UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
Before the Atomic Safety and Licensing Board

In the Matter of	)	Docket No. 72-1050 NRC-2016-0231
WCS Consolidated Interim Spent Fuel Storage Facility	)	November 13, 2018
	)	
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EXPERT DECLARATION OF ROBERT ALVAREZ

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MEMORANDUM

To: Terry Lodge
From: Robert Alvarez
Date: October 22, 2018

Re: Comments on the Application for a License for a Consolidated Interim Spent Fuel Storage Facility by Waste Control Specialists LLC (Docket No. 72-1050)

You have asked me to review the Application for a License for a Consolidated Interim Spent Fuel Storage Facility by Waste Control Specialists (WSC) LLC (Docket No. 72-1050).

I am familiar with the subject of spent power reactor fuel management and disposition and have experience with it as a senior federal official and have written about it in detail in several prior articles, which are attached to this memorandum.

I have extensive experience with the topic of spent power reactor fuel management in particular and with the workings of the Department of Energy more generally. While serving in the U.S. Department of Energy I was involved in providing analysis and other support to the Secretary of Energy regarding the storage and disposal of DOE and civilian spent nuclear reactor fuel. I currently serve as an Associate Fellow at the Institute for Policy Studies, and Adjunct Professor at Johns Hopkins University, where I teach a graduate course about nuclear non-proliferation.

I previously served as senior policy adviser to the Secretary of Energy and deputy assistant secretary for national security and the environment from 1993 to 1999. During this tenure, I led teams in North Korea to establish control of spent nuclear fuel containing weapons materials. I also coordinated the Energy Department's nuclear material strategic planning and established the department's first asset management program.

Before joining the Energy Department, I served for five years as a senior investigator for the US Senate Committee on Governmental Affairs, chaired by Sen. John Glenn, and as one of the Senate's primary staff experts on nuclear policies. In 1975, I helped found and direct the Environmental Policy Institute, a respected national public interest organization. I have published articles in *Science*, *Science and Global Security*, the *Bulletin of Atomic Scientists*, *Technology Review*, and *The Washington Post*. I have been featured in the television programs *NOVA* and *60 Minutes*. In 2003, as senior scholar at the Institute for Policy Studies, I co-authored an extensive report on reducing the storage hazards of spent power reactor fuel in the United States,[1] which subsequent reviews by the National Research Council have been in general agreement with regarding our findings. [2] [3]

[1] Robert Alvarez, Jan Beyea, Klaus Janberg, Jungmin Kang, Ed Lyman, Allison Macfarlane, Gordon Thompson, and Frank N. von Hippel, Reducing the Hazards from Stored Spent Power-Reactor Fuel in the United States, *Science and Global Security, 11:1–51, 2003*

[2] National Research Council, Board on Radioactive Waste Management, Committee on the Safety and Security of Commercial Spent Nuclear Fuel Storage, National Academies Press (2006)

Failure to Accurately Address Life-Cycle Costs

In my opinion, the License Application by WCS falls far short of what is logically or legally required, in large part because it fails to address the life-cycle cost implications from the assumption of ownership by the federal government of commercial spent nuclear fuel. Transfer of title of 5,000 MT (Metric Tons) of power reactor spent fuel requires legislation and is very likely subject to annual funding authorization and appropriations. The terms and conditions of an interim spent nuclear fuel storage contract between the U.S. Government and WCS does not exist. Nor, is there any degree of certainty that such federal legislation transferring title will occur.

WCS is undertaking a highly speculative view of its pre-disposal responsibilities for spent nuclear fuel, which the United States Government will be presumed to own. Under the Nuclear Waste Policy Act (42 U.S.C. 10101 et seq) "the *Contract for Disposal of Spent Nuclear Fuel and/or High-level Radioactive Waste"* states clearly that "the DOE has the responsibility, following commencement of operation of a repository…".[4]

In the absence of contract terms that are not established without new federal legislation this license application contains strong elements of speculation that are at odds with established research by the U.S. Department of Energy. Moreover, it is not the domain of the Nuclear Regulatory Commission (NRC) or WCS to speculate what the contractual requirements will be with the DOE or legislative stipulations by the U.S. Congress.

