:[61]

> Since September 2001, TSA [the Transportation Security Administration] has taken limited action to improve general aviation security, leaving it far more open and potentially vulnerable than commercial aviation. General aviation is vulnerable because general aviation pilots are not screened before takeoff and the contents of general aviation planes are not screened at any point. General aviation includes more than 200,000 privately owned airplanes, which are located in every state at more than 19,000 airports. Over 550 of these airports also provide commercial service. In the last 5 years, about 70 aircraft have been stolen from general aviation airports, indicating a potential weakness that could be exploited by terrorists.

Sub-national groups could obtain explosive devices that would be effective instruments of attack on a nuclear power plant.[62] Assistance from a government or access to classified information would not be required. Designs for sophisticated explosive devices capable of exploiting the vulnerabilities of the Pilgrim or Vermont Yankee spent-fuel pools are publicly available from sources including the web. Means for delivery of such devices to the target are also readily available.[63]

Motives for attack

Understanding the factors that could motivate a sub-national group to attack a civilian nuclear facility in the USA is a difficult task. Multiple, competing factors will be in play, and will affect different groups in different ways. An attacking group might be foreign, as was the case in New York and Washington in September 2001, or domestic, as was the case in Oklahoma City in April 1995 and London in July 2005. As we try to understand

[61] Dillingham, 2003, page 14.
[62] Walters, 2003.
[63] For example: Raytheon, 2004; the website www.aircraftdealer.com, accessed 6 November 2004.

the complex issue of motives, one requirement is clear. We must set aside our own perspectives, and attempt to understand the perspectives of those who might attack us. That understanding will help us to assess risks and prepare countermeasures.

One insight from experience is that an attack by a sub-national group could be part of an action-reaction cycle.[64] Former CIA Director Stansfield Turner has recounted how the October 1983 truck bombing of a US Marine barracks in Beirut was part of such a cycle.[65] A high-level task force convened by the Council on Foreign Relations recognized the potential for an action-reaction effect in the context of US military operations with counterterrorism objectives. They recommended that this effect be offset by greater protection of domestic targets. An October 2002 report of the task force stated:[66]

> *Homeland security measures have deterrence value*:
> US counterterrorism initiatives abroad can be reinforced by making the US homeland a less tempting target. We can transform the calculations of would-be terrorists by elevating the risk that (1) an attack on the United States will fail, and (2) the disruptive consequences of a successful attack will be minimal. It is especially critical that we bolster this deterrent now since an inevitable consequence of the US government's stepped-up military and diplomatic exertions will be to elevate the incentive to strike back before these efforts have their desired effect.

Probability of attack

For policy and planning purposes, it would be useful to have an estimate of the probability of an attack-induced spent-fuel-pool fire. The record of experience does not allow a statistically valid estimate of this probability. A decision maker or risk analyst must, therefore, rely on prudent judgment.[67] In the case of an attack-induced spent-fuel-pool fire in the USA, prudent judgment indicates that a probability of at least one per century is a reasonable assumption for policy purposes.

8. Options to Reduce the Risks of Pool Fires

Various options are available to reduce the probability and/or magnitude of an atmospheric release from a spent-fuel-pool fire at Pilgrim or Vermont Yankee. A useful option must achieve one or more of the following five effects: (i) reduce the probability of a loss of water; (ii) reduce the potential for ignition of fuel following a loss of water; (iii) reduce the potential for fire propagation following ignition of one or more fuel

[64] Davis, 2006.
[65] Turner, 1991.
[66] Hart et al, 2002, pp 14-15.
[67] The NRC has used qualitative judgment about the probability of attack as a basis for the 1994 vehicle-bomb rule and the present design basis threat.

assemblies; (iv) reduce the inventory of spent fuel in the pool; or (v) suppress a fire in the pool.

The fifth effect – fire suppression – would be extremely difficult to achieve. Spraying water on a fire could feed a zirconium-steam reaction. In principle, an air-zirconium reaction in the pool could be smothered, perhaps by spreading large amounts of a non-reactive powder. In practice, the high radiation field surrounding the pool would preclude the approach of firefighters. Here, the focus is on the first four effects.

Table 8-1 describes selected risk-reducing options that could, to some degree, achieve one or more of the first four effects. This table does not purport to identify a comprehensive set of risk-reducing options, or to provide a complete assessment of the listed options. Instead, this table illustrates the range of options and their properties.

The option that would achieve the largest risk reduction, during plant operation within a license extension period, would be to re-equip the pool with low-density, open-frame storage racks. Implementation of this option would return the plant to its original design configuration. Excess spent fuel would be placed in dry storage at the plant site. This option would not reduce the probability of a loss of water. Instead, it would allow the pool to survive a loss of water without damage to the fuel. It would prevent ignition of fuel in almost all scenarios of water loss. For the few, unlikely scenarios that would remain, it would inhibit fire propagation across the pool. By reducing the inventory of radioactive material in the pool, this option would limit the magnitude of the greatest possible release.

Re-equipping a spent-fuel pool with low-density, open-frame racks would be an entirely passive measure of risk reduction. Successful functioning of this option would not require electricity, a water supply, the presence of personnel, or any other active function. Passive risk-reduction measures of this type represent good practice in nuclear engineering design. Reactor vendors are seeking to use passive-safety principles in the design of new commercial reactors.

Nuclear power plants are important elements of the nation's critical infrastructure. Other elements of that infrastructure also offer opportunities to use passive measures of risk reduction. Passive measures can be highly reliable and predictable in their effectiveness. They can substitute for other measures to protect critical infrastructure, as shown in Table 8-2, yielding monetary and non-monetary benefits.

Table 8-3 provides an estimated cost for offloading spent fuel from the Pilgrim or Vermont Yankee pool, to allow the pool to be re-equipped with low-density, open-frame racks. There would be an additional, smaller cost for replacing the racks, which is neglected here. Note that Table 8-3 does not purport to provide a definitive specification for re-equipment of the pools, or a final estimate of the cost of this option. The analysis presented in Table 8-3 is illustrative. A more sophisticated analysis would not alter the basic findings of this report.

From Table 8-3 one sees that the estimated cost of a transition to low-density, open-frame racks would be $54-109 million at Pilgrim and $43-87 million at Vermont Yankee. Approximately the same cost would otherwise be incurred during decommissioning of the plant, when spent fuel would be offloaded from the pool to dry storage. The net additional cost of the option would reflect the comparative present values of approximately equal expenditures now or two decades in the future.

9. An Integrated View of Risks and Risk-Reducing Options

Preceding sections of this report have discussed particular aspects of the risks and risk-reducing options associated with pool storage of spent nuclear fuel. To produce useful policy findings, these separate discussions must be integrated.

Section 6 of this report provides, in Tables 6-1 and 6-2, licensee estimates of the probability of an early release as part of a severe reactor accident – of non-malicious origin – at Pilgrim or Vermont Yankee. Also, Section 6 develops the reasonable assumption that the conditional probability of a spent-fuel-pool fire, given an early release from the reactor, is 50 percent. Section 7 sets forth a judgment that the probability of a successful, attack-induced spent-fuel-pool fire in the USA can be assumed, for policy purposes, to be at least one per century. Section 8 provides an estimate that the cost of a transition to low-density, open-frame racks in a spent-fuel pool would be $54-109 million at Pilgrim and $43-87 million at Vermont Yankee.

Table 9-1 combines the findings of Sections 6 and 7, yielding an estimate that the total probability of a pool fire at Pilgrim or Vermont Yankee is 1.2 per 10,000 years at each plant. A number of simplifying assumptions are employed in Table 9-1, as is evident from the table. A more sophisticated analysis would not alter the general findings of this report.

Entergy's Environmental Reports for Pilgrim and Vermont Yankee present a cost-versus-benefit analysis as a means of evaluating Severe Accident Mitigation Alternatives. Table 9-2 illustrates this type of analysis. The table shows that an investment of $110-200 million (depending on discount rate) is justified to prevent a radioactive release with a probability of one per 10,000 years and a consequence cost of $100 billion.

A companion report by Dr. Jan Beyea shows that the consequence cost attributable to a spent-fuel-pool fire at Pilgrim or Vermont Yankee would exceed $100 billion across a range of release scenarios.[68] This report estimates that the probability of a pool fire at Pilgrim or Vermont Yankee is more than one per 10,000 years at each plant. Re-equipping the Pilgrim or Vermont Yankee pool with low-density, open-frame racks would substantially reduce the probability of a pool fire and the magnitude of its

[68] The findings in Dr. Beyea's companion report are consistent with previous analysis provided in: Beyea et al, 2004.

consequences. To a first-order approximation, re-equipping a pool in this manner would eliminate the risk of a pool fire. The cost of re-equipping a pool would be less than $110 million. Thus, a SAMA-type analysis shows that re-equipping both pools with low-density, open-frame racks is justified.

The analysis underlying this conclusion does not purport to be comprehensive. This analysis is, however, sufficient to show that Entergy and the NRC are obliged to perform new studies, as described in Section 10, below.

Probabilistic analysis, of the type that is used in Table 9-1 and in Entergy's Environmental Reports, should not be the only means of evaluating Severe Accident Mitigation Alternatives. People who are unfamiliar with probabilistic risk assessment may place unwarranted faith in the numerical values that it generates. A closer look at probabilistic risk assessment for nuclear power plants shows that its findings are plagued by incompleteness and uncertainty.[69] These findings cannot substitute for prudent, informed judgment. In exercising that judgment, decision makers should be aware of strategic considerations, such as those addressed in Table 8-2.

10. Analysis Required From Entergy and the Nuclear Regulatory Commission

Entergy's Environmental Reports for the Pilgrim and Vermont Yankee plants do not examine the potential for a radioactive release from a fire in a spent-fuel pool. Nor do they consider SAMA-type options that could reduce the probability and/or magnitude of such a release. Similarly, the NRC does not consider such options in its GEIS for re-licensing of nuclear power plants.

Yet, the NRC has determined that the potential for a reactor core-melt accident must be considered in a re-licensing EIS. Moreover, a spent-fuel-pool fire at Pilgrim or Vermont Yankee has, according to this report, a probability comparable to the probability of a reactor core-melt accident. Finally, the offsite radiological impact of the pool fire could be substantially greater than the impact of the core-melt accident, because the pool has a larger inventory of cesium-137. Therefore, the potential for a pool fire should be considered in an Environmental Report or EIS for re-licensing. Such studies should use at least the depth of analysis that is employed to consider the potential for a core-melt accident.

Entergy should withdraw, revise and re-submit its Environmental Reports. In addressing the potential for pool fires, each revised ER should consider the full range of potential initiating events, including acts of malice. Options for reducing the risks of pool fires should be considered to at least the depth of analysis that is employed for SAMAs in the context of reactor accidents.

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[69] Hirsch et al, 1989.

The NRC should prepare generic supplements to its August 1979 Generic Environmental Impact Statement on handling and storage of spent fuel (NUREG-0575), and its May 1996 GEIS on license renewal (NUREG-1437). These supplements should address the risks of spent-fuel-pool fires to at least the depth of analysis and experiment that was conducted to prepare the NRC's December 1990 study on the risks of reactor accidents (NUREG-1150).[70] In addition, the supplements should identify a range of options to reduce the risks of pool fires, and should comprehensively assess the benefits and costs of these options. An EIS prepared for re-licensing of Pilgrim or Vermont Yankee should incorporate the findings of the new, generic supplements to NUREG-0575 and NUREG-1437.

11. Conclusions

Discussions in preceding sections of this report lead to the following major conclusions:

C1. At the Pilgrim and Vermont Yankee plants, large amounts of spent nuclear fuel are stored in water-filled pools equipped with high-density, closed-form storage racks. Entergy plans to continue this practice during the period of license extension, operating the pools at near to full capacity.

C2. The radioactive isotope cesium-137 provides a useful indicator of the hazard potential of the Pilgrim and Vermont Yankee spent-fuel pools. During the period of license extension, it is likely that these pools will hold about 1.6 million TBq (Pilgrim) and 1.4 million TBq (Vermont Yankee) of cesium-137. Each pool will hold about 8 times as much cesium-137 as will be present in the adjacent reactor.

C3. Various studies by the NRC and other bodies have shown that loss of water from a spent-fuel pool equipped with high-density, closed-form storage racks would, over a range of scenarios, lead to self-ignition of some of the fuel assemblies in the pool, leading to a fire that could propagate across the pool. Burning of fuel assemblies would lead to a large atmospheric release of cesium-137 and other radioactive isotopes. These findings have been confirmed by a 2005 report prepared by the National Academy of Sciences at the request of the US Congress.

C4. Entergy has submitted an Environmental Report (ER) as part of each license extension application. Each ER examines potential reactor accidents involving damage to the reactor core and release of radioactive material to the atmosphere. That examination supports the ER's evaluation of Severe Accident Mitigation Alternatives (SAMAs) – options that could reduce the probability and/or magnitude of a radioactive release from the reactor. Neither ER examines the potential for a radioactive release from a fire in a spent-fuel pool, or considers SAMA-type options that could reduce the probability and/or magnitude of such a release.

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[70] NRC, 1990b.

C5. The NRC has published various documents that discuss aspects of the potential for a spent-fuel-pool fire. Only three of these documents are products of processes that provided an opportunity for formally structured public comment and, potentially, for in-depth analysis of risks and alternatives. One document is the August 1979 Generic Environmental Impact Statement (GEIS) on handling and storage of spent fuel (NUREG-0575). The second document is the May 1996 GEIS on license renewal (NUREG-1437). These two documents purported to provide systematic analysis of the risks and relative costs and benefits of alternative options. The third document is a September 1990 review (55 FR 38474) of the NRC's Waste Confidence Decision. That document did not purport to provide an analysis of risks and alternatives. None of the three documents provides a technically defensible examination of spent-fuel-pool fires and the associated risks and alternatives. The findings in each document are inconsistent with the more recent and more credible findings of the National Academy of Sciences, set forth in its 2005 report, and the findings of other studies conducted since 1996.

C6. The August 1979 GEIS (NUREG-0575) considered potential sabotage events at a spent-fuel pool. The GEIS did not recognize the potential for an attack with the postulated attributes to cause a fire in the pool. Technically-informed attackers operating within this envelope of attributes could, with high confidence, cause an unstoppable fire in a pool.

C7. Site-security measures mandated by the NRC have made access to a nuclear power plant more difficult for attackers approaching on foot or by land vehicle than was the case in 1979. Nevertheless, a successful attack could be mounted using resources of the scale assumed in NUREG-0575 or employed to attack the United States on 11 September 2001. The NRC has not prepared any environmental impact statement or comparable study that updates the sabotage analysis set forth in NUREG-0575.

C8. The record of experience does not allow a statistically valid estimate of the probability of an attack-induced spent-fuel-pool fire in the USA. Prudent judgment indicates that a probability of at least one per century is a reasonable assumption for policy purposes. This translates to a probability of one per 10,000 years at Pilgrim or Vermont Yankee, which is comparable to the estimated probability of a reactor core-melt accident according to probabilistic risk studies done for these plants.

C9. Probabilistic risk studies done by licensees for the Pilgrim and Vermont Yankee plants can support an estimate of the probability of a spent-fuel-pool fire that is caused by or accompanies a core-melt accident at the adjacent reactor. The connection between these events is particularly strong at these plants because the pool and the reactor are in close physical proximity within the same building, and some of their essential support systems are shared. A provisional estimate of the probability of a spent-fuel-pool fire associated with a core-melt accident, not involving malice, is about two per 100,000 years at each plant.

C10. Options are available to reduce the probability and/or magnitude of an atmospheric release from a spent-fuel-pool fire at Pilgrim or Vermont Yankee. The option that would achieve the largest risk reduction, during plant operation within a license extension period, would be to re-equip the pool with low-density, open-frame racks. This step would return the plant to its original design configuration. Excess spent fuel would be placed in dry storage at the plant site. The estimated cost of this option would be $54-109 million at Pilgrim and $43-87 million at Vermont Yankee. Approximately the same cost would otherwise be incurred during decommissioning of the plant, when spent fuel would be offloaded from the pool to dry storage. The net additional cost of the option would reflect the comparative present values of approximately equal expenditures now or two decades in the future.

C11. Re-equipping a spent-fuel pool with low-density, open-frame racks would be a passive measure that would eliminate most scenarios for a pool fire and greatly reduce the atmospheric release for the few, unlikely scenarios that would remain. Passive risk-reduction measures of this type represent good practice in nuclear engineering design. Substantial benefits, both monetary and non-monetary, could arise from the deployment of passive risk-reduction measures at nuclear power plants and other elements of critical infrastructure.

C12. Entergy's Environmental Reports present a cost-versus-benefit analysis as a means of evaluating Severe Accident Mitigation Alternatives. This type of analysis should not be the only basis for evaluating SAMAs, but can provide useful information. The analysis shows that an investment of $110-200 million (depending on discount rate) is justified to prevent a radioactive release with a probability of one per 10,000 years and a consequence cost of $100 billion. A companion report by Dr. Jan Beyea shows that the consequence cost attributable to a spent-fuel-pool fire at Pilgrim or Vermont Yankee would exceed $100 billion across a range of release scenarios. Given the pool-fire probability found in this report (at least one per 10,000 years), and the estimated cost of re-equipping the Pilgrim or Vermont Yankee pool with low-density, open-frame racks (less than $110 million), re-equipment of both pools in this manner is justified.

C13. The NRC has determined that the potential for a reactor core-melt accident must be considered in an environmental impact statement for the re-licensing of a nuclear power plant. Thus, the NRC has determined that such an accident is neither remote nor speculative. A spent-fuel-pool fire at Pilgrim or Vermont Yankee has, by estimation in this report, a probability comparable to the probability of a reactor core-melt accident. The offsite radiological impact of the pool fire could be substantially greater than the impact of the core-melt accident. Therefore, the potential for a pool fire should be considered in a re-licensing EIS to at least the depth accorded the consideration of a core-melt accident.

C14. Entergy should withdraw, revise and re-submit its Environmental Reports for Pilgrim and Vermont Yankee. The revised ERs should address the potential for pool fires to at least the depth of analysis that is employed for reactor accidents. The pool-fire analysis should consider the full range of potential initiating events, including acts of malice. *Options for reducing the risks of pool fires should be considered to at least the* depth of analysis that is employed for SAMAs in the context of reactor accidents.

C15. The NRC should prepare supplements to its August 1979 Generic Environmental Impact Statement on handling and storage of spent fuel (NUREG-0575), and its May 1996 GEIS on license renewal (NUREG-1437). These supplements should address the risks of spent-fuel-pool fires to at least the depth of analysis and experiment that was conducted to prepare the NRC's December 1990 study on the risks of reactor accidents (NUREG-1150). Acts of malice should be considered. In addition, the supplements should identify a range of options to reduce the risks of pool fires, and should comprehensively assess the benefits and costs of these options.

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Table 3-1
Selected Characteristics of the Pilgrim and Vermont Yankee Plants

Characteristic	Pilgrim	Vermont Yankee
Reactor type	BWR Mark 3	BWR Mark 4
Containment type	Mark 1: Drywell and free-standing torus	Mark 1: Drywell and free-standing torus
Rated power	2,028 MWt	1,593 MWt; application pending for 20% uprate to 1,912 MWt
Number of fuel assemblies in reactor core	580	368
Date of first commercial operation	December 1972	November 1972
Date of expiration of present operating license	June 2012	March 2012
Heat sink	Ocean	Connecticut River and/or cooling towers
Inventory of cesium-137 in reactor core	1.90E+17 Bq (Assumed power: 2,028 MWt)	1.79E+17 Bq (Assumed power: 1,912 MWt)

Sources:
(a) Jay R. Larson, *System Analysis Handbook, NUREG/CR-4041*, USNRC, November 1985.
(b) License renewal application, Appendix E (for each plant).

Table 3-2
Selected Characteristics of the Spent-Fuel Pools at the Pilgrim and Vermont Yankee Plants

Characteristic	Pilgrim	Vermont Yankee
Licensed capacity	3,859 fuel assemblies	• In 1988: 2,870 fuel assemblies; unused floor space could hold racks with potential additional capacity of about 360 assemblies • At present: 3,355 fuel assemblies, incl. temporary, 266-cell rack in cask position
Inventory at end of 2002	2,274 fuel assemblies	2,671 fuel assemblies
Capacity needed for full-core discharge	580 fuel assemblies.	368 fuel assemblies
Floor dimensions	40 ft 4 in by 30 ft 6 in; 5 ft 8 in thick	40 ft 0 in by 26 ft 0 in; 5 ft 0 in thick including 11 in of grout
Depth	38 ft 9 in	38 ft 9 in
Wall thicknesses	Reactor shield wall forms one face; thicknesses of other walls range from 4 ft 1 in to 6 ft 1 in.	Reactor shield wall forms one face; thicknesses of other walls range from 4 ft 6 in to 6 ft 0 in.
Typical spent fuel assembly	General Electric 8x8; 210 kgU per assembly	General Electric 8x8; 210 kgU per assembly

Sources:
(a) USNRC documentation of Amendment No. 155, Pilgrim operating license.
(b) USNRC documentation of Amendment No. 104, Vermont Yankee operating license.
(c) P. G. Prassinos et al, *Seismic Failure and Cask Drop Analyses of the Spent Fuel Pools at Two Representative Nuclear Power Plants, NUREG/CR-5176*, USNRC, January 1989.
(d) Vermont Yankee Nuclear Power Corporation, *Vermont Yankee Spent Fuel Storage Rack Replacement Report*, April 1986.
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Table 3-3
Estimation of Cesium-137 Inventory in a Spent-Fuel Assembly and the Reactor Core, for the Pilgrim and Vermont Yankee Plants

Estimation Step	Pilgrim	Vermont Yankee
Fuel burnup at discharge	B MWt-days per kgU	B MWt-days per kgU
Discharge burnup assuming each fuel assembly has a mass of 210 kgU	210xB MWt-days per assembly	210xB MWt-days per assembly
Reactor characteristics	• Rated power: 2,028 MWt • 580 fuel assemblies	• Rated power: 1,912 MWt • 368 fuel assemblies
Av. rated power per assembly	2,028/580 = 3.50 MWt	1,912/368 = 5.20 MWt
Av. full-power days per assembly	210xB/3.50 = 60.0xB days	210xB/5.20 = 40.4xB days
Av. full-power days per assembly, assuming B = 30	1,800 days = 4.93 yr	1,212 days = 3.32 yr
Av. actual days of exposure per assembly, assuming plant capacity factor = 0.90	2,000 days = 5.48 yr	1,347 days = 3.69 yr
Cesium-137 inventory in av. fuel assembly at completion of exposure	7.24E+14 Bq	7.39E+14 Bq
Approx. core inventory of cesium-137	((7.24E+14)/2)x580 = 2.10E+17 Bq	((7.39E+14)/2)x368 = 1.36E+17 Bq
Core inventory of cesium-137 as reported in Appendix E of license renewal application	1.90E+17 Bq	1.79E+17 Bq

Notes:
Here, calculation of the cesium-137 inventory in an average fuel assembly assumes steady-state fission of uranium-235 with an energy yield of 200 MeV per fission and a cesium-137 fission yield of 6.2 percent, over the actual days of exposure with a constant power level of 0.90 times the rated power level.

Table 3-4
Estimated Future Inventory and Selected Characteristics of Spent Fuel in Pools at the Pilgrim and Vermont Yankee Plants

Estimation Step	Pilgrim	Vermont Yankee
Licensed capacity	3,859 fuel assemblies	3,089 fuel assemblies (Not including temporary, 266-cell rack in cask position)
Capacity needed for full-core discharge	580 fuel assemblies	368 fuel assemblies
Assumed periodic offload of older fuel assemblies to onsite dry-storage modules	Offload to fill 3 modules, each of 68-assembly capacity: 204 assemblies	Offload to fill 3 modules, each of 68-assembly capacity: 204 assemblies
Average inventory of spent fuel, assuming pool used at near-full capacity	3,859 – 580 – 204/2 = 3,177 fuel assemblies	3,089 – 368 – 204/2 = 2,619 fuel assemblies
Av. period of exposure of assembly in core, assuming burnup of 30 MWt-days per kgU and plant capacity factor of 0.90	5.48 yr	3.69 yr
Av. age of fuel assemblies after discharge to pool	(3,177/(580/5.48))/2 = 15.0 yr	(2,619/(368/3.69))/2 = 13.1 yr
Cesium-137 in av. fuel assembly at discharge	7.24E+14 Bq	7.39E+14 Bq
Cesium-137 in pool, assuming all assemblies at average age	1.63E+18 Bq (44.1 MCi)	1.43E+18 Bq (38.6 MCi)
Mass of zirconium in pool, assuming 60 kg per fuel assembly	191,000 kg	157,000 kg

Notes:
Data on a General Electric 8x8 fuel assembly are provided in Table G.4 of: USNRC, *Generic EIS on Handling and Storage of Spent Light Water Power Reactor Fuel, NUREG-0575,* August 1979. The total mass of an assembly is 275 kg and the mass of uranium is 210 kg. If all non-U mass were Zr, then the mass ratio of Zr to U would be 0.31. For comparison, masses of U and Zr in the core of the Peach Bottom BWR are provided in Table 4.7 of: M. Silberberg et al, *Reassessment of the Technical Bases for Estimating Source Terms, NUREG-0956,* USNRC, July 1986. The U mass is 138 Mg and the Zr mass is 64.1 Mg. Thus, the mass ratio of Zr to U in the core is 0.46. In the table above, it is assumed that each fuel assembly contains 60 kg of Zr, representing a Zr-to-U mass ratio of 0.29.

Table 3-5
Illustrative Inventories of Cesium-137

Case	Inventory of Cesium-137 (TBq)
Produced during detonation of a 10-kilotonne fission weapon	67
Released to atmosphere during Chernobyl reactor accident of 1986	89,000
Released to atmosphere during nuclear-weapon tests, primarily in the 1950s and 1960s (Fallout was non-uniformly distributed across the planet, mostly in the Northern hemisphere.)	740,000
In Pilgrim spent-fuel pool during period of license extension	1,630,000
In Vermont Yankee spent-fuel pool during period of license extension	1,430,000
In Pilgrim reactor core	190,000
In Vermont Yankee reactor core	179,000

Notes:
(a) 1 Tbq = 1.0E+12 Bq = 27.0 Ci
(b) Inventories in the first three rows are from Table 3-2 of: Gordon Thompson, *Reasonably Foreseeable Security Events: Potential threats to options for long-term management of UK radioactive waste*, A report for the UK government's Committee on Radioactive Waste Management, IRSS, 2 November 2005.
(c) Inventories in the fourth and fifth rows are author's estimates set forth in this report.
(d) Inventories in the sixth and seventh rows are from Appendix E of the license renewal application for each plant.

Table 4-1
Estimated Duration of Phases of Implementation of the Yucca Mountain Repository

Phase of Repository Implementation		Duration of Phase (years)	
		If Yucca Mountain Total Inventory of Commercial Spent Fuel = 63,000 MgU	If Yucca Mountain Total Inventory of Commercial Spent Fuel = 105,000 MgU
Construction phase		5	5
Operation and monitoring phases	Development	22	36
	Emplacement	24-50	38-51
	Monitoring	76-300	62-300
Closure phase		10-17	12-23

Notes:
(a) These estimates are from the Final EIS for Yucca Mountain, DOE/EIS-0250F, Volume I, February 2002, pages 8-8 and 2-18.
(b) The Development and Emplacement phases would begin on the same date. Other phases would be sequential.
(c) The Construction phase would begin with issuance of construction authorization, and end with issuance of a license to receive and dispose of radioactive waste.

Table 4-2
Potential Emplacement Area of the Yucca Mountain Repository for Differing Spent-Fuel Inventories and Operating Modes

Total Inventory of Commercial Spent Fuel in Repository (MgU)	Emplacement Area (acres)	
	Higher-Temperature Operating Mode	Lower-Temperature Operating Modes
63,000	1,150	1,600 to 2,570
105,000	1,790	2,480 to 3,810

Source: Final EIS for Yucca Mountain, DOE/EIS-0250F, Volume I, February 2002, page 8-9.

Table 4-3
Estimated Number of Radioactive-Waste Shipments to the Yucca Mountain Site

Category of Radioactive Waste	Total Number of Shipments			
	If Yucca Mountain Total Inventory of Commercial Spent Fuel = 63,000 MgU		If Yucca Mountain Total Inventory of Commercial Spent Fuel = 105,000 MgU	
	By Truck	By Rail	By Truck	By Rail
** *If shipment mostly by truck* **				
Commercial spent fuel	41,000	0	80,000	0
All wastes	53,000	300	*109,000 to* 110,000	*300 to 360*
** *If shipment mostly by rail* **				
Commercial spent fuel	1,100	7,200	3,100	13,000
All wastes	1,100	9,700	3,100	18,000 to 19,000

Source: Final EIS for Yucca Mountain, DOE/EIS-0250F, Volume I, February 2002, page 8-8.

Table 4-4
Characteristics of BWR-Spent-Fuel Storage Canisters or Disposal Packages Proposed for Use at the Monticello or Skull Valley ISFSIs, or at Yucca Mountain

Category	*Characteristics of Storage Canister or Disposal Package*		
	NUHOMS 61BT Storage Canister (proposed for Monticello ISFSI)	**HI-STORM 100 MPC-68 Storage Canister (proposed for Skull Valley)**	**Proposed Disposal Package for Emplacement in Yucca Mountain**
Vendor	Transnuclear West	Holtec	Unknown
Capacity (number of BWR fuel assemblies)	61	68	24 or 44
Wall thickness	0.5 in. (stainless steel)	0.5 in. (stainless steel)	2.0 in. (stainless steel) plus 0.8 in. outer layer (Alloy 22)
Length	196.0 in.	190.3 in.	201.0 in. (for 24 assemblies) or 203.3 in. (for 44 assemblies)
Diameter	67.2 in.	68.4 in.	51.9 in. (for 24 assemblies) or 65.9 in. (for 44 assemblies)
Neutron absorber material	Boral	Boral	Borated stainless steel
Fill gas	Helium	Helium	Helium
Presence of aluminum thermal shunts to transfer interior heat to wall of vessel ?	No	No	No for 24 assemblies, Yes for 44 assemblies

Notes:
(a) NUHOMS data are from: Xcel Energy's Application to the Minnesota PUC for a Certificate of Need to Establish an ISFSI at the Monticello Generating Plant, 18 January 2005, Section 3.7; and Transnuclear West's FSAR for the Standardized NUHOMS system, Revision 6, non-proprietary version, October 2001.
(b) HI-STORM data are from Holtec's FSAR for the HI-STORM 100 system, Holtec Report HI-2002444, Revision 1.
(c) Characteristics of the Yucca Mountain package are from the Yucca Mountain Science and Engineering Report, DOE/RW-0539, May 2001, Section 3.

Table 5-1
Estimated Source Term for Atmospheric Release from Spent-Fuel-Pool Fire at the Pilgrim or Vermont Yankee Plant

Indicator	Pilgrim	Vermont Yankee
	** *Large Release* **	
Release to atmosphere of 100% of cesium-137 in pool	1.63E+18 Bq	1.43E+18 Bq
Thermal power of fire, assuming oxidation of 100% of Zr over 5 hrs	191,000x12.1/(5x60x60) = 128 MW	157,000x12.1/(5x60x60) = 106 MW
	** *Smaller Release* **	
Release to atmosphere of 10% of cesium-137 in pool	1.63E+17 Bq	1.43E+17 Bq
Thermal power of fire, assuming oxidation of 10% of Zr over 0.5 hrs	19,100x12.1/(0.5x60x60) = 128 MW	15,700x12.1/(0.5x60x60) = 106 MW

Notes:
(a) Pool inventories of cesium-137 and zirconium are from Table 3-4.
(b) The heat of reaction of Zr with oxygen or water is provided in Table 3-1 of: Louis Baker Jr. and Robert C. Liimatainen, "Chemical Reactions", Chapter 17 in T. J. Thompson and J. G. Beckerley (editors), *The Technology of Nuclear Reactor Safety*, MIT Press, 1973. The heat of reaction with oxygen is 12.1 MJ/kg, and the heat of reaction with water (steam) is 6.53 MJ/kg. In the table above, it is assumed that Zr reacts with air (oxygen).

Table 6-1
Licensee Estimates of Core Damage Frequency and Radioactive Release Frequency, Pilgrim Plant

Indicator	Source of Estimate	Estimated Frequency	Est. Frequency Adjusted (by factor of 6) to Account for External Events & Uncertainty
Core damage freq. (internal events)	License renewal application, App. E	6.4E-06 per yr	3.8E-05 per yr
Core damage frequency (fires)	License renewal application, App. E	1.9E-05 per yr	Not relevant
Core damage freq. (earthquakes)	License renewal application, App. E	3.2E-05 per yr	Not relevant
Large, early release frequency (internal events)	License renewal application, App. E	1.1E-07 per yr	6.8E-07 per yr
Medium, early release frequency (internal events)	License renewal application, App. E	6.5E-08 per yr	3.9E-07 per yr
Core damage frequency (internal events)	IPE, September 1992	5.8E-05 per yr	This adjustment not used in this source
Core damage frequency (fires)	IPEEE, July 1994	2.2E-05 per yr	Not relevant
Core damage frequency (earthquakes)	IPEEE, July 1994	5.8E-05 per yr (EPRI) 9.4E-05 per yr (LLNL)	Not relevant
Early release frequency (internal events)	IPE, September 1992	1.3E-05 per yr	This adjustment not used in this source
Early release frequency (earthquakes)	IPEEE, July 1994	1.6E-05 per yr (EPRI) 3.2E-05 per yr (LLNL)	Not relevant

Table 6-2
Licensee Estimates of Core Damage Frequency and Radioactive Release Frequency, Vermont Yankee Plant

Indicator	Source of Estimate	Estimated Frequency	Est. Frequency Adjusted (by factor of 10) to Account for External Events & Uncertainty
Core damage frequency (internal events)	License renewal application, App. E	5.0E-06 per yr	5.0E-05 per yr
Core damage frequency (fires)	License renewal application, App. E	5.6E-05 per yr	Not relevant
Core damage frequency (earthquakes)	License renewal application, App. E	Not estimated in this source or in IPEEE of June 1998	Not relevant
Large, early release frequency (internal events)	License renewal application, App. E	1.6E-06 per yr	1.6E-05 per yr
Medium, early release frequency (internal events)	License renewal application, App. E	2.1E-06 per yr	2.1E-05 per yr
Core damage frequency (internal events except intl. floods)	IPE, December 1993	4.3E-06 per yr	This adjustment not used in this source
Core damage frequency (internal floods)	IPEEE, June 1998	9.0E-06 per yr	Not relevant
Core damage frequency (fires)	IPEEE, June 1998	3.8E-05 per yr	Not relevant
Large, early release frequency (internal events except intl. floods)	IPE, December 1993	9.4E-07 per yr	This adjustment not used in this source
Medium, early release frequency (internal events except intl. floods)	IPE, December 1993	8.0E-07 per yr	This adjustment not used in this source

Table 6-3
Categories of Release to Atmosphere by Core-Damage Accidents at Pilgrim and Vermont Yankee Nuclear Plants

Release Magnitude		Release Timing	
Category	**Release of Cesium from Reactor Core to Atmosphere**	**Category**	**Timing of Release Initiation After Accident Begins**
High	Greater than 10%	Early	Less than 6 hrs
Medium	1% to 10%		
Low	0.1% to 1%	Intermediate	6 hrs to 24 hrs
Low-Low	0.001% to 0.1%		
Negligible	Less than 0.001%	Late	Greater than 24 hrs

Notes:
These release categories are set forth in Appendix E of the license renewal application for Vermont Yankee. In the license renewal application for Pilgrim, the same categories are used except that: (i) the Early and Intermediate categories shown in the table above are combined into one category designated as 'Early'; and (ii) the Low and Low-Low categories are combined into one category designated as 'Low'.

Table 7-1
Potential Sabotage Events at a Spent-Fuel-Storage Pool, as Postulated in the NRC's August 1979 GEIS on Handling and Storage of Spent LWR Fuel

Event Designator	General Description of Event	Additional Details
Mode 1	• Between 1 and 1,000 fuel assemblies undergo extensive damage by high-explosive charges detonated under water • Adversaries commandeer the central control room and hold it for approx. 0.5 hr to prevent the ventilation fans from being turned off	• One adversary can carry 3 charges, each of which can damage 4 fuel assemblies • Damage to 1,000 assemblies (i.e., by 83 adversaries) is a "worst-case bounding estimate"
Mode 2	• Identical to Mode 1 except that, in addition, an adversary enters the ventilation building and removes or ruptures the HEPA filters	
Mode 3	• Identical to Mode 1 within the pool building except that, in addition, adversaries breach two opposite walls of the building by explosives or other means	• Adversaries enter the central control room or ventilation building and turn off or disable the ventilation fans
Mode 4	• Identical to Mode 1 except that, in addition, adversaries use an additional explosive charge or other means to breach the pool liner and 5-ft-thick concrete floor of the pool	

Notes:
(a) Information in this table is from Appendix J of: USNRC, *Generic EIS on Handling and Storage of Spent Light Water Power Reactor Fuel, NUREG-0575*, August 1979.
(b) The postulated fuel damage ruptures the cladding of each rod in an affected fuel assembly, releasing "contained gases" (gap activity) to the pool water, whereupon the released gases bubble to the water surface and enter the air volume above that surface.

Table 7-2
Potential Modes and Instruments of Attack on a Nuclear Power Plant

Mode of Attack	Characteristics	Present Defense
Commando-style attack	• Could involve heavy weapons and sophisticated tactics • Successful attack would require substantial planning and resources	Alarms, fences and lightly-armed guards, with offsite backup
Land-vehicle bomb	• Readily obtainable • Highly destructive if detonated at target	Vehicle barriers at entry points to Protected Area
Anti-tank missile	• Readily obtainable • Highly destructive at point of impact	None if missile launched from offsite
Commercial aircraft	• More difficult to obtain than pre-9/11 • Can destroy larger, softer targets	None
Explosive-laden smaller aircraft	• Readily obtainable • Can destroy smaller, harder targets	None
10-kilotonne nuclear weapon	• Difficult to obtain • Assured destruction if detonated at target	None

Notes:
This table is adapted from a table, supported by analysis and citations, in: Gordon Thompson, *Robust Storage of Spent Nuclear Fuel: A Neglected Issue of Homeland Security*, IRSS, January 2003. Later sources confirming this table include:
(a) Gordon Thompson, testimony before the California Public Utilities Commission regarding Application No. 04-02-026, 13 December 2004.
(b) Jim Wells, US Government Accountability Office, testimony before the Subcommittee on National Security, Emerging Threats and International Relations, US House Committee on Government Reform, 4 April 2006.
(c) Marvin Fertel, Nuclear Energy Institute, testimony before the Subcommittee on National Security, Emerging Threats and International Relations, US House Committee on Government Reform, 4 April 2006.
(d) Danielle Brian, Project on Government Oversight, letter to NRC chair Nils J. Diaz, 22 February 2006.
(e) National Research Council, *Safety and Security of Commercial Spent Nuclear Fuel Storage: Public Report*, National Academies Press, 2006.

Table 8-1
Selected Options to Reduce Risks of Spent-Fuel-Pool Fires at the Pilgrim and Vermont Yankee Plants

Option	Passive or Active?	Does Option Address Fire Scenarios Arising From: Malice?	Does Option Address Fire Scenarios Arising From: Other Events?	Comments
Re-equip pool with low-density, open-frame racks	Passive	Yes	Yes	• Will substantially reduce pool inventory of radioactive material • Will prevent auto-ignition of fuel in almost all cases
Install emergency water sprays above pool	Active	Yes	Yes	• Spray system must be highly robust • Spraying water on overheated fuel can feed Zr-steam reaction
Mix hotter (younger) and colder (older) fuel in pool	Passive	Yes	Yes	• Can delay or prevent auto-ignition in some cases • Will be ineffective if debris or residual water block air flow • Can promote fire propagation to older fuel
Minimize movement of spent-fuel cask over pool	Active	No (Most cases)	Yes	• Can conflict with adoption of low-density, open-frame racks
Deploy air-defense system (e.g., Sentinel and Phalanx) at plant	Active	Yes	No	• Implementation requires presence of US military at plant
Develop enhanced onsite capability for damage control	Active	Yes	Yes	• Requires new equipment, staff and training • Personnel must function in extreme environments

Table 8-2
Selected Approaches to Protecting US Critical Infrastructure From Attack by Sub-National Groups, and Some of the Strengths and Weaknesses of these Approaches

Approach	Strengths	Weaknesses
Offensive military operations internationally	• Can deter or prevent governments from supporting sub-national groups hostile to the USA	• Can promote growth of sub-national groups hostile to the USA, and build sympathy for these groups in foreign populations • Can be costly in terms of lives, money and national reputation
International police cooperation within a legal framework	• Can identify and intercept potential attackers	• Implementation can be slow and/or incomplete • Requires ongoing international cooperation
Surveillance and control of the domestic population	• Can identify and intercept potential attackers	• Can destroy civil liberties, leading to political, social and economic decline of the nation
Active defense of infrastructure elements	• Can stop attackers before they reach the target	• Can involve higher operating costs • Requires ongoing vigilance
Passive defense of infrastructure elements	• Can allow target to survive attack without damage • Can substitute for other approaches, avoiding their costs	• Can involve higher capital costs

Table 8-3
Estimation of Cost to Offload Spent Fuel from Pools at the Pilgrim and Vermont Yankee Plants After 5 Years of Decay

Estimation Step	Pilgrim	Vermont Yankee
Present licensed capacity of pool	3,859 fuel assemblies	3,089 fuel assemblies
Pool capacity needed for full-core discharge	580 fuel assemblies	368 fuel assemblies
Anticipated av. pool inventory of spent fuel during period of license extension	3,177 fuel assemblies	2,619 fuel assemblies
Av. period of exposure of fuel assembly in core	5.48 yr	3.69 yr
Av. annual discharge of fuel from reactor	580/5.48 = 106 fuel assemblies	368/3.69 = 100 fuel assemblies
Pool capacity needed to store fuel for 5-yr decay, incl. 10% buffer	106x5x1.1 = 583 fuel assemblies	100x5x1.1 = 550 fuel assemblies
Total pool capacity needed for full-core discharge and 5-yr decay	580 + 583 = 1,163 fuel assemblies	368 + 550 = 918 fuel assemblies
Fuel requiring offload if pool storage is limited to fuel undergoing 5-yr decay	3,177 – 583 = 2,594 fuel assemblies	2,619 – 550 = 2,069 fuel assemblies
Capital cost to offload fuel, assuming 210 kgU per assembly and capital cost of $100-200 per kgU for dry storage	$54-109 million	$43-87 million

Notes:
A capital cost of $100-200 per kgU for dry storage of spent fuel is used by Robert Alvarez et al in their paper in *Science and Global Security,* Volume 11, 2003, pp 1-51.

Table 9-1
Provisional Estimate of the Probability of a Spent-Fuel-Pool Fire at the Pilgrim or Vermont Yankee Plant

Estimation Step	Pilgrim	Vermont Yankee
CDF (internal events)	2.8E-05 per yr	4.3E-06 + 9.0E-06 = 1.3E-05 per yr
CDF (fires + earthquakes)	2.2E-05 + (5.8E-05 + 9.4E-05)/2 = 9.8E-05 per yr	3.8E-05 + (5.8E-05 + 9.4E-05)/2 = 1.1E-04 per yr
CDF (internal events + fires + earthquakes)	1.3E-04 per yr	1.2E-04 per yr
Early release frequency (internal events + fires + earthquakes)	1.3E-05 + (1.3/5.8)x2.2E-05 + (1.6E-05 + 3.2E-05)/2 = 4.2E-05 per yr	1.7E-06 + (1.7/4.3)x(9.0E-06 + 3.8E-05) + (1.6E-05 + 3.2E-05)/2 = 4.4E-05 per yr
Conditional probability of a pool fire, given an early release from the reactor (internal events + fires + earthquakes)	0.5 (Author's assumption)	0.5 (Author's assumption)
Probability of a pool fire initiated by events not including malice	(4.2E-05)x0.5 = 2.1E-05 per yr	(4.4E-05)x0.5 = 2.2E-05 per yr
Probability of a maliciously-induced pool fire in the USA (99 pools)	1 per 100 yr (Author's assumption)	1 per 100 yr (Author's assumption)
Probability of a maliciously-induced pool fire at this plant	1.0E-04 per yr	1.0E-04 per yr
Total probability of a pool fire at this plant	2.1E-05 + 1.0E-04 = 1.2E-04 per yr	2.2E-05 + 1.0E-04 = 1.2E-04 per yr

Notes:
(a) CDF = core damage frequency
(b) Estimates in the first four rows are drawn from the IPEs and IPEEEs for each plant, except that the Pilgrim internal-events CDF is drawn from: Willard Thomas et al, *Pilgrim Technical Evaluation Report on the Individual Plant Examination Front End Analysis*, Science and Engineering Associates, prepared for the USNRC, 9 April 1996. Earthquake findings shown for Pilgrim are the average of the EPRI and LLNL values, and are used for both plants. The conditional probability of an early release, given core damage, is assumed to be the same for events initiated by fires and by internal events including internal flooding.
(c) The probability of a maliciously-induced pool fire in the USA is assumed to be uniformly distributed across all pools.

Table 9-2
Present Value of Cumulative (20-year) Economic Risk of a Potential Release of Radioactive Material

Selected Characteristics of the Potential Release		Present (Initial) Value of Cumulative (20-year) Economic Risk, for various Discount Rates (D)		
Economic Cost of the Release	**Probability of the Release**	**D = 7% per yr**	**D = 3% per yr**	**D = 0% per yr**
$100 billion	1.0E-03 per yr	$1.1 billion	$1.5 billion	$2 billion
	1.0E-04 per yr	$110 million	$150 million	$200 million
	1.0E-05 per yr	$11 million	$15 million	$20 million
	1.0E-06 per yr	$1.1 million	$1.5 million	$2 million

Notes:
(a) The discounted cumulative-value function is: (1-exp(-DT))/D, where T = 20.
(b) The present values shown in the table can be scaled linearly for alternative values of the economic cost or probability of the potential release.

Estimates of losses in property value. It is assumed that an area exists around the "main portion" of the plume, where potential property buyers would be concerned about residual risk. (The main portion of the plume is defined as the area where remediation or demolition takes place.) Outside the main plume, contamination would still be measurable. Lack of trust in statements by government would translate into loss in property values. All things being equal, persons would wish to live as far away from contaminated areas as possible.

Note that radioactive deposition would extend into these non-remediated areas, both from the immediate release and from resuspension in the weeks and years after the release and from subsequent demolition and remediation efforts. People would be accumulating long-term radiation doses, which government sources would say are too trivial to worry about. Expert opinion would differ on the seriousness of the long-term exposures. Confidence in government would likely drop over time based on revelations of government failings. If past patterns are followed, government leaders would early on feel compelled to downplay the true situation to prevent panic. Although it is hard to see how they could act otherwise, it is also hard to see how citizens enthusiasm for purchasing property in the vicinity of the main plume would not be weakened.

How much would property values decline? Based on expert reports filed in litigation concerning the Rocky Flats nuclear weapons facility, and the jury decision favorable to plaintiffs in that litigation (2006), I assume a 5% loss in property value for property lying within measurable contours of contamination. This is quite conservative, since the jury accepted Plaintiffs' expert assessment that residential values dropped by 7%,[13] vacant land by 30%, and commercial land by 53%. For the calculations in this report, I define the main, remediated plume as a 0.24 wedge extending out to 250 miles for the 10% release and 700 miles for the ~100% release.

Areas where property damage loss is assumed to take place extends outward from the plume to 1000 miles, which is where the damage calculations stop in (Beyea et al. 2004a). In addition, property in areas to the side of the plume are also expected to suffer a 5% loss in value. Because I have no firm basis for determining the distance to which property loss would extend, I have picked a ten-fold range. At the low end, as many people outside the main plume are assume to be affected as live in the main plume. At the high end, I pick ten times as many persons.

13 The "residential" figure appears to be some sort of compromise. It's within a range reported by expert Radke's year-by-year multiple regressions for 1988-95, but it's less than the 10% that expert Hunsperger ultimately estimated. Personal commuication, 2006, Peter Nordberg, Berger and Montague.

MACCS2 accounts for inhalation of resuspended material at the location where radioactivity is deposited (Chanin et al. 2004), Section 2, page 6-14. However, MACCS2 does not allow for redistribution of resuspended material to new locations. Yet, 10% of radioactivity deposited on vegetation may be blown off in the first few weeks,[14] with additional resuspension over decades,[15] increased dramatically by anthropogenic activity during clean up and remediation (Schershakov 1997). I adopt a net resuspension factor for Cesium-137 of 10% over the long term, which should be a conservative choice in this context.[16] To account for the latent cancers that would be caused by this redistribution of radioactivity, I have made the approximation that no such re-deposited material would be high enough to generate remediation. (If this assumption is violated, the number of latent cancers from redistributed radioactivity would go down, but it would then be necessary to increase clean-up costs.)

Based on wedge model calculations, I know that remediation reduces latent cancers by a factor of 10 or more. Thus, the contribution from redistributed radiation to total cancers, under the assumptions I have made, should be more than the direct contribution from the remediated plume (10% X 10 = 100%). A more precise calculation could be obtained by running MACCS2 in a special way, even though MACCS2 does not directly handle redistributed radioactivity. (MACCS2 only allows straight-line plume segments and does not allow wind trajectories (Chanin et al. 2004), Section 5, page 1-4.) However, MACCS2 does allow multiple straight-line segments with different starting times (Chanin et al. 2004), Section 2, page 6-14. If MACCS2 was run with extra plume segments added on to the end of a standard release sequence, with varying delay times, and a total added release equal to

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[14] (NUREG 1975), Appendix VI. Radioiodine after weapons fallout shows very rapid decline over periods of days, some of which must be due to wind action (NCI 1997), Table 4.8. The half-life for small particles is longer, about 14 days (Prohl et al. 1995). Resuspension *factors* in the early days after the Chernobyl accident have shown very high values, including 2.4 E-04 m^{-1} at one day after deposition (Schershakov 1997). Such a high rate could not be maintained without completely exhausting the surface concentration in a very short time. The resuspension factor has been estimated to drop as an inverse power of time in days, with an exponent of 0.5-to-1.67 (Schershakov 1997). At issue is the size of the resuspended material, because some radioactivity might deposit on relatively large particles on vegetation that are easily removed by wind.

[15] Resuspension *rates* measured for Chernobyl radiocesium are also high (1E-08 s^{-1}) (Schershakov 1997). When such a high uplift rate is totaled for periods of years, a 10% net loss is quite reasonable, although resuspension rates were measured to decrease by an order of magnitude over time (Schershakov 1997). Studies by my colleagues and I have indicated that underground material is brought to the surface by animal burrowing (Morrison et al. 1997; Smallwood et al. 1998), where it is subject to wind resuspension. Thus, movement into the soil of radiocesium does not keep it away from the surface forever. Smallwood has estimated from his measurements in California and Colorado that about 0.5 % of underground radioactivity should be brought to the surface each year by animal burrowing, including ant burrowing (Smallwood, personal communication, 1998). How relevant this number is to the East Coast is not known.

[16] Because of lack of data on particle sizes, analysts may differ as to how much resuspended material would be in particle sizes large enough to travel outside the main plume before remediation. However, most land area would not be remediated. In any case, it will be important for the field of contamination consequence analysis to have debates on this subject.

the assumed resuspension fraction times the initial release, then MACCS2 will produce as output the mathematical equivalent of resuspended material being carried in directions different from the main plume.

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Figure 1.

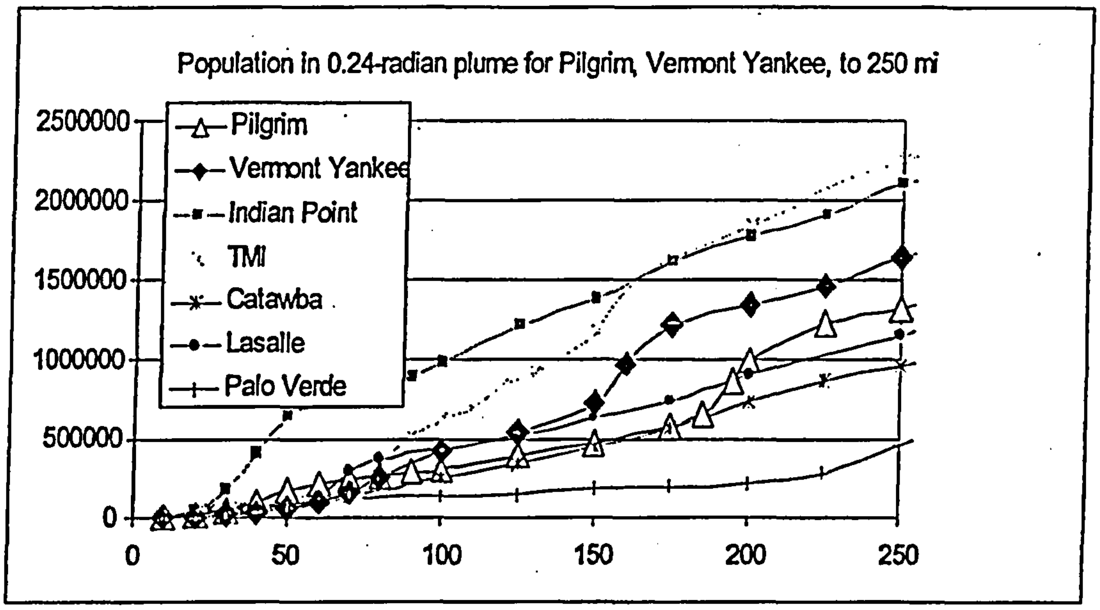
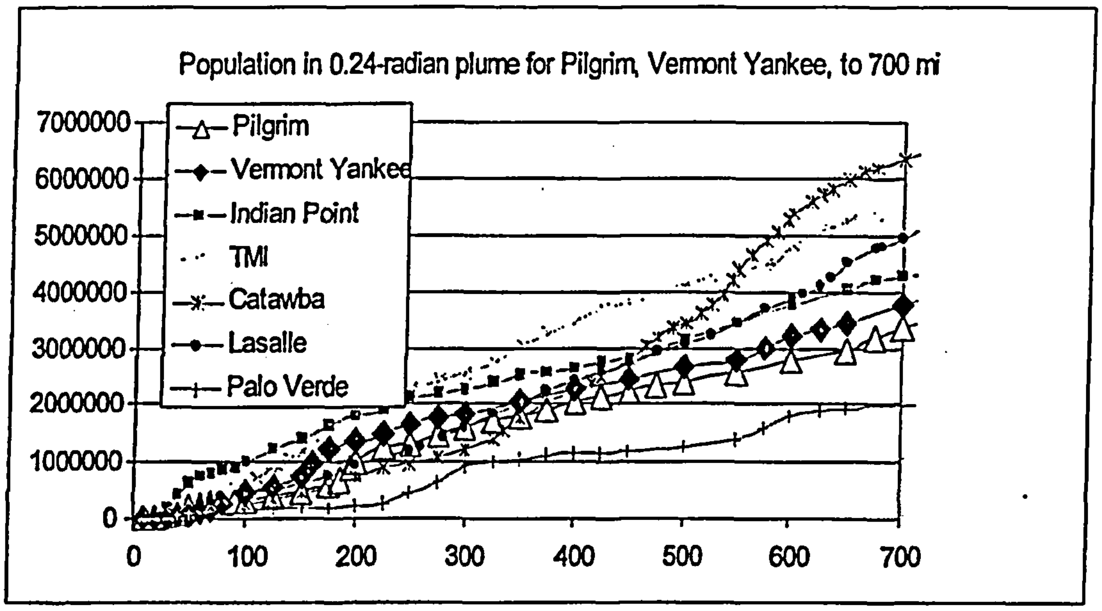

Population in 0.24-radian plume for Pilgrim, Vermont Yankee, to 250 mi
Pilgrim
Vermont Yankee
Indian Point
TMI
Catawba
Lasalle
Palo Verde
2500000
2000000
1500000
1000000
500000
0
0
50
100
150
200
250

Figure 2.



Population in 0.24-radian plume for Pilgrim, Vermont Yankee, to 700 mi
7000000
6000000
5000000
4000000
3000000
2000000
1000000
0
Pilgrim
Vermont Yankee
Indian Point
TMI
Catawba
Lasalle
Palo Verde
0
100
200
300
400
500
600
700

Figure 3. Calculated with the SECPOP 2000 computer code (Bixler et al. 2003).

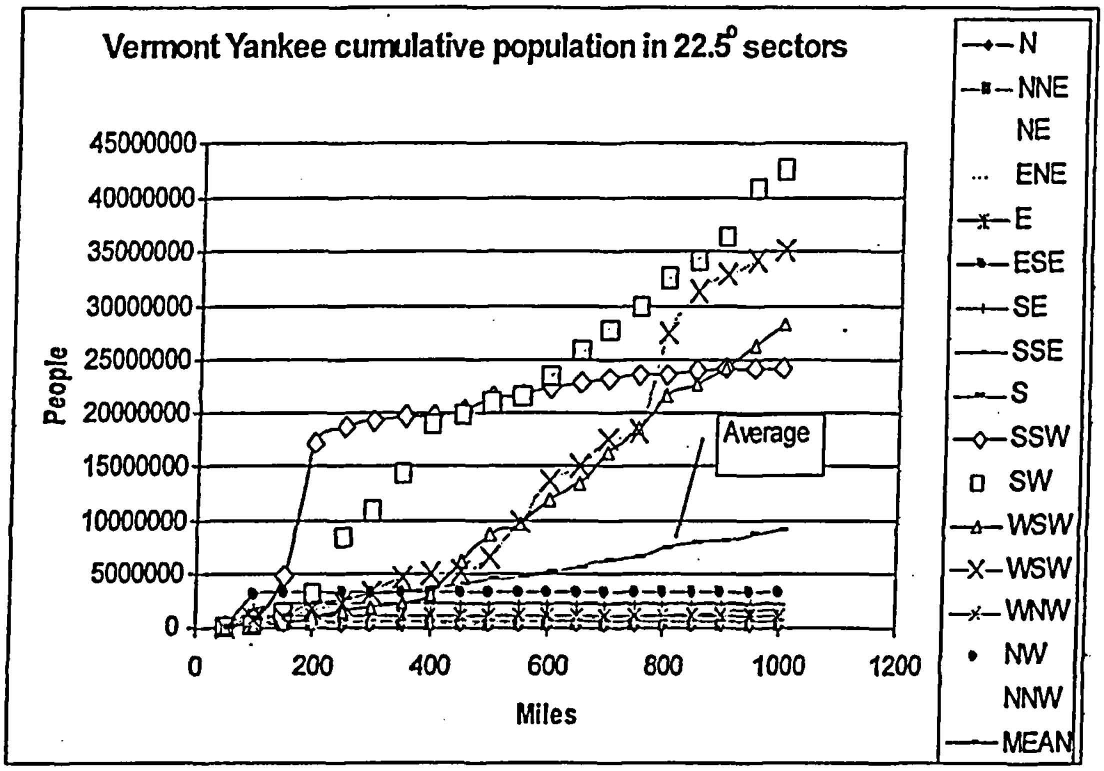


Figure 4. Calculated with the SECPOP 2000 computer code (Bixler et al. 2003).

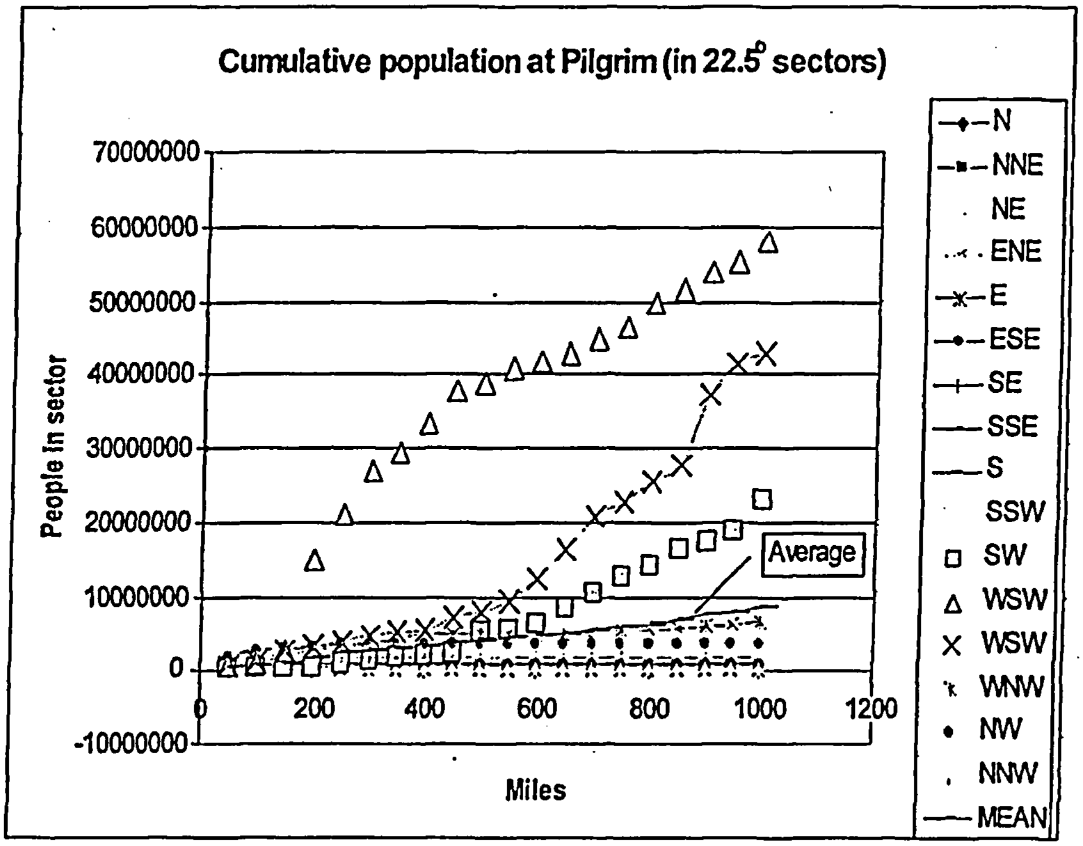


Figure 5: In the wind rose below for Pilgrim, an excess frequency beyond the 4% circle is shown for winds coming from the Southwest, which would blow out over the ocean. Ignoring return flows, such excess flows would not contribute to damage. The excess beyond the 4% circles is about 33% of the total year. Removing this excess leaves a roughly axially-symmetric flow, which matches the assumptions used in the paper by Beyea, Lyman, and von Hippel.

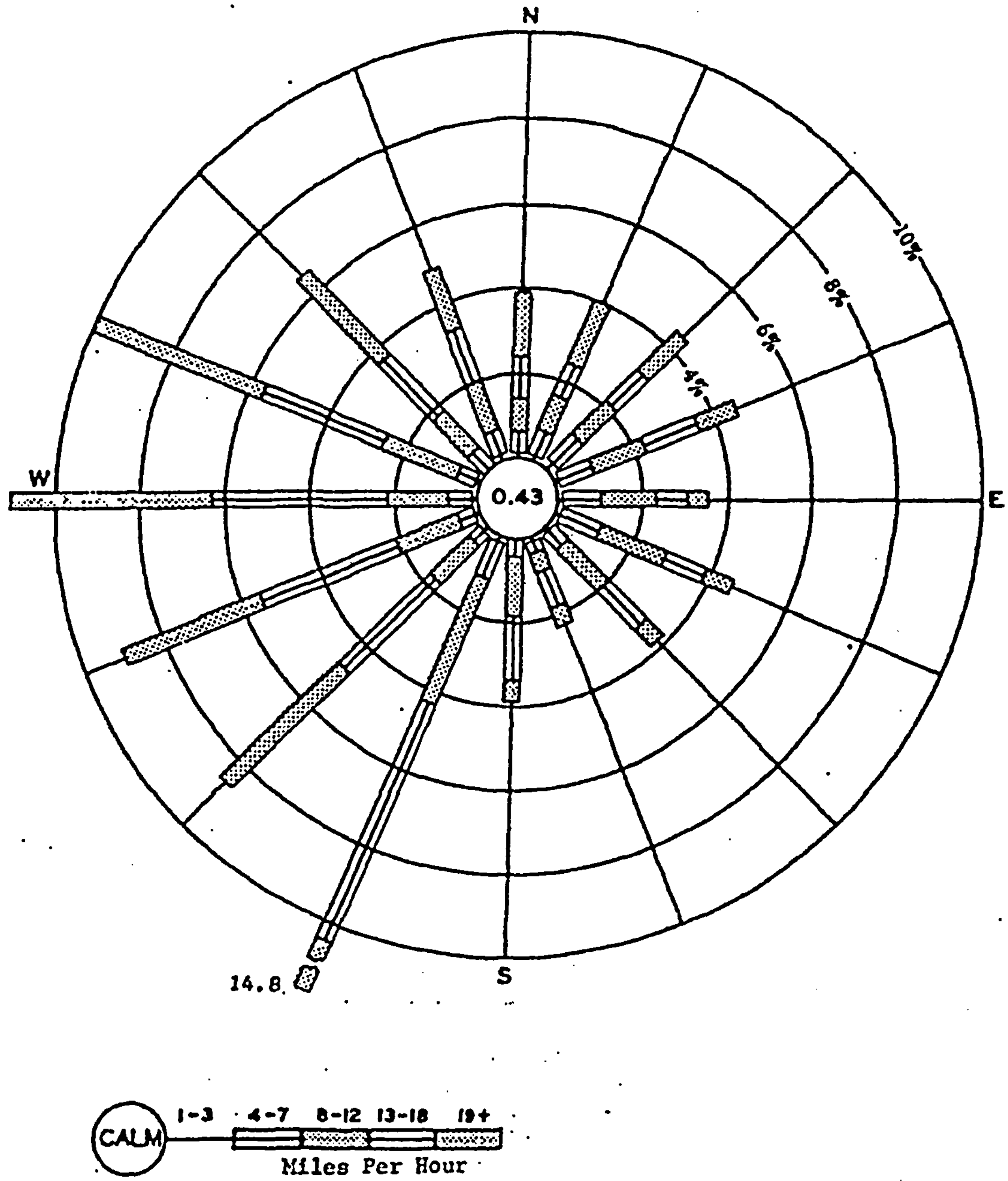


FIGURE 2.3-6
ELEVATION 300 FT. MSL
WIND ROSE ANNUAL
PILGRIM SITE
PILGRIM NUCLEAR POWER STATION
FINAL SAFETY ANALYSIS REPORT

EXHIBIT

2

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
BEFORE THE COMMISSION

In the Matter of Entergy Nuclear Operations, Inc. (Vermont Yankee Nuclear Power Station)	)))))))	Docket No. 50-271

DECLARATION OF DR. JAN BEYEA
IN SUPPORT OF MASSACHUSETTS ATTORNEY GENERAL'S
CONTENTION AND PETITION FOR BACKFIT ORDER

I, Jan, Beyea, *declare as follows:*

1. I am senior scientist at Consulting in the Public Interest, providing scientific assistance to not-for-profits, universities, government, and injured plaintiffs.

2. In support of the Massachusetts Attorney General's request for hearing, petition to intervene and backfit petition respect to the license renewal proceeding for the Vermont Yankee nuclear power plant, I have prepared a report entitled "report to the Massachusetts Attorney General on the Potential Consequences of a Spent-Fuel Pool Fire at the Pilgrim or Vermont Yankee Nuclear Plant (May 25, 2006). In preparing my report, I reviewed the environmental report, the 1972 EIS, the FSAR, and the NRC's 1996 generic relicensing EIS. In addition, I reviewed technical documents relating to risks of spent fuel storage at this facility, which are identified in my Report. One of those documents was the report of Gordon Thompson, Ph.D.

3. The technical factual statements in my report are true and correct to the best of my knowledge, and the technical opinions expressed therein are based on my best professional judgment.

4. I am an expert regarding the consequences of both real and hypothetical nuclear accidents, as well as strategies for mitigation. I also have expertise in technical safety and environmental analysis related to nuclear facilities. My Curriculum Vitae is provided here as Attachment A.

5. I am a regular member of panels and boards of the National Research Council of the National Academy of Sciences and an advisor to the Division of Engineering and Physical Sciences.

6. After receiving my Ph.D. in nuclear physics from Columbia University, I taught environmental studies at Holy Cross College. Next, I did research at Princeton's Center For Energy and Environmental Studies modeling the consequences of nuclear accidents. I then spent 15 years at the National Audubon Society as Senior Policy Scientist, and ultimately as Chief Scientist and Vice President.

7. I am the author of over 100 articles and reports that span a diverse range of topics. I am a regular peer reviewer of articles for scientific journals. One of my specialties is geographic exposure modeling of toxic releases. My reconstruction of exposures following the TMI accident has been used in radiation epidemiologic studies. My reconstructions of historical exposures to traffic pollution are being used in two ongoing epidemiologic studies of breast cancer. I am a co-author of studies on risks and consequences of spent-fuel-pool fires. I presented a briefing on this work to a committee of the National Research Council that was studying risks of spent fuel.

8. I am prepared to testify as an expert witness on behalf of the Massachusetts Attorney General with respect to the facts and opinions set forth in my Report.

****

I declare, under penalty of perjury, that the foregoing facts provided in my Declaration are true and correct to the best of my knowledge and belief, and that the opinions expressed herein are based on my best professional judgment.

Executed on 25 May 2006.

Jan Beyea

Jan Beyea

(609-397-2370), jbeyea@cipi.com

EDUCATION:

Ph.D., Columbia University, 1970 (Nuclear Physics).
B.A., Amherst College, 1962.

PROFESSIONAL EXPERIENCE:

1968 to 1970	Research Associate, Columbia University Physics Department.
1970 to 1976	Assistant Professor of Physics, Holy Cross College.
1976 to 1980	Research Staff, Ctr. for Energy & Env. Studies, Princeton Univ.
1980 to 1991	Senior Scientist, National Audubon Society, NY. NY.
1992 to 1995	Chief Scientist & Vice President, National Audubon Society, NY, NY
1996 to date	Senior Scientist, Consulting in the Public Interest, Lambertville, NJ

ADVISORY ACTIVITIES & APPOINTMENTS:

Current:
-Member, Committee on Alternatives to Indian Point, National Research Council
-Nat. Academies of Science, Division Advisor (Division on Engineering and Physical Sciences).
-Consultant on human exposure assessment to 1) Columbia U., 2) NCI's Radiation Division, 3) U Buffalo Dept. of Social & Preventive Med., and 4) UNC Epidemiology Dep't.
-Consultant to law firm of Berger & Montague on dose and health effects reconstruction from the Hanford and Rocky Flats nuclear weapons complexes.
-Consultant to the National Audubon Society on forest habitat research.

Past:
-Peer reviewer for the American Journal of Public Health, Environmental Health Perspectives, Environmental Toxicology and Chemistry, Bioscience, Atmospheric Chemistry and Physics, and various Boards of the National Research Council, including the Board on Radioactive Waste
-Nat. Research Council (Nat. Academies of Science), Committee on Alternatives for the Release of Solid Materials from Nuclear Regulatory Commission-Licensed Facilities, 2001-2002. Chair of technical committee.
-Member, Technical Advisory Committee on Forest Health Monitoring, Assessment and Evaluation, New York State Department of Environmental Conservation, 2001-2002
- Nat. Research Council, Comm. on DOE'S Fine Particulate Research Program, 1999
- Nat. Research Council, Board on Energy and Environmental Systems, 1993-1998.
- Nat. Research Council, Committee on "Linking Sci. & Tech. to Society's Environ. Goals."
- Board Member, Recycling Advisory Council, sponsored by the EPA, 1994-1996
- Composting Committee, Coalition of Northeastern Governors (co-chair) 1994-1996
- Member, Source Reduction Task Force, Coalition of Northeastern Governors 1991-1995
- Secretary of Energy's Advisory Board, Task Force on Economic Modeling, 1991
- National Research Council, Comm. on Alternative Energy R&D Strategies, 1990-1991
- Office of Technology Assessment, Advisor to various studies, 1984-1988

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"Plutonium distribution in the environs of Rocky Flats." (With Milton Hoenig), Health Physics (letter) 73(1), 271-272 (1997)

"Comments on 'A Reevaluation of Cancer Incidence near the Three Mile Island Nuclear Plant'" (with Hatch and Susser), Environ Health Perspectives 105(1), 12 (1997)

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Emergency Planning," testimony and cross-examination before the Nuclear Regulatory Commission's Atomic Safety and Licensing Board, on behalf of the New York State Attorney General and others, July, 1982.

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"Traffic Polycyclic Aromatic Hydrocarbons (PAHs), Genetic Susceptibility and Risk of Breast Cancer." (Nie, Beyea, Bonner, Han, Vena, Rogerson, Vito, Muti, Trevisan, Shields, and Freudenheim). 3rd International Congress of Developmental Origins of Health and Disease, November 16-19, 2005, Toronto.

"Residential environmental exposures and other characteristics associated with detectable PAH-DNA adducts in peripheral mononuclear cells in a population-based sample of adult females." Shantakumar S, et al., J Expo Anal Environ Epidemiol advance online publication, 27 April 2005; doi:10.1038/sj.jea.7500426.

"Emissions of polycyclic aromatic hydrocarbons from US gasoline-powered vehicles from 1960 to 1995 for use in epidemiologic studies." (Beyea, Hatch, Stellman, Gammon). Submitted.

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"Development of a traffic model for predicting airborne PAH exposures since 1960 on Long Island, New York," Beyea, Hatch et al., Report to the National Cancer Institute and the National Institute

of Environmental Health Sciences for work completed under USPHS Grant U01-CA/ES-66572.
http://www.cipi.com/pdf/beyea2005trafficpahmodel.pdf

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"Historical reconstruction of exposure to polycyclic aromatic hydrocarbons and model validation: examples from the Long Island Breast Cancer Study Project." (Beyea, Hatch, Stellman, Gammon et al.) Invited paper to be presented at the Joint Conference of the International Society of Exposure Analysis and the International Society for Environmental Epidemiology, Vancouver, August 2002.

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"The Power of Composting, The Power of Partnership", speeches for the National Recycling Confernece, Oct. 1993, GMA/FMI environmental conference, March 1993, the U.S. Conference of Mayors, April 1993, and the Biocycle conference, May 1993.

"Paper Versus Plastic" in The Plastic Waste Primer, The League of Women Voters/Handbook for Citizens, Lyons & Burford, Oct. 1992.

The Audubon Proposal for Solid Waste Management in Jefferson County and the City of Louisville, Kentucky, Dec. 1991. Also Review of Proposed Resource Recovery Agreement Between the City of Louisville and Louisville Energy and Environment.

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Plastics vs. Paper: Some Environmental Considerations, Audubon Report, 1989.

"Indoor Air Pollution", Bulletin of Atomic Scientists, 37, p. 63, Feb., 1981.

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Energy Policy and Global Warming", in Global Climate Change and Life on Earth, Chapman & Hall, New York, 1991.

"The CO2 Diet for a Greenhouse Planet: Assessing Individual Actions for Slowing Global Warming." In Energy Efficiency and the Environment: Forging the Link. American Council for an Energy-Efficient Economy; Washington, DC. (Also: "The CO2 Diet for a Greenhouse Planet: A Citizen's Guide for Slowing Global Warming." National Audubon Society Report). 1991; and "The Audubon Activist Carbon Dioxide Diet", Audubon Activist, p. 8-9, January/February, 1990.) (All with with DeCicco, Cook, and Bolze.)

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"Dealing with Uncertainties in Projections of Electricity Consumption", before the Committee on Energy and Natural Resources, U. S. Senate, July 25, 1985.

"Computer Modeling for Energy Policy Analysis", (Medsker, Beyea, and Lyons), Proceedings of the 15th Annual Modeling and Simulation Conference, Pittsburgh, PA, 15, part 3, p. 1111, 1984.

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Subcommittee on Oversight and Investigations of the House Committee on Science and Technology; Committee Print No. 14, June 1-2, 1981.

"Locating and Eliminating Obscure but Major Energy Losses in Residential Housing", (Harrje, Dutt, and Beyea), ASHRAE Transactions, 85, Part II, 1979. (Winner of ASHRAE outstanding paper award.)

"Attic Heat Loss and Conservation Policy", (Dutt, Beyea, and Sinden). ASME Technology and Society Division Paper 78-TS-5, Houston, Texas, 1978.

"Critical Significance of Attics and Basements in the Energy Balance of Twin Rivers Townhouses", (Beyea et al), Energy and Buildings, Vol. I (1977), p. 261. Also Chapter 3 of Saving Energy in the Home, Ballinger, 1978.

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"Long-Term Threats to Canada's James Bay from Hydroelectric Development", Information North, Arctic Institute of North America, Alberta, Canada, Sept. 1990.

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Articles and reports on resolving scientific uncertainties through partnership

"Guidelines to Sustain Biodiversity in Northeastern Pennsylvania Forests", (with T.S. Fredericksen, W. Hoffman, B.N. Johnson, and M.B. Lester), A Partnership Project with the Procter & Gamble Co., Poster at Mid-Atlantic Highlands Assessment Conference, Davis, WVA. October, 1995.

Report To The Massachusetts Attorney General On The Potential Consequences Of A Spent-Fuel-Pool Fire At The Pilgrim Or Vermont Yankee Nuclear Plant.

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May 25, 2006

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Personal Background. I am a nuclear physicist who has studied the consequences of both real and hypothetical nuclear accidents, as well as strategies for mitigation. I am a regular member of panels and boards of the National Research Council of the National Academy of Sciences and an advisor to the Division of Engineering and Physical Sciences. After receiving my Ph.D. in nuclear physics from Columbia University, I taught environmental studies at Holy Cross College. Next, I did research at Princeton's Center For Energy and Environmental Studies modeling the consequences of nuclear accidents. I then spent 15 years at the National Audubon Society as Senior Policy Scientist, and ultimately as Chief Scientist and Vice President. Currently, I am senior scientist at Consulting in the Public Interest, providing scientific assistance to not-for-profits, universities, government, and injured plaintiffs.

I am the author of over 100 articles and reports that span a diverse range of topics. I am a regular peer reviewer of articles for scientific journals. One of my specialties is geographic exposure modeling of toxic releases (Beyea and Hatch 1999). My reconstruction of exposures following the TMI accident has been used in radiation epidemiologic studies (Hatch et al. 1990; Hatch et al. 1991). My reconstructions of historical exposures to traffic pollution (Beyea et al.; Beyea et al. 2005) are being used in two ongoing epidemiologic studies of breast cancer (Gammon et al. 2002), (Nie et al. 2005). I am a co-author of studies on risks and consequences of spent-fuel-pool fires (Alvarez et al. 2003a), (Beyea et al. 2004a), (Beyea 1979). I presented a briefing on this work to a committee of the National Research Council that was studying risks of spent fuel.

Introduction I have been asked by the Office of the Attorney General, Commonwealth of Massachusetts, to consider the consequences of releases of radioactivity from spent-fuel-pool fires at the Pilgrim and Vermont Yankee nuclear plants, as part of a relicensing proceeding. In my report I consider important new information on the consequences of releases of radioactivity, in general, and spent-fuel-pool fires, in particular, that was not available to the analysts who prepared earlier documents that are relevant to these proceedings. For example, this new information, which deals with damage costs and radiation risks, was not available prior to the publication of the Environmental Reports for Pilgrim and Vermont Yankee; it was not available prior to the publication of the generic relicensing environmental impact statement (NUREG 1996); and, some of it was not available prior to the filing of Entergy's license renewal application. Consequently, these earlier documents are incomplete from the scientific perspective.

I have addressed the consequences of releases from spent-fuel pools prior to these proceedings (Alvarez et al. 2003a), (Beyea et al. 2004a), (Beyea 1979), in some cases in collaboration with Gordon Thompson, Ph.D., who is filing a separate report in these proceedings. The work we have done has led to a study of the National Research Council[1] and has generated considerable debate and commentary (Alvarez et al. 2003b; Alvarez et al. 2003c; Beyea et al. 2004b)). We have revised our calculations to account for criticisms we thought were valid and easily addressable. In particular, Edwin Lyman, Frank von Hippel and I, in our most recent published work (Beyea et al. 2004a), which forms the backbone of this report on Pilgrim and Vermont Yankee, have specifically responded to criticisms by NRC staff concerning the use of constant population densities around nuclear plants (Alvarez et al. 2003c). In this report, I have addressed additional limitations that raised concerns about our earlier work in some circles. Although critiques of our independent work indicate that there are differences among analysts on the quantity of radioactivity that might be released in a spent-fuel-pool fire and the probability of such releases, there is a consensus among the technical community that this problem needs to be addressed.[2,3]

For my report, I have considered releases of 10% and 100% of the pool inventory, using methodologies outlined in (Alvarez et al. 2003a) and (Beyea et al. 2004a). I have also provided

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1 For a discussion of the relationship between our study and the National Research Council's report (NatRC 2005), see remarks of Kevin Crowley before the Council on Foreign Relations (Crowley 2005).

2 Allan Benjamin, lead author of the original 1979 spent-fuel paper from Sandia Laboratory, was a reviewer of our 2003 paper in SG&S. He provided a public commentary on it, in which he stated, "In summary, the authors are to be commended for identifying a problem that needs to be addressed, and for scoping the boundaries of that problem. However, they fall short of demonstrating that their proposed solution is cost effective or that it is optimal." (Benjamin 2003). Whether or not we "fell short" in demonstrating cost effectiveness or optimality is not the issue at this stage in the relicensing proceedings.

3 It was in 2005, after the relicensing GEIS was completed, that the National Research Council (NatRC) released its study on risks of spent-fuel-pool fires.

> "The committee judges that successful terrorist attacks on spent fuel pools, though difficult, are possible.
>
> ... If an attack leads to a propagating zirconium cladding fire, it could result in the release of large amounts of radioactive material.
> ... Additional analyses are needed to understand more fully the vulnerabilities and consequences of events that could lead to propagating zirconium cladding fires.
> ... it appears to be feasible to reduce the likelihood of a zirconium cladding fire by rearranging spent fuel assemblies in the pool and making provision for water-spray systems that would be able to cool the fuel, even it the pool or overlying building were severely damaged.
> ...Dry cask storage has inherent security advantages over spent fuel pool storage, but it can only be used to store older spent fuel.
>
> The committee judges, however, that further engineering analyses and cost-benefit studies would be needed before decisions on this and other mitigative measures are taken." (NatRC 2005)

I note that such engineering analyses and cost-benefit studies have not been published by the applicants.

additional calculations that a) fill in some gaps left in earlier work, and b) take into account new information that has recently become available. 10% and 100% are the release fractions recommended for consideration by Gordon Thompson in his report. I have read his report and find it consistent with my knowledge of this field. These release fractions match earlier published work by Thompson, myself, and co-authors (Alvarez et al. 2003a), (Beyea et al. 2004a). They also are consistent in order of magnitude with values considered appropriate by the analyst who did the original work on releases from spent-fuel pools.[4] In addition to a 10% and 100% release fraction, I have also considered (briefly) a smaller release. I have presented general formulas that can be used to estimate consequences for a wide range of releases, other than 10% or 100%.

Thompson finds the inventory of Cesium-137 to be somewhat higher at Pilgrim and Vermont Yankee than the default inventory for a generic reactor considered in (Alvarez et al. 2003a). The differences are not major. I have reviewed Thompson's analysis and find his values reasonable for me to use.

Thompson has estimated the heat rate of a spent-fuel-pool fire to be higher at Pilgrim and Vermont Yankee than estimated for a generic spent-fuel pool in (Alvarez et al. 2003a). The difference in resulting plume rise is within one standard deviation for plume rise, using standard formulas, so it has not been necessary for me to modify my calculations with respect to plume rise.

Before submitting a report on consequences of a 10% and 100% release, I have made an independent assessment to assure myself that such releases are probable enough to be more than a mathematical exercise. I have already noted that many analysts have found that the generic, spent-fuel-pool problem needs to be addressed. In addition, I have reviewed the treatment of release probabilities in the companion report of Gordon Thompson, Ph.D. I find his analysis reasonable and conservative. I am certainly comfortable relying on his plant-specific probability numbers for this proceeding. I note that his estimate of the probability of a release caused by a malicious act increases his total probability estimate by only a factor of 6. A factor of 6 increase is modest, given the ingenuity that terrorists have shown in the past. Thompson's plant-specific numbers are consistent with generic probability analyses that were part of a scoping cost-benefit analysis that my colleagues and I made in 2003 (Alvarez et al.

[4] Allan Benjamin, lead author of the original 1979 paper from Sandia Laboratory, was a reviewer of our 2003 paper in SG&S. He provided a public commentary on it, in which he stated,. "Although there is clear evidence that some of the fuel would melt in such a situation, we don't know how much. Since we don't, it is conservative and appropriate to assume that a large fraction of the fission product inventory could become released to the environment. Whether that fraction is 0.20 or 1.00 doesn't change the fact that the release would be unacceptable." (Benjamin 2003)

2003a). Our analysis suggests that even using older probability numbers, and without considering threats of terrorism or new data on radiation risks to be discussed later, moving older fuel to dry cask storage is nearly cost-effective.[5] The Nuclear Regulatory Commission's response to the issues raised by the report of the National Research Council (NatRC 2005) and our paper in *Science and Global Security* (SG&S)(Alvarez et al. 2003a) is discussed in (Dorman 2005). The NRC does not appear to be addressing the scenarios of most concern to me, such as those addressed by Thompson in his report for Pilgrim and Vermont Yankee. The Commission essentially sees the spent-fuel pool problem as a non-issue that is diverting resources from more important areas. However, the basis for the Commission's overall judgment is secret, presenting a challenge in relicensing proceedings to independent scientists like myself, who are not allowed to review the secret analysis. Should I simply accept the Commission's judgment without review and remain silent to avoid any chance of providing useful information to terrorists? The problem with such a stance is that I do not believe the Commission (or any government agency) can best protect the public against terrorism in the absence of vigorous pressure from, and critical analysis by, a range of stakeholders. It would be irresponsible to say nothing, but equally irresponsible to say too much. I hope the balance I have struck in this report is the right one. I certainly conclude from all of the analysis carried out, both by me, Thompson, and others, and the lack of response by the NRC to date, that computing the consequences of large releases of Cesium-137 in regulatory proceedings is responsible and in the public interest.

Another reason that I find it important to make consequence calculations in these proceedings is that the NRC's own Inspector General has observed that the NRC appears to have informally established an unreasonably high burden of requiring absolute proof of a safety problem (IG 2003). Considerable evidence is available that a correspondingly high barrier has been set for alternatives to pool storage at reactors, based on comments by NRC staff on our 2003 paper and by my reading of (Dorman 2005). Thus, independent analysts may be the only vehicle for computing state-of-the-art consequences, if the NRC is reluctant to commission such calculations or require applicants to make them.

Consequences of a release. The first realistic study of the economic and land use consequences of

[5] The approach I took for our 2003 report, when it came to dealing with terrorism, was to think of scenarios that a terrorist group might come up with using the technical means I thought would be reasonably available to them. Since at least one of those generic scenarios I came up with seemed plausible, I considered at the time, and still do, that we need to understand the consequences of spent-fuel-pool fires.

releases of long-lived radioactivity that tried to go beyond bounding calculations was published in 1996 (Chanin and Murfin 1996). This work appeared in the same year of publication of the relicensing GEIS (NUREG 1996), so would not likely have been considered in the GEIS. More recently, in 2003 and 2004, estimates of the long-term health consequences of releases from spent-fuel fires were published by our group of independent analysts, as noted above. Some NRC Commissioners have referred to staff analyses refuting our published results, but such analyses have never been made public, as far as I am aware. If the new staff analysis does exist, it was also prepared after the GEIS and so should be incorporated into the EIS for Pilgrim and Vermont Yankee. The staff analysis that has been published is sobering and only applies specifically to decommissioning (Collins and Hubbard 2001).

For this report, components of damage costs not previously considered at other sites have been included. For instance, new damage cost and latent cancer calculations have been made to extend the work by Beyea, Lyman, and von Hippel to areas contaminated by resuspension. Results from "wedge model" calculations (discussed below) have been used for this purpose. Loss of property value outside remediated areas have also been considered, again with reliance on the wedge model. Approximate correction has been made for wind-rose effects, something that was not done in (Beyea et al. 2004a). In addition, I have made cost and latent cancer estimates, assuming that the latest radiation mortality studies are used in the calculations. As for the standard components of damage calculations, I have scaled, interpolated or extrapolated from values computed for other sites as reported in (Beyea et al. 2004a). Since the MACCS2 model was run in the paper by Beyea, Lyman, and von Hippel, with the parameter values listed there, the results in this report on Pilgrim and Vermont Yankee are based on the MACCS2 model.

The models included in the MACCS2 code are based largely on methodologies originally developed for the 1975 Reactor Safety Study (NUREG 1975), as refined in the CRAC2 code (Kocher et al. 1987; Ritchie et al. 1984). See (Young and Chanin 1996). A simpler approach to consequence analysis (wedge model) was developed by an American Physical Society group that reviewed the Reactor Safety Study (APS 1975). The wedge-model provides quick estimates of consequences that usually gives similar results to more detailed models, such as MACCS2, provided one uses appropriate effective parameters. The wedge model may underestimate acute consequences in situations where changing weather classes dominates health effects, but that is not a major issue for releases of cesium-137, where the risk is from long-term exposure.

Details of the calculations made for this report are given in Appendix I. Tables with quantitative results appear in a subsequent section. Reliance on output from the MACCS2 computer code or the wedge model to estimate consequences from releases of Cesium-137 in this report does not necessarily imply endorsement of the use of these methodologies in other contexts, nor endorsements of the parameter sets that applicants or others may use with them. All models have strengths and weaknesses that must not be forgotten by modelers. MACCS2 does not appear to have undergone extensive field validation (Young and Chanin 1997), but sensitivity studies have been undertaken (Helton et al. 1995; McKay and Beckman 1994), (Neymotin 1994) and a large number of expert elicitations have been carried out that provide uncertainty distribution for input parameters (Goossens et al. 1997; Harper et al. 1993; Little et al. 1997; USNRC 1995). The model has been used in a limited number of peer-reviewed publications. Edwin Lyman, who ran the MACCS2 code for (Beyea et al. 2004a) has probably the greatest number of peer-reviewed papers using MACCS2.

For late health effects, which are of interest in this report, the deposition velocity has been found to be a major parameter affecting MACCS results (Helton et al. 1995). Because the uncertainty distribution for deposition velocity is quite broad (USNRC 1995), the variance in the MACCS2 predictions for cancers (and damage costs) could be large. When possible, I prefer to rely on exposure models that have been tested against field data, such as those I have developed in recent years (Beyea et al.). However, by relying on results from MACCS2 in these proceedings with respect to consequences from releases of Cesium-137, I hope to avoid distracting debate over models.

In the next section, I present results of consequence calculations using standard cancer risk coefficients. In subsequent sections, I discuss major new studies on cancer risks from radiation that suggest the risk coefficients used in most versions of MACCS2 are way too low. I then present consequence calculations using higher cancer coefficients and discuss some of the implications for cost benefit analyses. Finally, I discuss some new developments in dispersion modeling at coastal sites. I suggest that the applicant at Pilgrim should undertake sensitivity studies using appropriate computer codes to see if this new knowledge of meteorology modifies cost-benefit computations.

Quantitative damage estimates for releases from Pilgrim and Vermont Yankee, assuming standard cancer risk coefficients:

This section presents a subset of consequence estimates for hypothetical releases of Cesium-137 from spent-fuel pools at Pilgrim and Vermont Yankee. Estimates are presented for economic costs and latent cancers. Variance in the estimates are not considered for the contention phase. Details of the estimates are given in the Table footnotes and in Appendix I. Political, psychological, and social impacts of hypothetical releases are not considered, although they could obviously be significant. For instance, there appears to exist a "radiation syndrome" that affects a subset of exposed populations, causing debilitating psychiatric symptoms (Vyner 1983). Psychological effects of radiation disasters are expected to be most serious for children (CEH 2003).

Releases of 10% and ~100% of the radiocesium in the spent-fuel pools at both Pilgrim and Vermont Yankee are considered. Results are presented in this section using the standard risk coefficients assumed in (Beyea et al. 2004a). Releases lower than 10% of the Cesium-137 inventory, even releases too low to justify remediation, could have costs associated with loss in property value in the range of 10 to 100 billion dollars.

The damage estimates shown in the Tables are much less than the GDP of the US, which is about 12 trillion per year. However, some of the numbers exceed the annual payment on the national debt, which is about 350 billion dollars per year, indicating that government borrowing to cover the damage payments from a spent-fuel-pool fire could represent a major perturbation on the economy. Thus, significant macroeconomic effects could be expected depending on the state of the economy at the time of any hypothetical release. The regional impacts would be expected to be the most serious. Estimating such effects are beyond the scope of this report.

The Tables include numbers in some cells to 3-significant figures. This does not imply any comparable level of accuracy.

Table 1. Cost estimates for a release of 10% of spent-fuel pool inventory of radioactive Cesium-137 assuming no change in cancer risk coefficient (billions of dollars)			
Category	Pilgrim	Vermont Yankee	Comment
Direct costs[a)]	49	39	
Indirect administrative costs[b)]	49	39	
Loss in property values adjacent to treated areas[c)]	7-74	9-87	
Costs associated with cleanup or demolition of downtown business and commercial districts, heavy industrial areas, or high-rise apartment buildings.[d)]	??	??	Particularly important for Pilgrim, with its proximity to Boston
Total	> 105-171	> 87-165	

a) As estimated from computations with MACCS2 at comparable sites with the parameters given in (Beyea et al. 2004a). Reduction by 1/3rd to account for wind rose effects.
b) Based on Chanin and Murfin. "We believe . . . that it might be reasonable to double the cost estimates provided [here] in order to account for indirect costs." (Chanin and Murfin 1996), p. 6-3. The factor might not be as great in the current case, however, because of economies of scale. We assume that litigation costs offset any economies of scale.
c) Assumes 5% loss in property value for an area surrounding the plume that includes 1 to 10 times as many persons as are in the (0.24 radian) plume extending out to 250 miles (see Appendix I). A similar 5% loss in property value is assumed in the plume from 250-1000 miles. $132,000 in property value assumed per capita (Beyea et al. 2004a). Although not included in this total for the contention phase, loss in property value upon sale by government of remediated property should be included here. MACCS2 assumes no such loss.
d) We have not attempted an estimate for this category in the contention phase.

Table 2. Cost estimates for a release of ~100% of spent-fuel pool inventory of Cs-137 assuming no increase in cancer risk coefficient (billions of dollars)			
Category	Pilgrim	Vermont Yankee	Comment
Direct costs[a)]	163	173	
Indirect administrative costs[b)]	163	173	
Loss in property values adjacent to treated areas[c)]	16-162	17-172	
Costs associated with cleanup or demolition of downtown business and commercial districts, heavy industrial areas, or high-rise apartment buildings.[d)]	??	??	Particularly important for Pilgrim, with its proximity to Boston
Total	> 342-488	> 364-518	

a) As estimated from computations with MACCS2 at comparable sites with the parameters given in (Beyea et al. 2004a). Figures reduced by 1/3rd to account for wind rose effects.
b) Based on Chanin and Murfin. "We believe . . . that it might be reasonable to double the cost estimates provided [here] in order to account for indirect costs." (Chanin and Murfin 1996), p. 6-3. The factor might not be as great in the current case, however, because of economies of scale. We assume that litigation costs offset the economies of scale.
c) Assumes 5% loss in property value for an area including 1 to 10 times as many persons as are in a 0.24 radian plume extending out to 700 miles (see text). A similar 5% loss in property value is assumed in the plume from 700-1000 miles. $132,000 in property value assumed per capita (Beyea et al. 2004a). Although not included in this total for the contention phase, loss in property value upon sale by government of remediated property should be included here. MACCS2 assumes no such loss.
d) We have not attempted an estimate for this category in the contention phase.

Note that the latent cancer estimates in Table 3, below, are lower limits, because they only include the cancers from Cesium-137. This approximation ignores shorter isotopes in the fresh fuel in the pool, especially Cesium-134 (Benjamin 2003).

Table 3. Estimates for latent cancers following releases from the spent-fuel pools at either Pilgrim or Vermont Yankee (assuming no increase in cancer risk number)

Category	10% release	~100% release
Latent cancers in main plume path from residual contamination[a)]	1300	4000
Latent cancers from deposited resuspension[b)]	1300	4000
Total	2,700	8,000

a) Based on typical numbers for plants analyzed in (Beyea et al. 2004a). Figures reduced by 1/3rd to account for wind rose effects. Cancers in the direct plume are reduced by more than a factor of ten from decontamination and deconstruction.
b) Assumes 10% resuspension and redistribution of deposited Cesium-137 resulting from a) wind removal in the first few weeks, and b) remediation/demolition efforts over successive years. It is possible that even the resuspended Cesium would produce concentrations high enough to justify remediation, with a corresponding reduction in projected cancers. However, clean-up costs would be increased.

I have not been able to incorporate new understanding of the flow of air over and around the New England Coastline that has been achieved in recent years. Still, this new knowledge should be taken into account in EISs for coastal facilities. Releases from Pilgrim headed initially out to sea will remain tightly concentrated due to reduced turbulence until winds blow the puffs back over land (Zagar et al.), (Angevine et al. 2006). This can lead to hot spots of radioactivity in unexpected locations (Angevine et al. 2004). Dismissing radioactivity blowing out to sea is inappropriate. Reduction of turbulence on transport from Pilgrim across the water to Boston should also be studied. Although incorporating such meteorological understanding into a PSA or equivalent at Pilgrim would not be likely to make more that a factor of two difference in risk, the change could bring more SAMAs into play and would be significant in an absolute sense, when combined with the increase arising from incorporation of new values of radiation dose conversion coefficients (discussed below). The program

CALPUFF (Scire et al. 2000) has the capability to account for reduced turbulence over ocean water and could be used in sensitivity studies to see how important the phenomenon is at Pilgrim.

New cancer risk coefficients There have been increases in the value of the cancer risk assigned to low doses of radiation that should be taken into account in EISs. These increases have been steady since 1972,[6] which makes the original EISs out of date. In addition, there has been a marked increase in the value of the cancer mortality risk per unit of radiation at low doses (2-to-3 rem average) as a result of recent studies published on a) radiation workers (Cardis et al. 2005) and b) the Techa River cohort (Krestinina et al. 2005). Both studies give similar values for low dose, protracted exposure, namely about 1 cancer death per Sievert (100 rem).

Worker study: The average dose for the workers was 2-rem. The authors of this large, international study of radiation workers included major figures in the field of radiation studies. The authors state, "On the basis of these estimates, 1-2% of deaths from cancer among workers in this cohort may be attributable to radiation." Although it can be misleading to interpret epidemiologic data in this way (Beyea and Greenland 1999), because it implies to non-experts a single-cause model of cancer, there is no doubt that a 1-2% increase in cancer mortality for a worker population is unusually high.

Techa River Cohort: The results for the Techa River cohort are equally striking, showing a strong linear effect down to a few rads. The average dose was 3 rads. The authors, who once again include major figures in the field of radiation studies, state: "It is estimated that about 2.5% of the solid cancer deaths...are associated with the radiation exposure." As in the worker population, an increase in solid cancer deaths of 2.5% from a dose of 3 rads is extraordinarily high compared to past estimates.

Such high risk coefficients imply that background radiation itself must increase cancer mortality by 3-5%.[7] (It has long been known that background radon concentrations may well increase lung cancer rates by 10% or more (Lubin et al. 1995), (Darby et al. 2005).) Critics of studies like those by

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[6] For instance, there was a large increase in the risk coefficients estimated between the 1980 BEIR III report and the 1990 BEIR V report. See Table 4-4 of (National Research Council 1990), where the lifetime risk estimates increased by a factor of 4.6-19, depending on the risk model.

7 Assuming 0.1 rem per year background, which ignores the "equivalent" dose to the lung from radon. It is more difficult to compare rates of lung cancer, because the interaction of smoking and radiation has been found to lie between a linear and relative model. Therefore, such interactions must be taken into account, before drawing conclusions about area-wide differences, or lack of differences, in lung cancer rates.

Cardis et al. and by Krestinina et al. argue that such big effects, if they were real, should show up in cancer statistics in places like Colorado, where background radiation is high, when compared to areas of the country where background radiation is lower. However, crude statistical analysis that does not adjust for covariates at an individual level is unlikely to be very reliable (Lubin 1998). Also, there is an issue of the confounding effect of hypoxia (Weinberg et al. 1987). Hypoxia also varies with altitude.

Because the average dose in these two new studies is so low and so close to background radiation dose, there is no way to escape the linear non-threshold model. Even were a hypothetical hormesis effect to lead to a minimum risk at background levels (5 rem lifetime dose), the risk has to rise again after another 2-3 rem dose, based on the studies by Cardis et al. and Krestinina et al.

Could the increased risk numbers be due to a systematic underestimate or underreporting of doses? Random errors in doses would tend, in most cases, to reduce the strength of associations (Carroll et al. 1998), (Thomas et al. 1993). On the other hand, if dose errors were not random, but were proportionately underestimated or proportionately underreported in the worker studies and the Techa River cohort, then the risk coefficients could be inflated. For this to happen in both studies would be a coincidence. And in the radiation worker study, the results for Hanford do not support the missing-dose hypothesis, even though we know the neutron doses were likely underreported at Hanford (CohenAssociates 2005). In fact, the cancer risk numbers at Hanford were lower than average, not higher (Cardis et al. 2005). Finally, should the Techa River cohort dose estimates be too low that would mean that modern dose reconstruction techniques are underestimating doses, suggesting that other modern dose estimation techniques, such as those used in MACCS2 (Chanin and Young 1997), the standard NRC consequence code, could well be too low. In that case, an upward adjustment of doses would be required, if the risk coefficients were kept the same. Certainly, from a public health point of view, the arguments are strong for making use of the new risk coefficients, one way or another, with programs like MACCS2 and other consequence codes.

Recent press reports around the anniversary of the Chernobyl accident seemed to suggest that effects of radiation doses were lower than expected. Not at all. The "new" estimates of 4,000 projected fatalities were merely a re-interpretation of a study from the 1990s. No longer were 5,000 projected cancers outside the most highly contaminated regions counted. Also, another 7,000 cancers projected to occur in Europe were not noted by the press (Cardis et al. 2006). A summary of all of these estimates can be found in (Cardis et al. 2006). Were the new risk coefficients discussed earlier applied to the population dose estimates, the projected numbers of fatalities from the Chernobyl releases would climb much higher.

The confusion over the Chernobyl numbers appears to be traceable to a typo in a highly publicized IAEA report (Forum 2005) that relied on a WHO report for its cancer numbers (WHO 2005). The WHO report stated that the "Expert Group" concluded that there may be up to 4 000 additional cancer deaths among the three *highest* exposed groups over their lifetime (emphasis added). This was translated in the IAEA report to, "The total number of people that could have died or could die in the future due to Chornobyl originated exposure over the lifetime of emergency workers and residents of *most* contaminated areas is estimated to be around 4 000." (Emphasis added.) In fact, in my view, the last clause should have referred to "residents of *the* most contaminated areas..."[8]

Impact of new cancer risks. As a result of these two radiation studies, all probabilistic safety analyses prepared prior to them need to be revisited. These new studies should change the threshold for adoption of severe accident mitigation alternatives (SAMA). For instance, the current Environmental Report for Pilgrim assigns a value of $2,000 per person rem in deciding whether a proposed SAMA is cost effective. According to the results of the study by Cardis et al., $2,000 per rem implies a valuation of $200,000 per cancer death before discounting, which is way to low.[9] The same low valuation of life would arise from use of the risk numbers derived from the Techa River cohort (Krestinina et al. 2005). As a result, the SAMA analyses prepared for the Pilgrim and Vermont Yankee facilities need to be redone, even without inclusion of spent-fuel-pool fires as a risk to be addressed. Presumably, a number of additional SAMAs that were previously rejected by the applicant's methodology will now become cost effective. In addition to affecting the existing SAMA calculations, the new cancer risk coefficients make the consideration in an EIS of mitigation measures for spent-fuel-pool fires especially important.

In addition to providing motivation for a reanalysis of past PSAs and SAMA thresholds, the results of these new epidemiologic studies throw into doubt the entire basis of the NRC culture, which maintains that the linear non-threshold theory (LNT) is conservative, providing a margin of safety. Although it has always been known that the dose-response at doses below the 25-rad average dose of the Atomic Bomb survivors could be supralinear, as opposed to sublinear, the possibility has not been

8 Note that the IAEA stands by its original wording, not accepting it as a typo. Personal Communication, 2006, D. Kinley, IAEA public information, Vienna.

9 $50,000 net present value for a cancer death occurring 20 years from now, based on the 7% per year discount rate assumed in rhe Pilgrim Environmental Report, which leads to a factor of 4 reduction in present value for a cancer induced 20 years from now.

given much attention in the radiation protection community until now.[10] This is not the time for *pro forma* treatment of licensing applications. Whereas it would be unreasonable to require an applicant to redo analysis after every new paper is published in the scientific literature, the increase at low doses is very dramatic in this case. It represents a 5-fold increase over the risk estimated in BEIR VII (NRC 2005). Based on information in (Little 1998), it appears to represent a factor of 10 over the standard value used in the MACCS2 computer code, which is the code on which the applicants' analyses are based. With such a high reported increase, public health considerations have to take precedence over applicant convenience. The paper by Cardis et al., at the very minimum, demands that a thorough analysis be made of mitigation and alternatives to spent-fuel pool storage.

For example, application of the new risk coefficients would drive the risk of spent-fuel-pool accidents during decommissioning (without even considering terrorist threats) above the NRC's safety goal. See Figures ES-1, ES-2 of (Collins and Hubbard 2001).

Quantitative damage estimates for releases from Pilgrim and Vermont Yankee, assuming cancer risk coefficients are increased to accommodate the new epidemiologic studies:

This section presents a subset of consequence estimates for hypothetical releases of Cesium-137 from spent-fuel pools at Pilgrim and Vermont Yankee, assuming a 3-fold increase in cancer risk coefficients to conservatively account for the latest studies on radiation risk at low dose. To account for some weighting of other studies, I have chosen a value lower than the factor of 5-to-10 increase that is suggested by the study of (Cardis et al. 2005).[11]

As with earlier Tables, estimates are presented for economic costs and latent cancers. Variance in the estimates are not considered for the contention phase. See the Table footnotes and Appendix I for details. Political, psychological, and social impacts of hypothetical releases are not considered, although they could obviously be significant. As stated earlier, there appears to exist a "radiation syndrome" that affects a subset of exposed populations, causing debilitating psychiatric symptoms (Vyner 1983). Psychological effects of radiation disasters are expected to be most serious for children (CEH 2003).

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10 There has been some discussion, however, that the A-Bomb survivor data produces low risk coefficients due to a healthy survivor effect (Stewart and Kneale 1993; Stewart and Kneale 1999). In addition, I have always wondered about the lowest dose data in Pierce, which seems to show a supralinear effect below 5 rem (Pierce et al. 1996), page 9.

11 Part of the factor of 5 comes from the use of a dose and dose rate effectiveness factor, which is commonly used with the MACCS2 code, as in (Beyea et al. 2004a).

Once again, releases lower than 10% of the Cesium-137 inventory, even releases too low to justify remediation, could have costs associated with loss in property value in the range of 10 to 100 billion dollars.

The damage estimates shown in the Tables are much less than the GDP of the US, which is about 12 trillion per year. However, some of the numbers are considerably larger than the annual payment on the national debt, which is about 350 billion dollars per year, indicating that government borrowing to cover the damage payments from a spent-fuel-pool fire could represent a major perturbation on the economy. Thus, once again, significant macroeconomic effects could be expected depending on the state of the economy at the time of any hypothetical release. The regional impacts would be expected to be the most serious. Estimating such effects are beyond the scope of this report.

The Tables include numbers in some cells to 3-significant figures. This does not imply any comparable level of accuracy.

Table 4. Cost estimates for a release of 10% of spent-fuel-pool inventory of Cs-137 assuming 3-fold increase in cancer risk coefficient (billions of dollars)			
Category	Pilgrim	Vermont Yankee	Comment
Direct costs[a)]	89	79	
Indirect administrative costs[b)]	89	79	
Loss in property values adjacent to treated areas[c)]	> 7-74	> 9-87	
Costs associated with cleanup or demolition of downtown business and commercial districts, heavy industrial areas, or high-rise apartment buildings.[d)]	??	??	Particularly important for Pilgrim, with its proximity to Boston
Total	> 186-253	> 167-245	

a) As estimated from computations with MACCS2 at comparable sites with the parameters given in (Beyea et al. 2004a). An increase in the cancer risk numbers is mathematically equivalent to an increase in release magnitude, which is how the numbers in the Table were computed. Figures reduced by 1/3rd to account for wind rose effects.
b) Based on Chanin and Murfin. "We believe . . . that it might be reasonable to double the cost estimates provided [here] in order to account for indirect costs." (Chanin and Murfin 1996), p. 6-3. The factor might not be as great in the current case, however, because of economies of scale. We assume that litigation costs offset the economies of scale.
c) Assumed to be at least as great as the figures calculated in Table 1, where the cancer risk coefficient was left unchanged. Although not included in this total for the contention phase, loss in property value upon sale by government of remediated property should be included here. MACCS2 assumes no such loss.
d) We have not attempted an estimate for this category in the contention phase.

Table 5. Cost estimates for a release of ~100% of spent-fuel-pool inventory of Cs-137 assuming a three-fold increase in cancer risk coefficient (billions of dollars)			
Category	Pilgrim	Vermont Yankee	Comment
Direct costs[a)	283	353	
Indirect administrative costs[b)]	283	353	
Loss in property values adjacent to treated areas[c)]	16-162	17-172	
Costs associated with cleanup or demolition of downtown business and commercial districts, heavy industrial areas, or high-rise apartment buildings[d)]	??	??	Particularly important for Pilgrim, with its proximity to Boston
Costs due to delays in implementing remediation and deconstruction[d)]	??	???	
Total	> 582-728	> 723-878	

a) As estimated from computations with MACCS2 at comparable sites with the parameters given in (Beyea et al. 2004a). An increase in the cancer risk numbers is mathematically equivalent to an increase in release magnitude, which is how the numbers in the Table were computed. Figures reduced by 1/3rd to account for wind rose effects.
b) Based on Chanin and Murfin. "We believe . . . that it might be reasonable to double the cost estimates provided [here] in order to account for indirect costs." (Chanin and Murfin 1996), p. 6-3. The factor might not be as great in the current case, however, because of economies of scale. We assume that litigation costs offset the economies of scale.
c) Assumed to be at least as great as the figures calculated in Table 2, where the cancer risk coefficient was left unchanged. Although not included in this total for the contention phase, loss in property value upon sale by government of remediated property should be included here. MACCS2 assumes no such loss.
d) We have not attempted an estimate for this category in the contention phase.