For instance, under Executive Order Order 13123, government agencies are required to use life cycle cost analysis (LCCA) to minimize the government's cost of ownership.[5] Over the life of the project, facility management cost is often two to three times higher than acquisition costs. For some 15 years, the U.S. Department of Energy has done life-cycle cost estimation for environmental restoration and waste management expenses at its nuclear sites in numerous Congressional Budget Requests.

Regardless, the estimated cost for an interim spent nuclear fuel storage facility of $424 million in construction, labor, storage and decommissioning costs cited by WCS,[6] significantly underestimates the costs from a detailed study for storage of 5,000 metric tons done for the U.S.

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[3] National Research Council, Committee on Lessons Learned from the Fukushima Nuclear Accident for Improving Safety and Security of U.S. Nuclear Plants, Phase 2, National Academies Press (2016)

[4] U.S. Department of Energy, Contract for Disposal of Spent Nuclear Fuel and/or High-level Radioactive Waste, https://www.energy.gov/sites/prod/files/gcprod/documents/New_Standard_Contract.pdf

[5] U.S. Department of Energy, Guidance on Life-Cycle Cost Analysis Required by Executive Order 13123 April 2005

[6] Application for a License for a Consolidated Interim Spent Fuel Storage Facility byWaste Control Specialists (WCS) LLC (Docket No. 72-1050), June 18, 2018, pp. 1-5 & 1-6.

Department of Energy in May 2015 by the nuclear industry.[7] As Table 1 from the study shows, costs are about 5 times the amount cited by WCS in its license application. Life-cycle costs are not mentioned by WCS, but over 40 years range from $2.17 Billion to $2.437 billion (escalated value). Over 80 years the life cycle costs range from $4.252 billion to $4.691 billion (escalated value).

Table 1

Pilot ISF Comparative Costs ($M) Using Commercial DPCs in a Low Seismic Area

Alternative	Capital Cost	Annual O&M Cost	D&D Cost	40 Year LCC	80 Year LCC
C-PAD	$780- $970	$39	$91	$1,226 $2,177 (EV)	$1,429 $4,252 (EV)
C-STD	$809 - $998	$40	$93	$1,269 $2,254 (EV)	$1,481 $4,411 (EV)
C-UGS	$793 - $990	$39	$118	$1,152 $2,213 (EV)	$1,290 $4,293 (EV)
C-BGV	$784 - $1,252	$39	$187	$1,178 $2,387 (EV)	$1,299 $4,657 (EV)
C-AGV	$838 - $1,383	$39	$181	$1,222 $2,437 (EV)	$1,345 $4,691 (EV)

Source: DOE/ Holtec International, CBI and Longenecker Associates, 2015

Subsequently, I identified the spent fuel from reactors, which matched the dry casks storage systems and other details WCS may deploy at its proposed storage facility based on DOE studies.[8] [9] Then on the basis of the 2015 nuclear industry study done for the DOE, costs were estimated based on spent nuclear fuel in storage systems at 11 closed reactors identified in the NRC license application made by WCS. As the table below shows, the life-cycle costs are significantly higher than indicated by WCS.

[7] Holtec International, CBI and Longenecker Associates, Task Order 15, Generic Design Alternatives for Dy Storage of Spent Nuclear Fuel, Prepared for the U.S. Department of Energy, May 15, 2015. https://www.energy.gov/sites/prod/files/2016/10/f33/to16-final-report_0.pdf

[8] U.S. Department of Energy, Preliminary Evaluation of Removing Used Nuclear Fuel from Shutdown Sites, Nuclear Fuels Storage and Transportation Planning Project, FCRD-2016-000478, September 2016.

[9] U.S. Department of Energy, Dry Storage Cask Inventory Assessment, Nuclear Fuels Storage and Transportation Planning Project, FCRD-NFST-2014-000602, Rev 2, August 2016.

Table 2
Estimated Cost For Spent Nuclear Fuel in WCS-Designated Cask Types

Reactor	Assemblies	Metric Tons	40 years	80 years
Haddam Neck	1019	413.5	$179,848,984	$ 351,220,675.00
Duane Arnold	2825	531	$231,234,408	$ 451,569,440.00
Lacrosse	333	38	$16,547,848	$ 32,315,704.00
Oyster Creek	4711	753	$327,908,580	$ 640,361,183.00
Yankee Rowe	533	127.2	$55,391,745	$ 108,172,566.00
Maine Yankee	1432	542.3	$236,155,215	$ 461,179,109.00
Zion 1&2	2226	1019.4	$443,917,807	$ 866,911,275.00
Kewaunee	1335	518.7	$225,878,131	$ 441,109,357.00
Songs 1,2&3	3855	1606.1	699,407,877	$ 1,365,848,733.00
TOTAL	18269	5549.2	$2,416,823,595	$ 4,718,688,042.00

Sources:
Waste Control Specialists, License Application, Docket-72-150, FCRD-NFST-2014-000602, Revision 2 (2016, DOE Generic Design Alternatives for. Dry Storage of Spent Nuclear Fuel , Appendix A-6 (2015)

Annual cost inflation =1.9%
Discount Rate=3.4%

High Burnup Spent Nuclear Fuel

Significant uncertainties surround prolonged storage of high burnup spent nuclear fuel. This fuel generally contains a higher percentage of uranium-235, allowing reactor operators to effectively double the amount of time the fuel can be used. Once it is used, high burnup significantly boosts the radioactivity in spent fuel and its commensurate decay heat. Of concern is the damage that high burnup fuel may have on the cladding of the fuel. The Nuclear Regulatory Commission (NRC) and the nuclear industry do not have the necessary information to determine if prolonged storage of high burnup fuel may damage fuel cladding and create leakage. Even NRC admits, "there is limited data to show that the cladding of spent fuel with burnups greater than 45,000 MWd/MTU [Mega-watt days per Metric Ton Uranium] will remain undamaged during the licensing period."[10]

Research shows that under high burnup conditions, the zirconium cladding of the fuel rods may not be relied upon as a key barrier to prevent the escape of radioactivity, especially during prolonged storage in the "dry casks" that are the preferred method of temporary storage for spent fuel. High burnup waste reduces the fuel cladding thickness and a hydrogen-based rust forms on the zirconium metal used for the cladding, which can cause the cladding to become brittle and fail. In addition, under high burnup conditions, increased pressure between the uranium fuel pellets in a fuel assembly and the inner wall of the cladding that encloses them causes the cladding to thin and elongate. In addition, the same research has shown that high burnup fuel temperatures make the used fuel more vulnerable to damage from handling and transport;

[10] U.S. Nuclear Regulatory Commission, Standard Review Plan for Spent Fuel Dry Storage Facilities, Final Report NUREG-1567, March 2000. P. 6-15. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1567/sr1567.pdf

cladding can fail when used fuel assemblies are removed from cooling pools, when they are vacuum dried, and when they are placed in storage canisters. [11] [12] [13] [14] [15] [16]

The pickup and transportation order of spent fuel has yet to be determined. It has been assumed that the oldest would have priority, leaving sites with fresher and thermally hotter fuel that may be "trapped" at sites to cool down further. As of the end of 2013, data provided to DOE indicates that about 24 percent of some 244,000 spent nuclear fuel assemblies in the United States are high burnup. About 83 percent of some 58,745 high burnup assemblies, remained in pools.[17]

WCS recognizes the concerns and uncertainties surrounding high burnup spent nuclear fuel by stipulating in its license application that, "all fuel with assembly average burnup greater than 45 GWd/MTHM [Giga-watt days per Metric Ton Heavy Metal] shall be canned inside the canister."[18] The Nuclear Waste Technical Review Board (NWTRB) concluded in 2010 that given "the damaged and unknown state of cladding at any point of time during dry storage, there is a possibility that accidents or handling could fail weakened fuel-rods. Furthermore, the uncertain hydrogen embrittlement and delayed hydride cracking mechanism could result in additional failed cladding. The likelihood of the latter mechanism increases with time. Accordingly, cladding failure during dry storage and handling could present significant hazardous conditions to workers and especially if the used fuel needs to be handled."[19]