Note that the latent cancer estimates in Table 6, below, are lower limits, because they only include the cancers from Cesium-137. This approximation ignores shorter isotopes in the fresh fuel in the pool, especially Cesium-134 (Benjamin 2003).

Table 6. Estimates for latent cancers following releases from the spent-fuel pools at either Pilgrim or Vermont Yankee (assuming a 3-fold increase in cancer risk number)

Category	10% release	~100% release
Latent cancers in main plume path from residual contamination[a)]	4,000	12,000
Latent cancers from deposited resuspension[b)]	4,000	12,000
Total	8,000	24,000

a) Based on typical numbers for plants analyzed in (Beyea et al. 2004a) multiplied by a factor of 3. Figures reduced by 1/3[rd] to account for wind rose effects. Cancers in the direct plume are reduced by more than a factor of ten from decontamination and deconstruction.
b) Assumes 10% resuspension and redistribution of deposited Cesium-137 resulting from a) wind removal in the first few weeks, and b) remediation/deconstruction efforts over successive years. It is possible that even the resuspended Cesium would produce concentrations high enough to justify remediation, with a corresponding reduction in projected cancers. However, clean-up costs would be increased.

Regulatory implications. The results in Tables 1-6, along with the discussion in the text suggest that: The applicant should withdraw and revise its Environmental Reports for Pilgrim and Vermont Yankee. The NRC should prepare supplements to the August 1979 Generic Environmental Impact Statement on handling and storage of spent fuel (NUREG-0575), and the May 1996 GEIS on license renewal (NUREG-1437). The revised documents should consider the new cancer risk coefficients published by Cardis et al. and Kristinina et al. For both reactor accidents and spent-fuel-pool fires, when relevant, the documents should consider loss of property value outside remediated areas. They should consider wind-driven resuspension, especially from remediation activities, that carries radioactivity to new areas in the immediate weeks and years following the release. Although MACCS2 does not directly account for such refinements, it may be possible to mimic their effects in the program.[12] In their economic calculations, the revised documents should include administrative and litigation costs associated with clean up and demolition. The ER for Pilgrim should consider the reduced turbulence over ocean water, including transport directly over water to the Boston area. The NUREG supplements should consider the impacts of coastal meteorology for reactors on the East and West Coasts. The program CALPUFF can be used to deal with dispersion over coastal waters.

[12] This might be done by adding on extra plume segments to the end of a standard run, with varying delay times, and a total added release equal to the assumed resuspension fraction times the initial release. This will tend to produce the mathematical equivalent of resuspended material being carried in directions different from the main plume.

Appendix I.

Variance in estimates are not considered in this report for the contention phase.

Based on the report of Gordon Thompson, the inventories at Pilgrim and Vermont Yankee are somewhat higher than the 35 MCi considered in (Beyea et al. 2004a). For Pilgrim, Dr. Thompson estimates 44 MCi; for Vermont Yankee, 39 MCi.

Thompson has also estimated a hotter heat rate for releases at Pilgrim and Vermont Yankee than was assumed in the calculations in (Beyea et al. 2004a). 106-128 MW vs 40 MW. Plume rise varies as the 1/3rd power of the heat rate in the standard "Briggs" formula for plume rise (Parks 1997), which implies a 50% greater rise than would have been calculated in the MACCS2 program that was used in the paper by Beyea, Lyman and von Hippel. For the contention phase of these proceedings, this difference has been ignored, since a 50% increase in plume rise is within 1-standard deviation of the value predicted by the formula (Irwin and Hanna 2004).

Rather than make new MACCS2 calculations for the contention phase of these proceedings, the azimuthally-averaged radial population distributions for both Pilgrim and Vermont Yankee have been compared as a function of distance with those for which economic and latent cancer consequences have been calculated in (Beyea et al. 2004a). It is the radial population numbers that drive the economic damage costs and cancer numbers. Figures 1 and 2 show the azimuthally-averaged radial population distributions for Pilgrim and Vermont Yankee for two different maximum distances. The CensusCD computer program (Geolytics 2002) was used to generate these population distributions. The same program was used in (Beyea et al. 2004a) for the five reactors, Catawba, Indian Point, LaSalle, Palo Verde, and TMI.

The effect of variation in wind direction at Pilgrim is to reduce the average damages and latent fatalities. Wind rose data taken from the Pilgrim FSAR shown in Figure 5 for the 300 foot tower suggest a reduction factor of 0.666 for that facility. See caption for Figure 5. I did not find similar data for a high tower in the FSAR for Vermont Yankee, so I have used the 0.666 factor determined for Pilgrim. Wind flows at the surface given in the Vermont Yankee FSAR are not particularly relevant to a hot release during a fire, since the plume will be elevated. The variance with angle appears to be quite large, because the population figures change with release angle, as shown in Figures 3 and 4.

For economic damages from the 10% releases, we are interested in populations out to 250 miles (based on wedge model calculations). For the ~100% releases, the corresponding distance is 700 miles. The Pilgrim population figures best match Catawba out to 250 miles. For Vermont Yankee the population figures best match Lasalle out to 250 miles. Out to 700 miles, both Pilgrim and Vermont Yankee are most similar to Lasalle, although I discount the Lasalle cost figures to account for the lower population values of Pilgrim and Vermont Yankee.

Table 7, shows the relevant costs extracted from Table 3 of (Beyea et al. 2004a) and adjusted as indicated in the Table footnotes. These numbers were then fit to a power law function of release magnitude. The corresponding functions were used to generate costs estimates for the Pilgrim and Vermont Yankee releases estimated by Thompson, which differ somewhat from the releases assumed for a spent-fuel fire in (Beyea et al. 2004a).

Table 7. Assigning damage cost estimates in billions of dollars based on Table 3 of (Beyea et al. 2004a)

Release magnitude	Pilgrim	Vermont Yankee
3.5 MCi	71[a)]	54[b)]
35 MCi	219[c)]	243[d)]

a) Cost figure for Catawba for a 3.5 MCi release.
b) Cost figure for Lasalle for a 3.5 MCi release.
c) Cost figure for Lasalle for a 35 MCi release reduced by 20%
d) Cost figure for Lasalle for a 35 MCi release reduced by 10%

Extrapolated and interpolated direct damage costs for Pilgrim and Vermont Yankee were computed from the following formulas:

Pilgrim: Damages = 0.66* 35* (release in Mci)$^{0.5}$

Vermont Yankee: Damages = 0.66 * 24 * (release in MCi)$^{0.65}$

The factor of 0.66 comes from wind-rose effects.

Administrative costs are taken equal to direct costs, following the suggestion of (Chanin and Murfin 1996). Property loss estimates are discussed below.

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EXHIBIT

3

Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants

October 2000

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Technical Study of Spent Fuel Pool Accidents at Decommissioning Plants

Table of Contents

List of Figures

List of Tables

Appendices

EXECUTIVE SUMMARY

This report documents a study of spent fuel pool (SFP) accident risk at decommissioning nuclear power plants. The study was undertaken to support development of a risk-informed technical basis for reviewing exemption requests and a regulatory framework for integrated rulemaking.

The staff published a draft study in February 2000 for public comment and significant comments were received from the public and the Advisory Committee on Reactor Safeguards (ACRS). To address these comments the staff did further analyses and also added sensitivity studies on evacuation timing to assess the risk significance of relaxed offsite emergency preparedness requirements during decommissioning. The staff based its sensitivity assessment on the guidance in Regulatory Guide (RG) 1.174, "An Approach for Using Probabilistic Risk Assessment In Risk-Informed Decisions On Plant-Specific Changes to the Licensing Basis." The staff's analyses and conclusions apply to decommissioning facilities with SFPs that meet the design and operational characteristics assumed in the risk analysis. These characteristics are identified in the study as industry decommissioning commitments (IDCs) and staff decommissioning assumptions (SDAs). Provisions for confirmation of these characteristics would need to be an integral part of rulemaking.

The results of the study indicate that the risk at SFPs is low and well within the Commission's Quantitative Health Objectives (QHOs). The risk is low because of the very low likelihood of a zirconium fire even though the consequences from a zirconium fire could be serious. The results are shown in Figures ES-1 and ES-2. Because of the importance of seismic events in the analysis, and the considerable uncertainty in seismic hazard estimates, the results are presented for both the Lawrence Livermore National Laboratory (LLNL) and the Electric Power Research Institute (EPRI) seismic hazard estimates. In addition, to address a concern raised by the ACRS, the results also include a sensitivity to a large ruthenium and fuel fines release fraction. As illustrated in the figures, the risk is well below the QHOs for both the individual risk of early fatality and the individual risk of latent cancer fatality.

The study includes use of a pool performance guideline (PPG) as an indicator of low risk at decommissioning facilities. The recommended PPG value for events leading to uncovery of the spent fuel was based on similarities in the consequences from a SFP zirconium fire to the consequences from a large early release event at an operating reactor. A value equal to the large early release frequency (LERF) criterion (1×10^{-5} per year) was recommended for the PPG. By maintaining the frequency of events leading to uncovery of the spent fuel at decommissioning facilities below the PPG, the risk from zirconium fires will be low and consistent with the guidance in RG 1.174 for allowing changes to the plant licensing basis that slightly increase risk. With one exception (the H.B. Robinson site) all Central and Eastern sites which implement the IDCs and SDAs would be expected to meet the PPG regardless of whether LLNL or EPRI seismic hazard estimates are assumed. The Robinson site would satisfy the PPG if the EPRI hazard estimate is applied but not if the LLNL hazard is used. Therefore, Western sites and Robinson would need to be considered on a site-specific basis because of important differences in seismically induced failure potential of the SFPs.

The appropriateness of the PPG was questioned by the ACRS in view of potential effects of the fission product ruthenium, the release of fuel fines, and the effects of revised plume parameters. The staff added sensitivity studies to its analyses to examine these issues. The consequences of a significant release of ruthenium and fuel fines were found to be notable, but not so important as to render inappropriate the staff's proposed PPG of $1x10^{-5}$ per year. The plume parameter sensitivities were found to be of lesser significance.

In its thermal-hydraulic analysis, documented in Appendix 1A, the staff concluded that it was not feasible, without numerous constraints, to establish a generic decay heat level (and therefore a decay time) beyond which a zirconium fire is physically impossible. Heat removal is very sensitive to these additional constraints, which involve factors such as fuel assembly geometry and SFP rack configuration. However, fuel assembly geometry and rack configuration are plant specific, and both are subject to unpredictable changes after an earthquake or cask drop that drains the pool. Therefore, since a non-negligible decay heat source lasts many years and since configurations ensuring sufficient air flow for cooling cannot be assured, the possibility of reaching the zirconium ignition temperature cannot be precluded on a generic basis.

The staff found that the event sequences important to risk at decommissioning plants are limited to large earthquakes and cask drop events. For emergency planning (EP) assessments this is an important difference relative to operating plants where typically a large number of different sequences make significant contributions to risk. Relaxation of offsite EP a few months after shutdown resulted in only a "small change" in risk, consistent with the guidance of RG 1.174. Figures ES-1 and ES-2 illustrate this finding. The change in risk due to relaxation of offsite EP is small because the overall risk is low, and because even under current EP requirements, EP was judged to have marginal impact on evacuation effectiveness in the severe earthquakes that dominate SFP risk. All other sequences including cask drops (for which emergency planning is expected to be more effective) are too low in likelihood to have a significant impact on risk. For comparison, at operating reactors additional risk-significant accidents for which EP is expected to provide dose savings are on the order of $1x10^{-5}$ per year, while for decommissioning facilities, the largest contributor for which EP would provide dose savings is about two orders of magnitude lower (cask drop sequence at $2x10^{-7}$ per year).[1] Other policy considerations beyond the scope of this technical study will need to be considered for EP requirement revisions and previous exemptions because a criteria of sufficient cooling to preclude a fire cannot be satisfied on a generic basis.

Insurance does not lend itself to a "small change in risk" analysis because insurance affects neither the probability nor the consequences of an event. As seen in figure ES-2, as long as a zirconium fire is possible, the long-term consequences of an SFP fire may be significant. These long-term consequences (and risk) decrease very slowly because cesium-137 has a half life of approximately 30 years. The thermal-hydraulic analysis indicates that when air flow has been restricted, such as might occur after a cask drop or major earthquake, the possibility of a fire lasts many years and a criterion of "sufficient cooling to preclude a fire" can not be defined on a

[1]Consistent with PRA limitations and practice, contributions to risk from safeguards events are not included in these frequency estimates. EP might also provide dose savings in such events.

generic basis. Other policy considerations beyond the scope of this technical study will therefore need to be considered for insurance requirements.

The study also discusses implications for security provisions at decommissioning plants. For security, risk insights can be used to determine what targets are important to protect against sabotage. However, any revisions in security provisions should be constrained by an effectiveness assessment of the safeguards provisions against a design-basis threat. Because the possibility of a zirconium fire leading to a large fission product release cannot be ruled out even many years after final shutdown, the safeguards provisions at decommissioning plants should undergo further review. The results of this study may have implications on previous exemptions at decommissioning sites, devitalization of spent fuel pools at operating reactors and related regulatory activities.

The staff's risk analyses were complicated by a lack of data on severe-earthquake return frequencies, source term generation in an air environment, and SFP design variability. Although the staff believes that decommissioning rulemaking can proceed on the basis of the current assessment, more research may be useful to reduce uncertainties and to provide insights on operating reactor safety. In particular, the staff believes that research may be useful on source term generation in air, which could also be important to the risk of accidents at operating reactors during shutdowns, when the reactor coolant system and the primary containment may both be open.

In summary, the study finds that:

1. The risk at decommissioning plants is low and well within the Commission's safety goals. The risk is low because of the very low likelihood of a zirconium fire even though the consequences from a zirconium fire could be serious.

2. The overall low risk in conjunction with important differences in dominant sequences relative to operating reactors, results in a small change in risk at decommissioning plants if offsite emergency planning is relaxed. The change is consistent with staff guidelines for small increases in risk.

3. Insurance, security, and emergency planning requirement revisions need to be considered in light of other policy considerations, because a criterion of "sufficient cooling to preclude a fire" cannot be satisfied on a generic basis.

4. Research on source term generation in an air environment would be useful for reducing uncertainties.

2.0 THERMAL-HYDRAULIC ANALYSES

Analyses were performed to evaluate the thermal-hydraulic characteristics of spent fuel stored in the spent fuel pools (SFPs) of decommissioning plants and determine the time available for plant operators to take actions to prevent a zirconium fire. These are discussed in Appendix 1A. The focus was the time available before fuel uncovery and the time available before the zirconium ignites after fuel uncovery. These times were utilized in performing the risk assessment discussed in Section 3.

To establish the times available before fuel uncovery, calculations were performed to determine the time to heat the SFP coolant to a point of boiling and then boil the coolant down to 3 feet above the top of the fuel. As can be seen in Table 2.1 below, the time available to take actions before any fuel uncovery is 100 hours or more for an SFP in which pressurized-water reactor (PWR) fuel has decayed at least 60 days.

Table 2.1 Time to Heatup and Boiloff SFP Inventory Down to 3 Feet Above Top of Fuel (60 GWD/MTU)

DECAY TIME	PWR	BWR
60 days	100 hours (>4 days)	145 hours (>6 days)
1 year	195 hours (>8 days)	253 hours (>10 days)
2 years	272 hours (>11 days)	337 hours (>14 days)
5 years	400 hours (>16 days)	459 hours (>19 days)
10 years	476 hours (>19 days)	532 hours (>22 days)

The analyses in Appendix 1A determined that the amount of time available (after complete fuel uncovery) before a zirconium fire depends on various factors, including decay heat rate, fuel burnup, fuel storage configuration, building ventilation rates and air flow paths, and fuel cladding oxidation rates. While the February 2000 study indicated that for the cases analyzed a required decay time of 5 years would preclude a zirconium fire, the revised analyses show that it is not feasible, without numerous constraints, to define a generic decay heat level (and therefore decay time) beyond which a zirconium fire is not physically possible. Heat removal is very sensitive to these constraints, and two of these constraints, fuel assembly geometry and spent fuel pool rack configuration, are plant specific. Both are also subject to unpredictable changes as a result of the severe seismic, cask drop, and possibly other dynamic events which could rapidly drain the pool. Therefore, since the decay heat source remains nonnegligible for many years and since configurations that ensure sufficient air flow[2] for cooling cannot be assured, a zirconium

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[2]Although a reduced air flow condition could reduce the oxygen levels to a point where a fire would not be possible, there is sufficient uncertainty in the available data as to when this level would be reached and if it could be maintained. It is not possible to predict when a zirconium fire would not occur because of a lack of oxygen. Blockage of the air flow around the fuel could be

fire cannot be precluded, although the likelihood may be reduced by accident management measures.

Figure 2.1 plots the heatup time air-cooled PWR and BWR fuel take to heat up from 30 °C to 900 °C versus time since reactor shutdown. The figure shows that after 4 years, PWR fuel could reach the point of fission product release in about 24 hours. Figure 2.2 shows the timing of the event by comparing the air-cooled calculations to an adiabatic heatup calculation for PWR fuel with a burnup of 60 GWD/MTU. The figure indicates an unrealistic result that until 2 years have passed the air-cooled heatup rates are faster than the adiabatic heatup rates. This is because the air-cooled case includes heat addition from oxidation while the adiabatic case does not. In the early years after shutdown, the additional heat source from oxidation at higher temperatures is high enough to offset any benefit from air cooling. This result is discussed further in Appendix 1A. The results using obstructed airflow (adiabatic heatup) show that at 5 years after shutdown, the release of fission products may occur approximately 24 hours after the accident.

In summary, 60 days after reactor shutdown for boildown type events, there is considerable time (>100 hours) to take action to preclude a fission product release or zirconium fire before uncovering the top of the fuel. However, if the fuel is uncovered, heatup to the zirconium ignition temperature during the first years after shutdown would take less than 10 hours even with unobstructed air flow. After 5 years, the heatup would take at least 24 hours even with obstructed air flow cases. Therefore, a zirconium fire would still be possible after 5 years for cases involving obstructed air flow and unsuccessful accident management measures. These results and how they affect SFP risk and decommissioning regulations are discussed in Sections 3 and 4 of this study.

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caused by collapsed structures and/or a partial draindown of the SFP coolant or by reconfiguration of the fuel assemblies during a seismic event or heavy load drop. A loss of SFP building ventilation could also preclude or inhibit effective cooling. As discussed in Appendix 1A, air flow blockage without any recovery actions could result in a near-adiabatic fuel heatup and a zirconium fire even after 5 years.

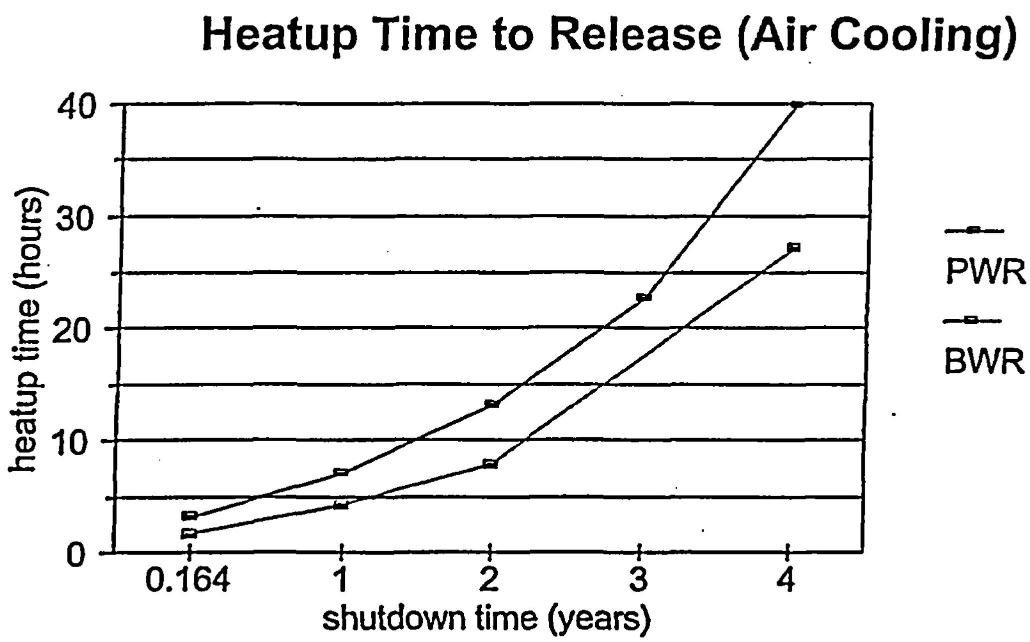


Figure 2.1 Heatup Time From 30 °C to 900 °C

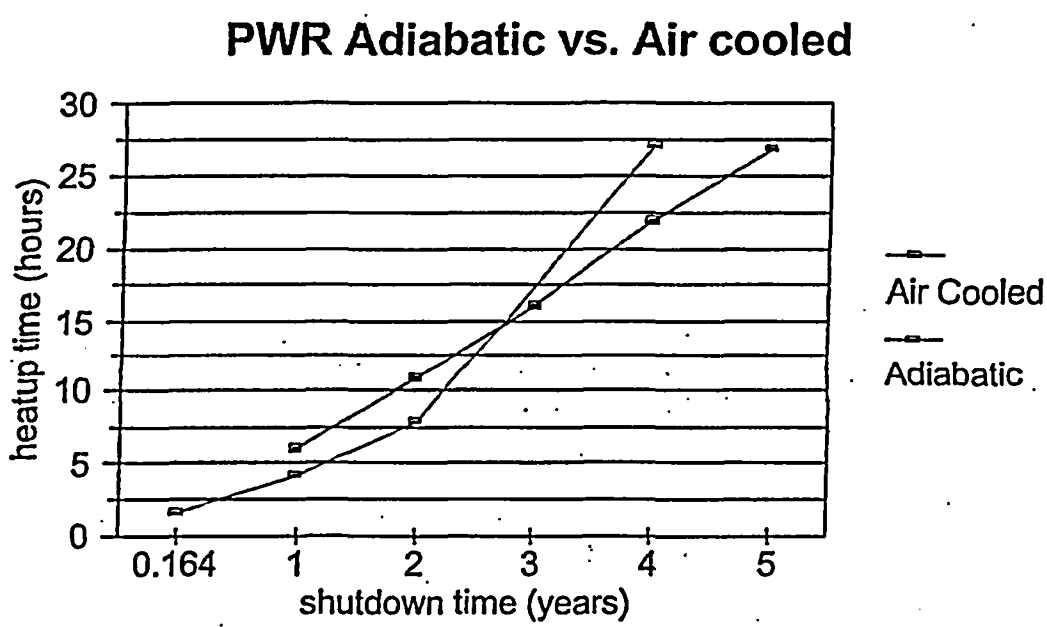
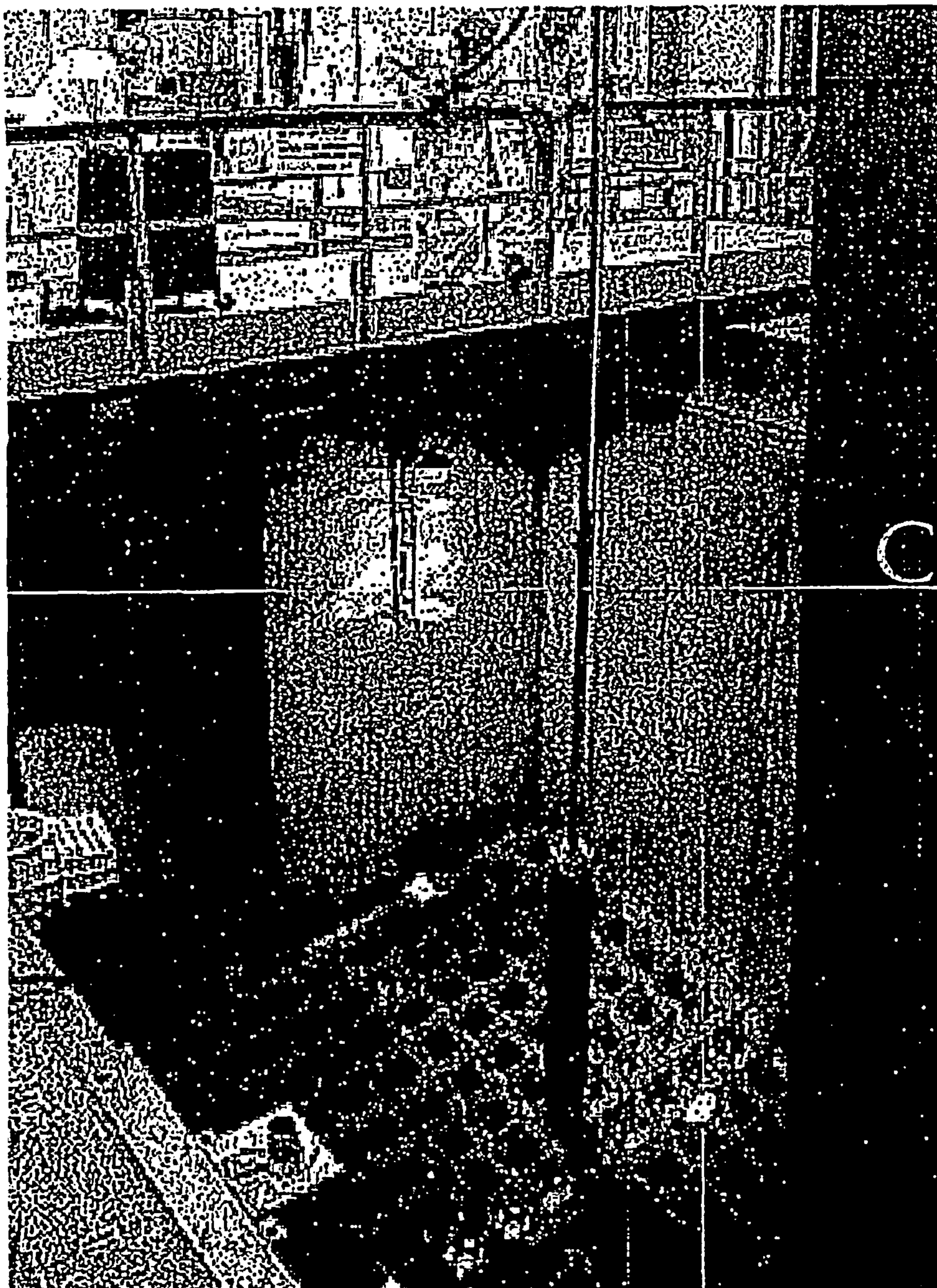


Figure 2.2 PWR Heatup Times for Air Cooling and Adiabatic Heatup

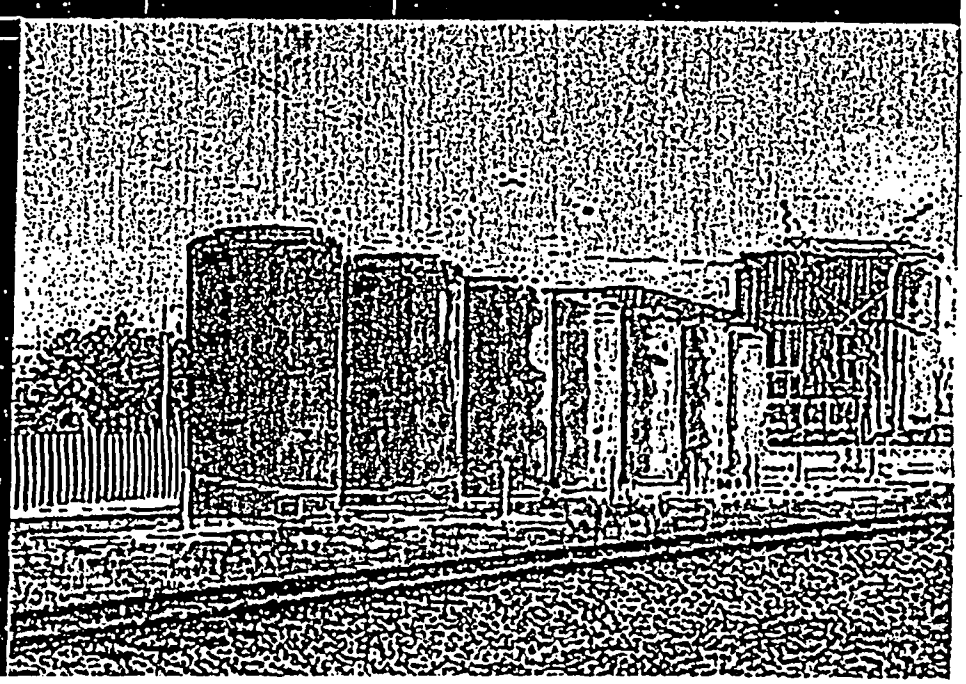
EXHIBIT

4



SAFETY AND SECURITY OF COMMERCIAL SPENT NUCLEAR FUEL STORAGE

PUBLIC REPORT



NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

SAFETY AND SECURITY
OF
COMMERCIAL
SPENT NUCLEAR FUEL STORAGE

Public Report

Committee on the Safety and Security of Commercial Spent Nuclear Fuel Storage

Board on Radioactive Waste Management

Division on Earth and Life Studies

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

THE NATIONAL ACADEMIES PRESS
Washington, D.C.
www.nap.edu

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This study was supported by grant number NRC-04-04-067 between the National Academy of Sciences and the U.S. Nuclear Regulatory Commission. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the organizations or agencies that provided support for the project.

International Standard Book Number 0-309-09647-2
Library of Congress Control Number 2005926244

Additional copies of this report are available from the National Academies Press, 500 Fifth Street, N.W., Lockbox 285, Washington, DC 20055; (800) 624-6242 or (202) 334-3313 (in the Washington metropolitan area); Internet, http://www.nap.edu

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[1] Drs. Cox and Wreathall resigned from the committee on February 26 and March 17, 2004, respectively.

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[1] Dr. Meserve did not participate in the oversight of this study.

ACKNOWLEDGMENTS

This study would not have been possible without the help of several organizations and individuals who were called upon for information and advice. The committee would like to acknowledge especially the following organizations and individuals for their help:

- Congressional staff members Kevin Cook, Terry Tyborowski, and Jeanne Wilson (retired) for their guidance on the study task.
- Nuclear Regulatory Commission staff Farouk Eltawila, who served as the primary liaison for this study, and Charles Tinkler and Francis (Skip) Young for their support of the committee's information-gathering activities.
- Department of Homeland Security staff member Jon MacLaren, who also served as a liaison to the committee.
- Steve Kraft and John Vincent (deceased) of the Nuclear Energy Institute and staff of Energy Resources International for providing information about spent fuel storage practices in industry.
- ENTERGY Corp., Exelon Corp, and Arizona Public Service Corp. staff for organizing tours of the Braidwood, Dresden, Indian Point, and Palo Verde nuclear generating stations.
- German organizations and individuals who helped organize a tour of spent fuel storage facilities in Germany. These organizations and individuals are explicitly acknowledged in Appendix C.
- Speakers (see Appendix A) and participants at committee meetings as well as those who sent written comments for providing their knowledge and perspectives on this important matter.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The content of the review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

John F. Ahearne, Sigma Xi and Duke University
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Donald R. Olander, University of California, Berkeley
Theofanis G. Theofanous, University of California, Santa Barbara
George W. Ullrich, SAIC
Frank N. von Hippel, Princeton University

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the report's conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by Chris G. Whipple, ENVIRON International Corporation, and R. Stephen Berry, University of Chicago. Appointed by the National Research Council, they were responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

CONTENTS

NOTE TO READERS

This report is based on a classified report that was developed at the request of the U.S. Congress with sponsorship from the Nuclear Regulatory Commission and the Department of Homeland Security. This report contains all of the findings and recommendations that appear in the classified report. Some have been slightly reworded and other sensitive information that might allow terrorists to exploit potential vulnerabilities has been redacted to protect national security. Nevertheless, the National Research Council and the authoring committee believe that this report provides an accurate summary of the classified report, including its findings and recommendations.

The authoring committee for this report examined the potential consequences of a large number of scenarios for attacking spent fuel storage facilities at commercial nuclear power plants. Some of these scenarios were developed by the Nuclear Regulatory Commission as part of its ongoing vulnerability analyses, whereas others were developed by the committee based upon the expertise of its members or suggestions from participants at the committee's open meetings. The committee focused its discussions about terrorist attacks on the concept of *maximum credible scenarios*. These are defined by the committee to be physically realistic classes of attacks that, if carried out successfully, would produce the most serious potential consequences within that class. In a practical sense they can be said to *bound* the consequences for a given type of attack. Such scenarios could in some cases be very difficult to carry out because they require a high level of skill and knowledge or luck on the part of the attackers. It was nevertheless useful to analyze these scenarios because they provide decision makers with a better understanding of the full range of potential consequences from terrorist attacks.

The committee uses the term *potential consequences* advisedly. It is important to recognize that a terrorist attack on a spent fuel storage facility would not necessarily result in the release of any radioactivity to the environment. The consequences of such an attack would depend not only on the nature of the attack itself, but also on the construction of the spent fuel storage facility; its location relative to surrounding features that might shield it from the attack; and the ability of the guards and operators at the facility to respond to the attack and/or mitigate its consequences. Facility-specific analyses are required to determine the potential vulnerability of a given facility to a given type of terrorist attack.

Congress asked the National Research Council for technical advice related to the vulnerability of spent fuel storage facilities to terrorist attacks. Congress, the Nuclear Regulatory Commission, and the Department of Homeland Security are responsible for translating this advice into policy actions. This will require the balancing of costs, risks, and benefits across the nation's industrial infrastructure. The committee was not asked to examine the potential vulnerabilities of other types of infrastructure to terrorist attacks or the consequences of such attacks. While such comparisons will likely be difficult, they will be essential for ensuring that the nation's limited resources are used judiciously in protecting its citizens from terrorist attacks.

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SUMMARY FOR CONGRESS

The U.S. Congress asked the National Academies to provide independent scientific and technical advice on the safety and security of commercial spent nuclear fuel storage in the United States, specifically with respect to the following charges:

- Potential safety and security risks of spent nuclear fuel presently stored in cooling pools at commercial nuclear reactor sites.
- Safety and security advantages, if any, of dry cask storage versus wet pool storage at these reactor sites.
- Potential safety and security advantages, if any, of dry cask storage using various single-, dual-, and multi-purpose cask designs.
- The risks of terrorist attacks on these materials and the risk these materials might be used to construct a radiological dispersal device.

Congress requested that the National Academies produce a classified report that addresses these charges within 6 months and also provide an unclassified summary for unlimited public distribution. The first request was fulfilled in July 2004. This report fulfills the second request.

The highlights of the report are as follows:

(1) Spent fuel pools are necessary at all operating nuclear power plants to store recently discharged fuel.

(2) The committee judges that successful terrorist attacks on spent fuel pools, though difficult, are possible.

(3) If an attack leads to a propagating zirconium cladding fire, it could result in the release of large amounts of radioactive material.

(4) Additional analyses are needed to understand more fully the vulnerabilities and consequences of events that could lead to propagating zirconium cladding fires.

(5) It appears to be feasible to reduce the likelihood of a zirconium cladding fire by rearranging spent fuel assemblies in the pool and making provision for water-spray systems that would be able to cool the fuel, even if the pool or overlying building were severely damaged.

(6) Dry cask storage has inherent security advantages over spent fuel pool storage, but it can only be used to store older spent fuel.

(7) There are no large security differences among different storage-cask designs.

(8) It would be difficult for terrorists to steal enough spent fuel from storage facilities for use in significant radiological dispersal devices (dirty bombs).

The statement of task does not direct the committee to recommend whether the transfer of spent fuel from pool to dry cask storage should be accelerated. The committee judges, however, that further engineering analyses and cost-benefit studies would be needed before decisions on this and other mitigative measures are taken. The report contains detailed recommendations for improving the security of spent fuel storage regardless of how it is stored.

EXECUTIVE SUMMARY

In the Fiscal Year 2004 Energy and Water Development Conference Report, the U.S. Congress asked the National Academies to provide independent scientific and technical advice on the safety and security[1] of commercial spent nuclear fuel storage in the United States, specifically with respect to the following four charges:

(1) Potential safety and security risks of spent nuclear fuel presently stored in cooling pools at commercial reactor sites.
(2) Safety and security advantages, if any, of dry cask storage versus wet pool storage at these reactor sites.
(3) Potential safety and security advantages, if any, of dry cask storage using various single-, dual-, and multi-purpose cask designs.
(4) The risks of terrorist attacks on these materials and the risk these materials might be used to construct a radiological dispersal device.

Congress requested that the National Academies produce a classified report that addresses these charges within 6 months and also provide an unclassified summary for unlimited public distribution. The first request was fulfilled in July 2004. This report fulfills the second request.

Spent nuclear fuel is stored at commercial nuclear power plant sites in two configurations:

- In water-filled pools, referred to as *spent fuel pools.*
- In *dry casks* that are designed either for storage (single-purpose casks) or both storage and transportation (dual-purpose casks). There are two basic cask designs: bare-fuel casks and canister-based casks, which can be licensed for either single- or dual-purpose use, depending on their design.

Spent fuel pools are currently in use at all 65 sites with operating commercial nuclear power reactors, at 8 sites where commercial power reactors have been shut down, and at one site not associated with an operating or shutdown power reactor. Dry-cask storage facilities have been established at 28 operating, shutdown, or decommissioned power plants. The nuclear industry projects that up to three or four nuclear power plants will reach full capacity in their spent fuel pools each year for at least the next 17 years.

The congressional request for this study was prompted by conflicting public claims about the safety and security of commercial spent nuclear fuel storage at nuclear power plants. Some analysts have argued that the dense packing of spent fuel in cooling pools at nuclear power plants does not allow a sufficient safety margin in the event of a loss-of-pool-coolant event from an accident or terrorist attack. They assert that such events could result in the release of large quantities of radioactive material to the environment if the zirconium cladding of the spent fuel overheats and ignites. To reduce the potential for such fires, these

[1] In the context of this study, *safety* refers to measures that protect spent nuclear fuel storage facilities against failure, damage, human error, or other accidents that would disperse radioactivity in the environment. *Security* refers to measures to protect spent fuel storage facilities against sabotage, attacks, or theft.

analysts have suggested that spent fuel more than five years old be removed from the pool and stored in dry casks, and that the remaining younger fuel be reconfigured in the pool to allow more space for air cooling in the event of a loss-of-pool-coolant event.

The committee that was appointed to perform the present study examined the vulnerability of spent fuel stored in pools and dry casks to accidents and terrorist attacks. Any event that results in the breach of a spent fuel pool or a dry cask, whether accidental or intentional, has the potential to release radioactive material to the environment. The committee therefore focused its limited time on understanding two issues: (1) Under what circumstances could pools or casks be breached? And (2) what would be the radioactive releases from such breaches?

To address these questions, the committee performed a critical review of the security analyses that have been carried out by the Nuclear Regulatory Commission and its contractors, the Department of Homeland Security, industry, and other independent experts to determine if they are objective, complete, and credible. The committee was unable to examine several important issues related to these questions either because it was unable to obtain needed information from the Nuclear Regulatory Commission or because of time constraints. Details are provided in Chapters 1 and 2.

The committee's findings and recommendations from this analysis are provided below, organized by the four charges of the study task. The ordering of the charges has been rearranged to provide a more logical exposition of results.

CHARGE 4: RISKS OF TERRORIST ATTACKS ON THESE MATERIALS AND THE RISK THESE MATERIALS MIGHT BE USED TO CONSTRUCT A RADIOLOGICAL DISPERSAL DEVICE

The concept of *risk* as applied to terrorist attacks underpins the entire statement of task for this study. Therefore, the committee examined this final charge first to provide the basis for addressing the remainder of the task statement. The committee's examination of Charge 4 is provided in Chapter 2. On the basis of this examination, the committee offers the following findings and recommendations numbered according to the chapters in which they appear:

FINDING 2A: The probability of terrorist attacks on spent fuel storage cannot be assessed quantitatively or comparatively. Spent fuel storage facilities cannot be dismissed as targets for such attacks because it is not possible to predict the behavior and motivations of terrorists, and because of the attractiveness of spent fuel as a terrorist target given the well known public dread of radiation. Terrorists view nuclear power plant facilities as desirable targets because of the large inventories of radioactivity they contain. While it would be difficult to attack such facilities, the committee judges that attacks by knowledgeable terrorists with access to appropriate technical means are possible. It is important to recognize, however, that an attack that damages a power plant or its spent fuel storage facilities would not necessarily result in the release of *any* radioactivity to the environment. There are potential steps that can be taken to lower the potential consequences of such attacks.

FINDING 2B: The committee judges that the likelihood terrorists could steal enough spent fuel for use in a significant radiological dispersal device is small. Removal of a spent fuel assembly from the pool or dry cask would prove extremely difficult under almost any terrorist attack scenario. Attempts by a knowledgeable insider(s) to remove single rods and related debris from the pool might prove easier, but the amount of material that could be removed would be small. Moreover, superior materials could be stolen or purchased more easily from other sources. Even though the likelihood of spent fuel theft appears to be small, it is nevertheless important that the protection of these materials be maintained and improved as vulnerabilities are identified.

> **RECOMMENDATION: The Nuclear Regulatory Commission should review and upgrade, where necessary, its security requirements for protecting spent fuel rods not contained in fuel assemblies from theft by knowledgeable insiders, especially in facilities where individual fuel rods or portions of rods are being stored in pools.**

FINDING 2C: A number of security improvements at nuclear power plants have been instituted since the events of September 11, 2001. However, the Nuclear Regulatory Commission did not provide the committee with enough information to evaluate the effectiveness of these procedures for protecting stored spent fuel. Surveillance and other human-factors related security procedures are just as important as the physical barriers in preventing and mitigating terrorist attacks. Although the committee did learn about some of the changes that have been instituted since the September 11, 2001, attacks, it was not provided with enough information to evaluate the effectiveness of procedures now in place.

> **RECOMMENDATION: Although the committee did not specifically investigate the effectiveness and adequacy of improved surveillance and security measures for protecting stored spent fuel, an assessment of current measures should be performed by an independent[2] organization.**

CHARGE 1: POTENTIAL SAFETY AND SECURITY RISKS OF SPENT NUCLEAR FUEL STORED IN POOLS

The committee's examination of Charge 1 is provided in Chapter 3. On the basis of this examination, the committee offers the following findings and recommendations:

FINDING 3A: Pool storage is required at all operating commercial nuclear power plants to cool newly discharged spent fuel. Freshly discharged spent fuel generates too much decay heat to be passively air cooled. This fuel must be stored in a pool that has an active heat removal system (i.e., water pumps and heat exchangers) for at least one year before being moved to dry storage. Most dry storage systems are licensed to store fuel that has been out of the reactor for at least five years. Although spent fuel younger than five years could be stored in dry casks, the changes required for shielding and heat-removal

[2] That is, independent of the Nuclear Regulatory Commission and the nuclear industry.

could be substantial, especially for fuel that has been discharged for less than about three years.

FINDING 3B: The committee finds that, under some conditions, a terrorist attack that partially or completely drained a spent fuel pool could lead to a propagating zirconium cladding fire and the release of large quantities of radioactive materials to the environment. Details are provided in the committee's classified report.

FINDING 3C: It appears to be feasible to reduce the likelihood of a zirconium cladding fire following a loss-of-pool-coolant event using readily implemented measures. *The following measures appear to have particular merit:* Reconfiguring the spent fuel in the pools (i.e., redistribution of high decay-heat assemblies so that they are surrounded by low decay-heat assemblies) to more evenly distribute decay-heat loads and enhance radiative heat transfer; limiting the frequency of offloads of full reactor cores into spent fuel pools, requiring longer shutdowns of the reactor before any fuel is offloaded, and providing enhanced security when such offloads must be made; and development of a redundant and diverse response system to mitigate loss-of-pool-coolant events that would be capable of operation even if the pool or overlying building were severely damaged.

FINDING 3D: The potential vulnerabilities of spent fuel pools to terrorist attacks are plant-design specific. Therefore, specific vulnerabilities can be understood only by examining the characteristics of spent fuel storage at each plant. As described in Chapter 3, there are substantial differences in the designs of spent fuel pools that make them more or less vulnerable to certain types of terrorist attacks.

FINDING 3E: The Nuclear Regulatory Commission and independent analysts have made progress in understanding some vulnerabilities of spent fuel pools to certain terrorist attacks and the consequences of such attacks for releases of radioactivity to the environment. However, additional work on specific issues is needed urgently. The analyses carried out to date provide a general understanding of spent fuel behavior in a loss-of-pool-coolant event and the vulnerability of spent fuel pools to certain terrorist attacks that could cause such events to occur. The work to date, however, has not been sufficient to adequately understand the vulnerabilities and consequences of such events. Additional analyses are needed to fill in the knowledge gaps so that well-informed policy decisions can be made.

> **RECOMMENDATION: The Nuclear Regulatory Commission should undertake additional best-estimate analyses to more fully understand the vulnerabilities and consequences of loss-of-pool-coolant events that could lead to a zirconium cladding fire. Based on these analyses, the Commission should take appropriate actions to address any significant vulnerabilities that are identified.** The committee provides details on additional analyses that should be carried out in its classified report. Cost-benefit considerations will be an important part of such decisions.

> **RECOMMENDATION: While the work described in the previous recommendation under Finding 3E, above, is being carried out, the Nuclear Regulatory Commission should ensure that power plant operators take prompt and effective measures to reduce the consequences of loss-of-pool-coolant**

events in spent fuel pools that could result in propagating zirconium cladding fires. The committee judges that there are at least two such measures that should be implemented promptly:

- Reconfiguring of fuel in the pools so that high decay-heat fuel assemblies are surrounded by low decay-heat assemblies. This will more evenly distribute decay-heat loads, thus enhancing radiative heat transfer in the event of a loss of pool coolant.
- Provision for water-spray systems that would be able to cool the fuel even if the pool or overlying building were severely damaged.

Reconfiguring of fuel in the pool would be a prudent measure that could probably be implemented at all plants at little cost, time, or exposure of workers to radiation. The second measure would probably be more expensive to implement and may not be needed at all plants, particularly plants in which spent fuel pools are located below grade or are protected from external line-of-sight attacks by exterior walls and other structures.

The committee anticipates that the costs and benefits of options for implementing the second measure would be examined to help decide what requirements would be imposed. Further, the committee does not presume to anticipate the best design of such a system—whether it should be installed on the walls of a pool or deployed from a location where it is unlikely to be compromised by the same attack—but simply notes the demanding requirements such a system must meet.

CHARGE 3: POTENTIAL SAFETY AND SECURITY ADVANTAGES, IF ANY, OF DIFFERENT DRY CASK STORAGE DESIGNS

The third charge to the committee focuses exclusively on the safety and security of dry casks. The committee addressed this charge first in Chapter 4 to provide the basis for the comparative analysis between dry casks and pools as called for in Charge 2.

FINDING 4A: Although there are differences in the robustness of different dry cask designs (e.g., bare-fuel versus canister-based), the differences are not large when measured by the absolute magnitudes of radionuclide releases in the event of a breach. All storage cask designs are vulnerable to some types of terrorist attacks, but the quantity of radioactive material releases predicted from such attacks is relatively small. These releases are not easily dispersed in the environment.

FINDING 4B: Additional steps can be taken to make dry casks less vulnerable to potential terrorist attacks. Although the vulnerabilities of current cask designs are already small, additional, relatively simple steps can be taken to reduce them as discussed in Chapter 4.

RECOMMENDATION: The Nuclear Regulatory Commission should consider using the results of the vulnerability analyses for possible upgrades of requirements in 10 CFR 72 for dry casks, specifically to improve their resistance to terrorist attacks. The committee was told by

Nuclear Regulatory Commission staff that such a step is already under consideration.

CHARGE 2: SAFETY AND SECURITY ADVANTAGES, IF ANY, OF DRY CASK STORAGE VERSUS WET POOL STORAGE

In Chapter 4, the committee offers the following findings and recommendations with respect to the comparative component of Charge 2:

FINDING 4C: Dry cask storage does not eliminate the need for pool storage at operating commercial reactors. Under present U.S. practices, dry cask storage can only be used to store fuel that has been out of the reactor long enough (generally greater than five years under current practices) to be passively air cooled.

FINDING 4D: Dry cask storage for older, cooler spent fuel has two inherent advantages over pool storage: (1) it is a passive system that relies on natural air circulation for cooling; and (2) it divides the inventory of that spent fuel among a large number of discrete, robust containers. These factors make it more difficult to attack a large amount of spent fuel at one time and also reduce the consequences of such attacks. The robust construction of these casks prevents large-scale releases of radioactivity in all of the attack scenarios examined by the committee in its classified report.

FINDING 4E: Depending on the outcome of plant-specific vulnerability analyses described in the committee's classified report, the Nuclear Regulatory Commission might determine that earlier movements of spent fuel from pools into dry cask storage would be prudent to reduce the potential consequences of terrorist attacks on pools at some commercial nuclear plants. The statement of task directs the committee to examine the risks of spent fuel storage options and alternatives for decision makers, not to recommend whether any spent fuel should be transferred from pool storage to cask storage. In fact, there may be some commercial plants that, because of pool designs or fuel loadings, may require some removal of spent fuel from their pools. If there is a need to remove spent fuel from the pools it should become clearer once the vulnerability and consequence analyses described in the classified report are completed. The committee expects that cost-benefit considerations would be a part of these analyses.

IMPLEMENTATION ISSUES

Implementation of the recommendations in Chapters 2-4 will require action and cooperation by a large number of parties. The final chapter of the report provides a brief discussion of two implementation issues that the committee believes are of special interest to Congress: *Timing Issues*: Ensuring that high-quality, expert analyses are completed in a timely manner; and *Communications Issues*: Ensuring that the results of the analyses are communicated to relevant parties so that appropriate and timely mitigating actions can be taken. This discussion leads to the following finding and recommendation.

FINDING 5A: Security restrictions on sharing of information and analyses are hindering progress in addressing potential vulnerabilities of spent fuel storage to

terrorist attacks. Current classification and security practices appear to discourage information sharing between the Nuclear Regulatory Commission and industry. They impede the review and feedback processes that can enhance the technical soundness of the analyses being carried out; they make it difficult to build support within the industry for potential mitigative measures; and they may undermine the confidence that the industry, expert panels such as this one, and the public place in the adequacy of such measures.

RECOMMENDATION: The Nuclear Regulatory Commission should improve the sharing of pertinent information on vulnerability and consequence analyses of spent fuel storage with nuclear power plant operators and dry cask storage system vendors on a timely basis.

The committee also believes that the public is an important audience for the work being carried out to assess and mitigate vulnerabilities of spent fuel storage facilities. While it would be inappropriate to share all information publicly, more constructive interaction with the public and independent analysts could improve the work being carried out and also increase public confidence in Nuclear Regulatory Commission and industry decisions and actions to reduce the vulnerability of spent fuel storage to terrorist threats.

1

INTRODUCTION AND BACKGROUND

In the Fiscal Year 2004 Energy and Water Development Conference Report, the U.S. Congress asked the National Academies to provide independent scientific and technical advice on the safety and security[1] of commercial spent nuclear fuel storage in the United States (see Box 1.1). The Nuclear Regulatory Commission and the Department of Homeland Security jointly sponsored this study, as directed by Congress.

Awareness and concerns about the threat of high-impact terrorism have become acute and pervasive since the attacks on September 11, 2001. The information gathered by the committee during this study led it to conclude that there were indeed credible concerns about the safety and security of spent nuclear fuel storage in the current threat environment. From the outset the committee believed that safety and security issues must be addressed quickly to determine whether additional measures are needed to prevent or mitigate attacks that could cause grave harm to people and cause widespread fear, disruption, and economic loss. The information gathered during this study reinforced that view. Any concern related to nuclear power plants[2] has added stakes: Many people fear radiation more than they fear exposure to other physical insults. This amplifies the concern over a potential terrorist attack involving radioactive materials beyond the physical injuries it might cause, and beyond the economic costs of the cleanup.

1.1 CONTEXT FOR THIS STUDY

The congressional request for this study was prompted by conflicting public claims about the safety and security of commercial spent nuclear fuel storage at nuclear power plants. Some have argued that the dense packing used for storing spent fuel in cooling pools at nearly every nuclear power plant does not provide a sufficient safety margin in the event of a pool breach and consequent water loss from an accident or terrorist attack.[3] In such cases, the potential exists for the fuel most recently discharged from a reactor to heat up sufficiently for its zirconium cladding to ignite, possibly resulting in the release of large amounts of radioactivity to the environment (Alvarez et al., 2003a). The Nuclear Regulatory Commission's own analyses have suggested that such zirconium cladding fires and releases of radioactivity are possible (e.g., USNRC, 2001a).

To reduce the potential for such an event, Alvarez et al. (2003a) suggested that spent fuel more than five years old be removed from the pool and stored in dry casks, and

[1] In the context of this study, *safety* refers to measures that protect spent nuclear fuel storage facilities against failure, damage, human error, or other accidents that would disperse radioactivity in the environment. *Security* refers to measures to protect spent fuel storage facilities against sabotage, attacks, or theft.
[2] Safety and security of reactors at nuclear power plants are outside of the committee's statement of task and have been addressed only where they could not be separated from spent fuel storage. The distinctions between spent fuel storage and operating nuclear power reactors are sometimes blurred in public discussions of nuclear and radiological concerns.
[3] The committee refers to such occurrences as *loss-of-pool-coolant events* in this report.

BOX 1.1 STATEMENT OF TASK

The issues to be addressed by this study are specified in the Energy and Water Development Conference Report and are as follows:

(1) Potential safety and security risks of spent nuclear fuel presently stored in cooling pools at commercial reactor sites (see Chapter 3).

(2) Safety and security advantages, if any, of dry cask storage versus wet pool storage at these reactor sites (see Chapter 4).

(3) Potential safety and security advantages, if any, of dry cask storage using various single-, dual-, and multi-purpose cask designs (see Chapter 4).

(4) In light of the September 11, 2001, terrorist attacks, this study will explicitly consider the risks of terrorist attacks on these materials and the risk these materials might be used to construct a radiological dispersal device (see Chapter 2).

that the remaining younger fuel be rearranged in the pool to allow more space for cooling (see also Marsh and Stanford, 2001; Thompson, 2003). The Nuclear Regulatory Commission staff, the nuclear industry, and some others have argued that densely packed pool storage can be carried out both safely and securely (USNRC, 2003a).

Policy actions to improve the safety and security of spent fuel storage could have significant national consequences. Nuclear power plants generate approximately 20 percent of the electricity produced in the United States. The issue of its future availability and use is critical to our nation's present and future energy security. The safety and security of spent fuel storage is an important aspect of the acceptability of nuclear power. Decisions that affect such a large portion of our nation's electricity supply must be considered carefully, wisely, and with a balanced view.

1.2 STRATEGY TO ADDRESS THE STUDY CHARGES

Congress directed the National Academies to produce a classified report that addresses the statement of task shown in Box 1.1 within 6 months and an unclassified summary for unlimited public dissemination within 12 months. This report, which has undergone a security review by the Nuclear Regulatory Commission and found to contain no classified national security or safeguards information, fulfills the second request.[4]

The National Research Council of the National Academies appointed a committee of 15 experts to carry out this study. Biographical sketches of the committee members are provided in Appendix B. The committee met six times from February to June 2004 to gather information and complete its classified report. The committee met again in August, October, and November 2004 and in January 2005 to develop this public report.

Details on the information-gathering sessions and speakers are provided in Appendix A. Most of the information-gathering sessions were not open to the public because they involved presentations and discussions of classified information. The committee recognized, however, that important contributions to this study could be made by industry representatives, independent analysts, and the public, so it scheduled open, unclassified

[4] The classified report was briefed to the agencies and Congress on July 15, 2004.

sessions at three of its meetings to obtain comments from interested organizations and individuals. Public comments at these meetings were encouraged and considered.

Subgroups of the committee visited several nuclear power plants to learn first-hand how spent fuel is being managed in wet and dry storage: the Dresden and Braidwood Nuclear Generating Stations in Illinois, which are owned and operated by Exelon Nuclear Corp.; the Indian Point Nuclear Generating Station in New York, which is owned and operated by ENTERGY Corp.; and the Palo Verde Nuclear Generating Station in Arizona, which is operated by Arizona Public Service Corp. A subgroup of committee members also traveled to Germany to visit spent fuel storage installations at Ahaus and Lingen and to talk with experts about the safety and security of German spent fuel storage. The German government has been concerned about security for a long time, and the German nuclear industry has made adjustments to spent fuel storage designs and operations that reduce their vulnerability to accidents and terrorist attacks. A summary of the trip to Germany is provided in Appendix C.

The statement of task for this study directed the committee to examine both the safety and the security of spent fuel storage. It is important to recognize that these are two sides of the same coin in the sense that any event that results in the breach of a spent fuel pool or a dry cask, whether accidental or intentional, has the potential to release radioactive material to the environment. The committee therefore focused its limited time on understanding two issues: (1) Under what circumstances could pools or casks be breached? And (2) what would be the radioactive releases from such breaches?

The initiating events that could lead to the *accidental* breach of a spent fuel pool are well known: A large seismic event or the accidental drop of a cask on the pool wall that could lead to the loss of pool coolant. The condition that could lead to an accidental breach of a dry storage cask is similarly well known: an accidental drop of the cask during handling operations. Current Nuclear Regulatory Commission regulations are designed to prevent such accidental conditions by imposing requirements on the design and operation of spent fuel storage facilities. These regulations have been in place for decades and have so far been effective in preventing accidental releases of radioactive materials from these facilities into the environment.

The initiating events that could lead to the *intentional* breach of a spent fuel pool or dry storage cask are not as well understood. The Nuclear Regulatory Commission has had long-standing requirements in place to deal with radiological sabotage (included in the "design basis threat"; see Chapter 2), but the September 11, 2001, terrorist attacks provided a graphic demonstration of a much broader array of potential threats. As described in the following chapters, the Nuclear Regulatory Commission is currently sponsoring studies to better understand the potential consequences of such terrorist attacks on spent fuel storage facilities.

Early on in this study, the committee made a judgment that it should focus most of its attention concerning such initiating events on the security aspects of its task statement. Many of the phenomena that follow an initiating event (e.g., loss of pool coolant or cask breach) would be the same whether it arose from an accident or terrorist attack, as noted previously. While the mitigation strategies for such events might be similar, they would require different kinds of preparation.

Given the relatively short time frame for this study, the committee focused its efforts on performing a critical review of the security analyses that have been carried out by the Nuclear Regulatory Commission and its contractors, the Department of Homeland Security, industry (i.e., EPRI, formerly named the Electric Power Research Institute; ENTERGY Corp.; and dry cask vendors), and other independent experts to determine if they are objective, complete, and credible. The committee could only perform limited independent safety and security analyses based on the information it gathered.

The committee made many requests for information from the Nuclear Regulatory Commission, its Sandia National Laboratories contractor, and other organizations and individuals, often with little advance notice. For the most part, all parties responded well to these requests. The committee was able to access experts who could answer its technical questions and was pleased with the cooperation and information it received during its visits to spent fuel storage facilities. This cooperation was essential in enabling the committee to complete its task within the requested six-month timeframe.

The committee was forced to circumscribe some aspects of its examinations, however, due to time and/or information constraints. In particular, the committee did not pursue in-depth examinations of the following topics:

- Human factors issues involved in responding to terrorist attacks on spent fuel storage. These include surveillance activities to identify potential threats (both inside and outside the plant); the response of security forces; and the preparation of plant personnel to deploy mitigative measures in the event of an attack.
- The behavior of radioactive material after it enters the environment from a spent fuel pool or dry cask. The committee assumed that any large release of radioactivity from a spent fuel storage facility would be problematic even in the absence of knowledge of how it would disperse in the environment. The committee instead focused its efforts on understanding how much radioactive material would be released, if any, in the case of an attack.
- The economic consequences of potential terrorist attacks, except insofar as noting the possible magnitude of cleanup costs after a catastrophic release of radioactivity.
- The costs of potential measures to mitigate spent fuel storage vulnerabilities. The committee understands that the Nuclear Regulatory Commission would include cost-benefit considerations in decisions to impose any new requirements on industry for such measures.

The committee also did not examine the potential vulnerability of commercial spent fuel while being transported. That topic is not only outside of the committee's task, but there is another National Academies study currently underway to examine transportation issues.[5]

Because most of the studies on spent fuel storage vulnerabilities undertaken for the Nuclear Regulatory Commission are still in progress, the committee was not able to review completed technical documents. Instead, the committee had to rely on presentations by and discussions with technical experts. The committee does not believe that these difficulties prevented it from developing sound findings and recommendations from the information it

[5] Committee on Transportation of Radioactive Waste. See *http://national-academies.org/transportofradwaste*. That committee's final report is now planned for completion in the late summer of 2005.

did receive. The committee was able to draw upon other information sources both domestic and foreign,[6] including the experience and expertise of its members, to fill some of the information gaps.

1.3 REPORT ROADMAP

The sections that follow in this chapter provide background on storage of spent nuclear fuel, which may be helpful to non-experts in understanding the issues discussed in the following chapters. The other chapters are organized to explicitly address the four charges of the committee's statement of task:

- Chapter 2 addresses the last charge to the committee to "explicitly consider the risks of terrorist attacks on these materials and the risk these materials might be used to construct a radiological dispersal device."
- Chapter 3 addresses the first charge to the committee to examine the "potential safety and security risks of spent nuclear fuel presently stored in cooling pools at commercial reactor sites."
- Chapter 4 addresses the second and third charges to examine the "safety and security advantages, if any, of dry cask storage versus wet pool storage at these reactor sites" and the "potential safety and security advantages, if any, of dry cask storage using various single-, dual-, and multi-purpose cask designs."
- Chapter 5 concerns implementation of the recommendations in this report, specifically concerning timing and communication issues.

The appendixes provide supporting information, including a glossary and acronym list, descriptions of the committee's meetings, and biographical sketches of the committee members.

1.4 BACKGROUND ON SPENT NUCLEAR FUEL AND ITS STORAGE

This section is provided for readers who are not familiar with the technical features of spent nuclear fuel and its storage. Other readers should skip directly to Chapter 2.

Spent nuclear fuel is fuel that has been irradiated or "burned" in the core of a nuclear reactor. In power reactors, the energy released from fission reactions in the nuclear fuel heats water[7] to produce steam that drives turbines to generate electricity. Spent nuclear fuel from non-commercial reactors (such as research reactors, naval propulsion reactors, and plutonium production reactors) is not considered in this study.

1.4.1 Nuclear Fuel

Almost all commercial reactor fuel in the United States is in the form of solid, cylindrical pellets of uranium dioxide. The pellets are about 0.4 to 0.65 inch (1.0 to 1.65 centimeters) in length and about 0.3 to 0.5 inch (0.8 to 1.25 centimeters) in diameter. The

[6] For example, the aforementioned visits to Lingen and Ahaus, in Germany.
[7] A different coolant can be used, but all power reactors now operating in the United States are water cooled.

pellets are loaded into tubes, called *fuel cladding*, made of a zirconium metal alloy, called zircaloy. A loaded tube, which is typically 11.5 to 14.75 feet (3.5 to 4.5 meters) in length, is called a *fuel rod* (also referred to as a *fuel pin* or *fuel element*). Fuel rods are bundled together, with a 0.12 to 0.18 inch (0.3 to 0.45 centimeter) space left between each for coolant to flow, to form a square fuel assembly (see FIGURE 1.1) measuring about 6 to 9 inches (15 to 23 centimeters) on a side.

Typical fuel assemblies for boiling water nuclear reactors (BWRs) hold 49 to 63 fuel rods, and fuel assemblies for pressurized water nuclear reactors (PWRs) hold 164 to 264 fuel rods.[8] Depending on reactor design, typically between 190 and 750 assemblies, each weighing from 275 to 685 kg (600 to 1500 pounds), make up a power reactor core. New fuel assemblies (i.e., those that have not been irradiated in a reactor) do not require special cooling or radiation shielding; they can be moved with a crane in open air. Once in the reactor, however, the fuel undergoes nuclear fission and begins to generate the radioactive fission products and activation products that require shielding and cooling.

The uranium oxide fuel essentially is composed of two isotopes of uranium: Initially, about 3-5 percent[9] by weight is fissile uranium (uranium-235), which is the component that sustains the fission chain reaction; and about 95-97 percent is uranium-238, which can capture a neutron to produce fissile plutonium and other radioactive heavy isotopes (actinides). Each fission event, whether in uranium or plutonium, releases energy and neutrons as the fissioning nucleus splits into two (and infrequently three) radioactive fragments, called fission products.

When the fissile material has been consumed to a level where it is no longer economically viable (typically 4.5 to 6 years of operation for current fuel designs), the fuel is considered *spent* and is removed from the reactor core. Spent fuel assemblies are highly radioactive. The decay of radioactive fission products and other constituents generates heat (called *decay heat*) and penetrating (gamma and neutron) radiation. Therefore cooling, shielding, and remote handling are required for spent nuclear fuel.

The amount of heat and radiation generated by a spent fuel assembly after its removal from a reactor depends on the number of fissions that have occurred in the fuel, called the *burn-up*, and the time that has elapsed since the fuel was removed from the reactor. The rate of decay-heat generation by spent reactor fuel and how it will change with time after the fuel is removed from the reactor can be calculated. The results of an example calculation are shown in FIGURE 1.2.

At discharge from the reactor, a spent fuel assembly generates on the order of tens of kilowatts of heat. Decay-heat production diminishes as very short-lived radionuclides decay away, dropping heat generation by a factor of 100 during the first year; dropping by another factor of 5 between year one and year five; and dropping about 40 percent between year five and year ten (see FIGURE 1.2). Within a year of discharge from the reactor, decay-heat production in spent nuclear fuel is dominated by four radionuclides: Ruthenium-106 (with a 372.6-day half-life), cerium-144 (284.4-day half-life), cesium-137 (30.2-year half-life),

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[8] Technical specifications for the fuel assemblies are taken from the American National Standard document for pool storage of spent nuclear fuel (American Nuclear Society, 1988).

[9] With only a few exceptions, commercial nuclear power reactors in the United States have been fueled with low-enriched uranium, that is, less than 20 percent of the uranium is uranium-235. Uranium found in nature has about 0.71 percent uranium-235 by weight.

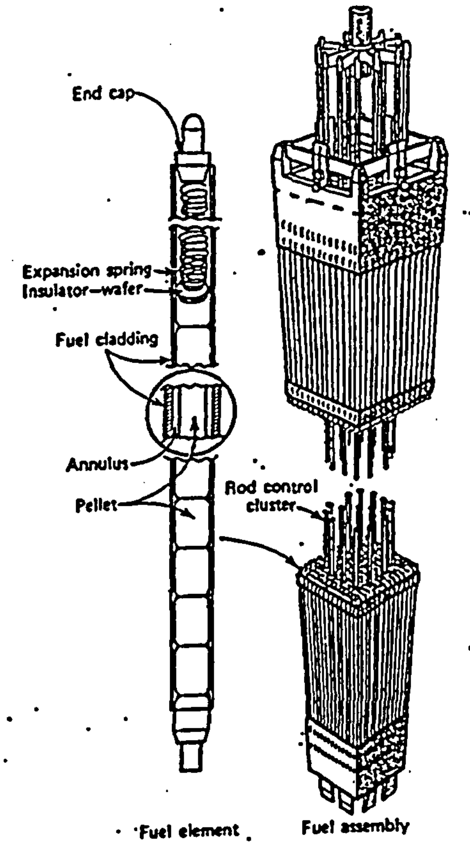

FIGURE 1.1 Fuel rods, also called fuel pins or elements, are bundled together into fuel assemblies as shown here. This fuel assembly is for a PWR reactor. SOURCE: Duderstadt and Hamilton (1976; Figure 3-7).

and cesium-134 (2.1-year half-life) and their short-lived decay products contribute nearly 90 percent of the decay heat from a spent fuel assembly.

Longer-lived radionuclides persist in the spent fuel even as the decay heat drops further. Cesium-137 decays to barium-137, emitting a beta particle and a high-energy gamma ray. The cesium-137 half-life of 30.2 years is sufficiently long to ensure that this radionuclide will persist during storage. It and other materials present in the fuel will form small particles, called *aerosols*, in a zirconium cladding fire.

Shorter-lived radionuclides decay away rapidly after removal of the spent fuel from the reactor. One of these is iodine-131, which is of particular concern in reactor core accidents because it can be taken up in large quantities by the human thyroid. This radionuclide has a half-life of about 8 days and typically persists in significant quantities in spent fuel only on the order of a few months.

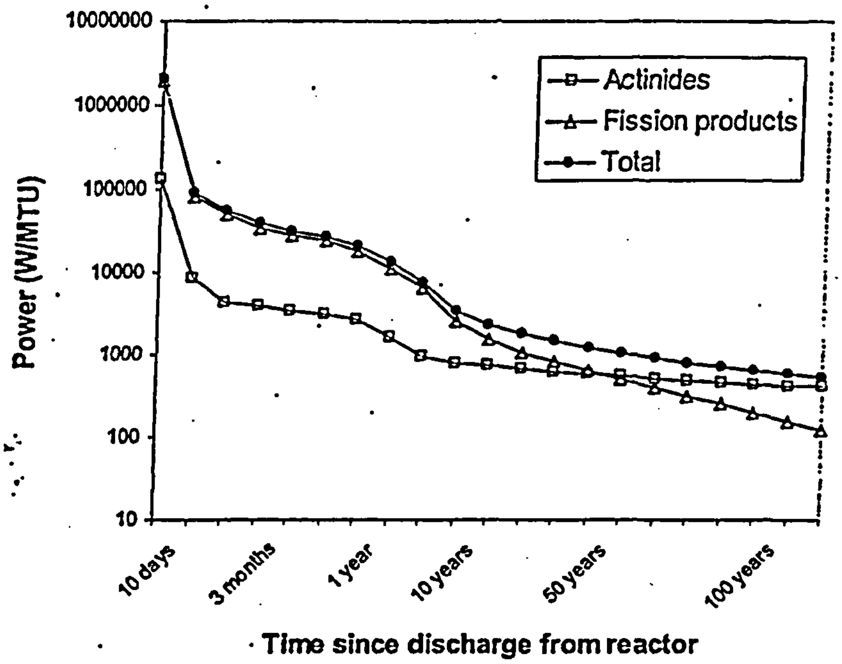

FIGURE 1.2 Decay-heat power for spent fuel (measured in watts per metric ton of uranium) plotted on a logarithmic scale as a function of time after reactor discharge. Note that the horizontal axis is a data series, not a scale. SOURCE: Based on data from USNRC (1984).

1.4.2 Storage of Spent Nuclear Fuel

Storage technologies for spent nuclear fuel have three primary objectives:

- Cool the fuel to prevent heat-up to high temperatures from radioactive decay.
- Shield workers and the public from the radiation emitted by radioactive decay in the spent fuel and provide a barrier for any releases of radioactivity.
- Prevent criticality accidents (uncontrolled fission chain reactions).

After the fuel assemblies are unloaded from the reactor they are stored in water pools, called *spent fuel pools*. The water in the pools provides radiation shielding and cooling and captures all but noble gas radionuclides in case of fuel rod leaks.[10] The geometry of the fuel and neutron absorbers (such as boron, hafnium, and cadmium) within the racks that hold the spent fuel or in the cooling water help prevent criticality events.[11] The water in the pool is circulated through heat exchangers for cooling and ion exchange filters to capture any radionuclides and other contaminants that get into the water. Makeup water is also added to the pool to replace pool water lost to evaporation. The operation of the pumps and heat exchangers is especially important during and immediately after reactor

[10] If the cladding in the fuel rods is breached some radioactive materials will be released into the pool.
[11] See the Glossary (Appendix E) for a definition of criticality. Most of the fuel's capacity for sustaining criticality is expended in the reactor as the uranium and plutonium are fissioned.

refueling operations, because this is when larger quantities of higher heat-generating spent fuel are placed into the pool.

Current U.S. regulations require that spent fuel be stored in the power plant's fuel pool for at least one year after its discharge from the reactor before being moved to dry storage. After that time the spent fuel can be moved, but only with active cooling. Active cooling is generally necessary for about three years after the spent fuel is removed from the reactor core (USNRC, 2003b).

When a spent fuel pool is filled to capacity, older fuel, which has lower decay-heat, is moved to other pools or placed into dry casks. Heat generated in the loaded dry casks is removed by air convection and thermal radiation. The cask provides shielding of penetrating radiation and confinement of the radionuclides in the spent fuel. As with pool storage, criticality control is accomplished by placing the fuel in a fixed geometry and separating individual fuel assemblies with neutron absorbers. Standard industry practice is to place in dry storage only spent fuel that has cooled for five years or more after discharge from the reactor.[12] Most spent fuel in wet or dry storage is located at nuclear power plant sites (i.e., on-site storage).

There are significant differences in the design and construction of wet and dry storage installations at commercial nuclear power plants. The characteristics depend on the type of the nuclear power plant, the age of the spent fuel storage installation, or the type of dry casks used. The design and features of spent fuel pools and dry storage facilities are discussed in Chapters 3 and 4, respectively.

1.4.3 Spent Fuel Inventories

As of 2003, approximately 50,000 MTU (metric tons of uranium) of spent fuel have been generated over the past four decades in the United States. A typical nuclear power plant generates about 20 MTU per year. The entire U.S. nuclear industry generates about 2000 MTU per year.

Of the approximately 50,000 MTU of commercial spent fuel in the United States, 43,600 MTU are currently stored in pools and 6200 MTU are in dry storage. Pool storage exists at all 65 sites with operating commercial nuclear power reactors[13] and at 8 sites where commercial power reactors are no longer operating (i.e., they have been shut down or decommissioned) (FIGURE 1.3). Additionally, there is an away-from-reactor spent fuel pool operating at the G.E. Morris Facility in Illinois (see Appendix D).

Of the spent fuel in dry storage, 4500 MTU are in storage at 22 sites with operating commercial nuclear power reactors, and 1700 MTU are in storage at 6 sites where the commercial reactors are no longer operating. An additional dry-storage facility is operated by the federal government at the Idaho National Laboratory. It stores most of the damaged fuel from the Three Mile Island Unit 2 reactor accident.

[12] Fuel aged as little as three years could be stored in passively cooled casks, but fewer assemblies could be accommodated in each cask because of the higher heat load.
[13] There are 103 operating commercial nuclear power reactors in the United States. Many sites have more than one operating reactor.

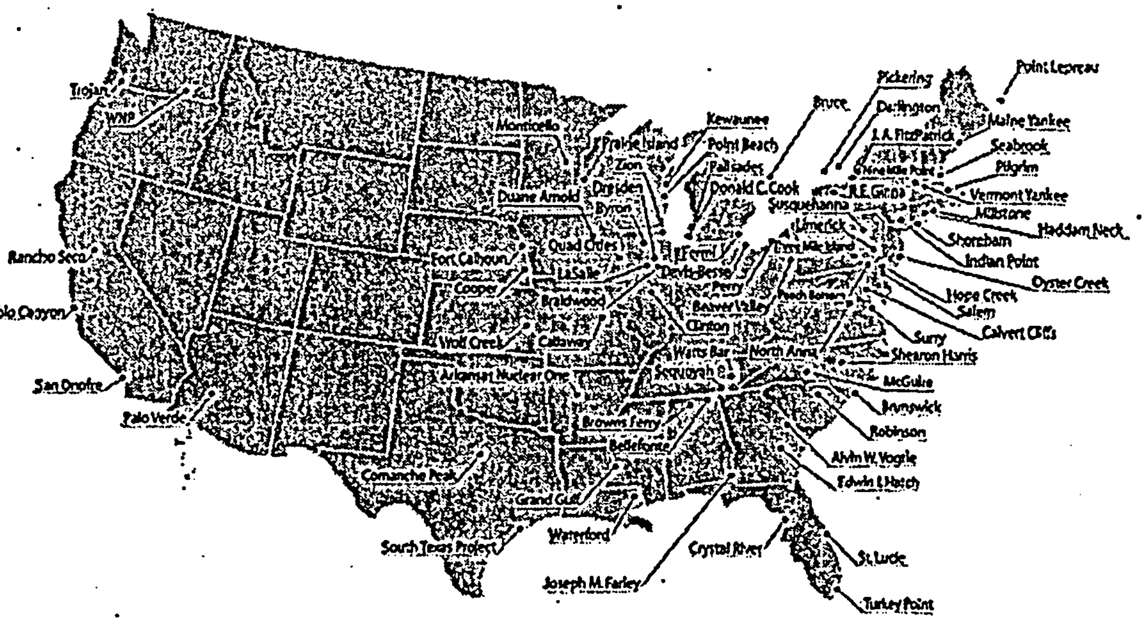

FIGURE 1.3 Locations of spent fuel storage facilities in the United States.

TABLE 1.1 provides a listing of the 30 operating Independent Spent Fuel Storage Installations (ISFSIs[14]) in the United States. These ISFSIs include the dry storage facilities at operating and shutdown commercial power reactor sites as well as the storage facilities at the Morris and Idaho sites, as described above. The committee did not examine the Morris and Idaho facilities as part of this study. At-reactor pool storage is not considered to be an ISFSI because it operates under the power reactor license.

1.4.4 History of Spent Fuel Storage

Spent fuel pools at commercial nuclear power plants were not designed to accommodate all the fuel used during the operating lifetime of the reactors they service. Most commercial power plants were designed with small pools under the assumption that fuel would be cooled for a short period of time after discharge from the reactor and then be sent offsite for recycling (i.e., reprocessing).[15] A commercial reprocessing industry never developed, however, for the reasons discussed in Appendix D. Newer power plants were designed with larger pool storage capacities. Even plants with larger-capacity pools will run out of pool space if they operate beyond their initial 40-year licenses. In 2000, the nuclear power industry projected that roughly three or four plants per year would run out of needed storage space in their pools without additional interim storage capacity (see FIGURE 1.4).

Another development that logically could reduce the demand for storage of spent nuclear fuel at the sites of power plants is the availability of a geologic repository for

[14] An ISFSI is a facility for storing spent fuel in wet pools or dry casks and is defined in Title 10, Part 72 of the Code of Federal Regulations.

[15] Residual uranium-235 and plutonium in the spent fuel would be recovered for the manufacture of new fuel. The waste products in the fuel, principally the fission products, would be immobilized in solid matrices and stored for eventual disposal.

TABLE 1.1: Operating ISFSIs in the United States as of July 2004

Name	Location
Palo Verde	Arizona
Arkansas Nuclear One	Arkansas
Rancho Seco	California
San Onofre	California
Diablo Canyon	California
Fort St. Vrain [1]	Colorado
Edwin L. Hatch	Georgia
DOE-INL [2]	Idaho
G.E. Morris [3]	Illinois
Dresden	Illinois
Duane Arnold	Iowa
Maine Yankee	Maine
Calvert Cliffs	Maryland
Big Rock Point	Michigan
Palisades	Michigan
Prairie Island	Minnesota
Yankee Rowe	Massachusetts
Oyster Creek	New Jersey
J.A. FitzPatrick	New York
McGuire	North Carolina
Davis-Besse	Ohio
Trojan	Oregon
Susquehanna	Pennsylvania
Peach Bottom	Pennsylvania
Robinson	South Carolina
Oconee	South Carolina
North Anna	Virginia
Surry	Virginia
Columbia Gen. Station	Washington
Point Beach	Wisconsin

NOTES:
[1]The Fort St. Vrain ISFSI stores fuel from a commercial gas-cooled reactor. The facility is operated by the Department of Energy.
[2]The DOE-INL facility stores fuel from the Three-Mile Island Unit 2 reactor. The facility is operated by the Department of Energy.
[3]The G.E. Morris ISFSI is a wet storage facility.

SOURCES: Data from the USNRC (2004).

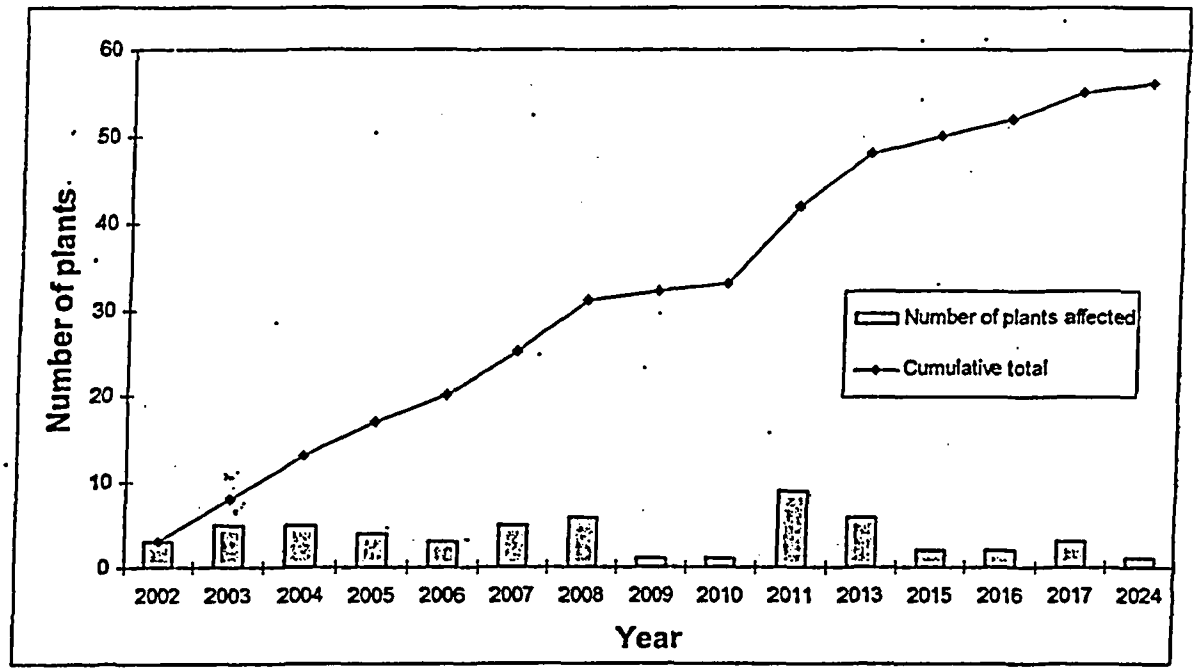

FIGURE 1.4 *Projection of the number of commercial nuclear power plants that will run out of needed space in their spent fuel pools in coming years if they do not add interim storage. These data, looking only at plants that did not already use dry cask storage, were provided to the Nuclear Regulatory Commission in 2000. SOURCE: USNRC (2001b).*

disposal of spent nuclear fuel. But a nuclear waste repository is not expected to be in operation until at least 2010, and even then it will take several decades for all of the spent fuel to be shipped for disposal. Thus, onsite storage of spent fuel is likely to continue for at least several decades.

Power plant operators have made two changes in spent fuel storage procedures to increase the capacity of onsite storage. First, starting in the late 1970s, plant operators began to install high-density racks that enable more spent fuel to be stored in the pools. This has increased storage capacities in some pools by up to about a factor of five (USNRC, 2003b). Second, as noted above, many plant operators have moved older spent fuel from the pools into dry cask storage systems (see Chapter 4) or into other pools when available to make room for freshly discharged spent fuel and to maintain the capacity for a full-core offload.[16]

The original spent fuel racks, sometimes called "open racks," were designed to store spent fuel in an open array, with open vertical and lateral channels between the fuel assemblies to promote water circulation. The high-density storage racks eliminated many of the channels so that the fuel assemblies could be packed closer together (FIGURE 1.5). This configuration does not allow as much water (or air circulation in loss-of-pool-coolant events) through the spent fuel assemblies as the original open-rack design.

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[16] Although not required by regulation, it is standard practice in the nuclear industry to maintain enough open space in the spent fuel pool to hold the entire core of the nuclear reactor. This provides an additional margin of safety should the fuel have to be removed from the reactor core in an emergency or for maintenance purposes.

Several nuclear utilities have already submitted license applications to the Nuclear Regulatory Commission to build 16 new ISFSIs. Among the potential new ISFSIs, a consortium of utilities has submitted a license for a private fuel storage facility (PFS) in Utah for interim dry storage of up to 40,000 metric tons of spent fuel.

Most or all pools store some spent fuel that has aged more than five years after discharge from the reactor, and so could be transferred to dry-cask storage. The amount that could be transferred depends on plant-specific information such as pool size and configuration, operating history of the reactor, the enrichment and burn-up level in the fuel, and availability of an ISFSI.

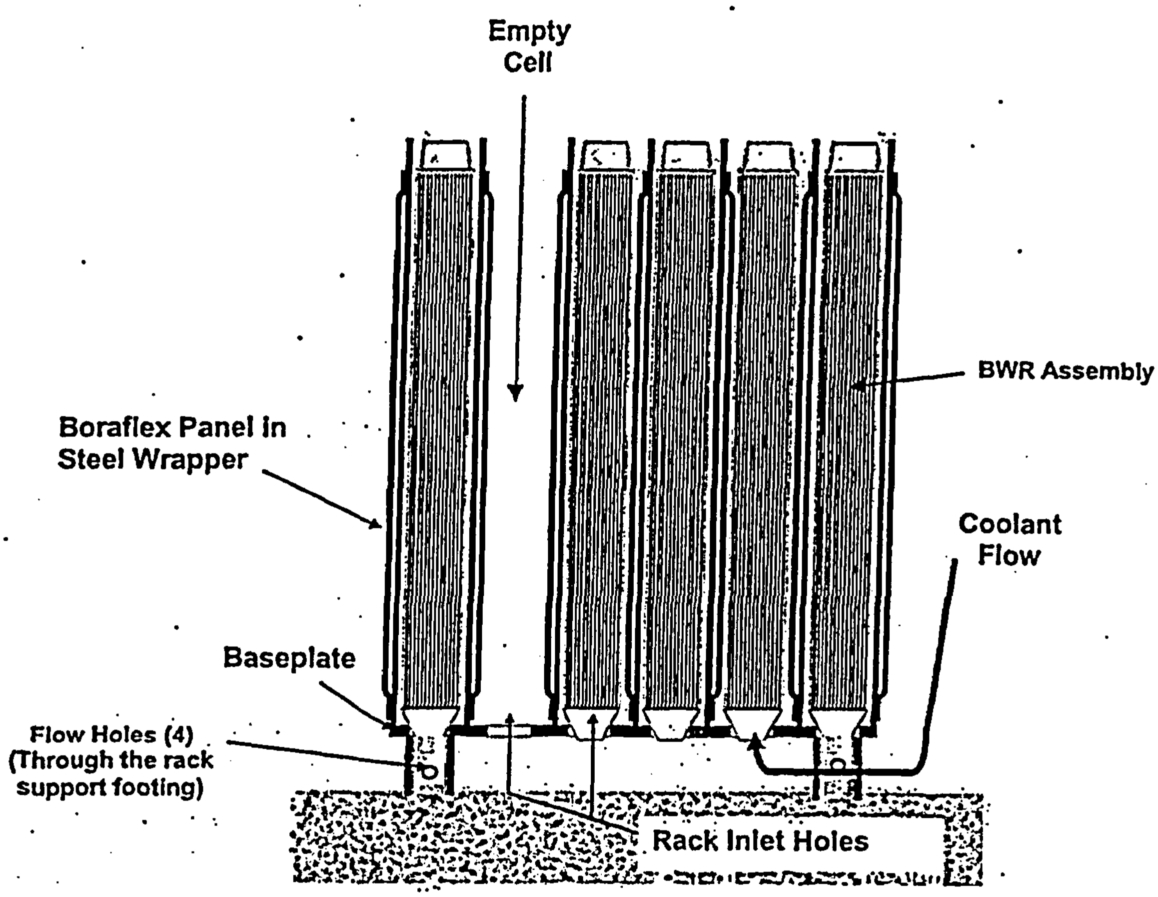

FIGURE 1.5 Dense spent fuel pool storage racks for BWR fuel. This cross-sectional illustration shows the principal elements of the spent fuel rack, which sits on the bottom of the pool. SOURCE: Nuclear Regulatory Commission briefing materials (2004).

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TERRORIST ATTACKS ON SPENT FUEL STORAGE

This chapter addresses the final charge to the committee to "explicitly consider the risks of terrorist attacks on [spent fuel] and the risk these materials might be used to construct a radiological dispersal device." The concept of *risk* as applied to terrorist attacks underpins the entire statement of task for this study. Therefore, the committee addresses this final charge first to provide the basis for addressing the remainder of the task statement.

The chapter is organized into the following sections:

- Background on risk.
- Terrorist attack scenarios.
- Risks of terrorist attacks on spent fuel storage facilities.
- *Findings and recommendations.*

2.1 BACKGROUND ON RISK

"Risk" is a function of three factors (Kaplan and Garrick, 1981):

- The *scenario* describing the undesirable event.
- The *probability* that the scenario will occur.
- The *consequences* if the scenario should occur.

In the context of the present report, a *scenario* describes the modes and mechanisms of a possible terrorist attack against a spent fuel storage facility. For example, a scenario might involve a suicide attack with a hijacked civilian airliner. Another might involve a ground assault with a truck bomb. Several such scenarios are described later in this chapter and discussed in more detail in the committee's classified report.

Probability is a dimensionless quantity that expresses the likelihood that a given scenario will occur over a specified time period. If the occurrence of a scenario is judged to be impossible, it would have a probability of 0.0. On the other hand, if the scenario were judged to be certain, it has a probability of 1.0. A scenario that had a 50 percent chance of occurrence during the period contemplated would have a probability of 0.5.

Consequences describe the undesirable results if the scenario were to occur. For example, a terrorist attack on a spent fuel storage facility could release ionizing radiation to the environment.[1] The exposure of the public to this radiation could have both deterministic and stochastic effects. The former would occur from short-term exposures to very high doses of ionizing radiation, the latter to smaller doses that might have no immediate effects

[1] Terrorist scenarios and consequences are being described here for the sake of illustration. One should not conclude from this description that the committee believes that such consequences would necessarily occur as the result of a terrorist attack on a spent fuel storage facility.

but could result in cancer induction some years or decades later.[2] Consequences also could be described in terms of economic damage. These could arise, for example, from the loss of use of the facility and surrounding areas or costs to clean up those areas. There also could be severe psychological consequences that could drive changes in public acceptance of commercial nuclear energy.

The quantitative expression for the risk of a particular scenario, for example a suicide terrorist attack with a hijacked airliner, is

$$\text{Risk}_{\text{airliner attack}} = \text{Probability}_{\text{airliner attack}} \times \text{Consequences}_{\text{airliner attack}} \quad (1)$$

The total risk would be the sum of the risks for all possible independent attack scenarios. For example, if a spent fuel storage facility was determined to be vulnerable to attacks using airliners, truck bombs, and armed assaults, the total risk would be calculated as

$$\text{Risk}_{\text{total}} = \text{Risk}_{\text{airliner attack}} + \text{Risk}_{\text{truck bomb attack}} + \text{Risk}_{\text{armed assault attack}} \quad (2)$$

Such equations are routinely used to calculate the risks of various industrial accidents, including accidents at nuclear power plants, through a process known as *probabilistic risk assessment*. Each accident is assigned a numerical probability based on a careful analysis of the sequence of failures (e.g., human or mechanical failures) that could produce the accident. The consequences of such accidents are typically expressed in terms of injuries, deaths, or economic losses.

It is possible to estimate the risks of industrial accidents because there are sufficient experience and data to quantify the probabilities and consequences. This is not the case for terrorist attacks. To date, experts have not found a way to apply these quantitative risk equations to terrorist attacks because of two primary difficulties: The first is to develop a complete set of bounding scenarios for such attacks; the second is to estimate their probabilities. These depend on impossible-to-quantify factors such as terrorist motivations, expertise, and access to technical means.[3] They also depend on the effectiveness of measures that might prevent or mitigate such attacks.

In the absence of quantitative information on risks, one could attempt to make qualitative risk comparisons. Such comparisons could estimate, for example, the relative risks of attacks on spent fuel storage facilities versus attacks on commercial nuclear power reactors or other critical infrastructure such as chemical plants. Although a comparison of such risks is beyond the scope of this study, the committee recognizes that policy decisions about spent fuel storage may need to take into account such comparative risk issues,

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[2] Such cancers would likely not be directly traceable to the radiation dose received from a terrorist attack and would likely be indistinguishable from the large population of cancers that result from other causes.

[3] Political scientists and counter-terror specialists have argued whether terrorists seek headlines, casualties, or both (e.g., Jenkins 1975, 1985). The September 11, 2001, attacks in the United States and the March 11, 2004, attacks in Spain demonstrate that some terrorists, particularly those of al-Qaida and its allies, intend to commit mass murder and/or mass economic disruption, both of which may have important political consequences. Further information about the motivation of terrorists is provided in NRC (2002).

especially for decisions regarding the expenditure of limited societal resources to address terrorist threats.

The 2002 National Research Council report *Making the Nation Safer: The Role of Science and Technology in Countering Terrorism* framed this issue as follows (NRC, 2002, p. 43):

> The potential vulnerabilities of NPPs [nuclear power plants] to terrorist attack seem to have captured the imagination of the public and the media, perhaps because of a perception that a successful attack could harm large populations and have severe economic and environmental consequences. There are, however, many other types of large industrial facilities that are potentially vulnerable to attack, for example, petroleum refineries, chemical plants, and oil and liquefied natural gas supertankers. These facilities do not have the robust construction and security features characteristic of NPPs, and many are located near highly populated urban areas.

Groups seeking to carry out high-impact terrorism will likely choose targets that have a high probability of being attacked successfully.[4] If success is measured by the number of people killed and injured or the permanent destruction of property, then spent fuel storage facilities may not make good terrorist targets owing to their relatively robust construction (see Chapters 1 and 3) and security. Industrialized societies like the United States provide terrorists a large number of "soft" (i.e., unprotected) targets that could be attacked more easily with greater effect than spent fuel storage facilities. These include chemical plants, refineries, transportation systems, and other facilities where large numbers of people gather (see NRC, 2002).

On the other hand, there are other success criteria that might influence a terrorist's decision to attack a "hard" (i.e., robust or well protected) target such as a commercial nuclear power plant and its spent fuel storage facilities. Such attacks could spread panic and shut down the power plant for an extended period of time even with no loss of life. Moreover, an attack that resulted in the release of radioactive material could threaten the viability of commercial nuclear power.

These considerations led the committee to conclude that it could not address its charge using quantitative and comparative risk assessments. The committee decided instead to examine a range of possible terrorist attack scenarios in terms of (1) their potential for damaging spent fuel pools and dry storage casks; and (2) their potential for radioactive material releases. This allowed the committee to make qualitative judgments about the vulnerability of spent fuel storage facilities to terrorist attacks and potential measures that could be taken to mitigate them.

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[4] This point was made to the committee in a briefing by the Department of Homeland Security, where "success" means that the terrorist was able to achieve the goals of the attack, whatever they might be.

2.2 TERRORIST ATTACK SCENARIOS

It is possible to imagine a wide range of terrorist attacks against spent fuel storage facilities. Each would have a range of potential consequences depending on the characteristics of the attack and the facility being targeted as well as any post-attack mitigative actions to prevent or reduce the release of radioactive material. The committee focused its discussions about terrorist attacks around the concept of a *maximum credible scenario*—that is, an attack that is physically possible to carry out and that produces the most serious potential consequences within a given class of attack scenarios.

The following example illustrates the concept: One of the scenario classes considered by the committee in this chapter involves suicide attacks against spent fuel storage facilities with civilian passenger aircraft. The physics of such attacks are well understood: In general, heavier and higher-speed aircraft produce greater impact forces than lighter and slower aircraft, all else being equal. Consequently, the maximum credible scenario for suicide attacks involving civilian passenger aircraft would utilize the largest civilian passenger aircraft widely used in the United States flying at maximum cruising speed and hitting the facility at its most vulnerable point. Such an attack provides an upper bound to the damage that could be inflicted by this type of aircraft attack.

The maximum credible scenario is particularly useful for obtaining a general understanding of the damage that could be inflicted, but it would not necessarily apply to every spent fuel storage facility. To be judged a "credible" scenario, the terrorist must be able to successfully carry it out as designed—for example, to hit a spent fuel storage facility with the largest civilian aircraft at its most vulnerable point. This would rule out attacks that are physically impossible, such as flying a large civilian aircraft into a facility that is located below ground level or protected by surrounding hills or buildings. This also would rule out attacks involving weapons that are not available to terrorists (e.g., aircraft-launched weapons such as "bunker-buster" bombs or nuclear weapons).

This is not intended, however, to rule out attacks that are judged to have a low probability for success simply because terrorists might lack the skill and knowledge or luck to carry them out. In fact, if the consequences of such attacks were severe, policy makers might still decide that prudent mitigating actions should be taken regardless of their low probabilities of occurrence.[5] This might be especially true if quick, inexpensive fixes could be implemented. The main benefit of analyzing the maximum credible scenario is that it provides decision makers with a better characterization of the full range of potential consequences so that sound policy judgments can be made.

The analyses carried out for the Nuclear Regulatory Commission (described in the committee's classified report) do not consider maximum credible scenarios. Instead, the analyses employ *reference scenarios* that are based either on the characteristics of previous terrorist attacks or on qualitative judgments of the technical means and methods that might be employed in attacks against spent fuel storage facilities. Although such reference scenarios are useful for gaining insights on potential consequences of terrorist attacks, they

[5] The Department of Energy, for example, routinely examines the consequences of very low probability events involving nuclear weapons safety and security; see, for example, AL 56XB Development and Production Manual published by the U.S. Department of Energy, National Nuclear Security Administration. See *http://prp.lanl.gov/documents/d_p_manual.asp.*

are not necessarily bounding. This becomes important when the reference scenario attack results in damage to a facility that verges on failure.

The committee prefers a maximum credible scenario approach for one important reason: It believes that terrorists who choose to attack hardened facilities like spent fuel storage facilities would choose weapons capable of producing maximum destruction. **Of course, once the consequences of such attacks are known, an element of expert judgment is required to determine whether such attacks have a high likelihood of being carried out as designed. Such judgment is especially important when making policy decisions about actions to reduce the vulnerabilities of facilities to such attacks.**

The consequences of terrorist attacks can be described in terms of either *maximum credible releases* or *best-estimate releases*. The former describes the largest releases of radioactive material following an attack based on quantitative analytical models (e.g., the MELCOR computer code described in Chapter 3). The latter describes the median estimates from such models. In both cases, the estimates may not account for mitigative actions that could be taken after an attack to reduce or even eliminate releases. The Nuclear Regulatory Commission analyses reviewed by the committee in its classified report are best-estimate releases for various terrorist attack scenarios. The estimates in NUREG-1738 (USNRC, 2001a) and Alvarez et al. (2003a), on the other hand, describe maximum-credible to worst-case releases.[6]

The committee considered four classes of terrorist attack scenarios in this study:

- Air attacks using large civilian aircraft or smaller aircraft laden with explosives.
- Ground attacks by groups of well-armed and well-trained individuals.
- Attacks involving combined air and land assaults.
- Thefts of spent fuel for use by terrorists (including knowledgeable insiders) in radiological dispersal devices.

The committee devoted time at its meetings discussing these scenarios. It also received briefings on possible scenarios from Nuclear Regulatory Commission staff and suggestions for scenarios from the Department of Homeland Security (DHS), other experts, and the public. Some scenarios were dismissed by the committee as not credible. An example of such a scenario is an attack on a spent fuel storage facility with a nuclear weapon. Such weapons would be relatively difficult[7] for terrorists to build or steal. Even if such a weapon could be obtained, the committee can think of no reason that it would be used against a spent fuel storage facility rather than another target. There are easier ways to attack spent fuel storage facilities, as discussed in the classified report, and there are more attractive targets for nuclear weapons, for example, large population centers.

[6] Worst-case releases are based on the most unfavorable conditions that could occur in a given scenario, regardless of whether those conditions were physically realistic. For example, a worst-case estimate of the radionuclide releases from an attack on a spent fuel pool might assume that all of the volatile radionuclides contained in the spent fuel would be released, even if quantitative analytical models showed that such releases were very unlikely to occur.

[7] Difficult but certainly not impossible. See Chapter 2 in NRC (2002).

Given the experience of September 11, 2001, and the attacks that have occurred in other parts of the world, it is clear to the committee that the ability of the most capable terrorists to carry out attacks is limited only by their access to technical means. It is probably not limited by the ability of terrorist organizations to recruit or train attackers or bring them and any needed equipment into the United States—if indeed they are not already here. Moreover, the demonstrated willingness of terrorists to carry out suicide attacks greatly expands the scenarios that need to be considered when analyzing potential threats.

As is discussed in some detail in Chapters 3 and 4, the facilities used to store spent fuel at nuclear power plants are very robust. Thus, only attacks that involve the application of large energy impulses or that allow terrorists to gain interior access have any chance of releasing substantial quantities of radioactive material. This further restricts the scenarios that need to be considered. For example, attacks using rocket-propelled grenades (RPGs) of the type that have been carried out in Iraq against U.S. and coalition forces would not likely be successful if the intent of the attack is to cause substantial damage to the facility. Of course, such an attack would get the public's attention and might even have economic consequences for the attacked plant and possibly the entire commercial nuclear power industry.

The threat scenarios summarized in this chapter are based on documents provided to the committee, briefings received at committee meetings, and the committee's own expert judgment.[8] Further overview and information on nuclear and radiological threats in general can be found in the NRC (2002) report and references therein.

2.2.1 Air Attacks

The September 11, 2001, attacks[9] demonstrated that terrorists are capable of successfully attacking fixed infrastructure with large civilian jetliners. The security of civilian passenger airliners has been improved since these attacks were carried out, and the vulnerability of civilian passenger aircraft to highjacking has been reduced. Nevertheless, the committee judges, based on the evidence made available to it during this study, that attacks with civilian aircraft remain a credible threat. Such aircraft are used routinely in freight and charter services, and large numbers of such aircraft enter the United States from other countries each day. Improvements to ground security or cargo inspection would likely not eliminate the threat posed by an air crew willing to stage a suicide attack with a chartered air freighter.

Although the September 11, 2001, attacks utilized Boeing 757 and 767 airliners, larger aircraft (Boeing 747, 777; Airbus 340) are in routine use around the world, and an even larger aircraft (Airbus 380) is entering production. Assaults by such large aircraft could impart enormous energy impulses to spent fuel storage facilities. Additionally, attacks with

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[8] The committee found limited information in the open literature on various scenarios for terrorist attacks on nuclear plants and their spent fuel storage facilities.

[9] The al-Qaida terrorist organization hijacked and crashed two Boeing 767 airliners into Towers 1 and 2 of the World Trade Center building in New York and a Boeing 757 airliner into the Pentagon building in Arlington, Virginia. A second Boeing 757, which was believed to be targeted either on the White House or the U.S. Capitol (see National Commission on Terrorist Attacks Upon the United States, Staff Statement No. 16 [Outline of the 9/11 Plot], pages 18-19) crashed in an open field near Jennerstown, Pennsylvania.

aircraft carrying large fuel loads could produce fires that would greatly complicate rescue and recovery efforts.

Previous studies on aircraft crash impacts (Droste et al., 2002; Lange et al., 2002; HSK, 2003; RBR Consultants, 2003; Thomauske, 2003) suggest that the consequences of a heavy aircraft crash on a nuclear installation depend on factors such as the following:

- Type and design of the aircraft.
- Speed of the aircraft.
- Fuel loading of the aircraft and total weight at impact.
- Angle-of-attack and point-of-impact on the facility.
- Construction of the facility.
- Location of the target with respect to ground level (i.e., below or above grade).[10]
- The presence of surrounding buildings and other obstacles (e.g., hills, transmission lines) that might block certain potential flight paths into the facility.

In other words, the consequences of such attacks are scenario- and plant-design specific. It is not possible to make any general statements about spent fuel storage facility vulnerabilities to air attacks that would apply to all U.S. commercial nuclear power plants.

U.S. commercial nuclear power plants are not required by the Nuclear Regulatory Commission to defend against air attacks. The Commission believes that it is the responsibility of the U.S. government to implement security measures to prevent such attacks. The commercial nuclear industry shares this view. The Nuclear Regulatory Commission staff informed the committee that the Commission has directed power plant operators to take steps to reduce the likelihood of serious consequences should such attacks occur. The staff also informed the committee that the Commission may issue additional directives once the vulnerability analyses it is sponsoring at Sandia National Laboratories are completed. These analyses are described in the committee's classified report (see also Chapters 3 and 4 in this report).

2.2.2 Ground Attacks

Ground attacks on a nuclear facility could take three forms: (1) a direct assault on the facility by armed groups, (2) a stand-off attack using appropriate weapons, or (3) an assault having both air and ground components. The direct assault would likely be carried out by a group of well-armed and trained attackers, perhaps working with the assistance of an insider. The objective of such an attack would likely be to gain entry to protected and vital areas of the plant (FIGURE 2.1) to carry out radiological sabotage. The attackers would need to have knowledge of the design, location, and operation of the spent fuel facility to carry out such an attack successfully.

Commercial nuclear power plants are required by the Nuclear Regulatory Commission to maintain a professional guard force at each plant to defend against a Commission-developed design basis threat (DBT), which includes a ground assault. The protective force is a critical part of a nuclear power plant's security system for deterring,

[10] All current dry cask storage facilities in the United States are constructed at ground level, whereas spent fuel pools can be located above or below grade, depending on plant design (see Chapter 3).

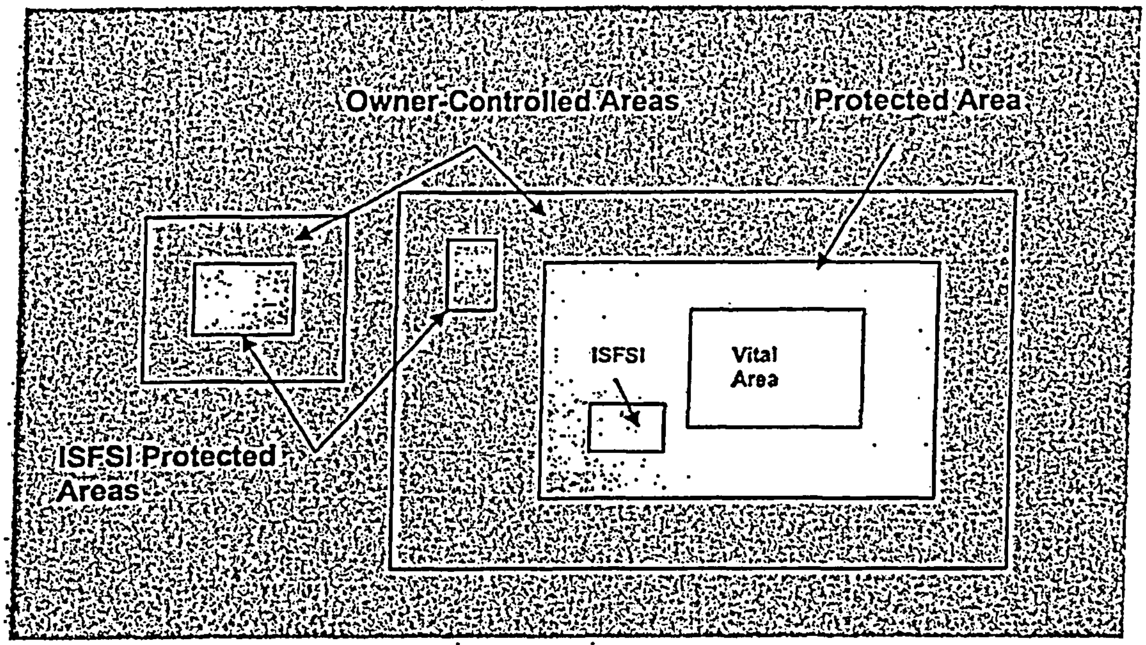

FIGURE 2.1 Commercial nuclear power plant sites are demarcated as shown for security purposes. The part of the power plant site over which the plant operator exercises control is referred to as the *owner-controlled area*. This usually corresponds to the boundary of the site. Located within this area are one or more *protected areas* to which access is restricted using guards, fences, and other barriers. Dry cask storage facilities, formally referred to as Independent Spent Fuel Storage Installations (ISFSIs), are located within these areas. The *vital area* of the plant contains the reactor core, support buildings, and the spent fuel pool. It is the most carefully controlled and guarded part of the plant site. SOURCE: Modified from Nuclear Regulatory Commission briefing materials (2004).

detecting, thwarting, or impeding attacks. The Commission staff declined to provide a formal briefing to the committee on the DBT for radiological sabotage, asserting that the committee did not have a need to know this information. Nevertheless, the committee was able to discern the details of the DBT from a series of presentations made by Nuclear Regulatory Commission staff. Commission staff also provided a fact check of this information as the classified report was being finalized.

Power plant operators are required to demonstrate to the Commission's satisfaction that there is "high assurance" that their guard forces can thwart the Commission-defined DBT assault. This guard force also must be able to provide deterrence against a beyond-DBT attack depending on the adversarial force. Reinforcing forces would be provided by local and state law enforcement as well as federal forces. The Commission staff also informed the committee that since the September 11, 2001, attacks, the Commission has been working with DHS to improve coordination procedures with federal, state, and local agencies to improve their response capabilities in the event of an attack. DHS also is making grants to local law enforcement agencies around power plant sites to raise their capabilities to respond to requests for assistance.

Since the September 11, 2001, attacks, the Nuclear Regulatory Commission has issued directives to power plant operators to enhance protection against vehicle bombs. The Commission also has issued directives to power plant operators to enhance protection against insider threats.

The committee does not have enough information to judge whether the measures at power plants are in fact sufficient to defend against either a DBT or a beyond-DBT attack on spent fuel storage. The Nuclear Regulatory Commission declined to provide detailed briefings to the committee on surveillance, security procedures, and security training at commercial nuclear power plants. Consequently, the committee was unable to evaluate their effectiveness. A recent General Accounting Office report (GAO, 2003) was critical of some of these procedures, but the committee has no basis for judging whether these criticisms were justified. Nevertheless, the committee judges that surveillance and security procedures at commercial nuclear power plants are just as important as physical barriers in preventing successful terrorist attacks and mitigating their consequences.

2.2.3 Attacks Having Both Air and Ground Components

Hybrid attacks that combine aspects of both air and ground attacks also could be mounted by terrorists. These could deliver attacking forces directly to a spent fuel storage facility, bypassing the security perimeters and security personnel deployed to protect against a ground attack. The committee considered various scenarios for such attacks. The committee judges that some scenarios are feasible. Details are provided in the classified report.

2.2.4 Terrorist Theft of Spent Fuel for Use in a Radiological Dispersal Device (RDD)

An RDD, or so-called dirty bomb, is a device that disperses radioactive material using chemical explosives or other means (NRC, 2002). RDDs do not involve fission-induced explosions of the kind associated with nuclear weapons. While RDD attacks can be carried out with any source of radioactivity, this discussion is confined to scenarios that involve the theft of spent fuel for such use.[11] A crude RDD device could be fabricated simply by loading stolen spent fuel onto a truck carrying high explosives. The truck could be driven to another location and detonated. The dispersal of radioactivity from such an attack would be unlikely to cause many immediate deaths, but there could be fatalities from the chemical explosion as well as considerable cleanup costs and adverse psychological effects.

It would be difficult for terrorists to steal a large quantity of spent fuel (e.g., a single spent fuel assembly) for use in an RDD for three reasons. First, spent fuel is highly radioactive and therefore requires heavy shielding to handle. Second, the use of heavy equipment would be required to remove spent fuel assemblies from a pool or dry cask. Third, controls are in place at plants to deter and detect such thefts. Additional details on these controls are provided in the classified report.

Theft and removal of an assembly or individual fuel rods during an assault on the plant might be easier, because the guard force would likely be preoccupied defending the plant. However, the amount of material that could be removed would be small, and getting it

[11] An attack on a spent fuel facility that resulted in the direct release of radioactivity would be an act of radiological sabotage of the kind considered previously in this chapter.

out of the plant would be time consuming and obvious to the plant defenders and other responding forces.

There are broken fuel rods and other debris, mostly from older assemblies, in storage at many plants. These materials are typically stored along the sides of the spent fuel pools and could be more easily removed from the plant than an entire assembly. Pieces of fuel rods also are sometimes intentionally removed from assemblies for offsite laboratory analysis. Some plants have misplaced fuel rod pieces.[12] A knowledgeable insider might be able to retrieve some of this material from the pool, but getting it out of the plant under normal operating conditions would be difficult.

Even the successful theft of a part of a spent fuel rod would provide a terrorist with only a relatively small amount of radioactive material. Superior materials could be obtained from other facilities. This material also can be purchased (Zimmerman and Loeb, 2004).

Moreover, even with explosive dissemination, it is unlikely that much of the spent fuel will be aerosolized unless it is incorporated into a well-designed RDD. More likely, such an event would break up and scatter the fuel pellets in relatively large chunks, which would not pose an overwhelming cleanup challenge.

Even though the likelihood of spent fuel theft appears to be small, it is nevertheless important that the protection of these materials be maintained and improved as vulnerabilities are identified.

2.3 RISKS OF TERRORIST ATTACKS ON SPENT FUEL STORAGE FACILITIES

Nuclear Regulatory Commission staff told the committee that it believes that the consequences of a terrorist attack on a spent fuel pool would likely unfold slowly enough that there would be time to take mitigative actions to prevent a large release of radioactivity. They also pointed out that since the September 11, 2001, attacks, the Nuclear Regulatory Commission has issued several orders that contain Interim Compensatory Measures that require power plant operators to consider potential mitigative actions in the event of such an attack. The committee received a briefing on some of these measures at one of its meetings. According to Commission staff, such measures provide an additional margin of safety.

The nuclear industry and the Nuclear Regulatory Commission have also asserted that the robust construction and stringent security requirements at nuclear power plants[13] make them less vulnerable to terrorist attack than softer targets such as chemical plants and refineries (e.g., Chapin et al., 2002). They argue that scarce resources should be devoted to

[12] For example, at the Millstone and Vermont Yankee plants in 2000 and 2003, respectively. In the case of Millstone, the Nuclear Regulatory Commission determined on the basis of extensive analysis that these rods were likely disposed of as low-level waste. After the committee's classified report was published, Commission staff informed the committee that Vermont Yankee had accounted for the missing rod segments and that Humbolt Bay had uncovered and is investigating an inventory discrepancy involving spent fuel rod segments.

[13] These arguments tend to be generic in nature and do not differentiate spent fuel pools from the rest of the power plant.

upgrading security at these other critical facilities rather than at already well-protected nuclear plants.

There are two unstated propositions in the argument that nuclear plants are less vulnerable than other facilities. The first speaks to the probability of terrorist attacks on such facilities; the second speaks to the consequences:

- *Proposition 1:* Nuclear power plants (and their spent fuel facilities) are less desirable as terrorist targets because they are robust and well protected.
- *Proposition 2:* If attacked, nuclear plants (and their spent fuel storage facilities) are likely to sustain little or no damage because they are robust and well protected.

The committee obtained a briefing from the Department of Homeland Security to address the first proposition. Details are provided in the classified report.

While the committee's classified report was in review, the National Commission on Terrorist Attacks Upon the United States issued a staff paper (Staff Statement No. 16, Outline of the 9/11 Plot, pages 12-13) suggesting that al-Qaida initially included unidentified nuclear plants among an expanded list of targets for the September 11, 2001, attacks. According to that report, these plants were eliminated from the target list along with several other facilities when the terrorist organization scaled back the number of planned attacks. Nevertheless, if this information is correct, it provides further indications that commercial nuclear power plants are of interest to terrorist groups,[14] even though softer targets may have a higher priority with many terrorists.

With respect to the first proposition, the committee judges that it is not prudent to dismiss nuclear plants, including their spent fuel storage facilities, as undesirable targets for attacks by terrorists.

As to the second proposition that terrorist attacks are likely to cause little or no damage, a poorly designed attack or an attack by unsophisticated terrorists might produce little physical damage to the plant. There could, however, be severe adverse psychological effects from such an attack that could have considerable economic consequences. On the other hand, attacks by knowledgeable terrorists with access to advanced weapons might cause considerable physical damage to a spent fuel storage facility, especially in a suicide attack.

It is important to recognize that an attack that damages a power plant or its spent fuel facilities would not necessarily result in the release of *any* radioactivity to the environment. While it may not be possible to deter such an attack, there are many potential mitigation steps that can be taken to lower its potential consequences should an attack occur. These are discussed in some detail in the committee's classified report (see also Chapters 3 and 4 in this report).

[14] In another example of concern, police in Toronto, Canada, detained 19 men in August 2003 based on suspicious activities that included surveillance and flying lessons that would take them over a nuclear power plant (Ferguson et al., 2004).

In summary, the committee judges that the plausibility of an attack on a spent fuel storage facility, coupled with the public fear associated with radioactivity, indicates that the possibility of attacks cannot be dismissed.

2.4 FINDINGS AND RECOMMENDATIONS

With respect to the committee's task to "explicitly consider the risks of terrorist attacks on [spent fuel] and the risk these materials might be used to construct a radiological dispersal device," the committee offers the following findings and recommendations:

FINDING 2A: The probability of terrorist attacks on spent fuel storage cannot be assessed quantitatively or comparatively. Spent fuel storage facilities cannot be dismissed as targets for such attacks because it is not possible to predict the behavior and motivations of terrorists, and because of the attractiveness of spent fuel as a terrorist target given the well-known public dread of radiation.

Terrorists view nuclear power plant facilities as desirable targets because of the large inventories of radionuclides they contain. The committee believes that knowledgeable terrorists might choose to attack spent fuel pools because (1) at U.S. commercial power plants, these pools are less well protected structurally than reactor cores; and (2) they typically contain inventories of medium- and long-lived radionuclides that are several times greater than those contained in individual reactor cores.

FINDING 2B: The committee judges that the likelihood terrorists could steal enough spent fuel for use in a significant radiological dispersal device is small.

Spent fuel assemblies in pools or dry casks are large, heavy, and highly radioactive. They are too large and radioactive to be handled by a single individual. Removal of an assembly from the pool or dry cask would prove extremely difficult under almost any terrorist attack scenario. Attempts by a knowledgeable insider(s) to remove single rods and related debris from the pool might prove easier, but it would likely be very difficult to get it out of the plant under normal operating conditions. Theft and removal during an assault on the plant might be easier because the guard force would likely be occupied defending the plant. However, the amount of material that could be removed would be small. Moreover, there are other facilities from which highly radioactive material could be more easily stolen, and this material also can be purchased. Even though the likelihood of spent fuel theft appears to be small, it is nevertheless important that the protection of these materials be maintained and improved as vulnerabilities are identified.

> **RECOMMENDATION: The Nuclear Regulatory Commission should review and upgrade, where necessary, its security requirements for protecting spent fuel rods not contained in fuel assemblies from theft by knowledgeable insiders, especially in facilities where individual fuel rods or portions of rods are being stored in pools.**

FINDING 2C: A number of security improvements at nuclear power plants have been instituted since the events of September 11, 2001. The Nuclear Regulatory Commission did not provide the committee with enough information to evaluate the effectiveness of these procedures for protecting stored spent fuel.

Surveillance and security procedures are just as important as physical barriers in preventing and mitigating terrorist attacks. The Nuclear Regulatory Commission declined to provide the committee with detailed briefings on the surveillance and security procedures that are now in place to protect spent fuel facilities at commercial nuclear power plants against terrorist attacks. Although the committee did learn about some of the changes that have been instituted since the September 11, 2001, attacks, it was not provided with enough information to evaluate the effectiveness of procedures now in place.

RECOMMENDATION: Although the committee did not specifically investigate the effectiveness and adequacy of improved surveillance and security measures for protecting stored spent fuel, an assessment of current measures should be performed by an independent[15] organization.

[15] That is, independent of the Nuclear Regulatory Commission and the nuclear industry.

3

SPENT FUEL POOL STORAGE

This chapter addresses the first charge of the committee's statement of task to assess "potential safety and security risks of spent nuclear fuel presently stored in cooling pools at commercial reactor sites."[1] As noted in Chapter 1, storage of spent fuel in pools at commercial reactor sites has three primary objectives:

- Cool the fuel to prevent heat-up to high temperatures from radioactive decay.
- Shield workers and the public from the radiation emitted by radioactive decay in the spent fuel and provide a barrier for any releases of radioactivity.
- Prevent criticality accidents.

The first two of these objectives could be compromised by a terrorist attack that partially or completely drains the spent fuel pool.[2] The committee will refer to such scenarios as "loss-of-pool-coolant" events. Such events could have several deleterious consequences: Most immediately, ionizing radiation levels in the spent fuel building rise as the water level in the pool falls. Once the water level drops to within a few feet (a meter or so) of the tops of the fuel racks, elevated radiation fields could prevent direct access to the immediate areas around the lip of the spent fuel pool building by workers. This might hamper but would not necessarily prevent the application of mitigative measures, such as deployment of fire hoses to replenish the water in the pool.

The ability to remove decay heat from the spent fuel also would be reduced as the water level drops, especially when it drops below the tops of the fuel assemblies. This would cause temperatures in the fuel assemblies to rise, accelerating the oxidation of the zirconium alloy (zircaloy) cladding that encases the uranium oxide pellets. This oxidation reaction can occur in the presence of both air and steam and is strongly exothermic—that is, the reaction releases large quantities of heat, which can further raise cladding temperatures. The steam reaction also generates large quantities of hydrogen:

Reaction in air:	$Zr + O_2 \rightarrow ZrO_2$	heat released = 1.2×10^7 joules/kilogram
Reaction in steam:	$Zr + 2H_2O \rightarrow ZrO_2 + 2H_2$	heat released = 5.8×10^6 joules/kilogram

[1] A basic description of pool storage can be found in Chapter 1 and historical background can be found in Appendix D. Section 3.1 provides additional technical details about pool storage.
[2] The committee could probably design configurations in which fuel might be deformed or relocated to enable its re-criticality, but the committee judges such an event to be unlikely. Also, the committee notes that while re-criticality would certainly be an undesirable outcome, criticality accidents have happened several times at locations around the world and have not been catastrophic offsite. An accompanying breach of the fuel cladding would still be the chief concern.

These oxidation reactions can become locally self-sustaining (i.e., autocatalytic[3]) at high temperatures (i.e., about a factor of 10 higher than the boiling point of water) if a supply of oxygen and/or steam is available to sustain the reactions. (These reactions will not occur when the spent fuel is under water because heat removal prevents such high temperatures from being reached).The result could be a runaway oxidation reaction—referred to in this report as a *zirconium cladding fire*—that proceeds as a burn front (e.g., as seen in a forest fire or a fireworks sparkler) along the axis of the fuel rod toward the source of oxidant (i.e., air or steam). The heat released from such fires can be even greater than the decay heat produced in newly discharged spent fuel.

As fuel rod temperatures increase, the gas pressure inside the fuel rod increases and eventually can cause the cladding to balloon out and rupture. At higher temperatures (around 1800°C [approximately 3300°F]), zirconium cladding reacts with the uranium oxide fuel to form a complex molten phase containing zirconium-uranium oxide. Beginning with the cladding rupture, these events would result in the release of radioactive fission gases and some of the fuel's radioactive material in the form of aerosols into the building that houses the spent fuel pool and possibly into the environment. If the heat from one burning assembly is not dissipated, the fire could spread to other spent fuel assemblies in the pool, producing a propagating zirconium cladding fire.

The high-temperature reaction of zirconium and steam has been described quantitatively since at least the early 1960s (e.g., Baker and Just, 1962). The accident at the Three Mile Island Unit 2 reactor and a set of experiments (e.g., CORA, FPT 1-6, CODEX, ORNL-VI, VERCORS) have provided a basis for understanding the phenomena of zirconium cladding fires and fission-product releases from irradiated fuel in a reactor core accident. This understanding and data from the experiments form the foundation for computer simulations of severe accidents involving nuclear fuel. These experiments and computer simulations are for inside-reactor vessel events rather than events in an open-air spent fuel pool array.

This chapter examines possible initiating factors for such loss-of-pool-coolant events and the potential consequences of such events. It is organized into the following four main sections:

- Background on spent fuel pool storage.
- Previous studies on safety and security of pool storage.
- Evaluation of the potential risks of pool storage.
- Findings and recommendations.

[3] That is, the reaction heat will increase temperatures in adjacent areas of the fuel rod, which in turn will accelerate oxidation and release even more heat. Autocatalytic oxidation leading to a "runaway" reaction requires a complex balance of heat and mass transfer, so assigning a specific ignition temperature is not possible. Empirical equations have been developed to predict the reaction rate as a function of temperature when steam and oxygen supply are not limited (see, e.g., Tong and Weisman, 1996, p. 223). Numerous scaled experiments have found that the oxidation reaction proceeds very slowly below approximately 900°C (1700°F).

3.1 BACKGROUND ON SPENT FUEL POOL STORAGE

After a power reactor is shut down, its nuclear fuel continues to produce heat from radioactive decay (see FIGURE 1.2). Although only one-third of the fuel in the reactor core is replaced during each refueling cycle, operators commonly offload the entire core (especially at pressurized water reactors [PWRs]) into the pool during refueling[4] to facilitate loading of fresh fuel or for inspection or repair of the reactor vessel and internals. Heat generation in the pool is at its highest point just after the full core has been offloaded.

Pool heat loads can be quite high, as exemplified by a "typical" boiling water reactor (BWR) which was used in some of the analyses discussed elsewhere in this chapter (this BWR is hereafter referred to as the "reference BWR"). This pool has approximately 3800 locations for storage of spent fuel assemblies, about 3000 of which are occupied by four-and-one-third reactor cores (13 one-third-core offloads) in a pool approximately 35 feet wide, 40 feet long, and 39 feet deep (10.7 meters wide, 12.2 meters long, and 11.9 meters deep) with a water capacity of almost 400,000 gallons (1.51 million liters). According to Nuclear Regulatory Commission staff, the total decay heat in the spent fuel pool is 3.9 megawatts (MW) ten days after a one-third-core offload. The vast majority of this heat is from decay in the newly discharged spent fuel. Heat loads would be substantially higher in spent fuel pools that contained a full-core offload.

Although spent fuel pools have a variety of designs, they share one common characteristic: Almost all spent fuel pools are located outside of the containment structure that holds the reactor pressure vessel.[5] In some reactor designs, the spent fuel pools are contained within the reactor building,[6] which is typically constructed of about 2 feet of reinforced concrete (see FIGURE 3.1). In other designs, however, one or more walls of the spent fuel pool may be located on the exterior wall of an auxiliary building that is located adjacent to the containment building (see FIGURE 3.2). As described in more detail below, some pools are built at or below grade, whereas others are located at the top of the reactor building.

The enclosing superstructures above the pool are typically steel, industrial-type buildings designed to house cranes that are used to move reactor components, spent fuel, and spent fuel casks. These superstructures above the pool are designed to resist damage from seismic loads but not from large tornado-borne missiles (e.g., cars and telephone poles), which would usually impact the superstructures at low angles (i.e., moving horizontally). In contrast, the typical spent fuel pool is robust. The pool walls and the external walls of the building housing the pool (these external walls may incorporate one or more pool walls in some plants) are designed for seismic stability and to resist horizontal

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[4] A 1996 survey by the Nuclear Regulatory Commission (USNRC, 1996) found that the majority of commercial power reactors routinely offload their entire core to the spent fuel pool during refueling outages. The practice is more common among PWRs than BWRs, which tend to offload only that fuel that is to be replaced, but some BWRs do offload the full core. In response to a committee inquiry, an Energy Resources International staff member confirmed that this is still the case today.

[5] The exceptions in the United States are the Mark III BWRs, which have two pools, one of which is inside the containment. As discussed in Appendix C, spent fuel pools at German commercial nuclear power plants also are located inside reactor containment structures.

[6] A PWR containment structure is a large, domed building that houses the reactor pressure vessel, the steam generators, and other equipment. In a BWR, the containment structure houses less equipment, is located closer in to the pressure vessel, and sits inside a building called the reactor building, which also houses the spent fuel pool and safety-related equipment to support the reactor.

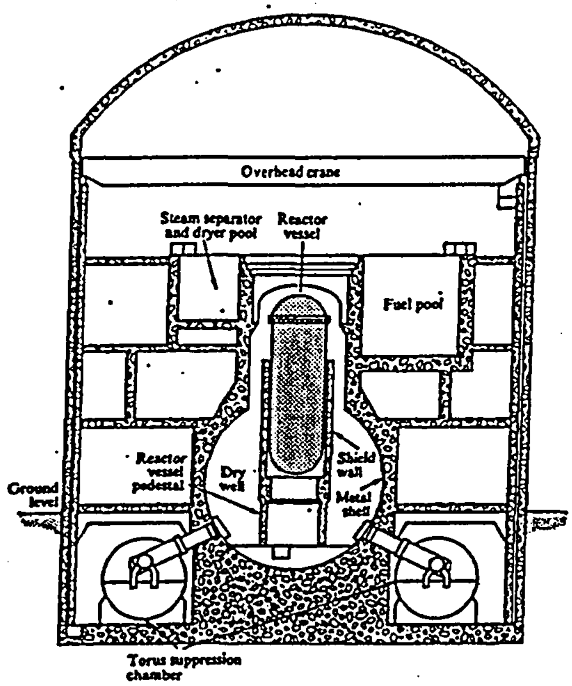

FIGURE 3.1 Schematic section through a G.E. Mark I BWR reactor plant. The spent fuel pool is located in the reactor building well above ground level. This diagram is for a BWR with a reinforced concrete superstructure (roof). Most designs have thin steel superstructures. SOURCE: Lamarsh (1975, Figure 11.3).

strikes of tornado missiles. The superstructures and pools were not, however, specifically designed to resist terrorist attacks.

The typical spent fuel pool is about 40 feet (12 meters) deep and can be 40 or more feet (12 meters) in each horizontal dimension. The pool walls are constructed of reinforced concrete typically having a thickness between 4 and 8 feet (1.2 to 2.4 meters). The pools contain a ¼- to ½-inch-thick (6 to 13 mm) stainless steel liner, which is attached to the walls with studs embedded in the concrete. The pools also contain vertical storage racks for holding spent and fresh fuel assemblies, and some pools have a gated compartment to hold a spent fuel storage cask while it is being loaded and sealed (see Chapter 4).

The storage racks are about 13 feet (4 meters) in height and are installed near the bottom of the spent fuel pool. The racks have feet to provide space between their bottoms and the pool floor. There is also space between the sides of the rack and the steel pool liners for circulation of water (FIGURE 3.3). There are about 26 feet (8 meters) of water above the top of the spent fuel racks. This provides substantial radiation shielding even when an assembly is being moved above the rack. Transfers of spent fuel from the reactor core to the spent fuel pool or from the pool to storage casks are carried out underwater to provide shielding and cooling.

The general elevation of the spent fuel pool matches that of the vessel containing the reactor core. Pressurized water reactor designs use comparatively shorter reactor

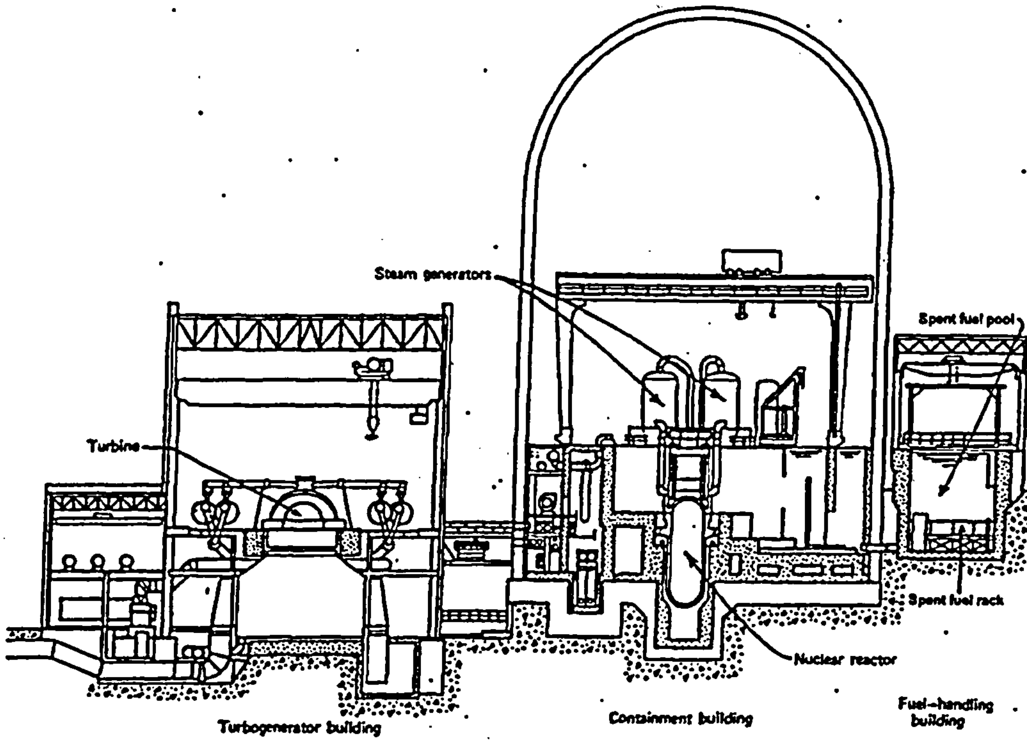

FIGURE 3.2 Schematic section through a PWR reactor plant. The spent fuel pool is located in the fuel-handling building next to the domed reactor containment building at or slightly below ground level. SOURCE: Modified from Duderstadt and Hamilton (1976, Figure 3-4).

vessels closer to ground level (grade) and also have spent fuel pools that are close to grade (FIGURE 3.2). The design shown in this figure is typical of the fuel pool arrangement for PWRs. Nuclear power plant sites that contain two reactors are usually arranged in a mirror-image fashion, with the two spent fuel pools (or a shared pool) located in a common area adjoining both reactor buildings. For single-plant or two-plant arrangements, the building covering the spent fuel pool and crane structures is typically an ordinary steel industrial building. There are 69 PWRs currently in operation in the United States; 6 PWRs have been decommissioned but continue to have active spent fuel pool storage.

In contrast, in boiling water reactor designs, the reactor vessel is at a higher elevation, and the BWR vessels are somewhat taller than PWR vessels.[7] Consequently, BWRs have more elevated spent fuel pools, generally well above grade. FIGURE 3.1 shows the general design for the 22 BWR Mark I plants operating in the United States.

Nuclear Regulatory Commission staff is conducting a survey of the plants to obtain a better understanding of the variations in design of spent fuel pools across the nation. The following information was provided to the committee from that survey:

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[7] The higher elevation accommodates control mechanisms that sit under the reactor, and the extra height accommodates steam separation and drying equipment at the top of the vessel. The fuel is about the same length as PWR fuel.

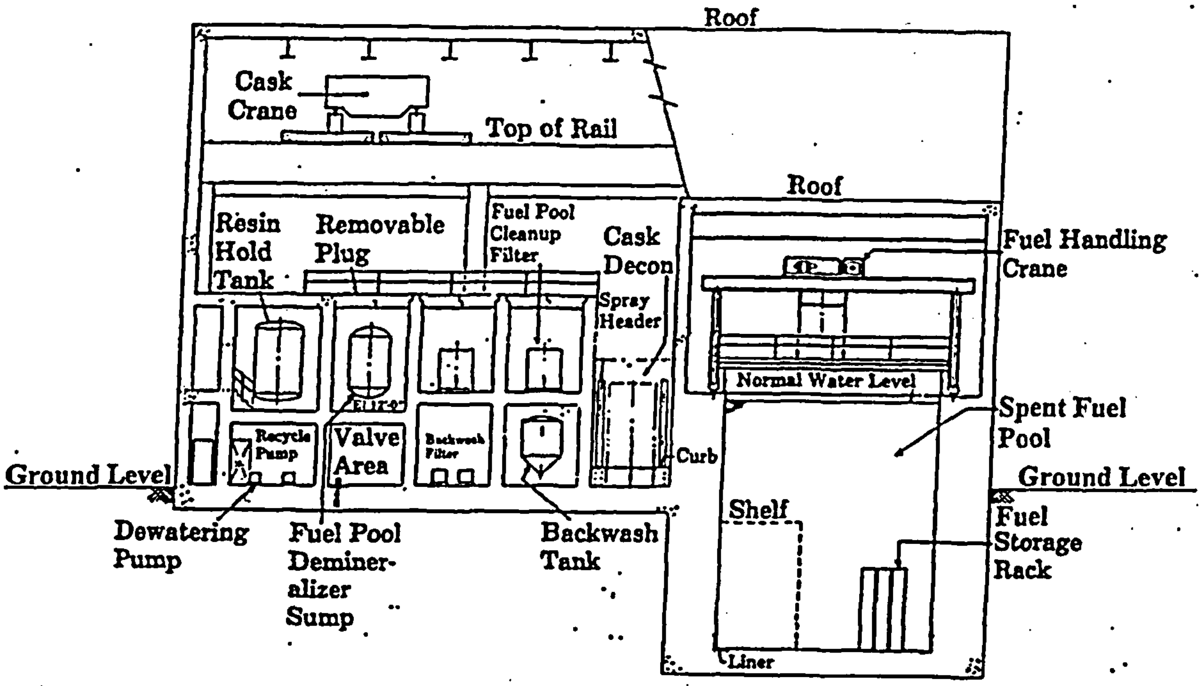

FIGURE 3.3 Example of a section of a PWR spent fuel pool and support facilities. The pool is located to the right in the figure; the support equipment to the left. SOURCE: American Nuclear Society (1988).

- PWR spent fuel pools: Spent fuel pools are located in buildings adjoining the reactor containment buildings at PWR plants (see FIGURE 3.2). Some pools are positioned such that their spent fuel is below grade. As shown in Figure 3.2, some pool walls also serve as the external walls of the spent fuel pool buildings. Some plants have structures surrounding the spent fuel pool building that would provide some shielding of the pools from low-angle line-of-sight attacks. A more complete plant survey would be needed to establish the extent of pool exposure to such attacks.
- BWR spent fuel pools: MARK I and II BWR plants are located above grade and are shielded by at least one exterior building wall. Some pools are also shielded by the reactor buildings. Some pools are also shielded by "significant" surrounding structures, and some have supplemental floor and column supports.

The vulnerability of a spent fuel pool to terrorist attack depends in part on its location with respect to ground level as well as its construction. Pools are potentially susceptible to attacks from above or from the sides depending on their elevation with respect to grade and the presence of surrounding shielding structures.

As noted in Chapter 1, nearly all pools contain high-density spent fuel racks. These racks allow approximately five times as many assemblies to be stored in the pool as would have been possible with the original racks, which had open lateral channels between the fuel assemblies to enhance water circulation.

3.2 PREVIOUS STUDIES ON SAFETY AND SECURITY OF POOL STORAGE

Several reports have been published on the safety of spent fuel pool storage. One of the earliest analyses was contained in the *Reactor Safety Study* (U.S. Atomic Energy Commission, 1975), which concluded that spent fuel pool safety risks were very much smaller than those involving the cores of nuclear reactors. This conclusion is not surprising: The cooling system in a spent fuel pool is simple. The coolant is at atmospheric pressure; the spent fuel is in a subcritical configuration and generates little heat relative to that generated in an operating reactor; and the design and location of piping in the pool make a severe loss-of-pool-coolant event unlikely during normal operating conditions. Despite changes in reactor and fuel storage operations, such as longer fuel residence times in the core and higher-density pool storage, the conclusions of that study are still broadly applicable today. It is important to recognize, however, that the *Reactor Safety Study* did not address the consequences of terrorist attacks.

The Nuclear Regulatory Commission and its contractors have periodically re-analyzed the safety of spent nuclear fuel storage (see Benjamin et al., 1979; BNL, 1987, 1997; USNRC, 1983, 2001a, 2003b). All of these studies suggest that a loss-of-pool-coolant event could trigger a zirconium cladding fire in the exposed spent fuel. The Nuclear Regulatory Commission considered such an accident to be so unlikely that no specific action was warranted, despite changes in reactor operations that have resulted in increased fuel burn-ups and fuel storage operations that have resulted in more densely packed spent fuel pools.

In 2001, the Nuclear Regulatory Commission published NUREG-1738, *Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants,* to provide a technical basis for rulemaking for power plant decommissioning (USNRC, 2001a). A draft of the study was issued for public comments, including comments by the Advisory Committee on Reactor Safeguards and a quality review of the methods, assumptions, and models used in the analysis was carried out by the Idaho National Engineering and Environmental Laboratory.

The study provided a probabilistic risk assessment that identified severe accident scenarios and estimated their consequences. The analysis determined, for a given set of fuel characteristics, how much time would be required to boil off enough water to allow the fuel rods to reach temperatures sufficient to initiate a zirconium cladding fire.

The analysis suggested that large earthquakes and drops of fuel casks from an overhead crane during transfer operations were the two event initiators that could lead to a loss-of-pool-coolant accident. For cases where active cooling (but not the coolant) has been lost, the thermal-hydraulic analyses suggested that operators would have about 100 hours (more than four days) to act before the fuel was uncovered sufficiently through boiling of cooling water in the pool to allow the fuel rods to ignite. This time was characterized as an "underestimate" given the simplifications assumed for the loss-of-pool-coolant scenario.

The overall conclusion of the study was that the risk of a spent fuel pool accident leading to a zirconium cladding fire was low despite the large consequences because the predicted frequency of such accidents was very low. The study also concluded, however, that the consequences of a zirconium cladding fire in a spent fuel pool could be serious and, that once the fuel was uncovered, it might take only a few hours for the most recently discharged spent fuel rods to ignite.

A paper by Alvarez et al. (2003a; see also Thompson, 2003) took the analyses in NUREG-1738 to their logical ends in light of the September 11, 2001, terrorist attacks: Namely, what would happen if there were a loss-of-pool-coolant event that drained the spent fuel pool? Such an event was not considered in NUREG-1738, but the analytical results in that study were presented in a manner that made such an analysis possible.

Alvarez and his co-authors concluded that such an event would lead to the rapid heat-up of spent fuel in a dense-packed pool to temperatures at which the zirconium alloy cladding would catch fire and release many of the fuel's fission products, particularly cesium-137. They suggested that the fire could spread to the older spent fuel, resulting in long-term contamination consequences that were worse than those from the Chernobyl accident. Citing two reports by Brookhaven National Laboratory (BNL, 1987, 1997), they estimated that between 10 and 100 percent of the cesium-137 could be mobilized in the plume from the burning spent fuel pool, which could cause tens of thousands of excess cancer deaths, loss of tens of thousands of square kilometers of land, and economic losses in the hundreds of billions of dollars. The excess cancer estimates were revised downward to between 2000 and 6000 cancer deaths in a subsequent paper (Beyea et al., 2004) that more accurately accounted for average population densities around U.S. power plants.

Alvarez and his co-authors recommended that spent fuel be transferred to dry storage within five years of discharge from the reactor. They noted that this would reduce the radioactive inventories in spent fuel pools and allow the remaining fuel to be returned to open-rack storage to allow for more effective coolant circulation, should a loss-of-pool-coolant event occur. The authors also discussed other compensatory measures that could be taken to reduce the consequences of such events.

The Alvarez et al. (2003a) paper received extensive attention and comments, including a comment from the Nuclear Regulatory Commission staff (USNRC, 2003a; see Alvarez et al., 2003b, for a response). None of the commentators challenged the main conclusion of the Alvarez et al. (2003a) paper that a severe loss-of-pool-coolant accident might lead to a spent fuel fire in a dense-packed pool. Rather, the commentators challenged the likelihood that such an event could occur through accident or sabotage, the assumptions used to calculate the offsite consequences of such an event, and the cost-effectiveness of the authors' proposal to move spent fuel into dry cask storage. One commentator summarized these differences in a single sentence (Benjamin, 2003, p. 53): "In a nutshell, [Alvarez et al.] correctly identify a problem that needs to be addressed, but they do not adequately demonstrate that the proposed solution is cost-effective or that it is optimal."

The Nuclear Regulatory Commission staff provided a briefing to the committee that provides a further critique of the Alvarez et al. (2003a) analysis that goes beyond the USNRC (2003a) paper. Commission staff told the committee that the NUREG-1738 analyses attempted to provide a bounding analysis of current and conceivable future spent fuel pools at plants undergoing decommissioning and therefore relied on conservative assumptions. The analysis assumed, for example, that the pool contained an equivalent of three-and-one-half reactor cores of spent fuel, including the core from the most recent reactor cycle. The staff also asserted that NUREG-1738 did not provide a realistic analysis of consequences. Commission staff concluded that "the risks and potential societal cost of [a] terrorist attack on spent fuel pools do not justify the complex and costly measures proposed in Alvarez et al. (2003) to move and store 1/3 of spent fuel pools [sic] inventory in dry storage casks."[8]

The committee provides a discussion of the Alvarez et al. (2003a) analysis in its classified report. The committee judges that some of their release estimates should not be dismissed.

The 2003 Nuclear Regulatory Commission (USNRC, 2003b) staff publication NUREG-0933, *A Prioritization of Generic Safety Issues*,[9] discusses beyond-design-basis accidents in spent fuel pools. The study draws some of the same consequence conclusions as the Alvarez et al. (2003a) paper. It notes that in a dense-packed pool, a zirconium cladding fire "would probably spread to most or all of the spent fuel pool" (p. 1). This could drive what the report refers to as "borderline aged fuel" into a molten condition leading to the release of fission products comparable to molten fuel in a reactor core.

The NUREG-0933 report (USNRC, 2003b) summarizes technical analyses of the frequencies of severe accidents for three BWR scenarios. The report concludes that the greatest risk is from a beyond-design-basis seismic event. While the consequences of such accidents are considerable, the report concludes that their frequencies are no greater than would be expected for reactor core damage accidents due to seismic events beyond the design basis safe shutdown earthquake.

An analysis of spent fuel operating experience by the Nuclear Regulatory Commission staff (USNRC, 1997) showed that several accidental partial-loss-of-pool-coolant events have occurred as a result of human error. Two of these involved the loss of more than 5 feet of water from the pool, but none had serious consequences. Nevertheless, Commission staff suggested that plant-specific analyses and corrective actions should be taken to reduce the potential for such events in the future.

It is important to recognize that with the exception of the Alvarez et al. (2003a) paper, all of the previous U.S. work reviewed by the committee has focused on safety risks, not security risks. The Nuclear Regulatory Commission analyses of spent fuel storage vulnerabilities were not completed by the time the committee finalized its information gathering for this report, but the committee did receive briefings on this work. In addition, analyses have been undertaken of external impacts on power plant structures by aircraft for the few commercial power plants that are located close enough to airports to consider hardening of the plant design to resist accidental aircraft crashes. These analyses were done as part of the plants' licensing safety analyses. The committee did not look further into these few plants because the aircraft considered were smaller and the impact velocities considered were much lower than those that might be brought to bear in a well-planned terrorist attack.

The committee did learn about work to assess the risks of spent fuel storage to terrorist attacks in Germany (see Appendix C for a description). However, the details of this work are classified by the German government and therefore are unavailable to the

[8] The quote is from a PowerPoint presentation made by Nuclear Regulatory Commission staff to the committee at one of its meetings.
[9] NUREG-0933 is a historical record that provides a yearly update of generic safety issues. It does not provide any additional technical analysis of these issues.

committee for review. Consequently, the committee was unable to provide a technical assessment.

3.3 EVALUATION OF THE POTENTIAL RISKS OF POOL STORAGE

Prior to the September 11, 2001, terrorist attacks, spent fuel pool analyses by the Nuclear Regulatory Commission were focused almost exclusively on safety. On the basis of these analyses, the Commission concluded that spent fuel storage carried risks that were no greater (and likely much lower) than risks for operating nuclear reactors, as discussed in the previous section of this chapter.

The September 11, 2001, terrorist attacks raised the possibility of a new kind of threat to commercial power plants and spent fuel storage: premeditated, carefully planned, high-impact attacks by terrorists to damage these facilities for the purpose of releasing radiation to the environment and spreading fear and panic among civilian populations. The Commission informed the committee that its conclusions about risks of spent fuel storage are now being reevaluated in light of these new threats.

Prior to September 11, the Nuclear Regulatory Commission viewed the most credible sabotage event as a violent external land assault by small groups of well-trained, heavily armed individuals aided by a knowledgeable insider.[10] The Commission has long-established requirements for physical protection systems at power plants to thwart such assaults. The committee was told that these requirements have been increased since the September 11, 2001, attacks. To the committee's knowledge, there are currently no requirements in place to defend against the kinds of larger-scale, premeditated, skillful attacks that were carried out on September 11, 2001, whether or not a commercial aircraft is involved. Staff from the Nuclear Regulatory Commission and representatives from the nuclear industry repeatedly told the committee that they view detecting, preventing, and thwarting such attacks as the federal government's responsibility.

It is important to recognize that nuclear power plants in the United States and most of the rest of the world[11] were designed primarily with safety, not security, in mind.[12] The reinforced concrete containment buildings that house the reactors were designed to contain internal pressures of up to about 4 atmospheres in case steam is released in the event of various hypothetical reactor accidents. These and other plant structures were not specifically designed to resist external terrorist attacks, although their robust construction would certainly provide significant protection against external assaults with airplanes or other types of weapons. Moreover, commercial power plants are substantially more robust than other critical infrastructure such as chemical plants, refineries, and fossil-fuel-fired electrical generating stations.

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[10] This is known as the "design basis threat" for radiological sabotage of nuclear power plants. See Chapter 2.

[11] Spent fuel storage facilities in Germany are designed to survive the impact of a Phantom military jet without a significant release of radiation. Since September 11, 2001, the Germans have also examined the impact of a range of aircraft, including large civilian airliners, on these facilities. A discussion is provided in Appendix C.

[12] No nuclear power plant ordered after the mid-1970s has been built in the United States, so the designs were developed long before domestic terrorism of the kind seen on September 11, 2001, became a concern.

In the wake of the September 11, 2001, attacks, a great deal of additional work has been or is being carried out by government and private entities to assess the security risks posed by terrorist attacks against nuclear power plants and spent fuel storage. The committee provides a discussion of these studies in the following subsections. Some of these studies are still in progress.

The committee's discussion of this work in the following subsections is organized around the following two questions:

(1) Could an accident or terrorist attack lead to a loss-of-pool-coolant event that would partially or completely drain a spent fuel pool?
(2) What would be the radioactive releases if a pool were drained?

3.3.1 Could a Terrorist Attack Lead to a Loss-of-Pool-Coolant Event?

A terrorist attack that either disrupted the cooling system for the spent fuel pool or damaged or collapsed the pool itself could potentially lead to a loss-of-pool-coolant event. The cooling system could be disrupted by disabling or damaging the system that circulates water from the pool to heat exchangers to remove decay heat. This system would not likely be a primary target of a terrorist attack, but it could be damaged as the result of an attack on the spent fuel pool or other targets at the plant (e.g., the power for the pumps could be interrupted). The loss of cooling capacity would be of much greater concern were it to occur during or shortly after a reactor offloading operation, because the pool would contain a large amount of high decay-heat fuel.

The consequences of a damaged cooling system would be quite predictable: The temperature of the pool water would rise until the pool began to boil. Steam produced by boiling would carry away heat, and the steam would cool as it expanded into the open space above the pool.[13] Boiling would slowly consume the water in the pool, and if no additional water were added the pool level would drop. It would likely take several days of continuous boiling to uncover the fuel. Unless physical access to the pool were completely restricted (e.g., by high radiation fields or debris), there would likely be sufficient time to bring in auxiliary water supplies to keep the water level in the pool at safe levels until the cooling system could be repaired. This conclusion presumes, of course, that technical means, trained workers, and a sufficient water supply were available to implement such measures. The Nuclear Regulatory Commission requires that alternative sources of water be identified and available as an element of each plant's operating license.

The pool-boiling event described above could result in the release of small amounts of radionuclides that are normally present in pool water.[14] These radionuclides would likely have little or no offsite impacts given their small concentrations in the steam and their subsequent dilution in air once released to the environment. Moreover, as long as the spent fuel is covered with a steam-water mixture, it would not heat up sufficiently for the cladding to ignite.

A loss-of-pool-coolant event resulting from damage or collapse of the pool could

[13] The building above the spent fuel pool contains blow-out panels that could be removed to provide additional ventilation.
[14] This contamination may enter the water from damaged fuel or from neutron-activated materials that build up on the external surfaces of the fuel assemblies. The latter material is referred to as "crud."

have more severe consequences. Severe damage of the pool wall could potentially result from several types of terrorist attacks, for instance:

(1) Attacks with large civilian aircraft.
(2) Attacks with high-energy weapons.
(3) Attacks with explosive charges.

The committee reviewed two independent analyses of aircraft impacts on power plant structures: A study sponsored by EPRI completed in 2002 provides a generic analysis of civilian airliner impacts on commercial power plant structures (EPRI, 2002). A study in progress by Sandia National Laboratories for the Nuclear Regulatory Commission examines the consequences of an aircraft impact on an actual BWR power plant.

The EPRI and Sandia analyses used different finite element and finite difference codes that are in common use in research and industry.[15] Both sets of analyses attempted to validate the codes against physical tests, such as the Sandia "slug tests" that impacted water barrels into a concrete test wall at high speeds. EPRI's analysis used a Riera impact loading condition, which models the aircraft impact on a rigid structure and is a slightly conservative assumption because the structures are in fact deformable. The Sandia analysis was carried out on powerful computers that allowed the aircraft to be included explicitly in the calculations.

The committee also reviewed the preliminary results of Nuclear Regulatory Commission studies on the response of thick reinforced concrete walls such as those used in spent fuel pools to attacks involving simple explosive charges and other high-energy devices. The details of the analyses were not provided and therefore could not be evaluated quantitatively. However, some of these preliminary results are described in the committee's classified report.

The results of these aircraft and assault studies are classified or safeguards information. The committee has concluded that there are some scenarios that could lead to the partial failure of the spent fuel pool wall, thereby resulting in the partial or complete loss of pool coolant. A zirconium cladding fire could result if timely mitigative actions to cool the fuel were not taken. Details are provided in the classified report.

3.3.2 What would be the Radioactive Releases if a Pool Were Drained?

There are two ways in which an attack on a spent fuel pool could spread radioactive contamination: mechanical dispersion and zirconium cladding fires. An explosion or high-energy impact directly on the spent fuel could mechanically pulverize and loft fuel out of the pool. This would contaminate the plant and surrounding site with pieces of spent fuel. Large-

[15] The EPRI analyses used several finite element models (ABAQUS, LS DYNA, ANACAP, and WINFRITH) and Riera impact functions. The Sandia analyses used the CTH finite difference model and the Pronto3D finite element analysis model. The CTH code has been used for a wide range of impact penetration and explosive detonation problems by the Department of Energy, the Department of Defense, and industry during the past decade. CTH results have been compared extensively with experimental results. As an Eulerian code (where material flows through a fixed grid) it can readily handle severe distortions. It also has a variety of computational material models for dynamic (high-strain-rate) conditions, although it is limited in that it does not explicitly model structural members, such as rebar and metal liners in the concrete structure, because of computational requirements.

scale offsite releases of the radioactive constituents would not occur, however, unless they were mobilized by a zirconium cladding fire that melted the fuel pellets and released some of their radionuclide inventory. Such fires would create thermal plumes that could potentially transport radioactive aerosols hundreds of miles downwind under appropriate atmospheric conditions.

The Nuclear Regulatory Commission is now sponsoring work at Sandia National Laboratories to improve upon the analyses in NUREG-1738 (USNRC, 2001a), and in particular to obtain an improved phenomenological understanding of the thermal and hydraulic processes that would occur in a spent fuel pool from a loss-of-pool-coolant event. The committee received briefings on this work from Commission and Sandia staff during the course of this study. Additionally, the committee received a briefing from ENTERGY Corp. staff and its consultants under contract to analyze and understand the consequences of a loss-of-pool-coolant event in a spent fuel pool in a PWR plant.

The Sandia analyses were carried out on the reference BWR described in Section 3.1. Sandia's analysis of a PWR spent fuel pool had only just begun by the end of May 2004 and has not yet yielded any results. The committee had less opportunity to examine ENTERGY's approach and results. Because of these limitations, the committee was unable to examine in any detail the effects of the differences between BWR and PWR pools and fuel, except as noted with respect to their locations relative to grade.

The analyses were carried out using several well-established computer codes. The MELCOR code, which was developed by Sandia for use in analyzing severe reactor core accidents, was used to model fluid flow, heat transfer, fuel cladding oxidation kinetics, and fission product release phenomena associated with spent fuel assemblies. This code has been benchmarked against data from experiments (e.g., the FPT experiments on the Phébus test facility, and the VERCORS, CORA, and ORNL VI experiments)[16] that involve zirconium oxidation kinetics and fission product release. However, none of the experiments was designed to simulate the physical conditions in a spent fuel pool. Many of the phenomena are not significantly different in a reactor core and in a spent fuel pool, but a few important differences, particularly concerning fire propagation from hotter fuel assemblies to cooler fuel assemblies and nuclear fuel volatilities, warrant more detailed analyses or further experiments. In principle, MELCOR can perform "best-estimate" calculations that address a range of accident evolutions, accounting for temperature, availability of oxidizing air and steam,[17] and speciation and transport of radionuclides.

Sandia calculated the decay heat in the assemblies using the ANSI/ANS 5.1 code based on actual characteristics of the spent fuel (i.e., actual fuel ages, burn-ups, and locations) in the reference BWR pool. Flow and mixing behavior in the pool and reactor building enclosing the pool were modeled using a separate computational fluid dynamics (CFD) code.

Two types of analyses were carried out. A "separate effects" analysis was undertaken to examine the thermal responses of a spent fuel assembly (FIGURE 3.4) in a

[16] These experiments were designed to examine phenomena that occur in reactor cores during severe accidents. The phenomena include core degradation.
[17] Oxygen feeds the zirconium reaction and enhances release and transport of ruthenium-106, and the steam reaction releases hydrogen; whereas limited availability of oxygen starves the reaction. Steam can also entrain released fission products.

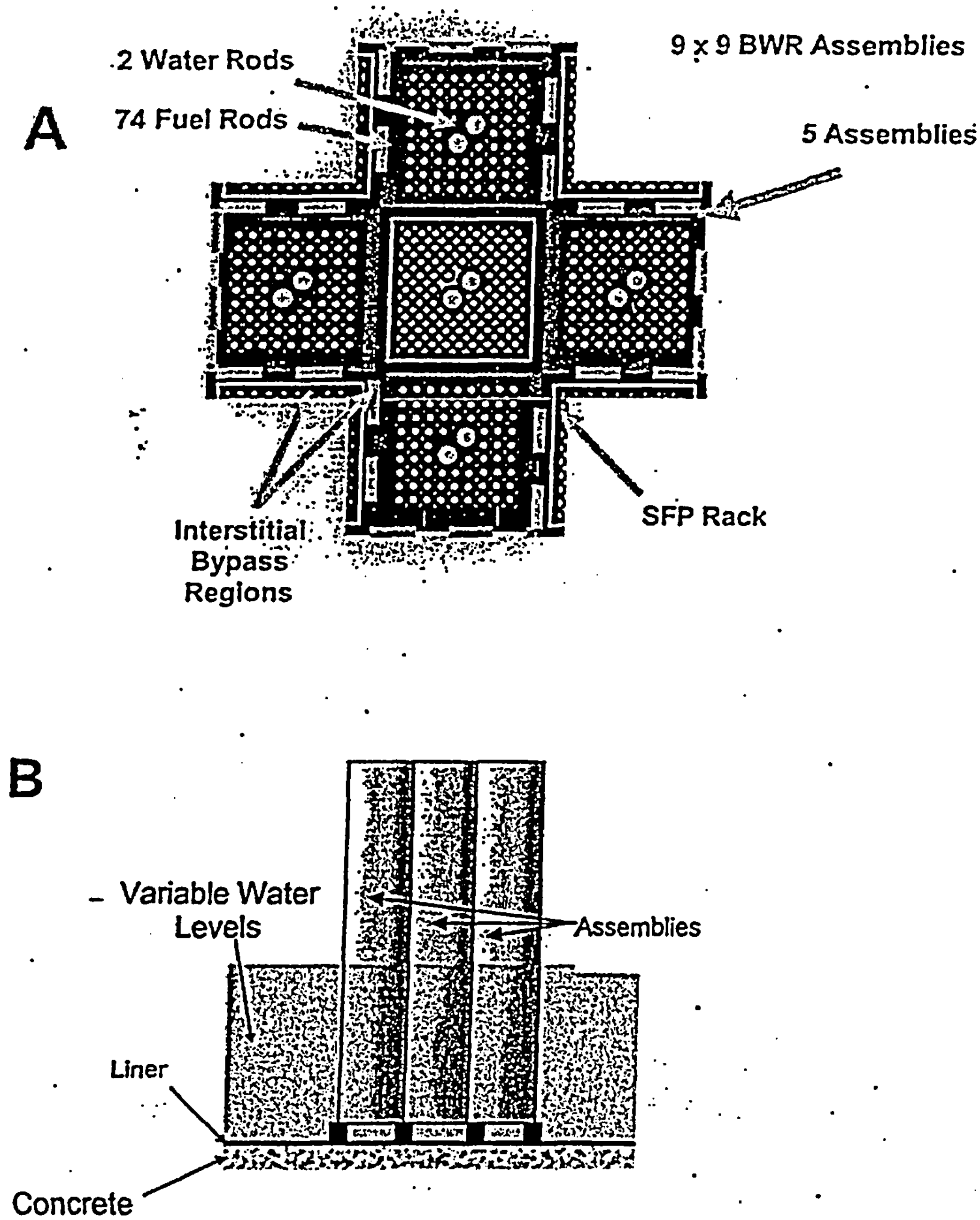
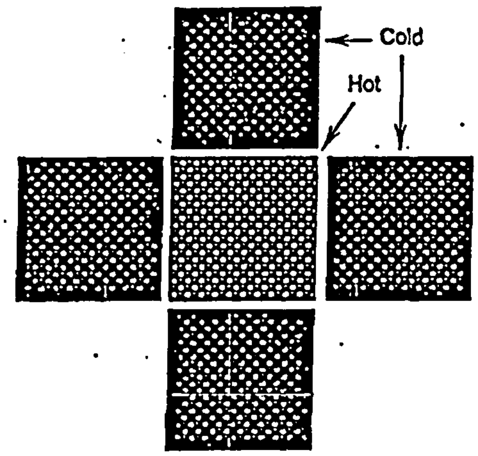


FIGURE 3.4 Configuration of fuel assemblies used for separate effects analysis. (A) Top view of BWR spent fuel assemblies used in the model. (B) Side view showing spent fuel assemblies in the pool. SOURCE: Nuclear Regulatory Commission briefing materials (2004).

A



B

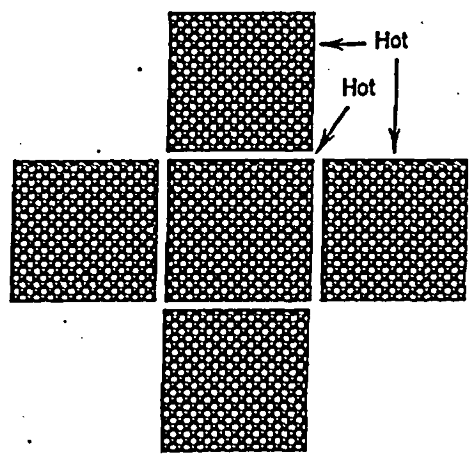


FIGURE 3.5 Two configurations used in the separate effects models shown in FIGURE 3.4: (A) Center hot spent fuel assembly surrounded by four cold assemblies; and (B) center hot spent fuel assembly surrounded by four hot assemblies. SOURCE: Nuclear Regulatory Commission briefing materials (2004).

loss-of-pool-coolant event. This analysis was used to understand how thermal behavior is influenced by factors such as decay heat in the fuel assembly, heat transfer with adjacent assemblies, and heat transfer to circulating air or steam in a drained spent fuel pool. This analysis was used to guide the development of "global response" models to examine the thermal-hydraulic behavior of an entire spent fuel pool.

The separate effects analysis examined the thermal behavior of a high decay-heat BWR spent fuel assembly surrounded either by four low decay-heat assemblies (FIGURE 3.5A) or four high decay-heat assemblies (FIGURE 3.5B). This analysis showed that the potential for heat build-up in a fuel assembly sufficient to initiate a zirconium cladding fire depends on its decay heat (which is related to its age) and on the rate at which heat can be transferred to adjacent assemblies and to circulating air or steam.

In the configuration shown in FIGURE 3.5A, the low decay-heat assemblies act as thermal radiation heat sinks, thereby allowing the more rapid transfer of heat away from the center fuel assembly than would be the case if the center assembly were surrounded by high decay-heat assemblies. The results from this analysis indicate that this configuration can be air cooled sufficiently to prevent the initiation of a zirconium cladding fire within a relatively short time after the center fuel assembly is discharged from the reactor. In the configuration shown in FIGURE 3.5B, heat transfer away from the center assembly is reduced and heat build-up is more rapid. Results indicate that this configuration cannot be air cooled for a significantly longer time after the center fuel assembly is discharged from the reactor.

The global analysis modeled the actual design and fuel loading pattern of the reference BWR spent fuel pool. The pool was divided into seven regions based on fuel age. Within each of those seven regions, the model for the fuel racks was subdivided into 16 zones. The grouping of assemblies into zones reduced the computational requirements compared to modeling every assembly.[18] Two scenarios were examined: (1) a complete loss-of-pool-coolant scenario in which the pool is drained to a level below the bottom of spent fuel assemblies; and (2) a partial-loss-of-pool-coolant scenario in which water levels in the pool drain to a level somewhere between the top and bottom of the fuel assemblies. In the former case, a convective air circulation path can be established along the entire length of the fuel assemblies, which promotes convective air cooling of the fuel. In the latter case, an effective air circulation path cannot form because the bottom of the assembly is blocked by water. Steam is generated by boiling of the pool water, and the zirconium cladding oxidation reaction produces hydrogen gas. This analysis suggests that circulation blockage has a significant impact on thermal behavior of the fuel assemblies. The specific impact depends on the depth to which the pool is drained.

The global analysis examined the thermal behavior of fuel assemblies in the pool at 1, 3, and 12 months after the offloading of one-third of a core of spent fuel from the reactor. Sensitivity studies were carried out to assess the importance of radiation heat transfer between different regions of the pool, the effects of building damage on releases of radioactive material to the environment, and the effects of varying the assumed location and size of the hole in the pool wall.

The results of these analyses are provided in the committee's classified report. For some scenarios, the fuel could be air cooled within a relatively short time after its removal from the reactor. If a loss-of-coolant event took place before the fuel could be air cooled, however, a zirconium cladding fire could be initiated if no mitigative actions were taken. Such fires could release some of the fuel's radioactive material inventory to the environment in the form of aerosols.

For a partial-loss-of-pool-coolant event, the analysis indicates that the potential for zirconium cladding fires would exist for an even greater time (compared to the complete-loss-of-pool-coolant event) after the spent fuel was discharged from the reactor because air circulation can be blocked by water at the bottom of the pool. Thermal coupling between adjacent assemblies will be due primarily to radiative rather than convective heat transfer. However, this heat transfer mode has been modeled simplistically in the MELCOR runs

[18] The global-response model runs took between 10 and 12 days on the personal computers used in the Sandia analyses.

performed by Sandia.[19]

If the water level is above the top of the fuel racks, decay heat in the fuel could cause the pool water to boil. Once water levels fall below a certain level in the fuel assembly, the exposed portion of the fuel cladding might heat up sufficiently to ignite if no mitigative actions were taken. This could result in the release of a substantial fraction of the cesium inventory to the environment in the form of aerosols.

A zirconium cladding fire in the presence of steam could generate hydrogen gas over the course of the event. The generation and transport of hydrogen gas in air was modeled in the Sandia calculations as was the deflagration of a hydrogen-air mixture in the closed building space above the spent fuel pool. The deflagration of hydrogen could enhance the release of radioactive material in some scenarios.

Sandia was just beginning to carry out a similar set of analyses for a "reference" PWR spent fuel pool when the committee completed information gathering for its classified report. There are reasons to believe that the results for a PWR pool could be somewhat different, and possibly more severe, than for a BWR pool: PWR assemblies are larger, have somewhat higher burn-ups, and some assemblies sit directly over the rack feet, which may impede cooling. While PWR fuel assemblies hold more fuel, they also have more open channels within them for water circulation. The committee was told that as part of this work, a sensitivity analysis will be carried out to understand how design differences among U.S. PWRs will influence the model results.

ENTERGY Corp. has carried out independent separate-effects modeling of a PWR spent fuel pool using the MELCOR code. The analyses addressed both partial and complete loss-of-pool-coolant events for its PWR spent fuel assemblies in a region of the pool where there are no water channels in the spent fuel racks. The analyses were made for relatively fresh spent fuel assemblies (i.e., separate models were run for assemblies that had been discharged from the reactor for 4, 30, and 90 days) surrounded by four "cold" assemblies that had been discharged for two years. In general, the ENTERGY results are similar to those from the Sandia separate-effects analyses mentioned above.

Several steps could be taken to mitigate the effects of such loss-of-pool-coolant events short of removal of spent fuel from the pool. Among these are the following:

- The spent fuel assemblies in the pools can be reconfigured in a "checkerboard" pattern so that newer, higher decay-heat fuel elements are surrounded by older, lower decay-heat elements. The older elements will act as radiation heat sinks in the event of a coolant loss so that the fuel is air coolable within a short time of its discharge from the reactor. Alternatively, newly discharged fuel can be placed near the pool wall, which also acts as a heat sink. ENTERGY staff estimates that reconfiguring the fuel in one of its pools into a checkerboard pattern would take only about 10 hours of extra work, but would not extend a refueling outage. Reconfiguring of fuel already in the pool could be done at any time. It does not require a reactor outage.

[19] In a reactor core accident, heat transfer by thermal radiation is not important because all of the fuel assemblies are at approximately the same temperature. Consequently, there is no net heat transfer between them. But spent fuel pools contain assemblies of different ages, burn-ups, and decay-heat production. The hotter assemblies will radiate heat to cooler assemblies.

- If there is sufficient space in the pool, empty slots can also be arranged to promote natural air convection in a complete-loss-of-pool-coolant event. The cask loading area in some pools may serve this purpose if it is in communication with the rest of the pool.
- Preinstalled emergency water makeup systems in spent fuel pools would provide a mechanism to replace pool water in the event of a coolant loss.
- Preinstalled water spray systems above or within the pool could also be used to cool the fuel in a loss-of-pool-coolant event.[20] The committee carried out a simple aggregate calculation suggesting that a water spray of about 50 to 60 gallons (about 190 to 225 liters) per minute for the whole pool would likely be adequate to prevent a zirconium cladding fire in a loss-of-pool-coolant event. A simple, low-pressure spray distribution experiment could verify what distribution of coolant would be sufficient to cool a spent fuel pool. Such a system would have to be designed to function even if the spent fuel pool or building were severely damaged in an attack.[21]
- Limiting full-core offloads to situations when such offloads are required would reduce the decay heat load in the pool during routine refueling outages. Alternatively, delaying the offload of fuel to the pool after a reactor shutdown would reduce the decay-heat load in the pool.
- The walls of spent fuel pools could be reinforced to prevent damage that could lead to a loss-of-pool-coolant event.
- Security levels at the plant could be increased during outages that involve core offloads.

Of course, damage to the pool and high radiation fields could make it difficult to take some of these mitigative measures. Multiple redundant and diverse measures may be required so that more than one remedy is available to mitigate a loss-of-pool-coolant event, especially when access to the pool is limited by damage or high radiation fields. Cost considerations might be significant, particularly for measures such as installing hardened spray systems and lengthening refueling outages, but the committee did not examine the costs of these measures.

3.3.3 Discussion

The Sandia and ENTERGY analyses described in this chapter were still in progress when the committee completed its classified report. As noted previously, draft technical documents describing the work were not available at the time this study was being completed. Consequently, the committee's understanding of these analyses is based on briefing materials (i.e., PowerPoint slides) presented before the committee by Nuclear

[20] There is an extensive analytic and experimental experience base confirming that spray systems are effective in providing emergency core cooling in BWR reactor cores, which generate much more decay heat than spent fuel. Detailed experiments have shown that some minimum amount of water must be delivered on top of each assembly, and if that is provided, the assembly will be cooled adequately even if there is significant blockage of the cooling channels.

[21] ENTERGY staff mentioned the possible use of a specially equipped fire engine to provide spray cooling. The committee does not know whether this would deliver sufficient spray cooling where it is needed or would provide sufficient protection if terrorists are attempting to prevent emergency response, but the strategy is worth further examination.

Regulatory Commission and ENTERGY staff and consultants, discussions with these experts, and the committee's own expert judgment.

The committee judges that these analyses provide a start for understanding the behavior of spent fuel pools in severe environments. The analyses were carried out by qualified experts using well-known analytical methods and engineering codes to model system behaviors. Although this is a start, the analyses have important limitations.

The aircraft attack scenarios consider one type of aircraft. Heavier aircraft could be used in such attacks. These planes are in common use in passenger and/or cargo operations, and some of these planes can be chartered.

Equally limiting assumptions were made in the analyses of spent fuel pool thermal behavior: To make the analysis tractable, it was assumed that the fuel in the pool was in an undamaged condition when the loss-of-pool-coolant event occurred. This is not necessarily a valid assumption. Whether such damage would change the outcome of the analyses described in this chapter is unknown.

Simplistic modeling assumptions were made about the fuel assembly geometry (e.g., individual fuel bundles were not modeled in the global effects calculation), convective cooling flow paths and mechanisms, thermal radiation heat transfer, propagation of cladding fires to low-power bundles, and radioactivity release mechanisms. In addition, flow blockage due to fission-gas-induced clad ballooning[22] was not considered. The thermal analysis experts on the committee judge that these simplistic assumptions could produce results that are more severe (i.e., overconservative) than would be the case had more realistic assumptions been used.

More sophisticated models, which involve clad ballooning and detailed thermal-hydraulics, including radiative heat transfer, have been developed for the analysis of severe in-core accidents. These models can be evaluated using more powerful computers. MELCOR appears to have sufficient capability to evaluate more sophisticated models of the spent fuel pool and Sandia has access to large, sophisticated computers. State-of-the-art calculations of this type are needed for the analysis of spent fuel pools so that more informed regulatory decisions can be made.

The analyses also do not consider the possibility of an attack that ejects spent fuel from the pool. The ejection of freshly discharged spent fuel from the pool might lead to a zirconium cladding fire if immediate mitigative actions could not be taken. The application of such measures could be hindered by the high radiation fields around the fuel.

While the committee judges that some attacks involving aircraft would be feasible to carry out, it can provide no assessment of the probability of such attacks. Nevertheless, analyzing their consequences is useful for informing policy decisions on steps to be taken to protect these facilities from terrorist attack.

[22] If a fuel rod reaches relatively high temperatures, the gases inside can cause the cladding to balloon out, restricting and even blocking coolant flow through the spaces between the rods within the assembly.

3.4 FINDINGS AND RECOMMENDATIONS

Based on its review of spent fuel pool risks, the committee offers the following findings and recommendations.

FINDING 3A: Pool storage is required at all operating commercial nuclear power plants to cool newly discharged spent fuel.

Operating nuclear power plants typically discharge about one-third of a reactor core of spent fuel every 18-24 months. Additionally, the entire reactor core may be placed into the spent fuel pool (offloaded) during outage periods for refueling. The analyses of spent fuel thermal behavior described in this chapter demonstrate that freshly discharged spent fuel generates too much decay heat to be passively air cooled. The Nuclear Regulatory Commission requires that this fuel be stored in a pool that has an active heat removal system (i.e., water pumps and heat exchangers) for at least one year as a safety matter. Current design practices for approved dry storage systems require five years' minimum decay in spent fuel pools. Although spent fuel younger than five years could be stored in dry casks, the changes required for shielding and heat removal could be substantial, especially for fuel that has been discharged for less than about three years.

FINDING 3B: The committee finds that, under some conditions, a terrorist attack that partially or completely drained a spent fuel pool could lead to a propagating zirconium cladding fire and the release of large quantities of radioactive materials to the environment. Details are provided in the committee's classified report.

It is not possible to predict the precise magnitude of such releases because the computer models have not been validated for this application.

FINDING 3C: It appears to be feasible to reduce the likelihood of a zirconium cladding fire following a loss-of-pool-coolant event using readily implemented measures.

There appear to be some measures that could be taken to mitigate the risks of spent fuel zirconium cladding fires in a loss-of-pool-coolant event. The following measures appear to have particular merit.

- Reconfiguring of spent fuel in the pools (i.e., redistribution of high decay-heat assemblies so that they are surrounded by low decay-heat assemblies) to more evenly distribute decay-heat loads. The analyses described elsewhere in this chapter suggest that the potential for zirconium cladding fires can be reduced substantially by surrounding freshly discharged spent fuel assemblies with older spent fuel assemblies in "checkerboard" patterns. The analyses suggest that such arrangements might even be more effective for reducing the potential for zirconium cladding fires than removing this older spent fuel from the pools be made. The offloading of the reactor core into the spent fuel pool during reactor outages substantially raises the decay-heat load of the pool and increases the risk of a zirconium cladding fire in a loss-of-pool-coolant event. Of course, any actions that increase the time a power reactor is shut down incur costs, which must be considered in cost-benefit analyses of possible actions to reduce risks.

- Development of a redundant and diverse response system to mitigate loss-of-pool-coolant events. Any mitigation system, such as a spray cooling system, must be capable of operation even when the pool is drained (which would result in high radiation fields and limit worker access to the pool) and the pool or overlying building, including equipment attached to the roof or walls, is severely damaged.

FINDING 3D: The potential vulnerabilities of spent fuel pools to terrorist attacks are plant-design specific. Therefore, specific vulnerabilities can be understood only by examining the characteristics of spent fuel storage at each plant.

As described in the classified report, there are substantial differences in the design of PWR and BWR spent fuel pools. PWR pools tend to be located near or below grade, whereas BWR pools typically are located well above grade but are protected by exterior walls and other structures. In addition, there are plant-specific differences among BWRs and PWRs that could increase or decrease the vulnerabilities of the pools to various kinds of terrorist attacks, making generic conclusions difficult.

FINDING 3E: The Nuclear Regulatory Commission and independent analysts have made progress in understanding some vulnerabilities of spent fuel pools to certain terrorist attacks and the consequences of such attacks for releases of radioactivity to the environment. However, additional work on specific issues listed in the following recommendation is needed urgently.

The analyses carried out to date for the Nuclear Regulatory Commission by Sandia National Laboratories and by other independent organizations such as EPRI and ENTERGY have provided a general understanding of spent fuel behavior in a loss-of-pool-coolant event and the vulnerability of spent fuel pools to certain terrorist attacks that could cause such events to occur. The work to date, however, has not been sufficient to adequately understand the vulnerabilities and consequences. This work has addressed a small number of plant designs that may not be representative of U.S. commercial nuclear power plants as a whole. It has considered only a limited number of threat scenarios that may underestimate the damage that can be inflicted on the pools by determined terrorists. Additional analyses are needed urgently to fill in the knowledge gaps so that well-informed policy decisions can be made.

> **RECOMMENDATION: The Nuclear Regulatory Commission should undertake additional best-estimate analyses to more fully understand the vulnerabilities and consequences of loss-of-pool-coolant events that could lead to a zirconium cladding fire. Based on these analyses, the Commission should take appropriate actions to address any significant vulnerabilities that are identified. The analyses of the BWR and PWR spent fuel pools should be extended to consider the consequences of loss-of-pool-coolant events that are described in the committee's classified report.**

The consequence analyses should address the following questions:

- To what extent would such attacks damage the spent fuel in the pool, and what would be the thermal consequences of such damage?
- Is it feasible to reconfigure the spent fuel within pools to prevent zirconium cladding fires given the actual characteristics (i.e., heat generation) of spent fuel assemblies in the pool, even if the fuel were damaged in an attack? Is there enough space in the pools at all commercial reactor sites to implement such fuel reconfiguration?
- In the event of a localized zirconium cladding fire, will such rearrangement prevent its spread to the rest of the pool?
- How much spray cooling is needed to prevent zirconium cladding fires and prevent propagation of such fires? Which of the different options for providing spray cooling are effective under attack and accident conditions?

Sensitivity analyses should also be undertaken to account for the full range of variation in spent fuel pool designs (e.g., rack designs, capacities, spent fuel burn-ups, and ages) at U.S. commercial nuclear power plants.

RECOMMENDATION: While the work described in the previous recommendation under Finding 3E, above, is being carried out, the Nuclear Regulatory Commission should ensure that power plant operators take prompt and effective measures to reduce the consequences of loss-of-pool-coolant events in spent fuel pools that could result in propagating zirconium cladding fires. The committee judges that there are at least two such measures that should be implemented promptly:

- -Reconfiguring of fuel in the pools so that high decay-heat fuel assemblies are surrounded by low decay-heat assemblies. This will more evenly distribute decay-heat loads, thus enhancing radiative heat transfer in the event of a loss of pool coolant.
- Provision for water-spray systems that would be able to cool the fuel even if the pool or overlying building were severely damaged.

Reconfiguring of fuel in the pool would be a prudent measure that could probably be implemented at all plants at little cost, time, or exposure of workers to radiation. The second measure would probably be more expensive to implement and may not be needed at all plants, particularly plants in which spent fuel pools are located below grade or are protected from external line-of-sight attacks by exterior walls and other structures.

The committee anticipates that the costs and benefits of options for implementing the second measure would be examined to help decide what requirements would be imposed. Further, the committee does not presume to anticipate the best design of such a system—whether it should be installed on the walls of a pool or deployed from a location where it is unlikely to be compromised by the same attack—but simply notes the demanding requirements such a system must meet.

4

DRY CASK STORAGE AND COMPARATIVE RISKS

This chapter addresses the second and third charges of the committee's statement of task:

- The safety and security advantages, if any, of dry cask storage[1] versus wet pool storage at reactor sites.
- Potential safety and security advantages, if any, of dry cask storage using various single-, dual-, or multi-purpose cask designs.

The second charge calls for a comparative analysis of dry cask storage versus pool storage, whereas the third charge focuses exclusively on dry casks. The committee will address the third charge first to provide the basis for the comparative analysis.

By the late 1970s, the need for alternatives to spent fuel pool storage was becoming obvious to both commercial nuclear power plant operators and the Nuclear Regulatory Commission. The U.S. government made a policy decision at that time not to support commercial reprocessing of spent nuclear fuel (see Appendix D). At the same time, efforts to open an underground repository for permanent disposal of commercial spent fuel were proving to be more difficult and time consuming than originally anticipated.[2] Commercial nuclear power plant operators had no place to ship their growing inventories of spent fuel and were running out of pool storage space.

Dry cask storage was developed to meet the need for expanded onsite storage of spent fuel at commercial nuclear power plants. The first dry cask storage facility in the United States was opened in 1986 at the Surry Nuclear Power Plant in Virginia. Such facilities are now in operation at 28 operating and decommissioned nuclear power plants. In 2000, the nuclear power industry projected that up to three or four plants per year would run out of needed storage space in their pools without additional interim storage capacity.

This chapter is organized into the following sections:

- Background on dry cask storage.
- Evaluation of potential risks of dry cask storage.
- Potential advantages of dry storage over wet storage.
- Findings and recommendations.

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[1] This storage system is referred to as "dry" because the fuel is stored out of water.
[2] The Nuclear Waste Policy Act of 1982 and the Amendments Act of 1987 laid out a process for identifying a site for a geologic repository. That repository was to be opened and operating by the end of January 1998. The federal government now hopes to open a repository at Yucca Mountain, which is located in southwestern Nevada, by the end of 2010.

4.1 BACKGROUND ON DRY CASK STORAGE

The storage of spent fuel in dry casks has the same three primary objectives as pool storage (Chapter 3):

- Cool the fuel to prevent heat-up to high temperatures from radioactive decay.
- Shield workers and the public from the radiation emitted by radioactive decay in the spent fuel and provide a barrier for any releases of radioactivity.
- Prevent criticality accidents.

Dry casks are designed to achieve the first two of these objectives without the use of water or mechanical systems. Fuel cooling is passive: that is, it relies upon a combination of heat conduction through solid materials and natural convection or thermal radiation through air to move decay heat from the spent fuel into the ambient environment. Radiation shielding is provided by the cask materials: Typically, concrete, lead, and steel are used to shield gamma radiation, and polyethylene, concrete, and boron-impregnated metals or resins are used to shield neutrons. Criticality control is provided by a lattice structure, referred to as a *basket*, which holds the spent fuel assemblies within individual compartments in the cask (FIGURE 4.1). These maintain the fuel in a fixed geometry, and the basket may contain boron-doped metals to absorb neutrons.[3]

Passive cooling and radiation shielding are possible because these casks are designed to store only older spent fuel. This fuel has much lower decay heat than freshly discharged spent fuel as well as smaller inventories of radionuclides.

The industry sometimes refers to these casks using the following terms:

- Single-, dual-, and multi-purpose casks.
- Bare-fuel and canister-based casks.

The terms in the first bullet indicate the application for which the casks are intended to be used. Single-purpose cask systems are licensed[4] only to store spent fuel. Dual-purpose casks are licensed for both storage and transportation. Multi-purpose casks are intended for storage, transportation, and disposal in a geologic repository. No true multi-purpose casks exist in the United States (or in any other country for that matter) because specifications for acceptable containers for geologic disposal have yet to be finalized by the Department of Energy. Current plans for Yucca Mountain do not contemplate the use of multi-purpose casks.

Nevertheless, some cask vendors still refer to their casks as "multi-purpose." These are at best dual-purpose casks, however, because they have been licensed only for storage and transport. **Because true multi-purpose casks do not now exist and are not likely to exist in the future, the committee did not consider them further in this study.**

[3] Criticality control is less of an issue in dry casks because there is no water moderator present after the cask is sealed and drained.
[4] Authority for licensing dry cask storage rests with the Nuclear Regulatory Commission.

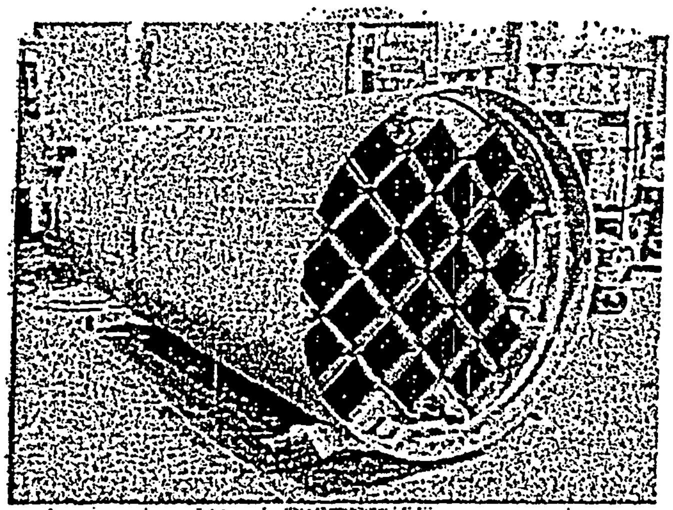

FIGURE 4.1 Photo of NUHOMS canister showing the internal basket for holding the spent fuel assemblies in a fixed geometry. This canister is shown for illustrative purposes only. SOURCE: Courtesy of Transnuclear, Inc., an Areva Company.

The terms in the second bullet indicate how spent fuel is loaded into the casks. In bare-fuel[5] casks, spent fuel assemblies are placed directly into a basket that is integrated into the cask itself (see FIGURE 4.3B). The cask has a bolted lid closure for sealing. In canister-based casks, spent fuel assemblies are loaded into baskets integrated into a thin-wall (typically ½-inch [1.3-centimeter] thick) steel cylinder, referred to as a *canister* (see FIGURE 4.1 and 4.3A). The canister is sealed with a welded lid. The canister can be stored or transported if it is placed within a suitable overpack. This overpack is closed with a bolted lid.

Bare-fuel and canister-based systems are sometimes referred to as "thick-walled" and "thin-walled" casks, respectively, by some cask vendors. This designation is not strictly correct because the overpacks in canister-based systems have thick walls. The only thin-walled component is the canister, which is designed to be stored or transported within the overpack.

The designation of a cask as single- or dual-purpose often has less to do with its design and more to do with licensing decisions. Indeed, bare-fuel and canister-based casks can be licensed for either single or dual purposes. Consequently, one should not expect the performance of a cask in accidents or terrorist attacks to depend on its designation as single- or dual-purpose. Rather, performance will depend on the type of attack and construction of the cask. For the purposes of discussion in this chapter, therefore, the committee uses the designations "bare-fuel" and "canister-based," rather than single- or dual-purpose, when referring to various cask designs.

All bare-fuel casks in use in the United States are designed to be stored vertically. Most canister-based systems also are designed for vertical storage, but one overpack

[5] The term *bare fuel* refers to the entire fuel assembly, including the uranium pellets within the fuel rods.

system is designed as a horizontal concrete module (FIGURE 4.2).[6] The principal characteristics of dry cask storage systems are summarized in TABLE 4.1, which is located at the end of this chapter.

Dry casks are designed to hold up to about 10 to 15 metric tons of spent fuel. This is equivalent to about 32 pressurized water nuclear reactor (PWR) spent fuel assemblies or 68 boiling water nuclear reactor (BWR) spent fuel assemblies. Although the dimensions vary among manufacturers, fuel types (i.e., BWR or PWR fuel), and amounts of fuel stored, the casks are typically about 19 feet (6 meters) in height, 8 feet (2.5 meters) in diameter, and weigh 100 tons or more when loaded.

The casks (for bare-fuel designs) or canisters (for canister-based designs) are placed directly into the spent fuel pool for loading. After they are loaded, the canisters or casks are drained, vacuum dried, and filled with an inert gas (typically helium). The loaded canisters or casks are then removed from the pool, their outer surfaces are decontaminated,[7] and they are moved to the dry storage facility on the property of the reactor site. Loading of a single cask or canister can take up to one week. The vacuum drying process is the longest step in the loading process.

In the United States, dry casks are stored on open concrete pads within a protected area of the plant site.[8,9] This protected area may be contiguous with the protected area of the plant itself or may be located some distance away in its own protected area (see FIGURE 2.1).

According to the information provided to the committee by cask vendors, nuclear power plant operators are currently purchasing mostly dual-purpose casks for spent fuel storage. The horizontal NUHOMS cask design is one of the most-ordered designs at present (TABLE 4.3). The vendors informed the committee that cost is the chief consideration for their customers when making purchasing decisions. Cost considerations are driving the cask industry away from all-metal cask designs and toward concrete designs for storage.

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[6] In addition, there is one modular concrete vault design in the United States: the Fort St. Vrain, Colorado, Independent Spent Fuel Storage Installation, which stores spent fuel from a high-temperature gas-cooled reactor. This reactor operated until 1989 and is now decommissioned. Because this is a one-of-a-kind facility, and the time available to the committee was short, it was not examined in this study.

[7] Small amounts of radioactive contamination are present in the cooling water in the spent fuel pool. Some of this contamination is transferred to the cask or canister surfaces when it is immersed in the pool for loading.

[8] There may be exceptions in the future. Private Fuel Storage has requested a license from the Nuclear Regulatory Commission to construct a dry cask storage facility in Utah that will store fuel from multiple reactor sites. An underground dry cask storage facility has been proposed at the Humbolt Bay power plant in California to store old, low decay-heat fuel. The underground design is being proposed primarily because the site has very demanding seismic design requirements and is possible only because the fuel to be stored generates little heat.

[9] In Germany, dry casks are stored in reinforced concrete buildings. These buildings were originally designed to provide additional radiation shielding (beyond what is provided by the cask itself) to reduce doses at plant site boundaries to background levels. Some of these buildings are sufficiently robust to provide protection against crashes of large aircraft. A subgroup of the committee visited spent fuel storage sites at Ahaus and Lingen during this study. See Appendix C for details.

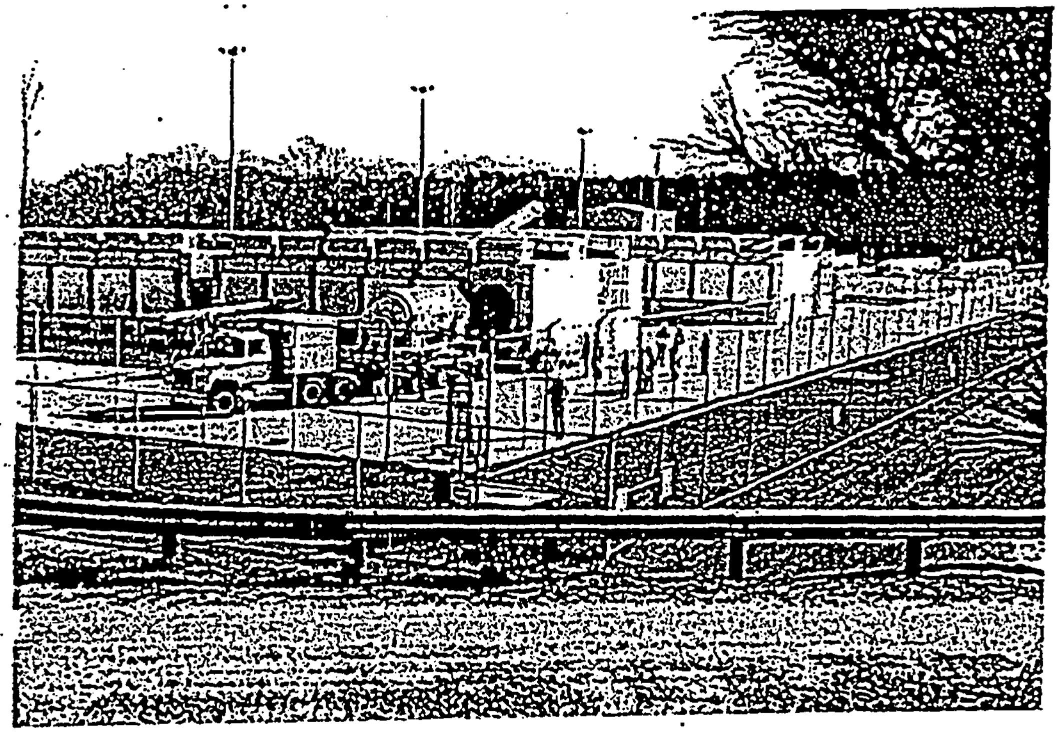

FIGURE 4.2 Photo showing a canister being loaded into a NUHOMS horizontal storage module. SOURCE: Courtesy of Transnuclear, Inc., an Areva Company.

4.2 EVALUATION OF POTENTIAL RISKS OF DRY CASK STORAGE

Dry casks were designed to ensure safe storage of spent fuel,[10] not to resist terrorist attacks. The regulations for these storage systems, which are given in Title 10, Part 72 of the Code of Federal Regulations (i.e., 10 CFR 72), are designed to ensure adequate passive heat removal and radiation shielding during normal operations, off-normal events, and accidents. The latter include, for example, accidental drops or tip-overs during routine cask movements. The robust construction of these casks provides some passive protection against external assaults, but the casks were not explicitly designed with this factor in mind.[11]

The regulations in 10 CFR 72 require that dry cask storage facilities (formally referred to as Independent Spent Fuel Storage Installations, or ISFSIs) be located within a protected area of the plant site (see FIGURE 2.1). However, the protection requirements for these installations are lower than those for reactors and spent fuel pools. The guard force is required to carry side arms, and its main function is surveillance: to detect and assess threats and to summon reinforcements. If the ISFSI is within the protected area of the plant

[10] Dual-purpose casks also were designed for safe transport under the requirements of Title 10, Part 71 of the Code of Federal Regulations. The committee did not examine transport of spent fuel in this study.

[11] A recent study by the German organization GRS (Gesellschaft für Anlagen- und Reaktorsicherheit, MBH) examined the vulnerability of CASTOR-type casks to large-aircraft impacts.

it would come directly under the protection of plant's guard forces. The protected area is surrounded by vehicle barriers to protect against the detonation of a design basis threat vehicle bomb.[12]

A terrorist attack that breached a dry cask could *potentially* result in the release of radioactive material from the spent fuel into the environment through one or both of the following two processes: (1) mechanical dispersion of fuel particles or fragments; and (2) dispersion of radioactive aerosols (e.g., cesium-137). As described in Chapter 3, the latter process would have greater offsite radiological consequences. The committee evaluates the potential for both of these processes later in this chapter.

In the wake of the September 11, 2001, attacks, additional work has been or is being carried out by government and private entities to assess the security risks to dry casks from terrorist attacks. Sandia National Laboratories is currently analyzing the response of dry casks to a number of potential terrorist attack scenarios at the request of the Nuclear Regulatory Commission. The committee was briefed on these analyses at two of its meetings.

Sandia is analyzing the responses of three vertical cask designs and one horizontal design to a variety of terrorist attack scenarios (FIGURE 4.3). These designs are considered to be broadly representative of the dry casks currently licensed for storage in the United States by the Nuclear Regulatory Commission (see TABLE 4.1 at the end of this chapter). The committee received briefings on these studies by Nuclear Regulatory Commission and Sandia staff.

Several attack scenarios are being considered in the Sandia analyses. They include large aircraft impacts and assaults with various types and sizes of explosive charges and other energetic devices. Details on the large aircraft impact scenarios are provided in the classified report.

Most of this work is still in progress and has not yet resulted in reviewable documents. Consequently, the committee had to rely on discussions with the experts who are carrying out these studies and its own expert judgment in assessing the quality and completeness of this work.

4.2.1 Large Aircraft Impacts

Sandia analyzed the impact of an airliner traveling at high speed into the four cask designs shown in FIGURE 4.3. These analyses examined the consequences of impacts of the fuselage and the "hard" components of the aircraft (i.e., the engines and wheel struts) into individual casks and arrays of casks on a storage pad. The latter analysis examined the potential consequences of cask-to-cask interactions resulting from cask sliding or partial tip-over. The objectives of the analyses were first to determine whether the casks would fail (i.e., the containment would be breached) and, if so, to estimate the radioactive material releases and their health consequences.

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[12] As noted in Chapter 2, the committee did not examine surveillance requirements or the placement or effectiveness of vehicle barriers and guard stations at commercial nuclear plants.

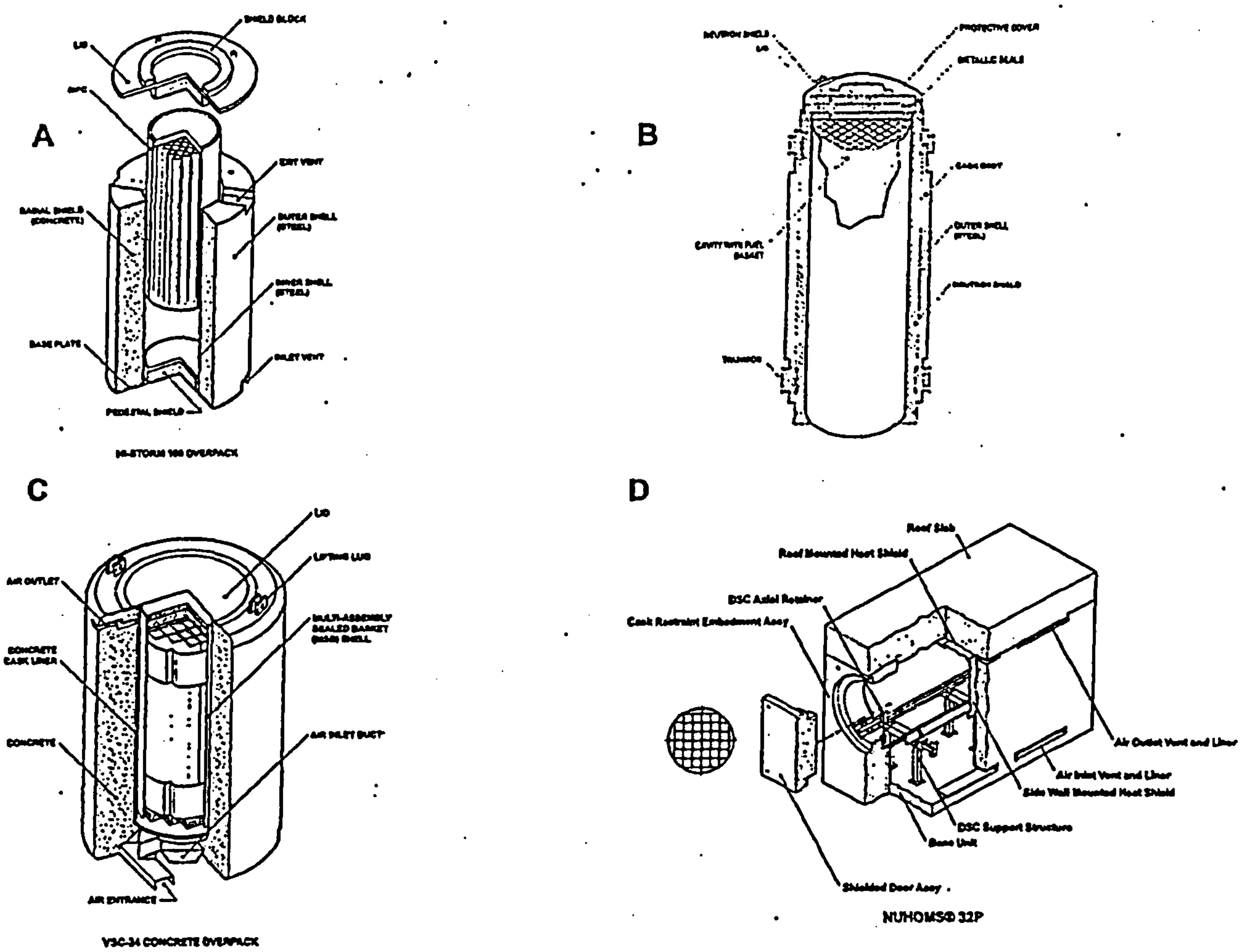

FIGURE 4.3 Four cask systems u: ;ed in the Sandia analyses described in this chapter: (A) HI-STORM-100, (B) TN-68, (C) V: .;C-24, (D) NUHOMS-32P. The casks shown in A, C, and D are canister-based casks; the c: ·ısk shown in B is a bare-fuel cask. SOURCE: Nuclear Regulatory Commission briefing n :aterials (2004).

The aircraft was modeled ι ..ısing Sandia-developed Eulerian CTH code (see footnote 15 in Chapter 3). The aircraft man :ıfacturer (Boeing Corp.) was consulted to ensure that the aircraft model used in the analyse ; was accurate. The casks were modeled with standard finite element codes using the puk ·lished characteristics of the casks. The casks were assumed to be filled with high-bur :ı-up, 10-year-old spent fuel. The fuel rods were assumed to fail (rupture) if the strains in the cladding exceeded 1 percent, which is a conservative assumption. Sandia evaluated the release of radioactive materials from the spent fuel pellets inside the fuel rods when s :ıch cladding failures occurred. Radiological consequences of such releases w ɜre calculated for "representative" (with respect to weather and population) site conditions for each cask based on the actual average conditions at the site that currently stores the most spent fuel in that cask type.[13] Site conditions differed for each cask.

The effects of jet fuel fires also were not considered in the analyses. Based on an analysis of actual aircraft accidents, Sandia determined that jet fuel would likely be dispersed over a large area in a low-angle impact. Consequently, the resulting petroleum fire would likely be of short duration (generally less than 15 minutes according to Sandia researchers). Long-duration fires that could damage the casks or even ignite the cladding of the spent fuel were not seen to be credible for the aircraft impact scenarios considered by Sandia.[14]

The results of these analyses, which are considered by the Nuclear Regulatory Commission to be classified or safeguards information, are detailed in the classified report. In general, the analyses show that some types of impacts will damage some types of casks. For some scenarios there could be substantial cask-to-cask interactions, including collisions and partial tip-overs.

Nevertheless, predicted releases of radioactive material from the casks, mainly noble gases, were relatively small for all of the scenarios considered by Sandia. The analyses show that the releases were governed by design-specific features of the casks. Sandia noted that the modeling of such releases is difficult and requires expert judgment for several elements of the calculation. Detailed calculations of the consequences were still in progress when the committee was briefed on these analyses.

4.2.2 Other Assaults

Analyses are also being carried out to understand the consequences of other types of assaults on the cask designs shown in FIGURE 4.3. These include assaults using explosives and certain types of high-energy devices. The analyses were still underway when the committee was briefed on these analyses, and the results were characterized by the Nuclear Regulatory Commission as preliminary. Details are provided in the classified report.

4.2.3 Discussion

As noted previously, the dry cask vulnerability analyses were still underway when the committee's classified study was completed. Based on the analyses it did receive, the committee judges that no cask provides complete protection against all types of terrorist attacks. The committee judges that releases of radioactive material from dry casks are low for the scenarios it examined with one possible exception as discussed in the classified report. It is not clear to the committee whether it is credible to assume that this "exceptional" scenario could actually be carried out.

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[13] As noted in Chapter 1, the committee did not concern itself with how radioactive materials would be transported through the environment once they were released from a dry cask. Rather, the committee confined its examination to whether and how much radioactive material might be released from a dry cask in the event of a terrorist attack.

[14] The committee subgroup that visited Germany was briefed on a fire test on the Castor cask that involved a fully engulfing one-hour petroleum fire. The cask maintained its integrity during and after this test. See Appendix C. The results of this test do not necessarily translate to casks having other designs.

In the committee's opinion, there are several relatively simple steps that could be taken to reduce the likelihood of releases of radioactive material from dry casks in the event of a terrorist attack:

- Additional surveillance could be added to dry cask storage facilities to detect and thwart ground attacks.[15]
- Certain types of cask systems could be protected against aircraft strikes by partial earthen berms. Such berms also would deflect the blasts from vehicle bombs.
- Visual barriers could be placed around storage pads to prevent targeting of individual casks by aircraft or standoff weapons.[16] These would have to be designed so that they would not trap jet fuel in the event of an aircraft attack.
- The spacing of vertical casks on the storage pads can be changed, or spacers (shims) can be placed between the casks, to reduce the likelihood of cask-to-cask interactions in the event of an aircraft attack.
- Relatively minor changes in the design of newly manufactured casks could be made to improve their resistance to certain types of attack scenarios.

4.3 POTENTIAL ADVANTAGES OF DRY STORAGE OVER WET STORAGE

Based on the analyses presented in Chapter 3 and previously in this chapter, the committee judges that dry cask storage has several potential safety and security advantages over pool storage. These differences can best be illustrated using scenarios for both storage systems based on the Sandia analyses reviewed by the committee. **The use of such scenarios should not be taken to imply that the committee believes that these scenarios are likely or even possible at all storage facilities. They are used only for illustrative purposes.**

The following statements can be made about the comparative advantages of dry-cask storage and pool storage based on the Sandia analyses:

Less spent fuel is at risk in an accident or attack on a dry storage cask than on a spent fuel pool. An accident or attack on a dry cask storage facility would likely affect at most a few casks and put a few tens of metric tons of spent fuel at risk. An accident or attack on a spent fuel pool puts the entire inventory of the pool, potentially hundreds of metric tons of spent fuel, at risk.

The potential consequences of an accident or terrorist attack on a dry cask storage facility are lower than those for a spent fuel pool. There are several reasons for this difference:

(1) There is less fuel in a dry cask than in a spent fuel pool and therefore less radioactive material available for release.

(2) *Measured on a per-fuel-assembly basis*, the inventories of radionuclides available

[15] As noted in Chapter 1, the committee did not examine surveillance activities at nuclear power plants and has no basis to judge whether current activities at dry cask storage facilities are adequate.
[16] The ISFSI at the Palo Verde Nuclear Power Plant in Arizona, which was visited by a subgroup of committee members, incorporates a berm into its design to provide a visual barrier.

for release from a dry cask are lower than those from a spent fuel pool because dry casks store older, lower decay-heat fuel.

(3) Radioactive material releases from a breach in a dry cask would occur through *mechanical dispersion.*[17] *Such releases would be relatively small.* Certain types of attacks on spent fuel pools could result in a much larger dispersal of spent fuel fragments. Radioactive material releases from a spent fuel pool also could occur as the result of a zirconium cladding fire, which would produce radioactive aerosols. Such fires have the potential to release large quantities of radioactive material to the environment.

The recovery from an attack on a dry cask would be much easier than the recovery from an attack on a spent fuel pool. Breaches in dry casks could be temporarily plugged with radiation-absorbing materials until permanent fixes or replacements could be made. The most significant contamination would likely be confined largely to areas near the cask storage pad and could be detected and decontaminated. The costs of recovery could be high, however, especially if the cask could not be repaired or the spent fuel could not be removed with equipment available at the plant. A special facility might have to be constructed or brought onto the site to transfer the damaged spent fuel to other casks.

Breaches in spent fuel pools could be much harder to plug, especially if high *radiation fields or the collapse of the overlying building prevented workers from reaching the* pool. Complete cleanup from a zirconium cladding fire would be extraordinarily expensive, and even after cleanup was completed large areas downwind of the site might remain contaminated to levels that prevented reoccupation (see Chapter 3).

It is the potential for zirconium cladding fires in spent fuel pools that gives dry cask storage most of its comparative safety and security advantages. This comparative advantage can be reduced by lowering the potential for zirconium cladding fires in loss-of-pool-coolant events. As discussed in Chapter 3, the committee believes that there are at least two steps that can be implemented immediately to lower the potential for such fires.

4.4 FINDINGS AND RECOMMENDATIONS

With respect to the committee's task to examine potential safety and security advantages of dry cask storage using various single-, dual-, or multi-purpose cask designs, the committee offers the following findings and recommendations:

FINDING 4A: Although there are differences in the robustness of different dry cask designs (e.g., bare-fuel versus canister-based), the differences are not large when measured by the absolute magnitudes of radionuclide releases in the event of a breach.

All storage cask designs are vulnerable to some types of terrorist attacks for which radionuclide releases would be possible. The vulnerabilities are related to the specific

[17] Since the committee's classified report was published, the committee received an additional briefing from the Nuclear Regulatory Commission suggesting that a radioactive aerosol could be released in one type of terrorist attack. However, the scenario in question does not appear to the committee to be credible.

design features of the casks, but the committee judges that the quantity of radioactive material releases predicted from such attacks is still relatively small.

FINDING 4B: Additional steps can be taken to make dry casks less vulnerable to potential terrorist attacks.

Although the vulnerabilities of current cask designs are already small, additional, relatively simple steps can be taken to reduce them. Such steps are listed in Section 4.2.3.

> **RECOMMENDATION: The Nuclear Regulatory Commission should consider using the results of the vulnerability analyses for possible upgrades of requirements in 10 CFR 72 for dry casks, specifically to improve their resistance to terrorist attacks.**
>
> The committee was told by Nuclear Regulatory Commission staff that such a step is already under consideration. Based on the material presented to the committee, there appear to be minor changes that can be made by plant operators and cask vendors to increase the resistance of existing and new casks to terrorist attacks (see Section 4.2.3).

With respect to the committee's task to examine the safety and security advantages of dry cask storage versus wet pool storage at reactor sites, the committee offers the following findings and recommendations:

FINDING 4C: Dry cask storage does not eliminate the need for pool storage at operating commercial reactors.

Newly discharged fuel from the reactor must be stored in the pool for cooling, as discussed in detail in Chapter 3. Under current U.S. practices, dry cask storage can be used only to store fuel that has been out of the reactor long enough (generally greater than five years under current practices) to be air cooled. The fuel in dry cask storage poses less of a risk in the event of a terrorist attack than newly discharged fuel in pools because there is substantially reduced probability of initiating a cladding fire.

FINDING 4D: Dry cask storage for older, cooler spent fuel has two inherent advantages over pool storage: (1) It is a passive system that relies on natural air circulation for cooling; and (2) it divides the inventory of that spent fuel among a large number of discrete, robust containers. These factors make it more difficult to attack a large amount of spent fuel at one time and also reduce the consequences of such attacks.

Each storage cask holds no more than about 10 to 15 metric tons of spent fuel, compared to the several hundred metric tons of spent fuel that is commonly stored in reactor pools. The robust construction of these casks prevents large-scale releases of radionuclides in all of the attack scenarios examined by the committee. Some of the attacks could breach the casks, but many of these breaches would be small and could probably be more easily plugged than a perforated spent fuel pool wall because radiation fields would be lower and there would be no escaping water to contend with. Even large breaches of the cask would result only in the mechanical dispersal of some of its radionuclide inventory in the immediate vicinity of the cask.

FINDING 4E: Depending on the outcome of plant-specific vulnerability analyses described in the committee's classified report, the Nuclear Regulatory Commission might determine that earlier movements of spent fuel from pools into dry cask storage would be prudent to reduce the potential consequences of terrorist attacks on pools at some commercial nuclear plants.

The statement of task directs the committee to examine the risks of spent fuel storage options and alternatives for decision makers, not to recommend whether any spent fuel should be transferred from pool storage to cask storage. In fact, there may be some commercial plants that, because of pool designs or fuel loadings, may require some removal of spent fuel from their pools. If there is a need to remove spent fuel it should become clearer once the vulnerability and consequence analyses described in Chapter 3 are completed. The committee expects that cost-benefit considerations would be a part of these analyses.

TABLE 4.1 Dry Casks Used for Spent Fuel Storage in the United States

Cask design used for storage	License holder	Type	Fuel type	Construction	Closure system	Number of casks used to date; sites; and number of casks on order[1]
CASTOR V/21	GNSI (General Nuclear Systems, Inc.)	Bare-fuel, storage-only	BWR	Ductile cast iron	Primary lid (44 bolts), secondary lid (48 bolts)	25 loaded (Surry); 0 purchased
CASTOR X/33	GNS (Gesellschaft für Nuklear-Service mbH)	Bare-fuel, storage-only	PWR	Ductile cast iron	Primary lid (44 bolts), secondary lid (70 cup screws)	1 loaded (Surry); 0 purchased
NAC S/T	NAC International	Bare-fuel, storage-only	PWR	Inner and outer stainless steel shells	Closure lid (24 bolts)	2 loaded (Surry); 0 purchased
MC-10	Westinghouse	Bare-fuel, storage-only	PWR	Stainless and carbon steel	One shield lid and two sealing lids, all bolted (number of bolts not available)	1 loaded (Surry); 0 purchased
TN-32, TN-40	Transnuclear Inc.	Bare-fuel, storage-only	PWR	Carbon steel	One lid (48 bolts)	61 loaded (4 sites); 22 purchased
TN-68	Transnuclear Inc.	Bare-fuel, dual-purpose	BWR	Carbon steel	One lid (48 bolts)	24 loaded (Peach Bottom); 20 purchased
Fuel Solution W-150 Storage Cask	BNFL Fuel Solutions	Canister-based, dual-purpose	PWR, BWR	Reinforced concrete with inner steel shell	Canister lid, welded cask lid (12 bolts)	7 loaded (Big Rock Point); 0 purchased
HI-STORM 100	Holtec International	Canister-based, storage-only module	PWR, BWR	Stainless steel shells with un-reinforced concrete filler	Canister lid, welded cask lid (4 bolts)	58 loaded (7 sites); 177 on order
HI-STAR 100	Holtec International	Canister-based, dual-purpose	PWR, BWR	Carbon steel shells with neutron absorber polymer	Canister lid, welded cask lid (54 bolts)	7 loaded (2 sites[1]); 5 on order

VSC-24 Ventilated Concrete Cask	BNFL Fuel Solutions	Canister-based, storage-only	PWR	Reinforced concrete with inner steel shell	Canister lid, welded cask lid (6 bolts)	58 loaded (3 sites); 4 purchased[2]
NAC-MPC	NAC International	Canister-based, dual-purpose	PWR	Metal canister surrounded by storage overpack. Storage overpack consists of an inner steel liner 3.5 in. thick, two rebar cages, and concrete	Canister lid, welded cask lid over a shield plug (6 high-strength bolts)	21 loaded (Yankee Rowe and CT Yankee); 59 purchased
NAC-UMS	NAC International	Canister-based, dual-purpose	PWR, BWR	Metal canister surrounded by storage overpack. Storage overpack consists of inner steel liner 2.5 in. thick, two rebar cages, and concrete	Canister lid, welded cask lid over a shield plug (6 high-strength bolts)	80 loaded (2 sites); 165 purchased
Holtec MPC 24E/EF	Holtec International	Canister based, dual-purpose	PWR, BWR	Metal canister surrounded by storage overpack. Storage overpack consists of inner and outer steel liners, a double-rebar cage, and concrete	Canister lid, welded cask lid, shield plug plus 48 bolts	34 loaded (Trojan); 0 purchased
NUHOMS 24P, 52B, 61BT, 24PT1, 24PT2, 32PT	Transnuclear Inc.	Canister-based, dual-purpose	PWR, BWR	Horizontal reinforced concrete storage module with shielded canister	Canister lid, welded storage module lid, reinforced concrete	239 loaded (10 sites); >150 purchased

NOTES:
[1]The Humboldt Bay Power Plant is licensing a site-specific variation of the HI-STAR System called HI-STAR HB.
[2] Some licensees have purchased additional casks that have not yet been loaded, nor are they planned for loading.

SOURCES: Data compiled from cask license holders (2004).

5

IMPLEMENTATION ISSUES

Implementation of the recommendations in this report will require actions and cooperation by a large number of parties. This chapter provides a brief discussion of two implementation issues that the committee believes will be of interest to Congress:

(1) Timing Issues: Ensuring that high-quality, expert analyses are completed in a timely manner.
(2) Communication Issues: Ensuring that the results of the analyses are communicated to industry so that appropriate and timely mitigating actions can be taken.

5.1 TIMING ISSUES

The September 11, 2001, terrorist attacks forced the nation to begin a reexamination of the vulnerability of its critical infrastructure to high-impact suicide attacks by terrorists. The Nuclear Regulatory Commission was no exception. The Commission began a top-to-bottom review of security procedures at commercial nuclear power plants. This review resulted in the issuance of numerous directives to power plant operators to upgrade their security practices. The Commission also began a series of vulnerability analyses of spent fuel storage to terrorist attacks. These analyses are described in Chapters 3 and 4.

More than three years have passed since the September 11, 2001, attacks. Vulnerability analyses of spent fuel pool storage to attacks with large aircraft have been performed by EPRI (Chapter 3), and analyses of vulnerabilities of dry cask storage to large aircraft attacks have been completed by the German organization GRS (Gesellschaft für Anlagen- und Reaktorsicherheit, mbH). However, the Nuclear Regulatory Commission's analyses of spent fuel storage vulnerabilities have not yet been completed, and actions to reduce vulnerabilities, such as those described in Chapter 3, on the basis of these analyses have not yet been taken. Moreover, some important additional analyses remain to be done. The slow pace in completing this work is of concern given the enormous potential consequences as described elsewhere in this report.

The committee does not know the reason for this delay, nor was it asked by Congress for an evaluation. It is important to note that the Nuclear Regulatory Commission's analyses are addressing a much broader range of vulnerabilities than just spent fuel storage. The committee nevertheless raises this issue because it appears to be having an impact on the timely completion of critical work and implementation of appropriate mitigative actions for spent fuel storage.

5.2 COMMUNICATION ISSUES

During the course of this study, the committee had the opportunity to interact with representatives of the nuclear power industry to discuss their concerns about safety and security issues. The committee received numerous comments from industry representatives about the lack of information sharing by the Nuclear Regulatory Commission on the vulnerability analyses described in Chapter 3. These representatives noted that information flow was predominately in one direction: from the industry to the Commission. The Commission was not providing a reciprocal flow of information that could help the industry better understand and take early actions to address identified vulnerabilities.

Restrictions on information sharing by the Commission have resulted in missed opportunities in at least two cases observed by the committee. Analyses of aircraft impacts into power plant structures described in Chapter 3 were being carried out independently by Sandia for the Commission and by EPRI for the nuclear power industry. Because of classification restrictions, EPRI was not provided with information about the Sandia work, including the results of physical tests that would have helped EPRI validate its models. Both Sandia and the industry would have benefited had their analysts been able to talk with each other about their models, assumptions, and results while the analyses were in progress. When the EPRI work was completed the Commission declared it to be safeguards information.[1] As a consequence, some of the EPRI analysts who generated the results no longer had access to them, and the results could not be shared widely within industry.

A similar situation exists with respect to the ENTERGY Corp. spent fuel pool separate effects analyses described in Chapter 3. ENTERGY is using similar approaches and models as Sandia but has received little or no guidance from Commission staff about whether the results are realistic or consistent. The ENTERGY analysts told the committee that they would have benefited had they been able to compare and discuss their approaches and results with Sandia analysts. Sandia analysts were prevented from doing so because of classification issues. Sharing of ENTERGY's results within the company or across industry may be problematical if they are determined to be classified or safeguards information by the Commission.