The uncertainties of storing a mix of high- and low burnup spent fuel in a canister are compounded by the lack of data on the long-term behavior of high burnup spent fuel. This problem was highlighted by the Nuclear Waste Technical Review Board, an expert panel that provides scientific oversight for the Energy Department on spent fuel disposal. That panel said there is little to no data to support dry storage and transport for spent fuel with burnups greater than 35 gigawatt days per metric ton of uranium. In a May 2016 letter to the Energy Department, the board raised elemental questions that should have been answered before the NRC and reactor

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11 U.S. Nuclear Regulatory Commission, Rulemaking Issue, Notation Vote, Memorandum from: R.W. Borchardt, Executive Director for Operations, Subject: Proposed Rulemaking – 10CFR50.46c, Emergency Core Cooling System Performance During Loss-of-Coolant Accidents (RIN 3150-AH42), SECY-12-0034, March 1, 2012, p. 2. http://www.nrc.gov/reading-rm/doc-collections/commission/secys/2012/2012-0034scy.pdf

12 Ibid.

13 Ibid

14 International Atomic Energy Agency, Impact of High Burnup Uranium Oxide and Mixed Uranium – Plutonium Oxide Water Reactor Fuel on Spent Fuel Management, IAEA Nuclear Energy Series, No.. NF-T-3.8, June 2011. P. 39. http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1490_web.pdf

15 Ibid.

16 Ibid. p.69.

17 U.S. Department of Energy, Energy Information Administration, Nuclear Fuel Data survey, Form-859, 2013

18 U.S. Nuclear Regulatory Commission, LICENSE FOR INDEPENDENT STORAGE OF SPENT NUCLEAR FUEL AND HIGH-LEVEL RADIOACTIVE WASTE, NRC Form 588, Docket No.72-1050, page 2.

19 United States Nuclear Waste Technical Review Board, Evaluation of the Technical Basis for Extended Dry Storage and Transportation of Used Nuclear Fuel, December 2010, P. 117. https://www.nwtrb.gov/docs/default-source/reports/eds-final.pdf?sfvrsn=8

operators took this leap of faith: "What could go wrong? How likely is it? What are the consequences?"[20] The board has yet to receive answers to those questions.

At sites like the San Onofre Nuclear Generating Station (SONGS), storage of about a third of spent nuclear fuel generated by reactors 2 & 3 will not be eligible for storage at the proposed WCS site. According to a DOE report, "there are 1115 uncanistered fuel assemblies from San Onofre-2 and -3 that have burnups greater than 45 GWd/MTHM. The San Onofre site has decided not to package these assemblies in damaged fuel cans."[21] As a result, the WCS license application indicates that it will not accept the high burnup spent fuel, from SONGS as well as other candidate sites, including Oyster Creek, Kewaunee, and Duane Arnold, unless it is considered *a priori* damaged and placed in more expensive double-shell canisters. The decision to forgo double-shell containment of high burnup spent nuclear fuel indicates that this material is likely to be "stranded" for decades, given the time frame required for research to assess long-term integrity. The NWTRB recommends "that a validation inspection program of both low and high-burnup fuels be instituted after 15 and 30 years of storage."[22]

At Maine Yankee and Zion, these high burnup used nuclear fuel assemblies are packaged in damaged fuel cans, which reduces the concern over the transportability of this high burnup fuel.[23]

Repackaging for Disposal

Dry cask storage systems are either single purpose (storage only) or dual purpose (storage and transportation). None are currently licensed for disposal. "Direct disposal of the large canisters currently used by the commercial nuclear power industry is beyond the current experience base globally," a 2013 DOE study observes, "and represents significant engineering and scientific challenges."[24] A 2013 report by the staff of the Nuclear Waste Technical Review Board concludes, "repackaging the SNF may be a lengthy process and could impact operational schedules at the utility sites, at a consolidated storage facility, or at the repository, depending on where repackaging is performed."[25] It's not out of the question that if DOE assumes title for

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[20] Nuclear Waste Technical Review Board, Letter to John Kotek, Acting Assistant Secretary for Nuclear Energy, U.S. Department of Energy, May 23, 2016. https://www.nwtrb.gov/docs/default-source/correspondence/rce0516.pdf?sfvrsn=15

[21] Op Cit Ref 9, p.229.