Several Nuclear Regulatory Commission staff also privately expressed to the committee their frustration at the difficulty in sharing information that they know would be useful to industry. In fact, from the contacts the committee had, there does not appear to be a lack of willingness to share information at the working staff level within the Commission. Rather, it seems to be an issue of getting permission from upper management and addressing the classification restrictions.

Much of the difficulty in sharing this information appears to arise because the information is considered by the Nuclear Regulatory Commission to be safeguards information or in some cases even classified national security information. Industry analysts and decision makers generally do not have the appropriate personal security clearances[2] to access this information. The committee learned that the Commission is making efforts to share more of this information with some industry representatives. The industry will be responsible for implementing any changes to spent fuel storage to make it less vulnerable to terrorist attack. Clearly, therefore, the industry needs to understand the results of the

[1] Safeguards information is defined in section 147 of the Atomic Energy Act and in the Code of Federal Regulations, Title 10, Part 73.2. See the glossary for a definition. Authority for designation of safeguards resides with the Nuclear Regulatory Commission.

[2] In fact, a personnel security clearance is not required to access safeguards information. One only needs to be of "good character" and have a "need to know" as determined by the Nuclear Regulatory Commission.

Commission's vulnerability analyses to ensure that effective implementation strategies are adopted.

The committee also received complaints during this study from members of the public about the lack of information sharing. Commission staff have responded to these complaints by stating that such sharing could reveal sensitive information to terrorists and that the public does not have a "need to know" this information.

The committee fully agrees that information that could prove useful to terrorists should not be released. On the other hand, the committee believes that there is information that could be shared without compromising national security. For example, general information about the kinds of threats being considered and general steps being taken to reduce vulnerabilities could be shared with the public. Information about specific vulnerabilities of spent fuel pools and dry storage casks to terrorist attacks as well as potential mitigative actions could be shared with industry without revealing the details about how such attacks might be carried out. Sharing information with industry is essential for ensuring that mitigative actions to reduce vulnerabilities are carried out. Sharing information with the public is essential in a nation with strong democratic traditions for sustaining public confidence in the Commission as an effective regulator of the nuclear industry, and for reducing the potential for severe environmental, health, economic, and psychological consequences from terrorist attacks should they occur.

5.3 FINDING AND RECOMMENDATION

FINDING 5A: Security restrictions on sharing of information and analyses are hindering progress in addressing potential vulnerabilities of spent fuel storage to terrorist attacks.

Current classification and security practices appear to discourage information sharing between the Nuclear Regulatory Commission and industry. During the course of the study the committee received comments from power plant operators, their contractors, and Nuclear Regulatory Commission staff about the difficulties of sharing the information on the vulnerability of spent fuel storage. Indeed, even the committee found it difficult and in some cases impossible to obtain needed information (e.g., information on the design basis threat). Such restrictions have several negative consequences: They impede the review and feedback processes that can enhance the technical soundness of the analyses being carried out; they make it difficult to build support within the industry for potential mitigative measures; and they may undermine the confidence that the industry, expert panels such as this one, and the public place in the adequacy of such measures.

RECOMMENDATION: The Nuclear Regulatory Commission should improve the sharing of pertinent information on vulnerability and consequence analyses of spent fuel storage with nuclear power plant operators and dry cask storage system vendors on a timely basis.

Implementation of this recommendation will allow timely mitigation actions. Certain current security practices may have to be modified to carry out this recommendation.

The committee also believes that the public is an important audience for the work being carried out to assess and mitigate vulnerabilities of spent fuel storage facilities. While it would be inappropriate to share all information publicly, more constructive interaction with the public and independent analysts could improve the work being carried out and also increase public confidence in Nuclear Regulatory Commission and industry decisions and actions to reduce the vulnerability of spent fuel storage to terrorist threats.

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A

INFORMATION-GATHERING SESSIONS

The committee organized several meetings and tours to obtain information about the safety and security of spent fuel storage. A list of these meetings and tours is provided below. The committee held several *data-gathering sessions not open to the public* to obtain classified and safeguards information about the safety and security of spent fuel storage. The committee also held several *data-gathering sessions open to the public* to receive unclassified briefings from industry, independent analysts, and other interested parties including members of the public. The written materials (e.g., PowerPoint presentations and written statements) obtained by the committee at these open sessions are posted on the web site for this project: *http://dels.nas.edu/sfs.*

A.1 FIRST MEETING, FEBRUARY 12-13, 2004, WASHINGTON, D.C.

The objective of this meeting was to obtain background information on the study request from staff of the House Committee on Appropriations, Energy and Water Development Subcommittee. The committee also was briefed by one of the sponsors of the study and by two independent experts. The following is the list of topics and speakers for the open session:

- Background on the congressional request for this study. Speaker: Kevin Cook, Professional Staff, House Committee on Appropriations, Energy and Water Development Subcommittee.
- Reducing the hazard from stored spent power-reactor fuel in the United States. Speakers: Frank von Hippel, Princeton University, and Klaus Janberg, independent consultant, co-authors of the paper entitled "Reducing the Hazard from Stored Spent Power-Reactor Fuel in the United States" (Alvarez et al., 2003).
- Nuclear power plants and their fuel as terrorist targets. Speaker: Ted Rockwell, MPR Associates, Inc., co-author of the paper entitled "Nuclear Power Plants and Their Fuel as Terrorist Targets" (Chapin et al., 2002).
- *Nuclear Regulatory Commission analyses of spent fuel safety and security.* Speaker: Farouk Eltawila, director, Division of Systems Analysis and Regulatory Effectiveness, Office of Research, Nuclear Regulatory Commission.

On the second day of the meeting, the committee held a data-gathering session not open to the public to obtain classified briefings from the U.S. Nuclear Regulatory Commission about its ongoing analyses of spent fuel storage security.

A.2 SECOND MEETING, MARCH 4-6, 2004, ARGONNE, ILLINOIS

During the second meeting, the committee held a data-gathering session not open to the public to receive classified briefings on spent fuel storage security from the U.S. Nuclear Regulatory Commission. The committee also toured the Dresden and Braidwood Nuclear

Generating Stations to see first-hand how spent fuel is managed and stored. The two plants were chosen because of the differences in their spent fuel storage facilities.

A.3 THIRD MEETING, APRIL 15-17, 2004, ALBUQUERQUE, NEW MEXICO

During the third meeting, the committee held a data-gathering session not open to the public to receive a briefing from EPRI on spent fuel storage vulnerabilities. The committee also held a data-gathering session open to the public to receive briefings on dry cask storage systems and radioactive releases from damaged spent fuel storage casks.

- Speakers on dry cask storage systems: William McConaghy (GNB-GNSI); Steven Sisley (BNFL); Alan Hanson (Transnuclear Inc.); Charles Pennington (NAC International); and Brian Gutherman (Holtec International, via telephone).
- Radionuclide releases from damaged spent fuel. Speaker: Robert Luna, Sandia National Laboratories (retired).

A.4 TOUR OF SELECTED SPENT FUEL STORAGE INSTALLATIONS IN GERMANY

On April 25-28, 2004, a group of committee members traveled to Germany to meet with German officials and to visit selected spent fuel storage installations. The agenda of the tour was as follows:

- Meeting with Michael Sailer, chairman of the German reactors safety commission (RSK, Reaktorsicherheitskommission).
- Visit to the dry cask manufacturer GNB (Gesellschaft für Nuklear-Behälter mbH) headquarters in Essen and the cask assembly facility and test museum in Mülheim.
- Tour of the Ahaus intermediate dry storage facility.
- Meeting with Florentin Lange, GRS (Gesellschaft für Anlagen- und Reaktorsicheheit mbH), co-author of the study entitled "Safety Margins of Transport and Storage Casks for Spent Fuel Assemblies and HAW Canisters Under Extreme Accident Loads and Effects from External Events" (Lange et al., 2002).
- Tour of the Lingen nuclear power plant and its spent fuel storage facilities.

A summary of information gathered during the tour is provided in Appendix C.

A.5 FOURTH MEETING, MAY 10-12, 2004, WASHINGTON, D.C.

During the fourth meeting, the committee held a data-gathering session not open to the public to hold in-depth technical discussions with Sandia National Laboratories staff and contractors on their spent fuel storage vulnerability analyses. The committee also received an intelligence briefing from Department of Homeland Security staff on terrorist capabilities and from the U.S. Nuclear Regulatory Commission staff on terrorist scenarios.

The meeting also included a data-gathering session open to the public that included the following briefings:

- Summary of the field trip to Germany. Speaker: Louis Lanzerotti (committee chair).
- Vulnerabilities of spent nuclear fuel pools to terrorist attacks: Issues with the design basis threat. Speaker: Peter Stockton, Project on Government Oversight.
- Consequences of a major release of ^{137}Cs into the atmosphere. Speaker: Jan Beyea, Consulting in the Public Interest.

A.6 FIFTH MEETING, MAY 26-28, 2004, WASHINGTON, D.C.

The objective of this closed meeting (i.e., open only to committee members and staff) was to finalize the classified report for National Research Council review.

A.7 TOURS OF SELECTED SPENT FUEL STORAGE FACILITIES AT U.S. NUCLEAR POWER PLANTS

On June 11 and June 14, 2004, respectively, committee subgroups visited the Palo Verde Nuclear Generating Station in Arizona and the Indian Point Nuclear Generating Station in New York.

A.8 SIXTH MEETING, JUNE 28-29, 2004

The objective of this closed meeting was to complete work on the classified report.

A.9 SEVENTH MEETING, AUGUST 12-13, 2004

The objective of this closed meeting was to develop a public version of the committee's report. The committee also held a data-gathering session not open to the public to receive a briefing from the Department of Homeland Security on steps being taken to address the findings and recommendations in the classified report.

A.10 EIGHTH MEETING, OCTOBER 28-29, 2004

The objective of this closed meeting was to continue work to develop a public version of the committee's report. The committee also held a data-gathering session not open to the public to receive a briefing from the Nuclear Regulatory Commission on steps being taken to address the findings and recommendations in the classified report.

A.11 NINTH MEETING, NOVEMBER 29-30, 2004

The objective of this closed meeting was to continue work to develop a public version of the committee's report.

A.12 TENTH MEETING, January 24-25, 2005

The objective of this closed meeting was to continue work to develop a public version of the committee's report. The committee also held a data-gathering session not open to the public to meet with three commissioners from the Nuclear Regulatory Commission (Chairman Nils Diaz and members Edward McGaffigan and Jeffrey Merrifield) to discuss what additional information the commission might be willing to make available to the committee on human-factors-related issues.

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B

BIOGRAPHICAL SKETCHES OF COMMITTEE MEMBERS

LOUIS J. LANZEROTTI, *Chair*, is an expert in geophysics and electromagnetic waves and a veteran of over 40 National Research Council (NRC) studies. He currently consults for Bell Laboratories, Lucent Technologies, and is a distinguished professor for solar-terrestrial research at the New Jersey Institute of Technology. Previously, he was a distinguished member of the technical staff at Bell Labs. His research interests include space plasmas and engineering problems related to the impacts of atmospheric and space processes on telecommunications on commercial satellites and transoceanic cables. He has been associated with numerous National Aeronautics and Space Administration (NASA) space missions as well, including Voyager, Ulysses, Galileo, and Cassini, and with commercial space satellite missions to research design and operational problems associated with spacecraft and cable operations. In 1988, he was elected to the National Academy of Engineering for his work on energetic particles and electromagnetic waves in the earth's magnetosphere, including their impact on space and terrestrial communication systems. He has twice received the NASA Distinguished Public Service Medal and has a geographic feature in Antarctica named in his honor. He was appointed to the National Science Board by President George W. Bush in 2004. Dr. Lanzerotti holds a Ph.D. in physics from Harvard University.

CARL A. ALEXANDER is an expert in the behavior of nuclear material at high temperatures and also in biological and chemical weapons. He is chief scientist and senior research leader at the Battelle Memorial Institute in Columbus, Ohio. Dr. Alexander worked on fuel design and behavior for the aircraft nuclear propulsion program and several space nuclear power projects, including the Viking, Voyager, and Cassini missions. He helped analyze the evolution of the Three Mile Island accident and is involved in the French Phebus fission product experiments, which are to reproduce all of the phenomena involved during a nuclear power reactor core meltdown accident. He has served as a consultant to the Nuclear Regulatory Commission and, in the 1970s, worked on the first experiments on the effects of an attack on spent fuel shipping containers using shaped charges. He currently leads research projects on agent neutralization and collateral effects for weapons of mass destruction for the Defense Threat Reduction Agency and the Navy, and on lethality of missile defense technologies for the Missile Defense Agency. Dr. Alexander has taught materials science and engineering at the Ohio State University and has served as graduate advisor and adjunct professor at the Massachusetts Institute of Technology, University of Southampton in the United Kingdom, and the University of Maryland. He has authored over 100 peer-reviewed articles and technical reports, many of which are classified. He holds a Ph.D. in materials science from Ohio State University.

ROBERT M. BERNERO is a nuclear engineering and regulatory expert. He is now an independent consultant after retiring from the U.S. Nuclear Regulatory Commission (USNRC) in 1995. In 23 years of service for the USNRC Mr. Bernero held numerous positions in reactor licensing, fuel cycle facility licensing, engineering standards development, risk assessment research, and waste management. His final position at USNRC was as director of the Office of Nuclear Materials Safety and Safeguards. Prior to joining the USNRC he worked for the General Electric Company in nuclear technology for 13 years. He has served as a member of the Commission of Inquiry for an International

Review of Swedish Nuclear Regulatory Activities, and he currently consults on nuclear safety-related matters; particularly regarding nuclear materials licensing and radioactive waste management. Mr. Bernero received his B.A. degree from St. Mary of the Lake (Illinois), a B.S. degree from the University of Illinois, and an M.S. degree from Rensselaer Polytechnic Institute.

M. QUINN BREWSTER is an expert in energetic solids and heat transfer. He is currently the Hermia G. Soo Professor of Mechanical Engineering at the University of Illinois at Urbana-Champaign. He is involved in the Academic Strategic Alliance Program, whose objective is to develop integrated software simulation capability for coupled, system simulation of solid rocket motors including internal ballistics (multi-phase, reacting flow) and structural response (propellant grain and motor case). Dr. Brewster has authored one book on thermal radiative transfer and chapters in four other books as well as several publications on combustion science. He is a fellow of the American Society of Mechanical Engineers and associate fellow of the American Institute of Aeronautics and Astronautics. Dr. Brewster holds a Ph.D. in mechanical engineering from the University of California at Berkeley.

GREGORY R. CHOPPIN is an actinide elements and radiochemistry expert. He is currently the R.O. Lawton Distinguished Professor Emeritus of Chemistry at Florida State University. His research interests involve the chemistry and separation of the f-elements and the physical chemistry of concentrated electrolyte solutions. During a postdoctoral period at the Lawrence Radiation Laboratory, University of California, Berkeley, he participated in the discovery of mendelevium, element 101. His research and educational activities have been recognized by the American Chemical Society's Award in Nuclear Chemistry, the Southern Chemist Award of the American Chemical Society, the Manufacturing Chemist Award in Chemical Education, the Chemical Pioneer Award of the American Institute of Chemistry, a Presidential Citation Award of the American Nuclear Society, the Becquerel Medal, British Royal Society, and honorary D.Sc. degrees from Loyola University and the Chalmers University of Technology (Sweden). Dr. Choppin previously served on the NRC's Board on Chemical Sciences and Technology and Board on Radioactive Waste Management. He holds a Ph.D. in inorganic chemistry from the University of Texas, Austin.

NANCY J. COOKE is an expert in the development, application, and evaluation of methodologies to elicit and assess individual and team knowledge. She is currently a professor in the applied psychology program at Arizona State University East. She also holds a National Research Council Associateship position with Air Force Research Laboratory and serves on the board of directors of the Cognitive Engineering Research Institute in Mesa, Arizona. Her current research areas are the following: cognitive engineering, knowledge elicitation, cognitive task analysis, team cognition, team situation awareness, mental models, expertise, and human-computer interaction. Her most recent work includes the development and validation of methods to measure shared knowledge and team situation awareness and research on the impact of cross- training, distributed mission environments, and workload on team knowledge, process, and performance. This work has been applied to team cognition in unmanned aerial vehicle and emergency operation center command-and-control. She contributed to the creation of the Cognitive Engineering Research on Team Tasks Laboratory to develop, apply, and evaluate measures of team cognition. She has authored or co-authored over 70 articles, chapters, and technical reports on measuring team cognition, knowledge elicitation, and human-computer interaction. Dr. Cooke holds a Ph.D. in cognitive psychology from New Mexico State University, Las Cruces.

GORDON R. JOHNSON is an expert in penetration mechanics and computational mechanics. He is currently a senior scientist and manager of the solid mechanics group at Network Computing Services. His recent work has included the development of computational mechanics codes that include finite elements and meshless particles. He has also developed computational material models to determine the strength and failure characteristics of a variety of materials subjected to large strains, strain rates, temperatures, and pressures. His work for the U.S. Departments of Energy and Defense has included a wide range of intense impulsive loading computations for high-velocity impact and explosive detonation. He was a chief engineering fellow during his 35 years at Alliant Techsystems (formerly Honeywell). He has served as a technical advisor for university contracts with the Army Research Office, and an industry representative for its strategic planning, and was a member of the founding board of directors for the Hypervelocity Impact Society. Dr. Johnson holds a Ph.D. in structures from the University of Minnesota, Minneapolis.

ROBERT P. KENNEDY has expertise in structural dynamics and earthquake engineering. He is currently an independent consultant in structural mechanics and engineering. Dr. Kennedy has worked on static and dynamic analysis and the design of special-purpose civil and mechanical-type structures, particularly for the nuclear, petroleum, and defense industries. He has designed structures to resist extreme loadings, including seismic loadings, missile impacts, extreme winds, impulsive loads, and nuclear environmental effects, and he has developed computerized structural analysis methods. He also served as a peer reviewer for an EPRI study on aircraft impacts on nuclear power plants. In 1991, he was elected to the National Academy of Engineering for developing design procedures for civil and mechanical structures to resist seismic and other extreme loading conditions. Dr. Kennedy holds a Ph.D. in structural engineering from Stanford University.

KENNETH K. KUO is an expert in combustion, rocket propulsion, ballistics, and fluid mechanics. He is a Distinguished Professor of Mechanical Engineering at the Pennsylvania State University. He is also the leader and director of the university's High Pressure Combustion Laboratory, a laboratory with advanced instrumentation and data acquisition devices. Dr. Kuo has directed team research projects in propulsion and combustion studies for 32 years. He has edited eight books and authored one book on combustion, published over 300 technical articles, and served as principal investigator for more than 70 projects, including a Multidisciplinary University Research Initiative (MURI) grant from the U.S. Army on "Ignition and Combustion of High Energy Materials." He is now serving as principal investigator and co-principal investigator for two MURI programs on rocket and energetic materials. In 1991, he was elected fellow of American Institute of Aeronautics and Astronautics and has received several awards for his work on solid propellants combustion processes. Dr. Kuo holds a Ph.D. in aerospace and mechanical sciences from Princeton University.

RICHARD T. LAHEY, JR., is an expert in multiphase flow and heat transfer technology, nuclear reactor safety, and the use of advanced technology for industrial applications. He is currently the Edward E. Hood Professor of Engineering at Rensselaer Polytechnic Institute (RPI) and was previously chair of the Department of Nuclear Engineering and Science, director of the Center for Multiphase Research, and the dean of engineering at RPI. Previously, Dr. Lahey held several technical and managerial positions with the General Electric Company, including overall responsibility for all domestic and foreign R&D programs associated with boiling water nuclear reactor thermal-hydraulic and safety technology. He has chaired several committees for the American Society of Mechanical Engineering, American Nuclear Society, American Institute for Chemical Engineering, American Society for Engineering Education, and NASA. His current research is funded by the Department of Energy's Naval Reactors Program, the Office of Naval Research, the National Science Foundation, the New York State Energy Research and Development Authority, Oak Ridge National Laboratory, and the Defense Advanced Research Projects Agency. He currently consults on nuclear reactor safety problems and the chemical processing of non-nuclear materials and is a member of the Board of Managers of PJM Interconnection, LLC. In 1994, he was elected to the National Academy of Engineering for his contributions to the fields of multiphase flow and heat transfer and nuclear reactor safety technology. In 1995, he became a member of the Russian Academy of Sciences-Baskortostan and he is a fellow of the American Nuclear Society and of the American Society of Mechanical Engineers. He has authored or co-authored over 300 technical publications, including 10 books or handbooks and 160 journal articles. Dr. Lahey holds a Ph.D. in mechanical engineering from Stanford University.

KATHLEEN R. MEYER has expertise in health physics and radiologic risk assessment. She is a principal of Keystone Scientific, Inc., and is currently involved in risk assessments for public health and the environment from radionuclides and chemicals at several U.S. Department of Energy sites. Other work includes an assessment of the interim radionuclide soil action levels adopted by the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency, and the Colorado Department of Health and Environment for cleanup at the Rocky Flats Environmental Technology Site. She has been a member of the National Council on Radiation Protection and Measurements Historical Dose Evaluation Committee. Dr. Meyer has authored or co-authored several peer-reviewed articles, including papers on cancer research, historical evaluation of past radionuclide and chemical releases, and risk assessment of radionuclides and chemicals. She holds a Ph.D. in radiological health sciences from Colorado State University.

FREDRICK J. MOODY is an expert thermal hydraulics and two-phase flow in nuclear power reactors. In 1999, he retired after 41 years of service at General Electric Company and 28 years as an adjunct professor of mechanical engineering at San Jose State University. Dr. Moody was the recipient of several prestigious career awards, including the General Electric Power Sector Award for Contributions to the State-of-the-Art for Two-Phase Flow and Reactor Accident Analysis. He has served as a consultant to the Nuclear Regulatory Commission's Advisory Committee on Reactor Safeguards, teaches thermal hydraulics for General Electric's Nuclear Energy Division, and continues to review thermal analyses for General Electric. Dr. Moody is a fellow of the American Society of Mechanical Engineers, which awarded him the George Westinghouse Gold Medal in 1980, and the Pressure Vessels and Piping Medal in 1999. He has also received prestigious career awards from General Electric and was elected to the Silicon Valley Engineering Hall of Fame. Dr. Moody was elected to the National Academy of Engineering in 2001 for pioneering and vital contributions to the safety design of boiling water reactors and for his role as educator. He has published three books and more than 50 papers. Dr. Moody holds a Ph.D in mechanical engineering from Stanford University.

TIMOTHY R. NEAL is an expert in weapons technology and explosives. He began his career at Los Alamos National Laboratory in 1967 and has led programs addressing weapon hydrodynamics, explosions inside structures and above ground, image analysis, and dynamic testing. He also has held several management positions within the Laboratory's nuclear weapons arena, including leadership of the Explosives Technology and Applications Division and of the Advanced Design and Production Technologies Initiative. He spearheaded Los Alamos' Stockpile Stewardship and Management Programmatic

Environmental Impact Statement and helped establish the U.S. Department of Energy's new Stockpile Stewardship Program. More recently, he has served as a senior technical advisor to the U.S. Department of Energy on nuclear explosive safety, and he has worked closely with the Pantex Plant for nuclear weapons production in Amarillo, Texas, in establishing a new formal basis for operational safety. Dr. Neal has received four DOE excellence awards, including one for hydrodynamics, and authored various technical papers and reports as well as one book on explosive phenomena. He holds a Ph.D. in physics from Carnegie-Mellon University.

LORING A. WYLLIE, JR. *is an expert in structural engineering and senior principal of* Degenkolb Engineers. His work has included seismic evaluations, analysis, and design of strengthening measures to improve seismic performance. He has performed seismic assessments and proposed strengthening solutions for several buildings within the U.S. Department of Energy weapons complex and for civilian buildings, some of which have historical *significance. Mr. Wyllie's expertise is also recognized in several countries,* including the former Soviet Union where he worked on an Exxon facility. Mr. Wyllie is a past president of the Earthquake Engineering Research Institute. His contributions to the profession of structural engineering were recognized by his election to the National Academy of Engineering in 1990 and his honorary membership in the Structural Engineers Association of Northern California. In recognition of Mr. Wyllie's expertise in concrete design and performance, the American Concrete Institute named him an honorary member in 2000. Mr. Wyllie also was elected an honorary member of the American Society of Civil Engineers in 2001. He holds a M.S. degree from the University of California, Berkeley.

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C

TOUR OF SELECTED SPENT FUEL STORAGE-RELATED INSTALLATIONS IN GERMANY

On April 25-28, 2004, six committee members visited spent fuel storage-related installations in Germany. The following is a summary of some of the pertinent information obtained from that trip.

Several organizations and individuals worked with committee staff to make this trip possible. The committee would especially like to acknowledge Alfons Lührmann and William McConaghy of GNB/GNSI (Gesellschaft für Nuklear-Behälter, mbH/General Nuclear Systems, Inc.), who organized site visits; Klaus Janberg (STP engineering); Michael Sailer, chairman of RSK (Reaktorsicherheitskommission—reactor safety commission); Holger Broeskamp manager of GNS (Gesellchaft für Nuklear-Service, mbH—Germany's nuclear industry consortium) and his staff; Wolfgang Sowa, managing director of GNB (Gesellschaft für Nuklear-Behälter, mbH) and his staff; Florentin Lange of GRS (Gesellschaft für Anlagen- und Reaktorsicherheit, mbH); and Hubertus Flügge, vice-president of the RWE Power AG plants in Lingen and his staff, who allowed the committee to visit the reactor building and the site's spent fuel storage facility.

C.1 GERMAN COMMERCIAL NUCLEAR POWER PLANTS

Germany currently has 18 operating commercial nuclear power reactors at 12 sites. Approximately one-third of the reactors are boiling water reactors (BWRs) and two-thirds are pressurized water reactors (PWRs).

The design for PWR plants is illustrated schematically in FIGURE C.1. It consists of a dome-shaped reactor building constructed of reinforced concrete and a spherical inner containment structure constructed of steel. The reactor core, spent fuel pool, and steam generators are located within the inner containment. The emergency core-cooling systems are located outside the inner containment but within the reactor building.

The German BWR reactor building design is generally similar to a PWR. However, the spent fuel pool is outside the inner containment structure but within the reactor building. The reactor building is also a different shape (rectangular or cylindrical).

There are three generations of commercial nuclear power plants in Germany, each having increasingly thick walls:

- First-generation plants have reactor building walls that are less than 1 meter thick. There are four plants of this type.
- Second-generation plants have reactor building walls that are slightly more than 1 meter thick. There are five plants of this type.
- Third-generation plants have reactor building walls that are about 2 meters thick. There are nine plants of this type.[1]

[1] The committee subgroup visited one of these plants (the Lingen power plant) during its tour.

Some first- and second-generation plants have independent emergency systems in a bunkered building that contains some safety trains and a control room. These systems are capable of delivering water to the reactor after an accident or attack if the pipe systems within the reactor building survive.

Second- and third-generation plants were designed to withstand the crash of military fighter jets. Second-generation plants were designed to withstand the crash of a Starfighter jet at the typical landing speed. Third-generation plants were designed to withstand the crash of a Phantom jet at the typical cruising speed. This is considered to be part of the "design basis threat" for nuclear power plants in Germany. This information on the design basis threat has been made available to the public by the German government.

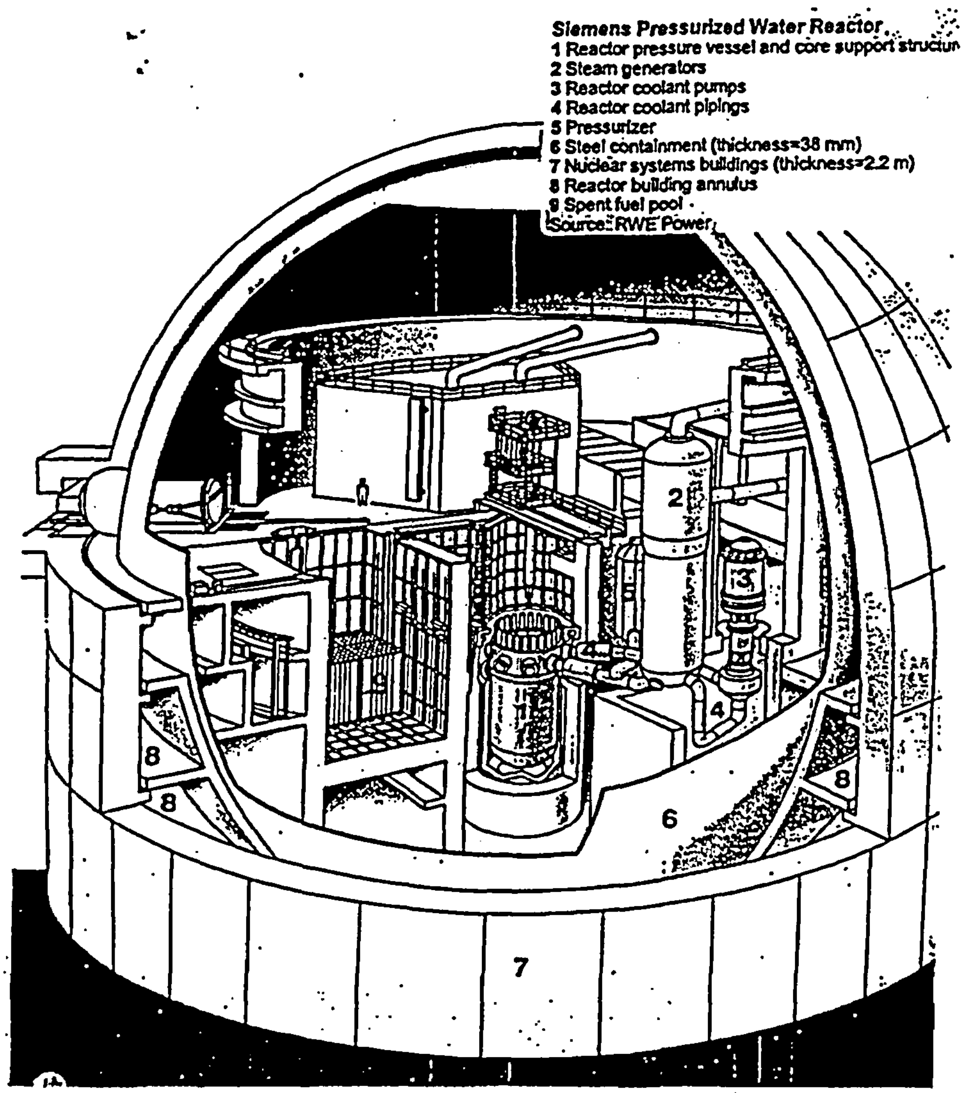

FIGURE C.1 Schematic illustration of the Lingen PWR power plant, a third-generation power plant design. SOURCE: RWE Power.

Plant operators must show that of the four safety trains (each train contains 50 percent of the safety system) at the plant, at least two will survive such a crash. The crash parameters (e.g., aircraft type, speed, and angle) have been established by RSK. The crash parameters have been published and the public knows about them. Each plant must perform an independent analysis of each reactor building. Sometimes two separate analyses have to be provided for the same site if there are two or more reactors with different designs.

In 1998, the German government decided to phase out nuclear energy. Commercial nuclear plants will be allowed to generate an agreed-to amount of electricity before shutdown. Currently, the Lingen and the Neckarwestheim-2 plants have the highest remaining electricity production allowance and will be shut down in 2021 or 2022, should no revision of this political decision be implemented.

C.2 SPENT FUEL STORAGE

Until recently, all spent fuel at German plants was stored in the reactor pools until it could be sent to Sellafield (U.K.) or La Hague (France) for reprocessing. In the 1980s, plants began to re-rack their spent fuel pools to increase storage capacities (the older German nuclear plants were designed to contain one full reactor core plus one third of a core). Regulators became concerned that the emergency cooling systems were not sufficient to handle the increased heat loads in spent fuel pools from this re-racking. Some plants added additional cooling circuits to address this concern. Only one power plant (an older plant at Obrigheim) has wet interim pool storage in a bunkered building.

A discussion of alternative spent fuel storage options began in 1979. A reprocessing plant had been proposed at Gorleben that would have had several thousand metric tons of pool storage. The German government concluded that while there were no major technical issues for reprocessing, wet fuel storage was a potential problem because cooling systems could be disrupted in a war. GNS decided to shift from wet to dry storage for centralized storage facilities.

There are two centralized storage facilities in Germany: Gorleben and Ahaus. Gorleben is designed to store vitrified high-level waste from spent fuel reprocessing and spent fuel from commercial power reactors. Ahaus is designed to store spent fuel from test reactors and other special types of fuel. Ahaus currently stores 305 casks of reactor fuel from the decommissioned Thorium High Temperature Reactor, three casks of PWR spent fuel from the Neckarwestheim site, and three casks of BWR spent fuel from the Gundremmingen site. The latter shipment produced large public demonstrations and required the deployment of 35,000 police officers to maintain security.

At the end of 2001, the German utility companies and the German federal government agreed to avoid all transport of spent fuel in Germany because of intense public opposition. The German government recently passed a law making it illegal to transport spent nuclear fuel to reprocessing plants in France and the United Kingdom after June 30, 2005. However, there is no legal restriction concerning the transport of spent fuel from power reactors to other destinations (e.g., to dry storage facilities). The government and power plant operators have negotiated an agreement to develop dry cask storage facilities at each of the 12 nuclear power plant sites to avoid the need for offsite spent fuel transport.

These dry cask storage facilities are to be constructed by 2006. They are licensed to store fuel for 40 years.

There are three dry cask storage facility designs in Germany:

1. WTI design: The walls and roof are constructed of 80 and 50 centimeters, respectively, of reinforced concrete.
2. STEAG design: The walls and roof are constructed of 1.2 and 1.3 meters, respectively, of reinforced concrete. This design is used at the Lingen Nuclear Power Plant dry storage facility visited by the committee (FIGURE C.2).
3. GNK design: This is a tunnel design and is under construction at the Neckarwestheim nuclear power plant.

The use of reinforced concrete in these facilities was originally intended for radiation protection and structural support, not for terrorist attacks.

In 1999, RSK issued guidelines for dry storage, which were released in 2001 (RSK, 2001). Licensing a dry storage facility in Germany requires several safety demonstrations and analyses. As part of the licensing procedures for a storage facility, the license applicant must do independent calculations that demonstrate how the building features meet the safety standards and the design basis threat. This threat includes an armed group of intruders and the impact of a Phantom 2 military jet. It also includes a shaped charge. The scenario of a deliberate crash of a large civilian airplane has been considered and analyzed as part of the recent licensing of onsite dry storage facilities but is not established as part of the design basis threat. There are public hearings during which the license applicant explains the safety features of the storage facility. The public is aware of the design basis threat, and it is provided with the results of the analysis but not with the details.

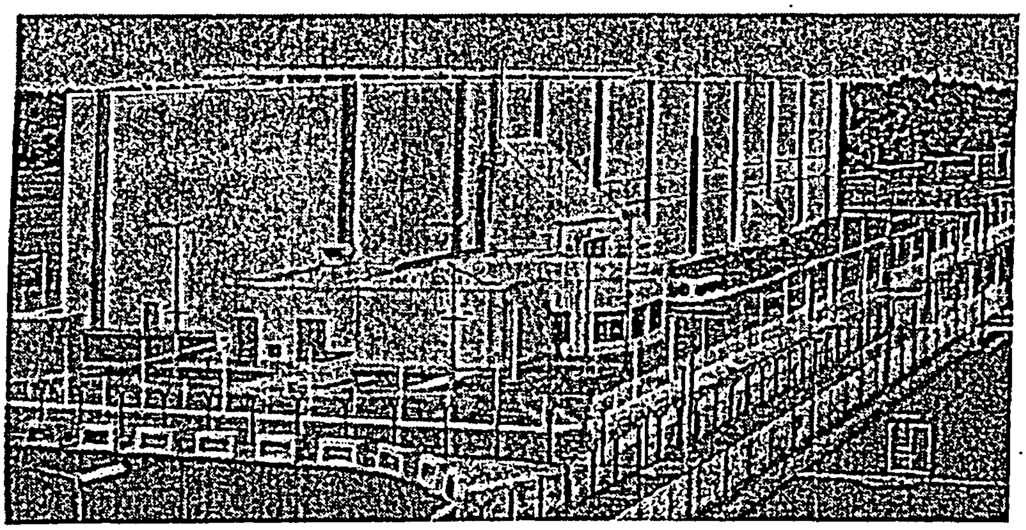

FIGURE C.2 Dry cask spent fuel storage building at the Lingen Nuclear Power Plant. SOURCE: RWE Power.

There are six temporary (i.e., five- to seven-year) storage facilities in use at reactor sites until these dry cask storage facilities become available. The casks in these temporary storage facilities are stored horizontally and are protected by concrete "garages" designed to withstand the impact of a Phantom military jet.

Spent commercial fuel is stored in CASTOR® casks (FIGURE C.3) that were originally designed and developed by the German utility-owned company GNB.[2] These casks can store either PWR or BWR spent fuel assemblies. The design consists of a ductile cast iron cylindrical cask body with integral circumferential fins machined into the outer surface to maximize heat transfer; inside, the spent fuel assemblies are inserted in a borated stainless steel basket. The cask has a double-lid system that is protected by a third steel plate. The cask complies with the international regulations of the International Atomic Energy Agency (IAEA) as a type B(U) package.

Spent fuel is typically cooled for five years in a pool before it is put in dry cask storage; some other custom-made cask designs can hold fuel that has been cooled for shorter (minimum two years) or longer times depending on the fuel characteristics and fuel burn-up. Current fuel burn-ups in Germany (52 to 55 gigawatt-days per metric ton) are similar to those in the United States.

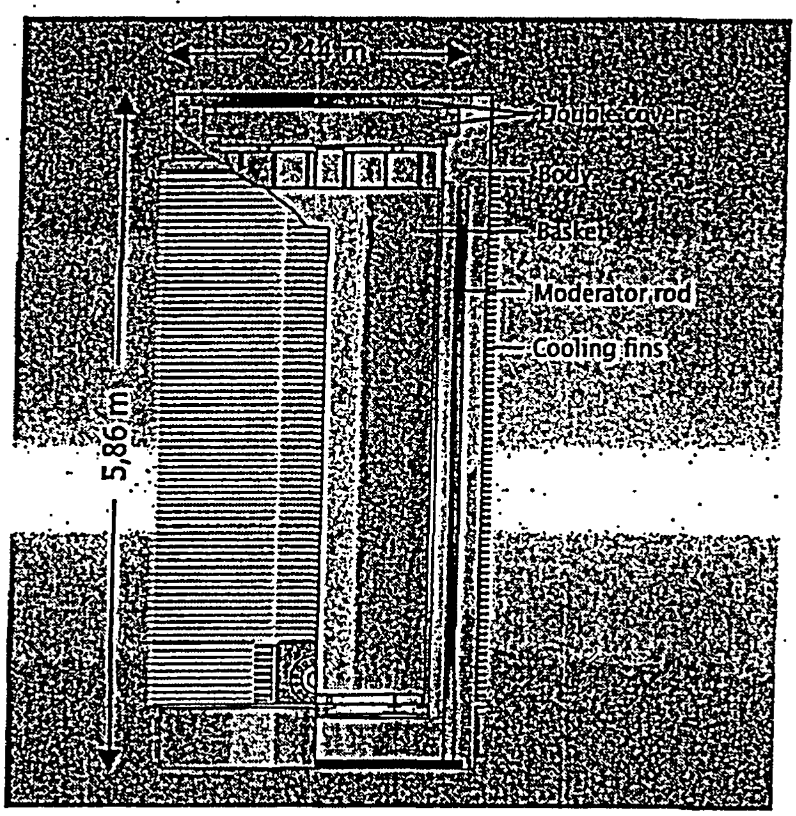

FIGURE C.3 Typical features of a CASTOR cask used at the Lingen Nuclear Power Plant. SOURCE: RWE Power AG Lingen Nuclear Power Plant.

[2] Gesellschaft für Nuklear-Behälter, mbH.

C.3 RESPONSE TO THE SEPTEMBER 11, 2001, TERRORIST ATTACKS IN THE UNITED STATES

The September 11, 2001, terrorist attacks on the United States caused the German government to reassess the security of its nuclear power plants and spent fuel storage facilities. RSK held meetings starting in October 2001 to discuss the implications of the September 11 attacks for German commercial nuclear power plants. It issued a short statement recommending that an analysis be carried out on each plant to assess its vulnerability to September 11-type attacks. These analyses have not yet been undertaken. Plant operators assert that terrorist attacks are a general risk of society and should be treated like attacks on other infrastructure (e.g., chemical facilities). The Länder (state) governments, which are responsible for licensing commercial power plants in Germany, do not require these analyses. RSK recommended that the federal government develop a checklist for such an analysis, but this also has not been done.

A general analysis of the impact of the different civilian aircraft on commercial nuclear plants was requested by BMU[3] and has been carried out by GRS.[4] The result of the discussions between RSK and BMU on the basis of this report was that plant specific sensitivity analyses are needed. GRS was also involved in the framing of the recent German licensing process in the analysis of the consequences of civilian aircraft attacks on STEAG- and WTI-design spent fuel storage facilities using three sizes of aircraft (ranging from Airbus A320- to Boeing 747-size aircraft).

C.4 TESTS ON GERMAN CASKS

The casks that are used in German dry cask storage facilities have been subjected to several tests that simulate accidents and terrorist attacks. The following types of tests were performed on these casks or cask materials.

Airplane crash test simulations with military aircraft (Phantom type) are part of the licensing requirements for both casks and storage facilities. Between 1970 and 1980 a number of tests on storage casks were carried out at the Meppen military facility in Germany. A one-third scale model of a GNB cask was used to simulate the impact of a turbine shaft of a military aircraft using a hollow-tube projectile. Two different impact orientations were used: perpendicular to upright cask body (lateral impact) and perpendicular to center of lid system. The projectile completely disintegrated in the test, but the cask sustained only minor damage.

The jet aircraft tests were carried out because of safety concerns, but after September 11, 2001, intentional crashes of aircraft also were considered. Investigations by BAM (Bundesanstalt für Materialforschung und -prüfung) and GRS concluded that CASTOR-type casks would maintain their integrity when intentionally hit by a commercial aircraft.

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[3] Bundesministerium für Umwelt, Naturschutz and Reaktorsicherheit (Federal Ministry for Environment, Nature Protection, and Nuclear Safety and Security).

[4] Gesellschaft für Anlagen- und Reaktorsicherheit (GRS), mbH (Company for Installation and Reactor Safety). GRS is Germany's main research institution on nuclear safety. It is an independent, nonprofit organization, founded in 1977, and has about 450 employees. GRS funds its work through research contracts. *Some have compared GRS to Sandia National Laboratories in the United States.*

Other types of terrorist attacks have been a long-standing concern to the German government because of terrorism activities in Europe in the 1970s and 1980s. A series of tests simulating terrorist attacks on casks were done in Germany, France, the United States (for the German government), and Switzerland (for the Swiss government). Additional tests may have been done that are not publicly acknowledged.

In 1979-1980 at the German Army facility in Meppen, a "hollow charge" (i.e., shaped charge) weapon was fired at a ductile cast iron plate and fuel assembly dummy to simulate a CASTOR cask. The cask plate was perforated but release fractions from the fuel assembly were not examined. From this experiment, the German government concluded that the wall thickness of the cask should not be less than 300 millimeters.

Other tests were carried out at the Centre d'Etude de Gramat in France in 1992 on behalf of the Germany Federal Ministry of Environment, Nature Protection and Nuclear Safety (BMU) (Lange et al., 1994). These tests involved shaped charges directed at a CASTOR cask (type CASTOR IIa, the cask was one third of the regular length) filled with nine fuel element dummies with depleted uranium. The fuel rods were pressurized to 40 bars to simulate fuel burn-up, but the cask interior was at atmospheric pressure or at reduced pressure of 0.8 bar. The shaped charge perforated the cask and penetrated fuel elements. This damaged the fuel and resulted in the release of fuel particles from the cask.

These particles were collected, and their particle size distribution was measured. About 1 gram of uranium was released in particles of less than 12.5-microns aerodynamic diameter, and 2.6 grams of uranium were released in particles with a size range between 12.5 and 100 microns. If the pressure inside the cask was reduced to 0.8 bar (to simulate the conditions during interim storage of spent fuel in Germany), the releases were reduced by two-thirds: 0.4 gram for particle sizes less than 12.5 microns and about 0.3 gram for particles between 12.5 and 100 microns.

In 1998, a demonstration was carried out at the Aberdeen Proving Ground in the United States using an anti-tank weapon on a CASTOR cask. The purpose of this demonstration was to show that a concrete jacket on the exterior of the cask could prevent perforation. The weapon was first fired at the cask without the jacket. It perforated the front wall of the cask. The concrete jacket was effective in preventing perforation of the cask. Committee members saw a specimen of this cask at the GNB workshop (see FIGURE C.4).

Also in 1999, explosion of a liquid gas tank next to a cask was performed by the German BAM (Federal Office of Material Research and Testing) to study the effect of accidents involving fire or explosions in the vicinity of the cask during transportation or storage. The gas tank and the CASTOR cask were initially about 8 feet (2.5 meters) apart. Explosion of the tank generated a fire ball 330 to 500 feet (100 to 150 meters) in diameter. The explosion projected the cask 23 feet (7 meters) away and tilted it by 180 degrees, causing it to hit the ground on the lid side. Examination after the explosion showed no change in the containment properties of the lid system.

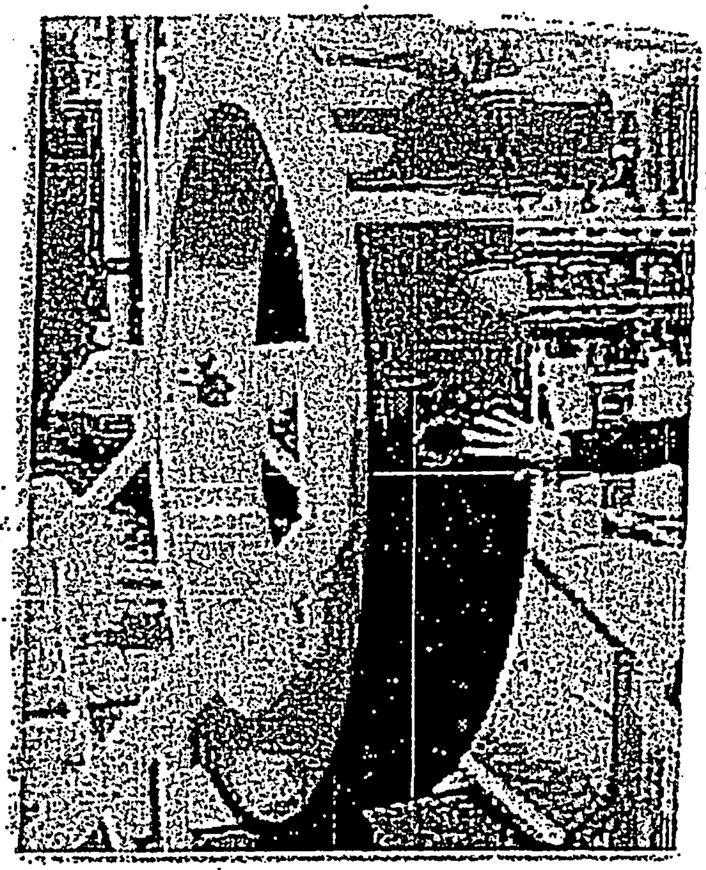

FIGURE C.4 Section of a CASTOR cask showing the perforation made by a shaped charge at the Aberdeen Proving Ground. SOURCE: Courtesy of GNB/GNSI.

REFERENCE

Lange, F., G. Pretzsch, J. Döhler, E. Hörmann, H. Busch, and W. Koch. 1994. Experimental Determination of UO_2-Release from a Spent Fuel Transport Cask after Shaped Charge Attack. 35th INMM Annual Meeting Proceedings (Naples, Florida). Vol. 23, pp. 408-413.

RSK (Reaktorsicherheitskommission). 2001. Safety-Related Guidelines for the Dry Interim Storage of Spent Fuel Elements in Storage Casks. Recommendation of the Commission on Reactor Safety. April 5. Available at *http://www.rskonline.de/Download/Leitlinien/English/RSK-GUIDELINES-DRY-INTERIM-STORAGE.pdf.*

D

HISTORICAL DEVELOPMENT OF CURRENT COMMERCIAL POWER REACTOR FUEL OPERATIONS

There are 103 commercial power reactors operating in the United States at this time. Almost all of them are operating with spent fuel pools that are too small to accommodate cumulative spent fuel discharges. This short appendix was prepared to provide a historical background for power reactor fuel operations and pool and dry-cask storage of spent fuel.

D.1 DESIGN FOR A CLOSED FUEL CYCLE

The first large generation of commercial reactors in the United States were almost all light water reactors (LWRs), that is, nuclear reactors that use ordinary water to cool the core and to moderate the neutrons emitted by fission. The hydrogen atoms in the water coolant moderate, or slow down the fission-emitted neutrons to an energy level that is more likely to cause fission when the neutron strikes a fissile atom. These reactors were designed, developed, and licensed in the 1960s and 1970s, although many were not completed until the 1980s. Their design power output increased rapidly, as it did for non-nuclear power plants, in order to achieve economies of scale. Thus, the earlier plants in this generation were designed to produce 500-900 megawatts of electrical power (MWe) while later units increased to 1000-1200 MWe. The number of LWRs built and ordered by the U.S. industry began to approach 200. All of these plants were being designed for a closed fuel cycle, that is, for the uranium oxide fuel, enriched to 2-5 percent uranium-235, to be loaded and "burned" to a level of 20-30 gigawatt-days per metric ton of uranium (GWd/MTU), then reprocessed in commercial plants to separate the still usable fissionable, or fissile, materials in the spent fuel from the radioactive waste. The reprocessing plants would recover the fissile plutonium-239 formed from uranium-238 during reactor operations and residual fissile uranium-235 for use as fuel in LWRs and later in breeder reactors (USNRC, 1976).

By the mid-1970s commercial reprocessing plants were built, under construction, or planned in New York, Illinois, South Carolina, and Tennessee, with a combined projected capacity to reprocess more than 6000 MTU of spent fuel per year. For comparison, a large LWR discharges about 20 MTU of spent fuel at a refueling. By this time the price of fresh uranium was dropping and the cost of fuel reprocessing made it difficult for recycle fuel to compete with fresh fuel. Also, there was controversy about the risk of fissile material diversion if recycled plutonium was moved in commercial traffic. Both existing fuel reprocessing plants withdrew from licensing for technical reasons and then, on April 7, 1977, President Carter issued a policy statement that "we will defer indefinitely the commercial reprocessing and recycling of the plutonium produced in the U.S. nuclear power programs." The statement went on to say: "The plant at Barnwell, South Carolina, will receive neither federal encouragement nor funding for its completion as a reprocessing facility." After consultation with the White House, the U.S. Nuclear Regulatory Commission (USNRC) terminated its Final Generic Environmental Statement on the Use of Recycled Plutonium in Mixed Oxide Fuel in Light-Water Cooled Reactors (GESMO) proceedings.

Thus, the U.S. nuclear industry was immediately changed from a closed fuel cycle, with recycle, to an open or once-through fuel cycle with the fuel loaded into the reactor in several consecutive locations to obtain maximum economic use of the fuel before it was finally removed as waste. The USNRC changed the legal definition of high-level radioactive waste to include the high-level waste from both nuclear fuel reprocessing and spent nuclear fuel.

For this study, the significance of this closed fuel cycle design is that this entire generation of more than 100 reactors was designed with small spent fuel pools, relying on prompt shipment away from the reactor to the reprocessing plant to make room for later discharges of spent fuel. Early spent fuel shipping casks were being designed with active cooling systems to support shipment of fuel less than a year out of the reactor to a reprocessing plant. BOX D.1 discusses the spent nuclear fuel at reprocessing plants. Supplementary wet and dry storage systems had to be developed to receive the older spent fuel to make room for fresh spent fuel from the reactor. Many plants had to remove and modify the storage racks in their spent fuel pools to accommodate more spent fuel in the pool itself until licensed supplementary systems were available.

D.2 RETRENCHMENT OF U.S. REACTOR PLANS

As noted in Section D.1, in the 1970s the United States was building reactors at a high rate. Then, in the late 1970s, three factors produced a retrenchment in power reactor plans: rising interest rates, reversal of the U.S. fuel reprocessing policy, and the Three Mile Island-2 accident.

D.2.1 Effect of Interest Rates

Commercial power reactors have characteristically high initial capital costs. The regulated public utilities have had to raise the capital with various debt instruments; to build, license, and operate the finished plant for a time before it can be declared commercial; and to change the electricity rates charged consumers to retire the debt on the capital cost. The soaring interest rates in the United States during the late 1970s drove the costs of new nuclear plants that were under construction to extreme heights. This, combined with slackening demand for electricity, led to the cancellation of many plants, some even in advanced stages of construction.

D.2.2 Effect of Reversal of U.S. Fuel Reprocessing Policy

President Carter enunciated a change in U.S. policy for reprocessing of spent nuclear fuel in early 1977. Those reactors then operating and those under construction had to begin modifying their reactor fuel cycle design to go from the closed (reprocessing) cycle to a "once-through" fuel cycle. This induced the designers to go to higher levels of uranium-235 enrichment in the new fuel, but still within the 5 percent licensing limit. It also induced the designers to revise the core loading and operating plans in order to burn or use the fissile content of the fuel to the greatest extent economically possible since the fissile residue could not be retrieved by reprocessing. As a result, spent fuel burnup levels rose to levels that are now almost double the 20-30 GWd/MTU characteristic of the original closed fuel cycle. This results in an increase in the decay-heat power of the spent fuel assembly by the time it is put into the spent fuel pool.

BOX D.1 Spent Fuel at Nuclear Fuel Reprocessing Plants

Up until the mid-1970s the commercial nuclear industry was expected to operate several nuclear fuel reprocessing plants to recover fissile plutonium from virtually all of the commercial spent fuel from U.S. reactors. These plants would use aqueous reprocessing methods developed by the Atomic Energy Commission (AEC). The recovered plutonium was to be used as mixed oxide fuel (PuO_2 and UO_2) in water reactors and, later, as fuel in breeder reactors. Each reprocessing plant had one or two storage pools to receive and store the fuel temporarily until it was reprocessed. No long-term storage of the spent fuel from commercial reactors was planned. Only two commercial reprocessing sites have received spent fuel: West Valley, New York, and G.E.-Morris, Illinois.

The first commercial reprocessing plant began operations by the Nuclear Fuel Services Company on a site in West Valley, New York, owned by the State of New York. The State of New York licensed a low-level radioactive waste disposal site adjacent to the reprocessing plant. The West Valley plant had a reprocessing capacity of about 1 metric ton of uranium (MTU) per day. It operated at reduced capacity because there was not yet much commercial spent fuel to reprocess. In fact, about half of the spent fuel reprocessed there was from the last in the series of plutonium production reactors, the N-Reactor, at the AEC site in Hanford, Washington. This spent fuel was provided to the West Valley plant to keep it working in the early days when little commercial spent fuel was available. The West Valley plant suspended operations in 1972 in order to expand its capacity to about 3 MTU per day. The work and the re-licensing effort went on until 1976 when the company withdrew its application for the new license and terminated reprocessing operations. The U.S. Department of Energy (DOE) took over the task of high-level radioactive waste retrieval and decommissioning under the West Valley Demonstration Project Act of 1980. About 137 MTU of commercial spent fuel remaining in the cooling pool was returned to its owners (USNRC, 1987). In 2003 the last of this spent fuel, about 25 MTU in two shipping casks, was shipped to the DOE-Idaho National Lab where it remains in dry storage in those casks.

The General Electric Company built a nuclear fuel reprocessing plant at Morris, Illinois, near the Dresden Nuclear Power Station. The plant was expected to reprocess 3 MTU per day. When the G.E.-Morris plant was in its final testing in 1975, the company determined that its performance would not be acceptable without extensive modifications. The request for a reprocessing plant operating license was withdrawn and the plant was licensed only to possess the spent nuclear fuel that it was under contract to reprocess. After modifying the storage system in its below-grade pool to hold more spent fuel, G.E.-Morris has received and stores 700 MTU of spent fuel for various owners.

Power reactors are refueled, and spent fuel is discharged to the storage pool, every one to two years. The decay-heat power of recently discharged spent fuel dominates the heat load of all the spent fuel in the pool, both freshly discharged and old, since the decay heat from a spent fuel assembly decreases by one to two orders of magnitude in the first year after it is removed from the reactor. Increasing the capacity of the spent fuel pool by re-racking, that is, modifying the storage racks to provide for closer spacing of the fuel assemblies,[1] allows older fuel to be accumulated in the pool rather than being removed for

[1]The capacity of spent fuel pools has typically been increased by replacing the original storage racks with racks that hold the spent fuel assemblies closer together. The fuel assembly channels in these

shipment or dry storage. Re-racking can make it more difficult to cool the freshly discharged fuel if there is catastrophic loss of the fuel pool water.

D.2.3 Effect of the Three Mile Island Accident

The final factor driving the retrenchment of the nuclear power industry was the Three Mile Island-2 (TMI-2) accident that occurred on March 28, 1979, in Pennsylvania (Walker, 2004). In that accident a small failure in the reactor coolant system was compounded by operator errors to result in catastrophic damage; a partial core melt occurred. The inability of the operators to understand and control the events, and the confusion among the state, the USNRC, and other responsible agencies about public protection had a devastating effect on public trust in the safety of nuclear power. The USNRC escalated safety requirements after the TMI-2 accident. These new requirements substantially modified the operation of licensed plants, delayed completion of new plants, and further increased their construction costs. The accident also resulted in the retrenchment of nuclear power in the 1980s and led to the cancellation of many plants, decommissioning of some plants, and the sale of some plants to other owners. The fleet of operating U.S. reactors was reduced to the presently operating 103 described here.

D.3 COMMERCIAL POWER REACTORS CURRENTLY OPERATING IN THE UNITED STATES

All of the commercial power reactors operating in the United States are light water reactors. BOX D.2 describes the LWRs that are currently operating in the United States.

D.3.1 Pressurized Water Reactors

About two-thirds of the U.S. reactors are pressurized-water reactors (PWRs), dual-cycle plants in which the primary cooling water is kept under a pressure of about 2000 pounds per square inch absolute (psia) as it circulates to remove fission and decay heat from the reactor fuel in the core and carry that energy to the steam generators, to generate steam in the lower-pressure secondary loop. The reactor, primary loop piping, and steam generators are all located in the containment structure; the steam lines penetrate the containment carrying the steam to the turbine to generate electrical power.

About one-third of the U.S. reactors are boiling-water reactors (BWRs), single-cycle plants in which the primary coolant of the reactor core is operated at about 1000 psia as it recirculates within the reactor core. The fission and decay heat generated in the core cause a substantial amount of the reactor coolant water to boil into steam that passes out directly from the reactor pressure vessel to the turbine-generator system. Plant differences stem initially from the different designs of the nuclear steam system supplier, the different designs of the architect-engineers that built the plants, and the owners that often specified additional modifications.

replacement racks typically have solid metal walls with neutron-absorbing material for nuclear safety reasons. This configuration inhibits water or air circulation more than the earlier configuration.

BOX D.2 U.S. Nuclear Power Plants

In the United States, 32 utility companies are licensed to manage the 103 operating reactors. There are also 27 shutdown reactors in storage or decommissioning. These reactors are situated at 65 nuclear power plant sites across the United States; a plant site may have 1, 2, or 3 reactors.

The fleet of 103 operating reactors in the United States is composed of the following:

- 69 pressurized water reactors (PWRs) and
- 34 boiling water reactors (BWRs).

The containment design for PWRs is divided into dry (56 reactors), ice condenser (9 reactors), and sub-atmospheric (4 reactors) containments. Among the BWR containment designs, 22 reactors are of design type Mark I, 8 of Mark II, and 4 of Mark III.

The PWRS operating in the United States were designed by three different nuclear steam system suppliers; Westinghouse Electric, Combustion Engineering, and Babcock & Wilcox. Most PWRs have what are called large dry containments, that is, containment structures of about 2 million cubic feet volume that can absorb the rapid release of steam and hot water from a postulated rupture of the primary coolant system without exceeding an internal pressure of about 4 atmospheres. FIGURE D.1 illustrates a PWR in a large dry containment. Some PWR containments are essentially as large but use ventilation fans to maintain the initial containment pressure mildly sub-atmospheric to provide an additional pressure margin. Finally, one set of nine Westinghouse PWRs uses ice-condenser containment structures, in which the containment has about the same pressure capability but is smaller, relying on massive baskets of ice maintained in the containment to condense steam releases and mitigate the pressure surge.

D.3.2 Boiling Water Reactors

The BWRs in operation today were designed by the General Electric Company. They all use pressure suppression containments, two-chamber systems with the reactor located in a dry well that is connected to a wet well containing a large pool of water.

In the event of a rupture of the reactor system in the dry well, the steam and hot water released are channeled into the water in the wet well, condensing and cooling the steam to mitigate the pressure surge. BOX D.2 lists the three successive generations of BWR containment design, and the number of each still operating. FIGURE D.2 illustrates three types of BWR containments: Mark I, Mark II, and Mark III. The Mark I containment is the most common type with 22 in operation. The reactor pressure vessel, containing the reactor core is located in a dry well of the containment in the shape of an inverted incandescent light bulb.

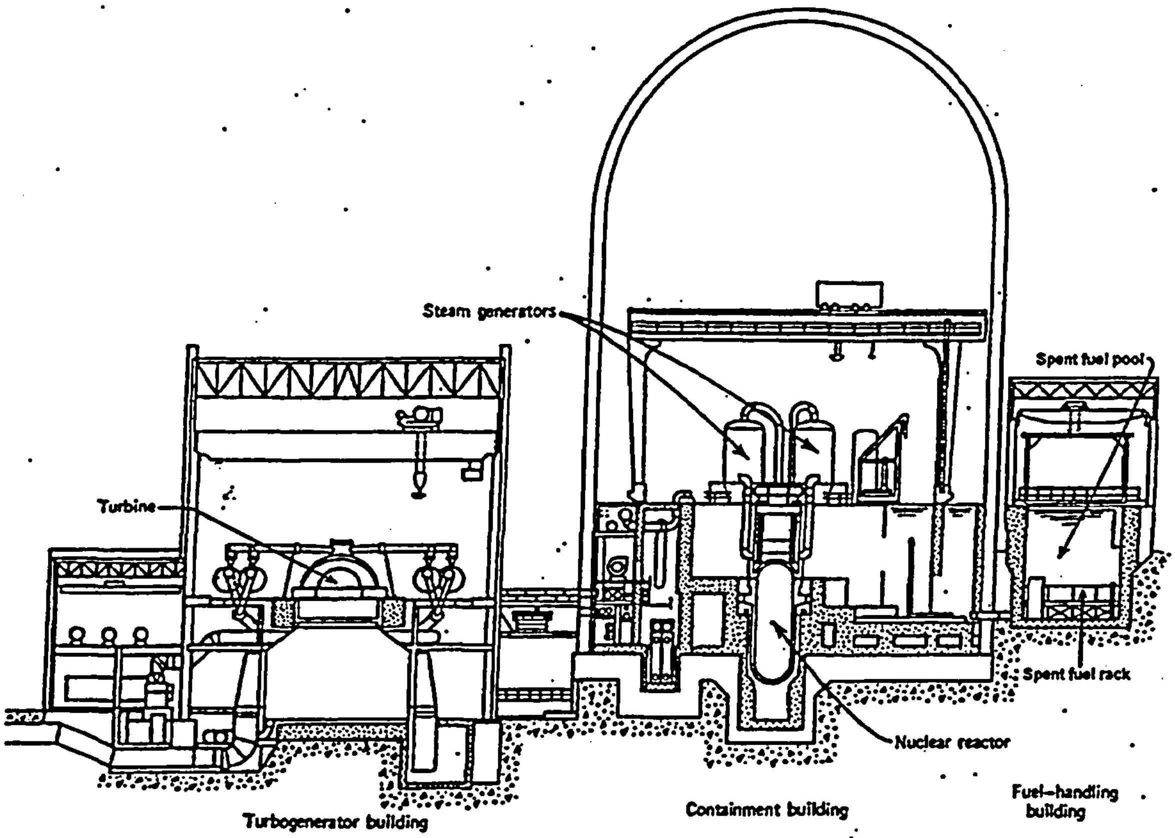

FIGURE D.1 A PWR in a large dry containment. SOURCE: Modified from Duderstadt and Hamilton (1976, Figure 3-4).

The dry well is connected by large ducts to the wet well, a large toroidal (i.e., doughnut-shaped) part of the containment that is partially filled with water. Gas and steam releases from an accident in the dry well would be passed through the connecting ducts into the water in the wet well, cooling the gas and condensing the steam to mitigate the accident pressure rise in the containment. The containment building Mark II BWR is similar to the Mark I except that in the Mark II containment the conical dry well is directly above the cylindrical wet well. Nine Mark II reactors are still operating in the United States. In the Mark III, the dry well around the reactor vessel is vented to the top of a cylindrical wet well that surrounds it.

Four Mark III BWRs are currently operating. The entire dry well-wet well system is contained within a large steel containment shell and a concrete shield building.

D.3.3 Reactor Fuel and Reactor Control

TABLE D.1 presents the range of dimensions and weights for a wide variety of the LWR fuel assemblies used in the operating reactors. The spent fuel pools and the dry storage systems used at a reactor must be tailored to the specific fuel design for that reactor.

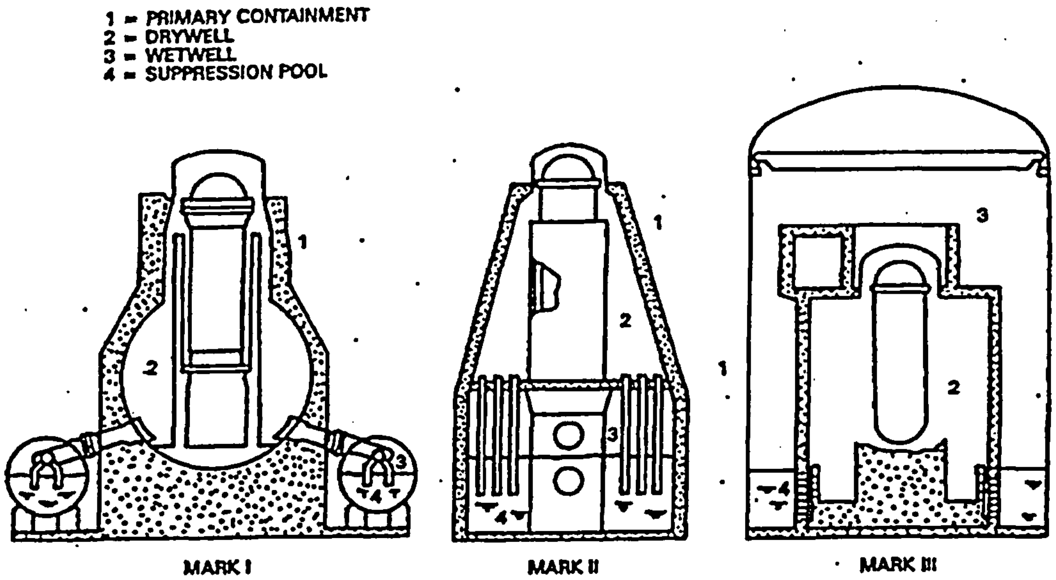

FIGURE D.2 Three types of BWR containment system: Mark I, Mark II, and Mark III. SOURCE: Modified from Lahey and Moody (1993, Figure 1-9).

*The fission process is controlled by the reactor operators through the use of neutron-*absorbing materials. The primary control is an array of control rods or blades that can be withdrawn from the core to the degree needed. In the PWRs, the control rods are moved within selected empty tubes within the assembly. In the BWRs, cruciform (cross-shaped) control blades are moved across the faces of the fuel assembly, typically narrower than those in a PWR fuel assembly. Reactor fuel designers also use burnable poisons within the fuel assembly to control the fission process. These poisons are placed in appropriate amounts within the fuel assembly so that they burn away, making the fuel assembly more reactive, as the continued fission process is making it less reactive. PWRs also use neutron control by dissolving neutron-absorbing sodium borate in the reactor coolant, gradually lowering the concentration from the peak after refueling to the minimum before the next refueling.

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TABLE D.1 Range of Dimensions and Weights for Light Water Reactor Fuel Assemblies Used in Operating Reactors in the United States.

Physical Characteristics of Typical LWR Fuel Assemblies

Reactor Type	BWR	BWR	PWR	PWR	PWR	PWR	PWR	PWR	PWR	PWR	PWR	PWR
Fuel Designer	GE	GE	B&W	B&W	CE	CE	W	W	W	W	W	W
Fuel Rod Array	7x7	8x8	15x15	17x17	14x14	16x16	14x14	14x14	15x15	15x15	17x17	17x17
Active Fuel Length (in.)	144	144	144	143	137	150	120	144	121	144	144	168
Nominal Envelope (in.)^2	5.438	5.47	8.536	8.536	8.25	8.25	7.763	7.763	8.449	8.426	8.426	8.426
Fuel Assembly Length (in.)	176	176	166	166	157	177	137	161	137	160	160	—
Weight (lbs.)	600	600	1,516	1,502	581 kg	—	501 kg	573 kg	594 kg	654 kg	665 kg	—
Fuel Rod												
Number	49	63	208	264	164	224-236	180	179	204	204	264	264
Length (in.)	163	—	153	—	147	161	127	152	127	152	152	—
Pitch, Square (in.)	0.738	0.640	0.568	0.501	0.580	0.506	0.556	0.556	0.563	0.563	0.496	0.496
O.D. (in.)	0.570	0.493	0.430	0.379	0.440	0.382	0.422	0.422	0.422	0.422	0.374	0.360
Clad Thickness (mils.)	35.5	34	26.5	23.5	26	25	16.5	24.3	16.5	24.3	22.5	22.5
Clad Material	Zr 2	Zr 2	Zr 4	Zr 4	Zr 4	Zr 4	sst	Zr 4	sst	Zr 4	Zr 4	Zr 4
Pellet O.D. (in.)	0.488	0.416	0.370	0.3232	0.3795	0.325	0.3835	0.3659	0.3835	0.3659	0.3225	0.3088
Pellet Length (in.)	—	—	—	0.375	0.650	0.390	0.600	0.600	0.600	0.600	0.530	0.530
Gap, Radial (mils.)	5.5	4.5	3.5	3.1	4.3	3.5	2.8	3.8	2.8	3.8	3.3	3.3
Density (STD)	—	—	92.5-95.0	93.5-95.0	93.0-95.0	94.75	93.0-94.0	92.0	93.0-94.0	92.0	95.0	95.0
Poison	Gd_2O_3	Gd_2O_3	None	None	B_4C/Al_2O_3	B_4C/Al_2O_3	—	—	—	—	—	—
Nonfueled Rods												
Number	0	1	17	25	6	6	16	17	21	21	25	25
Material	—	Zr 2	Zr 4	Zr 4	Zr 4	Zr 4	304 sst	Zr 4	304 sst	Zr 4	Zr 4	Zr 4
Spacer Grids												
Number	7	7	8	8	8	12	—	—	—	—	—	—
Material	Inconel X	Inconel X	Inconel 718	Inconel 718	Zr 4	Zr 4	—	—	—	—	—	—

SOURCE: American Nuclear Society (1988).

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Fuel Designer	GE	GE	B&W	B&W	CE	CE	W	W	W	W	W	W
Fuel Rod Array	7x7	8x8	15x15	17x17	14x14	16x16	14x14	14x14	15x15	15x15	17x17	17x17
Active Fuel Length (in.)	144	144	144	143	137	150	120	144	121	144	144	168
Nominal Envelope (in.)^2	5.438	5.47	8.536	8.536	8.25	8.25	7.763	7.763	8.449	8.426	8.426	8.426
Fuel Assembly Length (in.)	176	176	166	166	157	177	137	161	137	160	160	—
Weight (lbs.)	600	600	1,516	1,502	581 kg	—	501 kg	573 kg	594 kg	654 kg	665 kg	—
Fuel Rod												
Number	49	63	208	264	164	224-236	180	179	204	204	264	264
Length (in.)	163	—	153	—	147	161	127	152	127	152	152	—
Pitch, Square (in.)	0.738	0.640	0.568	0.501	0.580	0.506	0.556	0.556	0.563	0.563	0.496	0.496
O.D. (in.)	0.570	0.493	0.430	0.379	0.440	0.382	0.422	0.422	0.422	0.422	0.374	0.360
Clad Thickness (mils.)	35.5	34	26.5	23.5	26	25	16.5	24.3	16.5	24.3	22.5	22.5
Clad Material	Zr 2	Zr 2	Zr 4	Zr 4	Zr 4	Zr 4	sst	Zr 4	sst	Zr 4	Zr 4	Zr 4
Pellet O.D. (in.)	0.488	0.416	0.370	0.3232	0.3795	0.325	0.3835	0.3659	0.3835	0.3659	0.3225	0.3088
Pellet Length (in.)	—	—	—	0.375	0.650	0.390	0.600	0.600	0.600	0.600	0.530	0.530
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Density (STD)	—	—	92.5-95.0	93.5-95.0	93.0-95.0	94.75	93.0-94.0	92.0	93.0-94.0	92.0	95.0	95.0
Poison	Gd_2O_3	Gd_2O_3	None	None	B_4C/Al_2O_3	B_4C/Al_2O_3	—	—	—	—	—	—
Nonfueled Rods												
Number	0	1	17	25	6	6	16	17	21	21	25	25
Material	—	Zr 2	Zr 4	Zr 4	Zr 4	Zr 4	304 sst	Zr 4	304 sst	Zr 4	Zr 4	Zr 4
Spacer Grids												
Number	7	7	8	8	8	12	—	—	—	—	—	—
Material	Inconel X	Inconel X	Inconel 718	Inconel 718	Zr 4	Zr 4	—	—	—	—	—	—

SOURCE: American Nuclear Society (1988).

E
GLOSSARY

Actinide: Any of a series of chemically similar radioactive elements with atomic numbers ranging from 89 (actinium) through 103 (lawrencium). This group includes uranium and plutonium.

Alpha particle: Two neutrons and two protons bound as a single particle (a helium nucleus) emitted from certain radioactive isotopes when they undergo radioactive decay.

Bare-fuel cask: See *Cask.*

Beta particle: A charged particle consisting of a positron or electron emitted from certain radioactive isotopes when they undergo radioactive decay.

Beyond-design-basis accidents: Technical expression describing accident sequences outside of those used as design criteria for a facility. Beyond-design-basis accidents are generally more severe but are judged to be too unlikely to be a basis for design.

Boiling water reactor (BWR): A type of nuclear reactor in which the reactor's water coolant is allowed to boil to produce steam. The steam is used to drive a turbine and electrical generator to produce electricity.

Burn-up: Measure of the number of fission reactions that have occurred in a given mass of nuclear fuel, expressed as thermal energy released multiplied by the period of operation and divided by the mass of the fuel. Typical units are megawatt-days per metric ton of uranium (MWd/MTU) or gigawatt-days per metric ton of uranium (GWd/MTU).

Canister-based cask: See *Cask.*

Cask: Large, typically cylindrical containers constructed of steel and/or reinforced concrete that are used to store and/or transport spent nuclear fuel. Casks designed for storage of spent nuclear fuel can be of two types: "bare-fuel" or "canister-based." In bare-fuel casks, spent fuel is stored in a fuel basket surrounded by a heavily shielded and leak-tight container. In canister-based casks, the fuel is enclosed in a leak-tight steel cylinder, called a canister, which has a welded lid. The canister is placed in a heavily shielded cask overpack. Casks can be single-, dual-, or multiple-purpose, indicating that they can be used, respectively, for storage (also called storage-only casks), for storage and transportation, and for storage, transportation, and geologic disposal. There are no true multi-purpose casks for spent fuel currently available on the market.

Cesium-137: Radioactive isotope that is one of the products of nuclear fission.

Chain reaction: A series of fission reactions wherein the neutrons released in one fission event stimulate the next fission event or events.

Cladding: Thin-walled metal tube that forms the outer jacket of a nuclear fuel rod. It prevents corrosion of the nuclear fuel and the release of fission products into the coolant. Zirconium alloys (also called *zircaloy*, see below) are common cladding materials in commercial nuclear fuel.

Conduction: In the context of heat transfer, the transfer of heat within a medium through a diffusive process (i.e., molecular or atomic collisions).

Containment structure: A robust, airtight shell or other enclosure around a nuclear reactor core to prevent the release of radioactive material to the environment in the event of an accident.

Convection: Heat transfer by the physical movement of material within a fluid medium.

Cooling time: The amount of time elapsed since spent fuel was discharged from a nuclear reactor.

Core: That portion of a nuclear reactor containing the fuel elements.

Criticality: Term used in reactor physics to describe the state in which the number of neutrons released by the fission process is exactly balanced by the neutrons being absorbed and escaping the reactor core. At criticality, the nuclear fission chain reaction is self-sustaining.

Decay heat: Heat produced by the decay of radioactive isotopes contained in nuclear fuel.

Decay, radioactive: Disintegration of the nucleus of an unstable element by the spontaneous emission of charged particles (alpha, beta, positron) or photons of energy (gamma radiation) from the nucleus, spontaneous fission, or electron capture.

Depleted uranium: Uranium enriched in the element uranium-238 relative to uranium-235 compared to that usually found in nature. Also, uranium in which the uranium-235 content has been reduced through a physical process.

Design basis phenomena: Earthquakes, tornadoes, hurricanes, floods, and other events that a nuclear facility must be designed and built to withstand without loss of systems, structures, and components necessary to ensure public health and safety.

Design basis threat: In the context of this study, hypothetical ground assault threat against a commercial nuclear power plant. Some generic elements of the design basis threat are described in Title 10, Section 73.1(a) of the Code of Federal Regulations (10 CFR 73.1(a)).

Dirty bomb: See *Radiological Dispersal Device.*

Dry storage: Out-of-water storage of spent nuclear fuel in heavily shielded casks.

Drywell: The containment structure enclosing a boiling water nuclear reactor vessel. The drywell is connected to a pressure suppression system and provides a barrier to the release of radioactive material to the environment under accident conditions.

Dual-purpose cask: See *Cask*.

Fissile material: Material that undergoes fission from thermal (slow) neutrons. Although sometimes used as a synonym for fissionable material, the term "fissile" has acquired this more restricted meaning in nuclear reactor technology. The three primary fissile materials are uranium-233, uranium-235, and plutonium-239.

Fission: Splitting of a nucleus into at least two nuclei accompanied by the release of neutrons and a relatively large amount of energy.

Fissionable: Material that is capable of undergoing fission from fast neutrons.

Fission products: Nuclei resulting from the fission of elements such as uranium.

Fuel assembly: A square array of fuel rods.

Fuel pellet: A small cylinder of uranium usually in a ceramic form (uranium dioxide, UO_2), typically measuring about 0.4 to 0.65 inches (1.0 to 1.65 centimeters) tall and about 0.3 to 0.5 inch (0.8 to 1.25 centimeters) in diameter.

Fuel reprocessing: Chemical processing of reactor fuel to separate the unused fissionable material (uranium and plutonium) from waste material.

Fuel rod: Sometimes referred to as a *fuel element* or *fuel pin*. A long, slender tube that holds the uranium fuel pellets. Fuel rods are assembled into bundles called *fuel assemblies*.

Gamma ray: Electromagnetic radiation (high-energy photons) emitted from certain radioactive isotopes when they undergo radioactive decay.

Half-life (radioactive): Time required for half the atoms of a radioactive substance to undergo radioactive decay. Each radioactive isotope has a unique half-life. For example, cesium-137 decays with a half-life of 30.2 years, and plutonium-239 decays with a half-life of 24,065 years.

Independent Spent Fuel Storage Installation (ISFSI): A facility for storing spent fuel in wet pools or dry casks as defined in Title 10, Part 72 of the Code of Federal Regulations.

Irradiation: Process of exposing material to radiation, for example, the exposure of nuclear fuel in the reactor core to neutrons.

Isotope: Elements that have the same number of protons but different numbers of neutrons. For example, uranium-235 and uranium-238 are different isotopes of the element uranium.

Loss-of-pool-coolant event: A postulated accidental or malevolent event that results in a loss of the water coolant from a spent fuel pool at a rate in excess of the capability of the water makeup system to restore it.

Megawatt: One million watts.

MELCOR: A computer code developed by Sandia National Laboratories for use in analyzing severe reactor core accidents. The code has been adapted to model fluid flow, heat transfer, fuel cladding oxidation kinetics, and fission product release phenomena associated with spent fuel assemblies in spent fuel pools in loss-of-pool-coolant events.

Metric ton: Weight unit corresponding to 1000 kg or approximately 2200 pounds.

Metric tons of uranium: See *MTU.*

Moderator: Material, such as ordinary water, heavy water, or graphite, used in a reactor to slow down high-energy neutrons.

MTU (metric tons of uranium): Unit of measurement of the mass for spent nuclear fuel, also expressed in metric tons of heavy metal (MTHM). It refers to the initial mass of uranium that is contained in a fuel assembly. It does not include the mass of fuel cladding (zirconium alloy) or the oxygen in the fuel compound.

Multi-purpose cask: See *Cask.*

MWe: Megawatts of electrical energy output from a power plant.

MWt: Megawatts of thermal energy output from a power plant.

Neutron: Uncharged subatomic particle contained in the nucleus of an atom. Neutrons are emitted from the nucleus during the fission process.

Open rack: A storage rack in a spent fuel pool that has open space and lateral channels between the cells for storing spent fuel assemblies to permit water circulation.

Overpack: Metal or concrete cask used for storage or transportation of a canister containing spent nuclear fuel. See Cask.

Owner-controlled area: That part of the power plant site over which the plant operator exercises control. This usually corresponds to the boundary of the site.

Pellet: See *Fuel pellet.*

Penetrate: To pass into, but not completely through, a solid object.

Perforate: To produce a hole that goes completely through a solid object.

Plutonium-239: A fissile isotope of plutonium that contains 94 protons and 145 neutrons.

Pressurized water reactor (PWR): A type of nuclear reactor in which the reactor's water coolant is kept at high pressure to prevent it from boiling. The coolant transfers its heat to a secondary water system that boils into steam to drive the turbine and generator to produce electricity.

Probabilistic risk assessment: A systematic, quantitative method to assess risk (see below) as it relates to the performance of a complex system.

Protected area: A zone located within the owner-controlled area of a commercial nuclear power plant site in which access is restricted using guards, fences, and other barriers.

psia: Unit of pressure, pounds per square inch absolute, that is the total pressure including the pressure of the atmosphere.

Radioactivity: Spontaneous transformation of an unstable atom, often resulting in the emission of particles (alpha and beta) or gamma radiation. The process is referred to as radioactive decay.

Radiological Dispersal Device (RDD): A terrorist device in which sources of radioactive material are dispersed by explosives or other means. Also referred to as a *dirty bomb.*

Radiological sabotage: Any deliberate act directed against a nuclear power plant or spent fuel in storage or transport that could directly or indirectly endanger the public health and safety by exposure to radiation.

Radionuclide: Any form of an isotope of an element that is radioactive.

Re-racking: Replacement of the existing racks in a spent fuel pool with new racks that increase the number of spent fuel assemblies that can be stored.

Risk: The potential for an adverse effect from an accident or terrorist attack. This potential can be estimated quantitatively if answers to the following three questions can be obtained: (1) What can go wrong? (2) How likely is it? (3) What are the consequences?

Safety: In the context of spent fuel storage, measures that protect storage facilities against failure, damage, human error, or other accidents that would disperse radioactivity in the environment.

Safeguards: As used in the regulation of domestic nuclear facilities and materials, the use of material control and accounting programs to verify that all nuclear material is properly controlled and accounted for, and also the use of physical protection equipment and security forces to protect such material.

Safeguards information: Information not otherwise classified as National Security Information or Restricted Data that specifically identifies a U.S. Nuclear Regulatory Commission licensee's or applicant's detailed (1) security measures for the physical protection of special nuclear material or (2) security measures for the physical protection and location of certain plant equipment vital to the safety of production or utilization facilities (10 CFR 73.2). The U.S. Nuclear Regulatory Commission has the authority to determine whether information is "safeguards information."

Security: In the context of spent fuel storage, measures to protect storage facilities against sabotage, attacks, or theft.

Shaped charge: A demolition and wall penetration or perforation device that uses high explosive to create a high-velocity jet of material.

Single-purpose cask: See *Cask*.

Special nuclear material: Fissile elements such as uranium and plutonium.

Spent fuel: See *Spent nuclear fuel.*

Spent fuel pool: A water-filled pool that is used at all commercial nuclear reactors for storage of spent (used) fuel elements after their removal from a nuclear reactor. Spent fuel pools are constructed of reinforced concrete and lined with stainless steel. The inside of the pool has storage racks to hold the spent fuel assemblies and may contain a gated compartment to hold a spent fuel cask while it is being loaded and sealed.

Spent (or used or irradiated fuel) nuclear fuel: Fuel that has been "burned" in the core of a nuclear reactor and is no longer efficient for producing electricity. After discharge from a reactor, spent fuel is stored in water-filled pools (see *Wet storage*) for shielding and cooling.

Storage-only cask: See *Cask.*

Thermal power: Total heat output from the core of a nuclear reactor.

Uranium-235: A fissile isotope of uranium that contains 92 protons and 143 neutrons. It is the principal nuclear fuel in nuclear power reactors.

Uranium-238: An isotope of uranium that contains 92 protons and 146 neutrons.

Vital area: A zone located within the protected area of a commercial nuclear power plant site that contains the reactor control room, the reactor core, support buildings, and the spent fuel pool. It is the most carefully controlled and guarded part of the plant site.

Watt: Unit of power.

Watt-hour: Energy unit of measure equal to one watt of power supplied for one hour.

Wet storage: Storage of spent nuclear fuel in spent fuel pools.

Zircaloy: Zirconium alloy used as cladding for uranium oxide fuel pellets in reactor fuel assemblies.

Zirconium cladding fire: A self-sustaining, exothermic reaction caused by rapid oxidation of zirconium fuel cladding (zircaloy) at high temperatures.

F

ACRONYMS

ACRS: Advisory Committee on Reactor Safeguards

BAM: Bundesanstalt für Materialforschung und -prüfung

BMU: Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit

BNL: Brookhaven National Laboratory

BWR: Boiling Water Nuclear Reactor (see Appendix E)

CFD: Computational Fluid Dynamics

DBT: Design Basis Threat (see Appendix E)

DHS: United States Department of Homeland Security

DOE: United States Department of Energy

EPRI: Formerly referred to as the Electric Power Research Institute

GAO: United States Government Accountability Office (formerly the General Accounting Office)

GESMO: Final Generic Environmental Statement on the Use of Recycled Plutonium in *Mixed Oxide Fuel in Light-Water Cooled Reactors*

GNB: Gesellschaft für Nuklear-Behälter, mbH

GNS: Gesellschaft für Nuklear-Service, mbH

GNSI: General Nuclear Systems, Inc.

GRS: Gesellschaft für Anlagen- und Reaktorsicherheit, mbH

GWd/MTU: Gigawatt-Days per Metric Ton of Uranium (see *Burn-up* in Appendix E)

INL: Idaho National Laboratory (formerly Idaho National Engineering and Environmental Laboratory)

ISFSI: Independent Spent Fuel Storage Installation

HSK: Die Hauptabteilung für die Sicherheit der Kernanlagen

MTU: Metric Tons of Uranium (see Appendix E)

MWd/MTU: Megawatt-Days per Metric Ton of Uranium (see *Burn-up* in Appendix E)

NPP: Nuclear Power Plant

NRC: National Research Council

PFS: Private Fuel Storage

PWR: Pressurized Water Nuclear Reactor (see Appendix E)

RDD: Radiological Dispersal Device (see Appendix E)

RPG: Rocket-Propelled Grenade

Zircaloy: Zirconium alloy used as cladding for uranium oxide fuel pellets in reactor fuel assemblies.

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NPP: Nuclear Power Plant

NRC: National Research Council

PFS: Private Fuel Storage

PWR: Pressurized Water Nuclear Reactor (see Appendix E)

RDD: Radiological Dispersal Device (see Appendix E)

RPG: Rocket-Propelled Grenade

RSK: Reaktorsicherheitskommission

TOW: Tube-Launched, Optically Tracked, Wire Guided [Missile] (see Appendix E)

USNRC: United States Nuclear Regulatory Commission

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ML061730399

4/21/06
71FR 20733
3

From: "Becca King" <beccaking@crocker.com>
To: <VermontYankeeEIS@nrc.gov>
Date: Wed, Jun 14, 2006 7:30 PM
Subject: don't play with our lives

Dear NRC commissioners:

I urgently request that you refuse to re-license the VT Yankee Nuclear Power Plant. I am extremely worried about the dangers of this aging plant and all the harm it can do to us, as residents of the Pioneer Valley. I live immediately downwind, to the S. of Vernon, and I am an educator. We all know we will not be protected from the radiation of a nuclear accident.

Yes, we need cheap electrical power. I am unwilling however, to risk our lives for this. I will insure my car, my home, etc, but there is no insurance to protect us from radiation damage to our health, or from a terrorist attack. Already there are radiation and chemical leaks. What are you trying to do to us?

Our schools do not have adequate evacuation plans. THere is no safe evacuation plan for us. This is reality.

Please do not renew this license. It is an insane plan.

Are any of you living downwind from a reactor? If you are, you know what it feels like to be so vulnerable. If not, then how can you be so arrogant as to play with our lives by allowing this dangerous reactor to continue for many more years?

I hope you will listen to our voices.

Becca King
33 Allen St
Greenfield, MA 01301

beccaking@crocker.com

33 Allen St,Greenfield, MA 01301 413-773-7004
www.beccaking.com

RECEIVED
2006 JUN 23 PM 1:44
RULES AND DIRECTIVES BRANCH USNRC

Add me to your address book... Want a signature like this?

CC: <mcclinto@verizon.net>, <bostonS@aol.com>, <suzannec@crocker.com>, "Karen Brandow" <kbrandow2@aol.com>, "Bonnie Wodin" <gyarrow@crocker.com>

SUNSI Review Complete
Template = ADM-013

E-RIDS= ADM-03
Add= B. Emch (RLE)

Mail Envelope Properties (44909C0F.171 : 13 : 57713)

Subject:	don't play with our lives
Creation Date	Wed, Jun 14, 2006 7:29 PM
From:	"Becca King" <beccaking@crocker.com>
Created By:	beccaking@crocker.com

Recipients

nrc.gov
TWGWPO03.HQGWDO01
VermontYankeeEIS

crocker.com
gyarrow CC (Bonnie Wodin)
suzannec CC

aol.com
kbrandow2 CC (Karen Brandow)
bostonS CC

verizon.net
mcclinto CC

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TWGWPO03.HQGWDO01	nrc.gov
	crocker.com
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	verizon.net

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Mime.822	10697	

Options

Expiration Date:	None
Priority:	Standard
ReplyRequested:	No
Return Notification:	None
Concealed Subject:	No
Security:	Standard

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From: "Mike Hebert" <mikehebert@adelphia.net>
To: <VermontYankeeEIS@nrc.gov>
Date: Tue, Jun 20, 2006 9:49 AM
Subject: License extension

ML061730415

Dear Mr. Eads,
I have many more comments on this matter. However, I know how busy you are and that brievity would be appreciated. Thank you for your consideration of this important matter.
Respectfully,
Mike Hebert
Vernon

4/21/06
71FR20703
(4)

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2006 JUN 23 PM 1:44
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Add = R. Emch (RLE)

Chief, Rules and Directives Branch
Division of Administrative Services
Mailstop T-6D59
U.S. Nuclear Regulatory Commission
Washington, DC 20555

June 16, 2006

Dear Mr. Eads:

The Vermont Yankee nuclear power plant plays an integral role in Vermont's current energy portfolio, and must be part of our future.

Vermont Yankee is a clean, emissions free generating facility that provides stable, low-cost power to our state. These are all crucial factors that businesses take into consideration when determining whether to remain here, or relocate to Vermont.

If Vermont Yankee goes off-line in 2012 where will we find replacement power that is as clean and reliable?

Vermont Yankee is critical to Windham County and Southeast Vermont in particular. Currently, the plant and its contractors employ full time approximately 600 men and women, and provides $80 million to local Vermont businesses through the purchase of goods and services.

Its clean power, sound operations, well paying jobs, and community participation and support helps make the region a great place to live and work.

For all of these reasons, I encourage the Nuclear Regulatory Commission to extend the license of Vermont Yankee for another 20 years.

Sincerely,

Mike Hebert

Mail Envelope Properties (4497FCF2.519 : 24 : 29977)

Subject:	License extension
Creation Date	Tue, Jun 20, 2006 9:49 AM
From:	"Mike Hebert" <mikehebert@adelphia.net>
Created By:	mikehebert@adelphia.net

Recipients
nrc.gov
TWGWPO03.HQGWDO01
VermontYankeeEIS

Post Office	**Route**
TWGWPO03.HQGWDO01	nrc.gov

Files	**Size**	**Date & Time**
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Junk Mail handling disabled by User
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ML061730420

From: "Tina Emery-Howe" <tina_emery_howe@hotmail.com>
To: <VermontYankeeEIS@nrc.gov>
Date: Mon, Jun 19, 2006 3:18 PM
Subject: Support renewing operating license of Vermont Yankee

4/21/06
71 FR 20733
5

Attached is my letter supporting the license renewal for Vermont Yankee. If you have any questions, please feel free to email me.

Thanks,
Tina

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2006 JUN 23 PM 1:45
RULES AND DIRECTIVES BRANCH

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Template = ADM-013

E-RIDS = ADM-03

Add = R. Emch (RLE)

Chief, Rules and Directives Branch
Division of Administrative Services
Mailstop T-6D59
U.S. Nuclear Regulatory Commission
Washington, DC 20555

June 16, 2006

Dear Mr. Eads:

This letter is in support of renewing the operating license of the Vermont Yankee nuclear facility.

I believe the environmental benefits that Vermont Yankee provides are a crucial part of ensuring that Vermont's landscape remains clean and pristine. It has not gone unnoticed that Vermont has one of the lowest emissions ratings in the country, largely because of our nuclear plant in Vernon.

Nuclear energy avoids the emissions of harmful toxins or other pollutants into the atmosphere that other large power facilities, like coal or natural gas are guilty of. More and more environmental scientists have concluded that nuclear energy is the only power source that can help combat global warming.

Vermont and the entire New England region is in need of this plant, and as long as it maintains its high level of safe operations, there is no reason why this plant should not remain online.

Vermont Yankee is a necessary component to this state's current and future energy portfolio, and I hope that the NRC rules in favor of a license extension.

Sincerely,

Tina Emery-Howe

Mail Envelope Properties (4496F888.B81 : 13 : 7041)

Subject:	Support renewing operating license of Vermont Yankee
Creation Date	Mon, Jun 19, 2006 3:18 PM
From:	"Tina Emery-Howe" <tina_emery_howe@hotmail.com>
Created By:	tina_emery_howe@hotmail.com

Recipients
nrc.gov
TWGWPO03.HQGWDO01
VermontYankeeEIS

Post Office	**Route**
TWGWPO03.HQGWDO01	nrc.gov

Files	**Size**	**Date & Time**
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Mime.822	32195	

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Return Notification:	None
Concealed Subject:	No
Security:	Standard

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Junk Mail settings when this message was delivered
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Junk Mail handling disabled by Administrator
Junk List is not enabled
Junk Mail using personal address books is not enabled
Block List is not enabled

ML061730427

From: Jonathan von Ranson <commonfarm@crocker.com>
To: <VermontYankeeEIS@nrc.gov>
Date: Wed, Jun 14, 2006 3:21 PM
Subject: Vermont Yankee plant relicensing

4/21/06
71FR 20733
6

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2006 JUN 23 PM 1:45
RULES AND DIRECTIVES BRANCH

To reviewers at the Nuclear Regulatory Commission:

Living within about 14 miles of a nuclear plant weighs on the minds of people, and my friends and neighbors virtually unanimously feel a strain whenever they think about Vermont Yankee. I am in both the construction trades and farming, self-employed in both fields, and as a contractor, dealing with others in that line of work, I have seen how strongly many people in construction feel an aversion to the Vernon, Vt., area because of uneasiness about the nuclear plant. I have heard builders voice scruples against building spec housing in that area. They wouldn't want to live there themselves and don't feel right about selling a family a house so close to the potential danger of meltdown, or the actual, ongoing radiation health hazard from the plant's operation. The town of Vernon remains quite sparsely populated despite taxes being low, and I believe appropriate concern about the nuclear power plant explains why.

The effects of worry don't cease at the town boundary, either—by harming the peace of mind, they negatively influence the choices of home buyers, adders-on and renovators, and of businesses looking to relocate in a radius of easily a dozen or perhaps 20 miles.

As an organic farmer with livestock and vegetable crops, I consider the radiation emissions from the plant's operation to be one more degrading influence in the environment, added to a number of others, that affects both crop plants and livestock raised in this area. It is difficult to quantify but I am confident from reading about the experiences of farmers in the area of this plant and others that the radiation stressor exists.

For these reasons, I strongly oppose the relicensing of the Vernon nuclear plant beyond 2012. I am willing to use less electricity if the license extension is denied, and to pay more for it.

Yours truly,

Jonathan von Ranson,
Bear Mountain Stonemasonry
-and-
The Commonfarm
6 Lockes Village Rd.
Wendell MA 01379
978 544-3758

SUNSI Review Complete
Template = ADM-013

E-RIDS = ADM-03
Call = R. Emch (RLE)

Mail Envelope Properties (44906198.EE9 : 19 : 52969)

Subject:	Vermont Yankee plant relicensing
Creation Date	Wed, Jun 14, 2006 3:12 PM
From:	Jonathan von Ranson <commonfarm@crocker.com>
Created By:	commonfarm@crocker.com

Recipients
nrc.gov
TWGWPO03.HQGWDO01
VermontYankeeEIS

Post Office	**Route**
TWGWPO03.HQGWDO01	nrc.gov

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Options

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Junk Mail handling disabled by User
Junk Mail handling disabled by Administrator
Junk List is not enabled
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Block List is not enabled

ML061730431

From: "Pam Walker" <pamwalker@crocker.com>
To: "Ellen Brouillette" <ellenchesham@hotmail.com>, <VermontYankeeEIS@nrc.gov>
Date: Wed, Jun 14, 2006 6:24 PM
Subject: don't play with our lives!

4/21/06
71 FR 20733

(7)

Dear NRC commissioners:

I urgently request that you refuse to re-license the VT Yankee Nuclear Power Plant. I am extremely worried about the dangers of this aging plant and all the harm it can do to us, as residents of the Pioneer Valley. I live immediately downwind, to the S. of Vernon, and I am an educator. We all know we will not be protected from the radiation of a nuclear accident.

Yes, we need cheap electrical power. I am unwilling however, to risk our lives for this. I will insure my car, my home, etc, but there is no insurance to protect us from radiation damage to our health, or from a terrorist attack. Already there are radiation and chemical leaks. What are you trying to do to us?

Our schools do not have adequate evacuation plans. THere is no safe evacuation plan for us. This is reality.

Please do not renew this license. It is an insane plan.

Are any of you living downwind from a reactor? If you are, you know what it feels like to be so vulnerable. If not, then how can you be so arrogant as to play with our lives by allowing this dangerous reactor to continue for many more years?

I hope you will listen to our voices.

Pam Walker
48 Franklin St.
Shelburne Falls, MA 01370

CC: "Ellen Kaufmann and/or Marc Kaufmann" <Kaufmann@Crocker.com>, "Becca King" <beccaking@crocker.com>, <adelwalk@nyc.rr.com>, "Mike Brouillette" <mikeb@vcgi.org>, "Liza Walker" <Liza@vlt.org>

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Template = ADM-013

E-RIDS = ADM-03
Add = R. Emch (RLE)

Mail Envelope Properties (44908A0B.D9D : 8 : 56733)

Subject:	don't play with our lives!
Creation Date	Wed, Jun 14, 2006 6:13 PM
From:	"Pam Walker" <pamwalker@crocker.com>
Created By:	pamwalker@crocker.com

Recipients
nrc.gov
TWGWPO03.HQGWDO01
VermontYankeeEIS

vlt.org
Liza CC (Liza Walker)

vcgi.org
mikeb CC (Mike Brouillette)

nyc.rr.com
adelwalk CC

crocker.com
beccaking CC (Becca King)
Kaufmann CC (Ellen Kaufmann and/or Marc Kaufmann)

hotmail.com
ellenchesham (Ellen Brouillette)

Post Office	**Route**
TWGWPO03.HQGWDO01	nrc.gov
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	vcgi.org
	nyc.rr.com
	crocker.com
	hotmail.com

Files	**Size**	**Date & Time**
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Mime.822	6110	

Options

Expiration Date:	None
Priority:	Standard

ReplyRequested:	No
Return Notification:	None
Concealed Subject:	No
Security:	Standard

Junk Mail Handling Evaluation Results
Message is eligible for Junk Mail handling
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4/21/06
71FR 20733

8

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E-RIDS=ADM-03

Template=ADM-013

Add= R. Emch (RLE)

United States Nuclear Regulatory Commission

NRC FORM 659
(6-2003)

U.S. NUCLEAR REGULATORY COMMISSION

Category
3

NRC PUBLIC MEETING FEEDBACK

Meeting Date: 06/07/2006

Meeting Title: Public Meeting to discuss the Environmental Scoping Process for Vermont Yankee Nuclear Power Station, License Renewal Application

In order to better serve the public, we need to hear from the meeting participants. Please take a few minutes to fill out this feedback form and return it to NRC.

1. How did you hear about this meeting?
   - [ ] NRC Web Page
   - [ ] NRC Mailing List
   - [x] Newspaper
   - [ ] Radio/TV
   - [ ] Other ______

	Yes	No (Please explain below)	Somewhat (Please explain below)
2. Were you able to find supporting information prior to the meeting?	[ ]	[ ]	[x]
3. Did the meeting achieve its stated purpose?	[ ]	[ ]	[x]
4. Has this meeting helped you with your understanding of the topic?	[x]	[ ]	[ ]
5. Were the meeting starting time, duration, and location reasonably convenient?	[x]	[ ]	[ ]
6. Were you given sufficient opportunity to ask questions or express your views?	[x]	[ ]	[ ]
7. Are you satisfied overall with the NRC staff who participated in the meeting?	[x]	[ ]	[ ]

COMMENTS OR SUGGESTIONS:

Thank you for answering these questions.

I am concerned that the continued release of heated water into the Connecticut River from Vermont Yankee is adversely affecting aquatic life in the river. Several school and citizen awareness groups have measured temperatures as high as 10°F warmer below the plant than above, and it is my understanding that only 1° to 2° F is allowed. Since this has

Continue Comments on the reverse. ⇨

OPTIONAL

Name Jacob Iselin Organization None

Telephone No. (603)876-4036 E-Mail jiselin@bates.edu [x] *Check here if you would like a member of NRC staff to contact you.*

OMB NO. 3150-0197

Expires: 06/30/2006

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COMMENTS OR SUGGESTIONS: (Continued)

continued for many years. I fear that plant officials do not plan to stop this. I ask that you please address this ongoing problem in your considerations of whether or not to extend the license of the Vermont Yankee Nuclear Power Plant.

Thank you in advance for your time and consideration.

UNITED STATES
NUCLEAR REGULATORY
COMMISSION
WASHINGTON DC 20555-0001

MANCHESTER NH 031
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WASHINGTON DC 20277-2904

ML061740572

From: Jon Block <jonb@sover.net>
To: <VermontYankeeEIS@nrc.gov>, Deb Katz <deb@nukebusters.org>, Chris Nord <chrisnord@netzero.net>
Date: Fri, Jun 23, 2006 3:12 PM
Subject: Citizens Awareness Network's Scoping Comments on EIS for proposed VY License Renewal in Docket 50-271

4/21/06
71FR 20733
9

Attached hereto are scoping comments on the EIS for the proposed VY License Renewal in Docket 50-271 in both WP12 and PDF formats. Also attached is a copy of /S//an //L//uis //O//bispo //M//others For //P//eace v. NRC/, ___ F.3d ___, Docket No. 03-74628 (9th Cir. 2006). The file is called "Mothers v. NRC.PDF" and the contents are referenced in the scoping comments.

If you have any difficulty receiving this transmission or opening and using the attached PDF files, please contact sender immediately.

Thank you.

Jonathan M. Block
Attorney at Law
94 Main Street
P.O. Box 566
Putney, VT 05346
802-387-2646 (office)
jonb@sover.net

RECEIVED
2006 JUN 26 AM 10: 39
RULES AND DIRECTIVES BRANCH

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Template = ADM-013

E-RIDS = ADM-03
Add = R. Emch (RLE)

JONATHAN M. BLOCK
ATTORNEY AT LAW
94 Main Street
P.O. Box 566
Putney, VT. 05346-0566
802-387-2646 (vox)
-2667 (fax)
jonb@sover.net

June 23, 2006

Chief, Rules and Directives Branch
Division of Administrative Service
Mail Stop T-6D59
United States Nuclear Regulatory Commission
Washington, D.C. 20555
via email to: VermontYankeeEIS@nrc.gov

RE: Citizens Awareness Network's Written Comments on the Scope of the EIS for Proposed License Renewal of the Vermont Yankee Nuclear Power Station, Vernon, Vermont, NRC Docket Number 50-271, Scoping Process Notice, 71 FR 20733 (4/21/2006).

The following comments are provided to supplement oral comments of Deb Katz, Executive Director, and Chris Nord, Vice President, of Citizens Awareness Network, made during the public scoping meeting at the Latchis Theatre, Brattleboro, Vermont, on June 7, 2006. The live comments and the comments below are made pursuant to the regulations governing preparation of Environmental Impact Statements under 10 C.F.R. Part 51. CAN specifically requested to participate in making comments on this matter following direct contact by the NRC.

Background of the Commenting Organization

Citizens Awareness Network [CAN] is a non-profit Massachusetts corporation that is concerned with all environmental impacts of the nuclear fuel chain. CAN has members in Connecticut, Massachusetts, New Hampshire, New York, and Vermont. CAN members utilize the resources of the Connecticut River and Deerfield River ecosystems for living, working, aesthetic, recreational and sport-fishing purposes in the areas affected by the proposed relicensing of the Vermont Yankee Nuclear Power Station, Vernon, Vermont. Executive Director of CAN, Deborah B. Katz, P.O. Box 83, Shelburne Falls, MA 01370-0083, (413) 339-5781, has authorized these comments and representation of CAN in this matter for the limited purposes of filing supplemental written comments on the proper scope of the EIS in this matter.

Comments

CAN contends that the following are proper subjects of environmental concern that should be fully investigated prior to renewal of the Vermont Yankee license to operate:

1. Subjects to include in a supplement to the GEIS for Vermont Yankee and analyze in depth:

1.1 Accumulation of low-level radioactive waste on site.

1.2 Accumulation of chemical wastes on site.

1.3 Extent of on and off site contamination due to radioactive materials, chemicals and other VY waste in on and off site locations, including, but not limited to disposal in the Brattleboro and other area landfills that are now part of the Windham Solid Waste Management District and/or out of state landfills utilized by the WSWMD.

1.4 Extent of site contamination due to chemical and other hazardous wastes, including, but not limited to PCB contamination in paint, accumulated TCE, PERC and other organic solvents, lead, and asbestos.

1.5 Extent of groundwater contamination on (and beneath) site, including, but not limited to tritium contamination.

1.6 Extent of any off-site groundwater contamination, including, but not limited to tritium contamination of drinking water wells and other off site ground water locations.

1.7 Extent of radionuclide inventory and location of radioactive waste accumulated in on-site disposal locations for contaminated silt, sand, soil, sewage and other materials.

Rationale for including 1.1 - 1.7 within the scope of an EIS for Vermont Yankee license renewal:

Were Vermont Yankee to be denied renewal of its license, shut down in 2012, and then begin to undergo decommissioning, each of the listed environmental concerns would be considered in the decommissioning process. In the event that Vermont Yankee is given an additional twenty years (or less) of operation under license renewal, now is the time to access the above listed environmental issues in order to inventory and fully analyze the extent of these problems at the originally contemplated end-of-life for this reactor. This inventory and analysis is appropriate, as the use and improper disposal of many of the environmental hazards listed above, along with on-site disposal of construction waste during construction of the facility, were commonly accepted and customary business and industrial practices during a major portion of the original license period. Moreover, there is ample evidence in the publicly available records for Vermont Yankee that numerous spills occurred during operations under the original license and the facility engaged in shoddy record keeping to document the extent and location of such events.[1] Thus, including a complete inventory and analysis of all the items in the list within the

---

[1] The following is just a tiny sample of what a real inspection of records might disclose--let alone an actually complete and comprehensive inspection of the entire reactor facility and grounds. It was, perforce, based on the use of the NRC Public Document collection through "ADAMS" on line. This form of record access is slow, inaccurate and entirely "hit-or-miss"--yet there is still some evidence of a pattern of environmental contamination--on and off the VY site--that an EIS should evaluate:

Failure to keep records of spills, unusual events and spread of contaminated material

Accession # 9903240281 (Excerpt of a letter from Clifford J. Andersen, Chief, NRC Projects Branch 5, Division of Reactor Projects, to Gregory Maret, VY Director of Operations, re: NRC Integrated Inspection Report 50-271/99-01 (March 16, 1999) ("We also reviewed your recent efforts to update your records of spills or other unusual occurrences involving the spread of contamination in and around the facility for decommissioning planning purposes. Our review found that in some cases, documentation was not sufficiently detailed to fully assess some locations with respect to the requirements of 10 CFR 50.75 relative to its impact on decommissioning.") (Emphasis added.)

Accession # 9508140119 (Abstract excerpt) "Findings of Inspection 50-271/95-18 of Vermont Yankee Nuclear Power Station, on June 20 to 22, 1995." "This inspection consisted of observations regarding the Vermont Yankee Nuclear Corporation's controls for radioactive materials and contamination, surveys and monitoring, including review of the following: audits, appraisals and assessments; radioactive surveys and monitoring; radioactive materials and contamination controls; and other related items. During the inspection, one violation of the Tech Specs was identified regarding failure to effectively control personnel access to high radiation areas. (....) A weakness was identified in maintaining records for events or incidents including spills of radioactive materials that are important to decommissioning. Continued management attention is necessary to ensure that these records are maintained and available for eventual decommissioning of the facility." (Emphasis added.)

Permitting on-site disposal of radioactively contaminated silt, sand, and septic sludge

Accession # 9706200266(Abstract) "The NRC concludes that the plant site radiological conditions that would result from the onsite disposal of slightly contaminated silt material (as proposed by the licensee under 10CFR20.2002) and the previously approved onsite disposal of slightly contaminated septic waste material are within the applicable boundary conditions for the disposal of licensed material." (Emphasis added.)

Tritium in sewage system from unknown causes

Accession #9111180022, "Findings of Safety Inspection 50-271/91-24 of Vermont Yankee Nuclear Power Station on September 8 to October 15, 1991" (abstract) ("Root cause and corrective action determinations have not been fully effective in resolving the issue of tritium in the sewage system.") (Emphasis added.)

Offsite disposal of radioactive sludge and licensed material

Accession #8807250386, "Findings of Inspection 50-271/88-09 of Vermont Yankee Nuclear Power Station on June 20 to 24, 1988" (abstract) (review of VY offsite disposal of sewage waste containing scope of the EIS for Vermont Yankee license renewal makes good practical sense based on the historical record for this licensee. Further, as the NRC is aware[2], tritium contamination--which is a part of the historical record for this facility--has become a major issue at reactor sites across the country. Thus, on and off site tritium contamination due to past (and continued) operation of the Vermont Yankee Nuclear Power Station should be thoroughly investigated, including all sources and pathways on and off site, to assure if the NRC renews VY's license it will not permit continued radioactive contamination of groundwater.

1.8 Unique potential for a fuel-pool fire in a GE Mark-I-type Boiling Water Reactor [BWR] due to acts of sabotage and/or terrorism.

Rationale: See written comments of CAN VP, Chris Nord, below.

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licensed material during the period of January to May 1988. During the inspection, one unresolved item was identified regarding the potential improper disposal of licensed material.") (Emphasis added).

Spills of radioactively contaminated liquids

ADAMS # ML0209303370, Reportable Event Number: 27319 (May 31, 1994) ("220 gallons of reactor coolant were discharge into the RB floor drain system." [C]ontamination surveys near the supplemental fuel pool cooling system (located directly below the RWCU system) identified approximately 30kcpm/100sqcm general area and 800 mRad-beta near one floor drain indicating that the floor drain "backed up" when the relief valve lifted. Lower levels of radioactive concentrations have also been identified on most areas in the RB. The licensee identified a few gallons of reactor coolant and RWCU demineralizer resin in the vicinity of the floor drain.") (Emphasis added.)

Accession # 8711100481 (LER documenting a 2,000 gallon spill which was "communicated through the floor drain system" and "which resulted in contaminating local areas of the Reactor Building" with "minor seepages through the interface between the Reactor Building Refuel Floor Paneling and the Reactor Building exterior walls ... detected.") (Emphasis added.)

[2] See http://www.nrc.gov/reactors/operating/ops-experience/grndwtr-contam-tritium.html . This is the NRC response (to date) to the "tritium petition" filed with the NRC by NIRS, UCS, CAN and many other participating organizations.

1.9 The nature and extent of environmental harm due to a fuel-pool fire at Vermont Yankee caused by acts of sabotage and/or terrorism.

Rationale: See written comments of CAN VP, Chris Nord, below.

Written Comments of Chris Nord, Vice President, Citizens Awareness Network:

I hereby incorporate by reference my oral comments at the June 7 meeting in Brattleboro, and set forth additionally as follows:

1) The NRC must require that Entergy return to the original Design Basis for Spent Fuel Pool (SFP) rack configuration – that is "Low-Density" racking, which ensures a redundant safety component to SFP cooling. [A low-density pool will theoretically survive a Loss of Coolant (LOCA) accident without catching fire or going critical, due to ambient air-cooling]. Continuation of the High-Density scheme amounts to the sacrifice of an engineered protection for the public – and NRC's own Design Basis – for the sake of an economically driven expediency. This is an issue that could have dire consequences on the natural and human environment in and about the Vermont Yankee Nuclear Power Station in the event of a terrorist attack and/or act of sabotage against the SFP. Following the recent 9th Circuit decision, *San Luis Obispo Mothers For Peace v. NRC*, ___ F.3d ___, Docket No. 03-74628 (9th Cir. 2006) (a copy of which is attached hereto for your convenience), such consideration is properly within the scope of an EIS for the proposed license renewal of Vermont Yankee. It must be noted that NRC regulations on license renewal and related guidance documents, including those relating to the scope of the EIS, were all prepared prior to "9/11".

2) Because much of current inventory of SF must be removed for Low-Density Storage, NRC must create and enforce regulations regarding "robust storage" of this out-of-water inventory, per Dr. Gordon Thompson's supporting declaration of the contentions of the State of Massachusetts in the matter of the relicensing of Vermont Yankee. See ADAMS location file: ML061640065 (legal and factual arguments, contention), at Pp. 5-50 (which are incorporated by reference herein); see also reports and declarations of Dr. Gordon Thompson and Dr. Jan Beyea, attached thereto, which are incorporated herein by reference. The evidence in the cited contention filing makes it clear that failure to place the fuel in "robust" storage could have dire consequences on the natural and human environment in and about the Vermont Yankee Nuclear Power Station in the event of a terrorist attack and/or act of sabotage against the SFP. Following the recent 9th Circuit Decision of the Mothers and Others case, such consideration is properly within the scope of an EIS for the proposed license renewal of Vermont Yankee.

3) In light of the unquestionable vulnerability of the GE Mark-I type-BWRs to airborne terrorist attack (and the accessibility of Vermont Yankee from Canadian airspace), and because of the catastrophic consequences of such an attack, the NRC must expand the scope of emergency preparedness out to the boundaries of the Ingestion Pathway – a 50 radius. I hereby incorporate by reference my comments at the NRC's Plymouth, Massachusetts, meeting earlier in the spring (for Pilgrim), at the Brattleboro meeting, and in a meeting with NH Governor Lynch of New Hampshire on June 13, 2006, in which I recommended that the EPZ be extended to 50 miles. Governor Lynch acknowledged that his Capitol is within the 50-mile

radius of Vermont Yankee and just outside the 50-mile radius of Seabrook. When he indicated that he recognized this point, he was holding bull's-eye target maps showing the proximity of Vermont Yankee and Seabrook to Concord, New Hampshire. Again, this consideration flows from the recent 9th Circuit Decision of the Mothers and Others case and is properly within the scope of the EIS for the proposed Vermont Yankee relicensing for the reasons set forth above. 4) In light of evidence that terrorists targeted a least two nuclear reactors, the recent arrests of a terrorist cell in Canada, the accessibility of Vermont Yankee to Canadian airspace along the Connecticut River (a pilot would not need to be able to navigate – just follow the river right to their target), the enormity of the consequences of such an attack on the elevated Spent Fuel Pool at Vermont Yankee, and in light of the 9th Circuit Court of Appeals decision in this matter, the NRC's scope of the EIS for Vermont Yankee license renewal must include an evaluation of the environmental consequences of sabotage and/or terrorist attack on the Vermont Yankee fuel pool and/or dry cask storage facility to be constructed there, and the Design Basis Threat must be expanded to include the threat of airborne and robust terrorist attack.

Respectfully submitted:

By: ______________________

Jonathan M. Block
Attorney at Law
For Citizens Awareness Network

cc: Deborah B. Katz, Executive Director, CAN, deb@nukebusters.org
Chris Nord, VP, CAN, chrisnord@netzero.net

FOR PUBLICATION

UNITED STATES COURT OF APPEALS FOR THE NINTH CIRCUIT

SAN LUIS OBISPO MOTHERS FOR PEACE; SANTA LUCIA CHAPTER OF THE SIERRA CLUB; PEG PINARD, *Petitioners,* PACIFIC GAS AND ELECTRIC COMPANY, *Intervenor,* v. NUCLEAR REGULATORY COMMISSION; UNITED STATES OF AMERICA, *Respondents.*	No. 03-74628 NRC No. CLI-03-01; CLI-02-23 OPINION

On Petition for Review of an Order of the Nuclear Regulatory Commission

Argued and Submitted
October 17, 2005—San Francisco, California

Filed June 2, 2006

Before: Stephen Reinhardt and Sidney R. Thomas, Circuit Judges, and Jane A. Restani,* Chief Judge, United States Court of International Trade

Opinion by Judge Thomas

*The Honorable Jane A. Restani, Chief Judge, United States Court of International Trade, sitting by designation.

COUNSEL

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Sheldon L. Trubatch, Esq., Offices of Robert K. Temple, Esq., Chicago, Illinois, for amicus San Luis Obispo County.

Kevin James, California Department of Justice, Oakland, California, for amicus States of California, Massachusetts, Utah and Washington.

Jay E. Silberg, Shaw Pittman, L.L.P., Washington, D.C., for amicus Nuclear Energy Institute.

OPINION

THOMAS, Circuit Judge:

This case presents the question, *inter alia*, as to whether the likely environmental consequences of a potential terrorist attack on a nuclear facility must be considered in an environmental review required under the National Environmental Policy Act. The United States Nuclear Regulatory Commission ("NRC") contends that the possibility of a terrorist attack on a nuclear facility is so remote and speculative that the potential consequences of such an attack need not be considered at all in such a review. The San Luis Obispo Mothers for Peace and other groups disagree and petition for review of the NRC's approval of a proposed Interim Spent Fuel Storage Installation. We grant the petition in part and deny it in part.

I

The NRC is an independent federal agency established by the Energy Reorganization Act of 1974 to regulate the civilian use of nuclear materials. Intervenor Pacific Gas and Electric Company ("PG&E") filed an application with the NRC under 10 C.F.R. Part 72 for a license to construct and operate an Interim Spent Fuel Storage Installation ("Storage Installation" or "ISFSI") at PG&E's Diablo Canyon Power Plant ("Diablo Canyon") in San Luis Obispo, California. The NRC granted the license. The question presented by this petition for review is whether, in doing so, the NRC complied with federal statutes including the National Environmental Policy Act of 1969 ("NEPA"), 42 U.S.C. §§ 4321-4437, the Atomic Energy Act of 1954 ("AEA"), 42 U.S.C. §§ 2011-2297g, and the Administrative Procedure Act ("APA"), 5 U.S.C. §§ 551-706.

NEPA establishes a "national policy [to] encourage productive and enjoyable harmony between man and his environment," and was intended to reduce or eliminate environmental damage and to promote "the understanding of the ecological systems and natural resources important to" the United States. *Dept. of Transp. v. Pub. Citizen*, 541 U.S. 752, 756 (2004) (quoting 42 U.S.C. § 4321). The Supreme Court has identified NEPA's "twin aims" as "plac[ing] upon an agency the obligation to consider every significant aspect of the environmental impact of a proposed action[, and] ensur[ing] that the agency will inform the public that it has indeed considered environmental concerns in its decisionmaking process." *Baltimore Gas & Elec. Co. v. Natural Res. Def. Counsel, Inc.*, 462 U.S. 87, 97 (1983).

Rather than mandating particular results, NEPA imposes on federal agencies procedural requirements that force consideration of the environmental consequences of agency actions. *Pub. Citizen*, 541 U.S. at 756. At NEPA's core is the requirement that federal agencies prepare an environmental impact statement ("EIS"), or:

> include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on—(i) the environmental impact of the proposed action, (ii) any adverse environmental effects which cannot be avoided should the proposal be implemented, (iii) alternatives to the proposed action, (iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and (v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Id. at 757 (quoting 42 U.S.C. § 4332(2)(C)).

As an alternative to the EIS, an agency may prepare a more limited environmental assessment ("EA") concluding in a "Finding of No Significant Impact" ("FONSI"), briefly presenting the reasons why the action will not have a significant impact on the human environment. *Id.* at 757-58 (citing 40 C.F.R. §§ 1501.4(e), 1508.13). If, however, the EA does not lead to the conclusion that a FONSI is warranted, the agency remains obligated to prepare an EIS. *Id.* at 757.

While NEPA requires the NRC to consider environmental effects of its decisions, the AEA is primarily concerned with setting minimum safety standards for the licensing and operation of nuclear facilities. The NRC does not contest that the two statutes impose independent obligations, so that compliance with the AEA does not excuse the agency from its NEPA obligations. The AEA lays out the process for consideration of the public health and safety aspects of nuclear power plant licensing, and requires the NRC to determine whether the licensing and operation of a proposed facility is "in accord with the common defense and security and will provide adequate protection to the health and safety of the public." 42 U.S.C. § 2232(a).

The NRC is not, however, required to make this determination without assistance; federal law provides a framework for hearings on material issues that interested persons raise by specific and timely petition. 42 U.S.C. § 2239(a); 10 C.F.R. §§ 2.308-.348; 5 U.S.C. §§ 551-706. The initial hearing is held before a three-person Atomic Safety and Licensing Board ("Licensing Board"). 10 C.F.R. § 2.321. The Licensing Board's findings and decision constitute the agency's initial determination, although a party may file a petition for review with the Commission within 15 days of the Licensing Board's decision. 10 C.F.R. § 2.341. If the petition is granted, the Commission specifies the issues to be reviewed and the parties to the review proceedings, 10 C.F.R. § 2.341(c)(1), and renders a final decision. 10 C.F.R. § 2.344. A party may then petition this court for review of the Commission's final decision. 28 U.S.C. § 2344.

II

With this general statutory background, we turn to the facts underlying the petition for review. On December 21, 2001, PG&E applied to the NRC pursuant to 10 C.F.R. Part 72 for a license to construct and operate a Storage Installation at Diablo Canyon. The Storage Installation would permit the necessary and on-site storage of spent fuel, the byproduct of the two nuclear reactors at that site. PG&E expects to fill its existing spent fuel storage capacity at Diablo Canyon sometime this year. Therefore, unless additional spent fuel storage capacity is created, the Diablo Canyon reactors cannot continue to function beyond 2006.

PG&E proposes to build a dry cask storage facility. The basic unit of the storage system is the Multi-Purpose Canister ("Canister"), a stainless steel cylinder that is filled with radioactive waste materials and welded shut. The Canisters are loaded into concrete storage overpacks that are designed to permit passive cooling via the circulation of air. The storage casks, or the filled Canisters loaded into overpacks, are then placed on one of seven concrete pads. The Storage Installation would house a total of 140 storage casks, 2 more than the 138 projected to be required for storage of spent fuel generated at Diablo Canyon through 2025.

On April 22, 2002, the NRC published a Notice of Opportunity for Hearing. Under the regulatory scheme, interested parties could then request a hearing or petition for leave to intervene. 10 C.F.R. § 2.309(a). A written hearing request, which must contain the contentions the party wants litigated at the hearing, will be granted if the petitioner has standing, and has posed at least one admissible contention.[1] *Id.*

On July 19, 2002, the San Luis Obispo Mothers for Peace, a non-profit corporation concerned with Diablo Canyon's

[1]In order to be admissible, a contention must: be set forth with particularity, 10 C.F.R. § 2.309(f)(1); provide a specific statement of the disputed issue of law or fact, 10 C.F.R. § 2.309(f)(1)(i); provide the basis for the contention, 10 C.F.R. § 2.309(f)(1)(ii); demonstrate that the issue is within the scope of the proceeding, 10 C.F.R. § 2.309(f)(1)(iii); demonstrate that the issue is material to the findings the NRC must make, 10 C.F.R. § 2.309(f)(1)(iv); provide supporting references and expert opinions, 10 C.F.R. § 2.309(f)(1)(v); and provide sufficient information to show the existence of a genuine issue of law or fact, 10 C.F.R. § 2.309(f)(1)(vi).

local impact, the Sierra Club, a non-profit corporation concerned with national environmental policy, and Peg Pinard, an individual citizen, (collectively "Petitioners") submitted a hearing request and a petition to intervene, asserting contentions for admission.

In Licensing Board Proceeding LBP-02-23, 56 NRC 413 ("LBP 02-23"), the Atomic Safety and Licensing Board addressed the admissibility of the July 19 petition's five Technical and three Environmental Contentions.[2] One Technical Contention, TC-1, dealing with the state of PG&E's finances, was deemed admissible; the acceptance of at least one contention meant that the petition was granted. Although the Licensing Board deemed two Environmental Contentions, EC-1, dealing with the failure to address environmental impacts of terrorist or other acts of malice or insanity, and EC-3, dealing with the failure to evaluate environmental impacts of transportation of radioactive materials[3] inadmissible, the Licensing Board nonetheless referred the final ruling as to the admissibility of these two contentions to the NRC, "in light of the

[2]Technical Contention Number One ("TC-1") alleged Inadequate Seismic Analysis. TC-2 alleged PG&E's Financial Qualifications Are Not Demonstrated. TC-3 alleged PG&E May Not Apply for a License for a Third Party. TC-4 alleged Failure to Establish Financial Relationships Between Parties Involved in Construction and Operation of Installation. TC-5 alleged Failure to Provide Sufficient Description of Construction and Operation Costs. Environmental Contention Number One ("EC-1") alleged Failure to Address Environmental Impacts of Destructive Acts of Malice or Insanity. EC-2 alleged Failure to Fully Describe Purposes of Proposed Action or to Evaluate All Reasonably Associated Environmental Impacts and Alternatives. EC-3 alleged Failure to Evaluate Environmental Impacts of Transportation.

[3]Because the Storage Installation is not a permanent repository, this contention assumes the eventual transport of the materials stored there to a permanent site. Among the materials submitted to support the contention were some dealing with possible terrorist or other malicious attacks on the spent fuel while in transit. The ruling on the contention was "referr[ed] . . . to the Commission to the extent terrorism and sabotage matters are proffered in support of its admission." 56 NRC at 453.

Commission's ongoing 'top to bottom' review of the agency's safeguards and physical security programs." 56 NRC at 448.

In a memorandum and order, CLI-03-1, 57 NRC 1 ("CLI 03-01"), the NRC accepted the Licensing Board's referral of its decision to reject the environmental contentions related to terrorism. Although the Commission affirmed the Licensing Board's rejection of the contentions, it based its decision on a different rationale. The NRC relied on four prior decisions in which it held that the NEPA does not require a terrorism review.[4] These decisions, most particularly *Private Fuel Storage*, CLI-02-25, 56 NRC 340 (2002), outlined four reasons for this holding: (1) the possibility of terrorist attack is too far removed from the natural or expected consequences of agency action to require study under NEPA; (2) because the risk of a terrorist attack cannot be determined, the analysis is likely to be meaningless; (3) NEPA does not require a "worst-case" analysis; and (4) NEPA's public process is not an appropriate forum for sensitive security issues. The NRC concluded:

> Our decision today rests entirely on our understanding of NEPA and of what means are best suited to dealing with terrorism. Nonetheless, our conclusion comports with the practical realities of spent fuel storage and the congressional policy to encourage utilities to provide for spent fuel storage at reactor sites pending construction of a permanent repository. Storage of spent fuel at commercial reactor sites offers no unusual technological challenges. Indeed, it has been occurring at Diablo Canyon for many

[4]Those cases include: *Private Fuel Storage, L.L.C.*, CLI-02-25, 56 NRC 340 (2002) (Storage Installation); *Duke Cogema Stone & Webster* (Mixed Oxide Fuel Fabrication Facility), CLI-02-24, 56 NRC 335 (2002); *Dominion Nuclear Connecticut, Inc.* (Nuclear Power Station), CLI-02-27, 56 NRC 367 (2002); and *Duke Energy Corp.* (Nuclear Power Station), CLI-02-26, 56 NRC 358 (2002). All four cases were decided on December 18, 2002.

> years and will continue whether or not we license the proposed Installation.

57 NRC at 7.

In September of 2002, prior to the NRC's decision on the first petition, Petitioners submitted a second petition, this time requesting suspension of the Storage Installation licensing proceeding pending comprehensive review of the adequacy of Diablo Canyon's design and operation measures for protection against terrorist attack and other acts of malice or insanity. Unlike the July 19 petition, this one addressed security measures for the entire Diablo Canyon complex, not merely the Storage Installation. Petitioners explained that 10 C.F.R. § 2.335, which prohibits challenges to any NRC rule or regulation in an adjudicatory proceeding involving initial or renewal licensing, prevented the raising of contentions contesting the adequacy of NRC safety requirements protecting against terrorist or other malicious attacks on the entire complex in the July 19 Petition. Petitioners also stated that 10 C.F.R. § 72.32 prevented them from raising emergency planning contentions in the earlier petition. Thus, Petitioners insisted that the second petition "d[id] not constitute a request for rulemaking, nor . . . for enforcement action," and instead defined it, without reference to any particular hearing-granting provision of the regulations, as "a request for actions that are necessary to ensure that any licensing decision made by the Commission with respect to the proposed Diablo Canyon Installation complies with the Commission's statutory obligations under the Atomic Energy Act."

In a memorandum and order, CLI-02-23, 56 NRC 230 ("CLI 02-23"), the NRC denied the September 2002 petition. Because the petition did not, according to the NRC, "fit comfortably in any specific category, [the Commission] treat[ed] it as a general motion brought under the procedural requirements of 10 C.F.R. § 2.730."[5] In rejecting the petition, the

[5]Since renumbered as 10 C.F.R. § 2.323, this regulation provides, simply, for "motions".

Commission reasoned that by not suspending operating licenses at installations and power plants following the September 11, 2001 terrorist attacks, it had demonstrated its implicit conclusion that the continued operation of these facilities neither posed an imminent risk to the public health, nor was inimical to the common defense. Further, the Commission concluded that because it had already initiated a thorough review of its safeguards and physical security program, there was no reason to suspend the Diablo Canyon licensing proceeding to address the terrorism-related concerns raised by the Petitioners. It stated that "[t]here certainly is no reason to believe that any danger to public health and safety would result from mere continuation of this adjudicatory proceeding," given that the proceeding was in its initial stages, that construction was not scheduled to begin for several years, and that the Petitioners would be able to comment on any changes in the rules resulting from the Commission's ongoing review of terrorism-related matters if and when they were to occur.

In a memorandum and order, CLI-03-12, 58 NRC 185 (2003) ("CLI 03-02"), the NRC denied the petitions for agency review of the Licensing Board's decisions that "cumulatively, rejected challenges to [the PG&E] Installation application." This denial thus became a final order, reviewable by this court on petition for review. 28 U.S.C. § 2344.

In October of 2003, the Spent Fuel Project Office of the NRC's Office of Material Safety and Safeguards released its Environmental Assessment Related to the Construction and Operation of the Diablo Canyon Independent Spent Fuel Storage Installation. The 26-page document contains the NRC's conclusion "that the construction, operation, and decommissioning of the Diablo Canyon Installation will not result in significant impact to the environment," and therefore that "an [EIS] is not warranted for the proposed action, and pursuant to 10 C.F.R. [§] 51.31, a Finding of No Significant Impact is appropriate."

The EA is not devoid of discussion of terrorist attacks. Indeed, the document contains the Commission's response to a comment submitted by the California Energy Commission in response to an earlier draft that "there is no discussion in the EA of the potential destruction of the casks or blockage of air inlet ducts as the result of sabotage or a terrorist attack . . . [nor is there] a description of how decisions are being made regarding the configuration, design and spacing of the casks, the use of berms, and the location of the ISFSI to minimize the vulnerability of the ISFSI to potential attack." The NRC responded:

> In several recent cases, . . . the Commission has determined that an NRC environmental review is not the appropriate forum for the consideration of terrorist acts. The NRC staff considers the security of spent fuel as part of its safety review of each application for an ISFSI license. In addition to reviewing an ISFSI application against the requirements of 10 CFR Part 72, the NRC staff evaluates the proposed security plans and facility design features to determine whether the requirements in 10 CFR Part 73, "Physical Protection of Plants and Materials," are met. The details of specific security measures for each facility are Safeguards Information, and as such, can not be released to the public.
>
> The NRC has also initiated several actions to further ensure the safety of spent fuel in storage. Additional security measures have been put in place at nuclear facilities, including ISFSIs currently storing spent fuel. These measures include increased security patrols, augmented security forces and weapons, additional security posts, heightened coordination with law enforcement and military authorities, and additional limitations on vehicular access. Also, as part of its comprehensive review of its security program, the NRC is conducting several technical

> studies to assess potential vulnerabilities of spent fuel storage facilities to a spectrum of terrorist acts. The results of these studies will be used to determine if revisions to the current NRC security requirements are warranted.

Petitioners argue that, in denying their petitions, the NRC violated the AEA, the APA, and NEPA. Although we reject the AEA and APA claims, we agree with Petitioners that the agency has failed to comply with NEPA. We have jurisdiction over those final orders of the NRC made reviewable by 42 U.S.C. § 2239, which includes final orders entered in licensing proceedings, under 28 U.S.C. § 2342(4).

III

We turn first to Petitioners' AEA argument. Specifically, Petitioners argue that the NRC violated its regulations implementing the AEA, as well as the AEA's hearing provisions, when it denied Petitioners a hearing on whether NEPA required consideration of the environmental impact of a terrorist attack on the Storage Installation; they also argue that the NRC violated the AEA's hearing provisions in denying Petitioners a hearing on post-September 11th security measures for the entire Diablo Canyon complex. Both of these challenges fail.

A

[1] The NRC did not violate the AEA or its implementing regulations when it failed to explain its rejection of Petitioners' contentions by addressing each of their arguments. Nothing in the regulations or the AEA requires the NRC to provide such an explanation.

Section 189(a) of the AEA grants public hearing rights "upon the request of any person whose interest may be affected" by an NRC licensing proceeding. 42 U.S.C. § 2239. The

NRC public hearing regulations, at 10 C.F.R. § 2.309, "promulgated pursuant to the AEC's[6] power to make, promulgate, issue, rescind, and amend such rules and regulations as may be necessary to carry out the purposes of" the AEA, 12 U.S.C. § 2201(p), specify the procedures required of both petitioners and the NRC in making and deciding hearing petitions.

[2] Petitioners correctly observe that the NRC, in its decision, did not discuss whether Petitioners satisfied the regulatory standard. They are mistaken, however, in their unsupported contention that this omission amounts to the agency's failure to follow its own regulations and thus is "reversible error." The regulations simply do not require the NRC to explain its decisions in any particular manner. Although the NRC regulations are specific and demanding in what they require of petitioners, they demand far less of the NRC in responding to a petition: the regulations require only a timely "decision." *See* 10 C.F.R. § 2.714(i) ("Decision on request/petition. The presiding officer shall, within 45 days after the filing of answers and replies . . . issue a decision on each request for hearing/petition to intervene."). Because Petitioners do not claim that the NRC violated this requirement, we must reject this challenge.

B

[3] The NRC's denial of a hearing on whether NEPA requires consideration of the environmental effects of a terrorist attack on the Storage Installation did not violate the AEA's hearing provisions.

[4] Petitioners contend that the NRC relied on an improper ground in denying their request for a hearing on whether

[6]In 1974, Congress eliminated the Atomic Energy Commission ("AEC"). Regulatory functions went to the NRC, and promotional functions to the Energy Research and Development Administration. *See* Energy Reorganization Act of 1974, 42 U.S.C. § 5814.

NEPA requires the Commission to consider the environmental impacts of terrorism — namely, the ground that it had determined in earlier decisions that NEPA imposes no such obligation. Thus, Petitioners do not challenge the substantive validity or coherence of those earlier opinions in making their AEA claim, but rather the reliance upon a prior determination of the merits in order to reject a petition presenting the same issues. As such, *Sierra Club v. NRC*, 862 F.2d 222 (9th Cir. 1988), on which Petitioners rely, does not apply. In that case, the NRC rejected the petitioners' contentions as lacking in reasonable specificity, and yet went on to analyze the merits of those supposedly unacceptable contentions. *Id.* at 228. Here, however, where the agency is rejecting the contentions as contrary to a prior decision, the "merits" and the reason for the inadmissibility of the contention collapse. Put differently, the NRC did not reach the merits of the petition as much as it assessed the issues raised against issues resolved by prior decisions. We hold that in doing so, the Commission complied fully with the AEA. To hold otherwise would unduly restrict the agency's evaluation of hearing petitions, by requiring it to grant a hearing on issues it has already resolved whenever a petitioner claims to have new evidence. We can find, and Petitioners point to, nothing in the AEA that would require this result.

C

[5] The NRC's denial of a hearing on security measures for Diablo Canyon as a whole also did not violate the AEA. Petitioners argue that the AEA requires the NRC to grant petitioners a hearing on all issues of material fact, including the security of the entire Diablo Canyon complex. Petitioners therefore conclude, citing *Union of Concerned Scientists v. NRC*, 735 F.2d 1437 (D.C. Cir. 1984), that the NRC violated the AEA when it denied a hearing on that issue.

Petitioners' argument misreads *Union of Concerned Scientists*, in which the D.C. Circuit held only that the agency cannot by rule presumptively eliminate a material issue from consideration in a hearing petition. *Union of Concerned Scientists* requires the agency to consider a petition; it does not require that the agency grant it.

The NRC in CLI 02-23 did not deny that security requirements for the entire complex might need to be upgraded, but rather maintained that a licensing proceeding hearing (and one regarding an installation, not the entire complex) was not the correct forum in which to address the issue. The Commission directed Petitioners to participate in a rulemaking or to raise their concerns in a hearing then pending before the Licensing Board. Petitioners contend that these alternative fora are illusory, and that rejection of their petition amounted to the denial of any opportunity to participate in the consideration of post-9/11 security measures for the Diablo Canyon complex.

Petitioners argue "[i]f the NRC were going to resolve Petitioners' concerns that grossly inadequate security made the Diablo Canyon facility vulnerable to terrorist attacks generically, through a rulemaking, such a rulemaking would have been initiated as a result of the 'comprehensive security review' undertaken by the NRC." Thus, Petitioners argue that it would have been futile to submit a rulemaking petition. This argument must fail, as Petitioners did not use the available procedures for initiating a rulemaking. Petitioners cannot complain that NRC failed to institute a rulemaking they never requested.

[6] Given that rulemaking may have been an avenue for Petitioners' participation, had they chosen to pursue it, their argument that they had no forum in which to raise their contentions loses its force. However, even were Petitioners correct in their assertion that they were unfairly denied the opportunity to participate in a rulemaking proceeding, the argument that the Licensing Board hearing was similarly illusory would fail. In fact, Petitioners were attempting to use the present Storage Installation licensing proceeding as a means of launching a much broader challenge to the Diablo Canyon complex. The NRC correctly observes that a petition alleging that existing NRC regulations are "grossly inadequate to protect against terrorist attack, and therefore must be supplemented by additional requirements" cannot in fact be raised before the Licensing Board, which cannot hear challenges to NRC rules. The limited scope of licensing proceedings does not, however, amount to the arbitrary denial of a forum, as Petitioners claim. While Petitioners could have raised site-specific issues "relating to the 'common defense and security' " that were not controlled by existing rules or regulations to the Licensing Board, they are not entitled to expand those proceedings to include the entire complex, and issues already covered by agency rules.

D

In short, the NRC did not violate the AEA in denying the petitions for a hearing. Neither the AEA nor its implementing regulations required the NRC to grant Petitioners a hearing on whether NEPA required a consideration of the environmental impact of a terrorist attack on the Storage Installation or the security measures adopted for the entire Diablo Canyon complex.

IV

[7] The NRC's reliance on its own prior opinions in its decision in this case does not violate the APA's notice and comment provisions. Petitioners argue that the decisions in CLI 03-01 and *PFS* amount to the announcement "of a general policy of refusing to consider the environmental impacts of terrorist attacks in Environmental Impact Statements." Petitioners rely on *Mada-Luna v. Fitzpatrick*, 813 F.2d 1006, 1014 (9th Cir. 1987) to claim that this policy depends on factual determinations not found subsequent to an evidentiary proceeding, and constitutes a "binding substantive norm," the promulgation of which, without a public hearing, violates the

APA notice and comment provisions contained in 5 U.S.C. §§ 553(b), (c).[7] The flaw in Petitioners' argument is the mistaken assertion that the NRC's decisions were factual and not legal. If the NRC's conclusion that terrorism need not be examined under NEPA were factual, then Petitioners would be correct that its determination would have to comply with APA rulemaking requirements, including notice and comment, or else the agency would have to permit petitioners to challenge it in every proceeding where it was disputed.

[8] That NEPA does not require consideration of the environmental impacts of terrorism is a legal, and not a factual, conclusion. *Cf. Greenpeace Action v. Franklin*, 14 F.3d 1324, 1331 (9th Cir. 1993) (reasoning that a challenge to the adequacy of an EA turned on factual, not legal, principles where both NEPA's applicability and the requirements it imposed were uncontested); *see also Alaska Wilderness Recreation & Tourism Ass'n v. Morrison*, 67 F.3d 723, 727 (9th Cir. 1995) (noting that although "challenges to agency actions which raise predominantly legal, rather than technical questions, are rare," the court was there required to address "just such a challenge"). Petitioners' analysis is therefore inapposite. The agency has the discretion to use adjudication to establish a binding legal norm. *See Sec. & Exch. Comm'n v. Chenery*, 332 U.S. 194, 199-203 (1947) ("[T]he choice made between proceeding by general rule or by individual, ad hoc litigation, is one that lies primarily in the informed discretion of the administrative agency."). We therefore agree with the NRC's characterization in its brief to this court: having come to the legal conclusion that NEPA does not require consideration of the environmental consequences of terrorist attacks, "[w]hen

[7]U.S.C. § 553(b) states that "[g]eneral notice of proposed rulemaking shall be published in the Federal Register," and outlines the requirements that such notice must meet. 5 U.S.C. § 553(c) states that after such notice has been given, "the agency shall give interested persons an opportunity to participate in the rulemaking through submission of written data, views, or arguments with or without opportunity for oral presentation."

petitioners in this case presented a proposed contention seeking an EIS that analyzed the impacts of possible terrorist acts at the proposed Diablo Canyon Installation, the NRC reasonably concluded that this request was sufficiently similar to the request in *PFS* to justify the application of that decision here."

V

Although we hold that the agency did not violate the APA when it relied on the prior resolution of a legal issue through adjudication, we come to a different conclusion as to that determination's compliance with NEPA. Because the issue whether NEPA requires consideration of the environmental impacts of a terrorist attack is primarily a legal one, we review the NRC's determination that it does not for reasonableness. *See Alaska Wilderness Recreation & Tourism Ass'n*, 67 F.3d at 727 (reviewing predominately legal issue for reasonableness because "it makes sense to distinguish the strong level of deference we accord an agency in deciding factual or technical matters from that to be accorded in disputes involving predominately legal questions"); *Ka Makani'o Kohala Ohana, Inc. v. Water Supply*, 295 F.3d 955, 959 n.3 (9th Cir. 2002) ("Because this case involved primarily legal issues . . . based on undisputed historical facts, we conclude that the 'reasonableness' standard should apply to this case.").

Here, the NRC decided categorically that NEPA does not require consideration of the environmental effects of potential terrorist attacks. In making this determination, the NRC relied on *PFS*, where it "consider[ed] in some detail the legal question whether NEPA requires an inquiry into the threat of terrorism at nuclear facilities." 56 NRC 340, 343 (2002). In that case, intervenor State of Utah filed a contention claiming that the September 11 terrorist attacks "had materially changed the circumstances under which the Board had rejected previously proffered terrorism contentions by showing that a terrorist attack is both more likely and potentially more dangerous than previously thought." *Id.* at 345. The NRC concluded that even following the September 11th attacks, NEPA did not impose such a requirement, reasoning:

> In our view, an EIS is not an appropriate format to address the challenges of terrorism. The purpose of an EIS is to inform the decisionmaking authority and the public of a broad range of environmental impacts that will result, with a fair degree of likelihood, from a proposed project, rather than to speculate about 'worst-case' scenarios and how to prevent them.

Id. at 347.

The NRC determined that four grounds "cut[ ] against using the NEPA framework" to consider the environmental effects of a terrorist attack: (1) the possibility of a terrorist attack is far too removed from the natural or expected consequences of agency action; (2) because the risk of a terrorist attack cannot be determined, the analysis is likely to be meaningless; (3) NEPA does not require a "worst-case" analysis; and (4) NEPA's public process is not an appropriate forum for sensitive security issues. *Id.* at 348. We review each of these four grounds for reasonableness, and conclude that these grounds, either individually or collectively, do not support the NRC's categorical refusal to consider the environmental effects of a terrorist attack.

A

[9] The Commission relied first on finding that the possibility of a terrorist attack is too far removed from the natural or expected consequences of agency action. *Id.* at 347. Section 102 of NEPA requires federal agencies to prepare "a detailed statement . . . on the environmental impact" of any proposed major federal action "significantly affecting the quality of the human environment." 42 U.S.C. § 4332(1)(C)(i). The question thus becomes whether a given action "significantly affects" the environment.

The NRC claims that the appropriate analysis of Section 102 is that employed by the Supreme Court in *Metropolitan Edison Co. v. People Against Nuclear Power*, 460 U.S. 766, 773 (1983). In *Metropolitan Edison*, the Court noted that "[t]o determine whether Section 102 requires consideration of a particular effect, we must look to the relationship between that effect and the change in the physical environment caused by the major federal action at issue," looking for "a reasonably close causal relationship . . . like the familiar doctrine of proximate cause from tort law." 460 U.S. at 774. The Commission claims that its conclusion that the environmental impacts of a possible terrorist attack on an NRC-licensed facility is beyond a "reasonably close causal relationship" was a reasonable application of this "proximate cause" analogy.

The problem with the agency's argument, however, is that *Metropolitan Edison* and its proximate cause analogy are inapplicable here. In *Metropolitan Edison*, the petitioners argued that NEPA required the NRC to consider the potential risk of psychological damage upon reopening the Three Mile Island nuclear facilities to those in the vicinity. Noting that NEPA is an environmental statute, the Supreme Court held that the essential analysis must focus on the "closeness of the relationship between the change in the environment and the 'effect' at issue." 460 U.S. at 772.

The appropriate analysis is instead that developed by this court in *NoGwen Alliance v. Aldridge*, 855 F.2d 1380 (9th Cir. 1988). In *NoGwen*, the plaintiffs argued that NEPA required the Air Force to consider the threat of nuclear war in the implementation of the Ground Wave Emergency Network ("GWEN"). We held "that the nexus between construction of GWEN and nuclear war is too attenuated to require discussion of the environmental impacts of nuclear war in an [EA] or [EIS]." 855 F.2d at 1386.

[10] The events at issue here, as well as in *Metropolitan Edison* and *NoGwen*, form a chain of three events: (1) a major federal action; (2) a change in the physical environment; and (3) an effect. *Metropolitan Edison* was concerned with the relationship between events 2 and 3 (the change in the physical environment, or increased risk of accident resulting from the renewed operation of a nuclear reactor, and the effect, or the decline in the psychological health of the human population). The Court in *Metropolitan Edison* explicitly distinguished the case where the disputed relationship is between events 1 and 2: "we emphasize that in this case we are considering effects caused by the risk of accident. The situation where an agency is asked to consider effects that will occur if a risk is realized, for example, if an accident occurs . . . is an entirely different case." *Id.* at 775 n.9. In *NoGwen*, we followed the Court's admonition and, in addressing the relationship between events 1 and 2, we held that the *Metropolitan Edison* analysis did not apply "because it discusse[d] a different type of causation than that at issue in this case . . . [which] require[d] us to examine the relationship between the agency action and a potential impact on the environment." *Id.* at 1386. *NoGWEN* relied on our decision in *Warm Springs Dam Task Force v. Gribble*, 621 F.2d 1017, 1026 (9th Cir. 1980), which held that "an impact statement need not discuss remote and highly speculative consequences." Applying that standard to the plaintiffs' claims that the military GWEN system's installation would "increase the probability of nuclear war," and "that GWEN would be a primary target in a nuclear war," we held both propositions to be "remote and highly speculative," and, therefore, NEPA did not require their consideration.

[11] In the present case, as in *NoGwen*, the disputed relationship is between events 1 and 2 (the federal act, or the licensing of the Storage Installation, and the change in the physical environment, or the terrorist attack). The appropriate inquiry is therefore whether such attacks are so "remote and highly speculative" that NEPA's mandate does not include consideration of their potential environmental effects.

[12] The NRC responds by simply declaring without support that, as a matter of law, "the possibility of a terrorist attack . . . is speculative and simply too far removed from the natural or expected consequences of agency action to require a study under NEPA." 56 NRC at 349. In doing so, the NRC failed to address Petitioners' factual contentions that licensing the Storage Installation would lead to or increase the risk of a terrorist attack because (1) the presence of the Storage Installation would increase the probability of a terrorist attack on the Diablo Canyon nuclear facility, and (2) the Storage Installation itself would be a primary target for a terrorist attack. We conclude that it was unreasonable for the NRC to categorically dismiss the possibility of terrorist attack on the Storage Installation and on the entire Diablo Canyon facility as too "remote and highly speculative" to warrant consideration under NEPA.

[13] In so concluding, we also recognize that the NRC's position that terrorist attacks are "remote and highly speculative," as a matter of law, is inconsistent with the government's efforts and expenditures to combat this type of terrorist attack against nuclear facilities. In the PFS opinion, the NRC emphasized the agency's own post-September 11th efforts against the threat of terrorism:

> At the outset, however, we stress our determination, in the wake of the horrific September 11th terrorist attacks, to strengthen security at facilities we regulate. We currently are engaged in a comprehensive review of our security regulations and programs, acting under our AEA-rooted duty to protect "public health and safety" and the "common defense and security." We are reexamining, and in may cases have already improved, security and safeguards matters such as guard force size, physical security exercises, clearance requirements and background investigations for key employees, and fitness-for-duty requirements. More broadly, we are rethinking

> the NRC's threat assessment framework and design basis threat. We also are reviewing our own infrastructure, resources, and communications.
>
> Our comprehensive review may also yield permanent rule or policy changes that will apply to the proposed PFS facility and to other NRC-related facilities. The review process is ongoing and cumulative. It has already resulted in a number of security-related actions to address terrorism threats at both active and defunct nuclear facilities.

56 NRC at 343. Among these actions is the establishment of an Office of Nuclear Security and Incident Response, "responsible for immediate operational security and safeguards issues as well as for long-term policy development[,] work[-ing] closely with law enforcement agencies and the Office of Homeland Security[,] . . . coordinat[ing] the NRC's ongoing comprehensive security review." *Id.* at 344-45.

We find it difficult to reconcile the Commission's conclusion that, as a matter of law, the possibility of a terrorist attack on a nuclear facility is "remote and speculative," with its stated efforts to undertake a "top to bottom" security review against this same threat. Under the NRC's own formulation of the rule of reasonableness, it is required to make determinations that are consistent with its policy statements and procedures. Here, it appears as though the NRC is attempting, as a matter of policy, to insist on its preparedness and the seriousness with which it is responding to the post-September 11th terrorist threat, while concluding, as a matter of law, that all terrorist threats are "remote and highly speculative" for NEPA purposes.[8]

[8]The view that a terrorist attack is too speculative to be a required part of NEPA review would seem to be inconsistent with the NRC's pre-9/11 security procedures. Since 1977, the NRC has required licensed plants to have a security plan that is designed to protect against a "design basis

[14] In sum, in considering the policy goals of NEPA and the rule of reasonableness that governs its application, the possibility of terrorist attack is not so "remote and highly speculative" as to be beyond NEPA's requirements.

B

[15] The NRC's reliance upon the second *PFS* factor, that the Risk of a Terrorist Attack Cannot be Adequately Determined, 56 NRC at 350, is also not reasonable. First, the NRC's dismissal of the risk of terrorist attacks as "unquantifiable" misses the point. The numeric probability of a specific attack is not required in order to assess likely modes of attack, weapons, and vulnerabilities of a facility, and the possible impact of each of these on the physical environment, including the assessment of various release scenarios. Indeed, this is precisely what the NRC already analyzes in different contexts. It is therefore possible to conduct a low probability-high consequence analysis without quantifying the precise probability of risk. The NRC itself has recognized that consideration of uncertain risks may take a form other than quantitative "probabilistic" assessment. In its "Proposed Policy Statement on Severe Accidents and Related Views on Nuclear Reactor Regulation," 48 Fed.Reg. 16,014 (1983), the Commission stated that:

threat" for radiological sabotage. *See* General Accounting Office, *Nuclear Regulatory Commission: Oversight of Security at Commercial Nuclear Power Plants Needs to be Strengthened*, GAO-030752 (2003) at 6. "The design basis threat characterizes the elements of a postulated attack, including the number of attackers, their training, and the weapons and tactics they are capable of using." *Id.*

Thus, the NRC—even before the terrorist attacks of 9/11—did not consider such attacks too "remote and speculative" to be considered in agency planning. To the contrary, the agency has long required analysis of means and methods of hypothetical attacks against specific facilities, with the goal of establishing effective counter-measures.

> In addressing potential accident initiators (including earthquakes, sabotage, and multiple human errors) where empirical data are limited and *residual uncertainty is large*, the use of conceptual modeling and scenario assumptions in Safety Analysis Reports will be helpful. They should be based on *the best qualified judgments of experts*, either in the form of subjective numerical probability estimates *or qualitative assessments of initiating events and casual [sic] linkages in accident sequences.*

48 Fed.Reg. at 16,020 (emphasis added).

[16] No provision of NEPA, or any other authority cited by the Commission, allows the NRC to eliminate a possible environmental consequence from analysis by labeling the risk as "unquantifiable." *See Limerick Ecology Action, Inc. v. NRC*, 869 F.2d 719, 754 (3rd Cir. 1989) (J. Scirica, dissenting) (finding no "statutory provision, no NRC regulation or policy statement, and no case law that permits the NRC to ignore any risk found to be unquantifiable"). If the risk of a terrorist attack is not insignificant, then NEPA obligates the NRC to take a "hard look" at the environmental consequences of that risk. The NRC's actions in other contexts reveal that the agency does not view the risk of terrorist attacks to be insignificant. Precise quantification is therefore beside the point.

Even if we accept the agency's argument, the agency fails to adequately show that the risk of a terrorist act is unquantifiable. The agency merely offers the following analysis as to the quantifiability of a potential terrorist attack:

> The horrors of September 11 notwithstanding, it remains true that the likelihood of a terrorist attack being directed at a particular nuclear facility is not quantifiable. Any attempt at quantification or even qualitative assessment would be highly speculative. In fact, the likelihood of attack cannot be ascertained

> with confidence by any state-of-the-art methodology. That being the case, we have no means to assess, usefully, the risks of terrorism at the PFS facility.

56 NRC at 350. The agency nonetheless has simultaneously shown the ability to conduct a "top to bottom" terrorism review. This leaves the Commission in the tenuous position of insisting on the impossibility of a meaningful, i.e. quantifiable, assessment of terrorist attacks, while claiming to have undertaken precisely such an assessment in other contexts. Further, as we have noted, the NRC has required site-specific analysis of such threats, involving numerous recognized scenarios.[9]

[17] Thus, we conclude that precise quantification of a risk is not necessary to trigger NEPA's requirements, and even if it were, the NRC has not established that the risk of a terrorist attack is unquantifiable.

C

The NRC's third ground, that it is not required to conduct a "worst-case" analysis, is a non sequitur. Although it is a true statement of the law, the agency errs in equating an assessment of the environmental impact of terrorist attack with a demand for a worst-case analysis.

The Council on Environmental Quality ("CEQ") regulations, 40 C.F.R. §§ 1500.1 - 1518.4, promulgated with the "purpose [of] tell[ing] federal agencies what they must do to comply with [NEPA] procedures and achieve the goals of

[9]The NRC's assertion that a risk of terrorism cannot be quantified is also belied by the very existence of the Department of Homeland Security Advisory System, which provides a general assessment of the risk of terrorist attacks. *See, e.g.*, World Market Research Centre, Global Terrorism Index 2003/4 (offering a probabilistic risk assessment of terrorist activities over a 12-month period).

[NEPA]," have been interpreted by the Supreme Court as "entitled to substantial deference." *Robertson v. Methow Valley Citizens Council*, 490 U.S. 332, 355 (citing *Andrus v. Sierra Club*, 442 U.S. 347, 358 (1979)). These regulations mandated worst-case analyses until 1986, when CEQ replaced the former 40 C.F.R. § 1502.22, requiring an agency, when relevant information was either unavailable or too costly to obtain, to include in the EIS a "worst-case analysis and an indication of the probability or improbability of its occurrence," with the new and current version of the regulation, which requires an agency to instead deal with uncertainties by including within the EIS "a summary of existing credible scientific evidence which is relevant to evaluating the reasonable foreseeable significant adverse impacts on the human environment, and . . . the agency's evaluation of such impacts based upon theoretical approaches or research methods generally accepted in the scientific community." 40 C.F.R. §§ 1502.22(b)(3), (4). The current requirement applies to those events with potentially catastrophic consequences "even if their probability of occurrence is low, provided that the analysis of impacts is supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason." 40 C.F.R. § 1502.22 (b)(4). The Supreme Court held in *Robertson* that the amendment of the regulations had nullified the worst-case analysis requirement. 490 U.S. at 355; *Edwardsen v. U.S. Dep't of Interior*, 268 F.3d 781, 785 (9th Cir. 2001).

The Commission is therefore correct when it argues that NEPA does not require a worst-case analysis. It is mistaken, however, when it claims that "Petitioners' request for an analysis of [the environmental effects of] a successful terrorist attack at the Diablo Canyon ISFSI approximates a request for a 'worst-case' analysis that has long since been discarded by the CEQ regulations . . . and discredited by the Federal courts." According to the NRC, "[m]aking the various assumptions required by [P]etitioners' scenario requires the NRC to venture into the realm of 'pure conjecture.' " We disagree.

[18] An indication of what CEQ envisioned when it imposed the worst-case analysis requirement can be gleaned from a 1981 CEQ memorandum, Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations, reprinted at 46 FR 18026-01 (March 23, 1981). CEQ answered one of those questions, "[w]hat is the purpose of a worst-case analysis? How is it formulated and what is the scope of the analysis?" with the following:

> The purpose of the analysis is to . . . cause agencies to consider th[ ]e potential consequences [of agency decisions] when acting on the basis of scientific uncertainties or gaps in available information. The analysis is formulated on the basis of available information, using reasonable projections of the worst possible consequences of a proposed action.
>
> For example, if there are scientific uncertainty and gaps in the available information concerning the numbers of juvenile fish that would be entrained in a cooling water facility, the responsible agency must disclose and consider the possibility of the loss of the commercial or sport fishery. In addition to an analysis of a low probability/catastrophic impact event, the worst-case analysis should also include a spectrum of events of higher probability but less drastic impact.

46 FR 18026, 18032. While it is true that the agency is not required to consider consequences that are "speculative,"[10] the

[10]Because we disagree with the agency's interpretation of worst-case analysis, we do not reach the agency's characterization of the possibility of terrorist attack as "speculative." We note, however, that this characterization stands out as contrary to the vigilant stance that Americans are encouraged to take by the Department of Homeland Security. *See* www.dhs.gov/dhspublic/display?theme=29 (urging that "[a]ll Americans should continue to be vigilant" and noting that "[t]he country remains at an elevated risk . . . for terrorist attack.")

NRC's argument wrongly labels a terrorist attack the worst-case scenario because of the low or indeterminate probability of such an attack. The CEQ memo, by including as worst-case scenarios events of both higher and lower probability, reveals that worst-case analysis is not defined solely by the low probability of the occurrence of the events analyzed, but also by the range of outcomes of those events. *See also Greater Yellowstone Coalition v. Flowers*, 321 F.3d 1250, 1260 (10th Cir. 2003) (citing a witness's testimony that the loss of bald eagle nesting sites was both "likely" and "a worst-case scenario"). Petitioners do not seek to require the NRC to analyze the most extreme (i.e., the "worst") possible environmental impacts of a terrorist attack. Instead, they seek an analysis of the range of environmental impacts likely to result in the event of a terrorist attack on the Storage Installation. We reject the Commission's characterization of this request as a demand for a worst-case analysis.

D

[19] The NRC's reliance on the fourth *PFS* factor, that it cannot comply with its NEPA mandate because of security risks, is also unreasonable. There is no support for the use of security concerns as an excuse from NEPA's requirements. While it is true, as the agency claims, that NEPA's requirements are not absolute, and are to be implemented consistent with other programs and requirements, this has never been interpreted by the Supreme Court as excusing NEPA's application to a particularly sensitive issue. *See Weinberger v. Catholic Action of Hawaii*, 454 U.S. 139 (1981) (holding that the Navy was required to perform a NEPA review and to factor its results into decisionmaking even where the sensitivity of the information involved meant that the NEPA results could not be publicized or adjudicated). *Weinberger* can support only the proposition that security considerations may permit or require modification of some of the NEPA procedures, not the Commission's argument that sensitive security issues result in some kind of NEPA waiver.

The application of NEPA's requirements, under the rule of reason relied on by the NRC, is to be considered in light of the two purposes of the statute: first, ensuring that the agency will have and will consider detailed information concerning significant environmental impacts; and, second, ensuring that the public can both contribute to that body of information, and can access the information that is made public. *Pub. Citizen,* 541 U.S. at 768. To the extent that, as the NRC argues, certain information cannot be publicized, as in *Weinberger,* other statutory purposes continue to mandate NEPA's application. For example, that the public cannot access the resulting information does not explain the NRC's determination to prevent the public from *contributing* information to the decisionmaking process. The NRC simply does not explain its unwillingness to hear and consider the information that Petitioners seek to contribute to the process, which would fulfill both the information-gathering and the public participation functions of NEPA. These arguments explain why a *Weinberger*-style limited proceeding might be appropriate, but cannot support the NRC's conclusion that NEPA does not apply. As we stated in *NoGWEN*: "There is no 'national defense' exception to NEPA . . . 'The Navy, just like any federal agency, must carry out its NEPA mandate to the fullest extent possible and this mandate includes weighing the environmental costs of the [project] even though the project has serious security implications.' " 855 F.2d at 1384 (quoting *Concerned About Trident v. Rumsfeld,* 555 F.2d 817, 823 (D.C. Cir. 1977)).

E

[20] In sum, none of the four factors upon which the NRC relies to eschew consideration of the environmental effects of a terrorist attack satisfies the standard of reasonableness. We must therefore grant the petition in part and remand for the agency to fulfill its responsibilities under NEPA.

[21] Our identification of the inadequacies in the agency's NEPA analysis should not be construed as constraining the

NRC's consideration of the merits on remand, or circumscribing the procedures that the NRC must employ in conducting its analysis. There remain open to the agency a wide variety of actions it may take on remand, consistent with its statutory and regulatory requirements. We do not prejudge those alternatives. Nor do we prejudge the merits of the inquiry. We hold only that the NRC's stated reasons for categorically refusing to consider the possibility of terrorist attacks cannot withstand appellate review based on the record before us.

We are also mindful that the issues raised by the petition may involve questions of national security, requiring sensitive treatment on remand. However, the NRC has dealt with our nation's most sensitive nuclear secrets for many decades, and is well-suited to analyze the questions raised by the petition in an appropriate manner consistent with national security.

VI

We deny the petition as to the claims under the AEA and the APA. However, because we conclude that the NRC's determination that NEPA does not require a consideration of the environmental impact of terrorist attacks does not satisfy reasonableness review, we hold that the EA prepared in reliance on that determination is inadequate and fails to comply with NEPA's mandate. We grant the petition as to that issue and remand for further proceedings consistent with this opinion.

PETITION GRANTED IN PART; DENIED IN PART; REMANDED.

Mail Envelope Properties (449C3D1E.C69 : 8 : 56425)

Subject: Citizens Awareness Network's Scoping Comments on EIS for proposed VY License Renewal in Docket 50-271
Creation Date Fri, Jun 23, 2006 3:11 PM
From: Jon Block <jonb@sover.net>

Created By: jonb@sover.net

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Options
Expiration Date: None
Priority: Standard
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Return Notification: None

Concealed Subject: No
Security: Standard

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Junk Mail settings when this message was delivered
Junk Mail handling disabled by User
Junk Mail handling disabled by Administrator
Junk List is not enabled
Junk Mail using personal address books is not enabled
Block List is not enabled

ML061770052

From: "Sherman, William" <William.Sherman@state.vt.us>
To: <VermontYankeeEIS@nrc.gov>
Date: Fri, Jun 23, 2006 4:24 PM
Subject: VT Dept of Pub Service Comments - License Renewal EIS for Vermont Yankee

Please accept the attached comments from the Vermont Department of Public Service for the EIS for License Renewal of Vermont Yankee Nuclear Power Station.

<<VT-DPS Comments -VY-EIS.pdf>>

4/21/06
71 FR 20733

(10)

Bill Sherman
State Nuclear Engineer
Vermont Department of Public Service
(802) 828-3349

SUNSI Review Complete
Template=ADM-013

E-RIDS=ADM-03
Add= R. Emch (RLE)

June 23, 2006

Chief, Rules and Directives Branch
Division of Administrative Services
Office of the Administration
Mailstop T-6D59
U.S. Nuclear Regulatory Commission
Washington D.C. 20555-0001

Re: Vermont Yankee, 50-271, License Renewal
Vermont Department of Public Service comments on the Environmental Report

Vermont Department of Public Service comments on the scope of issues to be addressed in the Environmental Impact Statement (EIS) are provided on Attachment A to this letter. These comments are provided in accordance with Federal Register Notice, Vol 71, No. 77, Friday April 21, 2006, pages 20733-20735.

The Department of Public Service appreciates the opportunity to make these comments. Please call if there are questions.

Sincerely,

William Sherman
State Nuclear Engineer

Attachment A
Vermont Department of Public Service Comments
EIS for License Renewal for Vermont Yankee Nuclear Power Station

Category I item - Onsite Land Use

1. 10 C.F.R. §54.23 requires the Applicant to submit an environmental report that complies with Subpart A of 10 C.F.R. Part 51.

2. 10 CFR §51.53(c)(3)(iv) provides that the " [t]he environmental report must contain any new and significant information regarding the environmental impacts of license renewal of which the applicant is aware."

3. New and significant information exists regarding the time for which onsite land will be removed from other uses, and whether such land use is irretrievable, which was not provided in the ER by the Applicant in accordance with 10 C.F.R. §51.53(c)(3)(iv). The current estimate in the Generic Environment Impact Statement (GEIS) is on-site storage of spent fuel will not last beyond 30 years after the end of the license period (including an extended license period). GEIS, Sections 6.4.6.2, 3.

4. The GEIS evaluates the impacts associated with onsite land use as Category 1, SMALL. The basis for this assessment is the assumption that the land used for storage of nuclear wastes at the reactor site will not exceed 30 years after the end of the license term. GEIS, Section 3.2 (referring to GEIS Chapter 6). That assumption, in turn, relies upon the assumption that a permanent high level waste repository, and perhaps even a second repository, will be in place by that time to receive the reactor wastes. GEIS, Section 6.4.6.2 Based on those assumptions the use of the reactor site for storing spent fuel, in this case for a period ending in 2062, has been deemed to be a small impact. GEIS, Section 3.2.

5. However, as summarized below, these assumptions are flawed. Recent evidence, not evaluated previously in the GEIS, now discloses that: 1) the likelihood that a permanent high level waste repository will be in place by 2062 is slight due to unanticipated technical problems uncovered at the Yucca Mountain site coupled with changes in national policy; 2) the only currently contemplated high level waste repository can accommodate the quantity of spent nuclear fuel expected to be produced by Vermont Yankee through the end of its originally licensed life, but it would not have space for at least a part of the additional spent nuclear fuel generated by VY during extended licensing; 3) no present plans exist for building a second high level waste repository nor has any site been identified for consideration for such a facility; 4) the United States is now embarking upon a changed policy for waste disposal which will make all the current schedules obsolete and for which there is no reliable time frame for its implementation; 5) there is not now nor has there been any reasonable prospect that the federal government or any third party will take title to the license-renewal spent fuel waste and remove it from the site; and 6) it follows that it is reasonable to expect that at least a part of spent fuel to be generated at VY during the period of an extended license will remain at the site for a much longer time than evaluated in the GEIS and perhaps indefinitely.

6. Since this new information, not available at the time of development of the GEIS, demonstrates that the commitment of onsite land for storage/disposal of spent nuclear fuel from license renewal will be substantially longer than assumed in the *GEIS,* and may be indefinite, this results in an irretrievable commitment of onsite land with a MODERATE or LARGE impact.

7. As demonstrated below, Vermont and its communities have firmly established values associated with land use such that the long-term or indefinite use of a portion of the VY site for spent nuclear fuel storage should clearly be evaluated as a MODERATE or LARGE impact in the VY supplement to the GEIS.

8. Entergy identifies in Environmental Report (ER) Section 6.4.2, that the land required to dispose of spent nuclear fuel as a result of operation during an extended license represents a irreversible and irretrievable commitment of resources. Entergy does not qualify the irreversible or irretrievable nature of this land use to a limited time period. Therefore, Entergy is identifying this use as indefinite. This identification is in conflict with the GEIS which does not identify such land use as irreversible and irretrievable. This difference from the GEIS requires should be addressed in the EIS for the impact of onsite land use.

9. In ER Section 4.0, Entergy refers to 10 CFR 51, Appendix B, Table B-1, which identifies onsite land use as Category 1, SMALL impact. But this identification only refers to the portion of land from license renewal as being "a small fraction of any nuclear power plant site," and does not include evaluation of the indefinite removal of the land from any beneficial use.

10. Entergy demonstrates in the Environmental Report (ER) Section 4.0 a flawed application of its obligations to identify new and significant information. Section 4.0 contains the statement,

> "Entergy reviewed the NRC findings on these 52 issues and identified no new and significant information that would invalidate the findings for VYNPS."

The flaw is the identification of items in Table 4-2, which are purported to be the Category 1 issues applicable to VYNPS. *Land Use (license renewal period)* is listed in Table 4-2. But the adverse impact is from the land use beyond the license renewal period, caused by the actions during the license renewal period. If Table 4-2 has been stated correctly, then perhaps Entergy would have provided the new and significant information related to onsite land use.

11. The EIS should take into account that the nation's policy with regard to spent fuel management has changed since the GEIS. The current administration and Congress have

announced a major shift in policy called the Global Nuclear Energy Partnership (GNEP). Refer in general to the Administration's GNEP website - http://www.gnep.energy.gov/ - which contains the announcement and much information regarding this new policy direction. Proponents of this new policy hope this new approach will not separate out plutonium products. However the referenced website shows that this technique has neither been developed nor demonstrated.

12. This shift in policy will remove attention and resources from repository development such that the basis and conclusions that spent fuel will not have to be stored on site beyond 2062 are no longer valid. For example, see the report of comments below from Sen. Pete Domenici:

> MOVEMENT OF SPENT FUEL IN THE US COULD BE FURTHER DELAYED, according to Senator Pete Domenici, the New Mexico Republican who chairs the Energy and Natural Resources Committee. Domenici indicated during a status hearing on DOE's repository program at Yucca Mountain, Nevada that it was unrealistic to proceed with a status-quo repository project and later factor in spent fuel reprocessing waste and recycling activities associated with DOE's new fuel-cycle initiative, the Global Nuclear Energy Partnership. It ought to be pretty clear to everyone that spent fuel rods won't be put into Yucca Mountain, Domenici said in an apparent reference to GNEP, which is aimed, in part, at closing the nuclear fuel cycle in the US and abroad. Recycling will determine what kind of repository the US needs, he added. "It's a mess," Domenici said, of the Yucca Mountain program as reporters approached him after the hearing. He said that he believes any legislation on Yucca Mountain would have to include language on spent fuel recycling. Draft legislation DOE sent to Congress last month did not include language on spent fuel reprocessing.

Platts Nuclear News Flashes, Tuesday, May 16, 2006, Copyright McGraw Hill Publications 2005, reprinted with permission

13. In addition, the EIS should consider that the previous assumption regarding the suitability of Yucca Mountain as a permanent waste disposal site is no longer valid. At Yucca Mountain, contrary to the assumptions underlying the GEIS, it has been discovered that the disposal area is subject to water in-leakage. Therefore the design must be changed from that previously assumed and it is not clear a new design can be developed which will meet dose and integrity requirements. Partially in response to this discovery, DOE has abandoned previous cask designs and now proposes a concept called the TAD (transportation, aging and disposal) standard canister for which there is not presently even a preliminary design.

14. Further, the EIS should stated that these changes have occurred in an increasingly hostile political environment. Senate minority leader Harry Reid (D-NV) strongly opposes development of Yucca Mountain and is able to use his position as minority leader effectively to advance this opposition and would do so even more forcefully as majority leader if the Senate leadership changes parties. And, the Western Governor's Association (WGA) has the following active resolution (03-16):

> On December 1, 1989, the Western Governors' Association adopted Resolution 89-024 which stated that spent nuclear fuel should remain at reactor sites until a state has agreed to storage and DOE provides reasonable transportation, safety, and emergency response assurances to the western states. The resolution was readopted in 1992, 1995, 1997, and 1999.

All of the new information identified above provides additional arguments and evidence to bolster the opposition of Senator Reid and the WGA and undercut the assumed completion date for a usable high level waste repository.

15. In addition, the EIS should evaluate, because the GEIS was prepared before September 11, 2001, it does not factor in the impact of viable terrorist threats into an evaluation of the socioeconomic impacts of indefinitely storing spent fuel at the reactor site. The extended long-term or indefinite presence of spent nuclear fuel at Vermont Yankee after permanent shutdown means a defined terrorist target will be present for the long-term or indefinitely. In its news release No. 03-053 (April 29, 2003), NRC stated:

> The Commission believes that this DBT [Design Basis Threat] represents the largest reasonable threat against which a regulated private security force *should be expected to defend* under existing law.

(Emphasis added). The phrase, *should be expected to defend,* means there is a limit on the expectation on Entergy, and that state resources will be expected to provide additional security responses beyond Entergy's capability. The very presence of this target creates an effect on that land, contiguous lands, and the surrounding area, creating the need for continuous augmented emergency preparedness plans and security response from the State. The EIS should evaluate this increased, long term burden on state resources. See also the decision of *San Luis Obispo Mothers for Peace V. Nuclear Regulatory Commission,* U.S. Court of Appeals for the Ninth Circuit, No. 03-74628 (June 2, 2006).

16. Entergy has stated that all of the spent fuel projected to be generated by Vermont Yankee through the end of its current operating license (including increases of spent fuel from power uprate) will be within the 70,000 metric tons storage limits of the "first" repository. The

EIS should identify that at least some part of the spent fuel from license renewal will exceed the 70,000 metric ton limit (when all spent fuel being generated nationally is considered) and must go into a second repository, and that this entry of Entergy into the second repository is specifically the result of the license renewal.

17. The Massachusetts Institute of Technology (MIT), in 2003, performed a study: *The Future of Nuclear Power: An Interdisciplinary MIT Study.* Entergy should have identified that it sponsored the co-chair of the study, Dr. Ernest Moniz, Director of Energy Studies, Laboratory for Energy and the Environment, MIT Department of Physics, as a witness in PSB Docket No. 7082, regarding authorization for dry cask storage. In that docket, Dr. Moniz testified:

> [T]he MIT Study argues that "interim" storage of spent fuel (which can be carried out either at reactor sites or in consolidated facilities, possibly under federal control) for fifty to seventy years is in any case a preferred approach for design of an integrated spent fuel management system.

The implication of Entergy's testimony through Dr. Moniz is that the first repository will not be available for "fifty to seventy years." If the schedule for the first repository is "fifty to seventy years," a time period greater than evaluated in the GEIS, then the schedule for a second repository is indefinite at best, if such a repository could ever be built. The EIS should take note of this fact.

18. The EIS should identified how Vermont would evaluate the onsite land use which would occur if license renewal were granted. Vermont assigns a high value to land and its use within the state. The values are codified in the form of environmental protections in permitting criteria in 10 V.S.A Chapter 151, State Land Use and Development Plans (see Exhibit Vermont-5).

19. Criteria No. 7 of 10 V.S.A §6086 (a) states:

> [Before granting a permit, the district commission shall find that the subdivision or development:]
>
> (7) Will not place an unreasonable burden on the ability of the local governments to provide municipal or governmental services.

The long-term or indefinite storage of license renewal spent fuel at VY would trigger long-term burdens on local governments for emergency management and security services. It is highly likely that long-term or indefinite storage of the spent fuel created by license renewal would not comply with Criteria No. 7. Therefore, this would suggest the impact of the proposed onsite land use should be determined to be LARGE in the VY supplement to the GEIS.

20. Criteria No. 8 of 10 V.S.A §6086 (a) states:

> [Before granting a permit, the district commission shall find that the subdivision or development:]
>
> (8) Will not have an undue adverse effect on the scenic or natural beauty of the area, aesthetics, historic sites or rare and irreplaceable natural areas.

Under this criteria, the District Environmental Commission would evaluate the effect of spent nuclear fuel being left long-term or indefinitely on a riverbank site that would otherwise be fully returned to greenfield condition. It is highly likely the long-term or indefinite presence of spent nuclear fuels following decommissioning of VY would be deemed to create an undue adverse effect. Considering this criteria, the proposed onsite land use should be evaluated as MODERATE or LARGE in the VY supplement to the GEIS.

21. In addition, Vermont's land use law requires a finding that land uses are in conformance with local or regional plans:

> (10) Is in conformance with any duly adopted local or regional plan or capital program under chapter 117 of Title 24. In making this finding, if the district commission finds applicable provisions of the town plan to be ambiguous, the district commission, for interpretive purposes, shall consider bylaws, but only to the extent that they implement and are consistent with those provisions, and need not consider any other evidence.

10 V. S.A. §6086 (a)(10).

22. The Windham Regional Plan of October 30, 2001, which is applicable to VY, establishes land use requirements, and has the following provision:

> LAND USE POLICIES
>
> Rural Residential Lands
>
> 1. Ensure that any development of rural residential lands will be at densities that will serve to contain rural sprawl, and that are compatible with existing land uses and sensitive to the limitations of the land.

Once the bulk of the site is returned to a greenfield condition, it is doubtful that long-term or indefinite presence of spent nuclear fuel from license renewal would be considered "compatible with existing land uses". This provision suggests the onsite land use impact should at least be evaluated as MODERATE in the VY supplement to the GEIS.

23. The Windham Regional Plan also has the following provision:

COMMUNITY RESOURCE POLICIES

High Level Radioactive Waste

1. Encourage a requirement that permanent spent nuclear fuel (SNF) storage be resolved prior to any consideration of extending or reviewing the operating license of Vermont Yankee.

It is highly likely that a land use evaluation under 10 V.S.A. §6086 (a)(10) would find the proposal for long-term or indefinite storage of spent nuclear fuel from license renewal did not conform with the regional plan with regard to the item above. Thus, this provision suggests a LARGE impact from the onsite land use from the proposed license renewal.

24. There is also a Vernon Town Plan, Nov. 3, 2003, which is applicable to VY. This plan contains the following:

Section III: Resource and Economic Development

Recommendations:

#3 The Town should pursue discussions with appropriate representatives of the Vermont Yankee Nuclear power Company regarding the possible re-use of the power plant site for other commercial and industrial development following decommissioning.

The long-term or indefinite presence of spent nuclear fuel from license renewal has the potential for preventing "other commercial and industrial development following decommissioning." If the spent fuel storage completely prevented the use of the site for other developments, it is highly likely the impact from license-renewal onsite land use would be LARGE. If the spent fuel storage allowed some additional development but hindered other possible commercial and industrial uses, the impact would likely be MODERATE.

25. The extended long-term presence of spent fuel will prevent use of the immediate land

it occupies and will deter other possible uses of larger contiguous areas because of societal and commercial concerns regarding the proximity of radioactive material. From the foregoing, it is shown that the EIS should identify that Vermont has existing land use evaluation criteria, which establish the basis under which the impact from additional long-term or indefinite onsite land use resulting from the spent nuclear fuel generated from license renewal should be evaluated as MODERATE or LARGE in the VY supplement to the GEIS.

Mail Envelope Properties (449C4DE1.3C9 : 21 : 58313)

Subject: VT Dept of Pub Service Comments - License Renewal EIS for Vermont Yankee
Creation Date Fri, Jun 23, 2006 4:23 PM
From: "Sherman, William" <William.Sherman@state.vt.us>

Created By: William.Sherman@state.vt.us

Recipients
nrc.gov
TWGWPO03.HQGWDO01
VermontYankeeEIS

Post Office	**Route**
TWGWPO03.HQGWDO01	nrc.gov

Files	**Size**	**Date & Time**
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VT-DPS Comments -VY-EIS.pdf		56395
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Options

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Return Notification:	None
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Junk Mail Handling Evaluation Results
Message is eligible for Junk Mail handling
This message was not classified as Junk Mail

Junk Mail settings when this message was delivered
Junk Mail handling disabled by User
Junk Mail handling disabled by Administrator
Junk List is not enabled
Junk Mail using personal address books is not enabled
Block List is not enabled

ML061730415

From: "Mike Hebert" <mikehebert@adelphia.net>
To: <VermontYankeeEIS@nrc.gov>
Date: Tue, Jun 20, 2006 9:49 AM
Subject: License extension

Dear Mr. Eads,
I have many more comments on this matter. However, I know how busy you are and that brievity would be appreciated. Thank you for your consideration of this important matter.
Respectfully,
Mike Hebert
Vernon

4/21/06
71FR20703
4

RULES AND DIRECTIVES BRANCH
2006 JUN 23 PM 1:44
RECEIVED

SUNSI Review Complete
Template = ADM-013

E-RIDS = ADM-03
Add = R. Emch (RLE)

Chief, Rules and Directives Branch
Division of Administrative Services
Mailstop T-6D59
U.S. Nuclear Regulatory Commission
Washington, DC 20555

June 16, 2006

Dear Mr. Eads:

The Vermont Yankee nuclear power plant plays an integral role in Vermont's current energy portfolio, and must be part of our future.

Vermont Yankee is a clean, emissions free generating facility that provides stable, low-cost power to our state. These are all crucial factors that businesses take into consideration when determining whether to remain here, or relocate to Vermont.

If Vermont Yankee goes off-line in 2012 where will we find replacement power that is as clean and reliable?

Vermont Yankee is critical to Windham County and Southeast Vermont in particular. Currently, the plant and its contractors employ full time approximately 600 men and women, and provides $80 million to local Vermont businesses through the purchase of goods and services.

Its clean power, sound operations, well paying jobs, and community participation and support helps make the region a great place to live and work.

For all of these reasons, I encourage the Nuclear Regulatory Commission to extend the license of Vermont Yankee for another 20 years.

Sincerely,

Mike Hebert

Mail Envelope Properties (4497FCF2.519 : 24 : 29977)

Subject:	License extension
Creation Date	Tue, Jun 20, 2006 9:49 AM
From:	"Mike Hebert" <mikehebert@adelphia.net>
Created By:	mikehebert@adelphia.net

Recipients
nrc.gov
TWGWPO03.HQGWDO01
VermontYankeeEIS

Post Office	**Route**
TWGWPO03.HQGWDO01	nrc.gov

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NRC Comments - Environmental Scoping Hebert.doc	19968	
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Options

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Junk Mail Handling Evaluation Results
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Junk Mail settings when this message was delivered
Junk Mail handling disabled by User
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Junk List is not enabled
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ML061770071

From:	<sunny@traprockpeace.org>
To:	<vermontyankeeeis@nrc.gov>
Date:	Fri, Jun 23, 2006 11:57 PM
Subject:	Scope of environmental assessment

4/21/06
71 FR 20733
12

RECEIVED
2006 JUN 26 AM 10:40
RULES AND DIRECTIVES BRANCH

Proper Scope of
Environmental Assessment
Predicting Impacts of
End-Stage Operation of the Vernon Reactor

Sunny Miller, Executive
Director
Traprock Peace Center

103A Keets Road

Deerfield, MA 01342

413 773-7427

Background

Traprock Peace Center was founded in Deerfield, Massachusetts 1979 to promote nonviolent resolution of local, national and international conflicts, to work for economic justice and disarmament.

Traprock Peace Center staff, volunteers and supporters join with elders and consultants nationwide cautioning against excessive risks associated with continuing operations at our oldest nuclear reactors.

In the early 1990's we took a close look at
embrittlement at the nation's oldest reactor in Rowe, Massachusetts when they proposed 20 additional years beyond their 40 year license. Thanks to the scrutiny of nuclear engineer Bob Pollard, Pollard left the Nuclear Regulatory Commission after many years of service, distressed because the NRC would not enforce their own regulations. Using only NRC documentation, he showed that the chances of having a melt-down were unacceptably high – we had a greater chance of having a melt-down than winning the Mass Millions lottery. And we didn't have to buy a ticket to play. Regular users of nuclear electricity, and neighbors off the grid had a chance.

SUNSI Review Complete
Template = ADM-013

E-RIDS = ADM-03
Add = R. Emch (RLE)

When public scrutiny helped the NRC and Yankee Rowe operators consider the full details, economic realities helped the operators decide to close that facility. Managers, staff and regulators stayed to work on years of clean-up, retired, or moved on to work at other reactors. No blot of a melt-down smears their resumes, and no suicides that I know of reflected remorse over their decision.

Inadequate Inspections and Oversight at the Vernon reactor

Only after owners and managers of the Vernon reactor asked for the remarkable 20% increase in output, 20 excess years of operations and permission to store radioactive waste in the cheapest containers legally available, did we begin to turn our attentions to the problems at the Vernon reactor.

Proper assessment will take into account that:

For twenty-two years four pumps did not have adequate capacity to pump coolant. We needed this reliability. Neighbors to this nuke, and every other in the country, had perpetual assurances of quality control but no reliable control mechanism. I accepted long ago that people make mistakes. Does your job require that you engage in the fantasy that people won't make mistakes? On August 23, 1996, regulators said a VY violation (of theoretical requirements) involved the failure to include an analysis of the most damaging single failure vulnerability for certain loss of coolant accidents. This condition existed for 22 years without being identified during any of the Cycle analyses, even though a number of reactor and industry operating events and activities related to the RHR system had been reviewed and evaluated by Vermont Yankee staff, again and again during this twenty-two year period. This is just one example that thoroughly illustrates that REALITIES of operations bear only limited resemblance to the theoretical management of reactors. Our proper scope of environmental assessment will fully accept the many ways human beings make mistakes. Proper assessment will review the history of errors, enumerate them and calculate the predictable continuation of human error. The history of mishaps and failures, exposed in public record is only shameful if we do not respond honorably and respectfully to its reality.

In July of 1975, did faulty valves discharge radioactive water into the Connecticut River and Atlantic fisheries? In 1995 did faulty fuel assemblies interfere with valve closing? An adequate scope of environmental assessment will require an extensive period for assessing contamination levels in air, water, soil, plant, animal tissues. Adequate scope will establish radiation monitoring in a 100-mile radius of the Vernon reactor in Massachusetts, New Hampshire and Vermont, on an ongoing basis for the remainder of the license period.

The assessment team will have no fear of retribution for a report that constrains reactor operations.

The assessment team will compare the environmental impact of wind, solar, hydro and geo-thermal alternatives as if they enjoyed the full insurance and financial benefits enjoyed by nuclear energy utilities, and report those comparisons year by year for operations for 10,000 generations-- or for the length of time future generations will need to manage our waste without benefit.

Assessors will compare cultural willingness to isolate materials no longer in use, when those materials pose a health risk, whether is no longer interest in those materials, or whether substantial bribes are available to sell nuclear remains illegally, in both prosperous and desperate times.

An adequate assessment team will include sociologists who can assess the human factors relevant for environmental protection for the length of time needed for isolating wastes produced in a twenty year period, not the environmental protection needed in a twenty year period.

Corruption in the age of
Enron

Futhermore, adequate assessment will accept that excess profits entice excess corruption.

The assessment team will not fear a conclusion that advocates for replacement of nuclear technologies with sustainable and renewable technologies that pose far fewer health and safety risks, and can reduce the economic hardship of storing radioactive wastes, for generations to come. We believe that a thorough safety assessment will uncover numerous problems at New England's oldest operating nuclear reactor.

An effective assessment team will urge all local, state and federal officials to insist that a thorough, independent safety assessment must be done.

As we have learned from Rosa
Parks and Rev. Dr. Martin Luther King, Jr., thorough discourse and thoughtful, persistent nonviolent action are often needed to attain justice -- and some great songs might help us sustain our community, our commitment and our common understanding until we do.

###

CC: <charles@traprockpeace.org>

Mail Envelope Properties (449CB80E.FFC : 19 : 61436)

Subject:	Scope of environmental assessment
Creation Date	Fri, Jun 23, 2006 11:56 PM
From:	<sunny@traprockpeace.org>
Created By:	sunny@traprockpeace.org

Recipients
nrc.gov
TWGWPO03.HQGWDO01
VermontYankeeEIS

traprockpeace.org
charles CC

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Block List is not enabled

VermontYankeeEIS - Stop Vermont Yankee

ML061770078

From:	"Dory Zee" <doryzee@hotmail.com>
To:	<VermontYankeeEIS@nrc.gov>
Date:	06/26/2006 7:53 AM
Subject:	Stop Vermont Yankee

4/21/06

71FR 20733

13

Dear Sirs/Madams,

I am writing to express my grave concern about the re-authorization of the Vermont Yankee Nuclear Power Plant. I want the plant closed. Cheap, renewable and alternative sources of power need to be supported by the government. Nuclear power is not the answer.

I do not want to be irradiated. Nor my rivers, farmlands, children. I am a fisherman, an organic gardener living a wholesome rural lifestyle. You may not know what this lifestyle is like. It is about connecting with the land, with the seasons, with the ways of the earth. I am honored to work with children with special needs. Don't you realize that all these environmental insults cause diseases in our children? Why do you think so many have diseases like autism, mental retardation, cancer? It is no coincidence, our modern practices of poisoning earth, air and water have made us sick, literally. We must learn to live with greater integrity.

Please stop this nuclear madness. There is no safe way to store the spent fuel rods. There is no safe way to mine the uranium. There is no safe level of radiation sent down our rivers and streams. There is many other ways to address energy needs. Please help us protect our beautiful valley from further harm. Close the plant. Now.

Most sincerely,

Dory Zelman, MS, OTR/L

Occupational therapist

RECEIVED 2006 JUN 26 AM 10:40 RULES AND DIRECTIVES BRANCH

SUNSI Review Complete

template = ADM-013

E-RIDS = ADM-03

Add = R. Emch (RLE)

Mail Envelope Properties (449FCAB3.AE4 : 20 : 15076)

Subject:	Stop Vermont Yankee
Creation Date	Mon, Jun 26, 2006 7:53 AM
From:	"Dory Zee" <doryzee@hotmail.com>
Created By:	doryzee@hotmail.com

Recipients
nrc.gov
TWGWPO03.HQGWDO01
VermontYankeeEIS

Post Office	**Route**
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Options

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Security:	Standard

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Junk Mail settings when this message was delivered
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Junk Mail using personal address books is not enabled
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RULES AND DIRECTIVES
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United States Nuclear Regulatory Commission

2006 JUN 27 AM 9:06

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4/01/06
71FR20733

14

E-RIDS=ADM-03

SUNSI Review Complete

Template=ADM-013

Cal = R. Emch (RLE)

Jun 18 06

Dear Chief,

WHITE RIVER JUNCTION VT 050 1 T PM

Maybe you could allow the reactor in Vernon, VT. be shut down and ask Entergy to decomission as was promised.

The radioactive waste is a serious, unresolved problem. Hazardous. No reason to increase our risk to cancer & catastrophy. No reason to approve Entergy's

Cora Brooks

Chief, Rules + Directives
Division of Administrative Services
Office of Administration
Mail stop T 6D 59
U.S. Nuclear Regulatory Commission
Washington, D.C.
20555-0001

RULES AND DIRECTIVES
BRANCH
USNRC

2006 JUN 28 PM 3:38

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4/21/06
71FR20733

15

SUNSI Review Complete
E-RIDS = ADM-03

United States Nuclear Regulatory Commission

Add = R. Emch (RLE)

Template = ADM-013

Box 12 Colrain, MA 01340
June 18, 2006

Dear NRC members:

I recently attended a scoping meeting at Latchis theater in Brattleboro, VT about the Vermont Yankee Nuclear Power Plant. Everyone who spoke expressed their concerns about the safety of the aging plant, the ~~dangerously~~ dangerous and unsecure way in which the "spent" fuel rods are being stored, as well as general concerns about nuclear power plant safety and storage of nuclear wastes. Those who were employed by Vermont Yankee and their families were the only speakers who felt the plant was safe and necessary, but they did not specifically explain why the ~~plants~~ facility was safe, how it was being upkept or inspected, or how the nuclear wastes were being safely secured. They merely told about past safety and the fact that it emits less pollution than oil and coal power plants.

The facts show us that huge amounts of pollution are released during the mining and processing of uranium for fuel rods. The facts show that the potential for a terrorist plot to release high levels of radioactivity by bombing fuel rods ~~and~~ while in transit or in make-shift storage is the greatest terrorist threat we face in the northeast. The facts show that security at the Vermont Yankee Nuclear Facility was breached by protesto (over)

~~to~~ without weapons or planning! The facts show that our region~~s~~ could produce power more cheaply and without any pollution or risk of pollution by starting to install wind towers off shore or in the hills of our region over the next 5 years. ~~The facts~~ show that this region could reduce its power needs significantly by educating people about compact fluorescent bulbs, insulation, heat pumps, more efficient appliances, solar hot water heaters, and hundreds of ways of conserving energy. The mere price of electricity ~~and~~ is currently a huge incentive for conservation, but other tax incentives could also help us to reduce our power needs to ~~the~~ level~~s~~ that would allow the Vernon facility to close in 5 years.

Please respond to reason and our concern for the safety of our population, our tourist industry, organic farms, our colleges, and our homes. All these things would be severely and adversely affected by even a small release of nuclear radiation due to human error, aging machinery or pipes, or terrorism. Please help us by closing and decommissioning this facility in 5 or 6 years as origionally planned. Please help us reduce the risks to our health and safety instead of increasing them. Please save ~~the~~ Connecticut River from overheating.

Many of us are also concerned about the hot water that is being released into the Connecticut River. Studies have shown that the current levels of hot water are harmful and with the 20% "uprate" the temperatures are rising to much higher levels. Why do you want to destroy the ecology of this beautiful river?

Please let our region become an example to the rest of the Nation. Many regions are growing in population and energy usage. Our region is stable and able to reduce our useage through conservation. Please let us try. Please give us the incentive to try by closing this nuclear plant by 2012. Please stop saying that we need nuclear power and there is not a cleaner, safer solution. This is untrue in a region like ours where the population is stable, highly educated, and extremely concerned about the risks of ~~an~~ aging nuclear power plants and poorly stored, highly radioactive, "spent" fuel rods. Please listen to our concerns and respond by closing down this plant as planned. Thank you

Edward Stanes, Emma Stanes by [illegible]

112 STATE STREET
DRAWER 20
MONTPELIER VT 05620-2601
TEL: (802) 828-2811

FAX: (802) 828-2342
TTY (VT): 1-800-734-8390
e-mail: vtdps@psd.state.vt.us
Internet: http://www.state.vt.us/psd

STATE OF VERMONT
DEPARTMENT OF PUBLIC SERVICE

June 23, 2006

4/21/06
71FR 20733
16

RECEIVED
2006 JUN 29 AM 9:16
RULES AND DIRECTIVES

Chief, Rules and Directives Branch
Division of Administrative Services
Office of the Administration
Mailstop T-6D59
U.S. Nuclear Regulatory Commission
Washington D.C. 20555-0001

Re: Vermont Yankee, 50-271, License Renewal
Vermont Department of Public Service comments on the Environmental Report

Vermont Department of Public Service comments on the scope of issues to be addressed in the Environmental Impact Statement (EIS) are provided on Attachment A to this letter. These comments are provided in accordance with Federal Register Notice, Vol 71, No. 77, Friday April 21, 2006, pages 20733-20735.

The Department of Public Service appreciates the opportunity to make these comments. Please call if there are questions.

Sincerely,

William Sherman
William Sherman
State Nuclear Engineer

SUNSI Review Complete
Template = ADM-013

E-RIDS = ADM-03
Add = R. Emch (RLE)

Attachment A
Vermont Department of Public Service Comments
EIS for License Renewal for Vermont Yankee Nuclear Power Station

Category I item - Onsite Land Use

1. 10 C.F.R. §54.23 requires the Applicant to submit an environmental report that complies with Subpart A of 10 C.F.R. Part 51.

2. 10 CFR §51.53(c)(3)(iv) provides that the " [t]he environmental report must contain any new and significant information regarding the environmental impacts of license renewal of which the applicant is aware."

3. New and significant information exists regarding the time for which onsite land will be removed from other uses, and whether such land use is irretrievable, which was not provided in the ER by the Applicant in accordance with 10 C.F.R. §51.53(c)(3)(iv). The current estimate in the Generic Environment Impact Statement (GEIS) is on-site storage of spent fuel will not last beyond 30 years after the end of the license period (including an extended license period). GEIS, Sections 6.4.6.2, 3.

4. The GEIS evaluates the impacts associated with onsite land use as Category 1, SMALL. The basis for this assessment is the assumption that the land used for storage of nuclear wastes at the reactor site will not exceed 30 years after the end of the license term. GEIS, Section 3.2 (referring to GEIS Chapter 6). That assumption, in turn, relies upon the assumption that a permanent high level waste repository, and perhaps even a second repository, will be in place by that time to receive the reactor wastes. GEIS, Section 6.4.6.2 Based on those assumptions the use of the reactor site for storing spent fuel, in this case for a period ending in 2062, has been deemed to be a small impact. GEIS, Section 3.2.

5. However, as summarized below, these assumptions are flawed. Recent evidence, not evaluated previously in the GEIS, now discloses that: 1) the likelihood that a permanent high level waste repository will be in place by 2062 is slight due to unanticipated technical problems uncovered at the Yucca Mountain site coupled with changes in national policy; 2) the only currently contemplated high level waste repository can accommodate the quantity of spent nuclear fuel expected to be produced by Vermont Yankee through the end of its originally licensed life, but it would not have space for at least a part of the additional spent nuclear fuel generated by VY during extended licensing; 3) no present plans exist for building a second high level waste repository nor has any site been identified for consideration for such a facility; 4) the United States is now embarking upon a changed policy for waste disposal which will make all the current schedules obsolete and for which there is no reliable time frame for its implementation; 5) there is not now nor has there been any reasonable prospect that the federal government or any third party will take title to the license-renewal spent fuel waste and remove it from the site; and 6) it follows that it is reasonable to expect that at least a part of spent fuel to be generated at VY during the period of an extended license will remain at the site for a much longer time than evaluated in the GEIS and perhaps indefinitely.

6. Since this new information, not available at the time of development of the GEIS, demonstrates that the commitment of onsite land for storage/disposal of spent nuclear fuel from license renewal will be substantially longer than assumed in the *GEIS,* and may be indefinite, this results in an irretrievable commitment of onsite land with a MODERATE or LARGE impact.

7. As demonstrated below, Vermont and its communities have firmly established values associated with land use such that the long-term or indefinite use of a portion of the VY site for spent nuclear fuel storage should clearly be evaluated as a MODERATE or LARGE impact in the VY supplement to the GEIS.

8. Entergy identifies in Environmental Report (ER) Section 6.4.2, that the land required to dispose of spent nuclear fuel as a result of operation during an extended license represents a irreversible and irretrievable commitment of resources. Entergy does not qualify the irreversible or irretrievable nature of this land use to a limited time period. Therefore, Entergy is identifying this use as indefinite. This identification is in conflict with the GEIS which does not identify such land use as irreversible and irretrievable. This difference from the GEIS requires should be addressed in the EIS for the impact of onsite land use.

9. In ER Section 4.0, Entergy refers to 10 CFR 51, Appendix B, Table B-1, which identifies onsite land use as Category 1, SMALL impact. But this identification only refers to the portion of land from license renewal as being "a small fraction of any nuclear power plant site," and does not include evaluation of the indefinite removal of the land from any beneficial use.

10. Entergy demonstrates in the Environmental Report (ER) Section 4.0 a flawed application of its obligations to identify new and significant information. Section 4.0 contains the statement,

> "Entergy reviewed the NRC findings on these 52 issues and identified no new and significant information that would invalidate the findings for VYNPS."

The flaw is the identification of items in Table 4-2, which are purported to be the Category 1 issues applicable to VYNPS. *Land Use (license renewal period)* is listed in Table 4-2. But the adverse impact is from the land use beyond the license renewal period, caused by the actions during the license renewal period. If Table 4-2 has been stated correctly, then perhaps Entergy would have provided the new and significant information related to onsite land use.

11. The EIS should take into account that the nation's policy with regard to spent fuel management has changed since the GEIS. The current administration and Congress have

announced a major shift in policy called the Global Nuclear Energy Partnership (GNEP). Refer in general to the Administration's GNEP website - http://www.gnep.energy.gov/ - which contains the announcement and much information regarding this new policy direction. Proponents of this new policy hope this new approach will not separate out plutonium products. However the referenced website shows that this technique has neither been developed nor demonstrated.

12. This shift in policy will remove attention and resources from repository development such that the basis and conclusions that spent fuel will not have to be stored on site beyond 2062 are no longer valid. For example, see the report of comments below from Sen. Pete Domenici:

> MOVEMENT OF SPENT FUEL IN THE US COULD BE FURTHER DELAYED, according to Senator Pete Domenici, the New Mexico Republican who chairs the Energy and Natural Resources Committee. Domenici indicated during a status hearing on DOE's repository program at Yucca Mountain, Nevada that it was unrealistic to proceed with a status-quo repository project and later factor in spent fuel reprocessing waste and recycling activities associated with DOE's new fuel-cycle initiative, the Global Nuclear Energy Partnership. It ought to be pretty clear to everyone that spent fuel rods won't be put into Yucca Mountain, Domenici said in an apparent reference to GNEP, which is aimed, in part, at closing the nuclear fuel cycle in the US and abroad. Recycling will determine what kind of repository the US needs, he added. "It's a mess," Domenici said, of the Yucca Mountain program as reporters approached him after the hearing. He said that he believes any legislation on Yucca Mountain would have to include language on spent fuel recycling. Draft legislation DOE sent to Congress last month did not include language on spent fuel reprocessing.

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13. In addition, the EIS should consider that the previous assumption regarding the suitability of Yucca Mountain as a permanent waste disposal site is no longer valid. At Yucca Mountain, contrary to the assumptions underlying the GEIS, it has been discovered that the disposal area is subject to water in-leakage. Therefore the design must be changed from that previously assumed and it is not clear a new design can be developed which will meet dose and integrity requirements. Partially in response to this discovery, DOE has abandoned previous cask designs and now proposes a concept called the TAD (transportation, aging and disposal) standard canister for which there is not presently even a preliminary design.

14. Further, the EIS should stated that these changes have occurred in an increasingly hostile political environment. Senate minority leader Harry Reid (D-NV) strongly opposes development of Yucca Mountain and is able to use his position as minority leader effectively to advance this opposition and would do so even more forcefully as majority leader if the Senate leadership changes parties. And, the Western Governor's Association (WGA) has the following active resolution (03-16):

> On December 1, 1989, the Western Governors' Association adopted Resolution 89-024 which stated that spent nuclear fuel should remain at reactor sites until a state has agreed to storage and DOE provides reasonable transportation, safety, and emergency response assurances to the western states. The resolution was readopted in 1992, 1995, 1997, and 1999.

All of the new information identified above provides additional arguments and evidence to bolster the opposition of Senator Reid and the WGA and undercut the assumed completion date for a usable high level waste repository.

15. In addition, the EIS should evaluate, because the GEIS was prepared before September 11, 2001, it does not factor in the impact of viable terrorist threats into an evaluation of the socioeconomic impacts of indefinitely storing spent fuel at the reactor site. The extended long-term or indefinite presence of spent nuclear fuel at Vermont Yankee after permanent shutdown means a defined terrorist target will be present for the long-term or indefinitely. In its news release No. 03-053 (April 29, 2003), NRC stated:

> The Commission believes that this DBT [Design Basis Threat] represents the largest reasonable threat against which a regulated private security force *should be expected to defend* under existing law.

(Emphasis added). The phrase, *should be expected to defend,* means there is a limit on the expectation on Entergy, and that state resources will be expected to provide additional security responses beyond Entergy's capability. The very presence of this target creates an effect on that land, contiguous lands, and the surrounding area, creating the need for continuous augmented emergency preparedness plans and security response from the State. The EIS should evaluate this increased, long term burden on state resources. See also the decision of *San Luis Obispo Mothers for Peace V. Nuclear Regulatory Commission,* U.S. Court of Appeals for the Ninth Circuit, No. 03-74628 (June 2, 2006).

16. Entergy has stated that all of the spent fuel projected to be generated by Vermont Yankee through the end of its current operating license (including increases of spent fuel from power uprate) will be within the 70,000 metric tons storage limits of the "first" repository. The

EIS should identify that at least some part of the spent fuel from license renewal will exceed the 70,000 metric ton limit (when all spent fuel being generated nationally is considered) and must go into a second repository, and that this entry of Entergy into the second repository is specifically the result of the license renewal.

17. The Massachusetts Institute of Technology (MIT), in 2003, performed a study: *The Future of Nuclear Power: An Interdisciplinary MIT Study.* Entergy should have identified that it sponsored the co-chair of the study, Dr. Ernest Moniz, Director of Energy Studies, Laboratory for Energy and the Environment, MIT Department of Physics, as a witness in PSB Docket No. 7082, regarding authorization for dry cask storage. In that docket, Dr. Moniz testified:

> [T]he MIT Study argues that "interim" storage of spent fuel (which can be carried out either at reactor sites or in consolidated facilities, possibly under federal control) for fifty to seventy years is in any case a preferred approach for design of an integrated spent fuel management system.

The implication of Entergy's testimony through Dr. Moniz is that the first repository will not be available for "fifty to seventy years." If the schedule for the first repository is "fifty to seventy years," a time period greater than evaluated in the GEIS, then the schedule for a second repository is indefinite at best, if such a repository could ever be built. The EIS should take note of this fact.

18. The EIS should identified how Vermont would evaluate the onsite land use which would occur if license renewal were granted. Vermont assigns a high value to land and its use within the state. The values are codified in the form of environmental protections in permitting criteria in 10 V.S.A Chapter 151, State Land Use and Development Plans (see Exhibit Vermont-5).

19. Criteria No. 7 of 10 V.S.A §6086 (a) states:

> [Before granting a permit, the district commission shall find that the subdivision or development:]
>
> (7) Will not place an unreasonable burden on the ability of the local governments to provide municipal or governmental services.

The long-term or indefinite storage of license renewal spent fuel at VY would trigger long-term burdens on local governments for emergency management and security services. It is highly likely that long-term or indefinite storage of the spent fuel created by license renewal would not comply with Criteria No. 7. Therefore, this would suggest the impact of the proposed onsite land use should be determined to be LARGE in the VY supplement to the GEIS.

20. Criteria No. 8 of 10 V.S.A §6086 (a) states:

> [Before granting a permit, the district commission shall find that the subdivision or development:]
>
> (8) Will not have an undue adverse effect on the scenic or natural beauty of the area, aesthetics, historic sites or rare and irreplaceable natural areas.

Under this criteria, the District Environmental Commission would evaluate the effect of spent nuclear fuel being left long-term or indefinitely on a riverbank site that would otherwise be fully returned to greenfield condition. It is highly likely the long-term or indefinite presence of spent nuclear fuels following decommissioning of VY would be deemed to create an undue adverse effect. Considering this criteria, the proposed onsite land use should be evaluated as MODERATE or LARGE in the VY supplement to the GEIS.

21. In addition, Vermont's land use law requires a finding that land uses are in conformance with local or regional plans:

> (10) Is in conformance with any duly adopted local or regional plan or capital program under chapter 117 of Title 24. In making this finding, if the district commission finds applicable provisions of the town plan to be ambiguous, the district commission, for interpretive purposes, shall consider bylaws, but only to the extent that they implement and are consistent with those provisions, and need not consider any other evidence.

10 V. S.A. §6086 (a)(10).

22. The Windham Regional Plan of October 30, 2001, which is applicable to VY, establishes land use requirements, and has the following provision:

> LAND USE POLICIES
>
> Rural Residential Lands
>
> 1. Ensure that any development of rural residential lands will be at densities that will serve to contain rural sprawl, and that are compatible with existing land uses and sensitive to the limitations of the land.

Once the bulk of the site is returned to a greenfield condition, it is doubtful that long-term or indefinite presence of spent nuclear fuel from license renewal would be considered "compatible with existing land uses". This provision suggests the onsite land use impact should at least be evaluated as MODERATE in the VY supplement to the GEIS.

23. The Windham Regional Plan also has the following provision:

COMMUNITY RESOURCE POLICIES

High Level Radioactive Waste

1. Encourage a requirement that permanent spent nuclear fuel (SNF) storage be resolved prior to any consideration of extending or reviewing the operating license of Vermont Yankee.

It is highly likely that a land use evaluation under 10 V.S.A. §6086 (a)(10) would find the proposal for long-term or indefinite storage of spent nuclear fuel from license renewal did not conform with the regional plan with regard to the item above. Thus, this provision suggests a LARGE impact from the onsite land use from the proposed license renewal.

24. There is also a Vernon Town Plan, Nov. 3, 2003, which is applicable to VY. This plan contains the following:

Section III: Resource and Economic Development

Recommendations:

#3 The Town should pursue discussions with appropriate representatives of the Vermont Yankee Nuclear power Company regarding the possible re-use of the power plant site for other commercial and industrial development following decommissioning.

The long-term or indefinite presence of spent nuclear fuel from license renewal has the potential for preventing "other commercial and industrial development following decommissioning." If the spent fuel storage completely prevented the use of the site for other developments, it is highly likely the impact from license-renewal onsite land use would be LARGE. If the spent fuel storage allowed some additional development but hindered other possible commercial and industrial uses, the impact would likely be MODERATE.

25. The extended long-term presence of spent fuel will prevent use of the immediate land

it occupies and will deter other possible uses of larger contiguous areas because of societal and commercial concerns regarding the proximity of radioactive material. From the foregoing, it is shown that the EIS should identify that Vermont has existing land use evaluation criteria, which establish the basis under which the impact from additional long-term or indefinite onsite land use resulting from the spent nuclear fuel generated from license renewal should be evaluated as MODERATE or LARGE in the VY supplement to the GEIS.

Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title:	Vermont Yankee License Renewal Public Scoping Meeting
Docket Number:	(050-00271)
Location:	Brattleboro, Vermont
Date:	Tuesday, June 6, 2006

Work Order No.: NRC-1071 Pages 1-7

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NUCLEAR REGULATORY COMMISSION

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PUBLIC MEETING TO DISCUSS ENVIRONMENTAL SCOPING

FOR THE VERMONT YANKEE NUCLEAR POWER STATION,

LICENSE RENEWAL APPLICATION

+ + + + +

TUESDAY,

JUNE 6, 2006

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BRATTLEBORO, VERMONT

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The Public Meeting was convened at the Quality Inn at 1380 Putney Road in Brattleboro, Vermont, at 2:00 p.m.

<u>SPEAKERS</u>:

MICHAEL MULLIGAN

NANCY CROMPTON

ELLEN KAYE

P-R-O-C-E-E-D-I-N-G-S

2:34 p.m.

MR. MULLIGAN: Hello. I'm Mike Mulligan. I live in Hinsdale, New Hampshire, P.O. Box, 161, Hinsdale, New Hampshire 03451. And my concern is with global warming. What I understand is that the Connecticut River, upstream of Vermont Yankee has been heating up slightly, especially during the summers. It's been turning up for a decade or so, the peak summertime temperatures, as an example.

Or how about river low-flows in a drought situation? So the question is will the re-licensing of Vermont Yankee have -- will they consider what global warming could potentially do with the river temperatures? Will Vermont Yankee have to power down at times for that? Will the environmental temperatures inside the buildings and stuff, are they -- the design environmental temperatures, are they adequate enough so that we wouldn't be confronted with shutting down the plant during the summer, summer time?

I'm concerned about say we're in a drought in the summer time and the plant -- and we approach their limits. Probably around that time other plants would be stressed and the grid of New England would be stressed. So the question is well, do you want to make the grid worse at its most vulnerable time with shutting down Vermont Yankee? Do you want to push the grid electric prices to astronomical prices? Do you want to de-stabilize, the grid maybe, because of not enough voltage or whatever it is.

So I'm generally concerned about projecting out what global warming could potentially do and make sure that there's an adequate margin so that you wouldn't have to cycle down the plant during the summer times. That's it. I talked about cycling down the plant. I meant reducing power. So that's either shutting down the plant or reducing power to 50 percent or some sort of percent type of thing and stuff.

(Off the record.)

MS. CROMPTON: Hi. I'm Nancy Crompton, a resident of Brattleboro, Vermont. I live four miles from Vermont Yankee Nuclear Power Plant. My concerns about living so close to the power plant are concerns that, in fact, would not be alleviated even if I were living far away from the nuclear power plant which I have over the past few months been contemplating. The fact is that there are people, there are 103 nuclear power plants in the United States, all of them generating nuclear waste for which we have no long-term disposal solution.

I've been told that the Federal Government is supposed to have a plan in place by 2025 and I wish to state that that is utterly unacceptable. It is on our watch right now. It is our generation that is responsible for the creation of the nuclear waste and we need a solution, not soon, not tomorrow, but yesterday, decades ago.

We have no moral right to create a poison that can affect the earth and all living creatures for a half life of 25,000 years, if I remember that correctly. We have no moral right to do this. We also do not have to demand so much electricity. We don't really require it. Our inflated desires for the expansion of electrical power have been -- are a 20th century notion of progress at any cost. The cost is now coming due and we are going to have to begin paying for the expansion and -- oh dear, I'm starting to ramble. Can we turn it off?

(Off the record.)

And I very much want to hear the NRC, the Regulatory Commission and other leaders in our country talking about conservation. This is indeed a war. It's as if we are at war against our unchecked desire to progress at the expense of other nations and at the expense of the environment. And we can indeed change our ways and show a willingness to conserve.

I'm concerned about also climate change. Although the nuclear power plant was probably built to withstand a 500-year storm and its effects on the Connecticut River, since we have been seeing 100-year storms in this area and in Boston over the last six months, perhaps the infrastructure is indeed not adequate to be worse worst case scenario, the kinds of storms that we perhaps should be anticipating will happen in the future.

And therefore, I'm very concerned about dry-cask storage, alongside the Connecticut River which flows through Massachusetts and Connecticut to the Long Island Sound and just the idea that nuclear radioactivity could be carried by that water all the way to Long Island Sound should give us great pause. I believe we have to take responsibility right now for the effect that we are having because we are already seeing its effects upon our children and grandchildren.

We know that mercury in the ponds in the fish that we happily go out and catch on a Sunday already in Vermont, we can't allow the children to eat more than four ounces a month and we have seen the effects of children who have more than that. The illnesses and cancers and neurological damage already caused by different kinds of pollutants in Vermont is staggering. We certainly don't need any more.

(Off the record.)

MS. KAYE: I'm Ellen Kaye. I live in Brattleboro, right on the edge of the evacuation zone, the 10-mile radius of Vermont Yankee. My comments about environmental issues regarding Vermont Yankee that I think should be given serious consideration: (a) maybe the only issue is the waste. We're having an increase in production and a relicensing and a lengthening of the time that Vermont Yankee can operate.

What we're getting is more and more waste which we have no way to deal with. That waste is going to last for many, many, many generations. We have no idea what the health effects are going to be. We have no idea what the effects on humans, animals, plant life, everything that makes this place this place. And I am tired of hearing everybody associated with the nuclear power industry and the NRC talk about nuclear power generation without ever addressing waste. So what we have is a hazardous waste dump, a nuclear waste dump on the banks of the Connecticut River.

I'm raising a child here. I hear that cancer rates near the plant are higher than in other places. There's some studies. I hear that Strontium-90 turns up in baby teeth. So this is an experimental thing and we're being experimented on and I don't think it should continue. It should be closed down. We should be looking for safer forms of energy production and we should be conserving.

But what I want the NRC to weigh heavily, it's the waste issue, environmentally, and the cancer issue. Are there cancer clusters around nuclear power plants? Are there elevated rates of breast cancer around nuclear power plants? I read reports that say that there are and it is unfair to experiment with a population when these are questions hanging in the air. It's unconscionable.

I think that's all I need to say today.

(Whereupon, at 7:12 p.m., the public meeting was concluded.)

Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title:	Vermont Yankee Nuclear Power Plant Public Meeting: Afternoon Session
Docket Number:	(050-00271)
Location:	Brattleboro, Vermont
Date:	Wednesday, June 7, 2006

Work Order No.: NRC-1072 Pages 1-116

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NUCLEAR REGULATORY COMMISSION

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PUBLIC MEETING TO DISCUSS ENVIRONMENTAL SCOPING

FOR THE VERMONT YANKEE NUCLEAR POWER STATION,

LICENSE RENEWAL APPLICATION

AFTERNOON SESSION

+ + + + +

WEDNESDAY

JUNE 7, 2006

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BRATTLEBORO, VERMONT

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The Public Meeting was convened at the Latchis Theater at 50 Main Street in Brattleboro, Vermont, at 1:30 p.m., F. "Chip" Cameron, Facilitator, presiding.

NRC STAFF PARTICIPATING:

F. "CHIP" CAMERON

RANI FRANOVICH

RICHARD EMCH

ERIC BENNER

FRANK GILLESPIE

SPEAKERS:

BETH ADAMS
SHAWN BANFIELD
JOHN BLOCK
CAROL BOYER
CORA BROOKS
BILL BURTON
JOHNNY EADS
ROBERT ENGLISH
ANN ELIZABETH HOWES
SARAH KOTKOV
DAN MACARTHUR
DAVID MCELWEE
EVAN MULHOLLAND
JILL NEITLICH
NANCY NELKIN
JANE NEWTON
DEBRA REGER
GARY SACHS
RAY SHADIS
SALLY SHAW
CHRIS WILLIAMS
MEGAN

P-R-O-C-E-E-D-I-N-G-S

1:35 p.m.

MR. CAMERON: Good afternoon, everybody. If we could ask you all to take your seats and we'll get started with this afternoon's meeting.

Okay, Ray, Evan, would you like to join us down here? Are we going to have a lot of continuing feedback with this thing? If we do, let's try to fix it. It seems like there is a lot of feedback.

Again, good afternoon and welcome everybody. My name is Chip Cameron, I'm the Special Counsel for Public Liaison at the Nuclear Regulatory Commission, which we'll be referring to as the NRC, today.

And it's my pleasure to serve as your Facilitator for today's meeting. And our subject today is the environmental review that the NRC conducts as part of its evaluation of a license application that we received from the Entergy Company to renew the operating license for the Vermont Yankee Reactor.

And I just wanted to cover three items of meeting process for you, very quickly, before we get to the substance of our discussions today. And I'd like to talk a little bit about what the format for the meeting is. Secondly, some simple ground rules for running the meeting, and, lastly, I'd just like to introduce the NRC staff who are going to be speaking to you today.

In terms of format, we're going to start out with some brief NRC presentations, to give you some background on the license renewal process. What we look at, what we evaluate in making a decision about whether to renew a license for a reactor.

And we'll have time for some brief questions after those presentations on the license renewal process, to make sure that you understand it before we go to the primary purpose of today's meeting, which is to hear from all of you on this process.

This meeting, as the NRC staff will tell you, is a scoping meeting. That's a term that's used in connection with the preparation of environmental impact statements.

And, basically, what we would like to hear from all of you on, is what issues should be looked at, as the NRC prepares the draft environmental impact statement. What methodology should be used? What alternatives?

And we're looking forward to hearing from you on that today. And we are taking written comments on these issues, and the staff will tell you how to submit written comments, but we wanted to be here with you in person today to talk with you and to listen to you.

In terms of ground rules, they're pretty simple. When you do speak, please introduce yourself to us and give us an affiliation, if you're affiliated with a group.

If that's appropriate, tell us that. And I would ask that only one person speak at a time. Most importantly, so we can give our full attention to whomever has the floor at the moment.

Also, so that our Court Reporter, Pete Holland, up here, can get a clean transcript. So that he knows who is talking. That transcript is the public record of this meeting.

It's our record of the comments and it's your record of what was said here this afternoon. And that will be available to anybody who wants it.

I would ask everybody to try to be brief, so that we can give everyone an opportunity to talk this afternoon. And I'm asking everybody to follow a five minute guideline, when they come up here to the podium to give us their comments.

If you could limit it to five minutes, that would be helpful, and when it gets close to five minutes I may ask you to summarize your comments for us, so that we can go on to the next person.

Five minutes may not seem like a lot of time, but it does accomplish a number of important things. One, it's usually enough time for people to summarize their main points that they want us to hear.

Secondly, it alerts us to issues before written comments come in, so that we can start working on those issues right away. And, lastly, it alerts everybody in the audience, in the community, to what some of the concerns are that people have with the renewal application.

So, we'll be following that five-minute rule. There is an ability to follow up with more extensive comments in writing. There's also an ability to talk to the NRC staff, who are here from our Headquarters Office and from Region, after the meeting.

And we'll also be giving you some contact information so that you can contact people, from the NRC staff, if you have concerns or questions.

And I guess, finally, I just would ask all of us, everyone, to just extend courtesy to everybody else. We may hear different opinions on the issues, different opinions from the ones that we hold today.

And I would just ask everybody to respect those opinions. In terms of the NRC speakers, we're going to start out this afternoon with an overview of the license renewal process.

And we're going to have Rani Franovich, who is right here, to start out for us. And she's the Chief of the Environmental Projects Branch, within the License Renewal Program.

And Rani and her staff manage the Environmental Review for all License Renewal Applications, including this one for Vermont Yankee.

And Rani has been with the NRC for 14 years, in a number of positions and areas of responsibility. She was a Resident Inspector, these are the NRC staff who are at every reactor that we licensed throughout the country, to make sure that NRC regulations are complied with.

She also was a Project Manager on the Safety Review for several plants, I believe, that came in for license renewal. She was also the Coordinator of Reactor Enforcement, which was a position that ensured that compliance steps were taken against companies that may have violated the regulations.

And, in terms of her educational background, she has a Bachelor's Degree and a Master's Degree from Virginia Tech. And the Master's Degree was in Industrial and Systems Engineering.

And after Rani is done, we're going to go right to Mr. Rich Emch, who is right over here. And Richard is the Project Manager for the Environmental Review for the Vermont Yankee License Renewal Application.

And he'll be talking about the specifics of the Environmental Review, and how to submit comments. And Rich is an old hand at the NRC. He's been with us for 32 years, and a lot of different positions, mostly related to radiological health and protection.

And his background is in Health Physics. He has a Bachelor's in Physics from Louisiana Tech University, and a Master's in Health Physics from the Georgia Institute of Technology.

And Rani is going to introduce a number of people, but I just wanted to introduce two people before we get started.

One is Eric Benner. And Eric is the, is a Branch Chief of the Branch that does the technical review of the environmental issues that are in the

Environmental Impact Statement. And he'll be talking to us tonight and I'll give him a full introduction at that time.

And, also, we have Mr. Frank Gillespie here. He is a Senior NRC Manager. Frank is the Division Director of the Division of License Renewal at the NRC in our Office of Nuclear Reactor Regulation.

And I just would thank you all for being here to help us with this decision. Rani.

MS. FRANOVICH: Thank you, Chip. You guys, can everyone hear me? Is this better? Alright. Thank you, Chip. I just wanted to open up the meeting by thanking you all for coming here.

It's nasty weather outside and I understand Vermont has had quite a bit of that recently, and so I'm sorry we couldn't arrange for a prettier day for the meeting, but we're really glad you took the time out of your busy schedules to come and talk with us today.

I hope the information that we provide will help you understand the process we will be going through in renewing the application for renewal for Vermont Yankee.

And help you understand the role that you can play in helping us to make sure that the Environmental Impact Statement we prepare for Vermont Yankee License Renewal, is complete and accurate.

Next slide, please, Sam. I'd like to start off by briefly going over the purpose of today's meeting. We'll explain the NRC's license renewal process for nuclear power plants, with emphasis on the environmental review process.

And we'll talk about the typical -- is this better? Okay. We'll talk about the typical areas included in the scope of our review. We'll also share with you the License Renewal Review Schedule.

And really the most important part of today's meeting, is to receive any comments that you have on the scope of our review. They will also give you some information about how you can submit comments to us, outside of this meeting.

At the conclusion of the staff's presentation, we will be happy to answer questions and receive comments that you may have on the process and the scope of our review.

However, I must ask you to limit your participation to questions only, and hold your comments until the appropriate time during today's meeting.

Once all questions are answered, we can begin receiving any comments that you have on the scope of our Environmental Review. Next slide, please.

Before I get into a discussion of the License Renewal Process, I'd like to take a minute to talk about the NRC in terms of what we do and what our mission is.

The Atomic Energy Act is the legislation that authorizes the NRC to issue operating licenses. The Atomic Energy Act provides for a 40-year license term for power reactors.

This 40-year term is based primarily on economic considerations and anti-trust factors, not on safety limitations of the plant. The Atomic Energy Act also authorizes the NRC to regulate civilian use of nuclear materials in the United States.

In exercising that authority, the NRC's mission is three-fold. To ensure adequate protection of public health and safety. To promote the common defense and security, and to protect the environment.

The NRC accomplishes its mission through a combination of regulatory programs and processes, such as conducting inspections, issuing enforcement actions, assessing Licensee performance, and evaluating operating experience from nuclear plants across the country and internationally. The regulations that the NRC enforces are contained in Title 10 of the Code of Federal Regulations, which is commonly referred to as 10 CFR. Next slide, please.

As I've mentioned, the Atomic Energy Act provides for a 40-year license term for power reactors. Our regulations also include provisions for extending plant operation for up to an additional 20 years.

For Vermont Yankee the operating license will expire March 21st, 2012. Entergy has requested license renewal for Vermont Yankee. As part of the NRC's review of the License Renewal Application, we will perform an environmental review to look at the impacts on the environment of an additional 20 years of operation.

The purpose of this meeting is to give you information about the process, and to seek your input on what issues we should consider, within the scope of our review. Next slide, please.

NRC's License Renewal Review is similar to the original licensing processes, in that it involves two parts. An Environmental Review and a safety review. This slide really gives a big picture overview of the License Renewal Process, which involves these two parallel paths. I'm going to briefly describe how these two review processes work, starting with the safety review. Next slide, please.

Two guiding principles form the basis of the NRC's approach in performing its safety review. The first principle is that the current regulatory process is adequate to ensure that the licensing basis of all currently operating plants provides and maintains an acceptable level of safety, with the possible exception of the effects of aging on certain structures, systems and components.

The second principle is that the current plant-specific licensing basis must be maintained during the renewal term, in the same manner, and to the same extent, as during the original license term.

Next slide, please. You might ask what does the safety review consider? For license renewal, the safety review focuses on aging management of systems, structures and components, which are important to safety, as determined by the license renewal scoping criteria, contained in 10 CFR, Part 5.

The license renewal safety review does not assess current operational issues, such as emergency planning and safety performance. The NRC monitors and provides regulatory oversight of these issues on an ongoing basis, under the current operation license. Because the NRC is addressing these current operating issues, on a continuing basis, we do not re-evaluate them in license renewal. Next slide, please.

As I have mentioned, the license renewal safety review focuses on plant aging. And the programs that the Licensee has already implemented, or will implement, to manage the effects of aging.

Let me introduce Mr. Johnny Eads, the Safety Project Manager. Thank you, Johnny. Johnny is in charge of the staff's safety review. The safety review involves the NRC staff's evaluation of technical information that's contained in the License Renewal Application.

This is referred to as the Safety Evaluation. The NRC staff also conducts audits as part of its Safety Evaluation. There's a team of about 30 NRC Technical Reviewers and Contractors who are conducting the Safety Evaluation at this time.

The Safety Review also includes plant inspections. The inspections are conducted by a team of Inspectors, from both Headquarters and the NRC's Region 1 Office in King of Prussia, Pennsylvania.

A Representative from Inspection Program is here today. The Resident Inspector of Vermont Yankee is Beth Sienel. Beth, thank you. As Chip mentioned, the Inspectors work at the plant 40 hours a week. They live in the community, and they are the eyes and the ears of the NRC.

We have at least two, Nuclear Regulatory Commission Inspectors at every plant in the United States. The results of the inspections are documented in separate inspection reports.

The staff documents the results of its review in a safety evaluation report. That report is then independently reviewed by the Advisory Committee on Reactor Safeguards or the ACRS.

The ACRS is a group of nationally-recognized technical experts that serve as a consulting body to the Commission. They review each License Renewal Application and Safety Evaluation Report.

They form their own conclusions and recommendations on the requested action, and they report those conclusions and recommendations directly to the Commission. Next slide, please.

This slide illustrates how these various activities make up the Safety Review Process. I'd like to point out that these hexagons, the yellow hexagons on this slide, represent opportunities for public participation. Also, the staff will present the results of the Safety Review, to the ACRS, and that presentation will be open to the public.

Next slide, please. The second part of the review process involves an Environmental Review with scoping activities and the development of an Environmental Impact Statement.

As I have said, we're here today to receive your comments on the scope of that review. We'll consider any comments on the scope that we receive at this meeting, or in written comments.

Then, in December of this year, we expect to issue the draft Environmental Impact Statement, for comment. Next slide. So, the final Agency decision on whether or not to issue a renewed license, depends on several inputs.

Inspection Reports and a confirmatory letter from the Region 1 Administrator. Conclusions and recommendations of the ACRS, which are documented in a letter to the Commission. The Safety Evaluation Report, which documents the results of the staff's Safety Review.

And the final Environmental Impact Statement which documents the results of the staff's

Environmental Review. Again, the yellow hexagons on the slide indicate opportunities for public participation.

An early opportunity is during the scoping meeting today. A meeting on the draft Environmental Impact Statement is another opportunity. The opportunity to request a hearing ended on May 27th.

I understand that three Petitions to Intervene were proffered, and among those three there are about ten issues that are in contention. As I mentioned, the ACRS meetings, also, are open to the public.

That completes my overview of the License Renewal Review and the Environmental Review in more detail, and Richard Emch, the Project Manager is going to discuss the Environmental Review in a little more detail now.

MR. EMCH: Next slide, please. As this slide indicates, we perform our environmental review along the guidelines of the National Environmental Policy Act of 1969.

What that Act requires is that Federal agencies use a systematic approach to consider the environmental impacts of major projects. The environmental impact requirement or Environmental

Impact Statement is required any time one of those major Federal actions is going to significantly affect the quality of the human environment.

In this particular case for a license renewal, the Commission made the decision that we would issue an Environmental Impact Statement for all License Renewal Applications, and that's what we're about in this process. Next slide, please.

This is a, so to speak, a flowchart of the analysis process that we follow. In the 1996 and 1999, the Nuclear Regulatory Commission developed something we refer to as the GEIS, the Generic Environmental Impact for License Renewal.

This statement evaluated the 92 aspects of environmental impact for all 103 plants in the United States. Of those, 69 of those impact issues were considered to be Category 1 issues, which in our parlance means they were the same, essentially, for all plants and they were small.

The rest of the issues are what we call Category 2 issues. The Category 1 issues we do not have to do a plant-specific in-depth evaluation of those issues for each plant.

The Category 2 issues we do have to do a plant-specific review for each plant. For Category 1 issues, even though we don't do a plant-specific, in-depth review, we do what we call a search for new and significant information.

That means we look to see if there's any information that is new and significant, that would cause us to want to reconsider that generic conclusion on the Category 1 issues.

On the Category 2 issues, as I said, we do a complete in-depth review. An example of a Category 1 issue is radiation protection. The effect on humans of radiation from the plant, releases from the plant.

The reason that's a Category 1 issue, is because the NRC has regulatory requirements and has standards and limitations for doses to the public, and the conclusion is, it's a generic conclusion. Because as long as the plant continues to meet those regulations, the impact is considered to be small.

An example of a Category 2 issue, is what we call impingement. When the plant is drawing in water from the Connecticut River for their cooling systems, this water comes in through screens and there is the chance that some aquatic organisms will be trapped on those screens and die.

And that's an example of an Environmental Impact that we do a plant-specific review for. For the new and significant information, that's the one that has the little yellow arrow on it.

If we find, if in the course of doing our review, if we find that there is new and significant information, that would cause us to question the applicability of the Category 1, the generic conclusion, then, if we find that information then that causes us to change our mind and to do an in-depth review of that issue for the plant.

Next slide, please. This is the decision standard that we are reviewing against. Basically, my version of it is, we are evaluating the plant to determine if the environmental impact of an additional 20 years of operations is acceptable, is okay.

Next slide, please. When I say the environmental impact of an additional 20 years, it's important to remember here, I think, that the evaluation that we are doing, is the impact from year 2012 to year 2032.

In order to do that, though, we have to examine a lot of what is going on today in the environmental impact from the plant. This slide has a, is a schedule for the entire process.

I believe you folks all have this slide, but I'm just going to hit a few of the high points.

Obviously, the scoping meeting today is part of our scoping process. The scoping process, in the parlance of NEPA, is we come into the community and we ask the people who live and work near the plant, I sometimes refer to you folks as our local environmental experts because you live and work here.

We ask you if there's any information that you think we need to know about. Any issues that you think we need to review, in the environmental impact, and any information that you think we need to be available, that we need to be aware of.

That's our purpose, our stated purpose for being here tonight. My purpose for being here tonight is to hear what you folks have to say about that issue.

There are other ways to give us those comments. You can send them to us in writing. You can send them by e-mail. And if you choose to do that, instead of speaking tonight, we need to receive those comments by June 23rd.

After we get those comments, we'll evaluate them all, along with all the other information that we have, and we'll develop a draft Environmental Impact Statement.

We'll issue that. The current schedule

for that is December of this year. After we issue that draft Environmental Impact Statement, we will come back, probably to this same theater, in January, and hold another public meeting where we will ask you, the public, to give us your comments about that draft Environmental Report.

You can tell us what you like, what you don't like; what you think we missed, that sort of thing. And, to help you with that, those of you who are attending tonight, there were blue and yellow cards.

If you filled out one of those cards, hopefully you gave us your address, and when we publish the draft Environmental Impact Statement, we'll send a copy of it to you, so that you will know that the process has started and you'll have good head start on the process.

After we collect the public comments, we'll then issue, we'll take those into consideration, make adjustments as necessary in the draft, the draft statement, and issue the final statement in August of 2007. Next slide, please.

This is a depiction of all the various areas that we draw information from. First is, of course, the Licensee's Application. There's a piece of the Application called the Environmental Report.

There's copies of it outside, if you want to take a look at it. If anybody wants to get a copy of it, if you'll so note, on that little yellow or blue card, we'll send you a copy of it.

We'll probably send you a cd, it's kind of heavy, the whole report is. We also do, we have a team of people from the Nuclear Regulatory Commission and our Contractor, Argonne National Laboratory.

The head of the team, the Lab Team, is David Miller. David Miller is the Head of the Lab Team from Argonne National Laboratory. They are a team of experts in various areas, that help us do the review for the environmental aspect, for the environmental impact.

When we do an audit, we come out to the site for a week-long look at the facility, at the environs, we examine documentation. We meet with people who we need to consult with, such as in the state of Vermont, one is the Agency for Natural Resources.

We met with the State Radiation Protection people. We'll be meeting with others as time goes on. We met with the State Historic Preservation Officer. And we meet with local government officials, as well.

We meet with Social Services. One of the issues that we look into is socio-economics. We talked to permitting authorities in the state of Vermont.

The state is responsible, has been delegated the responsibility by EPA, to issue what we call the National Pollutant Discharge Elimination System Permit.

This is a permit that talks about what level of heat and chemicals are allowed to be released by the plant. And then finally, the thing that we're here for tonight, is the public comments.

To get information from you folks to help us with our review. Next slide, please. This is a depiction of all the various areas, in a broad sense, that we look at.

We look at environmental justice. We look at socio-economics, air quality, water quality, terrestrial and aquatic ecology, radiation protection, hydrology, and archeology and culture resources. And if I missed any, they're on the chart behind me.

Now I'd like to talk directly, give you some additional information. First, as I said, my name is Rich Emch. The phone number that you can reach me at is on that slide up there.

We have made arrangements to have the documents involved in the review, the Environmental Report, any letters that we sent to the Licensee, any requests for additional information, and, indeed, when we issue the draft Environmental Statement, it will be sent to these four libraries.

The Vernon Free Library in Vernon, the Brooks Memorial Library here in Brattleboro. The Hinsdale Public Library in Hinsdale, New Hampshire, and the Dickinson Memorial Library in Northfield, Massachusetts.

All four of these public libraries graciously volunteered to make the documents available so that members of the public can see them, just in case you don't have access to a computer, to the Internet.

If you do have access to the Internet, the documents can also be viewed at the web site on the slide up here. To send us written comments on, during this scoping process, you can send them, by mail, to the address that's up here.

You can send them by e-mail to the address that's up there, VermontYankeeeis@NRC.gov. My staff and I will be checking that web address everyday. Or, you can deliver them in person to our offices in

Rockville, Maryland.

Again, as I mentioned before, we need to receive the comments by June 23rd. If you don't quite meet the June 23 rd, date - anything that we get by June 23rd, we will consider.

Anything that we get after June 23rd, we'll consider if there's time to do it. With that, that completes my presentation. Actually, it completes the NRC!s presentation, and Chip, are you ready for questions?

MR. CAMERON: Yes, I think we are. Are there questions on, that will help you to understand this process a little bit more clearly, before we go into the comment part of the meeting. Yes, ma'am, if you could just introduce yourself to us, please.

MS. NEITLICH: Yeah, my name is Jill Neitlich. And I have a question about the democratic process, and I did ask you before, Rich. And basically what I think you said to me was that you have a script and there's no room for the democratic process.

But I'm kind of concerned about the democratic process within the NRC. Because what I've noted is that you haven't really turned down an application for an uprate or for a license renewal.

So that's a little confusing to me.

So does that mean that actually there is no democratic process within the NRC?

MR. CAMERON: Thank you, Jill, and Rich, there's a number of issues there, and one is the turning down of applications, and I'm not sure what Jill is referring to by a democratic process within the NRC.

But you might talk about what that process is, for her.

MR. EMCH: Okay. Yes, Jill, and I did talk before the meeting. Sort of a paraphrase of what I said, Jill, but I'll try to be a little more complete here.

MR. CAMERON: Rich, excuse me for interrupting you, but this is for everybody. When you come down to this mic, I guess it's not projecting back, so you really sort of need to speak into the mic, so that everybody can hear you.

This one is, but you can't hear this one, at all.

MR. EMCH: You can't hear me when I talk on this mic? Oh, you have to be really close to it, okay.

MR. CAMERON: Try to do it with that one, and then if it doesn't work, then we'll figure this out. Go ahead.

MR. EMCH: All right, I'm going to try to hold it up real close, without actually inhaling it. All right.

MR. CAMERON: Closer and louder.

MR. EMCH: Okay, I'll see what I can do. What I was trying to say earlier was the democratic process, if you will, occurs before we get to this, here, okay.

The democratic process, if you will, is when you go, when you as a community vote for the members of your select board, your state representative, your congressmen and state senators.

Your elected officials are the democratic process. They're the ones who you rely on to make decisions about what you, how things are going to work in your state. The process that we're involved in is, the Nuclear Regulatory Commissions's process is the Licensee makes an application and the Nuclear Regulatory Commission reviews it and makes decisions based on its review of that application.

We do not, as part of that review process, we, our review is against a set of technical review standards, both either on the safety side or the environmental side, and we don't, there is nothing in our process that calls for a vote, by the people of Brattleboro, about whether or not they want this plant to be re-licensed.

As I said, the democratic process occurs when you go to the polls, the voting booths, to vote for your elected officials, and then they're the ones who you rely on to make your decisions for your state and your community.

MR. CAMERON: And, Rich, something that I think, a point that Jill raised that's of interest to everybody, is the status of our review of other License Renewal Applications, and not just direct answer to, well how many have we approved or denied, but what that process is like in terms of a License Application coming in?

Is there enough information in it to request for additional information? If you could just address that briefly, and then we'll go to other people.

MR. EMCH: When an application is first sent in, we do what we call an Acceptance Review. Those of you who were here on March 1st, heard Johnny describe the Acceptance Review.

Basically, that review is just to make

sure that there's enough of the appropriate kind of information in the application to allow the NRC staff to start its review.

Later on, as we go through the review, we do our review against published technical standards, both in the safety and environmental area. You've heard Rani talk about the audits, the inspections.

And what we're doing in our review process, is we're doing our review to make sure that whatever the Licensee has put forward as their application, meets our standards.

And if it meets our standards, the Commission is probably going to accept the application and probably going to approve the application, because that's the way we do our work, we use standards.

Along the way, we're going to ask a lot of questions. We refer to them as a request for additional information. There will be hundreds of them on Vermont Yankee, if it's anything like the other plants.

There will be times along the way when we will tell them that they, that what they have given us does not meet our standards. And we will say you need to consider, you either need to go back to the drawing board in that particular area, but whatever you do, you're going to have to do something, because you're not meeting our standards in that area. And the Licensee, the Applicant, will almost undoubtedly, as all the 42 that have followed before them have done, in all those areas the Licensee will go back and make adjustments and eventually give us plans and information that meets our standards and then the application will be approved. That's the process that we follow.

MR. CAMERON: Okay, other, thank you, Rich. Are there other questions on process that we can answer for you, before we go to comments? Evan, if you could just introduce yourself.

MR. MULHOLLAND: My name is Evan Mulholland. You had a slide, information gathering. And my question is does the NRC, on the environmental front, does the NRC passively take information that's submitted, or there are staff members that go out and do extra studies and assessments and that sort?

MR. EMCH: We consult with a wide range of people, Fish and Wildlife Service, NOAA Marine Fishery Service, the Agency for Natural Resources in the state of Vermont, with the state organizations in New Hampshire and Massachusetts.

We consult with a wide range of experts

and people who are in the know. We don't go out and actually count fish, no. But we talk to the people who do.

MR. CAMERON: Okay, and part of the purpose of the scoping and comment process on the draft Environmental Impact Statement, is to the extent that we have not found information on our own, we look for people to submit information that may be relevant to our review, right?

MR. EMCH: Correct.

MR. CAMERON: Okay. Anybody else have a question on the License Renewal Process? Okay, let's go over there and find out what the questions is. And if you could just introduce yourself to us now.

MS. NELKIN: Hi, I'm Nancy Nelkin. Well, referring to the democratic process question before, one of the issues is, you know, you are saying well we elected our representatives.

This plant is in Vermont, just miles from the Massachusetts border. Those of us in Massachusetts and in New Hampshire, don't have a democratic process.

Furthermore, the Nuclear Regulatory Commission, you know, you guys have this whole bureaucracy and lawyers, and it's really not fair, it's not a fair fight.

MR. EMCH: I'm not sure what your question is, ma'am?

MS. NELKIN: Actually, I have a number of questions, so bear with me. It was said early in the presentation that the 40-year license was not based on a safety concern, it was based on an economic concern.

How do we know when a plant is no longer safe to operate? That's a question I have. One of the speakers went over and said, oh, we're going to do assessments and inspections, and inspections and almost counted how many times she said the word inspections, but it's never been an independent safety assessment that we have asked for.

And, essentially, has been rammed down our throats. So, you know, my feeling is that the idea of assessments, you know, as long as you're going over paperwork and talking to people who, you know, aren't taking a fresh look at it, we don't feel safe.

MS. FRANOVICH: Let me address --

MS. NELKIN: And I have another question. And that is --

MS. FRANOVICH: Before you ask, before you ask --

MS. NELKIN: -- this is the third

question.

MS. FRANOVICH: -- but let me answer that one, so I don't lose track of it, before you get to your third one, and then, Rich, can we come back and get our third one, after I answer the --

MR. CAMERON: Yeah, and I just want to say is that we welcome your comments and hope that you make some of your conclusions, give those to us when we go to the speaking part.

But if you could just give us the questions and we'll try to answer them. And, Rani, you want to go to the second question?

MS. FRANOVICH: If it's okay, I'd like to go on and answer the 40-year license term, and then the reliance on inspections. And then we'll get to your third one.

The 40-year license term is based on economic considerations and anti-trust factors. When it comes to plant aging, and when a plant becomes too old to safely operate, it's really not so much about the plant, it's about the systems, the structures and the components that are relied on to make sure the plant can operate safely.

And so we don't look at it on a plant basis, we look at each individual structure, component and system, that's important to safety. And we make sure that either it's replaced, it's refurbished, or they test it or they monitor it, or they do something to manage the aging of that structure, component or system. So that's how --

MS. NELKIN: So you're suggesting that a plant will never be obsolete as long as you can replace the parts?

MS. FRANOVICH: I'm suggesting that for license renewal, what we look at is the management of aging of structures, components and systems, rather than when does the magic day happen when the plant is no longer safe.

As to the inspections, yeah, we do conduct inspections. We send people to the plant to look at the material condition. To look at aging management in place, aging management programs the Applicant is relying on today, to manage the effects of aging.

And so it's not just a paper review. We actually do --

MS. NELKIN: But the people from the NRC, who already have a track record --

MS. FRANOVICH: Right.

MS. NELKIN: -- don't we know, to let things go --

MS. FRANOVICH: And so, the NRC --

MS. NELKIN: -- in lieu of the regulations.

MS. FRANOVICH: Could I please answer your question. The NRC's position is that it's an independent Federal agency that has the role and responsibility of regulating nuclear material use in this country, including operators of nuclear power plants.

There's also the Advisory Committee on Reactor Safeguards, that then independently reviews the work of the staff and reports its recommendations and conclusions directly to the Commission.

MS. NELKIN: Okay, one more question, and that is why are we looking at this license renewal in 2006. You know, I would like to see the track record of Vermont Yankee between now and at least 2010, before we make this decision.

MS. FRANOVICH: The regulations require that an Applicant have about 20 years of operating experience before they can come in for renewal. But in order to ensure that there is a timely review of their application, because this is, it's a significant capital investment for an Applicant to apply for license renewal.

They want to know the outcome of the Regulators decision process in a timely manner. So, we require that they submit their applications within five years of the end of their 40-year license term.

So anywhere between 20, year 20 and year 35, an Applicant can come in for renewal. And when they decide to do that, it is really kind of an economic decision of there's of their choosing.

MR. CAMERON: Okay, thank you. Thank you for those questions and, thanks, Rani and Rich. Yes, sir.

MR. BLOCK: I have two questions that are connected. My name is John Block, that's B-l-o-c-k. The first question is how often does the input that you receive from the public, actually effect the scope of a GEIS?

And the second is, please cite for me which specific cases I could look up and find, in a GEIS, or a draft GEIS, evidence of the effect of the public comments upon that process. Thank you.

MR. CAMERON: Okay, thank you, Jonathan. Richard.

MR. EMCH: I don't know that I can tell you how many, you know, on every single one, but I'll give you an example, sir. I was the Project Manager for the Millstone Plant review in Waterford, Connecticut that ended last year. And during scoping a number of local citizens provided us, during the scoping meeting, they provided us copies of studies about radiation heath effects.

Most of them we already knew about, but there were a couple of them that were fairly local, that we were not aware of. And so they provided those to us.

And in Section 4.7 of the Final Environmental Impact Statement that we wrote, we discussed the status review of those studies.

MR. CAMERON: Okay, thank you, John. We're going to take two final questions here and then we're going to go to public comment. Yes.

MEGAN: My name is Megan, and I was wondering if the Hinsdale Evacuation Point is in Keene, and is it part of the evaluation assessment?

MR. CAMERON: Okay, Rich, could you, there's a, did you hear the question?

MR. EMCH: I did, Chip.

MR. CAMERON: Okay.

MR. EMCH: As Rani mentioned in her presentation, license renewal does not really address emergency preparedness. As Rani also mentioned, the reasons why it doesn't and is, that it's just not considered to be something that we would, it's a today issue.

If there was a problem, it's a today issue. If there is a problem with an Emergency Preparedness Plan, it's not something that we want to be waiting until 2010 or 2012, to be assessing.

If there's an issue with emergency preparedness, it's something that needs to be addressed now, for the current operating plant. And there are processes in place to do that.

The Nuclear Regulatory has processes. FEMA has processes. The state of Vermont, the state of New Hampshire have processes to do that. They have regular drills and exercises where they identify places in the plan that need to be improved, and that is indeed what is happening here.

I understand there were some questions about school buses, during the last exercise in New Hampshire, and the state of New Hampshire is taking actions to address those.

MR. CAMERON: Okay, and that answers the question about the relationship of emergency planning to license renewal.

But just as an emergency planning issue

for Megan's benefit, Hinsdale is part of the emergency planning review? I guess I'm asking a question?

MR. EMCH: Hinsdale is inside the ten mile EPZ, yes sir.

MR. CAMERON: Okay, all right, thank you. And let's go to Gary. If you could just introduce yourself to us.

MR. SACHS: Gary Sachs, Brattleboro. I heard you say that you look to these environmental impact meetings to determine the scope of your impact, to learn things from us.

And this is a partial comment and a partial question. For the most part, we, in the local environment are volunteers. And very few of us have enough time, very, very few of us have the dedication to this issue that we certainly would expect from you, as the NRC, and from individuals who work with Entergy.

And, so I think it's an awful lot to ask the locals to come to you with how we should approach the environmental scope and how it affects the environment.

My other question is more direct. How many NRC paid employees are here today, given the number of us, residents, who are not paid here? Thank you.

MR. CAMERON: Okay, thank you, Gary. And, Rich, in regard to Gary's first point, you did mentioned that you talked to state and local government agencies about issues, right?

MR. EMCH: Let me give a slightly broader answer than that, Chip.

MR. CAMERON: Okay, all right.

MR. EMCH: As I mentioned earlier, we have the Generic Environmental Impact Statement, and what we did was we found approximately, we searched and found approximately, decided approximately 92 issues that are always part of the scope of the review.

And we do a search, an exhaustive search for additional information. And when I said that we're here to ask you for your help, we can do the review without your help, if that's what you're driving at, sir.

But we think it's important for us to come out and ask you for your help, just in case there is some information that you have that we don't. And that's why we're here.

MR. CAMERON: And I guess there was a question. Gary asked about the number of NRC employees, and I would say that all of the NRC employees who are here tonight, or today, are paid as employees of the government. And I don't know approximately how many people we have here, but Rich?

MR. EMCH: Approximately 25.

MR. CAMERON: Okay. We're going to go to public comment now, and thank you for those questions, and thank you Rich. We're going to go to Mr. Ray Shadis, first, to lead off for us.

And Ray is with the New England Coalition and he'll tell you more about that. And I don't think we, Deb Katz is not here right now. So, I'll let you know who is going to speak next.

MR. SHADIS: The New England Coalition intends to file written comments. We have a number of comments. I pulled out four to address in the two meetings this afternoon and this evening.

And by agreement with the NRC folks, just as to not take up too much time, I'm going to deal with two of them this afternoon and then the other two this evening.

Basically, the four issues are the off-site spent fuel pool accident consequences, radiological consequences. The cumulative off-site radiological impact of routine operations, as well as the radiological impact of routine operations on eventual decommissioning.

And the cumulative off-site impact of chemical releases unplanned. And, finally, consideration of the advances in the discipline of seismological evaluation.

And I would just start with the spent fuel pool accident off-site consequences. I don't know if a spent fuel pool accident or act of sabotage, is within the design basis accident that are considered in the environmental assessment or not.

The credibility of such accidents was roundly studied by NRC staff in NUREG 1738, on the accident risk and decommissioning nuclear power stations. And that study, in turn, referenced a number of other NRC studies, many of them having to do with operating plants.

Two of those studies specifically considered Vermont Yankee on a site-specific basis. One of those studies dealt with the seismic fragility of two spent fuel pools. One in a PWR, and then one in a boiler water reactor that happens to be Vermont Yankee.

NRC's consultant, seismic consultant, Dr. Robert P. Kennedy, in an appendix to NUREG 1738, says that the postulated critical failure mode for the

Vermont Yankee spent fuel pool, would be a plane sheer failure of the floor slat. Then it goes on to say, possibly, the entire floor will drop out.

But I think such a gross failure is unlikely. And then he goes on to say, that in his opinion, a more likely failure would be a wall failure, in that case leaving as much as four feet of water in the bottom of the pool.

And, of course, you gentlemen know that if there is some water left in the pool, it is a far more dangerous situation, then if the pool was drained completely.

Because that water will then block cooling up through the fuel assemblies. And I need to point out that, from our perspective, that the issue that probably needs to be addressed, in your environmental impact study, or in a supplement to it, would be the consequences.

And the appendix, let's see, where is it now. Just one moment. Yeah, Table A4-7, this is in Appendix 4. Using the base case of Millstone 1, which is a reactor almost identical to Vermont Yankee, with just three and a half cores in the spent fuel pool.

Vermont Yankee has probably twice that or close to twice that. It speculates that with 95 percent evacuation, the Table includes an estimate of 26,800 cancer fatalities within a distance of zero to 500 miles.

Whether that's strictly speculative, postulated or whatever, they're at six, in the Table, in a referenced NRC study, NUREG CR-5176. And those numbers have not be repudiated, they have not been put out there in speculative space.

I think, when the original license was issued, for Vermont Yankee and estimates were made, public representations were made as to the potential for consequences of a design-basis accident, we had certain numbers given to us.

And, since that time, of course there's been a lot of representation from the industry and also from NRC, in essence, diminishing those numbers, putting all of those numbers away.

I guess it's New England Coalition's position that NRC really needs to reconcile the numbers from the original license time, license period, and the representations that are being made by NRC spokespersons today.

By the Utility spokespersons and the numbers in this report, which I think are quite outstanding. So, that is, that is one comment.

And the, on the second topic, cumulative off-site radiological impact of routine operations and also the cumulative impact of routine operations and radiologically on decommissioning.

There are two things that we would like you to consider. One is that, as you know, the state of Vermont posts radiation measuring devices, TLDs, around the plant perimeter.

And the state reports that three times in the last decade or so, that the state limit of 20 millirem per year has been exceeded at the fence line.

And we took a quick look at those reports for those three years, and then also at a study, I believe, done by Duke Engineering for Vermont Yankee, and found that the TLDs in the same sector were the ones that read high in each of those instances.

And, you know, this is not an anomaly for a bad detection instrument, because they are changed out quarterly, and the excess is the average over a year.

The other thing that we noticed is that the only other abnormally high reading, that occurred in each of those three instances, was at the interior of the Vernon Elementary School. The other thing that we noticed was that the turbine hall and the offending

TLD, and the elementary school, line up axially. There's a straight line to be drawn from the turbine hall, to the one monitor that read high, to the elementary school reading high.

The state folks thought this might be an artifact of excess of radon in the school. But, of course, we don't generally use TLDs to go chasing radon. The other thing that we noticed, was that there was no correlation between the measured amount of radon in the school, for those instances, and the high TLD readings.

From an amateur science point of view, we believe there's enough here to warrant real investigation.

(Applause.)

MR. SHADIS: I should point out to you that we have not looked for correlation on weather or meteorological conditions, but it might well be a consideration that these high readings are a result of temperature inversion and downdraft from the release stack.

In any case, just for the sake of these little nuclear workers over there in the elementary school, we really do think this shall be part of the environmental scoping.

The other thing, very quickly, in terms of cumulative radiological impact, I discussed this briefly with Dr. Masnik, here from NRC, earlier.

Vermont Yankee had gotten permission to store contaminated soil on site, starting back, I think in 1998, maybe a little earlier. And, at the time, the amount was some excavated soil from a construction project, about 135 cubic yards.

And then roughly at 35 or 40 cubic yards per year, they anticipated generating through contaminated sanding salts from the roads from silt in the cooling towers, and also from waste sludge.

And, in 2004, Entergy received permission to increase that amount. They had accumulated, they thought, about 500 cubic meters of contaminated soil on site, and they wished to dispose of, on-site, an additional 150 cubic meters per year.

That's about ten big dump truck loads. And this disposal site or, excuse me, this storage site is on the south end of the site, just south of the cooling towers.

It is constantly sprayed down with what is called drift, sideways spray from the cooling towers. It is on the riverbank. We believe that the phenomenon of bio uptake, of sedimentary separation, of chemical combination, can leach and separate and concentrate the radioactive material in that disposed of or stored soil, complicating decommissioning, polluting the river, winding up in the biota.

And so we believe that should also be investigated as part of the environmental assessment. Those are the two topics. Thank you for listening that long.

MR. CAMERON: Well, great, and thank you for those specific comments, Ray.

MR. SHADIS: And we'll provide documents. As I said, we will be doing written comments.

MR. CAMERON: Okay. Thank you, Ray. Let's go to Evan, Evan Mulholland. And then we'll go to Chris Williams and then Shawn Banfield. Evan Mulholland.

MR. MULHOLLAND: I have written comments, I'm just going to read them. My name is Evan Mulholland. I'm an attorney representing the New England Coalition in its appeal in Vermont Environmental Court of the Clean Water Act Permanent Amendment recently issued for the Vermont Yankee Power Plant, as full disclosure.

I'm here today, though, as a member of the public and I'm concerned about the impact on our environment of 20 more years of operation of the Vermont Yankee reactor.

Specifically, I've got concerns about the effect on the Connecticut River and on the fish and other wildlife that live in and on the river. According to the environmental report drafted for this license renewal process, Entergy states that it withdraws water to cool the reactor, from the river, at a rate of up to 360,000 gallons per minute when using once through cooling.

The majority of this water is discharged back into the river at temperatures that can reach 100 degrees Fahrenheit, at the point of discharge. The recently issued NPDES Permit Amendment, which New England Coalition is appealing, allows for Vermont Yankee to increase the temperature of the river by an additional one degree Fahrenheit over what it was previously allowed.

The environmental impact of this extra thermal waste discharged into the river, is potentially significant. Temperature is critical for American Shad and other fish species, particularly during migration and spawning.

Even this one degree increase in water temperature may adversely effect the Shad and other species, reducing their population in the river system. In its report, however, Entergy does not assess these impacts.

Entergy's conclusion that the impact on the environment is small, is based on the fact that the discharge complies with state and Federal pollution limits.

There's no further discussion of what effect another 20 years of increased thermal discharge will have on the eco-system. Whether or not the discharge from Vermont Yankee is in compliance with its State and Federal permits, Entergy should be required to take a hard look at, and assess a direct, indirect and cumulative impacts on the river eco-system of 20 more years of increased thermal discharge. Thanks.

MR. CAMERON: Thank you very much, Evan. Is Chris Williams here? Chris.

MR. WILLIAMS: My name is Chris Williams. I live in Hancock in Addison County. And I'm not certain that my unprepared remarks here are going to be completely on point, but I believe that the safe operation and safe oversight of any operating nuclear power plant in this country, or in the world, has a significant long-term impact on the environment in the area where the plant is located. And, just for the record, standing here in Brattleboro, I want to point out some experiences I've had in two locations in the United States.

The first is in the state of Ohio. I lived in the Midwest for quite a while, doing battle with the nuclear industry, as well as the coal-fired electric industry.

In Port Clinton, Ohio, the Davis Besse Nuclear Power Plant is operated by First Energy Corporation. Several years ago, with significant Nuclear Regulatory Commission on-site oversight, it was discovered that a boric acid leak had eaten a hole in the reactor vessel lid, which is about 18 inches thick.

That hole came within several millimeters, several millimeters of breaching. The whole thing happened, as I said, under the oversight of the Nuclear Regulatory Commission.

Outside that plant, there's a big sign. It has safety is Job One. What happened at Davis Besse was criminal. That the Nuclear Regulatory Commission allowed them to go get another vessel head from Midland Plant, which was canceled, up in Michigan, and put that plant back in operation, was nothing short of criminal. The second reactor that I had quite of a bit of experience with in the Midwest was in Bridgeman, Michigan.

It was the DC Cook Nuclear Power Plant, owned by then, American Electric Power. The Bridgeman Plant was shut down after it was discovered that significant safety features in the plant were not operating, in some cases, for more, not operating properly, for some cases, for more than ten years.

Outside that plant there's another sign that said safety is Job One. Those safety systems were non-operational with significant daily oversight, on-site, by the Nuclear Regulatory Commission.

Here at Vernon, as in the rest of the country, it's part of the operating license that the Nuclear Regulatory Commission gives the companies that operate these power plants, as part of that process and part of that license, they're allowed to routinely emit radioactive releases, in both the air and water.

I'm sure everybody in this room knows that. Long-term, that's a problem. We'd like to know how much has been released by the operation of Vermont Yankee, year-to-date, or operational lifetime to date.

And how much is projected under routine operational conditions? How much is going to be released over the proposed license extension?

I want to close with just one other observation. Recently, several people, four from Vermont, traveled to Kiev to attend a conference, marking the 20 th Anniversary of the accident at Chernobyl.

There were probably 150 of us that took the conference organizers up on the opportunity to go visit the Chernobyl site. And I have to say, we've all seen the pictures. And the pictures actually, they do the situation justice.

What struck me the most was that the people living 30, 40 kilometers away, from the accident site, very basic, poor, agrarian folks. They were people that depend on their land for everything.

And what's just painfully obvious, when you visit there? Is that their lives have been destroyed by the technology that was arrogantly placed and operated 30 to 40 kilometers away.

And the folks that lived in Pripyat, the community that built and operated Chernobyl, well, you know, they're not there anymore. Pripyat is a ghost town.

But the one thing that the locals, the non-nuclear locals had, was their land. And it was taken away from them. So as we look to re-license Vermont Yankee, we have to draw a parallel.

We're not so different from the, from the people in the Ukraine or in Belarus. And when these companies tell us that safety is their Number One job and the Nuclear Regulatory Commission assures us that they're on the job all the time.

I don't believe we can take those claims seriously, and have to do everything we can to ensure that arrogance doesn't prevail. Just because you're scientifically smart, doesn't mean you have your act together. And I'll just leave it at that, thanks.

(Applause.)

MR. CAMERON: Thank you, Mr. Williams. Shawn Banfield.

MS. BANFIELD: Good afternoon. My name is Shawn Banfield and I'm here today as an active member and an Officer of the Board of Director for the Vermont Energy Partnership.

I'd first like to thank the NRC for hosting this meeting today. I do have a prepared statement, which I will read from. And I'll start with the Vermont Energy Partnership was founded in 2005, shortly after the state report warned the series of energy challenges they will face in Vermont.

Our founding members came together because they recognized the importance of making sure we have adequate electricity, so Vermont continues to be a great place to live and work.

The Partnership is a diverse group of more than 50 business, labor, community leaders, committed to addressing the immense electricity supply issues that we are going to face in Vermont, in the very near future.

Our members include a cross-section of experts of the energy sector. Our members employ thousands of Vermonters. They run big and small businesses.

They represent Union workers, some of whom devote their professional lives to upgrading the Vermont Yankee Plant safely. The Partnership fully supports the re-licensing of the Vermont Yankee Nuclear Power Plant in Vernon, and I will explain to you why.

It is no secret that Vermont's demand for energy is continuing to grow. It may be a less known fact, however, that Vermont faces uncertainty over its future energy supply.

Currently, one-third of Vermont's electric supply comes from Hydro Quebec. These long-term contracts with the state will begin to expire in 2014, and there is no guarantee that these contracts will either be renewed or renegotiated given the company's, Hydro Quebec's more local business opportunities in the province.

Another approximate one-third of our supply here in Vermont, is made up of a wide array of both in-state and out-of-state sources, renewable and non-renewable.

The Partnership supports the in-state development of renewable sources, and we encourage the increased used of energy efficiency in the expansion on conservation measures.

However, the fact remains a reliable energy portfolio, here in Vermont, must be made up elsewhere, of base load sources of power. Vermont Yankee accounts for the last one-third of our Vermont portfolio.

About 34 percent of Vermont's total electricity supply needs are met by the Vermont Yankee Plant. So let me put this debate into proper context. Vermont has not brought on a single, significant power generating facility in over 20 years.

And there are no plans to do so in the near term. To make matters worse, proposals to develop small scale generation in Vermont, have been met with sharp criticism and serious opposition. In a time when energy costs are at their highest, Vermont Yankee will not only play an essential role in our state's energy portfolio, it is critically important to the Vermont economy and environment.

From an economic standpoint, I would just quickly say that a stable, relatively low-cost power provider will help to maintain and expand businesses here in Vermont, while at the same time providing for an opportunity to bring and attract new businesses to the state.

In a time where Vermont faces an increasing, aging population, the plant provides employment to 600 highly skilled men and women. These individuals and the company provide more than 200 million in economic benefits to the Windham County Region and the state as a whole.

According to the Vermont Public Board, I'm sorry, the Public Service Department, the company, through the State's Power Purchase Agreement, will provide customers in Vermont, approximately 250 million dollars in savings over the life of the contract.

But aside from the important economic

benefits, the Vermont Yankee's continued operation, I'm sorry, there are also some relative environmental benefits from this in-state power generation source.

In 2005, alone, according to the Nuclear Energy Institute, Vermont Yankee avoided emissions of 7,700 tons of sulphur dioxide, 2,000 tons of nitrogen oxides, and 2.5 million tons of carbon dioxide.

Emissions of sulphur dioxide, lead to the formation of acid rain. Nitrogen oxide is the precursor to both ground-level ozone and smog. And greenhouse gases, like carbon dioxide, contribute to global warming.

We live in a country where half the electricity generated comes from coal-burning sources. Yet, in Vermont, we can be very proud to say that that's not the case.

Vermont Yankee does not release harmful greenhouse gases or other toxins into the atmosphere which are the primary cause for global warming. The issue of global warming, a climate change, has rapidly reached alarming levels.

And power-generated facilities have been at the heart of that crisis. In the United States, coal is the leading power provider with over 600 plants operating.

Of these plants, of the 600 plants, 36 percent of all U.S. emissions are accounted by those plants' generation. It has become abundantly clear that the nuclear energy is the only emission-free source that can meet consumer demand, reliably and at a reasonable cost.

Leading environmentalists, from around the world, like Dr. Patrick Moore, Co-Founder of Green Peace, have come to the conclusion that nuclear power is the only source that can help remedy and save the planet from catastrophic climate change.

Just last month, Dr. Moore said in the Washington Post, nuclear energy is the only large scale, cost effective energy source that can reduce these emissions, while continuing to satisfy the growing demand for power.

And these days, in these days it can do so safely. He went on to say that it's extremists who fail to consider the enormous and obvious benefits of nuclear power, also fail to understand that nuclear energy is practical, safe and environmentally friendly.

Without Vermont Yankee, Vermont utilities would be forced to buy additional power on the spot market that would be less reliable and certainly considerably more expensive.

So the Partnership asks, do Vermonters really want to pay more and to depend on power from fossil fuel sources, such as natural gas and coal, which contribute to the global warming and the earth's degradation?

The Vermont Partnership thinks not. In closing, the Vermont Yankee has an important and crucial role to play in the future of your state.

It is both environmentally and economically appropriate to grant the plant a license extension. We know that there is a wide array of support for the continued operation of this plant, for the reasons I have articulated here today.

Its essential economic benefits. Its environmentally sound operations, and its important role as a component of the Vermont energy portfolio.

On behalf of the Partnership, we would like to thank you for taking the time to hear from us today.

MR. CAMERON: Thank you, Shawn. Is Dan MacArthur here? Dan.

MR. MACARTHUR: Hi, my name is Dan MacArthur, I'm the Emergency Management Director for the town of Marlboro. I want to make several points here.

First of all, Marlboro has actually, is one of those formal petitions for hearing that the NRC should have received, and we are requesting that Marlboro be included in the EPZ.

It's the only town with any property within the ten mile radius, which was not included when the original license was granted in the 1960s, I guess. And we are formally requesting that if there is going to be an extension of the license, that the license be changed so that Marlboro can be included.

It's only fair, and there's no, as far as we're concerned, there's no other possible way to reconfigure the EPZ. I've drawn a little map of it and I will, if the current license that the NRC has granted to Vermont Yankee shows a really funny shaped EPZ with Marlboro just completely hacked out of it.

So we would like to be included in that, and that will be part of an ongoing formal request that we have. As for the purpose of the meeting here today, the environmental scoping, I'd like to follow up a little bit on comments that Ray Shadis made and Chris Williams, as well.

We, there's many of us in the local citizenry know that our environment, our homes, our farms, our entire livelihood are at risk here. If there's ever a sizeable release of radioactivity, then our property values will plummet. Our ability to sell, possibly even eat our own produce, will be diminished.

And I can't imagine a greater environmental impact than that. I mean we're talking about all or nothing, here. And I don't know whether you want to try to do a mathematical analysis of all or nothing, or not.

But from my perspective, it doesn't make any sense. If there's any possibility, that there's going to be any kind of impact like that, then I think that the NRC can only include that in the environmental scoping.

And this goes on. I understand that the NRC is only looking at environmental impact until the year 2032, but that doesn't do much good for those of us who live in this area, and I think more and more are coming to grips with the fact that the waste that's being generated is going to be stored here, in our backyard.

And it's going to be incredibly dangerous for thousands of years. So, unless the NRC can promise us that we aren't going to be the ones who monitor that material, then we're going to have to insist that the effect of that material be included in any environmental scoping review.

(Applause.)

MR. MACARTHUR: As I said earlier, I can't imagine any greater environmental impact, and I can't imagine the NRC extending the license if there's any possibility of this happening.

I was interested, the person before me was going through the benefits of nuclear energy, but, as we all know, there are many, many hidden costs included in producing energy from nuclear power.

One of them being that there is a sizeable payroll at the Federal level, paid for by our taxes, which is specifically for the purpose of seeing that nuclear energy continues to operate fairly cheaply.

So just think of that. The people who are here today getting paid by us, the citizenry, we're paying for that in our taxes, but it's really a cost that should be associated with the electric costs of nuclear power.

Now somebody asked earlier, how many people are here from the NRC. And it occurred to me and I think this is the reason that you're all here today, is to try to establish some sort of comfort level with those of us who live here, with the fact that there is in fact a good and a quality oversight of this process.

I, my question is this. There are approximately 25 people here who work for the NRC now. Of those 25 people, and I was at all of the previous meetings and I heard distinguished scientists stand up and say well I worked in the nuclear industry, and now I work for the NRC.

Of the people here today, who work for the NRC, how many people have been in the nuclear industry and are currently working for NRC? I wonder if we could have a show of hands on that?

MR. CAMERON: Dan, I'm sure that some of our people have worked for the nuclear industry, others have not. But we're not going to conduct a poll right now, okay?

So if you could finish up with your comments, we'd appreciate it.

MR. MACARTHUR: I don't think I need to say anymore. That seems to have said it very well, thanks.

(Applause.)

MR. CAMERON: I don't think it did say it fairly well, but I did have a question for you, to make sure that your request, formal request that Marlboro be considered in the Emergency Planning Zone. I want to make sure that doesn't get lost, and you said you had filed a Petition to Intervene and that there would be perhaps something other coming in as a formal request.

Should we, should we consider your comments today the formal request, or is there another written request that's going to follow? I guess that's my question for you, just so that I know what, we know what to respond to.

MR. MACARTHUR: Yeah, thanks. I will ask that you include my today's comments as a follow up to that request. I also understood that having petitioned by the 27th of May, or whatever it was, that we wouldn't need to follow up.

Just today's comments are just to reinforce our official request, which I believe has already gone in. So if there's more needed, let me know.

MR. CAMERON: Okay, and the reason that I wanted to distinguish this, is that your request to participate in the Hearing and the request to be part of the Emergency Planning Zone, can also be treated separately, so that if your Petition to Intervene, is not granted, that your request is still before the agency to be part of the Emergency Planning. John, and okay. John, do you have something to say on that? John Eads.

MR. EADS: Sure, let me just acknowledge first that by letter dated April 27 th, the town of Marlboro submitted a request, as they put it a Petition for a hearing.

That request was postmarked by envelope, I think it was May 15th. I don't know the two week time difference there, but we did receive your request.

It did not specify that it was submitted in accordance with 2.309, which is the formal hearing request process. I know that it was addressed to the Secretary for their review, and I believe it's under the review process as we speak.

I don't know that it fell under the formal Petition for Hearing Process, submitted in accordance with 2.309, which was specified in the Federal Register Notice.

But we did receive your letter dated April 27th, and it is being processed.

MR. CAMERON: Okay, and we heard your additional request today. Okay. Is Claire Chang with us? Okay, let's go to, how about Sunny Miller and Ischa Williams next. Sunny Miller? Ischa Williams?

(No response.)

MR. CAMERON: Okay, Elizabeth Wood? And let's go to, let's go to Bill Burton. Bill?

MR. BURTON: Good afternoon. My name is Bill Burton, I'm not an expert on energy, but I have had some experience dealing with energy.

I'm a retired educator. I taught Physics, Chemistry, Environmental Science, and a course entitled Energy Economics and the Environment, for about 35 years.

I taught in the public schools in Bellows Falls(Phonetic), Vermont. I also did some teaching in the Vermont State College System, and have been a visiting lecturer at the University of Massachusetts, Lowell.

I'm probably one of the few people here from Windham County that endorses the re-licensing of Vermont Yankee, and its, and hopefully looks upon with the environmental issues, favorably.

In my experience as an energy teacher, I probably visited almost every conceivable form of electrical energy generation that exists. I've been to large nuclear plants, coal-fired plants, oil-fired plants, wood chip, solar, wind. You name it, I've been there to learn more about the issues.

I feel that in any electrical generation, no matter what type of process you are using, there are benefits and risks. And I firmly believe that the benefits of nuclear power, greatly exceed the risks.

I know a lot of you are in disagreement. The main reason that I feel this way is other than hydro-electric power, all of the other forms of electrical generation involve carbon fuels.

Either coal, oil, natural gas, biomass, you name it. All of these are going to produce gases that are going to be harmful to the environment. They are going to produce greenhouse gases.

And I know some people don't believe in global warming, certainly the President of the United States doesn't agree about global warming, but it does exist. And I originally came from the state of Maine, where we used to go fishing a lot in northern lakes.

Now there are no fish. Acid rain from coal-fired plants. In those coal-fired plants there is also -- I heard a comment from someone?

Would you like to come up and make, I don't believe I bothered you while you were making your comments, right, sir?

MR. CAMERON: Okay.

MR. BURTON: Okay, thank you.

MR. CAMERON: All right.

MR. BURTON: All right. I knew the people when they were called the Clam Shell Alliance, way back.

All right, now getting back to the issues that I want to deal with, I've been involved with a lot of environmental issues. I'd like to consider myself an Environmentalist.

Many of my students lived off the grid. I've had students that have driven in wood-fired cars. I have students who are living in straw houses. So I've seen it all, and I believe that we have to have nuclear power in order to exist, especially here in the Northeast.

When I started teaching, oil was $2.00 a barrel, now it's $70 something. When I was heating my house with oil, it used to be 16 cents a gallon. I pre-bought for $2.76 the other day. So the cost of these fossil fuels that we use here in the Northeast, are increasing so that I feel this year, many people in Vermont, are going to freeze to death.

It's just going to be pretty bad when you have to burn 1,000 gallons of oil in your house and it's going to cost almost $3.00 a gallon. Who is going to be able to afford it?

We've had no national energy policy. We're talking about 20 years down the road. That's short-term, 40 years down the road is short-term. I started out dealing with energy in 1962, and one of my students made a hydrogen fuel cell, that's how I got enlightened in this thing.

1962, that's a lot of years ago. And I've been involved in learning about energy for all these years. All right, now, what's going to happen? I really feel we not only need to re-license Vermont Yankee, but we need more nuclear power plants throughout the country.

Because fossil fuels are going to diminish. China wants them, everybody else wants them. They're polluting the atmosphere. They're going to kill the earth in just a very, very few decades.

Now with nuclear power we have the ability to get the fuel right here in North America. We can use nuclear power to generate electricity. We can use nuclear power to electrolyze water and get hydrogen. And hydrogen is going to be the fuel of the future.

And granted, there's a lot of things about getting hydrogen from the source, the production, to its use. It's a very small molecule, but we can drive cars with hydrogen. We can heat with hydrogen, you can do a lot of things.

So once we get a long-term energy policy, it doesn't matter if you're a Republican or Democrat, I don't know when it's going to come down the road, but we need a long-term energy policy with nuclear power, and hydrogen replacing gasoline.

Because I know, right here in town, we have soybean oil for diesel and people are burning it. That's fine, you're not using gasoline, but you're polluting the atmosphere, just the same, with those greenhouse gases.

So I'm convinced that we need a long-term policy and I hope that some, it won't be in my lifetime, but I guaranteed if you can look forward, 150 years from now, you're going to be driving around in your hydrogen cars.

That's all I have to say, oh, by the way, concerning fishing and so forth. I spent the last weekend stocking salmon in the tributaries of the Connecticut River, so I'm not, you know, a polluter. I'm an Environmentalist, I'm a Fisherman, but I am concerned about our energy future, not only in Vermont but the United States. Thank you.

MR. CAMERON: Okay, thank you very much, Mr. Burton. How about Mr. English, then Bernie Buteau, and Dan Jeffries. Is Bob English here? Okay, this is Mr. Robert English.

MR. ENGLISH: Hello. About 30 years ago the Union of Concerned Scientists developed a program that provided the way that the United States could be 70 percent solar-powered by the year 2000. Well, here it's 2006, and we're talking about energy problems and energy shortages.

Well, for the last 25 years, I've lived in a solar home that I built, and I've lived off the grid with solar electricity from portable tag panels. If you came into my house, you wouldn't notice much difference from your house.

I have computers, I have monitors, I have televisions, I have a microwave. I have a washing machine. I cook on electric hot plates in the summer and I cook on a wood cook stove in the winter. I don't use any oil to heat my house.

So when people tell you that we need to risk the very ground that we stand on, that we need to risk making it uninhabitable for 15 generations, in order to heat our homes and have electricity, it simply isn't true.

(Applause.)

MR. ENGLISH: Technologically we can solve energy problems, we can do it without destroying the environment. The problem is political and social. We need to say we want renewable energy, we are not willing to pay the price of the destruction of the earth, to heat our homes.

We do not need to do that. Thank you.

(Applause.)

MR. CAMERON: Thank you, Mr. English. Is Bernie here, Mr. Buteau, I'm not sure I'm pronouncing that correctly.

(No response.)

MR. CAMERON: Okay, how about Mr. Jeffries, Dan Jeffries? And Ted Sullivan? John Dreyfus?

(No response.)

MR. CAMERON: Okay, Carol, Carol Boyer. I think Carol is here, isn't she? Carol, do you want to come down and talk to us?

MS. BOYER: Hello, everyone, can you hear me. This is my first experience attending a hearing of this sort, and I had actually not planned to speak.

What I would like to say is to build on what the last speaker described, which is his experience living with a solar home.

I'm imagining how good it must feel to know that you're meeting your basic needs without adding anything to the debt that we, as humans, have accumulated in our attempts to meet our needs, and also in our, really, we're so full of ideas and we can do so many things, we seem to have lost track of our relationship to the larger circle of life.

And I would like to suggest that we follow up and that each of us become responsible for learning that, for example, our own Department of Energy has very firm studies that clearly tell us that if we exerted the political and social will, we would have no need for any of the risky enterprises that we use now to meet our needs for energy and heat.

I'm not going to repeat what was just said about the time table on this, but I would like to say, say it this way. That we need to be forward thinking. And my sense is that nuclear power is kind of passe.

We've all looked at this. We see what the risks are, and there are huge chunks in Russia that have been, in their terms, withdrawn from public use, for the foreseeable future because of an accident.

And, as far as I know, nobody has repealed Murphy's Law. So I'd like to suggest that we be responsible and that we get this message today that we are asking all of you to look beyond what has become an old mantra, and make use of the truly up-to-date technology, that could allow all of us to feel good about living our lives without adding to the environmental burdens. Thank you.

(Applause.)

MR. CAMERON: We thank you, Carol. Nancy, Nancy Nelkin.

MS. NELKIN: Hi, I'm Nancy Nelkin, I'm from Western Mass, I'm an educator. I guess I wanted to start out with the comment, I think it was Rich. He said something about us being, referring to us as the public experts.

That was flattering, however, I think there are really only a few true experts among us, like Ray Shadis. I think part of the problem is, as taxpayers, we're paying the NRC as our employees, to be the knowledgeable representatives of public interest.

The NRC is responsible for overseeing the nuclear industry. And when they do a poor job, they risk our health and well being, when you do not rigorously and objectively evaluate the impacts of nuclear power on us.

And my understanding with this license renewal process, there's a safety review. And you're talking about looking at aging management. And I still ask when will you determine when a nuclear plant is not environmentally or otherwise, fit to continue.

I get the feeling that as long as you can put a band aid on this or tighten a screw here, that you will continue to run the nuclear reactors, which really has more benefits for the corporations that run them, than for us, as the people who live in the area.

Because we have to live with the effects on the Connecticut River. We have to live with the effects on our health, increased cancers. These are things that need to be looked seriously, by the NRC, in this process.

Not to mention the nuclear waste that's stored in our backyard. It's bad enough that it's already there, it's at risk by an accident. It's at risk by criminal act.

And the company is resisting taking measures to make that more safe. I want that to be considered in this process. And if we continue to re-license the plant, we will have that much more nuclear waste.

In fact, it will be, the nuclear waste

will reach its capacity and go beyond. I want to add that I question this assumption that we need more and more energy and that the only choices are centralized forms of energy that use fossil fuels, coal that uses, uranium.

This is not an automatic assumption. One aspect of this renewal, as I understand it, is to consider alternatives. And I want to ask my neighbors, who live in this area, to really look seriously at alternatives.

There are so many renewable options. There's solar, there's wind, and people have a way of making it sound like, oh, well you know you really can't do that, that's not practical. That's not true.

It's very practical, it's very doable. This is an article that's very low researched. It's being done in other countries. It's being done in Western Europe.

People are putting solar panels on their homes and getting paid by the utility for producing that electricity. So we need to open our minds and not get into an either/or situation where people saying well coal plants are so bad for the environment and it's making, causing global warming.

So we have to run the other way to

nuclear. You have to really think hard about all of the nuclear waste that's going to be with us forever. And will Entergy be with us forever.

Will they be footing the bill to take care of that, forever. As long as it takes for the radiation to dissipate.

So I just, I'm pleading with the NRC to take a really objective and rigorous approach to this. I think that, you know, all of the areas that we have to look at are out there. Thank you.

(Applause.)

MR. CAMERON: Thank you, Nancy. Is Mike Hame here, by any chance? Or a Mr. Peyton?

(No response.)

MR. CAMERON: Let's go to, Sally, Sally Shaw, do you want to talk?

MS. SHAW: (off mic.)

MR. CAMERON: Thank you, Sally, for sending, you're going to send the comments and then we'll go to Sally, Sally Shaw, thank you.

MS. SHAW: In the interest of full disclosure, I work for New England Coalition, but I'm speaking here today as a Resident of the ten mile EPZ. I live in Gill, Massachusetts.

As an ecologist, I'm compelled to point

out that environmental impacts are multi-variate impacts. They are not generic. Life is not generic. And although biological systems are resilient and they recover from damage, radiation exposure causes genetic impacts that will change life forever.

Genetic damage can be passed on to our offspring and theirs. It can change biological communities forever. I submit that the very idea of a GEIS is sheis. In NRC's Executive Summary of their Generic Environmental Impact Statement, which I consider an oxymoron.

They state that among the 150 million people who live within 50 miles of a U.S. Nuclear Power Plant, I prefer to call it a reactor, not a plant. About 30 million who will die of spontaneous cancers.

That's one in five people, by their calculations. And they say that since we can't prove a one of them was caused by radiation, therefore the NRC doesn't have to worry about them, note bene.

They admit that five calculated fatalities associated with nuclear powered induced cancers will occur. So I ask which one of us, or our children, living within 50 miles, will die of radiation induced cancer, over the lifetime of this plant.

That's the cost of progress. Tough luck, sucker. Most of the people who die of radiation induced cancers, will live within ten miles.

Thus, there's a very good possibility that we will know, we in this room, will know some of them. At last count, my husband and I counted, between us, 28 people we know who have died or are living with cancer, in our extended community.

Can I prove that their cancers are radiation related? No. Therefore, the effects, the impact of these deaths, on our life, is considered by the NRC to be of small significance.

The Executive Summary of the 600 some odd page Environmental Impact Statement, is full of little items like that. Here's another. The staff concludes that the generic analysis of a severe accident, applies to all reactors.

The probability weighted consequences of atmospheric releases fall out onto open bodies of water, groundwater releases and the societal and economic impacts are of small significance, for all reactors.

That, with the stroke of a pen, wipes out all our concerns. They also conclude that the environmental impacts of design-basis accidents, are of small significance for all plants.

And, because additional measures to reduce such impacts would be costly, don't worry, they won't burden the Licensee with extra mitigations.

At a recent ACRS hearing in Rockville, Maryland, NRC staff, I think maybe it was NRR staff, testified that in a design-basis accident or loss of cooling accident, under upgraded conditions, which they're not looking at, of course, with this re-licensing thing.

The entire quantity of the core would be released in about 30 seconds. And accident impacts after uprate, are greater than the 20 percent uprate, they may approach 40 percent, maybe more.

And this might result in a 500 roentgen exposure at the limiting location, which happens to be very near a residence, which happens to be on the plant perimeter.

I submit that such an accident would have a significant impact on the person or family living there. So I would ask the NRC to recalculate. That goes on and on, I'm going to skip.

In the Appendices of the GEIS, your estimates of risk quantities, for early fatalities, normalized doses and cost, were made using an aptly named crack code. We know about cracks.

Our steam dryer has 62 of them, at last count. And it uses the middle year of current license, or the flat part of the bathtub curve that nuclear scientists know represent the stability or the stable running of nuclear plants.

Experience shows that Vermont Yankee exceeded radiation release limits, several times during the early part of its life. Theory predicts, as it ages, it will release more again.

NRC variances, such as doubling the allowable main steam line leak rate, exempting Entergy from doing the ten-year primary containment leak rate test that was supposed to have been done in 2005.

All of that implies to me that the theory is correct, and they don't want to find out. And then there's the small fact that Entergy is negotiating with Vermont and the NRC to mask their actual releases, with a 29 percent discount.

That's been discussed at other meetings. I think the jury is still out on that one, but I can take a really good guess how it will go. I propose to the NRC that you come up with a more realistic way to model dose, since the bathtub is overflowing and with the uprate and the license extension, you're going beyond the rim of the bathtub.

So your middle year of current license criteria, seems to me, flawed. New and significant information.

I would like to submit the BEIR 7 Report of the National Academy of Sciences. The biological effects of ionizing radiation. The National Academy of Sciences told us that, in fact, there is not a threshold dose phenomenon.

The GEIS presupposes a threshold dose phenomenon. Therefore, it claims that it does make sense to normalize early fatalities. That's based on the BEIR 5 Report, not BEIR 7.

I would like to suggest that you recalculate using the conclusions of BEIR 7. What does BEIR 7 say about radiation risks to workers under exposure of one REM per year. That was another little nugget in the Appendices of the GEIS.

I'm just curious. I would love to see that calculated. I think your Appendix E.4.1.2 is faulty, also based on BEIR 7, because it's based on the notion of a threshold of effects. That does not seem to be the case.

Your Appendices E.8.2, these Appendices show the tables and the calculations behind a lot of their conclusions in the GEIS.

Quantities and units, assumes non-stochastic effects will not occur if the dose equivalent from internal and external sources combined, is less than 50 rems or fewer in a year.

This, too, contradicts the conclusions of the BEIR 7 Study. Your cost estimates also use BEIR 5, not 7, and the costs are based on 1980 costs, or maybe they were updated to 1994, 12 years ago.

In my experience, prices have changed quite a bit in that 12 years. The other thing, quarrel I have with your cost estimates, is that you skip Indian Point, hypothetical accident costs for Indian Point.

I don't blame the NRC for skipping Indian Point. Lots of folks live down there. The cost of an accident would be astronomical, but it's not good science to leave out a big outlier like that, in this case.

I would just like to pause for a second, to say this is really crazy. No other power generation source comes close to having to expend so much money and so much energy, just to convince us that it won't kill thousands of us.

If Entergy, Excelon and others just

invested in wind and solar, none of this would be necessary.

(Applause.)

MS. SHAW: I do hope that you will consider that possibility in your NEPA required look at alternatives to re-licensing ENVY.

The tax-funded labor costs of the NRC, ACRS, ASLB, etcetera, etcetera, would be eliminated. Please, save our tax dollars, we need them. In Appendix E, I think it was Page E-43, we talk about ALARA limits.

That stands for As Low As Reasonably Achievable. These are radiation exposure limits for workers. And they were derived using analytic techniques to identify the approximate point at which the cost of providing additional protection, would exceed the risk averted.

You see, it sounds like apples and oranges to me, so I'm just curious what, this is a question, I guess I missed the question part, I should have asked it then.

But what dollar value do you place on a workers life? I'm just curious. I guess I'll conclude with saying that it seems to me that your Generic Environmental Impact Statement is fatally flawed, in many ways.

Recalculations of early fatalities and latent fatalities, are biased. They are based on old information, BEIR 5, not BEIR 7, and I humbly request that you recalculate them based on the most currently available knowledge on the effects of radiation.

Particularly, low level radiation. Thank you, Chip.

MR. CAMERON: Thank you, Sally.

(Applause.)

MR. CAMERON: Could we, could we have someone from the NRC staff answer Sally's question? Not right now, but at the end of the meeting. She has a question, if anybody can answer that for her, I would appreciate it.

Our next speakers are going to be, first we're going to go to Mandy Arms, then to Sally Kotkov, and then to Bill Wittmer. Mandy? Okay, how about Sarah, Sarah Kotkov? And then we'll go to Mr. Wittmer.

MR. KOTKOV: Hi, I'm on the Board of New England Coalition, but my comments are my own personal views. At the outset, Rani said that, apologized for the weather. And I like to say that I don't think the that the weather is the reason that a larger number of people have not come out this afternoon.

I think that many of us are quite disgusted by the fact that the Atomic Safety and Licensing Board has recently refused to hear, or refused to accept the contentions, the new contentions of New England Coalition, based solely on their lack of timeliness in filing.

And yet, in a few weeks, we'll have another one of these public meetings. We think that these decisions, the decisions on uprate and on re-licensing, are based, and should be based on science and engineering, and to have a show of soliciting the views of the citizens, many of us believe is a sham and a travesty and I think that is why people have not shown up today, not because it's a little bit rainy.

As a citizen living here in Guilford, frankly I didn't think much about the power plant until 9/11, and then I thought a lot about the fuel pool and the risk of terrorism here.

Frankly, my only hope is that a terrorist would find this area too boring. The NRC, I think, thinks that the low population density here is a reason not to pay more attention to the safety of this outdated and aging structure.

The Mark 1 containment requires that the fuel pool be high up in the air, where it is not shielded by being below grade, as some other plants are. Here it's 70 feet in the air and it's, of course, highly vulnerable to attack by aircraft. When this plant was built, it was intended to hold the fuel, what's called spent fuel, which is, of course, highly, highly radioactive and dangerous.

It was intended to hold this fuel for six months. Now, of course, there's 33 years of fuel in the pool, there will be another seven by the time the license expires.

And now we are looking at the prospect of another 20 years beyond that, of fuel. And, of course, when the fuel, after the fuel is in the pool for five years, and then it's cooled sufficiently to put in dry casks, we're looking at the prospect of many, many more casks on the banks of the Connecticut River, where this, of course, also a terrorist target.

Especially if Entergy gets its way and does not even have to provide berms around the casks. And, of course, there's also a flooding danger. In 1991, there was a study regarding the construction of a low-level waste repository down on the plant grounds, and it was deemed not wise.

Now we're, of course, looking at high

level waste on the plant grounds. I think that's all I have to say, thank you.

(Applause.)

MR. CAMERON: Thank you. We're going to go to Mr. Wittmer, then Joyce Morin, then Linda Madkom. Is Mr. Wittmer still here?

(No response.)

MR. CAMERON: Okay, how about Joyce Morin? Mr. Madkom?

(No response.)

MR. CAMERON: Gary? Gary Sachs. And then after Gary we'll go to Ann Elizabeth Howes. Gary Sachs.

MR. SACHS: Nuclear is not cheap electricity. Protect the waste for 100,000 years, tell us how much that's going to cost. Spend some of that money to protect that waste, and then tell us it's cheap, affordable or inexpensive electricity.

I challenge you on that. To anyone who claims that there was a benefit to nuclear power, please show me this cost benefit analysis, including the price of dealing with this waste.

Because the rate we're given as for the power purchase agreement, from 2002, does not tell us the true cost of the economics behind this.

It was great for you to hear Ms. Banfield refer to the Department of Public Service Studies. I intend tonight, at tonight's meeting, to bring more economic data on how that Department of Public Service Study breaks down and to actually how much per person that will cost, if we didn't have Vermont Yankee starting in this year or in a couple of years.

And one of my concerns, when I hear the NRC at this meeting, in regard to the data that they use for their studies, is that they take much of their data, not from their own sources, but from the Licensee. And, in my opinion, that's poor practice.

(Applause.)

MR. SACHS: For those people here, who have less experience than some of us who live locally, who've been following this issue for quite a while, this re-licensing issue is actually about no moving parts.

It's not about dry cask storage. It's not about the uprate. It's not about the evacuation plan. And it's not about any moving parts in the reactor itself. Just so you know.

And to relate to that man who spoke earlier, who was the teacher in Bellows Falls. In order for nuclear to cover the carbon-based emissions, better used in coal and in natural gas plants, etcetera, we would have to have a new nuclear power plant built every two weeks, between now and 2050. I don't think that's going to happen, sir.

Last Friday, the Ninth Circuit Court in California stated the NRC, in doing these Environmental Impact Statements, must take into account risk of terrorism.

And here at Vermont Yankee we have a radioactive water pond, that is 60 feet up, covered by basically an aluminum, corrugated aluminum roof that has a breakaway roof with a pound and a half pressure per square inch.

To me that, I'm not sure what level of containment we have at Vermont Yankee, and I'd like that addressed in whatever this Environmental Impact Study is that you all are planning.

Richard Monson of the Harvard School of Public Health stated, quote, the scientific research base shows that there is no threshold below which low levels of ionizing radiation can be demonstrated to be harmless or beneficial.

I'm going to repeat that. There is no threshold below which low levels of ionizing radiation can be demonstrated to be harmless or beneficial. The health risks, particularly the development of solid cancers in organs, rise proportionately with exposure. At low doses of radiation, the risk of inducing solid cancers is very small.

As the overall lifetime exposure increases, so does the risk. Every nuclear reactor emits small amounts of radiation. Even, supposedly, zero-emission reactors.

On March 31st, 2004, the NRC arrived in Vernon, Vermont to inform us that they would not be performing the independent engineering assessment that had been a requirement, put on the uprate by the State Public Service Board.

For anybody who knows that they did do the independent engineering assessment, in my opinion, the NRC is not to be trusted. 5-4-04 the NRC changed its tune and announced that it had long been planning such an independent engineering assessment.

You, the NRC, say that Three Mile Island was a wake up call for the industry. That was March 28th, 1979. That same year the NRC publicly stated that there was no such thing as a safe amount of radiation.

Since 1979, I'm going to list some of the events that have occurred. February 11 th, 1981, Tennessee Valley Authorities, Sequoia One Plant in Tennessee. A rookie operator caused a 110,000 gallon radioactive coolant release.

January 25th, `82, the Ginna Plant near Rochester, New York, a steam generator pipe broke. Fifteen thousand gallons of radioactive coolant spilled. Small amounts of radioactive steam escaped into the air.

January 15th and 16th, 1983, Brown's Ferry Station. Nearly 208,000 gallons of low level radioactive contaminated water was accidently dumped into the Tennessee River.

1981, `82, and `83, Salem One and Two in New Jersey. Ninety seconds from catastrophe when the plant was shut down manually, after the failure of an automatic shut down system.

A 3,000 gallon radioactive water leak in June of `81. A 23,000 gallon leak of mildly radioactive water, which splashed onto 16 workers by -the-by, in February of `82.

And radioactive gas leaks in March of `81, and September of `82. Then, in 1996, NRC Chairperson Shirley Jackson, speaking of Millstone in Time Magazine, quote, clearly the NRC dropped the ball. We won't do it again.

1997, Yankee Rowe, 20 miles of here. In the process of closing it, they determined they had found that they had dumped, for 30 years, radioactive water into the Deerfield River. Many people swim downstream from that river.

February 15 th, 2000, New York's Indian Point Two, aging steam generator ruptured, venting radioactive steam. The NRC initially reported no radioactive material released.

They later changed their report to say there was a leak, but not enough to threaten public safety. Wait, didn't the NRC in 1979, say there's no such thing as a safe amount of radiation? Hmm.

2004, new NRC Chairman Nils Diaz, about Davis Besse, said the Agency, quote, dropped the ball again. Hmm. A lot of balls getting dropped by the NRC.

If Three Mile Island was a wake up call, were you guys asleep at the control panel during these other events, or just napping. I heard someone refer earlier to the fact that Mr. Emch has been involved with the NRC for 30 years.

That means he's been involved since before you guys knew what you're doing to apparently the mid to late `80s, when you claimed to have a handle on these events and not be making mistakes any longer.

Okay, so here we are in a NRC meeting. Please tell me how the NRC does not stand for nobody really cares? The environmental impact of Vermont Yankee.

We have an ineffective evacuation plan, which has been untested in its entirety. What about those people who don't have vehicles? What about the daycare centers and all the schools being tested together?

What about the transient local members in the community who are in hotels? A worst case scenario accident at Vermont Yankee would lead to an area the size of western Mass, Vermont and New Hampshire, being uninhabitable for possibly 30 or more years.

The plumes from the National Aeronautics and Atmospherics Administration, shows plumes going as far north as deep into Canada, over Montpelier. As far south as North Carolina, and as far east as over Cape Cod.

Getting the Ninth Circuit Court's decision last week, it appears that the NRC has some excuses to make. In 2001, just a month before 9/11, Vermont Yankee failed the Operational Safety Response

Evaluation Drill of the NRC.

In this drill, mock attackers, who work for the NRC, tried to enter the Control Room by getting over the fence and past security at Vermont Yankee.

Prior to the test, the time and where the mock attackers would be coming from, was told to the Security. The mock attackers were able to enter the Control Room, got past the Security and VY won the notoriety, calling itself the least secure nuclear station in the country.

Needless to say, the NRC no longer does that test. I have a question that comes up, that I didn't ask in the beginning of the meeting, which is, on what do you base radiation exposure? Is it the ICRP? International Committee on Radiological Protection?

Or is it on the European, on the European Committee on Radiation Risk? Thank you.

MR. CAMERON: Okay, thank you, Gary.

(Applause.)

MR. CAMERON: So that we can go on with other speakers I would just ask, again, if any of the NRC staff has the information about, that Gary is asking about, please talk with him.

We have a few more speakers and then I'm going to ask one of the Senior NRC people to close out the afternoon meeting. And I believe this is, this is Ann Elizabeth Howes, and then we're going to go to David McElwee, Debra Reger, and Cora Brooks. Ann Elizabeth.

MS. HOWES: I'm a common citizen with relatively low technical education. And I haven't pursued the subject at all.

I guess it was last week when we had the 17 low level warning system and we had to replace the blower. But, you know, I rarely stay up late and I was watching movies, and at about 5:00 I went upstairs and I could see the dawn approaching and I thought, well, I mean it was probably 4:00.

I was feeling, it's dark out. Like we've lost power somewhere, it's very quiet and still. And that's kind of like a tiny, little feeling of fear, but that the experts are taking care of it, and I went to bed as I usually do.

And I really think I probably will, I don't really think that I'm an important member of the experience. I kind of compare it to the feelings I had when the World Trade Towers collapsed, that I sort of felt as though I was an American adult and, you know, with nothing to stress my life.

I was experiencing stress, and when the Towers collapsed I felt something has been shut off. And when experiencing a profound natural peace.

And I run on little dreams, every once in a while, like an indication in my house, I have a kitchen leak. And I think we had cracks in the blower or something like, cracks in the towers that we had to think about.

And I'm like, just a little animal out there and I'm getting the same poetic feeling that there's, you know, stretch marks in the towers and people are concerned about the foundation.

And this afternoon I hear, you know, it's sitting on the Connecticut River, and I have an odd dream. That the Connecticut River runs on top of a little shell that is a dirt shell.

And that a disruption the size of Vermont Yankee, would cause the river to disappear into a gorge and emerge further downstream. I haven't verified that, though I do think that we're technologically capable enough to check on that.

This afternoon is the first time, maybe the second time I've heard that the reactor is 70 feet in the air, which is a decision as to whether or not any kind of explosion would suck water and dirt into the air and emit, you know, to the hills, but it would probably be buffeted. Like there is a higher rate of survivor-hood, on the other side of the mountains from Hiroshima.

That it's at, you're buffeted by the earth. There's one other detail. I feel as though we have gotten excited to secure the strength of the foundation.

But I also feel as though it's in our own, honest, personal assessment, as animals working in the reactor, that it's an older, radioactive installation. And my feeling is that we would experience a kind of removal of the radioactive jewelry.

A reduction of the vin diagrams of overloaded electromagnetic force fields that is causing a depression of our circulatory systems, our blood chemistry.

But if we were to stop the creation of nuclear waste, and stop our mental dependence on extremely bright street lights. Over, hugely over air-conditioned environments and brought our electrical usage, personally at home, down to seriously conservative levels, that we would feel some relaxation of social economic status stress, that is the equation of the success of industrial America.

And it's, you know, you're at that big decision point in your life, where you straighten up and start respecting incredible simplicity, and really learn solar panel.

Really contemplate wind farms and harness the hydro-electric potential in the rivers and streams and waterfalls. And gauge down to accepting that as the amount of electricity that you can look at and use.

I grew up in the automotive industry, I don't drive a car. I haven't gotten it together. But I know that I have to respect the integrity of the industry, the transport of food, I mean, dependent on stores and supermarkets and the refrigeration factor.

But I had also another dream. And it's sort of coming around to, you know, this last week of level low emergency, that there is a metallic fatigue that's like you know you have an automobile, and you have seen three of them in ten years.

Because you have a job, you can shift out of one automobile into another one, but there's that rest factor that's going on all the time.

MR. CAMERON: I hate to interrupt you, but could you finish up for us, please, so we can get in all the speakers.

MS. HOWES: So my fear, my point is to get behind security as the fun end that you're capable to cope with that puzzle.

MR. CAMERON: Thank you. Thank you very much, Ann Elizabeth. We're going to go to David McElwee, at this point, and then we have Debra Reger, Cora Brooks and Beth Adams.

MR. MCELWEE: My name is David McElwee and, in this spirit of full disclosure tonight, I'm an Engineer at Vermont Yankee, and I also live in the ten mile EPZ.

I could talk about the safe operation of the plant, as an Engineer at Vermont Yankee. But today I'd like to talk as a resident of the area, not as an employee of Vermont Yankee, but to talk a little bit about 20 additional years of the operation of Vermont Yankee.

Because 20 years in the future, we need to do something about the environment, about greenhouse gases. My wife and I have lived in West Brattleboro for nearly 30 years.

We own and operate a small business in town. I've raised two children here and feel very lucky that we have been able to join the rural country setting and lifestyle that's been afforded to us.

Prior to working at Vermont Yankee, I taught school in a public school system in a local high school. Part of my teaching was in the area of science, where my students and I would look at the environment and the effects that fossil fuels had on it.

Greenhouse gas emissions are a real problem and we need to do something about it. We need to stop relying on fossil fuels for the generation of electricity and turn more towards nuclear energy.

Nuclear energy is safe, clean and readily available for use in this country, and it does not contribute to the greenhouse gas emissions and helps keep our green mountains green.

To not allow Vermont Yankee to operate an additional 20 years, would be a significant impact on our environment. I'm very proud to be a member of this community, and also to have spent the last 25 years working at Vermont Yankee.

Vermont Yankee is a safe, well run plant and is a great asset to the area. It provides good paying jobs, provides an infrastructure to attract new businesses to the area.

To help, and help eliminate tons of

pollutants that would otherwise be put into the air that we breathe. And I look forward to another 20 years of operation at Vermont Yankee, and hope that the NRC will approve the license renewal application. Thank you.

MR. CAMERON: Okay, Debra Reger, I'm not sure I pronounced that correctly. Is this Debra?

MS. REGER: Yes.

MR. CAMERON: Oh, good, okay. So we have a duo or duet?

MS. REGER: Martha is part of my Affinity Group and I asked her to just stand with me for support, if that's okay.

MR. CAMERON: This is Leftover Affinity?

MS. REGER: Yes, we're leftovers and since it's our turn to talk, I just want to have the appropriate banner. Shut It Down Now, it says. I'm from central Vermont, near Montpelier, and I think this is so important that I drove two hours, with my Affinity Group, to be here.

(Applause.)

MS. REGER: So, I did want to start with, I really believe that we are trespassing with this nuclear power plant on a fragile web of life on our dear planet, the Mother Earth.

So I speak from my heart, with these concerns. I think the uranium that's mined to operate this nuclear power plant, is coming from native land, from very, people that have lived for over 30, what, 40 years, with the tailings of the uranium mining.

And why doesn't the environmental scoping include the people that live, you know, with these tailings, with the still births and the water, from the water, from the polluted water, from the polluted air.

And now we're going full cycle with storing of radioactive waste back on the Indian Reservations. I don't think this is fair. I don't think there's been any, you know, where does the generic scoping, you know, where does that fit in.

(Applause.)

MS. REGER: You want to use coal. What is this group, Vermont Energy Partnership, you know, they want to use coal that's that's taken from the Mother Earth. The water in the slurry. The Peabody Coal has been doing this for like 20 years, using all that precious water. We're running out of water.

You know here we have the threat of the radioactive, you know polluting the Connecticut water. You know they'd rather use coal but they're gonna, you know transport it by coal slurry. You know, it's not fair that the corporations, you know get away with this.

I want to thank all the grandmothers, and the mothers, since November, have risked arrest here in Brattleboro, and have stood, you know in the lobby of Entergy* [phonetic], and have stood at the gates of Vermont Yankee, and where is it that we have to send our grandmothers and mothers to risk arrest? What does that say?

And maybe we don't have the auditorium full today, but I know that people don't want to live with this risk anymore, and it's really not fair. Okay. I want to speak to alternatives. In my home town of Corinth, we publish Northern Woodlands magazine. Last month--I want to give these, I don't have enough for all 25 employees, but I want to give you all a copy to read tonight in your hotel. "Energy From Wood: Turning Woodchips Into Power, Heat and Ethanol." We have the answers. We have the alternatives. We've listened to Amory Levans* [phonetic], Rocky Mountain Institute, and other experts. We can use energy efficiency.

Finally, Vermont just passed a bill that we will be selling appliances that really turn off when you turn them off. You know it seems like a little thing but all this stuff will really add up. We have the program in Vermont, Vermont Efficiency.

We can like use this and we don't need the power from this nuke; we really don't. So I want to give you all a copy of this to read tonight, and I guess in closing, I just want to thank my affinity group for coming down, especially to Martha, this is-- and Monica, and Sal.

MR.   : [off-microphone comment]

MS. REGER: Yeah. It is really difficult to--you know, workers do have a choice. We protested a lot, as the New Hampshire Women's Peace Network, at Sanders, in New Hampshire, in Nashua, New Hampshire. They were making parts for the cruise missile.

And, you know you do have a choice. Every worker has a choice. I don't think it's our job to provide alternative jobs, but we can convert that plant, we can still have a good economy, we can convert that plant, run it on gas, like I said we can use alternatives and provide the same amount of energy.

I do feel that people need to look within when--and all you guys that work for the Nuclear Regulatory Commission, you know, I don't know how you can sleep at night. I really don't.

So that's all I'm gonna say.

MR. CAMERON: All right. Thank you very much. And thank you for the magazines too.

Cora. So we have Cora and Beth, and then we're going to have Rani Franovich close the meeting for us.

Cora.

MS. BROOKS: I found a country journal from 1980, and I thought, well, I wondered why I had saved it. There was a nice article about mushrooms in it. And then I kept looking through it--and I just found it this week, and there's an article about Vermont Yankee from 1980, about the town of Vernon, and how much anxiety--1980, we're talking about. How much anxiety exists in the communities around this plant. And not only does this plant--let's say it--causes cancer, causes cancer of unborn, yet unborn children. Not only does it cause cancer, it causes heart attacks for the anxiety that people live with.

People are in denial as much as possible, the way you are when somebody dies. In some religions, you come back a year later to make sure no one has seen that person. Because it's hard to believe when somebody dies. It's hard to believe that the nuclear plant that's serving your community and the state of Vermont, and is giving jobs to a lot of the people that you know and care about, that's hard, to feel that it's a shaky situation.

Now Copernicus and Galileo suggested the most outrageous thing. They said, you know, the sun doesn't rise in the east and set in the west. The world turns around. Now we also know that the world wobbles. I'm not making this up.

The scientists: I have a New York Times headline that says the world wobbles, the sun rings like a bell. The scientists know that. We know that there are volcanoes that erupt. We know that there is lightning that strikes. We know that this year alone, there have been three or four significant coal mine operations that have faltered and killed people.

The light isn't very good for me here but I am going to try and read to you from this article that was written by David Riley in 1980.

Country Journal. A few of the Vermont Yankee, up until 1980, wobbles. High-pressure turbine leaks shut down 82 hours. That was in 1973. 4-27-74, following scheduled shutdown, plant restricted to 80 percent power output due to excessive radioactivity levels in off-gas system.

5-24-74. Leaks in drywall exterior, containment vessel shut eleven days. Again '74. Multiple lightning strikes, shut down 75 hours. That was on 7-5-74.

3-23-75. Operator error, high reactor water level, shut down three days.

6-5-75. Failure of start-up transformer, power source for cooling tower fans, shut down ten days.

1975. Vibration problems in nuclear reactor, shut down 23 days. 9.1 million cost passed on to consumers. This is our cheap electricity.

11-12-75. Vermont Yankee given seven months to begin building a gamma radiation shield to protect people at elementary school across the street from plant.

1-27-76. General Electric company, manufacturer of reactor, indicates that the torus could lurch upward under pressure, causing major damage. The torus is a donut-shaped pool inside the containment vessel. Shut down 18 days.

5-14-76. Lightning causes fire and radiation releases.

I don't care how good the workers are in the plants. May they stay alive and not become angels. I don't care how good they are. They're human stuff. It doesn't matter that we're on a world that wobbles, lightning and earthquakes.

7-18-76. Plant releases 83,000 gallons of water containing low levels of radioactive tritium into Connecticut River. Yankee settles with state of Vermont for $30,000.

Now it goes on. But I want to say that I had a grandmother who was related to her sister, who was once married to a governor of Vermont, and I came up here as a child because there was no electricity when we came up to the place that we came up to, and I loved that, and I came back, and my grandmother, the sister of one of the governor's old wives, she died in childbirth, but she said when you come to a place, she said, you take care of it and leave it a little better than you found it.

When you come to visit a place, you leave it a little better than you found it. And what she said about her land in Vermont. She said this isn't my land. This isn't our land. This is land that we take care of while we have it. And we take care of it and make it a little bit better than it was.

So I'd like to ask the NRC to take a really close look, and I would like to reverse the understanding. You asked us to help you. I'm asking you to help us.

MR. CAMERON: Okay. Thank you, Cora. We actually have two speakers and then I'm going to go to Rani. And we have Beth Adams from Citizens Awareness Network and then Jane Newton will be our final speaker.

I think this is Beth coming down now, all right, and then we'll go to Jane.

MS. ADAMS: Hi, there, how are you? I'm a new resident of Greenfield, which is ten miles away from Vermont Yankee. I came down in February, not really knowing about Vermont Yankee. So I must say that I'm not up to speed on all the details, and I appreciate all the research that people that have spoken before me have shared.

I've been an anti-nuclear activist, however, since 1979, and at that time I opposed nuclear power plants and I still any nuclear power plant, and I do not believe that Vermont Yankee should be open one more day.

We need to close Vermont Yankee, not just think about extending licensing for 20 years. How foolish is it to develop an energy that we don't know what the waste, what we're going to do with the waste, we're just going to let it sit there, and, in fact, others that have spoken before me have shared that this waste puts us in greater danger. Not only does it put us in greater danger. Not one of you yet has spoken about the people that have died already in Kosovo, in Vieques, in Iraq, in Afghanistan, having been poisoned by depleted uranium on the tips of the missiles that were dropped there, either by protests, as in Vieques, or so that we could, so that corporations could control their profits.

It is time, as others have shared before me, that we take a hard look at what we are doing. Taking a different course now, I'd like to go in a direction of what we can do, and others have shared about this already as well.

We can, as Citizens Awareness Network well knows, we can develop the technology at a reasonable price, relatively much more reasonable price than creating nuclear, keeping this plant alive, create wind power, geothermal, which hasn't been mentioned. Geothermal energy and hydro energy to create sustainable energy resources.

I came from Maine. We closed Vermont Yankee. They have a viable renewal energy plan in Maine. They have a dam that actually has little elevators that lift the fish uphill and people can buy into energy produced by that type of energy. Geothermal. There's a lot of hope in what that can do.

We have a heated core from the center of the Earth, that we're not utilizing, we're not resourcing ourselves with that yet, except in areas of--when I say "we" I'm thinking of this area. But other areas of the world and other parts of the country rely on geothermal energy for electricity and fuel already.

So there are things that we can do and that's what I think we should be focusing on, and it should be a regional discussion since it affects regional issues. Thank you.

MR. CAMERON: Okay. Thank you, Beth. Our final speaker is Jane Newton.

MS. NEWTON: I really didn't plan to speak at all but I sort a can't help it. I have no real qualifications, except that I'm a really terrified mother and grandmother, and I can tell, I can recognize a corporate con, corporate lies, and what I believe is a corporate crime against humanity, and for the people who are trying to tell us that nuclear energy is clean and it doesn't contribute to greenhouse gases, are not taking into consideration the amount of nonrenewable energy used to dig up and process the uranium, to make it into a fissionable form.

And as the person before me mentioned, the side product of making uranium fissionable is what's known as depleted uranium which is not depleted at all, and it's providing free, it has been providing free, since about 1990, the means for the U.S. military to fight a secret ongoing nuclear war. Therefore, nuclear energy is fueling war, which is just one more way to destroy the world.

MR. CAMERON: Okay. Thank you, Jane, and thank all of you for your comments today, and I'm just going to have Rani Franovich close the meeting for us.

Rani.

MS. FRANOVICH: Thank you, Chip. I just wanted to thank you all for coming again. I know a lot of you don't necessarily feel that the NRC takes your comments into consideration. I can assure you we do. Not all of you may be happy with how we change or incorporate the comments, depending on how they fit into the process, but I can assure you that we will respond to the comments that we receive at this meeting and in writing.

So thanks again for coming. Those of you who registered and met our attendants at the front table out here, they have meeting feedback forms, that we're hoping you will out, if you have any suggestions for how we can improve the conduct of our public meetings, things we can do better, how we may serve you better. Please let us know. The forms are addressed, pre-paid. All you have to do is fill them out and mail them in, or you can deliver them to a member of the staff.

And I just want to remind everyone that we will be receiving comments, in writing, until June 23rd, as Rich Emch mentioned, and he is the point of contact for receiving those comments.

Any comments received after that time, we will do our best to consider, and again, thanks for attending our meeting.

One other thing. The NRC staff will be around here for a few minutes, if there are any questions that people have, that we weren't able to discuss with you during the meeting. Thank you.

(Off the record.)

Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title: Vermont Yankee Nuclear Power Plant Public Meeting: Evening Session

Docket Number: (050-00271)

Location: Brattleboro, Vermont

Date: Wednesday, June 7, 2006

Work Order No.: NRC-1072 Pages 1-143

NEAL R. GROSS AND CO., INC.
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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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PUBLIC MEETING TO DISCUSS ENVIRONMENTAL SCOPING

FOR THE VERMONT YANKEE NUCLEAR POWER STATION,

LICENSE RENEWAL APPLICATION

EVENING SESSION

+ + + + +

WEDNESDAY,

JUNE 7, 2006

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BRATTLEBORO, VERMONT

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The Public Meeting was convened at the Latchis Theatre at 50 Main Street in Brattleboro, Vermont, at 7:00 p.m., F. "Chip" Cameron, Facilitator, presiding.

NRC STAFF PARTICIPATING:

F. "CHIP" CAMERON

ERIC BENNER

RICHARD EMCH

FRANK GILLESPIE

SPEAKERS:

SHAWN BANFIELD

BERNIE BUTEAU

SPEAKERS (continued):

CLAIRE CHANG

ELLEN COTA

JOSHUA DOSTIS

JOHN DREYFUSS

JOHNNY EADS

DART EVERETT

MIKE FLORY

DENNIS GIRROIR

MIKE HAMER

JOAN HORMAN

GEORGE ISELIN

DAN JEFFRIES

DEB KATZ

MARIAN KELNER

LARRY LAKENS

BETH MCELWEE

SUNNY MILLER

EVAN MULHOLLAND, ESQ.

KAREN MURPHY

CHRIS NORD

BILL PEARSON

GARY SACHS

GOV. THOMAS P. SALMON

RAY SHADIS

SPEAKERS (continued):

EMMA STAMAS

TED SULLIVAN

EMILY TINKHAM

CLAY TURNBULL

SHERRY ZABRISKIE

BETH

I N D E X

P R O C E E D I N G S

7:00 P.M.

MR. CAMERON: If you could take a seat, we're going to get started with the meeting tonight.

(Pause.)

Good evening, everyone. Nice to see all of you and thank you for coming out tonight on a rainy night and my name is Chip Cameron and I'm the Special Counsel for Public Liaison at the Nuclear Regulatory Commission which we're going to be referring to as the NRC tonight.

Welcome to the meeting. The subject of the meeting tonight is going to be the environmental review that the NRC conducts as part of its evaluation of an application that we received from the Entergy Company to review the operating license for Vermont Yankee and it's my pleasure to serve as your facilitator tonight. And in that role, I'll try to help everybody to have a productive meeting this evening.

I just wanted to cover three items of meeting process before we get to the substance of the discussions. And one is the format for the meeting tonight. Secondly, I'd like to talk about some very simply ground rules and last, I'd just like to introduce the two NRC speakers who will be giving you some background information tonight.

In terms of the format for the meeting, we're going to start out with a couple of brief NRC presentations to give you some background on license renewal at the NRC and on the environmental review, specifically that part of license renewal so that you know what we look at in deciding whether to grant a renewal for any particular reactor and so that you know how to get information about the process, the schedule for the license renewal and how you can participate.

We'll have time for a few questions on process after those presentations, to make sure that we've explained things clearly to you, but the most important part of the meeting tonight is to hear from all of you, to hear your views.

This particular meeting is called a scoping meeting and very simply, that's to ask for public comments, advice, recommendations on what the scope of the draft environmental impact statement should be. The NRC is going to prepare a draft environmental impact statement and we'd like to know what issues we should look at, what alternatives should be considered as we develop the environmental impact statement.

The staff will tell you about submitting written comments. We're taking written comments as well as meeting with you tonight, but we did want to be here in person to talk with you.

Any comments you give tonight are going to carry the same weight as any written comments that we receive.

In terms of ground rules, they're very simple. When you speak, please introduce yourself and give us any affiliation, if that's appropriate. And I would ask that only one person speak at a time. Most importantly, so that we can give our full attention to whomever has the floor at the moment, but also so that we can get a clear transcript. We have a court stenographer, Mr. Peter Holland, who is up here. He's going to be recording all the comments tonight. And that's going to be our record. It's also going to be your record of what transpired here tonight.

I would also ask you to try to be brief, so that we can have an opportunity for everybody who wants to talk to speak tonight and I'm asking you to follow a five-minute guideline. When you come up here to give us your comments and I'll ask you to summarize, as we get close to the five-minute guideline.

And I found that five minutes is usually enough for someone to summarize their major points for us and you can elaborate, if you want to with detailed, written comments that you submit to us, but even though it's only five minutes, it does two important things. One, it alerts the NRC staff to what they should begin looking at immediately, even to exploring that in more detail with you after the meeting. And secondly, it alerts everybody else in the audience to what concerns people might have about the license renewal.

And finally, I would just, as usual for any meeting, is to just display courtesy to those that might have different opinions from you tonight. And I want to introduce the NRC speakers this evening and we're going to Mr. Eric Benner who is right here. Eric is the Chief of the Technical Review Branch within the License Renewal Program. And Eric and his staff, they are responsible for looking at the technical review issues in the environmental impact statement.

And just to give you some background on Eric, he's been with the Agency for about 15 years.

He's been a reactor inspector in one of the NRC regions. He's also been on the staff of the individual Commissioners who make up the Nuclear Regulatory Commission and has been an advisor to the NRC and the United States in terms of the development of the international convention, the Treaty on Nuclear Safety. He has a Bachelor's in nuclear engineering from Rensselaer Polytechnic Institute and he has a Master's in environmental engineering, I believe, from Johns Hopkins University.

Eric will be giving you an overview of license renewal and then when Eric is done, we're going to turn to Mr. Rich Emch who is right here. He's the project manager for the environmental review on Vermont Yankee. And he'll be providing some of his detailed contact information to you in a few minutes. But Rich has been with the Agency for over 30 years with the Nuclear Regulatory Commission. He's been involved in all aspects of reactor regulation, focusing on radiological protection and safety and his academic background is a Bachelor's in physics from Louisiana Tech University, and a Master's in health physics from the Georgia Institute of Technology.

And with that, I would just thank you all for being here with us tonight and I'll turn it over to Eric.

MR. BENNER: Thank you, Chip. I'd like to begin by thanking all of you for taking the time to come out and talk to us tonight. I hope the information we provide will help you understand the NRC's license renewal process and your role in ensuring that our environmental impact statement that we prepare for the Vermont Yankee license renewal is accurate and complete.

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(Slide change.)

MR. CAMERON: I think you need to raise it and --

MR. BENNER: Can everyone hear? Okay. No?

MR. CAMERON: Well, say something and then we'll be able to tell.

MR. BENNER: Can everyone hear now? Okay, I see heads nodding in the back, so I'm going to take that as affirmative.

We have several purposes for tonight's meeting and this is going to reiterate some of what Chip said. First, is background. We'll discuss the NRC's mission and process for renewal of nuclear power plant licenses with particular emphasis on our environmental review process, including the typical areas we look at in the environmental review and the schedule for the Vermont Yankee review.

Well, I'm sure that many of you are familiar with the NRC's mission and some of our processes. I'll ask you to be patient with me as we go through this for the people who are not familiar with these processes.

At the conclusion of the presentations, we'll have some time, as Chip said, for questions about the process. After the question and answer portion is complete, then we'll move into what we consider one of the more important purposes of the meeting and that is to receive any comments that you may have on the breadth and depth, commonly called the scope of our environmental review. I'd ask you to hold your comments until that time because for purposes of the transcription, it's easier to have the presentation portion, the Q & A portion and then the comment portion all discrete.

Additionally, we'll also give you some information about how you can submit comments outside of this meeting.

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(Slide change.)

MR. BENNER: Before I discuss the license renewal process, I'd like to take a minute to talk about the NRC in terms of what we do and what our mission is.

The Atomic Energy Act is the legislation that authorizes the NRC to, among other things, issue operating licenses for nuclear power plants. The Atomic Energy Act allows for 40-year license for power plants. This 40-year term is not based on safety limitations, but is instead based primarily on economic considerations and anti-trust factors.

The Atomic Energy Act also authorizes the NRC to regulate the civilian use of nuclear materials in the United States. In exercising that authority, the NRC's mission is three-fold: to ensure adequate protection of public health and safety; to promote the common defense and security; and to protect the environment.

The NRC accomplishes this mission through a combination of regulatory processes such as conducting inspections to verify compliance with our regulations; evaluating operating experience from power plants domestically and internationally; and issuing enforcement actions when licensees are found to be not in compliance.

The regulations that the NRC enforces are contained in Title 10 of the Code of Federal Regulations which is commonly referred to as 10 CFR.

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(Slide change.)

MR. BENNER: As I have mentioned, the Atomic Energy Act provides for a 40-year license term for nuclear power plants. The NRC's regulations also include provisions to allow for an extension of the license for up to an additional 20 years. For Vermont Yankee, the current operating license will expire on March 21, 2012. The licensee for Vermont Yankee, Entergy, has requested license renewal for the plant.

As part of the NRC's review of the license renewal application, we'll perform an environmental review to look at the potential impacts of the environment associated with an additional 20 years of operation. As I stated earlier, the purpose of this meeting is to give you information about this process and to seek your input as to what issues we conduct in our environmental review.

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MR. BENNER: The NRC's license renewal review involves two parts: an environmental review and a safety review. This slide really gives a big picture overview of the license renewal review process which involves these two parallel paths. I'm going to briefly describe these two review processes, starting with the safety review.

Next slide.

(Slide change.)

MR. BENNER: Two guiding principles form the basis of the NRC's approach in performing its safety review. The first principle is that the current regulatory process is adequate to ensure that the licensing basis of all currently operating plants provides and maintains an acceptable level of safety with the possible exception of the effects of aging on certain structure's systems and components.

The second principle is that the current plant specific licensing basis must be maintained during the renewal term in the same manner and to the same extent as during the original license term.

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(Slide change.)

MR. BENNER: The safety review for license renewal focuses on aging management of systems, structures and components that are important to safety as determined by the license renewal scoping criteria contained in 10 CFR Part 54. The license renewal safety review does not assess current operational issues such as security, emergency planning and safety performance. The NRC monitors and provides regulatory oversight of these issues on an on-going basis, under the current operating license. Because the NRC is addressing these current operating issues on an continuing basis, we do not re-evaluate them during license renewal.

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MR. BENNER: As I mentioned, the license renewal safety review focuses on plant aging and the programs that the licensee has already implemented or will implement to manage the effects of aging. Let me introduce Mr. Johnny Eads. Johnny is the safety project manager and he's in charge of the safety review.

The safety review involves the NRC staff's evaluation of technical information that's contained in the license renewal application. This is referred to as a safety evaluation. The NRC staff also conducts audits as part of the evaluation, and there's a team of about 30 NRC technical reviewers and contractors who are conducting the safety evaluation at this time.

The safety review also includes plant inspections. The inspections are conducted by a team of inspectors from both headquarters and NRC's Region 1 office in King of Prussia, Pennsylvania. A representative from our Inspection Program is here today, Senior Resident Inspector Dave Pelton. And the Resident Inspector lives in this area, works at the plant 40 hours a week conducting independent inspections of the licensee's activities to ensure compliance. The result of inspections are documented in separate inspection reports.

The staff documents the results of its review and safety evaluation report. That report is then independently reviewed by the Advisory Committee on Reactor Safeguards or ACRS. The ACRS is a group of nationally-recognized technical experts that serve as a consulting body to the Commission. They review each license renewal application and safety evaluation report, form their own conclusions and recommendations on the requested action and report those conclusions and recommendations directly to the Commission.

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MR. BENNER: This slide illustrates how these various activities make up the safety review process. I'd like to point out that the hexagons on the slide, the yellow hexagons, indicate opportunities for public participation. Also, the staff will present the results of its safety review to the ACRS and that presentation will be open to the public.

Next slide, please.

(Slide change.)

MR. BENNER: The second part of the review process involves an environmental review with scoping activities and the development of an environmental impact statement. As I've said, we are here today to receive your comments on the scope of that review. We'll consider any comments on the scope that we receive at this meeting or any written comments. Then in December, we expect to issue a draft environmental impact statement for comment.

Next slide, please.

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MR. BENNER: So the final Agency decision on whether or not to issue a renewed operating licenses depends on several inputs, inspection reports, and an associated confirmatory letter from the Region 1 Regional Administrator, conclusions and recommendations of the ACRS which are documented in a letter to the Commission, the Safety Evaluation Report which documents the result of the staff's safety review, and the final environmental impact statement, which documents the results of the environmental review.

Again, the yellow hexagons on the slide indicate opportunities for public participation. An early opportunity is during the scoping meeting today. The meeting on the draft EIS is another opportunity. The opportunity to request a hearing ended on May 27 of this year, and three petitions were proffered containing about 10 separate issues. As I mentioned, the ACRS meetings also are open to the public.

Now I will turn it over to Richard Emch, who will discuss the environmental review in more detail.

MR. EMCH: I'm Rich Emch. I'm the Environmental Project Manager for the Nuclear Regulatory Commission for the Environmental Review of the license renewal application for Vermont Yankee.

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MR. EMCH: We conduct this review under the guidelines of the National Environmental Policy

Act of 1969. NEPA requires that Federal agencies use a systematic approach to consider environmental impacts. They also require that an environmental impact statement be prepared anytime there is a major Federal action which has the potential to significantly affect the quality of the human environment.

The Commission decided that we would issue an environmental statement for any license renewal projects. In 1996 and revised in 1999, the Commission prepared a generic environmental impact statement that looked at the 92 aspects of environmental impact for the 103 operating reactors in the United States. This generic environmental impact statement was for license renewals specifically.

Next slide, please.

(Slide change.)

MR. EMCH: I mentioned that there were 92 issues that were evaluated in that generic environmental impact statement. Approximately 69 of those issues were labeled as what we call Category 1 issues which means that we concluded that the impact was essentially the same at all power plants in the United States and that it was small. For the other issues, the decision was made that there was enough variability in the impacts of those areas from power plant to power plant that we needed to do a plant specific analysis of those aspects of the environmental impact.

Going back again for the Category 1 issues, in addition to the plant specific reviews, we do it for the Category 2 issues. For Category 1 are the ones where we made the generic conclusion. We do what's called a search for new and significant information. What that means is we're looking for any information, we will look for any information affecting that particular plant that would cause us to want to decide whether or not, or cause us to think that there might be some challenge to that generic conclusion.

If we find such new and significant information after evaluating, then we come to the conclusion that it is new and significant, and then it does challenge the conclusion, then we need to do a plant specific review for that issue for that plant. That's that first yellow arrow on my right-hand side there.

For the issues that are in Category 2 issues, we do conduct a plant specific review. All that goes into this generic, all this goes into what we call a supplement to the generic environmental impact statement. It's a plant-specific supplement for each plant, in this case, Vermont Yankee.

Next slide, please.

(Slide change.)

MR. EMCH: The purpose of all this review is against this decision standard. In simple language, to me, this decision standard says what we're trying to do is determine whether it is acceptable, whether the environmental impact of an additional 20 years of operation of the plant is acceptable.

Next slide, please.

(Slide change.)

MR. EMCH: Now that we talked about what we're going to do, let's talk about the schedule. As you can see from -- I'm not going to read the entire schedule, but let me just hit a few of the high points.

The first high point I'm going to hit is tonight, this scoping meeting. In the parlance of NEPA, this is a scoping meeting. In other words, this is where we come talk to the public, the people who live and work near this plant and ask you if you have any information about issues or if you have information that you want us to be specifically aware of as part of our review of this plant.

We already know we're going to be looking at the 92 Category 1 and 2 issues, but it's possible that you might have some issue that we need to know about or you might have some information that we need to know about.

On June 23 is when the end of the scoping period occurs. There are a number of ways to do -- to give us comments. One is by speaking tonight. You can send it in by email. You can write them by letter. We'll talk a little bit more about that at the end of my presentation.

The next big events are the public meeting. After we take your scoping comments and all the other information that we find as part of our review, we will develop a draft environmental impact statement and we will send that draft environmental impact statement out with preliminary conclusions. We'll send it out to the public for review. When you signed up tonight, we asked you to sign up on a yellow or blue card. If you put your address on either one of those cards, we'll send you a copy of that draft environmental impact statement when we develop it.

Then we'll come back in January, probably at this same theater for another meeting where we will ask you, give you the opportunity to give us comments about that draft environmental impact statement. You can tell us what you like, what you don't like, what you wished we had changed, what you think we missed.

And then finally, and the comment period will run into March and then in the end we'll issue a final environmental impact statement in August of 2007.

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MR. EMCH: This depicts all the various areas where we gather information. The first area of information -- place where we get information is from the licensee's application. The licensee includes an environmental report in the application that they send in for license renewal. That environmental report does a couple of things. First, it includes plant-specific analyses for the Category 2 issues. The other thing it does is it includes licensee's description of the extent that they went to try to find new and significant information that might affect the Category 1 issues.

We also have our staff audit. I have a team of people from the Nuclear Regulatory Commission.

I also have a team of various environmental science experts from the Argonne National Laboratory, led by Mr. Dave Miller.

Together, we do on-site audit activities. We've done some. We'll be doing additional ones where we look at the site. We look at the site environs. We go out and talk to various government agencies. We consult with them about information that we need in order to carry out our review. That kind of moves down to the next box. We talk to the Agency for Natural Resources here in Vermont. We talk to the people, the Historic Preservation Officer. We talk to the State Health people. Talk to a wide range of Federal agencies such as Fish and Wildlife Service, NOAA Fisheries Service and gather all the information that we need to do the review.

We also talk to -- what we call permitting authorities. In the State of Vermont, EPA has delegated the responsibility for issuance of what we call a national pollutant discharge elimination system permit and that's been delegated to the State of Vermont and we talk with the officials in the State of Vermont who are responsible for issuing that permit to make sure we understand what's going on there.

We also will talk with social services in the State or in the community near the plant. And finally, what we're here for tonight, as I mentioned before, is to get comments from you folks about the issues that we need to look at and information that you believe we need to look at as part of our review.

Next slide, please.

(Slide change.)

MR. EMCH: This picture depicts in a broad sense the areas that we look at as part of the review. You'll see terrestrial and aquatic ecology there. You'll see water quality, air quality, socio-economics, environmental justice, radiation protection, and looking at archeological and cultural resources -- I believe I covered all of them.

That's a kind of a broad view of the things that we do as part of our review.

Next slide, please.

(Slide change.)

MR. EMCH: This is some additional information about how to contact us or to get more information about the review. As I said, my name is Rich Emch. There's the phone number up there that you can contact me at. Four libraries in the local area have agreed to make the documents involved in the review available. This is the licensee's application.

The draft environmental impact statement, when we issue it, those can be found at these libraries: the Vernon Free Library in Vernon, Vermont; the Brooks Memorial Library here in Brattleboro; the Hinsdale and the Dickinson Memorial Library in Northfield, Massachusetts. You can also find these documents on the web at the web address that's up there.

Let's talk again about how to submit comments. First and foremost, of course, you can give us comments by making a presentation here tonight. You can also send them to us by mail at the address that's up there. You can email them to us. The email address that's been set up specifically for that purpose is VermontYankeeEIS@nrc.gov and then if you wish, you can deliver them to us in person in Rockville, Maryland.

Again, the scoping comments, we need to receive them by June 23rd or they need to be postmarked by June 23rd. If they are, I assure you we will consider them. If they come in after that, we'll consider them to the extent that we have time to do so.

With that, I'm finished with my presentation.

Chip, are you ready to take some

questions?

MR. CAMERON: Yes, thanks, Rich. And thanks, Eric.

Unfortunately, we don't have a lot of time for questions, but if there are a few that we could address at this point, we'll be glad to do so and the staff will be here after the meeting to talk to you, if we don't get to your questions.

Let's go right here and please, just introduce yourself to us.

MS. MILLER: Yes, I'm Sunny Miller. I live and work at Trap Rock Peace Center in Deerfield, Massachusetts.

I'd like to ask why at the nrc.gov website I can't select Vermont Yankee and get simply all the reports for this reactor separate from the myriad collection of reports at all reactors? I find it very difficult to isolate the information that I'm looking for. It takes me hours and hours to look at what's there and I can't select easily what I want to find.

MR. CAMERON: Thank you, Sunny.

MR. EMCH: If you go to the website and select Vermont Yankee under license renewal you can find fairly simply a number of the documents, but if you're talking about -- I'm not sure what range of documents you're talking about.

MS. MILLER: I'm specifically interested in emissions, in mishaps, in irregularities of all kinds and that is blended into -- it looks like it's blended into the entire national history of thousands of mishaps and problems nationwide.

MR. EMCH: Yes, I understand what you're talking about, ma'am. In fact, I understand it can be difficult. I don't really have a good answer for that. We can take your name and number and I can get in touch with you and I can try to help lead you to some of those documents, but -- do you have something to add?

MR. EADS: Yes, like you, I face that same challenge. If you'll end your search on ADAMS, there's a place where you put in a docket number. If you'll insert the number 05000271, that docket number, that is the docket number for Vermont Yankee and it will only pull up those documents related to Vermont Yankee.

You can then do a key word search and find those items particular to VY that you'd like to see. You can also specify a day range.

MR. CAMERON: And Johnny, are there -- when you talk about key words for Sunny's search and you heard the types of things that she's interested in, are there particular terms of art that the NRC uses that cover things like that?

MR. EMCH: Yes. As a matter of fact, thank you, Johnny, for that. Yes, as a matter of fact, when I'm doing searches like the ones you're talking about, ma'am, one key word that I often use is effluent and another key word that I often use is environmental. Those will usually pull up their effluent reports and those will usually pull up their environmental -- radiological environmental monitoring reports.

MR. CAMERON: Great, thank you for that.

Yes, sir?

MR. NORD: You mentioned a couple of minutes ago that you anticipate that the generic environmental impact statement is going to show small effects. And so my question is directed at those small effects. In light of the recent publication of the National Academies of Science BEIR VII report, Biological Effectives of Ionizing Radiation which has finally shown something that many people have suspected for decades which is that there is no threshold below which radiation doses are safe. So I want to know how the NRC has taken this new finding of

BEIR VII from our own national academies into account in their assessment? That's one half of the question.

The other half is I've always thought that environmental impact statements relating to specific sites would have to be specific and so why is it that we're talking about generic environmental impact statements?

MR. CAMERON: This is Chris, right? Chris Nord, okay.

Rich, can you answer the question?

MR. EMCH: Right. I want to answer in reverse order, if that's all right with you. The first one which -- or the second one rather was why generic, right. Okay.

When we say Category 1 issue, that means that we've already examined it for all the plants and we've determined it's small and it's the same for all plants. An example of an issue that is considered a Category 1 issue is, indeed, exposure to the public of radiation. The reason it's considered to be a Category 1 issue and to have a small impact is because the NRC, the EPA issue radiation standards for the public and the plants follow those standards, stay within those standards and therefore our conclusion is that if they're within those standards, that the impact is small.

Now let's move to the other part of your question. Actually, that particular aspect of BEIR VII wasn't entirely new and actually BEIR I, BEIR III, BEIR V and BEIR VII all talk about similar issues and from the very beginning, the BEIRs have always said and all the international agencies and indeed the NRC has always taken the approach that there is some health risk associated with any amount of radiation exposure.

Excuse me, sir, I'm talking. There is some health risk associated with any amount of radiation exposure. Now BEIR also talked about how small that risk is for very small doses, but basically in that respect BEIR VII, it's not new. We have known that for some time. We have used that theory for some time.

MR. CAMERON: Okay, thank you, Rich. Let's go to Evan and please introduce yourself.

MR. MULHOLLAND: My name is Evan Mulholland. I have a question about the slide decision standard for environmental review. You mentioned that standard and my question is can you give us some examples of what environmental impacts might be unacceptable so that it would result in a non-issuance of the new license? What types of impacts might cause that decision to happen?

Thank you.

MR. EMCH: It's fairly difficult for me to answer that because we haven't run into it yet, but we use the standards or the descriptors, if you will, from NEPA which is small, moderate and large. If one -- if we were to find a large impact, that would certainly -- we would certainly be in a category where we'd have to give serious consideration to whether that was acceptable or not.

Now there are other ways of dealing with it. There are mitigating measures and things like that, but if we ran into that, we would be in that kind of a range.

I will mention that in all the 42 that we have finished up to date, the impacts were all small with the exception of the impact of entrainment on the winter flounder fishery at the Millstone Plant in Connecticut which was a moderate.

MR. CAMERON: Okay, thank you, Rich. I think Gary has a question over here. Your question, Gary?

MR. SACHS: The question is what is the basis the NRC uses to determine radiation exposure?

MR. EMCH: That's a pretty broad subject. I'm going to kind of put that together with the question that you asked when you were here earlier today.

Basically, the NRC uses not only standards from EPA. We look at broad range of standards that have been published. ICRP, you mentioned that earlier today, International -- I'm never quite sure exactly -- International Committee on Radiation Protection, I think it is. There's also the NCRP, National Committee on Radiation Measurements and Protection.

There's the BEIR report. There's a fairly wide range in number of the National Academy of Sciences, etcetera and after we look at all of those, the NRC uses information from all of those to base the radiation standards. In the case of EPA, the overall standard from EPA is 25 millirem per year to any member of the public from the entire fuel cycle, including reactors.

MR. SACHS: The follow-up question would be given BEIR VII, BEIR I, III, V and VII, all of which say that any radiation is damaging to the public, how can you as officers, so to speak, of the public good, expect us to say oh, sure, fine, extend the license for 20 more years, keeping putting out radiation? It is damaging to the public.

MR. EMCH: You said "damaging". I said there is some health risk from any amount of radiation exposure. As I said, BEIR VII also talked about the very, very low risk at very low doses at the kinds of doses that we're talking about for public exposure here.

MR. CAMERON: We don't have time for an extended dialogue, but to the extent that we're saying things here, let's make sure we get it on the record, and Gary, you said?

MR. SACHS: You mean hurting us a little bit. Thank you, sir.

MR. EMCH: I mean there is a certain level, small though it may be, of risk associated with any radiation exposure at the levels that we are talking about. The levels that the NRC has defined for nuclear power plants, we regard those doses as being relatively safe for humans.

MR. CAMERON: Rich, can you just -- it's not just the NRC in terms of -- I mean there's the EPA. Can you just talk a little bit about other Federal agencies?

MR. EMCH: Chip, we just went through the whole thing. I said there's an EPA standard. There's an ICRP --

MR. CAMERON: All right.

MR. EMCH: BEIR.

MR. CAMERON: Okay. Let's go right here for a question. Yes, ma'am. And please introduce yourself.

MS. MURPHY: My name is Karen Murphy. I have a question. The 9th Circuit Court of Appeals just made a ruling in California and it said that the NRC must consider the consequences of acts of terrorism and all licensing proceedings as part of the environmental impact statement under NEPA. So will you be doing that for VY?

MR. BENNER: As you indicate, that's a very recent decision and there is an appeal and review process associated with that decision. Right now, the NRC lawyers are reviewing that decision to see whether or not we would make any appeal attempts, but I would say that there will be some movement on that decision, either implemented or appealed well before the draft environmental impact statement would be published for Vermont Yankee.

MR. CAMERON: I guess it should be noted that that decision did concern the consideration of terrorism in the environment assessment and it should be clear to people that does not mean that the NRC was not considering terrorism as part of its safety review.

Yes, sir?

MR. DOSTIS: I'm the waffle man. My question is about background radiation. Do we have a baseline that we can compare background radiation as currently happening on the planet to, a baseline perhaps 10, 20 years ago and to note what our background radiation levels are now? That's my first question.

Second question, it's known that ionizing radiation occurs through solar, occurs through rocks, through -- occurs TV and computers. Do you think that sitting in front of your screen, your computer screen is as safe or safer than being in a nuclear power plant?

MR. EMCH: Let's do the first part of it first and I'll get to the second part of it. The first part of it is, not exactly sure what it was all, but I'll try to hit some -- and you'll let me know if I don't get it, okay. I think I got it. I'll try it. If I miss something, you let me know.

Currently, what we saw and there's a chart out in the hallway that talks about this, approximately, everybody as a member of planet earth gets about 360 millirem per year of background radiation. Now that includes cosmic radiation which you mentioned. It includes radiation from naturally occurring radionuclides in the crust of the earth such as granite and building materials. It includes radionuclides that are in your body as a course of nature. It includes medical x-rays, things like that and usually included in that 360 we have the line that says "less than one millirem per year from the nuclear fuel cycle".

So that's -- approximately 360 that includes radon in your homes, that sort of thing. There's a wide range of sources of radiation.

Now I don't know -- I don't recall reading anything that that number has gone up in the last 20 to 25 years what you were asking earlier. What I can tell you though as far as a background, before Vermont Yankee ever started operation, they did a pre-operational radiological environmental monitoring program for I think it was approximately three years to establish what the background levels of radiation were in the same areas they were going to be taking measurements during operation.

So they established their background, yes.

There's a baseline around the plant to the extent that they had monitoring stations in Brattleboro, yes.

MR. CAMERON: Okay.

MR. EMCH: Pardon?

MR. CAMERON: We've got to get this on the record, so -- and it is the waffle man, right?

MR. DOSTIS: Yes.

MR. CAMERON: Can you just ask that and then we're going to take two more questions and we're going to go the public comment.

Yes sir.

MR. DOSTIS: Okay, you have a baseline that was formed 33 years ago, I would say. Has that been updated to recent times?

MR. EMCH: Okay, well, at the locations right at the plant, it's obviously very difficult to do that because the plant is now operating, but as part of their environmental monitoring program, they do still have what they call control stations, what we refer to as control stations. They have indicator stations that are very close to the plant, control stations that are a sizeable distance from the plant. The assumption is that those control stations at a sizeable distance from the plant, where they're taking measurements, that there is absolutely no influence from the plant on those, so you can watch for variations in natural background which there are variations. You can look for variations in natural background that way, sir.

MR. CAMERON: Okay, thank you. We're going to take this gentleman and then this lady down here and then I think other questions are going to have to wait until after the meeting.

Yes sir. Please introduce yourself.

MR. JEFFRIES: Thank you. My name is Dan Jeffries. I'm an engineer at the Vermont Yankee nuclear power plant. The question relates to this matter of personnel exposure to ionizing radiation. We have about 100 nuclear power plants in the country and roughly with retirements, I'm just going to make an estimate that maybe we've had a thousand people work at those nuclear power plants. So we've got about 100,000 people who have been working at nuclear power plants for about the last 30 years. Does the NRC or does any agency that you're aware of evaluate the health condition of those 100,000 employees in regard to any adverse effects on their health as a result of their having worked at these nuclear power plants for all this time?

MR. CAMERON: Thank you, Dan.

Rich?

MR. EMCH: There have been some studies. There was one completed fairly recently that was published in the British Medical Journal, I believe it was. It was a study of -- with using records of occupational exposure, plant workers, etcetera, for 15 nations. It was led by a Dr. Cardis, C-A-R-D-I-S. The NRC is still evaluating it, but I think, in general, what it showed was that by and large, no, there was no excess cancers amongst that group.

MR. CAMERON: Okay, thank you. Yes ma'am.

MS. KELNER: I have a question. The woman back here said that there was a decision to take into account terrorist threats to nuclear plants and the response that you gave immediately was the NRC is thinking of appealing it and I'm wondering why that would be the first response to something like that instead of wow, we better take this more seriously or what are the valid points in that?

So I'm a little concerned with that initial response. I'm wondering why.

MR. BENNER: Like Chip said, the Court's ruling was not directed at whether or not the NRC was doing a good job at assessing terrorism at nuclear power plants. The Court's decision was specific to does the NRC need to talk about the environmental impacts of terrorism in our environmental -- in that case it was environmental assessment. For this activity, it would be for the environmental impact statement.

Now going into that decision, the NRC had arguments of why it felt that terrorism did not need to be considered in the environmental impact statement. So certainly we are going to do whatever the Courts instruct us to do, but we need to look at, we need to go through the ruling of the Court to see if there was a misunderstanding, we didn't convey what we intended to convey or whether there's something we can learn from it.

MR. CAMERON: That's right, but let me try -- your name is?

MS. KELNER: Marian Kelner.

MR. CAMERON: Marian, can I just try to answer your question?

MS. KELNER: Why do you think terrorism shouldn't be part of the environmental impact statement?

MR. CAMERON: That wasn't your first question. You were upset about the fact that why should the NRC think about appealing this. And with any agency that gets a negative ruling on something from Federal Court, one of the things that the agency has to do and in concert with the Department of Justice is just to consider that option. So that's just sort of a matter of course. It doesn't mean that because the NRC, the Commission is considering that that the NRC thinks that terrorism shouldn't be part of the licensing review. And we do have one of our members of the General Counsel here who can talk to you a little bit more about that after the meeting. Steven Hamrick.

If you could explore that further with her, Steve.

I think we need to go to public comment. We've got a lot of speakers which is good, but we want to make sure we hear from all of you and I'm going to just list the first few speakers so that you know when to expect to speak and I guess I'm just going to ask you all to try to be as brief as possible so we can get everybody on.

But our first speaker is former Governor of Vermont, Governor Thomas P. Salmon, who we're going to ask to speak and then we're going to go to Debbie Katz and Sunny Miller.

So Governor?

And we're going to ask everybody to come up here and use the podium. Thank you.

GOV. SALMON: Thank you, Mr. Cameron, ladies and gentlemen. My name is Thomas P. Salmon. I've lived in this county for 47 years. I was privileged to serve as Governor of Vermont for two terms in the 1970s. More recently, for much of the 1990s, I served as president of the University of Vermont. I currently am a member of the Vermont Energy Partnership which is represented here this evening here.

Let me try to be mercifully brief, if I may. It was my understanding that the environmental considerations were the primary focus of this meeting and I've tried to structure my brief remarks on environmental concerns. First among equals is that since 1972, when the Vernon plant came online, the State of Vermont has avoided some 100 million metric tons of fossil fuel pollution and that's not an inconsequential environmental effect of life, particularly given the realities of potential replacement power later in this century with the candidates principally being natural gas and coal, both of which cause gaseous greenhouse emissions into the environment.

Point two is the fact that we're in the midst of a global warming debate in this country. And in my view, decisions ultimately made by regulatory bodies such as the NRC must factor in the realities of global warming and the clear and present danger suggested by unnecessary and unwanted ingestions of improper pollution into the Vermont and the environment of the country.

Now I have an old-fashioned view, having watched this plant grow, having been in the legislature of Vermont when it was authorized many years ago and that view is not likely accepted by all, maybe viewed as heresy in some quarters, but it speaks to the notion that this plant has been both safe and environmentally friendly over these many years and in that context in terms of its contribution or I should say noncontribution to pollution in this state, has helped make Vermont a cleaner place in which to live.

Now we're engaged in our state in a conversation about energy as we speak and this meeting tonight is an exceedingly important meeting on that subject. Now there are some interesting participants in this discussion and I'm aware of one. The Sharon Academy up in Sharon, Vermont, senior class, this past winter, put together an energy plan and they went up to Montpelier and introduced the plan before the House Natural Resources Committee. We had opportunity in the Vermont Energy Partnership, myself and Amanda Eiby, got to visit with the students and offer a critique of their remarkable work, but what we learned is this. These students in their analysis of Vermont's energy future included that nuclear energy is "clean, reliable, affordable and long lasting." And in opting for renewal of the license issue before us tonight and beyond, to describe the "cultural negativity about nuclear power as unjustified." That was the students' view in their words.

The point is this. People of all ages and perspectives are entitled to participate in this debate and maybe, just maybe, our kids might teach us a lesson or two on this important subject.

Now this Commission will travel many miles before it sleeps on these issues. You begin the process here in Brattleboro tonight and I for one wish you well in your profoundly important work.

(Applause.)

MR. CAMERON: Thank you, Governor Salmon. And next, we're going to go to Deb Katz of Citizens Awareness Network.

MS. KATZ: The NRC is here tonight to talk about it's environmental impact study. Now you'd think this is a no brainer, right? To store toxic waste along the banks of the Connecticut River is dangerous and vulnerable and to store more of this waste would be even more dangerous and vulnerable for another 20 years. And yet, that's exactly what they're talking about doing.

And the waste confidence rule of the NRC which at this point is a commitment that this waste is going to move somewhere is basically bankrupt, giving the legislative problems with getting waste anywhere.

And it's a no brainer, isn't it, to store toxic waste, 35 million curies of cesium alone, 70 feet in the air, outside of containment. That seems pretty dangerous and vulnerable as well, and yet, they want to do more of this. And they don't have a solution to what to do with the stuff they have now.

This all seems like a no brainer, but it doesn't seem to be a no brainer to Entergy or the NRC. They think all of this potentially makes a lot of sense and in this post-9/11 world, this isn't just dangerous, this is irresponsible and unconscionable. And although the NRC continually says we can't talk about terrorism, we can't talk about terrorism because they're dealing with it every day.

The truth is the California Appellate Court said we can and we must and they rejected NRC's arguments that looking at a terrorist attack in terms of licensing was too speculative, that it was looking at a worse case scenario, that it was secrecy and so we couldn't ever talk about it.

The truth is we better start talking about it be cause if this reactor is here and it's a prime target for terrorism, we're all affected by it and even if it's not attacked by terrorism to have nuclear waste that will be dangerous for 250,000 years stored on this site for decades, if not hundreds of years is something that should not be allowed. Without a solution to the waste problem, there should be no relicensing. And that should be it, cut and dry.

The truth is the 9th Circuit, in its decision won't save us. It acknowledges our fears and our concerns, but remember, the NRC is in the permitting business. It believes in safe nuclear power. We do not.

To create a sustainable energy future, we can't just put ourselves in the hands of the NRC although we want to thank New England Coalition, the Massachusetts AG and the State of Vermont for, in fact, intervening to hold Vermont Yankee and the NRC accountable. It is the Vermont legislators that will decide our future. They will decide what is best for all of us and we must keep this process open and honest.

In New York State, Congresswoman Nita Lowey commissioned a study by the National Academy of Sciences about whether Indian Point could be replaced, the Indian Point reactors. And it, in fact, found that Indian Point reactors could be replaced in the State of New York. It wouldn't be easy, but it was possible.

But why don't we have a National Academy of Science study here? Why haven't our legislators called for that so that we can have an independent look at what it would take to replace Vermont Yankee, not done by the NRC as part of their environmental impact study which is set up to permit Vermont Yankee to go ahead, not done just by the Public Service Commission which has mixed loyalties in terms of this, but a real independent study. It is the will that we have to exert on our legislators to do what's right. We need a clear vision at this point of a safe energy future, a future that we know is safe for our children.

I want to end with this notion of a vision. We envision a future of safety, prosperity and health for all. People generate their own electricity in their own homes. Local energy production is easy and accessible for all. We live in a world where safety, prosperity and human health are what we value above all and it is something that we have to hold sacred for all of us, not relicensing Vermont Yankee.

Thank you.

(Applause.)

MR. CAMERON: Thank you, Deb Katz. We're going to go to Sunny Miller now. Then we're going to go Mike Flory and Shawn Banfield.

Sunny?

MS. MILLER: Thank you, neighbors, for coming. I note that the relatively sparse number of people here. A large number of us, willing to come out on a dreary night, but many others unwilling to come and hear a charade because we don't believe that this environmental review will adequately investigate the details that need to be investigated.

First of all, a point of order. These are plants. On the shores of the Connecticut River, we have a nuclear power station and if our friends in

Washington aren't willing to notice that plants are green, we, in Vermont, New Hampshire and Massachusetts are going to revise our language and quit calling the nuclear power station a plant, because it's a euphemism that obscures the reality.

Smell them. They are sweet.

Secondly, radiation monitoring is now inadequate and will be inadequate. In Western Massachusetts, the Department of Health is doing no radiological monitoring. When I called them and asked how long would it take to find out my levels in Deerfield, they said well, one to two hours. But of course, that's a theoretical possibility. If the call comes in the middle of the night, will the response be prompt? If there's uncertainty about whether the person who called was a little daft, will the response be prompt? It will not be adequate because government likes for us to remain calm. Government likes for us to conspire with the illusion that everything is under control.

And we tolerate and are polite to listen and to consider things together, but there will come a time when the process is failing, that the people arise and insist as they did on Cochibamba, Bolivia, when Bechtel came and announced that they had made a deal and owned all the water. The people of Cochibamba came to the streets and asserted successfully using little more than conch shells, that the water belongs to the people. This air, this land, this water belongs to the people and with all due respect, former Governor, I don't know where you went, Salmon, the 250,000 years of radioactive waste storage and management which, of course, will be fraught with problems has an untold greenhouse effect. So please don't imagine that nuclear power is saving us from greenhouse effects.

Thirdly, health monitoring is inadequate. And it will be inadequate, except that where there's a will, there's a way and we have been successful in collecting a number of baby teeth. At Traprock Peace Center, at the Radiation Health Project, Radiation and Health Project -- radiation.org is their website. Ours is traprockpeace.org. You can download a form to mail in baby teeth. We need more baby teeth from the 10-mile radius and we can assess Strontium-90 levels to actually see the differences. Mothers who were carrying their children while they lived within the 10-mile zone and breastfeeding while they lived in the 10-mile zone are particularly important. Please ask your neighbors if they've been saving baby teeth and there are forms outside. If all of you who care, even if you work at the reactor, please, I invite you to participate in this science project to see what our levels are. I don't expect the environmental group to be doing that for us. We have to do it for ourselves.

Fourth, thank you, Deb, for mentioning the future because down in Franklin County, Massachusetts and the rest of Western Massachusetts, there's a group called Co-op Power is working to form a biodiesel co-op and you have a chance to invest, so that the people own this co-op and determine that after the biodiesel factory, not a plant, is successful, those investments will turn to solar and wind power because where there's a will, there's a way, whether government sees it or not.

Fourthly -- that was number four. Number five, do we have an in-depth -- defense-in-depth? Do we expect environmental impact in detail and in depth? No, I'm sorry, I don't expect it, but I do expect that on father's day when Citizens Awareness Network and Traprock Peace Center and probably the New England Peace Pagoda, I hope and others will join together in a walk to the Entergy Headquarters. Some will gather at Entergy, the reactor site. Others will gather beginning at 10. Others will gather at noon at the

Brattleboro Common and come together to the Entergy offices. Let's bring our plants, our strawberries and anticipate the success of our people who are willing to endure and persevere for what is right.

Thank you all for envisioning that bright future together.

MR. CAMERON: Thank you very much, Sunny, and --

(Applause.)

MR. CAMERON: Thank you. And I wanted to switch the order to allow two people to come up next who perhaps need to leave early. One is Beth McElwee and the other one is Ellen Cota. So if we could have Beth come and then Ellen.

Beth? And Ellen, you're right there. Okay, good.

MS. McELWEE: Good evening. My name is Beth McElwee and I'm here tonight to share a unique perspective on the socio-economic benefits of Vermont Yankee to our surrounding communities. I was born and raised in Brattleboro and have had the opportunity to interact with Vermont Yankee in a variety of capacities over the past 24 years.

As a young teenager, I worked alongside other kids my age at Vermont Yankee functions, preparing rooms, serving meals and distributing materials to attendees. By providing these opportunities to responsible youth, Vermont Yankee introduced us to a high standard of work, while encouraging us to further develop our interpersonal communication skills.

As an active member of my high school class, I approached Vermont Yankee on several occasions to request their sponsorship of various club activities and events, including Register to Vote Day and High School Day Under the Dome. With enthusiasm and generosity, Vermont Yankee went above and beyond my requests with their donations to both of these community-oriented activities.

As a college business student, I served as a part-time summer intern for Vermont Yankee Nuclear Power Corporation during their transition to Entergy Vermont Yankee. The internship and co-op opportunities provided by Vermont Yankee are highly utilized and greatly beneficial to students of all disciplines throughout many regions of the country. The contacts and experience gained in this internship helped me to excel academically and gave me the credentials to obtain a highly sought position in the Boston area following graduation.

Two years later, I've made the decision to return to the Brattleboro area and pursue my professional and personal aspirations in this beautiful rural community. As I suspected, the job market in this area is significantly different than that of Greater Boston and I found it difficult to find professional employment opportunities, to utilize the experience and skills I've worked so hard to obtain.

Vermont Yankee is one of the few organizations in this area at which these skills could be fully realized. In addition, Vermont Yankee provides the needed infrastructure to attract other businesses to this area, so that young adults like me will be able to stay in Vermont and enjoy the area we've grown to appreciate.

We need to make sure that there are jobs available here to support those who wish to make this area our home. Vermont Yankee goes a long way in helping to secure this future for Vermonters.

Vermont Yankee should stand tall in this community. In addition to providing the most reliable, clean and safe source of energy throughout New England, their commitment to community involvement, youth development, and vast employment opportunities makes them a crucial and highly beneficial component of this community. A renewal of their operating license is integral to the continuation of the flourishing New England rural communities that we've all come to love.

Thank you.

(Applause.)

MR. CAMERON: Thank you, Beth. We're going to go to Ellen Cota. Then we're going to continue with Mike Flory, Shawn Banfield, Claire Chang and Ray Shadis.

Ellen Cota.

MS. COTA: Yes, I'm Ellen Cota. I am a mother. I work at Vermont Yankee and I live in the Emergency Planning Zone and it make sense to approve the license renewal.

Entergy is committed to being environmentally and socially responsible and has given a lot to this community.

The financial impact of not extending the license would affect Vermont negatively for many years. But more importantly, the environmental impact of closing Vermont Yankee would pose even greater threat. People have been told not to eat the fish out of the Connecticut River because of the mercury levels. Well, Vermont Yankee and other nuclear power plants do not emit the poisons or greenhouse gases which are slowly devastating our environment.

In addition, Vermont Yankee has a proven record of safe operations. Safety is and has been its number one priority. Entergy is a business. Corporate Entergy is a business. And I can assure you that Corporate Entergy would not put money into this license renewal process if they did not believe that Vermont Yankee was a well run, well maintained, safe facility.

Vermont Yankee is committed to safe operation and if I did not believe this, I would not work there.

The environmental benefits of generating electricity without emitting greenhouse gases is a wonderful legacy for our children and our grandchildren. I believe that we should approve the license renewal process.

Thank you.

(Applause.)

MR. CAMERON: Thank you, Ellen. Please, you're going to hear opinions that are different than yours and just, you know, just respect those opinions, that's all. Thank you.

Next four speakers, Mike Flory, Shawn Banfield, Claire Chang, Ray Shadis.

Mike Flory.

MR. FLORY: Thank you for the opportunity to be here and speak this evening. My name is Michael Flory. Some of you may have read about me a few weeks ago. I was the fire brigade member reported as injured in our unusual event and I'm happy to say that reports of my demise were just a bit exaggerated.

(Laughter.)

I am the chairman of Unit 8, Local 300 of the International Brotherhood of Electrical Workers. I work at Vermont Yankee along with more than 120 IBEW members. I'm proud to say that I was born and raised here in Vermont and I currently live just a few hundred yards from the front gate.

We are proud to work at Vermont Yankee because of the essential power it produces. We know that our work at the plant helps to make Vermont a cleaner, more prosperous place to live. Without Vermont Yankee, the 620 megawatts that we currently supply to the New England grid would have to come from a fossil fuel power plant. Wind power, the Connecticut River hydro project and energy conservation, while all nice ideas, simply cannot replace the steady, reliable, baseline power that we produce.

Since opening in 1972, Vermont Yankee has prevented more than 100 million tons of fossil fuel emissions from entering the atmosphere. This has been prevented not only by rendering an in-state coal plant unnecessary, but also from reducing the amount of out-of-state electricity that we have to purchase, most of which would come from coal plants, as coal still accounts for half of the power produced in America today.

In 2005, Vermont Yankee avoided the emissions of 7,700 tons of sulphur dioxide; 2,000 tons of nitrogen oxide and 2.5 million metric tons of carbon dioxide. Emissions of sulphur dioxide lead to the formation of acid rain. Nitrogen oxides are a key precursor of both ground level ozone and smog and greenhouse gases like carbon dioxide contribute to global warming.

The 2,000 tons of nitrogen oxide prevented by Vermont Yankee last year is the equivalent of what would have been generated by 105,000 vehicles. For comparison, in Vermont, we have 280,000 registered cars. Let me repeat. We at Vermont Yankee are proud of what we do, proud to produce power cleanly and safely and safety is our highest priority.

We would not work in the plant, let alone live near it with our families, if we felt that that place was not safe or that safety was not a priority at Vermont Yankee.

We have seen and been instrumental in the plant's continued enhancements and upgrades, most recently during the power uprate process. The cost of Vermont Yankee's power to Vermont consumers like myself is also far below regional market prices. As a baseload generator, we are able to provide lower cost power which is so critical for this state.

I respectfully submit that if you like having lights that go on at the flick of a switch, if you like computers that don't fry as a result of rolling brownouts, if you enjoyed air conditioning during last week's heat wave or heat during last month's cold snap, you should like Vermont Yankee's low cost, clean, safe power.

Vermont Yankee's value to my home state can only become more valuable as time goes on. As global warming becomes more and more destructive, we can remain an environmentally friendly source of power with zero greenhouse gas emissions. As the world energy market has become more competitive, we can continue to be a source of reliable, economic, baseload power and that is why we encourage the NRC to renew Vermont Yankee's license.

Thank you.

(Applause.)

MR. CAMERON: Okay. Thank you, Mike. And is Shawn -- Shawn is here. Shawn Banfield. And I would just encourage everybody -- I would thank everybody for following the guidelines and just encourage everybody to be as brief as possible. Thank you.

Shawn.

MS. BANFIELD: Thank you. Good evening. My name is Shawn Banfield. I'm here tonight as an active member and officer of the board of directors for the Vermont Energy Partnership. I'd like to thank the Nuclear Regulatory Commission for holding this hearing tonight.

The Vermont Energy Partnership was founded in January of 2005, shortly after the state report warned of a serious energy challenge facing us in the near future.

Our founding members came together, because they recognized the importance of making sure that adequate electricity was available so Vermont could continue to be a great place to live and work. The partnership is a diverse group of more than 50 business, labor and community leaders, committed to addressing the immense electricity supply gap issues facing Vermont. Our members include a cross section of experts in the energy sector. Our members employ thousands of Vermonters. They run businesses, large and small. And represent union workers, some of whom devote their professional lives to the operation of Vermont Yankee in a safe manner.

The partnership fully supports the relicensing of the Vermont Yankee nuclear power plant in Vernon and I will explain why. It is no secret that Vermont's demand for energy is continuing to grow. But it may be a less known fact that Vermont faces uncertainty over its future energy supply. Currently, one third of Vermont's electric supply comes from the Hydro Quebec -- from Hydro Quebec. And these long-term contracts will begin to expire starting in 2014. There is no guarantee that the contracts will either be renewed or renegotiated, given the other more local business opportunities Hydro Quebec has in the province.

Another approximate one third of Vermont's electric supply is made up of a wide array of both in-state and out-of-state renewable sources and nonrenewable sources. The Partnership supports the in-state development of renewable energy supplies, encourages the increased use of energy efficiency and the expansion of conservation measures. However, the fact remains a reliable energy portfolio must be made up of a baseload source of power.

Vermont Yankee accounts for the last one third of the Vermont portfolio, energy portfolio. About 34 percent of Vermont's total electricity supply needs are met by Vermont Yankee today.

So let me put this debate in further context. Vermont has not brought online a significant power generating facility in over 20 years and there are no plans to date to do so in the near future. To make matters worse, proposals to develop small-scale generation in Vermont have been met with sharp criticism and severe opposition.

In a time when energy costs are at their highest, the Vermont Yankee plant will not only play an essential role in our state's energy portfolio, it is critically important to Vermont's economy and environment.

From an economic standpoint, a stable, relatively low-cost power provider helps to maintain and expand businesses in Vermont, while at the same time providing an opportunity to attract new business. In a time when Vermont faces an increasing, aging population the plant provides employment to 600 highly skilled men and women. Those individuals in the company provide more than $200 million in economic benefits to the Wyndham County region and the State of Vermont as a whole.

According to the Vermont Public Service Department, the company through the power purchase agreement, will provide Vermont customers approximately $250 million in savings over the life of the contract. This estimate, it should be noted, was made when energy prices were far lower than they are today. And in fact, at 3.95 cents per kilowatt hour, Vermont Yankee power today costs Vermonters 40 percent less than other sources of electricity. This matters most to Vermont's elderly and the poor.

But aside from the important economic benefits of Vermont Yankee's continued operation, there are also relative environmental benefits from this in-state generation source. Today, we live in a country where half of the electricity generated comes from coal-burning sources, yet Vermonters can be proud to say that that is not true here. Vermont Yankee is a clean, emissions-free facility. Unlike fossil fuel-generating facilities, nuclear power does not release harmful greenhouse gases and other toxins into the atmosphere that are the primary cause for global warming.

It is becoming abundantly clearly that nuclear energy is the only emissions-free source that can meet consumers' demand for reliability and at a reasonable cost.

Leading environmentalists around the world, like Dr. Patrick Moore, co-founder of Greenpeace, have come to the conclusion that nuclear power is the only source that can help remedy and save the planet from catastrophic climate change. Just last month, Dr. Moore said in the Washington Post "nuclear energy is the only large-scale, cost-effective energy source that can reduce these greenhouse emissions while continuing to satisfy a growing demand for power. In these days, it can do so safely."

He went on to say, "the extremists who fail to consider the enormous and obvious benefits of nuclear power also fail to understand that nuclear energy is practical, safe and environmentally friendly."

In closing, without Vermont Yankee, Vermont utilities will be forced to buy additional power on the spot market that would be less reliable and considerably more expensive.

Do Vermonters really want to pay more and be dependent on power from fossil fuel sources such as natural gas and coal which now contribute to global warming and the earth's degradation? The Vermont Energy Partnership thinks not.

Vermont Yankee has an important and crucial to play in the future of our state. It is both economically and environmentally appropriate to grant the plant's license extension. We know there's a wide array of support for the continued operation of this plant for the reasons I have articulated here tonight: its essential economic benefits, its environmentally sound operations and its important role as a component in the Vermont energy portfolio.

On behalf of the Partnership, I'd like to thank you for the time here today and I appreciate the opportunity.

MR. CAMERON: Thank you, Shawn.

(Applause.)

MR. CAMERON: Claire Chang is going to join us down here and then we're going to go to Ray

Shadis and then to Sky Churchill.

This is Claire.

MS. CHANG: Hi, I'm Claire Chang. I recently saw a very interesting movie. It was called "Enron, the Smartest Guys in the Room." And in this movie, the movie was based on a book that was written called The Smartest Guys in the Room and these -- Enron is an energy company. They were dealing with originally natural gas and then they moved into a number of other energy sources including electricity. And what they were doing was -- I don't know how to explain it. It's very complicated. But the California energy crisis, quote unquote, which we all knew a little bit about, but didn't really know a lot about, is covered pretty heavily in this film in which Enron, Duke Energy and a number of other utilities, which Entergy is also a utility -- it is a power company that sells energy, electricity and other forms of energy at the highest cost that it can possibly get to reap the highest profits that it can possibly get.

However much they're paying their workers or they spend on publicity or community groups or high school soccer clubs or whatever else, Entergy is a profit-making company.

(Applause.)]

So in this movie, it turns out that the utilities colluded with the electrical generating plant to restrict and divert and artificially reduce the demand -- I mean reduce the supply causing an increase in costs and therefore an increase in profit to the amount of $9 billion in one year. California paid out $9 billion that it didn't need to pay out.

Entergy, because it's also a public -- not a public, but a privately-owned utility company, also sells its electricity out on the market and trades. Traders buy it and compete for whatever can be generated. So for Vermont Yankee, all of its electrical generating capacity has been planned out for 2006. That's the rest of this year and for part of 2007. All that electricity has already been sold and paid for, speculatively, by traders, by the national grid, by whoever Entergy can sell the power to.

So there isn't any way that they can now change the cost of that electricity that they've sold it for and I don't know the numbers. I just know that it was sold.

So it's committed to this generation of a set price of baseload power and baseload power means that it's running 24/7 at a very even amount and I think Vermont Yankee is now at 650 kilowatt hours or something -- huh? Megawatt hours, right, sorry.

So they've already sold all this to the grid and the grid has already agreed to a price, but the national grid or the regional grid actually for New England currently has a surplus. There's extra electricity out there. We don't actually have to have part of the electricity that's coming from VY right now. And I don't know the technical aspects of how the grid works, what happens to this extra electricity. But what we need to do is to investigate other ways of producing this electricity and to make it economically unfeasible for Entergy to continue running Vermont Yankee at its rate right now, which does not mean firing all the workers.

All the workers at Vermont Yankee right now will be employed for decades when Vermont Yankee gets shut down, whether it's tomorrow, in 2012 or whatever year it is because there is decommissioning. The plant doesn't just -- nobody just goes through the plant and turns out the lights and says "we're done, goodbye." No, there's an awful lot of work that needs to be done at that power plant.

So anyone who says that by turning off Vermont Yankee means losing your job, it's not true.

There's no need for that to happen. So one of the ways that we can economically make it unfeasible to Entergy to not run Vermont Yankee is to reduce our energy demand.

Energy efficiency and conservation are the easiest and lowest cost ways of reducing that energy demand. It's already been estimated that even in Vermont, if we replace five lightbulbs with compact fluorescents and a refrigerator or other major appliance like an air conditioner or home heating, other large electrical demand with energy-efficient or EnergyStar-rated appliances, we could reduce the demand in Vermont by 25 percent. Now this does require the participation of every household or double participation by half the households. But I don't think that that's an unreasonable goal to have, especially since it would mean that we would no longer have to depend on Vermont Yankee's electrical generation.

Another thing that you can do is you look at your electric bill. The average kilowatt hour per day usage is approximately 21 kilowatt hours a day. So 25 percent of that would be about 5 kilowatt hours a day. This is on your electric bill that you get every month. So if you look at that, that would be about 16 kilowatt hours. You can use that monthly bill that you get to gauge how well you're doing in reducing your energy demand. It's not something that's impossible. It's not something that's so beyond our own personal efforts, we can all take it upon ourselves to make something, to effect a change here and to do something different.

Lots of simple things that you can do, just changing your light bulbs, putting your appliances on power strips and turning them off when you're not using them. A lot of television sets and radios, stereos and appliances have a pre-heat on them which means that they instantly turn on with the remote control. But if you put them on a power strip, it's amazing how much electricity you'll actually save by not having these appliances warming 24 hours a day, 7 days a week.

The power strip also, amazingly enough, can save your appliances because you're then no longer susceptible to power surges and lightning strikes. I know that we don't get those around here very much, but -- you can turn your hot water down to 125 degrees or 120 degrees and if you have an electric hot water heater, it will also reduce your demand.

So in order to think about what other

choices we have and what we need to do, as individuals, it's really hard to think about wind power and solar power and what can we do as individuals.

The best thing that I can think of that we need to do is to read. Read books, read magazines, read articles, go to the web and Harvey Wasserman has a wonderful book out called Solar Topia which is a fantasy, but it gives you something to hold on to and something to dream about and something to think about of how you can apply it to your every day life. In it he says that basically wind power right now, as it is technologically developed is capable of replacing a majority of the electrical generation in the United States from fossil fuels and nuclear power. We're not just talking about only nuclear.

Now some of the complaints about wind power are that it kills birds. Well, the first wind towers that went up and I can't remember where the path in California where they went up, those wind towers were placed -- yes -- those wind towers were designed without thinking about the birds. They were like the erector set towers that have lots of braces, four legs and cross bracing and then finally the wind turbine at the top. Well, what was happening was that the birds were resting on these bracings and then when they'd see a squirrel or a chipmunk or whatever they wanted to get, these birds of prey would then fly down and get knocked out by the blades as they were coming around.

Well, now the towers are not built like that. They're single pole structures, so there's nothing the birds can rest on. The other thing is that the turbines turn so slowly now that you'd really have to have a suicidally-depressed bird to fly into one of these and get knocked out. So the arguments about birds is really un -- my brain is fried, I'm sorry. Unfounded. Good.

And the other thing about nuclear power, not nuclear power, wind power is that it's not something that's just a dream. In 2002, the Conference on American Wind Power Generating Association, was attended by maybe 1500 people. Last year, it was attended by more than 5,000 people. It had grown so much that it is not something that's just a pipe dream. You can go and visit wind towers that are installed in Vermont, in New Hampshire and in Massachusetts right now and see how they operate.

You can listen that they're not noisy and you can talk to the residents there who live next to them who really like their wind power and really like that they are in charge of and they are the ones who control their own electricity generation which is another issue here, is that Entergy is the company that's owned and operated out of Louisiana. It's not local. It's not based in Vernon. It's not based in Vermont. It's very far away and they own nine nuclear power plants. So they're not some little small player. But we need to take control of our lives here in our local area and decide for ourselves how we're going to live, how we're going to generate our electricity and how we're going to control it because we don't want somebody else from far away saying what we're going to do and how we're going to live.

And I think that that's really important to think about those kinds of issues.

MR. CAMERON: Claire, are you done? Could you sum up for us, please?

MS. CHANG: Sure. I can be done. I sense there's some -- I have nothing else.

MR. CAMERON: Thank you very much.

(Applause.)

We're going to go to Ray Shadis and then Sky Churchill and then Eesha Williams.

Ray?

MR. SHADIS: My name is Raymond Shadis. I work for the New England Coalition. From 1982 to 1997, I served on the New England Coalition Board of Trustees and from 1997 through to the present, I had served as their Staff Technical Advisor.

I was very concerned in presenting some scoping issues earlier that they met strict criteria for examination by the NRC and the criteria are strict, no active components and so on. But then after hearing the presentations this evening, I feel a little more at ease to address them and to address at least one externality.

In the uprate proceeding before the Vermont Public Service Board, Entergy presented quite a remarkable witness, Dr. Ernest Moniz, M-O-N-I-Z, from MIT and he is a former Assistant Secretary of Energy and I had the privilege of cross examining the good doctor and he made some startling admissions. Number one is that all of the fuel, commercial nuclear fuel produced in the United States to his best recollection was produced at the Portsmouth enrichment plant and the Paducah enrichment plant and both of those plants, which absorb enormous quantities of electricity in the process, are supplied by coal-fired stations.

My question for Dr. Moniz was well, then the pollution gets here ahead of the fuel, doesn't it? And in fact, the mercury that some speaker referred to earlier, those heavy, heavy coal-fired plants in Ohio and the ones that provide electricity to enrich nuclear fuel, among the dirtiest, do send their mercury to our waters and our fish.

The other thing that I brought to Dr. Moniz' attention and got his say on, were two publications from the early 1980s when a lot of us were beginning to be real concerned about global warming, greenhouse gases. One, a book by Senator George Mitchell and I want to call it The World is Burning, but then again I keep thinking of Billy Graham's, World Afire and I can't remember which one is which. And the other was a publication by World Watch Institute and their numbers more or less reconciled. And it was this, that in order to offset the growth in greenhouse gases, the world would need to undertake an unprecedented construction of nuclear power stations amounting to about a thousand on an average of one every three days for start-up, over the next 20 years.

And their net effect would be to reduce the growth in greenhouse gases by 20 percent, not reduce greenhouse gases by 20 percent. Please understand the difference. Reduce the rate of growth.

And I asked Dr. Moniz if he thought that was correct and he did a little bit of back of the envelope calculation and he said yeah, that would be approximately correct. The other figure that was astounding was that if we were to undertake that type of programming, we would then require the launching of another Yucca Mountain every two to three years. We can't seem to get the first one off the ground in 50 or 60. So those are some externalities, environmental effects that I regret to say I don't think NRC can consider them.

Going to some elements for potential scoping in the environmental impact statement, in the afternoon session I presented on spent-fuel pool accident off-site consequences, much, much worse than a reactor meltdown; much worse because the amount of fuel accumulated is much more than the fuel in the reactor. And what I neglected to mention in my summation on that was that NRC Staff in their study, NUREG-1738, said it really didn't make any difference how old the fuel was. You could not eliminate completely the potential for a nuclear fuel fire, zirconium-cladding fire. And that's of critical importance here because Vermont Yankee, like so many plants, has undertaken to checkerboard their fuel to segregate new and old fuel.

However, with the uprate, the fuel going in the fresh offloads are so hot that they have to integrate their reactor cooling system with the spent-fuel pool cooling system and actually run the residual heat removal pumps for the reactor at least for the first several days that they put the new fuel in. And this is a borderline critical situation. And I don't mean critical in the nuclear sense, but I mean critical in terms of the thermal considerations.

The other thing that NRC Staff said which goes to earlier conversation on this was that you could not assign probabilities to an act of terror or an act of malevolence. And the conservative regulator, protector of human health and safety, would then have to assign a probability of 1, absolute would be the scenario you would work under. Not one in a thousand or one in 250 or some other made up number, but if you can assign probabilities and you want to be proactive and protective of human health, then you go to 1. And it's absolute and you must protect absolutely.

And now I will get to the two scoping

issue items that we reserved for this evening. Number one, I want NRC Staff to be aware and take into consideration that the science of seismic assessment, seismology has evolved to a remarkable extent since 1971 when the plant was licensed. And to that effect, we're going to leave them a letter from Mr. Lawrence Becker, who is the Vermont State Geologist. This was a letter provided to our State Nuclear Engineer and entered into evidence in the Vermont Public Service Board case. But Mr. Becker points out that there are a number of new reports including among the more recent, 1995, a report on seismic vulnerability of the State of Vermont and then 1996, we have the real emergence of probabilistic risk assessment for seismic events.

NRC loves probabilistic risk assessment ever since Three Mile Island and here we have this risk assessment being developed for seismic events. NRC has in its routine inspection activities acknowledged the emerging changes in the science. In 1987, they issued a notice on an unresolved Safety Item A-46 which is essentially the beginning of applying this kind of risk assessment to various components within the plant and I want to direct their attention to a couple of critical components. One is the core shroud at Vermont Yankee. Like so many boiling water reactors, the core shroud after a decade in service began to crack and at Vermont Yankee, like other plants, it has this single monolithic, if you will, structure has not been bolted back together. If you can imagine large threaded pipe clamp-type structures. It's been gerry-rigged, bolted together. The question is has it been reanalyzed seismically using the new seismic investigation regimen?

The other item that I want to point to very quickly is the torus -- torus is a huge water tank shaped like a donut. It sits underneath the reactor. The task of the torus is to receive steam in the event of an accident and condense that steam and reduce pressure on the primary containment.

The torus at Vermont Yankee has been modified many, many times. The modifications began with an issue called torus lifting back in the very early days of this plant. Since then we have anecdotal accounts from workers, people in in-service inspection, who describe the welding of gussets on that torus and the abandonment of that project and the grinding away of those gussets.

We don't know if the torus has been properly heat treated and annealed to relieve stresses that are induced whenever you weld anything on a big steel structure like that or not. We don't know if it has been seismically reanalyzed, given those modifications or not.

One of the problems that citizens have and citizen-intervenors have is that when issues like this are found within a plant, typically a condition report will be written. That is not public. That does not go into the NRC public document room. And then the item may or may not be entered into the company's Corrective Action Program. That's a place where NRC buries a lot of issues too. They sort of hand it back to the company and say you guys fix it and make sure you keep records. But those records are not public and there's really no way to access them unless you get involved in a legal proceeding and then maybe you can touch them.

MR. CAMERON: Ray?

MR. SHADIS: Yes sir?

UNIDENTIFIED AUDIENCE MEMBER: Let him speak.

MR. CAMERON: I just want to talk to Ray and not to the waffle man. Ray, it's been about 15 minutes and we have about 25 people left to go. So if you could just give us your point. I mean it's all wonderful, wonderful on-point stuff and we appreciate it.

MR. SHADIS: We will provide written comments. NRC really needs to delve into the seismicity issues for all of these components and that would include switch yard stuff as well. We had our problems.

The other thing I wanted to point to very quickly is the cumulative off-site impact of chemical releases. The cooling towers that you're familiar with at Vermont Yankee put out those huge clouds of vapor and for our purposes that is not the issue or the problem. Clouds of vapor are clouds of vapor. It's pretty much clean stuff. However, the cooling towers are not 100 percent efficient. There are big fans. There is water tumbling down corrugated material called fill. Fans blow across it and the result is that a lot of droplets are blown sideways out of the towers. When you tour the plant, you can feel these little droplets hitting your skin as you walk around the plant. People wonder if it's drizzling or what.

The company uses an oxidizer called glutaraldehyde in small parts, two-tenths of a part per million. It triggers asthma. Two-tenths of a part per million exceeds California's occupational exposure standards. In all the regulation, we don't find any place that the regulation anticipates spray. It anticipates fumes. It anticipates skin contact, but I don't think any regulator ever figured you would spray people with this stuff.

The glutaraldehyde plus, surfactant, anti-rust compounds, other pesticides, other biocides, and fluorine and bromine compounds are used by the company. The water gets circulated in the cooling towers. It flows out in spray. It goes up to a mile downwind. And I just want to point out that in terms of concentrations as those droplets travel, they dry and we don't know what the concentrations are when they land on the skin, but unless it's quantified, we have to assume that it's toxic. Unless it's quantified, we have to assume that there are health effects and those things need to be measured in the Village of Vernon and across the river in Hinsdale. And that's my comments and thank you.

MR. CAMERON: Thank you, Ray. Thank you very much.

(Applause.)

MR. CAMERON: Sky Churchill and Eesha Williams. Is Sky here? How about Eesha.

Bob Catlon? How about Joyce, Joyce Warren. Mandy Arms. I see people leaving when I call your name. Hopefully, they're not the people I'm calling.

Bill Whitmer. Bernie Buteau?

This battery is going, so we'll do our best.

MR. BUTEAU: Bernie Buteau, good evening. Nuclear engineer by training. Worked up at Vermont Yankee for 30 years in a number of different jobs. And a citizen of the planet, along with all of you. Inhaler of fossil-fueled effluence, 24/7/365.

Thank you for the opportunity to speak tonight on the operation of VY beyond its current license lifetime.

I see your consideration of Vermont Yankee's request for license renewal as very straight forward and to some degree we've done the same homework and so I'm going to repeat a few of the things that you mentioned earlier because I'd like to recite a couple of excerpts right from your own website, that I think help support the position to allow Vermont Yankee to consider operation.

It's the NRC primary mission to protect the public health and safety and the environment.

That's what we're talking about tonight is the environmental effects. In the environment, the effects of radiation from nuclear reactors, materials and waste facilities and you also regulate these nuclear materials and facilities to promote the common defense and security.

There's also a section there that talks about reactor license renewal overview. And it states that the Atomic Energy Act and the NRC regulations limit commercial power reactor licenses to an initial 40-year -- 40 years, as you said, but also permits such licenses to be renewed. That original 40-year term for reactor licenses was based on economic and anti-trust considerations and not on limitations of nuclear technology.

Due to this selective period, however, some structures and components may have been engineered on the basis of a 40-year service life. The NRC has established a timely license renewal process which we've heard something about tonight and clear requirements codified in 10 CFR parts 51 and 54 that are needed to assure safe plant operation for extended plant life.

The timely renewal of licenses for an additional 20 years, where appropriate to renew them, may be important to ensuring an adequate energy supply for the United States during the first half of the 21st century.

In surfing the web recently, I found an interesting article. It was an excerpt from Physics Today. It was dated June 4th. It states, "Some two dozen power plants are scheduled to be built or refurbished during the next five years in Canada, China, several European Union countries, India, Iran, Pakistan, Russia, South Africa. In the U.S. and U.K., government preparations are underway that may lead to 15 new reactor orders by 2007. The new interest in civilian nuclear energy results from attempts to reduce carbon dioxide emissions and increasing concerns about energy security."

Considering what I've presented, the worldwide recognition of the need for additional nuclear power to help save our environment from the effluence of fossil fuels and to help establish energy security and I would go on to say world peace, and considering the existing guidance for granting license extensions, I would submit that it would be arbitrary and in defiance of the rules and guidelines already in place to not grant Vermont Yankee an operating license extension if all requirements established in 10 CFR

Parts 51 and 54 are met.

Finally, I'd just ask that when all the input that you receive is considered, you separate the facts from the rhetoric. Thank you very much.

(Applause.)

MR. CAMERON: We're going to go to Marian Kelner and then Ted Sullivan, John Dreyfuss and Mike Hamer.

This is Marian Kelner. Marian.

MS. KELNER: Hi. This is just one brief point that I'd like to make. Nobody knows what's going to happen in the future. There are people who believe that this plant is safe. There are other people who believe that it's not safe. There's no way to determine this, I guess. Time will tell, but the criteria that I'd like to present is what happens for each side if that side is wrong? If the people who believe the nuclear power plant is safe and they're wrong, the land becomes polluted, thousands of people die. This will be an effect that will be in effect for hundreds of thousands of years. If the people who believe that the nuclear power plant is unsafe and they're wrong, what will be the effect? The effect will be that there will be other sources of power, conservation and nobody gets hurt.

So since nobody on the planet knows which side is correct, I think that using this criteria might guide us in the right direction. That's all, thank you.

(Applause.)

MR. CAMERON: Thank you, Marian. Mr. Sullivan? There he is. This is Mr. Ted Sullivan, and then we'll go to John Dreyfuss.

MR. SULLIVAN: Good evening, thank you for the opportunity to speak. My name is Ted Sullivan and I'm a resident of West Chesterfield and I do work at the Vermont Yankee nuclear power plant and West Chesterfield is within the 10 mile emergency planning zone. So what goes on at that plant is very important to me as a professional and me as a family man because my family lives in West Chesterfield.

There's a couple of things, a couple of points I want to talk about tonight. One is that the economic impact of shutting down or not granting a license extension for Vermont Yankee is very, very severe. To take one third of the electricity out of the state, one third of what it needs to run, that electricity has to be generated somewhere and come from some other means. And if it is a fossil means, whether it's oil, coal or gas, it's going to increase the pollutants that are going in the air. It will affect the environment, much, much, more worse than what the effect is of nuclear power.

The 100 million tons that the government talked about, that is a very, very significant amount of pollutants in the air and there's empirical data that supports that that has caused global warming and that is now causing the oceans to heat up and that is having a dramatic effect on things like hurricanes. The number of hurricanes that we're having now is a direct result of this global warming.

Go talk to the people that lived through Katrina and Rita, and the intensity of that storm. There's empirical data that proves that that effect made those hurricanes much more severe than what they really are. That's one point I want to make.

Another point is that we are regulated in this industry and when you're regulated, there's rules that you have to follow and those -- and we are governed by the NRC and we have to follow all those rules. As we apply for this application, the look that is given to the site and to all the processes that it has is exhaustive. It's a mess. And all of those rules have to be met. So let's let the facts decide what it is. If the NRC after their investigation into what's going on at the plant and whether or not we're following the rules, if they conclude that we will have an effect on the environment that are of such a nature that it doesn't meet the regulations, then they need to not approve this license application. But if it does meet the rules and regulations, then it needs to be approved.

That's the last thing I really want to say. The facts will speak for themselves and all the rhetoric and all the scare tactics and all the threats and things have to come out of that. Just let the facts speak for themselves. Thank you for the opportunity.

(Applause.)

MR. CAMERON: This is Mr. Dreyfuss.

MR. DREYFUSS: Good evening, my name is John Dreyfuss. I also work at Vermont Yankee. I'm the Director of Engineering at the plant. Thanks everybody for coming out. The rain kept probably a few people away, but it's good to see a lot of faces out here expressing opinion as well as, you know, quite a few more people I think in support of renewing the license of Vermont Yankee.

You know, we're very proud of the impeccable environmental record that this plant currently enjoys. We've had a sustained, safe, operational record with excellent environmental stewardship. We pledge to continue that going forward. I'm also very proud of the people and the processes we have in place that helps sustain that environmental performance. The scope of the environmental audit conducted by the NRC was very broad. It touched on many subjects. There were many people here, both NRC staff and the contractors. They were very challenging. They were very rigorous. They were very thorough. And we've resolved the issues and we're answering questions, many questions that came up.

Again, I am satisfied that the process will hold true and the questions will be answered. And if we can provide satisfactory record and good answers to the questions that came up, the license should be renewed.

Another thing I wanted to touch on here, just very briefly, is that there was a report by the National Academy of Sciences that talked about Indian Point. One of the key conclusions of that report are that the economic and environmental impact of closing those plants, shutting those plants down, was very significant. And that was the key conclusion of it.

So I urge you to educate yourself, read about it, and understand, you know, the impact of closing down a plant like Vermont Yankee. Thank you.

(Applause.)

MR. CAMERON: Thank you very much, Mr. Dreyfuss. We're going to go to Mike Hamer, Mr. Peyton, and then to Chris Nord from Citizens Awareness Network. Is this Mike Hamer coming down? All right.

MR. HAMER: Good evening. First I'd like to thank the NRC for putting on this meeting tonight for giving us all a chance to come out and talk about our community and the future. I'd also like to thank the police officers here tonight that are missing dinner with their families to come out here and ensure our safety. And for all of you, I mean, we had a lot more people in this room when we started tonight, it's gone down a little bit, but for everyone who stayed here to the bitter end to speak out about the community, round of applause for all of us. Come on, here we go.

I have one point, one simple point to talk about, 620 megawatts thermal. It's a lot of power. That's not what I'm going to talk about. I'm going to talk about the evolution of technology. When we first started making power in this country, a lot of heavy polluters. We're all ruining the environment. We're damming up rivers for hydro, a lot of coal-fired power plants, the most abundant source of electricity in this country is coal. Fifty-eight percent of our power in the United States is made from coal. We're the largest coal burning country in the world, as a matter of fact.

We're starting to see a lot of the results of that over the years. You can't take a hike into the mountains without finding a little mountain stream or a little run-off on the side. You'll see fluorocarbons, you see little rainbows in the water. My daughter pointed it out to me one day and said "Daddy, look at the pretty rainbows". I said "well, that's pollution, honey, at its best."

We're looking at 20 more years of operation from this facility right here. I believe that there will be a better technology one day and than our current technology for making power. I honestly believe that. We're on the verge of a lot of those things right now to this. Hydrogen cell power, but scientists are predicting right now that maybe ten years, possibly twenty years to be able to make megawatts of hydrogen cells. Ironically, nuclear power plants produce hydrogen. But then we use some more energy to take that hydrogen and re-combine it back with the oxygen and make water out of it and put it back to the power plant.

So imagine if you have a hydrogen cell sitting outside a nuclear power plant to make power from that hydrogen. Stepping stones of technology. I think that we can't get from one point to another point to being completely nuclear free without going through that process. We started out with plants years ago, but we've improved on those technologies. We've made them more efficient. We've learned from our lessons of the past and made better plants to continue on in the future with.

Our station here, I work for Entergy by the way. Our station here we made significant upgrades to the station since I've been here in the last eight years and worked as a contractor for four or five years before that, including major jobs like replacing the entire LP turbine 10 years ago, replacing the HP turbine. Those things are the size of football fields and we did that safely with no injuries on the job, employing a lot of people in the surrounding communities to help do these things.

One day, we'll reach that point where we can probably start shutting down these plants. But that day isn't today. Six hundred twenty megawatts of power electric. What scares me is how are going to, if we shut this plant down in 2012, where are going to produce that power from right now? That's baseload electricity. That's not wind power with a 20 percent efficiency factor. Those numbers you can look them up on NEPAX. It's a website that tells how much power the capacity, how much those places actually stay online.

I'll support any power made from any source that's safe like that. I believe Vermont Yankee is a very safe plant having worked there for as long as I have. But I don't believe that we're going to be ready in the next 10 or 15 years to get away from nuclear power. It's not feasible. We're not going to be able to produce 620 megawatts without going to coal, without going to gas power, which gas has been touted as being the clean source of energy, it's not. It produces half of the amount of waste that our coal plants produce.

Oil is out of the question. Oil is like less than 10 percent, less than 5 percent of the entire production of power in this country, just because of the unavailability of it and that we need it for automobiles and other things like that, other smaller, small-type things. But consider that. Consider where we're going to get our power from if we shut this plant down. We have to get it from somewhere. It's not in my back yard. It's here. It's safe. We have a proven track record of being safe. Why not continue for 20 more years.

This license renewal team, the application can be viewed at any library and online. It's huge. They have a very, very large team of inspectors looking at every possible aspect you can look at for aging management, for how we're going to handle aging management. It's the future replacement of certain parts that wear out, things like that, based on operating experience, etcetera and everything. It's a very involved process. It's not taken lightly by the NRC or Vermont Yankee.

Something you can consider also too is if you look at Entergy, go to their website. You can look at their portfolio of all the power they have. You probably heard about nine nuclear plants that Entergy has? We have percentages in wind power, coal, gas, oil, you name it, right across the board and once solar takes off or anything like that, believe me, Entergy as a power company, will be on it,one of the first companies on it.

So consider that when you think about it. Look at the facts. Have we been operating safely? And where are we going to get our power in the future if we shut this plant down now in 2012.

Thank you.

(Applause.)

MR. CAMERON: Thank you, Mr. Hamer. Is there a Mr. Peyton here? Then we're going to go to Chris, Chris Nord from Citizens Awareness Network.

MR. NORD: Well, thank you to those who have stuck around. My name is Chris Nord. I'm the vice president of the Citizens Awareness Network. I'm also on the board of the C10 Foundation over in Newbury Port, Massachusetts which runs one of the two state-of-the-art real-time radiation monitoring systems in the United States.

I wanted to address first an issue that has come up over and over again that Governor Salmon, I think was the first to speak to the issue of global warming and how nuclear is purported to be a solution, a near-term solution for global warming, just to say that it has been shown in numerous studies, chief among them, out of Rocky Mountain Institute which is run by world renown Emory Lovins and his wife, Hunter, a couple of researchers back in the late 1990s looked at global carbon mitigation strategies, using nuclear and using renewables as two alternative paths. And they discovered a finding that they put two different ways which I think are provocative. One, that for every $100 spent on nuclear that could otherwise have been spent on what we call renewables, an extra ton of carbon is released to the atmosphere that would have otherwise been prevented. And that's because, as Ray Shadis pointed out earlier, it's going to take many, many years of many, many hundreds of nuclear plants to begin to cut back on the acceleration of global carbon using nuclear. And the energy efficiency and renewable strategy is a much simpler, more direct, cost-effective way to go about it.

The other way that they put it, I'm drawing a blank on it. I'll leave it alone. Let's see. Someone mentioned nuclear as a method of retaining world peace and maintaining world peace in the world and I just had to speak to that because it's obvious to all of us, if we allow ourselves to think about it because of current controversies on the international scene where there is a country that is claiming that they just want to have a nuclear power system, that it is impossible to separate the production of electricity through the fission process from nuclear bomb technology. And we are engaged in a long-term Faustian bargain to think that nuclear is a way to a cleaner environment and that it's going to somehow protect world peace.

In fact, if we are to go that way, then we would be nothing but hypocritical to not allow other nations of the world to do that, but that is precisely what we're attempting to do in the international sphere right now.

Okay, as to my original plan, I really wanted to address my comments tonight to the Nuclear Regulatory Commission and that's why we're here. I have no doubt that the workers of Vermont Yankee believe that they're doing the absolute best job that they can and I applaud that. I do the best possible job I can at my work as well, so I have no doubt that you're proud of what you do and you deserve to be proud of what you do.

The NRC has returned to the homeland of the democratic process, to come to New England. They're in New England at Plymouth for the Pilgrim plant. They're in New England at Seabrook for the Seabrook nuclear power station. And they're here for Vermont Yankee. And I really have one question and I think that many people who are concerned citizens have one question that we can create permutations for and that is who do you work for? And who do you serve? Who do you actually serve?

The permutations that I'm talking about have to do with many things that fall within this larger category of design basis. And the first one I want to mention is the design basis for spent-fuel pools. Okay, the design basis for the spent-fuel pool at Vermont Yankee originally was what is called low-density racking. Now low-density racking was created originally as a way to configure spent fuel because it guaranteed a redundancy in the safety system for spent fuel.

Now I hope that the NRC is actually paying attention because I drove all the way over here from Newton, New Hampshire, in order to speak to the NRC hoping that the NRC would, in fact, take these comments seriously. You have high-density racking at Vermont Yankee because the NRC was willing to sacrifice the redundant safety system because there's no place to put the fuel.

What that has meant though is that were there a fire -- I'll back up. Were there to be a loss of coolant accident by any means in the spent-fuel pool that is racked in high-density racking, that fire cannot be put out. A fire in a high density pool will burn until it burns itself out. And when you're talking about radionuclides that extend as much as 20 times the extent of radionuclides that were released during the Chernobyl accident, sitting in a spent-fuel pool 70 feet off of the ground, not within a concrete dome, but underneath sheet metal, we're looking at a terrorist catastrophe in the making.

So first step, design basis. I call upon the NRC to return nationally to the original design basis configuration for spent fuel. Spent-fuel pools should not be allowed to be racked in high-density racking. You're giving away the safety system that was originally built in that would allow that spent fuel to be cooled with ambient air were there a loss of coolant accident. That no longer exists at Vermont Yankee. So that's number one, design basis.

Following that, and because of this extraordinary threat of terrorism in this post 9/11 world, and because of the unusual way that Vermont Yankee sits in relationship to the top of this country right along the Connecticut River that goes all the way to the Canadian border, there's a scenario that we need to consider. And along with that scenario comes my second request that we need in this new age of terrorism to remake the emergency planning zone so that it is not ten miles, that it extends to the full extent of the ingestion pathway.

That means a 50 mile radius. And that is too little, but it's a start. We need to have contingency plans for what is going to be done out to the city of Keene, and actually all the way out to the city of Concord and out to Rutland, in many different directions, because were there a loss of coolant accident at that spent-fuel pool for any reason, the calamity that would be created as a result of that would definitely reach major cities far away depending on which way the wind blows. So point two, extend the emergency planning zone.

At Plymouth, at a license extension meeting before the NRC earlier this year, I asked the NRC for any features concerning their emergency plans, emergency response plans, for the greater Boston area in light of the possibility of an awful event, a terrorist attack, catastrophic event, at their also highly densely racked, highly overfull 35 million curies of just Cesium in their spent-fuel pool at Pilgrim, and there was no answer. I got blank stares. That's because there are no contingency plans for the children, for the mothers, of the greater Boston area.

And in this age of terrorism, it's only going to take one terrorist attack against one U.S. nuclear reactor for this to all be a very bad idea. And we need to wake up, smell the coffee, and start to do something about this.

Remember that a 20-mile an hour wind blowing out of the south from the Pilgrim plant would reach the greater Boston area in two hours. At Hampton, in New Hampshire earlier this year, I heard an NRC on-site inspector say to the audience that when he puts his children to bed at night he realizes, he believes, that he and his children are as safe as they can possibly be. And so I had to point out to him a scenario that I'm going to bring up tonight, because it bears directly on the plant that we are talking about, the Vernon plant that the workers here and the owners and those that work for Entergy are so proud of. And that is a terrorist cell hijacking a plane in airspace Canada. They don't have to be able to navigate very well. All they got to do is follow the river under radar, 500 miles an hour, straight down the Connecticut River right into the spent-fuel pool of Vermont Yankee. It would happen so fast and so I said to him I want you to not go to sleep at night thinking how safe you are.

I want you to be lying in bed at night awake being worried about this stuff until you, the NRC, decides to actually take the public health and safety into consideration and start making good on all of these promises that you're making of protecting the environment and protecting public health. We can't go on like this any longer. This has to change. So that's the third one.

We need to revise the design basis threat as the 9th Circuit Court has indicated. And I think it's actually, I have to say, NRC members, that it's deplorable that you're considering appealing it. Like why is it not in your interest to just assume the responsibility? In other words, the way that we need to be living, en masse, is by what is known as the precautionary principle.

We need to learn the precautionary principle, we need to teach the precautionary principle, and we need to act the precautionary principle on the part of our regulators so that we can hand off a clean, safe, healthy environment to future generations. If we don't act the precautionary principle, one day, one bleak day we're going to wake up and some awful event is going to happen and we will have gotten caught not having been prepared for it, and that's what this is all about.

I don't know how to state it any more strongly. I'll go back to my original question, who do you actually work for? Are these meetings, these public meetings, merely an appeasement so you have the general public come up to the microphone, make a few statements, and then they go away and you get to go on your merry business and decide in collusion with this industry how it's going to go. Or are you actually taking into account the real concerns that are obvious, if you just sit and think about them, we're talking about 35 million curies of Cesium-137 sitting in that spent-fuel pool.

It's deplorable that there's nothing being done. And I think that it's high time that something be done and the license extension hearings for Vermont Yankee are a great time to do it.

I will finish by saying that once that is returned to low-density storage, what that necessitates is that the fuel that is taken out of the spent-fuel pool must be put in interim storage that is robust which means that it is a hardened, cast structure. It is a dispersed structure so that they can't be all hit with one terrorist attack and it probably should be put in a berm. I mean there's a technology for this and you're going to be hearing all about it because the State of Massachusetts is bringing their contentions on the Vermont Yankee issue exactly on the basis of what I've been describing, robust storage for spent fuel at Vermont Yankee and the rest of the boiling water reactors for a start, for a start.

Those are my comments. Thank you for listening.

(Applause.)

MR. CAMERON: Thank you. Thank you very much.

Is Dart Everitt still here and Bill Pearson? While Dart is coming down and Bill Pearson still here?

Let's go to Dart. This is Dart Everitt and then we're going to go to Emily Tinkham.

MR. EVERITT: I will be brief. According to Rich Smalley, who is a Nobel Peace Prize winner for chemistry in 1996 for his work on nanotechnology by mid-century the world will require a doubling of its current world-wide energy demand of 14 terawatts of power. To achieve this demand will require the equivalent of one 1,000 megawatt power plant going online every day for nearly 38 years. And this is from <u>Discover</u> of February 2005 and I have it in the testimony here.

Although I assume the initial mandate of the NRC regarding environmental issues 30 to 40 years ago concerned the rather micro impact that is of the areas immediately surrounding a nuclear plant, certainly now the issue is equally a global concern of greenhouse gases, foremost carbon dioxide.

I'm not an expert. I am a concerned citizen, concerned about the future of energy for the State of Vermont, the future energy requirement for the world, and the environmental impact the sources of that energy will have.

Dr. Arthur Westing, a resident of Putney, Vermont, 10 miles up the road, is an expert. He has served on the faculty or been a research fellow at several education institutions, including Harvard University, the Stockholm International Peace Research Institute. He has served as the director of the United Nations Environmental Program Project, Peace, Security and the Environment, and is the author of many articles and several books on the environment. At the moment, unfortunately, he is in Sweden.

He told me he wished he could be here to testify on the importance of Vermont Yankee to the energy future of Vermont and give his wholehearted supported to the relicensing. I am submitting an email from him to me giving me the authority to give you two letters he has written on energy and the environmental issues, as well as his résumé. His latest letter cites a British report on the role of nuclear power and low carbon economy which he uses to calculate the impact shown on the following page.

Thank you for beginning this lengthy process for the relicensing of Entergy and Nuclear Vermont Yankee Power Plant. I hope the evidence supports a positive decision.

I think this is very important. It shows that for CO_2 production from various sources of power, that kilograms of CO_2 per kilowatt of electricity for cradle to grave or a full production cycle. Coal, it's 891. Natural gas is 356. Photovoltaics, interestingly enough is 50, while wind and nuclear are 16. Nuclear power is very important to the future energy of this world and this state and please, I hope you consider relicensing it.

Thank you.

(Applause.)

MR. CAMERON: Thank you. If you could just give that to Eric and we'll try to -- for those of you who might be interested in reading these documents, we'll see if we can get put on the transcript for people to look at for their information.

Bill Pearson. Bill.

MR. PEARSON: Bill Pearson. I live in Brattleboro. I appreciate the opportunity to speak. Can you hear me now?

Bill Pearson. I live in Brattleboro. I appreciate the chance to speak tonight.

I went to Brooks Memorial Library in Brattleboro to read Entergy's environmental impact statement. I found a six-page glossary of abbreviations and acronyms. I couldn't find any section on ethics and morality.

We are fixated on Vermont Yankee's production of 30 percent of Vermont's electrical energy needs without comprehending that Vermont Yankee also produces high level radioactive waste that will be hazardous for thousands, tens of thousands, hundreds of thousands of years. Is there something genetic about our mental makeup that causes us to not take this into account?

The typical commercial reactor contains around 15 billion curies of radioactivity during operations. Those dry-cask storage units can hold hundreds of thousands to millions of curies. Smaller truck-sized casks for highway use each contain 40 times the radiation released at Hiroshima. After 60 years of blustering by the Federal Government, there still is not any safe way to deal with dangerous spent fuel from nuclear power plants.

How ethical is it then to continue making it? What system of morality allows us to condemn hundreds, perhaps thousands of future generations the worry and expense of safeguarding radioactive waste material? Also protection from natural disasters or terrorism. Replacing those Holtec dry casks every 20 years or is it 50 years, I don't remember, for 100,000 years? That's not going to be cheap.

That consideration alone ought to be enough to shut down our nuclear power plants. One product of the Iranian enrichment process is so-called depleted uranium. The United States has been using it by the thousands of tons in munitions in Iraq. The United States has now sold depleted uranium to 29 other countries. When DU explodes, it produces tiny ceramic uranium oxide particles that easily invade the body. And eventually produce a variety of cancers and other illnesses. Human DNA is affected. Deformed babies are born.

The United Nations has called DU a weapon of mass destruction. How ironic.

It is also genocidal. Global winds are wafting DU dust all over the world. It's half-life is 4.5 billion years. How much DU was produced over the years in enriching uranium for Vermont Yankee's fuel rods? How complicit is Vermont Yankee, and are we, in the weapons industry?

Vermont Yankee routinely emits radioactive material into the air, soil and water. Presumably these emissions are permissible. But who knows? Permissible emissions are not the same thing as safe emissions.

In July of 2005, and this has already been brought up tonight, the U.S. National Academy of Sciences released its latest biological effects of ionizing radiation report, otherwise known as BEIR VII. Basically what it pointed out was that no amount of radiation can be considered safe.

How ethical and moral is it then to site an elementary school directly across the street from Vermont Yankee? Children are far more vulnerable to radiological damage that adults.

Nuclear power plants, especially geriatric ones like Vermont Yankee, are prone to accidents and leaks. We've seen this in recent history. Let me give you a quick review of some results from accidents at other nuclear facilities.

A 400 percent increase in leukemia incidents in the population living downwind of the Pilgrim nuclear power reactor in Massachusetts in the first five years after fuel was known to have leaked excess radioactivity.

Three to 400 percent increase in lung cancer in the general population within the plume of the Three Mile Island accident.

Six to 700 percent increase in leukemia in the general population within the plume of Three Mile Island.

Eight thousand percent increase in thyroid cancer in Belarus children living near Chernobyl, reported six years after the meltdown.

Further effects found in victims of the Chernobyl accident, less than 10 years after the meltdown include the following. A 500 percent increase in thyroid cancer in children in Ukraine. A 75 percent increase, incidence of heart disease.

A 200 percent increase in respiratory and digestive disease. A 200 percent increase in birth defects.

Among atomic workers, a 250 percent increase in all cancers. And finally, a 1200 percent increase in all cancers exist around the Sellafield reprocessing facility in England.

I would urge us not to take too seriously Entergy's environmental impact statement. Despite the hard work of lots of people--and this is the point--they forgot to deal with ethics and morality.

They were also in error to dismiss as, quote, inadequate, alternative energy sources.

We need to understand that solar wind, biomass, geothermal and others are safe, clean, dependable, and most important, sustainable. Conservation and efficiency should also be added to the list.

If given the billions in Federal subsidies that nuclear has enjoyed over the years, these alternative energies could easily meet our energy needs without harming the environment.

Until and unless we can ensure the health and safety of human beings, and of all the environment, and all forms of life, we shouldn't even be using nuclear power. Let me register my vote as not being in favor of a 20 year extension of Vermont

Yankee. Thank you.

MR. CAMERON: Thank you, Mr. Pearson. We're going to go to Emily Tinkham, if she's still here, and then to Mr. Turnbull.

Emily.

MS. TINKHAM: Good evening. My name is Emily Tinkham and I live in Keene, New Hampshire. I am a daughter, a sister, and an Entergy Vermont Yankee employee. I truly believe that the only way to keep this amazing area that we live in environmentally friendly, while producing 34 percent of Vermont's electricity is to continue the safe and reliable operation of Vermont Yankee.

PARTICIPANT: (speaking from an un-miced location)

MS. TINKHAM: Vermont Yankee produces enough--

MR. CAMERON: Could you just let people talk. Okay? Thank you; thank you.

MS. TINKHAM: Vermont Yankee produces enough electricity to power about 620,000 homes and it does not burn fossil fuel. Over the years, this has avoided millions of tons of fossil air pollution. If Vermont Yankee were to close, it would be replaced with large amounts of fossil fuel generation and greenhouse gas emissions that lead to global warming.

Thank you.

MR. CAMERON: Thank you.

Mr. Turnbull.

MR. TURNBULL: After a while it starts feeling like a family reunion at these meetings, and I extend that to everyone here.

Hi, my name is Clay Turnbull. I'm a resident here of Windham County. I own a home in Townsend. There's some level of emotional energy around the environment impacts of operation of Vermont Yankee, and I know that emotions can lead to unclear and unobjective thinking.

Global warming. Are you concerned about global warming? Twenty years ago, folks were, scientists were making quite a bit of noise about it, and the administrator at the time said, nah. Do you believe it? And if you do believe global warming is an issue, and you think it's upon us, do you want your power coming from coal-burning facilities that generate greenhouse gases and smog?

We know that our use of electricity contributes to global warming. If you believe we can fulfill our electric needs in Vermont without Vermont Yankee's baseload electricity, if you want economical power, then please listen closely.

If you are concerned about greenhouse gases, we can't afford this distraction of dangerous, dirty, expensive source of electricity. Low cost, safe, clean power, zero greenhouse gases emissions. That must be wind and solar.

Slide 17. Can we get slide 17, or is that all torn down?

MR. CAMERON: I think it probably would be difficult. If you could just summarize what was on it, Mr. Turnbull.

MR. TURNBULL: Sure. It was an image of a nuclear power station with some green grass and blue river, and puffy white clouds. It was a very serene place you'd want to go picnicking, and I thought because we're looking at environmental impacts, the slide would be more appropriate to show what are the forms of effluent from a nuclear power station.

You know, through the effluent discharges, emissions, radiation, chemicals, other pollutants.

Now that's just my opinion. I'm not saying anyone in this room is bad or anyone in this room is better than someone else. We are all in this together. From my perspective, I want to share something with both sides of the aisle, if we're gonna play politics and be like so much of the rest of the world.

I look in these white boxes up top, these lights, and I assume that they're incandescent lights because I see that there's a number of them burned out, and they probably are a hassle to replace, and the two lights on top of each box I can see are clearly incandescents.

That light's incandescent. We're in a room filled with incandescent lights. The most inefficient light source that you can use. The only thing inefficient way to light this room would be to have torches. And actually that might be more efficient, to tell you the truth.

So we need more power. We won't be able to survive without the nuclear power station!

Well, geez, you know if I look in my sap bucket and I see there there's a hole in the bottom of it, most Vermonters aren't gonna look at that and say, oh, there's a hole in the bottom of the bucket, I better tap more trees.

They'll say, well, I should start by plugging the hole. That's not to say that we could shutter Vermont Yankee tomorrow. But I do believe that in the long run, we really need to embrace safe, clean energy--wind, solar, and other sustainable long-term renewables.

And I see him walking up to the side here. Let me just take a quick scan. A reliable source of power must include baseload power, so let's buy windpower from New York, if Governor Douglas won't get out of the way and let the public get their wind generation in Vermont, when the wind's not blowing we'll use hydro, and as a last resort, we'll use the power that we get off the open market, not spot market, though.

Vermonters overwhelmingly embrace renewable energy. 75 percent want wind. There's probably even more that want solar. Small-scale renewables. When the first incentive program came out in Vermont two years ago, they thought it would last for two years. In seven months, it was all used up. People wanted solar. People wanted wind.

Our elderly, who must choose between electricity, or food, or medicine, they need solar hot water systems. They need energy audits. They need efficiency upgrades of their homes and their apartments.

And there's jobs in doing that. Lots of jobs. Vermont needs jobs. We need plumbers, carpenters, engineers, concrete workers, electricians, energy planners, and that's exactly why we need to implement a clean, renewable energy program today, putting nice tradespeople to work.

Thanks for listening. Those are my thoughts.

MR. CAMERON: Thank you very much, Mr. Turnbull. Thank you.

How about Hattie Nestor and Joan Horman, Vedrana Wren? Karen Murphy? Shaun Murphy? George Clain. Dennis Girroir? George?

MR. GIRROIR: Good evening. My name is Dennis Girroir. I will try to keep it simple and relatively brief. This is pretty familiar to me here. Tom Salmon is pretty familiar. I'm a Vermont Yankee employee for better than 30 years, almost like Bernie Buteau is. But my roots are here in Brattleboro. I was born in this town, frequented this theater, graduated from the local schools here, and never really left. Came back after going off to school.

I know the area exceptionally well; intimately. I grew up north of here. I raised a family a little bit south of here, all within the EPZ. I've observed how the environment has changed over the last 50 years.

In many areas it hasn't changed at all. In many areas it's quite improved. Being down in Vernon, working for Entergy, I've watched how we've conducted business down there and the effect on the very local environment down there, the changes taking place and the effect on the plant.

I've watched as we've operated very, very well, and have witnessed the very, very exceptional operation we have down there.

I see the impact on me personally, the impact on my family and friends, and my peers.

I look at the overall impact of Vermont Yankee, environmentally, economically, and very personally, and I've got some pretty significant observations over the last 30-35 years, and I'm still waiting to identify one that is truly negative, truly negatively impacting all of us. All of us. My family, my friends, all of you, and me, personally. I don't plan on leaving this area. I love this area. This is home. It's beautiful everywhere but it's really beautiful to me here, and because of that, I have that very vested interest.

I'm very much in favor of alternate powers, power generation. I'm very much in favor of conservation. I'm very much in favor of acknowledging reality, and the reality is that Vermont Yankee has a very, very positive influence on this area, and all of us. I need this continued operation of Vermont Yankee for myself, for my children that are grown now, and most certainly for my grandchildren. I thank you very much.

MR. CAMERON: Thank you; thank you, Dennis. Is Emma Stamas? And then we'll go to George Iselin and Michael LaPorte. This is Emma.

MS. STAMAS: I'm a citizen of this area, actually in Massachusetts, I live just outside the ten mile limit, and I know dozens of farmers, retired people, students that live in that area, some within the ten mile limit, that are very concerned about allowing the plant to have its life extended even five more years, let alone twenty.

And the reason is this. If I had been driving a car for 32 years, which is the life of this plant, and I had never had an accident, would that mean that over the next five, ten, fifteen, twenty years, you could guarantee that that same car would drive me safely through life without a single mishap or accident? I do not think that we are being very logical if we think that our technology is so wonderful, that we can stand here and say we are not gonna have any problems over the next 20 years, because we know exactly what we're doing, how we're going to present any kind of crack or malfunction from developing into something more serious.

I don't think any of you could make that bet, that I'm gonna be fine in my 32 year old car for the next 20 years, and we're all sitting here betting, if we approve this plant to be, have its license extended for 20 years, we'll all making that bet, not just with my life but with the lives of every single citizen, child, mother, father, whatever, and every plant and animal that lives in this area.

We're making that bet, and I think that that's a foolish bet because I think we're not so dumb, that we're willing to take that risk, and I also think we're not so dumb that we can't create better technologies, safer technologies, other than continuing to rely on fossil fuels and nuclear power and all the old standbys that we've continued to try to pretend are our only choices.

We have lots of choices to make, lots of decisions to make, and they can create jobs, they can create energy, they can create a better life for the future inhabitants of this region.

If we're so smart to create this

technology, so well, that we can be positive it's gonna be safe over the next 20 years, why aren't we smart enough to make it better, to create safer nuclear power plants with safer designs, and to close those that are no longer capable of operating safely?

And why aren't we capable of beginning to create more wind and solar and conservation technologies that could create immediate jobs for many more people who wouldn't have to be as highly educated as the people who build nuclear power plants or decommission them?

I don't think we are so dumb, that we have to sit here and listen to, oh, the plant has worked great for 32 years, and believe that we're never going to have any problems in the future.

I think we're smarter than that and I think we can do better than that, and I think that in every meeting that the NRC is a part of, they had better rethink who they're working for and start thinking about the children and grandchildren who are going to have to get out of this technology of nuclear energy and nuclear waste proliferation, and get into something safer and more sustainable.

And I ask everyone to go home and urge people to write letters, those of you who left early, or those that know people who left early, write letters, get them in by June 23rd, make your comments known.

This isn't about, oh, the plant is great, let's just continue it. It's about a lot more than that. Thank you.

MR. CAMERON: Thank you, Emma.

George Iselin, Michael LaPorte, and Sherry? Okay. This is Mr. Iselin? Okay; great.

MR. ISELIN: We live just 17 miles downwind of the nuclear plant. Anyways, I'm concerned mainly about the effects of waste storage of the nuclear industry not having any known way to not have to have this material guarded for, virtually forever. And the dry cask storage, the new way of storing it, isn't something that's really viable to continue renewing and guarding for the next 250,000 years, and it's being stored in an unstable situation.

The cement pad it sits on has a geologic formation that's virtually mud underneath it, and it's on the edge of a river, and this is considered the solution.

Meanwhile, we have the problem of re-racked spent fuel storage. Anyway, I think the solution, even better than soft-path technology of windmills and solar and photovoltaics, which we need, is conservation.

Like Clay said about the incandescent lights, if anyone's flown in an airplane at night down on the Eastern seaboard, just the streetlights alone, that we don't need to keep burning everywhere. I mean, certainly it's nice to have some in the inner city for safety, but there's just so much lifestyle change that we need, like mainly outfitting our own homes to be energy efficient.

And get away from the economics of centralized power, which these large power stations lend themselves to, get more into diversified means of sustaining ourselves.

Anyway, I think that the main issue is whether we are gonna let this outfit produce more waste, contributing hot water to the rivers, and things that actually do contribute to the global warming, and we need to decide whether it's suicidal, actually murderous, to allow these wastes to be put on to future generations. Thank you.

MR. CAMERON: Thanks, Mr. Iselin.

Is Mr. LaPorte here? we're going to go to Sherry and then we're going to go to Gary Sachs.

Sherry.

MS. ZABRISKIE: Hello. I'm Sherry Zabriskie. I live in Guilford, Vermont. I've come to many hearings regarding the sale of Vermont Yankee, the operator, the license extension. I feel like I've spoken many times against nuclear power and I'm at the point where I feel like nobody's listening as far as Vermont Yankee or Entergy.

The government, the NRC for sure. And so I'm not here to speak to those people. I'm here to speak to the people. I feel like it's time--it's wonderful when ten people get arrested protesting here, and five people on Tuesday got arrested, standing up for what we believe in. But we know that this is not clean, there's no answer for the waste. You know Vermonters don't want this. We know there's other answers.

I, for one, live off the grid. I don't rely on this power, we don't need it, and like Clay said, 75 percent of Vermonters know this, and we can move on.

So what I'm here to say is it's time for us to gather as the masses, people, like a thousand of us at the same time, in the same place, to stand at Vermont Yankee's doors or wherever. I don't know what the answer is but let's make a date with thousands of us, because I know, personally, hundreds of people in this community that are fed up, that don't want this.

So let's get together. Let's make a date with thousands of people. I don't know where we're gonna be but we're gonna like block the road at the power plant, or something, for days, and stand together, until they're willing to sign something saying they'll close, at least in 2012.

It takes massive--like in the sixties, or whatever--it takes us altogether at the same place, at the same time, to say we don't want this, and stand together. I know Citizens Awareness Network gets together every other Thursday night at Greenfield's Market in Greenfield, Mass., 5:30 tomorrow night. 5:30, they have a meeting and it happens every other Thursday.

And I don't go. I send them money and I get their newsletter, but I'm fed up and I'm ready for us all, hundreds, thousands of us to be at the same place at the same time, to be strong together at once. So let's do it, people. I'm going tomorrow night, 5:30, Greenfield. That's it. Thanks.

MR. CAMERON: All right. Thank you.

Gary. Is Gary still here? Here he is. Gary Sachs.

MR. SACHS: Well, I'm gonna briefly respond to the woman from the Vermont Business Partnership who spoke earlier and mentioned the Department of Public Service, and how they said how much money we would lose if Vermont Yankee were to close.

So let's take Commissioner David O'Brien who's the head of the state department of Public Service. He put a $60 million figure on the cost that would come to Vermont ratepayers if VY closed in 2008. Vermont Yankee provides roughly 250 megawatts to Vermont. That represents one-third of our Vermont total energy demand, which is about 750 megawatts.

A recent PSB study determined that energy efficiency measures could reduce Vermont's total electricity use by 20 percent, or 150 megawatts. Let's apply that savings to what VY provides. Then we'd reduce the amount of power needed to replace VY to 100 megawatts. That's 250 minus 150.

If it would cost Vermont 60 million bucks to replace the 250 megawatts over four years, it would cost us 40 percent of that or $24 million to replace the 100 megawatts that would remain, if we implemented all the efficiency measures we could.

Now we're down to $24 million. Spread

that over four years. That's $6 million a year, divided by 250,000 households in Vermont, and the increase in each household's electricity bill for the entire year would be roughly $24.00. That's not even considering the contribution from industrial and commercial users.

That doesn't sound like a lot of money to invest in freeing Vermont from this role in the production of hundreds of tons and millions, hundreds of tons of radioactive waste, millions of curies of deadly nuclear substances created by the Vermont Yankee nuclear reactor, stored on the banks of the Connecticut River. It doesn't sound like a lotta money to spend to get rid of Vermont Yankee.

Now I'm gonna repeat what I said earlier today for the few of you who are left in this evening's event. Richard Monson, Harvard School of Public Health, stated: "The scientific research base shows that there is no threshold below which low levels of ionizing radiation can be demonstrated to be harmless or beneficial."

There is no threshold below which low levels of ionizing radiation can be demonstrated to be harmless or beneficial. The health risks, particularly the development of solid cancers in organs, rise proportionally with exposure.

At low doses of radiation, the risk of inducing solid cancers is very small. Low doses. It sounds like what the NRC was giving me earlier in tonight's case.

As the overall lifetime exposure increases, so does the risk. Every nuclear reactor emits small amounts of radiation, even so-called zero emission reactors.

3-29-2004 was two days before the NRC arrived in Vernon, when they came to inform us that they would not be performing the independent engineering assessment which had been considered a requirement on the proposed uprate by the Vermont Public Service Board, the state's regulatory body.

5-4 of 04, the NRC changed its tune and announced that it had long been planning such an independent engineering assessment. They must have been planning it since at least March 15th.

You, the NRC, say that Three Mile Island was a wake-up call for the industry. That was March 28th, 1979. That is the same year the NRC publicly stated there was no such thing as a safe amount of radiation.

Since 1979, these are some of the events.

February 11th, 1981, Tennessee Valley Authority's Sequoia One Plant in Tennessee, a rookie operator caused a 110,000 gallon radioactive coolant release.

February 25th 1982. The Ginna Plant near Rochester, New York. Its steam generator pipe broke, 15,000 gallons of radioactive coolant spilled, small amounts of radioactive steam escaped into the air.

January 15th and 16th, 1983, the Browns Ferry Station, nearly 208,000 gallons of low-level radioactive contaminated water was accidentally dumped into the Tennessee River.

1981, 1982, and 1983, Salem One and Two in New Jersey, 90 seconds from catastrophe when the plant was shut down manually, after the failure of an automatic shutdown system. A 3000 gallon radioactive water leak in June of '81, a 23,000 gallon leak of mildly radioactive water, which did splash on to 16 workers in February of '82, and radioactive gas leaks in March of '81 and September of '82.

Let's go to 1996. NRC Chairperson Shirley Jackson, speaking of Millstone in Time magazine. Quote. "Clearly the NRC dropped the ball. We won't do it again." End quote.

1997. Yankee Row, 20 miles from here,

roughly, out west, was closed. It's in Rome, Massachusetts. The NRC had allowed Yankee Row to dump radiation, for about 30 years, into the Deerfield River.

February 15th, 2000, New York's Indian Point Two, aging steam generator rupture, venting radioactive steam. The NRC initially reported no radioactive material to have been released. Later, they changed their report to say that there was a leak, oh, yes, but not enough to threaten public safety.

2004. New NRC Chairman Nils Diaz, about Davis Besse, said--catch this--"The agency," quote, unquote, "dropped the ball," end quote. Again. Hmm. I thought you said it wouldn't happen again. I guess it did. Accidents do happen. That's our NRC.

If Three Mile Island was a wake-up call, what exactly was happening at Davis Besse? I do, I would like to know that. Oh, so here we are in an NRC meeting. The environmental impact of Vermont Yankee. We have virtually an ineffective evacuation plan, untested in its entirety. What about those people without vehicles? What about day care centers and all the schools together? What about the transient hotel guests?

A worst-case scenario accident at VY would lead to an area the size of western Mass., Vermont, and New Hampshire being uninhabitable for possibly 30 years or more.

The plumes, from the National Oceanic and Atmospheric Administration, shows plumes going as far north as deep into Canada. That's over Montpelier. As far south as deep into North Carolina and as far east as over Cape Cod, into the ocean.

Then in 2001, on top of that, there's this, something called an Operational Safety Response Evaluation. This was just a test--Operational Safety Response Evaluation test. It occurred about a month before 9/11. In this test, the NRC would stage mock attackers to test the security of nuclear reactors. They came up here to Vermont Yankee and they let the security system at VY know where the people would be attacking from, when they'd be attacking.

But that of course is to make sure that if there were some real attacks at the same time, the security agents would know. That's not what they said. So they knew the whereabouts of where these attackers were coming from.

And the test was to make sure that the attackers could not get into the control room.

Obviously, stop them at the fence line would be the logical thing to do.

Vermont Yankee failed. Oh, I'm sorry. The NRC doesn't use that word. I think there's some jargonistic terminology, I can't get my grip around. They certainly had a low security rating on that one.

So the mock attackers were able to enter the control room, and VY, one of the least secure nuclear stations in the country--notoriety.

Around Vermont Yankee, numerous engineers looked at me and said after 9/11, we fortified our security, we invested $8 million into our security system. Well, here's a question for an environmental impact. Has anybody, any other reactors invested after 9/11? Did everybody have to invest $8 million? And if that is the case, let's say that's a given--if everybody's adding $8 million to their security systems but yet VY was already behind the eight ball, where does that put us today?
I think we're still behind the eight ball because we saw the same amount invested.

I wonder if the fact that there have been no legislators to speak here tonight, speaks to the futility of this event.

MR. LUKENS: Good evening. My name's

Larry Lukens. I live in Vernon, in the emergency planning zone, and I work at Vermont Yankee. We've heard a lot tonight, there've been a lot of really eloquent speakers. I'm not going to try to match that.

This is about the scoping for the environmental review, as I understand it, and we've heard a lot of things that weren't really about the environment. One of the tests says, I recall from the slide, is that NRC has to look at environmental effects and determine whether these environmental effects constitute a new and significant change in things that have already been evaluated.

I haven't heard anything tonight that says there's anything new and significant. Actually, I haven't heard anything new, and I haven't heard anything that sounds significant.

We have met all the requirements. We have exceeded many of them. We continue to meet the environmental requirements. We continue to be, as John Dreyfus said, good stewards of our environment. This plant emits no carbon dioxide. In fact it emits nothing that would be considered a hazard. We don't emit radioactivity.

And the people who have spoken tonight

have, as far as I can tell, not raised a substantive issue that identifies a new or significant environmental impact that would be an obstacle to the renewal of this plant's license.

Thank you.

MR. CAMERON: Thank you. Thank you, Mr. Lukens.

Joan, and then we have Beth, and is there a Mr. Bosquet, Paul Bosquet? Okay.

Joan, thank you, and then Beth, and then I'm going to ask Frank Gillespie to close out the meeting for us.

MS. HORMAN: I'm just a concerned citizen and I'm here in the interest of safety, as I hope we all are. I don't want to talk to you as a group or corporation but as people, people who have a choice in how we will proceed in a world that often has conflicting interests.

Although I value my comfort and the ease nuclear power provides, my concern about our safety and the safety of our future generations brings me here.

It is easy to slip into denial, or pray to God to take care of our problems. What is more difficult is to take responsibilities for what we, as a group, and as individuals, are doing.

At what point do we take responsibilities for the damage we are doing with nuclear energy and radiation? At what point do we say to ourselves, that we have gone too far, and that this is not about profit or power or comfort but about safety for us, our world, and its future?

Do we want to risk another Chernobyl, or another Three Mile Island? Safety is defined as a state of being safe, freedom from injury or damage, the quality of ensuring against hurt, injury, danger or risk, or the state of being protected from harm.

Do we want to risk our safety with toxic nuclear byproducts that jeopardize our future generations and ourselves? Please. I hope you can take a moment and hear me from my heart to your heart, and then act from that place.

Do our personal comforts, and your profits, justify the risk of proceeding with nuclear power, particularly at this staging facility? Thank you.

MR. CAMERON: Thank you, Joan.

Beth, would you like to come up.

BETH: Hi there. Thank you very much for holding this public comment session tonight.

I am a citizen of, a new citizen, actually, of Greenfield. I moved from Maine, where I lived eight years, and prior to that I lived in Princeton, Massachusetts, for 18 years, and just going back to the beginning of my time in Massachusetts, in 18 years in Princeton, all those years we have a windmill, thanks to the citizens of that town, and they've now decided to improve on the windmill that has been there, and it has provided well for, without any pollution at all, for 30 percent of the energy needed for that community.

And I believe they're adding another windmill. I'm not sure of the statistics. But I then went to Maine. Maine got rid of its nuclear power plant, Maine Yankee, I'm not sure what year, and the governor of Maine has led the people that work for the government to create a plan, a 50-point plan of creating renewable energies in the state of Maine.

They're encouraging cities and towns to develop renewable energies that they will market elsewhere, that universities can use, that can provide jobs for people, that can be safe and viable for the next generations.

Why don't we go that direction? I attended a recent conference at Smith College at which there was all different kinds of renewables presented, and for the first time, I found out about geothermal energy and that people in Massachusetts, at least there, I'm not sure about Vermont or anywhere else, are utilizing geothermal energy for commercial buildings as well as residential properties, either by going straight down to the center of the Earth, not the center, but down where it's hotter than it is on the surface--I'm not sure how many feet down you have to go--but going straight down or else spreading out along a piece of land next to your building and creating energy right from the Earth itself, with of course no pollutants in that process at all.

I believe that this problem of renewables has to be regional and that we do need to contact our legislators and take actions in our cities and towns, and together that we can change the dependence on nuclear and fossil fuels, and gas that have caused such terrible devastation all over the world and in our own communities.

I was a nuclear activist back in 1979, in Princeton. We were asking the same questions then that we're asking the NRC now, and that is, why produce power when you don't know what to do with the waste? When you don't know what to do with the waste.

When you don't know what to do with the waste. When the waste, now, has become subject to the possibility of a terrorist attack.

We can do better than this. We can join together and do better than this, and I think we should and I think this plant should be closed as soon as possible, and that planned into the closing of it should be planning for jobs for the people that have worked so well at Vermont Yankee.

Thank you.

MR. CAMERON: Thank you, Beth.

I'm going to ask Frank Gillespie, who's the director of the Division of License Renewal to close the meeting for us, and I think he has some important things to say to all of you.

Frank.

MR. GILLESPIE: I think besides thanking the few that have struggled through, the people I really wanted to thank actually had to leave early, and that's people who exercised the system from the first day we came out here.

We got three sets of petition with contentions from the state of Vermont, state of Massachusetts, and from the New England Coalition, and it actually is gratifying, as hard as this may sound, to see people actually exercise a system where we came out and talked to these people and talked to the governments, way before the application even came in, to make sure that they were fully aware and had full knowledge of what was going on, to make the time frame to get those contentions in. Which leads me to tonight's meeting.

Please give us your comments after this meeting, in writing. We've got them on a transcript, we'll try to pick them out, and I think I got two things from this. Besides the concerns of the citizens who came to talk is also potentially the NRC's ability to communicate why we do what we do, to some extent.

Questions on the BEIR VII report, we've looked, as an agency, at the BEIR VII report, and done written evaluations on it.

Obviously you haven't read those written evaluations, but that's not your fault, if we hadn't made them available. So in answering some of the questions, I think we're going to have to string together these references. We may not agree, but all we can do is at least understand and see the basis for why we're coming to those conclusions we come to.

So we may not get to agreement but we

should at least achieve understanding and read each other's justification and backgrounds.

So with that, thank you for the about twenty people who are still left in the room. Yeah?

PARTICIPANT: (speaking from an un-miced location)

MR. GILLESPIE: Okay. It'll be sent out, but how is it available to him?

MR. EMCH: I got it. First, it'll be on our Web site, or it'll be in the ADAMS, but the other thing is, we'll make copies available, we'll send it out to anybody. If you're interested in us sending it to you, we can do that. If you give us your address, you gave us your address when you signed in. If you send me an e-mail or whatever, and I'll make sure that you get it. But it will be publicly available through the NRC's Web site.

PARTICIPANT: (speaking from an un-miced location)

MR. EMCH: RLE@NRC.gov.

PARTICIPANT: (speaking from an un-miced location)

MR. CAMERON: We're going to have to go on the transcript; okay.

PARTICIPANT: (speaking from an un-miced

location)

MR. CAMERON: You want to close. Let's close down and you guys can talk.

MR. EMCH: I'll talk to you, sir.

MR. CAMERON: Yeah; he can let you know. Okay. With that, thank you very much, everybody.

[Whereupon, at 10:36 p.m., the proceedings was closed.]

DART W. EVERETT

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802-257-2627 FAX

TO: Nuclear Regulatory Commission
DATE: June 7, 2006
FROM: Dart W. Everett

It is estimated that by mid-century, the world will require a doubling of the current worldwide energy demand of 14 terawatts of power. To achieve this demand will require the equivalent of one 1,000 megawatt power plant going on line every day for nearly 38 years (article from Discover, February 2005, pp 16-17 attached).

Although I assume the initial mandate to the NRC regarding environmental issues 30 to 40 years ago concerned the rather micro impact, that is of a limited area surrounding a nuclear plant, certainly now the issue is equally the global concern of greenhouse gasses, foremost carbon dioxide.

I am not an expert. I am a concerned citizen, concerned about the future of energy for the State of Vermont, the future energy requirement for the world and the environmental impact the sources of that energy will have.

Dr. Arthur Westing, a resident of Putney, VT, 10 miles up the road, is an expert. He has served on the faculty of, or been a research fellow at several education institutions, including Harvard University and the Stockholm International Peace Research Institute, served as the director of the United Nations Environmental Programme project on 'Peace, Security, & the Environment," and is the author of many articles and books on the environment. At the moment, Dr. Westing is in Sweden. He told me he wished he could be here to testify on the importance of Vermont Yankee to the energy future of Vermont, and give his wholehearted support to the relicensing. I am submitting an e-mail from Dr. Westing to me giving me the authority to give you two letters he has written on energy and environmental issues, as well as his resume'. His latest letter cites a British report on *The Role of Nuclear Poser in a Low Carbon Economy* which he uses to calculate the impacts shown on the following page.

Thank you for beginning this lengthy process for the relicensing of the Entergy Nuclear Vermont Yankee Nuclear Plant. I hope the evidence supports a positive decision.

CO_2 PRODUCTION FROM VARIOUS SOURCES OF POWER

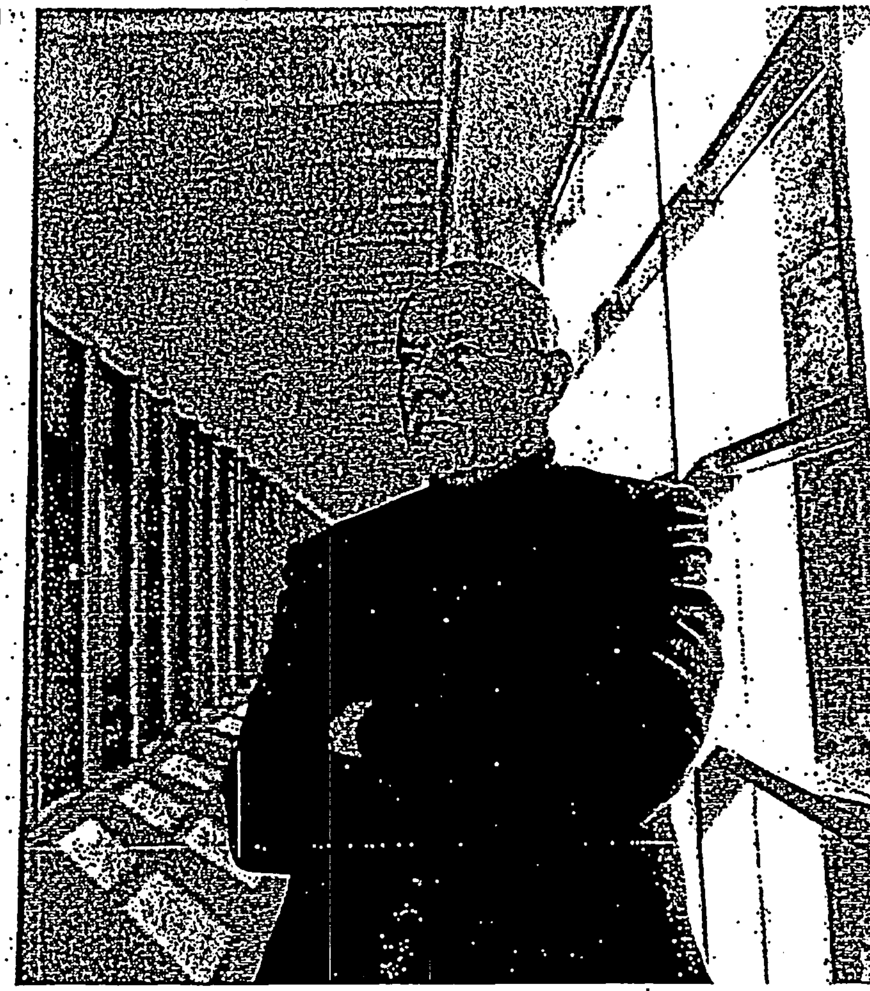
Kilograms of CO_2 per kiloWatt of Electricity for "Cradle-to-Grave" or a full production cycle

COAL	891
NATURAL GAS	356
PHOTO-VOLTAICS	50
WIND	16
NUCLEAR	16

Source:
http://www.sd-commission.org.uk/publications/downloads/SDC-NuclearPosition-2006.pdf

A Chemist's Plan to Save Planet Earth

'We are used to a world where we are rich in energy, driven by low-cost oil. That will not go on for much longer'



RICK SMALLEY SHARED THE NOBEL PRIZE IN Chemistry in 1996 for his pioneering research in nanotechnology. He discovered carbon 60, which he named buckminsterfullerene—buckyballs for short—because the molecule carries the structure of geodesic domes created by Buckminster Fuller. Buckyballs have led to the development of carbon nanotubes, used in many contemporary developments in nanotechnology. Smalley, who teaches at Rice University in Houston, is using his Nobel Prize as a bully pulpit to discuss energy, an issue he calls the most important problem facing humanity.

What is the energy problem, and why are you, a chemistry professor, so concerned about it?
S: The core of the energy problem is that we have a lot more people on this planet than we used to have. Right now most of the billions of people in the underdeveloped world are not consuming energy at any significant rate, yet they certainly will as time goes on. Either we find a way of enabling energy prosperity for everyone on this planet, or we will inherit a plague of troubles.

Such as?
S: Prosperity is determined by the abundance, quality, and cost of energy. We are used to living in a world where we are incredibly rich in energy, driven primarily by low-cost oil. That will not go on for much longer. It cannot because rapid economic development in China, India, and Africa, combined with increasing demand for fuel in the developed world will soon outpace worldwide oil production.

What will happen as energy costs climb?
S: The cost of energy going up will cause prosperity to go down. There will be inflation as billions of people compete for insufficient resources. There will be famine. There will be terrorism and war.

Why are you the right person to take this on?
S: The answer to these problems has to come out of the physical sciences and engineering. If I can't see the answer, who can?

Why don't more people seem to care about this?
S: Cheap oil. Our biggest problem for the past 20 years has been low oil prices.

Do you think it will require another shocking event like the 1970s oil crisis?
S: I'm afraid it will. I have dedicated much of my time to trying to bring this issue to the top of the agenda, hoping that the Bush administration would realize the political poetry of launching a grand new challenge to solve the energy problem. If that doesn't happen, then we will have to wait for events to bring this issue to a raging crisis.

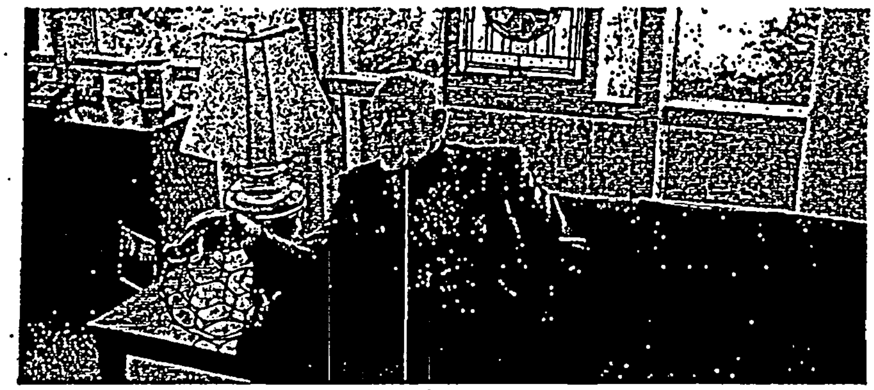
What should we be doing?
S: We should concentrate on finding a new energy resource and a new energy infrastructure to augment and ultimately replace oil, natural gas, and eventually coal. It's a huge enterprise. Worldwide, energy is a $3-trillion-a-year operation, twice the size of global agriculture and four or five times larger than all the world's military expenses.

What about the energy companies?
S: Many people working in the big energy companies have great hopes that there are vast resources of natural gas around the planet that will keep us going for many decades. I share their hope, but I believe it is wishful thinking.

So where should research be focused now?
S: One area is in the transmission and storage of electrical energy. It would be transforming to have much more efficient electrical energy transport by wire over continental distances in hundreds of gigawatts. It would also be transforming to have electrical energy storage on a vast scale. I believe it's best to do this locally in our houses and small businesses. We need to be able to pull electrical power off the grid when it is cheapest and tuck it away

somewhere so that it is available for use later, whenever that home or business needs it. Long-distance electrical power transfer would allow primary energy producers to market their energy thousands of miles away. Imagine vast solar farms in the deserts. You know, if you look at the planet, virtually every continent has deserts. Those deserts have tremendous energy resources in the form of sunlight. Even if we find a way of generating the electricity, you've got to transport that energy from the deserts, where people don't live, to other places on the continents where they do live, and you've got to shift the time when the energy is available. I'm confident that the best answer is going to be enabled by nanotechnology.

'Carbon nanotubes are capable of handling incredible levels of electrical current, as much as a billion amps per square centimeter'



What can nanotechnology do?
S: Let's talk first about transmission. The angle I've been devoting my efforts to is a new kind of conducting cable made of what are called armchair quantum wires: single-walled carbon nanotubes [buckytubes] with a particular structure. These are quantum wave guides for electrons. I am confident over time we will be able to find new ways of spinning continuous cables using such technology. This approach could yield cables with the conductivity of copper but with a strength greater than steel at one-sixth the weight. Carbon nanotubes are capable of handling incredible levels of electrical current, as much as a billion amps per square centimeter. That's compared with conventional cabling material, which can carry only a couple thousand amps per square centimeter. In storage, our hope is to develop new batteries. The chemistry of batteries needs to be improved at the nano level and brought up to the macro level. The best candidates include buckytubes in lithium ion batteries, flow cells, and hydrogen fuel cells.

How far away are we from being able to store and transmit energy these ways?
S: I believe if we launch a major national research program, we can have the necessary enabling scientific discoveries—little miracles and big miracles—within the next 10 to 15 years.

Solar doesn't work very well now. Why are you so keen for it?
S: If you survey the sources for primary energy at the massive scale that we're going to need, there are only a few places you can find energy of that magnitude. Nuclear fission power plants, if you were willing to have thousands of breeder reactors around the world, would be perfectly adequate. Hydrogen fusion would be perfectly adequate. Both are probably going to be too expensive, but we ought to push them anyway.

Can any other energy sources help us until we develop solar better?
S: Coal. But we cannot burn coal much longer without somehow sequestering the resultant CO_2. Unfortunately, I doubt that we will ever be able to do that on a global scale in a practical, reliable way at the required rate of tens of billions of tons per year, year after year. That sends us right back to solar. There is thousands of times more solar hitting the earth than we will need to power 10 billion people. The only way to do it cheaply is with photovoltaics or a photocatalytic agent that is as cheap as paint. There's a lot of buzz around about nano entities that can be coated onto photovoltaic films cheaply.

So research dollars should go to solar first?
S: Yes, together with electrical power transmission and local storage. We ought to stomp on it. I realize that we'll need miracles to get there, and we can't guarantee that all those miracles are possible within the laws of physics and chemistry as we now know them, but I have faith that somehow we will find a way to make it work.

How much time do you think we have?
S: Well, we should have dealt with all of this back in the 1980s. The challenge we face is to provide for a doubling of worldwide energy production by midcentury. Right now the world runs on about 14 terawatts of power, the equivalent of 220 million barrels of oil per day. By midcentury, most analysts agree you have to at least double that to more than 440 million barrels of oil equivalent per day, or 28 terawatts.

Can we do that?
S: Not by burning things that put CO_2 into the atmosphere—too much risk to the planet. What we need is clean energy that is cheap enough to permit the development of India, China, sub-Saharan Africa, and South America. We need it at no more than three cents a kilowatt hour. If I knew how to do that now, and I turned on one such new carbon-free 1,000-megawatt power plant tomorrow, and then the next day another plant and the next day another plant, I would have to do that for 27 years each and every day in order to just get 10 more terawatts. And we need more than that.

It seems hopeless....
S: Addressing this challenge will be good for us. Even if we fail to find the miracles that allow us to make and then transport hundreds of gigawatts of power over 3,000 miles at pennies per kilowatt-hour, and even if we can never find photovoltaics that are as cheap as dirt, the enterprise of trying to do it will push our science and our engineering so far forward that we'll generate a cornucopia of unexpected new technologies that will be the basis of vast new industries.

What will inspire us to do it?
S: Presidential leadership. A president could inspire a new generation of scientists and engineers, a new Sputnik generation that would be of tremendous benefit to this country and to the world. This bold new enterprise would be good business, good politics, and most important, good for the soul. ⊠

PHOTOGRAPHS BY BETH PERKINS

From: "Westing" <westing@sover.net>
To: "Dart W. Everett" <deverett@sover.net>
Subject: Energy matters

Dr Arthur H. Westing
Westing Associates in Environment, Security, & Education
134 Fred Houghton Rd; Putney, VT 05346; USA
T&F: 1-802-387-2152; E: westing@sover.net

Dear Dart,

Thank you for your call of this morning. As requested, attached (in WordPerfect) you will find three items: (1) My very recent letter on global warming and CO2 (Brattleboro Reformer, 1 Jun 06); (2) My earlier letter on electricity for Vermont (Brattlebor Reformer, 22-23 Mar 03); and (3) a brief Vermont-oriented bio.

As requested, you are welcome to submit these on my behalf to the Nuclear Regulatory Commission or similar Vermont energy-related hearings and meetings.

I shall be out of town and unreachable from 4 to 24 June.

Sincerely yours,
Arthur

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Ltr - CO2.wpd

WESTING ASSOCIATES
IN ENVIRONMENT, SECURITY, & EDUCATION

134 Fred Houghton Rd
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ARTHUR H. WESTING, M.F., Ph.D.
CAROL E. WESTING, M.Ed.

1/802-387-2152 (ph. & fax)
westing@sover.net

ARTHUR H. WESTING — BIOGRAPHY

Westing's undergraduate training was in botany (Columbia, AB, 1950). After two years in the United States Marine Corps (serving as an artillery officer in the Korean War) he became a forest ecologist (Yale, MF, 1954; PhD, 1959). He has been a Research Forester with the United States Forest Service, has taught forestry, ecology, and conservation at various colleges and universities, has twice been a Research Fellow at Harvard, and has been a Senior Researcher at the Stockholm International Peace Research Institute and the Peace Research Institute Oslo. For eight years he directed the United Nations Environment Programme project on 'Peace, Security, & the Environment', a position which took him to many countries throughout the world; and is the author of numerous articles and several books in that subject area.

Westing has been on the faculty of the European Peace University, a member of the World Conservation Union (IUCN) World Commission on Protected Areas, Vice-President of the International Society of Naturalists (INSONA), and also a member of or advisor to a number of other international environmental nongovernmental organizations and scholarly journals. He has been awarded an honorary doctorate (DSc, Windham, 1973) and a medal from the New York Academy of Sciences (1983); and he is one of the 500 individuals worldwide to have been appointed to the United Nations 'Global 500 Roll of Honour' (1990). He has been a Consultant in Environmental Security since 1990, variously to the World Bank, UNEP, UNIDIR, and UNESCO, to the International Committee of the Red Cross, to the International Organization for Migration, the Government of Eritrea, and to several other national and international agencies.

Westing moved to Vermont in 1965, and has been on the faculties of Middlebury and Windham Colleges, and an outside examiner at Marlboro College. He has served on the Governor's Environmental Control Advisory Committee, has been a Contributing Editor of the *Vermont Freeman*, and on the statewide Boards of the Vermont Wild Land Foundation, Vermont Academy of Arts & Sciences, and Vermont Coverts. Locally he has served on the Boards of the Windham Regional Commission, Windham World Affairs Council, Brattleboro Museum & Art Center, Woodland Owners' Association, and Windmill Hill Pinnacle Association.

—AHW/060603

ELECTRICITY FOR VERMONT

Arthur H. Westing
Putney (20 March 2003)

According to the Vermont Department of Public Service, roughly 40% of Vermont's electricity currently derives from hydro-power, 35% from nuclear power, 15% from fossil fuels, and 5% from wood (the remaining 5% being imported with source unspecified). Wind and solar power currently contribute negligible amounts to Vermont's electricity (each under 0.1%). Moreover, the use of electricity in Vermont has in recent decades been rising quite steadily — since 1980 at the rate of about 2.6% per year, and the State projects that this trend will continue. In this regard it is important to note that the increase in electrical use has been three times as rapid as Vermont's increase in population during that same period.

Various of my friends and acquaintances in the area are outspoken in their opposition to nuclear power plants, and seem baffled that I do not join them in their anti-nuclear activities. There is no denying that a nuclear power plant has a risk associated with it, namely the exceedingly remote possibility of catastrophic releases to its surrounding area of airborne radioactive contamination, either from faulty operation or malicious act. However, under normal operation the radioactive releases of a nuclear power plant are below those of a fossil fuel plant (especially so when coal is used, which generally contains more thorium and uranium than oil); and its contributions to greenhouse gases and immediately dangerous air pollutants are virtually non-existent. In terms of the energy obtained, uranium mining is orders of magnitude less environmentally intrusive than coal mining or oil extraction. The ultimate disposal of spent fuel and other radioactive wastes does present a problem that remains to be solved to complete satisfaction, presumably by a combination of reprocessing and burial at some remote and tectonically stable site, either in this country or elsewhere.

By contrast, the use of fossil fuels inevitably results in huge ongoing insults to the human and natural environments in at least two major forms: acid precipitation and greenhouse gases. The former seriously debilitates our terrestrial and freshwater ecosystems and the latter is a major contributor to the global warming that is on its way to becoming the ultimate insult to both the global biosphere and global sociosphere. Moreover, the oil (which now accounts for about one-third of the fossil fuels used for generating Vermont's electricity) leads our country to deal with such ruthlessly totalitarian states as Saudi Arabia and Iraq, or might well lead to the despoliation of Alaska's still relatively pristine north shore. And then to consider are the blighted lives and landscapes where the coal we use originates. As to hydro-power, more than two-thirds of what Vermont now uses comes from Canada, for which the James Bay region has paid dearly. That electricity comes to us with the legacy of a devastated environment over huge areas of the taiga ecosystem, and the utter disruption and social breakdown of the indigenous Cree population.

If nuclear-generated electricity is curtailed, this will be at the inexorable expense of almost comparable increases in the use of fossil fuels. Substitution by wind turbines — a non-polluting source of electricity that could replace modest amounts of the loss — is currently being fought with extraordinary vehemence, especially for aesthetic reasons, wherever attempts in Windham County and elsewhere in Vermont are now being made to introduce them (and this despite the largely trouble-free Searsburg pilot operation). Vermont is already using wood to a larger extent than any of our neighboring states. Indeed, greater use of wood (now plentiful in Vermont) should be encouraged, but if substantially increased our air must be monitored for the possibility of significant contributions to its pollution.

Substitution by water power generated in Vermont could in theory replace another modest amount of the loss. However, to obtain the electricity for Vermont from the eight Connecticut and Deerfield River dams now available for sale (if not dismantled, as environmental considerations might suggest) would require a fundamental change in the State's relationship with the New England Power Pool, or even withdrawal from it. And any construction of new dams (if suitable sites could be found) would be at the expense of further disruptions to what relatively little remains of Vermont's free-flowing stream ecosystems.

Efficiency, frugality, retrenchment, and population limitations could alleviate some of the strains of any electrical deprivation — and should certainly be encouraged by all means at hand. But the simple fact remains that most of the electricity lost by eschewing nuclear power is sure to be made up by fossil fuels — and thus at a terrible continuing actual (not hypothetical) cost to humans and nature, in both the short and long terms. Regrettably, I do not have much hope for significant help from this direction, given that per-capita use of electricity in the State has increased by about 40% since 1980 despite a huge amount of publicity urging us all to be more conservative in our use of electrical (and other) energy. It is no slip of the lip that "energy use" is usually referred to as "energy demand". And even the thought of population limitations for Vermont (or the nation) is anathema to many people.

In short, I would be ready to support the phasing out of nuclear power plants in the unlikely situation that such action were unfailingly linked to replacement — as needed beyond savings from efficiency, frugality, retrenchment, and population limitations — by sources that were medically and environmentally benign (fossil fuels certainly not among them). Moreover, it is useful to recognize that electricity makes up less than one-fifth of the total energy currently being used in Vermont — transportation and space heating together accounting for the lion's share — so any energy conservation efforts must certainly take this differential into account. Finally, it is clear that Vermont does not, and cannot, act in isolation regarding many of the energy challenges we face today. Even if we direct a blind eye toward the distant unpleasantries associated with the sources of the electricity we import, we cannot forget that we also import most of our air pollution from electrical-generation plants more or less distant from Vermont.

[This appeared in the *Brattleboro Reformer* 91(18):5; 22-23 March 2003, under the title "Why I support nuclear power", and also otherwise slightly edited.]

GLOBAL WARMING, ENERGY PRODUCTION, AND CARBON DIOXIDE

The most serious long-term threat to the well-being and survival of the plants and animals with which we share the earth is global warming. And the major cause of global warming is the carbon dioxide gas we humans release into the atmosphere. That carbon dioxide is largely a byproduct of our profligate use of coal, oil, and natural gas (and, among other lesser sources, the manufacture of cement). Our output of carbon dioxide has been steadily increasing since the late 19th century, and about 50 years ago surpassed the earth's ability to absorb it.

None of the ways in which we produce energy is fully benign, so clearly the most sensible way to address the problem of global warming is some combination of using less energy and of using the energy we do need more efficiently. Next it becomes important to know how the several ways of producing energy compare in their production of carbon dioxide. To be meaningful, such comparison must take into account the full production cycle, including fuel extraction, plant construction, routine plant operation, energy distribution, ultimate decommissioning, and so forth (a "cradle-to-grave" analysis); moreover, the comparison must be done on an energy unit basis (for example, per kiloWatt-hour of electricity generated).

It turns out that, on top of its staggering immediate environmental and health impacts, coal is by far the worst carbon dioxide — that is, global-warming — culprit. An authoritative study comparing several means of producing electricity throughout western Europe was published in March of this year by the British Sustainable Development Commission (see pages 21-22 at www.sd-commission.org.uk/publications/downloads/SDC-NuclearPosition-2006.pdf). For each kiloWatt-hour generated, coal produced, on average, 891 kilograms of carbon dioxide; natural gas 356 kilograms; and wind turbines and nuclear power stations each about 16 kilograms. In other words, in a cradle-to-grave analysis nuclear produced only about 2% of the carbon dioxide of coal, only about 4% of natural gas, and about the same as wind. I might add that a recent separate German report found that nuclear produced about 30% of that produced by photo-voltaics (solar panels).

There is no denying that nuclear power has drawbacks associated with its use, including the remote possibility of a catastrophic accident, the safe disposal of the still radioactive spent fuel rods, and the potential facilitation of nuclear-weapon proliferation. But to suggest that nuclear contributes significantly to our awesome global warming crisis — more so than wind or even natural gas, as recently reported by the Vermont Public Interest Research Group of Montpelier (VPIRG) on page 11 of its booklet "Global Warming in Vermont" — is slovenly if not disingenuous advocacy.

Finally it should be of interest to note that the electricity we currently obtain from our local provider, Green Mountain Power, contributes relatively little to global warming. About 92% comes from low carbon dioxide producers (45% nuclear, 43% hydro, 4% wood) and the remaining 8% from high carbon dioxide producers (5% natural gas, 3% oil) — our local low/high breakdown being about twice as favorable as for the state as a whole.

Arthur H. Westing
Putney, Vermont

[Published in: *Brattleboro [Vt] Reformer* 94(78):4. 1 June 2006]

Union support for Vermont Yankee Re-licensing

Brattleboro, VT/June 7, 2006 – Mike Flory, Chairman of Unit 8, Local 300, of the International Brotherhood of Electrical Workers, which is also a member of the Vermont Energy partnership, issued the following statement at this evenings re-licensing hearing.

Thank you for the opportunity to be here.

My name is Michael Flory. Some of you may have read about me a few weeks ago. I was the fire brigade member reported as injured in our Unusual Event, and I'm happy to say that reports of my demise were a bit exaggerated.

I am the Chairman of Unit 8, Local 300 of the International Brotherhood of Electrical Workers. I work at Vermont Yankee, along with more than 120 IBEW members. I am proud to say that I was born and raised in Vermont, and I currently live just a few hundred yards from the front gate.

We are proud to work at Vermont Yankee because of the essential power it produces. We know that our work at the plant helps to make Vermont a cleaner and more. prosperous place to live.

Without Vermont Yankee the 620 megawatts that we currently supply to the New England grid would have to come from a fossil fuel power plant. Wind Power, Connecticut River hydro power and energy conservation, all nice ideas, simply cannot replace the reliable, steady, baseline power we produce.

Since opening in 1972, Vermont Yankee has prevented more than 700 million tons of fossil fuel emissions from entering the atmosphere. This has been prevented not only by rendering an in-state coal plant unnecessary, but also from reducing the amount of out-of-state electricity we have to purchase, most of which would come from coal plants as coal still accounts for half the power produced in America today.

In 2005, Vermont Yankee avoided the emission of

- 7,700 tons of sulfur dioxide,
- 2,000 tons of nitrogen oxides,
- 2.5 million metric tons of carbon dioxide.

Emissions of sulfur dioxide lead to the formation of acid rain. Nitrogen oxides are a key precursor of both ground level ozone and smog. Greenhouse gases, like carbon dioxide, contribute to global warming.

The 2,000 tons of nitrogen oxides prevented by Vermont Yankee last year is the equivalent of what would have been generated by 105,000 vehicles. In Vermont, we have 280,000 cars.

NRC-1

Let me repeat, we at Vermont Yankee are proud of what we do – proud to produce power cleanly and safely.

Safety is our highest priority. We would not work in the plant, let alone live near it with our families, if we felt that the plant was not safe or that safety was not a priority at Vermont Yankee. We have seen, and been instrumental in the plants continual enhancements and upgrades, most recently during the "power uprate" process.

The cost of Vermont Yankee's power to Vermont consumers like myself is also far below regional market prices. As a base-load generator we are able to provide lower-cost power which is so critical for the state.

I respectfully submit that if you like having lights that go on at the flick of a switch, if you like computers that don't fry as a result of rolling brownouts; if you enjoyed air conditioning during last weeks heat wave, or heat during last months' cold snap you should like Vermont Yankee's low-cost, clean, and safe power.

Vermont Yankee's value to my home state can only become more valuable as time goes on. As global warming becomes more and more destructive, we can remain an environmentally friendly source of power with zero greenhouse gas emissions. As the world energy markets become more competitive, we can continue to be a source of reliable, economic baseload power.

That is why we encourage the NRC to renew Vermont Yankee's license.

Thank you.

VEDRANA WREN
802 451 3145
VEX_HR@YAHOO.COM

Hello

My name is Vedrana. I work @ Vermont Yankee. ~~and~~ I also worked @ Brattleboro Food coop for the first two years of living in Vermont. You could say that I have experienced ~~both~~ the two opposites that this community encompasses. One thing I have noticed is that a lot of the negative sentiment is founded in the clear lack of understanding of nuclear power. ~~You have to wonder how much does the average citizen know about nuclear power? Probably as little as possible with the exception of those that live near one. They want to know as much as possible.~~ In our community the negative sentiment is very vocal. It is time that we join in the dialogue that goes beyond these ~~few~~ ~~community~~ meetings. ~~It is my firm belief that we as~~ a company and ~~as~~ members of this community we need to dedicate funds and develop an educational outlet. NO OPINIONS [illegible] JUST FACTS. THEY WILL SPEAK ENOUGH. ~~Then~~ The most common counter argument I hear ~~to this little~~ "pet" theory ~~of mine~~ is that those who oppose nuclear power don't want to listen. Yes, there is a certain percentage of the ~~community~~ population that very firmly believes that nuclear energy is bad. They base that belief on their

VEDRANA ?WRON
802-457-3145

vision of the world. This is where we embrace our differences. There is also a great segment of the population that doesn't know what to think. ~~But~~ the only voice they hear is the negative one: the one that fills them with fear and misinformation.

I have met many that want to listen ~~[illegible]~~ are eager to listen. ~~Them~~ ~~[illegible]~~ We should be ~~one~~ rational ~~of the voices~~ ~~[illegible]~~ they hear ~~[illegible]~~

Vermont is known for its close relationship with environmentalism and progressive way of life. In many other places environmentalists and ~~[illegible]~~ nuclear energy have formed very strong coalitions for the betterment of all of us. They are one and the same!

We are one and the same ~~We could~~ join them ~~We could learn a lot~~ from them

name – appointed EMD town of M..
we have petitioned the NRC re: inclusion

June 7 2006

The Town of Marlbopro Vermont hereby (again) formally requests that Marlbor be included in thje EPZ for tyhe Vermont nuclear power plant. Marlboro is the only Town with property within the ten-mile radius of the power plant which is not included, and in all other cases where part opf a town falls within the ten-mile radius ther entire town is included in the EPZ. A map showing this discrepancy is a part of the original Vermont Yankee license with the NRC. I have made a similar but less detailed map for inclusiuon with his request.

Has Marlboro's request for hearing been granted?

We are entitled to the same protections as other residents who live near the power plant and being excluded from the EPZ does not allow us these protections. Items such as notification, training, input into environmental issues and etc. will all be addressed when Marlboro is included in the EPZ. Marlboro requests that as the NRC looks over the license extension, a change mandating Marlboro's inclusion in the EPZ is the only reasonable stance for the NRC to take- after all, the NRC issues the license and the goal of the NRC is to protect the citizens of this country from undue exposure to risk.

want to re-inforce our request here today.

Thanks,... Dan MacArthur Marlboro VT 05344 Emergency Management director.

as for the purpose of today's meeting –
Environmental Scoping – follow up on the comments of Ray Shadis & Chris Williams –
we the local citizeny ~~feel very strongly~~ know that our entire environment – our homes our farms our livelyhood – are at risk if there is ever a sizeable release of radio activity ~~material~~. Our property values will plommet and our ability ~~of~~ to sell and eat/ our own produce will be diminished – I cannot imagine a greater environmental impact and with the radioactive waste being stored on-site – probably for thousands of years – there is a greater mathematical probability that this will happen.

we are taking about all or nothing here –

~~Please do not~~ Extending the license greatly increases the

~~likely hood of an environmental radioactive event in the future and as a local Emergency Mgmt. Director I ask that~~ you mandate Marlboro's inclusion in the ~~I believe that Marlboro's inclusion in the EPZ gives us a greater say in the oversight of this potential environmental event~~

~~Any Environmental Scoping must take into account the impact on our lives of thousands of years of storage here in our back yard.~~

As Marlboro's EMD I insist that your review cannot be complete until you consider the environmental impact on our lives of any radioactive event. I know that technically your review ends in 2032 but our lives will be impacted for many times that long - even any event during the next 25 years could completely destroy our environment and [illegible]

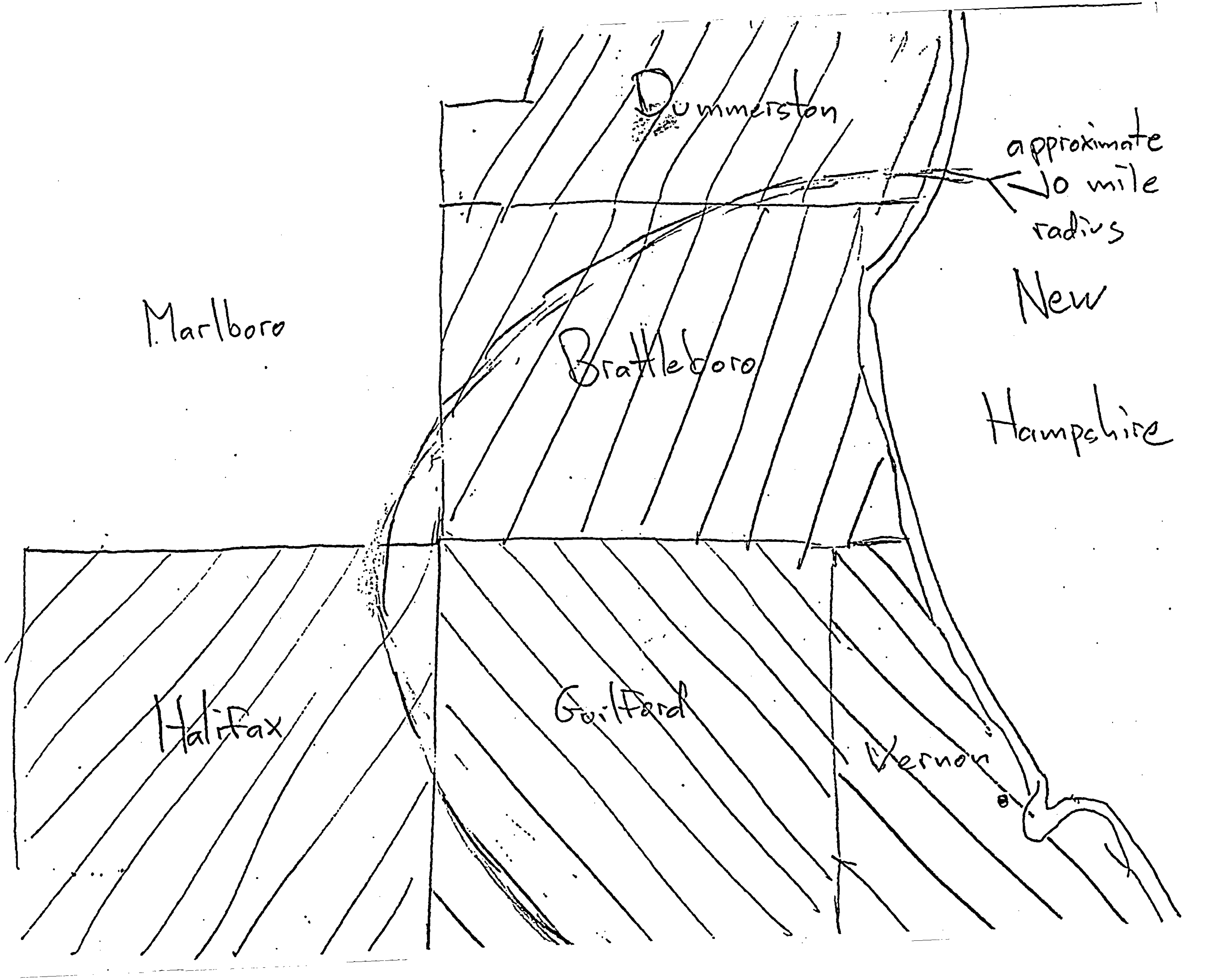
~~Marlboro has petitioned for Hearing to be included in EPZ but I will re-iterate our request today—~~

~~unless the owners of VY can~~ guarantee ~~that we will have no radiologica active releases— say less than one in a million I think that the potential risks are too great~~

possibly ~~make~~ our lives as well. As I said earlier, I cannot imagine a greater environmental impact and I cannot imagine the NRC extending this license if there is any possibility of this happening—

Question: to establish a comfort level with NRC— could I see a show of hands here— who is with NRC? Now, who among you has previously worked in the energy industry ??

And, re: Shawn Bonfield— hidden costs of nuclear are huge— look at the federal payroll here today paid out of taxes but dedicated to nuclear electricity.


Dummerston
approximate
10 mile
radius
Marlboro
Brattleboro
New
Hampshire
Halifax
Guilford
Vernor

Sustainable Development Commission

SDC position paper

The role of nuclear power in a low carbon economy

introduction

1.1 Why the SDC is re-examining its nuclear position

The SDC's previous position on nuclear power was agreed in 2001 as part of our input into the Energy Review conducted by the Performance and Innovation Unit of the Cabinet Office. This formed the basis of our input to the Energy White Paper (EWP) process.

The 2003 Energy White Paper was a watershed in energy policy, and was unique internationally for committing the UK to a 60% cut in CO_2 emissions by 2050. Although it is now possible that this target will need to be increased, in order to meet the international obligation to avoid dangerous climate change, the EWP contained a bold vision for future energy supply and demand. The four primary goals were:

> **Putting the UK on a path to cut CO_2 emissions by 60% by 2050, with real progress by 2020**

> **To maintain the reliability of energy supplies**

> **To promote competitive markets in the UK and beyond**

> **To ensure that every home is adequately and affordably heated.**

The EWP outlined a vision for energy supply in 2020, which saw electricity supplies still based on a market-based grid, but with increasing commitment to more local generation and microgeneration. With a strong focus on energy efficiency, renewables, and greater use of combined heat and power (CHP), the EWP stressed the need for technological and economic innovation to help bring new technologies to the market, thereby creating future options.

Since then, there has been mixed success with the policy measures put in place to deliver these goals. Carbon emissions have been rising for the past three years, mainly as a result of increased use of coal in power stations due to high gas prices, but also due to increased demand for energy, despite the effect of a number of energy efficiency measures. Progress with renewables has been reasonably encouraging, and despite concerns over delays in the offshore wind sector, it is still considered possible for the UK to meet or get close to its 10% renewables target by 2010.

However, rising oil and gas prices have put pressure on consumers, and there is increasing concern that, over the longer term, the inevitable decline in the UK's North Sea reserves will lead to energy security problems. In the electricity sector there are worries that the decline of the UK's nuclear power capacity, due to scheduled closures, will reduce total generating capacity and could increase CO_2 emissions unless this capacity is replaced by carbon-free generation.

In response to these concerns, the Government has announced a new Energy Review, which will report after the Climate Change Programme Review finishes, in mid 2006. As the Government's advisor on sustainable development, the SDC decided during 2005 that it needed to revisit its position on nuclear power so that it was well placed to advise the Government on this important and controversial issue.

1.2 Nuclear power in context

Nuclear power currently provides around 20% of the UK's electricity. This translates into 8% of the UK's energy needs once other sources of energy, such as transport fuel and non-electric heating, are taken into account. Our evidence base shows how this contribution is scheduled to decrease over the next 30 or so years, assuming no plant lifetime extensions.

Since the 2003 Energy White Paper the fundamentals have not radically changed, and many of the measures introduced since 2000 polarised, with heavily entrenched positions on both sides. This does not help with a considered analysis of nuclear power, and tends to result in reports that seek to justify a pre-determined position. Such reports are easily dismissed by opponents and will be regarded with suspicion by those that are truly 'neutral'; they are therefore of limited value to the public debate.

Our stand-alone evidence base is published alongside this paper, as a separate resource.

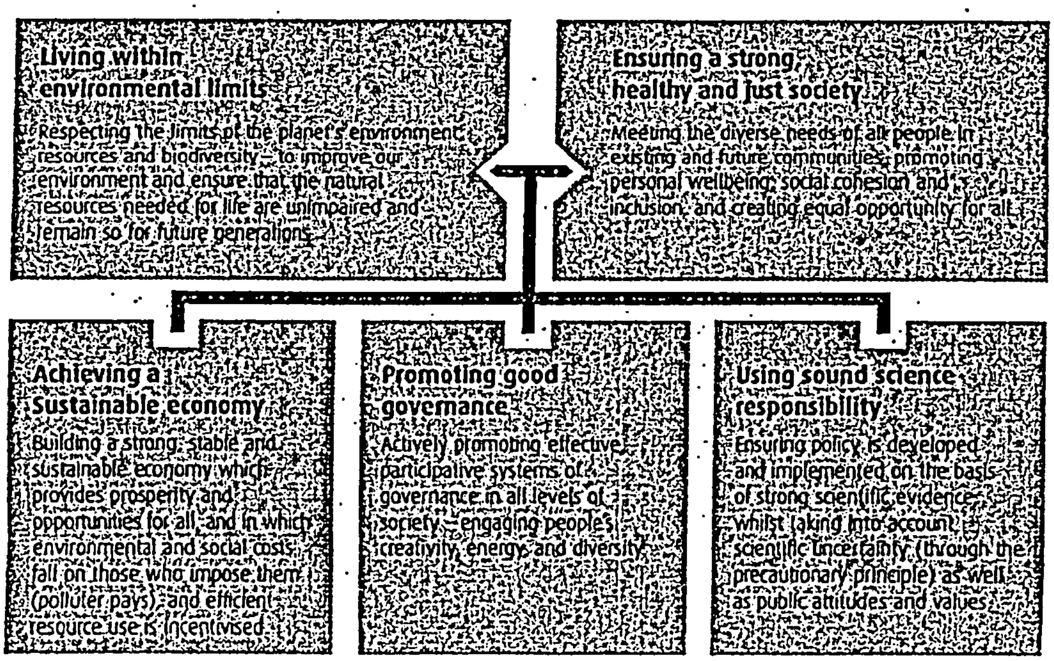
1.3 Our approach

In March 2005 the UK Government and the Devolved Administrations jointly published a shared framework for sustainable development, *'One future – different paths'*, in which five new principles of sustainable development were agreed across Government for all policy development, delivery and evaluation – see Figure 1. Based on these principles, the UK Government published its Sustainable Development Strategy, *'Securing the future'* to guide its policy-making process across different departments. We have therefore examined new nuclear development against these five principles.

In this paper we have not followed the five principles slavishly, as some are more significant for the nuclear issue than others. We have dealt with 'environmental limits' and 'sound science' together; we have looked in considerable depth at 'sustainable economy'; we have covered 'good governance' in relation to public engagement and in conjunction with 'a healthy and just society'.

In examining the evidence base, and taking into account the context of the five principles and the 2006 Energy Review, we have

Figure 1: UK sustainable development principles



Securing the Future – delivering UK sustainable development strategy

2. Sustainable Development Analysis

This section will look at the case for nuclear power based on three areas of analysis, and using the five principles of sustainable development. The analysis below draws exclusively on the SDC's evidence base, which consists of eight separate reports that are published alongside this paper.

2.1 Environment

2.1.1 Low carbon status[2]

No energy technology is currently carbon free. Even renewable technologies will lead to fossil fuels being burnt at some point in their construction due to the high levels of fossil fuel usage in almost every transport mode and industrial process, including electricity generation. For example, wind turbines are built of steel, and fossil fuels are therefore consumed in their construction either directly, during manufacture, and also from petroleum usage when the parts are transported to the construction site. However, the fossil fuel used over the life of the turbine is 'repaid' in less than 10 months, as the turbines themselves generate zero carbon energy[3].

Nuclear power stations are no different, with large up-front energy requirements during construction[4], although this is balanced by the high power output of each plant. However, nuclear differs from many renewables in its requirement for mined fuel (uranium ore). Although the total volume of fuel used is low compared to the volumes of fossil fuel required in gas or coal plants, uranium mining and the subsequent fuel processing is an energy intensive activity that must be included for full lifecycle emissions analysis. Decommissioning and waste activities are also likely to require energy inputs, and therefore their long-term impact on nuclear power's CO_2 emissions will depend on the carbon intensity of future energy supplies.

Our evidence shows that taking into account the emissions associated with plant construction and the fuel cycle, the emissions associated with nuclear power production are relatively low, with an average value of 4.4tC/GWh, compared to 243tC/GWh for coal

However, emissions from decommissioning and the treatment of waste also need to be assessed but this is difficult for two main reasons:

> **in the UK, decommissioning of existing plant is highly complex and involves plant that was not designed with decommissioning in mind**

> **the UK has not decided on its approach to waste management, which makes it difficult to assess the associated CO_2 emissions.**

The carbon impact associated with the 'back-end' of the nuclear fuel cycle is spread across all of the UK's nuclear power plants (active and decommissioned) and includes all of the electricity generated over their lifetime. Newly commissioned plants are likely to have lower lifecycle carbon emissions than for previous reactor designs, because of improvements in plant design (for example, smaller size, and improved thermal efficiency and use of fuel), and because new plant is designed so that it can be dismantled and decommissioned more easily.

A number of commentators have expressed concerns that any move to low-grade uranium ores could substantially increase the carbon intensity of nuclear power. Our evidence on uranium resource availability[6] shows that predicting if and when this might happen is very difficult to do with any accuracy. Resource availability is discussed in more detail below, but it is by no means certain that all the high grade ores have been discovered, and any increase in the price of uranium could trigger renewed interest in uranium prospecting.

It is worth noting that the CO_2 emissions associated with many of the construction inputs into a nuclear power plant could be subject to emissions trading schemes, depending on their country of origin. This presents a possible solution to the lifecycle emissions problem if

[2] Paper 2 – *Reducing CO_2 emissions: nuclear and the alternatives*
[3] Sustainable Development Commission (2005). *Wind Power in the UK.*
[4] In addition to carbon emissions from the production of concrete.
[5] These figures are for carbon (C) rather than CO_2. They have been converted from the data used in our evidence base by multiplying the CO_2 figures by 12/44.

programme would deliver sizeable reductions in CO_2 emissions. However, it is also important to realise that cuts of at least 50% would still be needed from other measures to meet the 2050 target, even with a doubling of nuclear capacity from current levels. Nuclear power can therefore be seen as a potential carbon reduction technology, but this must be viewed within the context of the much larger challenge we face. We will need a wide variety of solutions; those that decrease our demand for energy, and those that can deliver low or zero carbon energy supplies.

2.1.3 Waste and decommissioning issues[8]

There is a need to distinguish between the legacy impacts of decommissioning and waste management of the existing nuclear capacity, to which the UK is already committed, and the impacts that would result from a new nuclear programme.

The current legacy for decommissioning existing nuclear power plants is not directly relevant to decisions about whether to progress with nuclear new-build. However, such a legacy is one of public concern, particularly in relation to the cost. A recent review by the NDA suggests that their accelerated approach for the decommissioning of existing sites will cost approximately £56bn. Much of this covers a large number of non-power producing facilities, but certainly the costs of decommissioning old Magnox reactors are substantial. Our evidence points to costs of £1.3bn and £1.8bn in two cases, and this is before waste disposal.

The proposed new nuclear plant designs are expected to require much less expensive decommissioning, as unlike most existing plants, decommissioning has been given more consideration in the design process. They are also expected to produce less waste by volume. Our evidence estimates decommissioning costs at between £220m and £440m per GW of capacity, but this is before long-term waste disposal costs.

A new-build replacement programme (10GW) would add less than 10% to the total UK nuclear waste inventory (by volume). Assessing the increase in radioactivity of the inventory is complex and depends on reactor design and use, and the time chosen for the comparison. Thus, ten years after removal, the increase in activity could be a factor of nine, declining to a factor of 0.9 of current total activity 100 years after final fuel removal.

The role of reprocessing as a waste management tool is complex because of the costs (relative to the price of primary uranium) and safety and security issues (for example, the risks of proliferation – this is discussed further in Section 2.2.2 on security).

long-term so as to protect people and the environment. A dominant challenge of much nuclear waste is the period of hundreds of thousands of years over which it must be effectively isolated from people and the environment. This raises issues that are unique to nuclear waste, such as the long-term stability of our civilisation and climate, and the extent to which future technological advances might bring forward solutions so-far unknown.

Nuclear wastes in the UK are divided into three categories:

> **High level wastes (HLW)** are those in which the temperature may rise significantly as a result of radioactive decay. This factor has to be taken into account in the design of storage or disposal facilities. HLW comprises the waste products from reprocessing spent nuclear fuels.

> **Intermediate level wastes (ILW)** are those exceeding the levels of radioactivity for Low Level Waste (LLW), but which do not require heat production to be taken into account in the design of their storage facilities. ILW include nuclear fuel casing and nuclear reactor components, moderator graphite from reactor cores, and sludges from the treatment of radioactive effluents.

> **Low level wastes (LLW)** are wastes not suitable for disposal with ordinary refuse but do not exceed specified levels of radioactivity. Most LLW can be sent for disposal at the National Low Level Waste repository at Drigg. LLW that is unsuitable for disposal is mostly reflector and shield graphite from reactor cores, which contains concentrations of carbon-14 radioactivity above those acceptable at Drigg.

Spent fuel, which contains uranium and plutonium, is currently not classified as waste in the UK because it contains resources that can be reprocessed and used again as fuel or for other uses. If, however, the UK decided to abandon reprocessing as part of its waste management strategy, then spent fuel would need to be reclassified as HLW.

The Committee on Radioactive Waste Management (CoRWM) has established a baseline inventory, based on planned closure of existing plant, no new-build, reprocessing of spent fuels, and continuation of current practices for the definitions of waste. All radioactive wastes, including spent fuel, are packaged so that they are in a form suitable for storage, volume estimates are based on packaged wastes. The baseline inventory includes all wastes both in existence and forecast to arise in the future (for example from decommissioning). The baseline inventory shows that over 90% of radioactivity is associated with HLW and spent fuels, but

[8] Paper 5 – *Waste management and decommissioning*

self-regulation is appropriate

> ongoing surface and ground-water pollution issues both for current and future activities.

Some of these problems can be managed through regulation and management, but this can be compromised by, for example, poor governance, short-term cost considerations and possible conflict with economic goals and development aims. This can result in products being brought to world markets at prices that do not reflect the full social and environmental costs of their production.

However, any mining impact from nuclear power activities needs to be balanced against the potential environmental and health impacts of the energy sources it might displace. The health and safety impacts of coal, for example, are significant, as are coal's environmental impacts in the form of air and groundwater pollution. Oil and gas exploration also have environmental and health impacts.

There is general agreement that any new nuclear power programme would try to make use of existing nuclear sites, thereby limiting landscape and visual impacts. It is also the case that nuclear power plants are very similar to conventional fossil fuel plants in terms of local environmental and landscape impact, so the net impact of additional nuclear capacity is likely to be minimal[14].

However, some coastal sites may not be suitable for new nuclear power stations and flood-risk criteria may lead to a preference for new inland sites. This is because of the need to 'climate change-proof' decisions on where to locate new plant to be sure they take into account changes in climate that are already in the pipeline. The criteria that were used to select the current mainly coastal locations are up to 50 years old and will need to be reviewed, as many nuclear power stations and other facilities are vulnerable to sea-level rise, storm surges and coastal erosion over the next few decades.

In view of the need to reassess the suitability of existing sites, further consideration needs to be given to their viability over the longer term.

2.1.6 Summary

Our evidence shows that nuclear power could theoretically make a substantial contribution to efforts to reduce CO_2 emissions, as a viable low carbon technology. However, the evidence also shows that even by doubling our existing nuclear capacity, a new nuclear power programme can only contribute an 8% cut in emissions on 1990 levels, so a wide variety of other measures will be needed for tackling climate change, but as we state in Section 1.3, for the UK it is a choice whether it is part of the overall energy supply mix, rather than a necessity.

Nuclear waste and decommissioning raise a set of complicated issues with very long-term impacts. Considering the impact of nuclear new-build in isolation, we accept that future nuclear plant designs will be far easier to decommission and that it is possible to do this in a way that limits the environmental impacts. However, the long-term management of nuclear waste poses significant environmental problems that are difficult and costly to resolve.

We look at intergenerational considerations in Section 2.3.6, but on the environmental side it is difficult to be completely confident that the solution proposed for long-term waste management will avoid any adverse environmental impacts over the time periods involved.

On reprocessing, there remain serious concerns over the long-term security and economic viability of this form of waste management, with many in the industry now calling for a 'once-through' fuel cycle. The evidence would seem to support this conclusion, although there remains the question of dealing with the UK's plutonium stockpile.

Other environmental impacts from nuclear power centre on uranium mining, which can have a number of adverse effects in producer countries. However, such impacts must be balanced against the environmental and health & safety concerns related to alternatives sources of energy, especially fossil fuels.

2.2 Economy

What is the public good for our economy? (Achieving a sustainable economy)

2.2.1 Total cost of nuclear power[15]

Our evidence strongly suggests that attempts to estimate the cost of a new nuclear programme are unlikely to be accurate. This is primarily because there is not enough reliable, independent and up-to-date information available on the nuclear plant designs available for such calculations to be made. In addition, waste and decommissioning costs are, at present, not fully known.

The levelised cost of nuclear power (the p/kWh cost of output) is heavily dependent on capital costs. This makes the cost of nuclear output very sensitive to both construction costs, and the discount rate used (the required rate of return for the project).

[14] Paper 5 – *This is under the assumption that nuclear capacity would most likely be replaced by fossil fuel plant, with or without carbon capture and storage technologies.*

[15] Paper 4 – *Economics of nuclear power*

the next decade also highlights a potential weakness in the uranium market: the long lead times for developing new resources.

For domestic electricity supply, nuclear power may offer a hedge against high fossil fuel prices or temporary supply disruptions, but cannot offer complete security due to its reliance on imported uranium. In this regard, nuclear power is not a domestic source of electricity in the same way as renewables.

Uranium resources may also show price volatility, particularly in the short-term when shortages are expected. However, evidence on portfolio theory suggests that greater diversification of supply sources tends to reduce price risk, particularly when fuel costs are zero (as in the case of most renewables) or low (as in the case of nuclear)[18].

On balance, nuclear power has positive attributes for security of supply consideration, but these should be viewed on a portfolio basis and are not exclusive to this technology. Diversification into any basket of electricity generating options will help to reduce price risk and increase security.

It is also frequently claimed that nuclear power is necessary to provide baseload power. However, there is no justification for assuming that other plant cannot also perform a baseload function, and contrary to popular perception, the increased variability (sometimes termed 'intermittency') of some renewable technologies does not increase the need for more 'firm', or baseload, capacity[19]. Therefore, nuclear plant will need to be assessed against the long-term wholesale price of electricity within the confines of a carbon constrained, and environmentally sensitive, economy.

2.2.3 Market delivery

Our evidence suggests that nuclear power may find it difficult to compete in the UK's liberalised energy market without some form of public sector support. This is due to the long lead times of nuclear power and its high risk profile, which may discourage investors. However, the Government has made it clear that any new nuclear programme will need to be delivered solely by the private sector.

This does not rule out the possibility that the Government may decide to help support the development of new-build plant, either financially or through 'practical measures'. Our evidence points to a number of financial support options that the Government may consider, but there is uncertainty over whether they would be both legal (under EU state aid rules), or compatible with the Government's stated belief in liberalised markets.

The concept of specifying the ideal proportion of each single technology in the UK's generating mix belongs to a previous regime, where electricity supply was a nationalised industry. If liberalised markets are to be the primary mechanism for the delivery of electricity supplies, then this constrains the ability of Government to centrally plan the fuel mix, without major interventions in the market.

Energy policy aims such as CO_2 emission reductions and security of supply can be delivered by markets if the right structures are put in place. The market has so far performed well on security of supply, and the incentives are in place to ensure that new capacity is developed before shortfalls in supply develop – this is done through a simple price mechanism. To deliver this new capacity whilst reducing CO_2 emissions requires the electricity market to take account of national or international carbon constraints, and to factor these in to long-term investment decisions.

The current market for carbon is based on the EU Emissions Trading Scheme (EUETS), which is currently designed to run in three year periods, with caps set by national governments in advance of each commitment stage. This inherently short-term system provides no long-term framework for investors, and is currently based on emissions cuts from projected baselines rather than absolute cuts from current levels.

The SDC believes that the EUETS should aim towards total downstream emissions trading, which would eventually need to include the whole economy – business, transport (including aviation), the public sector, agriculture and, very importantly, individuals. EU-wide caps on emissions should be determined by a long-term emissions reduction target, which should then be divided into annual decreases which would form the basis of the EUETS or its successor. This system would give near complete certainty of intention, and should assist investors in taking long-term decisions on low carbon investments.

There are two alternatives to this approach: develop mechanisms which intervene in the market to encourage specific technologies or technology groups, or reform the current market design to allow for more centralised planning.

The Renewables Obligation is an example of market intervention, and was justified by the Government as necessary to promote the innovation and scale needed to create a viable, large-scale renewables sector. In this regard, renewables were identified as suffering from market failure due to their lack of collective technological maturity. Can the same be said about nuclear power?

[18] Shimon Awerbuch (University of Sussex) has done extensive work in this area.

[19] A large percentage of variable renewables would increase the need for 'balancing services', but would not lead to the need for additional baseload capacity, as the increase in reserve requirement is met from remaining plant. In addition, diversity of sources will always reduce the need for reserves. This issue is explained in detail in the SDC's publication, *Wind Power in the UK* (2005).

[20] Paper 4 – *Economics of nuclear power*

disagreement over these costs, but if they are high, there is the potential for conflict. This is because the transmission and distribution of electricity in the UK is a regulated industry, and all investments need to be approved by Ofgem as part of the district network operators' (DNO) price control agreements. Faced with calls for large investments across the network, Ofgem might have to prioritise what it allows, unless it is willing to accept higher costs for consumers.

There is also the related problem that continued reliance on centralised supply may exacerbate the current institutional bias towards large-scale generation, and the reluctance to really embrace the reforms necessary to ensure a more decentralised and sustainable energy economy. The role of Ofgem is central to this issue.

The lack of flexibility, or 'lock-in', associated with investment in large-scale centralised supply like nuclear power is also a concern. This relates to the issue of sunk costs. A new nuclear programme would commit the UK to that technology, and a centralised supply infrastructure, for at least 50 years.

During this time there are likely to be significant advances in decentralised technologies, and there is a risk that continued dependence on more centralised supplies may lock out some alternatives. Decentralised supply is generally more flexible because it is modular, and can adapt quicker and at less cost to changed circumstances. More locally-based energy provision may also be conducive to the sustainable communities agenda, a key part of the UK Government's Sustainable Development Strategy.

Any bias towards one mode over another essentially prevents a level playing field, and does not therefore encourage true competition. It may be hard for the microgeneration sector to overcome such bias, and this may prevent or slow it from reaching the economies of scale necessary to show its full potential.

2.2.6 Summary

Nuclear power may be able to make a useful contribution to the UK's economy, by providing low carbon electricity at a competitive price. However, our evidence shows that it is very difficult to assess the total cost of the available nuclear technologies, particularly as the only recent development that is relevant to the UK (in Finland) has a number of hidden subsidies that obscure its true cost.

In our view commercial investors are best placed to make a real assessment of the risks, and will have much better information on likely construction costs and therefore the final cost of power produced. They will also be able to the price of carbon, which is likely to be central to their business case.

There are still a number of outstanding costs that, unless internalised, may not allow a full reflection of the cost of nuclear power in those investor calculations. There is also the issue of moral hazard, and the impact that might have on reducing the apparent cost of nuclear power by increasing the financial risks to the taxpayer.

The case for nuclear power tends to be viewed in isolation, but this takes no account of the impacts that a nuclear development route might have on other alternatives, and on the prospects for a level playing field for all technologies. Although the measurable economic impacts may be limited, the political implications of a shift in emphasis towards nuclear could be to further weaken the commitment of Government, and therefore the investment community, to renewables and specifically microgeneration technologies.

On balance, the economic case for nuclear power is heavily dependent on its position in relation to other low carbon alternatives, and the effect it might have on the long-term ability of the UK to meet its emission reduction targets. If nuclear power can prove itself to be an economically viable competitor in a low carbon economy, without leading to a drain of investment for other alternatives, then its contribution to a sustainable economy may be positive. If, however, nuclear power requires public support (whether immediately or in the long-term) and/or it diverts funds away from other viable alternatives, then its contribution may well be negative.

It is of little doubt where the UK's current nuclear capacity stands. The burden of proof would now seem to be on the nuclear industry to show that updated designs, combined with private sector financing and project management, could lead to a different outcome. However, this must take place on a truly equal and transparent basis, so that costs are internalised and the taxpayer is protected from long-term liabilities. An assessment of the cost – and public acceptance – of nuclear waste policy is essential for this to take place.

[22] Sustainable Consumption Roundtable (2005). *Seeing the light*.

attack would not lead to significantly adverse consequences.

Use of nuclear fuel (reactor grade and spent fuel) by terrorists is raised as a concern. Reactor grade fuel must be processed to produce weapons-grade material to raise it from 4-5% uranium-235 to over 90% uranium-235. Spent fuel is an even more difficult starting material because it contains much less Uranium-235 than fresh reactor fuel.

However shipments of spent fuel for reprocessing could be attacked en route from the station to the reprocessing plant, either with the intention to spread contamination over a wide area or to steal the material for future use in a nuclear weapon. Reactor grade fuel could be used to make a 'dirty bomb'.

The industry assessment is that spent fuel containers are robust and undergo stringent testing and that the spent fuel pellets they contain are not easily dispersed even under severe impact and fire. But an alternative view is that stolen spent fuel would be valuable as a dirty bomb in itself and is therefore of value to terrorists. It would appear, therefore, that the potential use of nuclear fuels by terrorists remains a risk, and therefore a concern.

Nuclear accidents are recorded and ascribed levels on a scale 0-7 (Chernobyl was level 7), and most accidental releases in the UK are at levels 0,1 or 2. While major accidents are rare, evidence from Sellafield and Japan reveals that human error and management lapses are most often responsible – circumstances which undermine public confidence in the industry, even in industrialised countries with tight regulatory regimes.

Public confidence in the regulatory regimes for nuclear power stations in *all* countries, not just the UK, is also important because unplanned discharges can have serious transboundary effects. This raises a number of problems, including the difficulties of ensuring that the regulatory institutions in less developed countries are sufficiently resourced, and for identifying and dealing with poor health and safety practices which could lead to transboundary environmental or health risks.

2.3.4 Proliferation risks[25]

Terrorist organisations, almost by definition, operate outside national and international law, and therefore safeguards to protect against proliferation are almost irrelevant to such groups. Similarly it is very difficult to protect against civil nuclear power being developed into a military nuclear capability where motivations are strong enough, as has been shown in a number of countries.

of the implications of developing new nuclear capacity, particularly in the context of international treaties such as the Framework Convention on Climate Change. If nuclear power is part of the UK's chosen solution to climate change, then it would be considered a suitable solution for all countries. The UNFCCC explicitly encourages "the development, application and diffusion, including transfer of technologies, practices and processes that control, reduce or prevent anthropogenic emission of greenhouse gases" (Article 4.1c).

Reprocessing nuclear reactor fuel can raise it to the quality required for nuclear warheads, most easily from light water reactors. Pressurised water reactors would have to be closed down for several months, but in a country that wishes to do this the only barriers are political, as there is no engineering constraint.

Several international treaties have been concluded with the aim of making sure either that civil nuclear power is not used for military purposes or that any attempts to do so are detected. The two principal treaties that concern the UK are the 1970 Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and the Euratom Treaty, to which the UK became a partner on joining the European Community in 1973.

Out of the 188 states that have signed the NPT, the UK is one of five declared Nuclear Weapons States (NWS), the others being France, the USA, the USSR and China. The only states that have not signed the NPT are India, Pakistan and Israel, all of which are known to have nuclear weapons, while North Korea has chosen to withdraw from the NPT.

The provisions of the NPT are implemented by the International Atomic Energy Agency (IAEA). Following the difficulties of carrying out inspections in Iraq before 2003, additional protocols were developed giving IAEA inspectors greater rights of access and requiring administrative procedures to be streamlined so that, for instance, states cannot delay the issuing of visas as a means of delaying an unwanted inspection.

States also have to provide significantly more information, including details of nuclear-related imports and exports, which the IAEA is then able to verify. The IAEA concludes that without the NPT, there might be perhaps 30 to 40 Nuclear Weapon States, whereas more states have abandoned nuclear weapons programmes than started them.

Nevertheless, a number of difficulties in the relationship between civil and military applications continue to cause concern among many commentators, including:

[25] Paper 6 – *Safety and security*

has to be taken in the context of the current waste legacy, albeit that future waste arisings are likely to be considerably smaller than existing volumes.

2.3.7 Summary

Our evidence shows that it is essential for the Government to allow the fullest public consultation in developing a policy on nuclear power. Not doing this would compromise the principle of good governance, and risks a huge public backlash against top-down decision-making. The Government needs to engage the public in a wider debate where nuclear power is considered as one of the many options that could be required for a sustainable energy policy.

We are satisfied that any new nuclear power plant in the UK would be built and operated to the highest safety and security standards. However the same level of confidence cannot always be applied to other countries, and this remains a cause for serious concern. In addition, nuclear power facilities and processes are vulnerable to attempted exploitation by terrorist groups, and although standards may be high, this does not rule out the possibility of a successful strike.

The proliferation of nuclear materials is equally a cause for concern in this context. A decision to develop nuclear power in the UK essentially removes our ability, both morally and legally, to deny the technology to others. The widespread adoption of nuclear power would greatly increase the chances of nuclear proliferation, both through the efforts of nation states and possibly terrorist organisations.

Whilst the health impacts of a well-regulated nuclear power industry are low, the risk of a low probability, but high impact event must be considered, especially in the context of the international concerns raised above.

Finally, we remain deeply concerned about the intergenerational impacts of the legacy of nuclear waste. Considering the current uncertainties over total costs and the science of long-term waste management, we find it difficult to reconcile these issues with sustainable development principles.

renewables

The UK's renewable resources are some of the best in the world, and could provide all the UK's electricity over the longer term. Despite some significant developments, our current approach remains half-hearted, and the levels of public investment needed to bring forward new technologies are inadequate when compared to our international competitors.

It is critical that the Government should now invest far more (both politically and financially) in renewables, particularly microgeneration and biomass technologies, and marine renewables and offshore wind, where the UK has a clear natural advantage.

3.2.3 The clean and more efficient use of fossil fuels

It is clear to us that fossil fuels will remain a necessary part of our energy mix for some time. We fully support the Government's stated target for 10GW of good quality CHP by 2010 as a way of increasing the overall efficiency of energy supply. However, based on our lack of progress on this target, the foundations for expanding the use of this energy efficient technology are not strong.

We also support the recent interest from Government in carbon capture and storage (CCS) technologies, which could effectively remove the CO_2 emissions that come from burning fossil fuels such as gas and coal. These could provide a bridge to a more sustainable energy future whilst providing the UK with significant export potential in another area of expertise. Of course we must recognise that CCS is as yet an unproven technology, and its development could allow a future role for coal, about which we have concerns both for reasons of sustainability and human health.

3.3 Nuclear power: our advice

It is clear that nuclear power could generate large quantities of electricity, contribute materially to stabilising CO_2 emissions and add to the diversity of the UK's energy supply. However, even if we were to double our existing nuclear capacity, this would bring an 8% cut on total carbon emissions from 1990 levels by 2035, and would contribute little before 2020. Nuclear cannot tackle climate change alone.

A key issue that the Commission explored through the evidence base was whether the UK could have a viable energy future without nuclear power. Or in other words, whether nuclear power is a ***choice***, or whether is it an ***absolute necessity***.

The conclusion from the analysis was that the UK could meet our CO_2 reduction targets and energy needs without nuclear power, using a combination of demand reduction, renewables, and more efficient use of fossil fuels combined with carbon capture and storage technologies.

In this context, the Sustainable Development Commission assessed whether nuclear power has a role to play in future UK electricity supply. We have a number of serious concerns:

Intergenerational issues

The intergenerational impacts of a new nuclear programme are of great concern, particularly with regard to decommissioning and the disposal of nuclear waste. Even if a policy for long-term nuclear waste is developed and implemented, the timescales involved (many thousands of years) lead to uncertainties over the level to which safety can be assured. We are also concerned that a new nuclear programme could impose unanticipated costs on future generations without commensurate benefits.

Cost

There is very little certainty over the economics of nuclear power. A new nuclear power programme could divert public funding away from more sustainable technologies that will be needed regardless, hampering other long-term efforts to move to a low carbon economy with diverse energy sources. Nuclear power is also prone to moral hazard, which could lead to forced public subsidy regardless of the Government's original intentions.

A Forest Full of Energy

Wood Grows as a Major Fuel in the Northeast

By Eric Kingsley

Since the time of the first humans, wood has served as an important fuel source. We relied upon it first for heat, today for electricity, and tomorrow maybe for liquid fuels. Wood used simply as a fuel source – not as lumber, pulp, or other value-added products – is known as biomass and today still accounts for half of all wood harvested worldwide. The northeastern U.S. has long been a leader in the use of wood as a source of energy, and efforts continue to keep the region at the vanguard of biomass energy and bio-product development.

Wood energy has been a meaningful part of our region's electricity mix for about 20 years, and it was a part of many paper mills' electricity supply long before that. It has seen its ups and downs over the last decade, but today, wood energy is looking as attractive as ever.

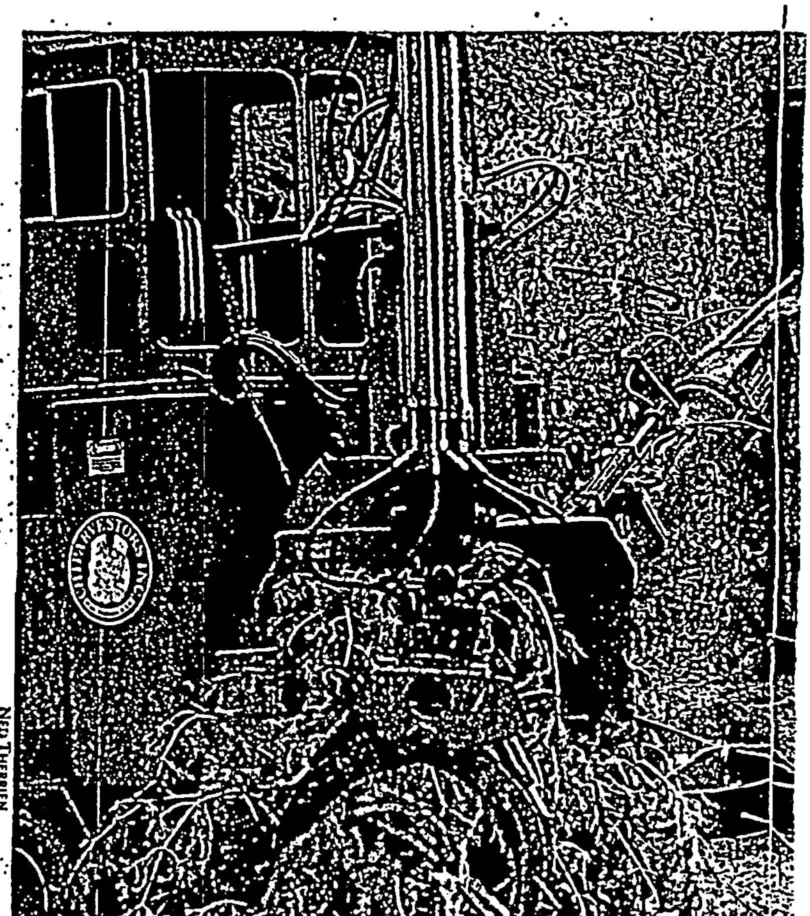
The region's wood energy industry developed in response to the last energy crisis in the 1970s. Wood was recognized as a local, renewable, and abundant energy source, and facilities to turn this resource into power were built. When projections of oil shortages made in the late 1970s and early 1980s turned out to be wrong (or at least premature), these wood-fired plants became high-cost producers in comparison to nuclear, coal, and oil. Today, we are coming full circle, with biomass power plants around the region operating at full-tilt, long-idle plants back online, and developers scouring the region for suitable locations to build new facilities.

Why? While wood energy hasn't gotten any cheaper, the competition (particularly natural gas) has become much more expensive. Faced with very real concerns about the current capacity to meet the peak electricity demand during extreme weather events (hot spells and cold snaps), public policy makers at both the state and federal levels are once again encouraging development of renewable energy.

Biomass energy in the region

In travels around the North Woods, it's hard not to occasionally end up behind a truck full of wood chips. Where are they going, and to what end? Most will shed their loads at one of many wood-fired power plants scattered across New England and New York, which each year turn millions of tons of low-grade wood into electricity to power homes and businesses.

In the power grid that serves most of New England, biomass is a small but important electricity source. Natural gas serves as the fuel for almost 40 percent of the electricity generated in the



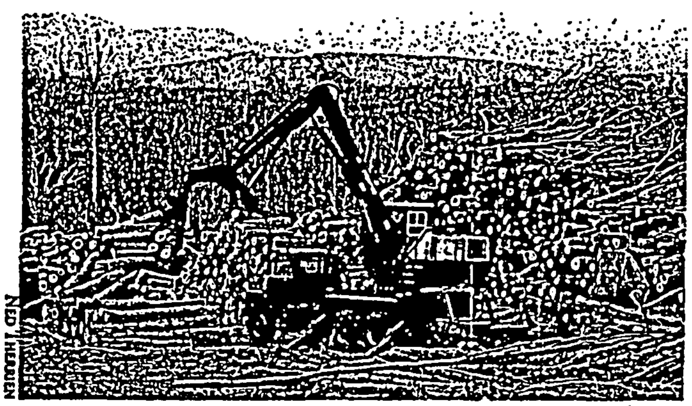
NED THERRIEN

region, with nuclear supplying a quarter. Coal-fired and oil-fired power accounts for a little over 20 percent, leaving the rest – about 15 percent – to renewable types of electricity generation. Of this, hydropower makes up more than half, with the rest coming from biomass, landfill gasses, and a few wind farms.

Five years ago, construction of new natural gas power plants was all the rage. Proponents argued that the use of natural gas would significantly decrease the cost of electricity in the region, and a wave of new plants was built. Just like previous forecasts of cheap power, this one, too, was wrong. Today, natural gas provides some of the most expensive electricity and often sets the price for the power you buy.

The cost to produce electricity varies widely, depending on fuel costs, debt service, economy of scale, maintenance requirements, technology used, and emissions controls. It can cost $40 per megawatt (MW) or, in a perfect storm of complicating factors, it could cost nearly four times that.

In the present environment, wood energy is competitive, and many facilities are operating at or near capacity. Biomass energy facilities, long thought of as too expensive, are suddenly looking attractive when compared to some of their competitors. Couple this with a demand that is growing faster than supply, and there is clearly a spot for biomass power.



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Public policy encourages biomass power

In addition to the underlying energy market, public policy plays a significant role in the retention and growth of renewable power, including biomass. On the public policy side, the desire for cleaner fuels, energy security, and local economic development is causing leaders to evaluate ways to encourage renewable energy development. Non-market benefits of wood energy include:

- Biomass power plants have very low emissions when compared with other fuels. At Public Service of New Hampshire's Northern Wood Power Project, conversion of an existing 50 MW, coal-fired unit to wood will result in significant reductions in sulfur dioxide, nitrogen oxides, and mercury emissions. (In the interest of full disclosure, the company I work for, Innovative Natural Resource Solutions, has served as a consultant on this project.)

CHARLES LEVESQUE

Clockwise from left: Adam Mock Logging chipping trees and tops for fuel; A&B Logging's log loader and chipping pile at Twin Mountain in the White Mountain National Forest; some operations use delimbers in the woods.

- As we station troops around the world, it's hard not to wonder which domestic fuels can help meet our energy needs. While oil is a very small part of our national and regional electricity mix, adding renewables to the mix helps diversify energy supplies and cushion price swings. Energy sources found here – wood, wind, water, and some coal – are buffered from the complexities of foreign trade and diplomacy.
- Wood energy can provide a significant economic boost to our region's rural areas and help support loggers, landowners, and wood-using industries. A 2002 study in New Hampshire found that the state's six then-operating wood-fired power plants provided up to 400 jobs and had an economic contribution of nearly $100 million. Wood fuel dollars stay in the local economy; the same can't be said for coal, oil, or natural gas.

Recognizing the public benefits associated with biomass power production, the federal and state governments have responded with incentives. On the federal level, support for biomass comes in the form of a confusing mix of loans, grants, technical expertise, and tax credits. Dividing these programs between the U.S. Forest Service, the Department of Energy, and others doesn't do much to clarify things, but one incentive – the Production Tax Credit – is easily accessible to a broad range of biomass and renewable energy projects. This tax credit allows power plant owners to receive $9 per megawatt-hour in financial support, a significant help to the economics of a biomass facility.

Additionally, at the state level, New York, Massachusetts, Connecticut, Rhode Island, and Maine have adopted a "Renewable Portfolio Standard," or RPS. In essence, an RPS requires electricity providers (the folks you send a check to each month) to get a certain, and often growing, percentage of their power from renewable energy suppliers. These programs vary widely from state to state but have proven to be a true incentive for new and existing biomass power plants. The funding comes from electricity providers, who pay a little extra to comply with the renewable energy mandate and pass the cost on to every customer, including the large ratepayers.

Besides requiring renewable energy production, an RPS can improve the economics of the biomass power plants themselves. For example, a biomass plant that qualified for the Massachusetts RPS in 2005 would have received around $50 per megawatt-hour produced, in addition to revenue from the sale of the electricity itself. With some long-term electricity contracts paying producers as much as $80 per megawatt-hour, adding the federal credit and the RPS payment can combine to make biomass energy look attractive to developers.

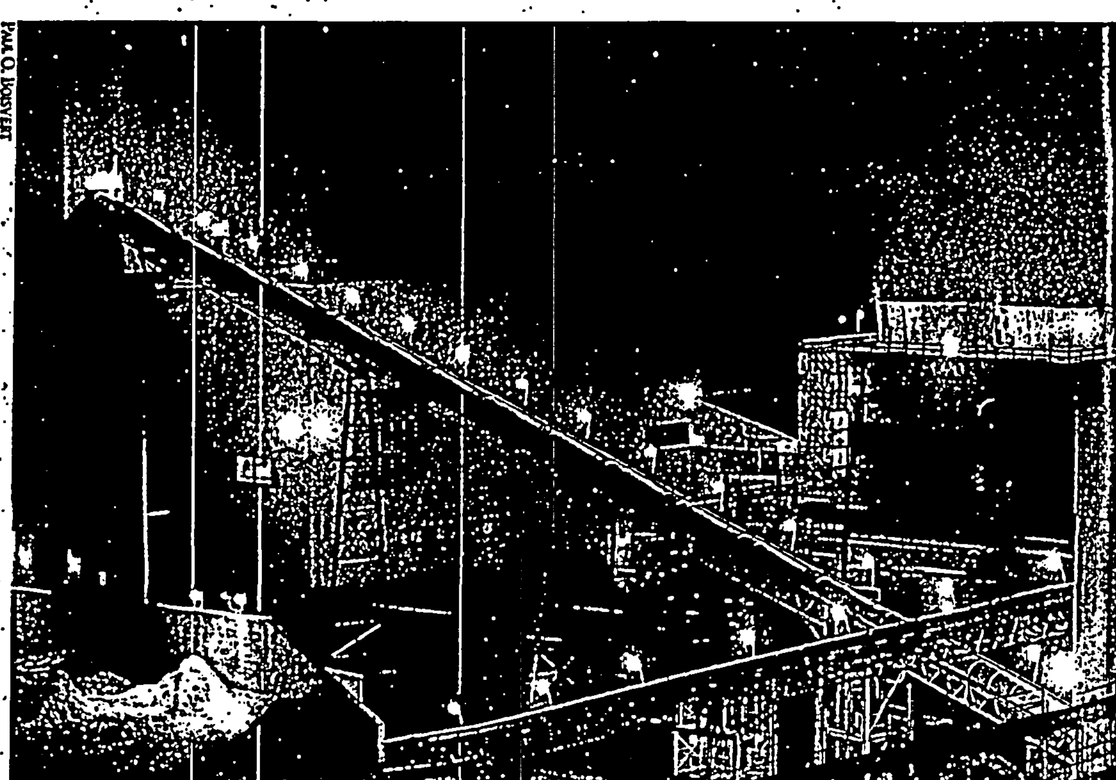
Of course, "look" is the key word in the previous sentence, and it is important to note that renewable energy payments are in their infancy, and as in any developing market, prices can swing quickly. In Connecticut, RPS payments dropped from near $40 to near $2 per megawatt-hour in 2005 alone when a new supplier unexpectedly entered the market and helped create an oversupply. Additionally, qualifying to participate in the Massachusetts RPS is not easy, with stringent technology and emissions requirements that few plants can meet.

The next generation of renewables

Today, biomass electricity is generated with wood chips from timber harvesting operations. With state and federal incentives, as well as the rise in overall energy costs, we will generate even more tomorrow. But what's beyond that?

For decades, researchers and developers have heralded the "bio-refinery revolution," where the myriad of products made today from oil (gasoline, chemicals, plastics, and more) will be made from wood. In fact, production of ethanol from wood was common in World War II Germany, when access to oil was severely limited. In the U.S., a wood-ethanol project was active in the South during World War I. The technology exists, but it hasn't yet proven competitive with oil in an open global marketplace.

The U.S. economy, and to a lesser extent the world economy,


PAUL O. BOISVERT

Clockwise from left: Night view of Burlington Electric's McNeil Generating Station, a wood-fired power plant.

Public Service of New Hampshire's Northern Wood Power Project involves replacing a coal-fired power plant with a wood-burning facility, shown here under construction.

This method gets chips out of trailers in a jiffy.

runs on oil. Our ships, cars, trains, and even loggers' skidders rely on oil to operate. The U.S., ever the consumer, accounts for a quarter of global oil consumption, more than the next five highest-consuming countries combined. This huge appetite is nearly all based on imports – we own only two percent of the world's known oil reserves.

In recent years, developers have proposed facilities making ethanol, diesel additives, bio-oil, plastic, and other products that would use wood as the feedstock. Many of these proposals died on the drawing board because investors were unwilling to take the risk with a new technology competing against low-cost oil. With oil momentarily topping $70 a barrel in 2005, however, and no return to the days of $35 barrels in the forecast, many bio-product business plans are being dusted off and updated.

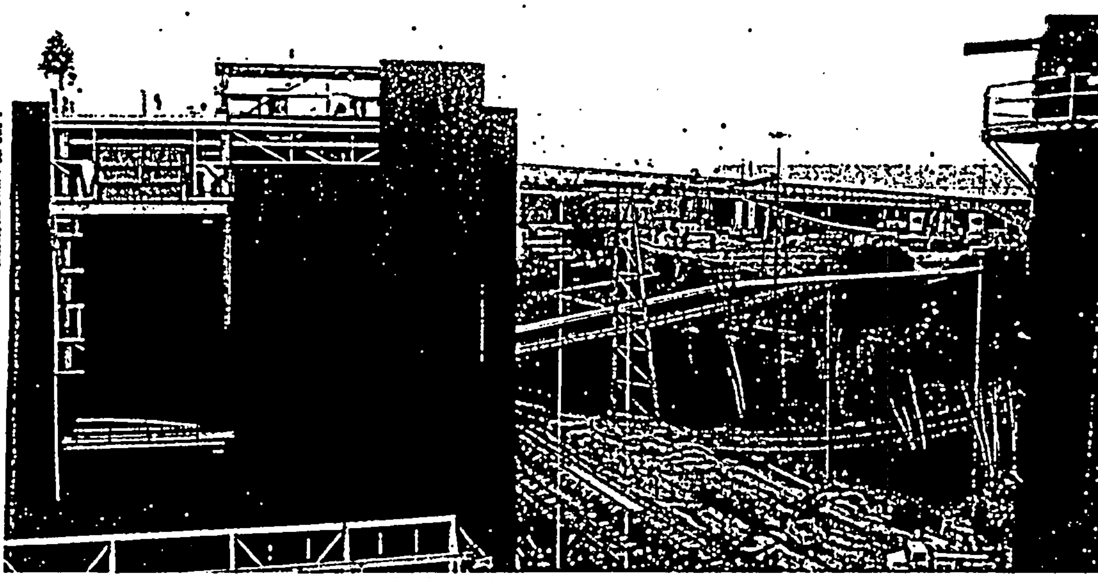
Biomass does have real potential to substitute for or compete with fuels and products currently made exclusively from oil; the corn-to-ethanol industry has demonstrated that. We know that some products can be made in the lab, so today's considerable challenge is moving these to commercial production. Maine, Wisconsin, New York, New Hampshire, and others are racing to develop this emerging industry, in the hope that this could revolutionize the region's forest industry. It may, but it's also clear the revolution will be gradual, will build upon existing industries and infrastructure, and will see a large number of failures for each commercial success.

The Impact on forests and forest landowners

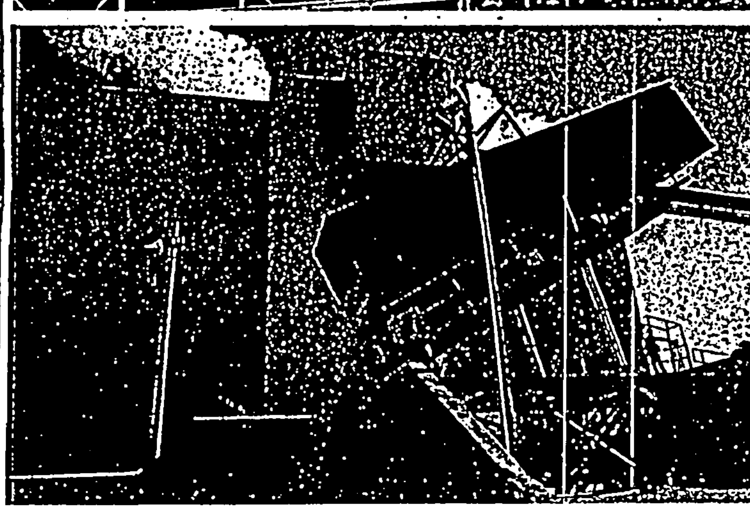
The resurgent biomass industry, and the prospect of a new and growing bio-product industry, may have some forestland owners seeing dollar signs. It's important they not see too many. Biomass as an electricity source has historically paid little (if anything) to the landowner; this will likely continue for the foreseeable future. Landowner and logger profits are made on sawlogs and, to a lesser extent, pulpwood. Biomass provides landowners with a low-grade market for their tops, branches, and cull trees. It allows foresters to use an important management tool, and it can provide true benefits to landowners, making it possible to remove poor-quality growth that would otherwise dominate a stand's future. Just don't expect to count the benefits in a large stack of bills.

For loggers, biomass prices are now as high as they have ever been, even adjusted for inflation. However, input costs – including diesel to run the feller-buncher, skidder, chipper, and truck – are at their highest levels in 20 years. Most increases in wood price have been quickly eaten up by cost increases, so loggers aren't necessarily seeing increased profits.

Add to this the increased competition from other wood sources, including paper cubes (pelletized paper that can't be economically recycled) and construction and demolition waste, whose use is highly controversial, and it doesn't appear that further price increases are coming for supplying biomass (at least when adjusted for the cost of oil).



Courtesy PSNH



Paul O. Boisvert

For bio-products, developers have been heard to promise they will pay untold fortunes to landowners. Without production facilities, these promises are worth little. When factories are built, we can expect them to pay market price for wood, and – like everyone else – seek ways to limit wood costs. They may grow the market, and therefore raise the price of wood, but don't expect $200 a cord on the stump.

The Northeast has an abundant and sustainable supply of biomass, a landowner and logging infrastructure prepared to meet supply needs, public policy that favors biomass energy, and a population that recognizes the many benefits that wood-derived electricity and fuels can provide. As a region, we are well positioned to continue a leadership role in the adoption and advancement of biomass energy.

ERIC KINGSLEY, VICE-PRESIDENT OF THE CONSULTING FIRM INNOVATIVE NATURAL RESOURCE SOLUTIONS LLC (WWW.INRSLLC.COM), HAS BEEN INVOLVED IN THE SITING, CONVERSION, OR UPGRADING OF A NUMBER OF BIOMASS POWER PLANTS IN THE REGION AND ACROSS THE COUNTRY.

Wood Chips Keep Schools Warm

By Hamilton E. Davis

Well before first light on an icy winter morning, a tractor-trailer unit wheels out of the yard at the Claire Lathrop sawmill in Bristol, Vermont, and heads for Barre Town Elementary and Middle School atop Quarry Hill. Dawn is just breaking as the rig pulls into the still-empty school parking lot and backs up to one of the twin bays in a small building adjacent to the school itself. When the bay door opens, the driver activates the moveable floor of the truck, and 30 tons of wood chips cascade into the storage bin.

Throughout the week, the chips will move in a herky-jerky fashion out of the bin onto a conveyer system, across the floor of the building, up above head height to a hopper, and then into a huge boiler, where they are burned to heat water in a heat exchanger. The hot water is then pumped through the school to heat the main building.

This system, which cost about half a million dollars, was installed in 1996 to replace electrical heat that had been installed in the 1970s, when electricity was so cheap that people said it wasn't worth metering. By the mid 1990s, however, electricity was ferociously expensive, so as soon as the wood chip system went online, the school's fuel costs dropped by 90 percent. They saved $100,000 the first year; the system paid for itself in five years.

Ted Riggen, the principal at Barre Elementary, loves everything about the system. He likes the reduced heating bill, of course, but he is also a former forester, and the idea of a sustainable fuel source has tremendous appeal to him. Administrators considering wood heat in their schools often visit, and Riggen likes giving them the tour himself. He especially likes taking them out to the storage bin and smelling the raw chips.

"Sometimes I think I could pour milk over a bowl of these chips and eat them like cereal," he says.

The most powerful appeal, of course, is the relatively low cost of the chips. Twenty-five Vermont elementary and high schools, serving roughly 10 percent of the state's students, use wood heat. In the last several years, they have saved 35 to 40 percent over oil heat, the most common alternative fuel. And that margin has been rising with the run-up in oil prices over the last year or two. According to the Vermont Superintendents Association, Vermont schools using wood in the last full school year saved a total of more than $600,000, a figure that gets a lot of attention in a financially strapped system.

According to Cathy Hilgendorf, the school construction coordinator for the Vermont Department of Education, several more communities have approved or are actively considering installing wood chip systems in their schools. "It's such a slam dunk, especially for larger schools," she says. "These systems pay for themselves in a few years. They're an easy sell, particularly since the state will reimburse the community for 90 percent of a renewable energy system." In contrast, the state pays just 30 percent of other elements of construction projects, including conventional heating systems.

While Vermont is poised to take even greater advantage of the abundant fuel its extensive forests provide, other states across the Northeast have thus far mostly ignored wood heat's potential for their schools. New York has no wood-heated schools; Maine, the most heavily forested state in the country, has just one, in Turner, in the middle of the state; New Hampshire has two, one of which is in a twin-state district with Norwich, Vermont.

Massachusetts has just one high school with wood chip heat, in Athol, in the northern part of the state. Cooley Dickenson Hospital in Northampton uses wood heat, as does the Mt. Wachusett Community College in Gardner. Joe Smith, who heads

John Douglas/Flying Squirrel

Principal Ted Riggen shows off his school's wood-chip boiler.

the Forest and Wood Products Institute at the college, says that wood-heat advocates in his region had to overcome considerable original resistance to heating with wood. There was the simple fact that they had to cut trees, which some people thought was bad, he says. Moreover, the shift to wood heat entailed significant changes in infrastructure, especially retrofitting an electric-heat campus. Just the planning and implementation of the conversion required the addition of full-time staff. Yet the conversion has paid off handsomely. The project cost was about two million dollars, but according to Rob Rizzo, the facilities chief at Mt. Wachusett, the $35-per-ton cost of wood chips is just one-tenth the cost of electricity and a fifth the cost of oil. This performance, according to Smith, has inspired Massachusetts state education officials to launch a major study of the advantages of converting elementary and secondary schools to wood heat.

JOHN DOUGLAS/FLYING SQUIRREL

Tim Maker (left) of the Biomass Energy Resource Center and principal Ted Riggen stand outside of Barre Town Elementary and Middle School's wood-chip boiler smokestack.

It was 20 years ago that wood chip heat first came to schools in Vermont. It started in the little town of Calais, in the north-central part of the state. In the mid 1980s, Calais was paying a fortune for electric heat for its elementary school, so the town set up an ad hoc committee of volunteers to look for a solution. After considering a range of alternatives, the committee settled on wood heat; it estimated the town could save 80 percent of its fuel costs by switching from electric heat to chips and convinced the town to go ahead and install a system.

One of the local volunteers was Tim Maker, who had worked in the residential energy audit program run by the University of Vermont Extension Service and then, when that program lost its funding, established his own energy consulting company. Now 59, Maker grew up in Springfield, Vermont, and earned a degree in engineering physics at Cornell University. After working on the Calais project, Maker went on to serve as project manager for wood installations in 10 Vermont schools.

And in 2000, he set up the Biomass Energy Research Center (BERC), with offices in Montpelier, Vermont. BERC is a nonprofit corporation that carries out a wide range of studies and projects on wood energy. One of the most important of these efforts has been to serve as midwife to the installation of wood systems in schools. In addition to the Vermont projects, Maker has served as a consultant to school districts in Idaho, Montana, and New Mexico. The Center is now functioning as a partner with the Massachusetts education officials to consider extending wood heat in their schools.

Maker is an unabashed advocate for wood chips; he also believes that the best way to advance this interest is by the most rigorous technical analysis of all of the issues involved – technical, scientific, environmental, political, economic. At the root of this analysis is Maker's conviction that the use of wood chips for heat is good for everybody in the Northern Forest.

It is good for rural communities because it turns a byproduct

STEPHEN LONG

The three types of wood chips, from high-grade sawmill chips (left), to medium-grade bole chips (center), to low-grade whole tree chips (right). Many schools are limited to using sawmill chips, which are also the most expensive, but some are starting to use bole chips.

into public use and produces both revenues and jobs; it saves school systems large amounts of money; it improves the forest by encouraging the weeding out of low-quality trees; and it slows global warming because it backs out the use of fossil fuels, whose consumption only adds carbon to the atmosphere. The only ambiguous area is air quality. Wood chip heat in small institutions produces lower sulfate emissions than oil heat and about the same level of nitrate emissions. But its particulate emissions are higher. These tiny particles are a problem because they can get into people's lungs. The school projects deal with this by building tall enough smoke stacks to get the particulates away from the school site; and in any event, the school system boilers are far less of a problem than woodstoves in homes, Maker argues.

The use of wood chip heat in schools has been pretty much an unalloyed success, but now the system is coming under some pressure, with chip prices drifting up after remaining low for more than a decade, and with some of the advocates beginning to worry about the stability of the chip supply. No shortages have appeared yet, but technical issues and the health of the forest products industry itself have become a concern to people like Maker.

The key to the whole system is the wood chip itself. The chips come from two sources: sawmills like Lathrop's and mobile chippers used on log landings. By far the highest-quality chips come from sawmills. The mills acquire logs, mostly hardwood, remove the bark, and saw the clean logs into lumber. Turning an imperfect round log into sound, square-edged lumber produces some waste wood – slabs and edgings – which is then passed through a chipper and then run through a screen to ensure uniform size. The result is a pale, tan piece of hardwood about two-thirds the size of a paper book of matches. Paper mills buy these chips to augment the chips they produce themselves from debarked logs. And they are coveted by the schools. As Steve Murray, the operations chief at Barre Town Elementary, says, "These are the Cadillac of chips."

At the other end of the spectrum are chips that are not even of Kia quality: whole-tree chips that come from logging jobs and land-clearing operations. In these circumstances, whole trees are fed into a chipper, and the resulting biomass is shipped off to wood-fired power plants. The chips include bark, twigs, and leaves, and they are not screened, so that there are lots of odd sizes, including long, skinny stringers that often result when small branches are chipped. These are called "dirty chips," as opposed to papermaking-grade "clean chips."

In between is a third category, called "bole chips," which are similar to whole-tree chips except that they come from the tree's bole – there are no small branches, only trunks and large limbs. The chips aren't screened, but since there are no small branches, there are few if any stringers.

It is ironic that schools, the smallest systems and by far the smallest consumer of chips, have to use the highest-quality chips. The reason is that the delivery systems in the schools, which move the chips from the storage conveyer systems and from the hoppers into the boilers themselves, have relatively small augers. These augers are easily jammed by stringers, so schools will have nothing to do with whole-tree chips, though they are the most readily available kind.

Despite these stringent requirements, nobody has worried about the supply of these chips to schools – until now. In the last year, the price of chips to schools has begun to rise, and there is considerable concern about the supply. One of the problems is that the schools use such a small piece of the chip stream, just 16,000 to 18,000 tons of the million or so tons that are harvested in Vermont each year, so they have little pricing power with the chip suppliers. In fact, Bob DeGeus of Vermont Department of Forests, Parks and Recreation, says that the mills essentially supply the schools as a community service. "They have a good-neighbor policy," he says.

Moreover, the special equipment needed to supply the schools is expensive. The big users, such as electric power plants and pulp and paper companies, have massive infrastructure to process wood, but most schools have only simple, below-ground storage bins. Jim Lathrop says the walking-bottom trailers needed to get chips to schools cost $45,000 apiece; he has two. Also, the tractors that pull the trailers have to have special hydraulics to operate the walking bottoms; he has five of those. Then there is the screening and the extra work to guarantee the highest-quality chips. "You've got a million-dollar deal to stay in this business," he says.

Finally, wood-heat advocates worry about gathering stresses and crosscurrents within the forest products industry itself. From the perspective of the schools, the biggest threat is erosion in the financial outlook for loggers and mills. One problem is the struggle going on in the pulp and paper industry, one of the biggest purchasers of wood. The Northeast segment of that industry is being pressured by competitors in other parts of the U.S., South America, Europe, and now Asia.

The sawmills are also in a financial squeeze. Their costs are going up steadily, and the price of lumber is not keeping pace. And the loggers who supply them have their own set of challenges, including high workers' comp rates and high fuel costs that erode profitability. According to Tim Maker, this dynamic can eat away at the infrastructure needed to keep the wood chip stream flowing.

"If the paper mills go out and the number of sawmills declines, the infrastructure that supports the industry likewise begins to contract – the chipping machines and the log trucks, and the special equipment gets scarcer," he says. The chip supply for schools is critically at risk from this perspective.

BERC now has a $50,000 grant from the federal and state governments, along with some contributions from private industry, to seek a solution to this gathering problem. Maker says they are looking for ways to tweak the business model for chip producers in a way that would bolster the chip supply. "We now see an advantage to higher chip prices," he says. "Schools would still save a lot of money over oil, and it might be possible for someone to make a living in this business."

However that works out, there appears to be one step that the schools can make themselves: they could persuade the manufacturers of the wood boilers to beef up the augers and other elements of the delivery system so that the schools could routinely use bole chips. Jim Lathrop strongly supports that. "They would be a bit more expensive," he says, "but they would be much more flexible."

Though most schools prefer sawmill chips, some are making the gradual shift to bole chips. This year, about half of the supply at Barre Town is bole chips, supplied by Limlaw Chipping, one of the largest chip suppliers. Adam Sherman, who works with Maker at BERC, says, "I think the future for the schools is bole chips."

Despite these caveats, Vermont school officials at all levels continue to be upbeat about wood chip heat. Cathy Hilgendorf at the state education department is pushing it as hard as she can. And principals like Ted Riggen do likewise. Riggen, in fact, is talking about how to use the 88 acres of woods surrounding his school as a source of sustainable fuel. He thinks that the local vocational high school should consider adding a forest products course to its academic offerings.

"You manage the forest well," he says, "and you can sustain this flow forever."

Hamilton Davis is a writer and policy analyst based in Burlington, Vermont.

Unlike schools, wood-chip-fired power plants like the McNeil Generating Station in Burlington, Vermont, buy large quantities of chips.

Paul O. Boisvert

Ned Therrien; John Douglas/Flying Squirrel (inset)

Putting Wood in Your Gas Tank

Wood Fiber Could Be Important Source of Ethanol

By Gail Dutton

The Midwest is making a reputation for itself turning corn stalks and husks into bioethanol, while the South is eyeing rice husks.

The Northeast, however, has a biomass that may be more valuable than either: wood. The United States Department of Agriculture (USDA) estimates that woody biomass could replace as much as 30 percent of the petroleum used in the U.S. Much of that would come from the Northeast, where forests tend to be rich with hardwoods, and "hardwoods are better than softwoods for this," says Lee Lynd, an engineering professor at Dartmouth College.

The Northeast has a long history of converting wood to paper and, in the past few decades, of converting some of the steam produced in papermaking into electricity. Wood-fired power plants have been burning chips to make electricity in the region for a couple of decades. Now wood chips, along with wastes from the pulp and paper mills, have another possible use. Researchers have found a way to convert them into liquid fuel – specifically, into bioethanol that can be mixed with gasoline and used to reduce our dependence on hydrocarbon-based fuels and also help those fuels burn cleaner.

The term "bioethanol" is commonly used to describe ethanol that is made exclusively from carbohydrates, such as corn or wood, that are found in the biosphere. This distinguishes it from ethanol in general, which can be manufactured from petroleum.

There are two broad – and very different – approaches to converting wood to bioethanol, according to Thomas Amidon, director of the Empire State Research Institute. Neither is in commercial use yet. One process – called cellulose conversion – makes bioethanol from cellulose, which, with lignin, makes up the woody parts of trees and plants. In virtually all research labs, this process has been replaced with the second, and more efficient, method – called hemicellulose conversion – which extracts the sugars from wood and uses them to make other products, including bioethanol.

Cellulose comprises about 45 percent of the wood, but, Amidon says, "cellulose is very hard to take apart." Basically, the wood is ground into fine particles and fermented, yielding about 8 percent bioethanol and 92 percent water. That mixture is distilled three times – using considerable fossil-fuel-based energy – to produce 100 percent bioethanol.

In the more efficient hemicellulose conversion, biorefineries convert hemicelluloses (wood sugars, especially xylan) to ethanol. Xylan is the second largest component in hardwood fiber, and paper companies dissolve and burn most of it in the process of making chemical pulp. But xylan can be readily captured by extracting it from the wood prior to pulping. It can then be purified and concentrated with a membrane and then fermented to make ethanol. To top it off, energy produced in the process can help power the ethanol conversion and concentration process.

By using a biorefinery model and by using energy generated during the conversion process to operate the conversion plant, much peer-reviewed research is showing a net energy gain, notes Lynd. The National Renewable Energy Laboratory in 2004 estimated that using enzymes to convert biomass into sugars could result in cost reductions of more than 20-fold per gallon of bioethanol produced, compared to the cellulose conversion.

"The idea of biorefineries is that [similar to oil refineries] you make multiple products at once," Lynd says. A biorefinery, for example, could produce steam for power generation, acetic acid, and biodegradable plastic, as well as bioethanol.

"Ethanol is one of the earliest products that will be made, but it's not the most valuable," Lynd says. Acetic acid, at about 45 cents per pound for its use in making acetates, has nearly twice the value of ethanol, and you don't have to ferment it, he says.

Using biorefineries could more than double the value of the energy extracted from wood waste products in the forest industry,

A mountain of chips; Inset: Lee Lynd, engineering professor at Dartmouth College, and some of his bioethanol-conversion equipment.

from the equivalent of 300 million barrels of oil in 1990 to more than 600 millions of barrels of oil by 2030, according to a report by the American Forest & Paper Association.

Hardwoods will play a particular role in this conversion. "Different species of trees have different utilities," explains Thomas Jeffries, a microbiologist who works for the USDA Forest Service's Forest Products Labs. "Hexose sugars – glucose and galactose, for instance – are abundant in softwoods, but softwoods aren't as easy to convert to liquid fuels." Softwoods are more difficult to degrade, and their sticky pitch makes them more difficult to process than hardwoods. Although technology to degrade softwood is being developed simultaneously in the U.S., Canada, and Sweden, conifers currently are more valuable for their fiber.

Hardwoods, in contrast, have shorter fibers and more-readily degraded cellulose crystals, which allows the fibers to be taken apart by enzymes more easily than softwood fibers. Among hardwoods, the lower-density woods, such as poplar, cottonwood, and willow, are easier to convert to bioethanol. In such species, the lignin is less cross-linked and the wood has a higher hemicellulose content, lower bark content, and lower extractive components – features that make them more amenable to conversion.

Boon for the paper industry?

The still-emerging hemicellulose-conversion method offers a distinct advantage for the pulp and paper industry in the form of a new revenue stream. Traditionally, converting wood to both paper and bioethanol is a bit tricky, Jeffries says, because the acids used to break down the wood can destroy some of the cellulose, and the resulting degradation products reduce fiber yield and strength. "The toxic byproducts also inhibit fermentation of the sugars into ethanol," he says.

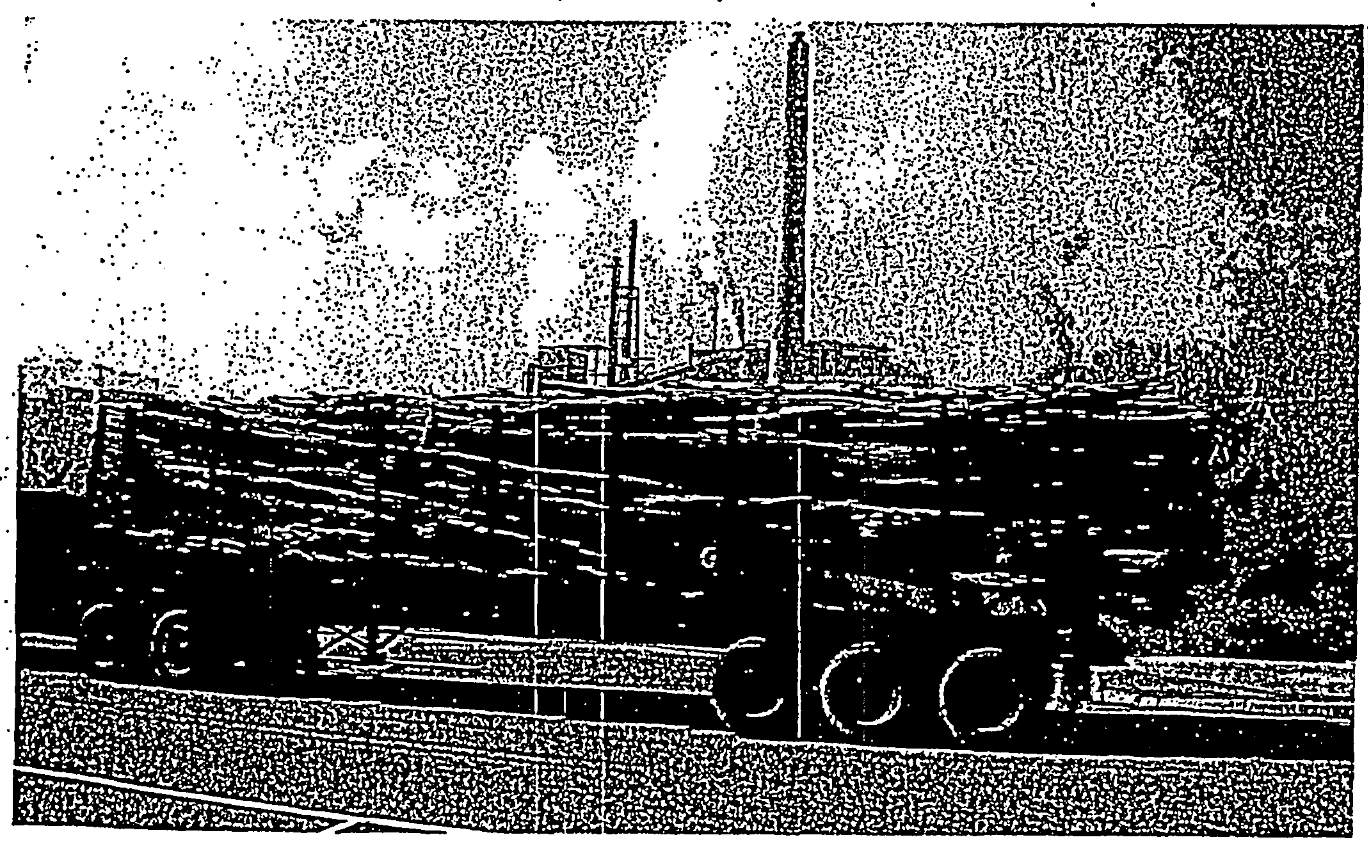
The hemicellulose conversion process, however, overcomes that problem and complements the way paper is made today. Currently, the pulp and paper industry extracts hemicellulosic sugars as one step in converting cellulose into paper, but treats them as waste. Those wasted dollars can be converted into bioethanol, either by fermenting the sugars in solution, or by converting the waste sludge using either enzymes or microbes. Processing it is economical, too, particularly when viewed against the price of oil. It can boost a paper mill's bottom line without significantly changing operations.

Economically, as a source of energy, "wood-based ethanol is a fifth the cost of oil," Lynd says. Currently, he explains, the raw material costs about $40 per ton for cellulosic biomass or $20 per wet ton for wood chips. Converting biomass to ethanol using a biorefinery is the equivalent of buying oil at $13 per barrel, he says.

That figure doesn't include the capital costs of establishing biorefineries or distribution systems, however. When those and other related costs are added into the equation, wood-based biomass could compete with oil that costs $30 to $35 per barrel – about half the peak cost of a barrel of oil in 2005.

Those numbers sound good, but starting a wood-to-bioethanol

Low-grade wood could become an important feedstock for bioethanol refineries.



NED THERRIEN

Ethanol is essentially alcohol, made through a variety of processes. The feedstock can be either biological or fossil fuel. Ethanol made from biological sources (wood chips or corn husks, for example) is called bioethanol.

plant means risk and involves a large amount of capital, Lynd says. No commercial entity is as yet using wood to produce bioethanol. To build a viable wood-to-bioethanol market, "we need two complementary actions: to lower the investment hump for new plants and to do breakthrough research and development."

Most existing bioethanol plants in the U.S. rely upon corn stover – the stalks and other materials not used as food – and corn grain. Theoretically, according to the National Renewable Energy Laboratory, one dry ton of feedstock would produce nearly 125 gallons of bioethanol from corn, or 113 gallons from corn stover. It estimates that a ton of forest thinnings processed through hemicellulose conversion would produce nearly 82 gallons of bioethanol.

Grain is the main feedstock for bioethanol now, but wood has some benefits over competing biomass sources that will boost its use. Unlike such seasonal biomass crops as corn, soybeans, or switchgrass, wood can be harvested throughout the year, stored for months as chips without degrading (longer if left in log form), and can be left growing in the forest until it's needed, thus enabling just-in-time delivery systems. Wood also is denser than alternative biomass sources and so on a volume basis contains more potential energy.

Researchers agree that more study is needed to increase wood-conversion efficiency. In the meantime, Jeffries says, bioethanol plants are likely to be designed to handle multiple fuel types, such as trees, corn stover, rice hulls, and other biomass.

Other issues must also be resolved before wood-based bioethanol plants become a reality, including guaranteeing long-term feedstock supplies for the plants, Lynd says. The feedstock issue isn't trivial, Jeffries emphasizes. "Plants want 20-year contracts but can't get even 5- or 10-year contracts" with suppliers of biomass. Despite these hurdles, "There's every reason to believe we can be very successful," Lynd adds.

The interest in bioethanol extends beyond the fuel and paper industries. Lyonsdale Biomass LLC, a division of Catalyst Renewables Corporation, runs a 19-megawatt wood-fired power plant in Lyonsdale, New York, on the western side of the Adirondacks. It currently burns upwards of 200,000 tons of wood each year. Lyonsdale is working with the state government to develop a renewable portfolio project that provides an incentive to help develop the wood-to-biomass industry. Like other biomass companies, Lyonsdale burns only low-grade woods – tops, limbs, and poorly formed trees – in its existing wood-to-energy plant.

Lyonsdale is participating in biomass research being done by the State University of New York's College of Environmental Science and Forestry (SUNY-ESF). "This year, we're sending samples [of our wood biomass] to SUNY-ESF to determine potential quantities and identify potential markets," according to David BonDurant, Lyonsdale plant manager. The goal is to determine whether it's financially feasible for Lyonsdale to produce bioethanol as a byproduct of its normal operations. Lyonsdale's participation gives SUNY-ESF researchers real-world samples and feedback. Bioethanol, to BonDurant, is a value-added product that could help his plant and others become more viable. Depending on the results of the testing, bioethanol production could augment revenues from generating electricity.

"Any way of keeping the facility open is in my best interest, and the best interest of the Northeast," he says. "Until recently, biomass plants weren't competitive. The cost of fuel was high, so many biomass plants shut down in the past five years." If we can make a value-added product from the wood – like sugars for bioethanol – the plants could become more competitive, he says.

Making the plants more competitive could in turn result in better forestry in the region by providing stable markets for low-grade wood, which would be chipped as a fuel source for biorefineries. The presence of that market, in turn, encourages woodlot owners to improve their timber stands by removing poor-quality trees because they can recoup at least part of the expense of their removal. Thinning out the low-grade wood improves the long-term value of the forests. But without that market, improvement work is an expense that many landowners will not choose to incur.

"A rising tide raises all boats," Lynd says, noting that small landowners could sell the thinnings directly to biorefineries and then eventually get a higher price for their mature timber in the future because it will be of higher quality.

Lynd's optimistic outlook for bioethanol is partially based on the existing fuel market. Several states are requiring that ethanol be added to gasoline and diesel to help those fuels burn hotter, and thus more completely, which reduces air pollution

Right now, more than 30 percent of all gasoline in the U.S. is blended with ethanol, according to the Renewable Fuels Association. In early 2005, the U.S had 81 ethanol plants in 20 states, with the capacity to produce more than 4 billion gallons annually. Another 16 plants are in construction and will add another 750 million gallons of capacity, according to the Renewable Fuels Association, thus indicating the growing market for bioethanol. If the current research can turn wood as a feedstock for bioethanol into a commercial reality, northeastern motorists could find themselves filling their tanks with a fuel that's at least partly made from the forest that surrounds us.

Gail Dutton focuses on science and technology, writing from her family's tree farm in Washington state.