[22] Op Cit Ref 19, p.117.

[23] U.S. Department of Energy, Preliminary Evaluation of Removing Used Nuclear Fuel From Nine Shutdown Sites, PNNL-22418, April 30, 2013. http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22418.pdf

[24] U.S. Department of Energy, Office of Nuclear Energy, Task Order 12: Standardized Transportation, Aging, and Disposal Canister Feasibility Study, June 14, 2013. https://curie.ornl.gov/system/files/documents/not%20yet%20assigned/STAD_Canister_Feasibility_Study_AREVA_Final_1.pdf

[25] U.S. Department of Energy, Nuclear Waste Technical Review Board, Staff Briefing Document, Framework for the Technical Workshop on the Impacts of Dry-Storage Canister Designs on the Future Handling, Storage, Transportation, and Geologic Disposal of Spent Nuclear Fuel in the United States, Washington, DC, November 18–19, 2013. http://www.nwtrb.gov/meetings/2013/nov/framework.pdf

spent nuclear fuel for a pilot consolidated interim storage facility it may elect to do detailed development of repackaging as recommended by some in the nuclear industry.[26]

Under the Nuclear Waste Policy Act (42 USC 10101), which sets forth the process for disposal of high-level radioactive wastes, the U.S. Government cannot accept title to spent nuclear fuel until it is received at an open permanent repository site. According to the law, "the persons owning and operating civilian nuclear power reactors have the primary responsibility for providing interim storage of spent nuclear fuel from such reactors."[27] The U.S. Government Accountability Office reported in 2014: "per DOE, under provisions of the standard contract, the agency does not consider spent nuclear fuel in canisters to be an acceptable form for waste it will receive. This may require utilities to remove the spent nuclear fuel already packaged in dry storage canisters".[28]

In 2012, Energy Department researchers concluded that "waste package sizes for the geologic media under consideration…are significantly smaller than the canisters being used for on-site dry storage by the nuclear utilities."[29] A nuclear industry study concluded in 2014 that "casks and canisters being used by the power utilities will be at least partially, and maybe largely, incompatible with future transport and repository requirements, meaning that some if not all, of the [used nuclear fuel] that is moved to dry storage by the utilities will ultimately need to be repackaged."[30] Existing large canisters can place a major burden on a geological repository, such as: handling, emplacement and post closure of cumbersome packages with higher heat loads, radioactivity and fissile materials. Repackaging expenses rely on the transportability of the canisters, but more importantly on the compatibility of the canisters with heat loading requirements for disposal.

WCS has not included a repackaging capability in its license application. According to DOE research:

> **"Repackaging at reactors would be challenging** Operating sites: Impact operations- Shutdown sites: Build new facility or pools
>
> "**Repackaging at ISF [Interim Storage Facility] or repository would offer flexibility** Purpose-built facility (minimize dose, maximize throughput)
>
> "**Repackaging may impact transportation** Probably more canisters to move (if not performed at repository)

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[26] Op cit Ref. 20

[27] 42 U.S.C. 10101, Sections 123 & 131.

[28] U.S. Government Accountability Office, Spent Nuclear Fuel Management: Outreach Needed to Help Gain Public Acceptance for Federal Activities That Address Liability, GAO-15.141, October 2014, P. 30. http://www.gao.gov/assets/670/666454.pdf

[29] Ibid.

[30] Chris Phillips, Ivan Thomas and Steven McNiven, Nuclear Industry Study on the Feasibility of Standardized Transportation, Aging and Disposal Canisters for Used Nuclear Fuel, Energy Solutions Federal EPC. WM2014 Conference, March 2-6, 2014, Phoenix, Arizona, USA. http://www.wmsym.org/archives/2014/papers/14011.pdf

Empty canisters, overpacks, and materials generated in repackaging process would have to be managed Low-level waste on the order of $9500 / assembly".[31]

According to DOE research the costs of repackaging at a centralized storage site are large,[32] ranging in an additional expense from about $40,000 to about $87,000 per assembly from a pressurized reactor (PWR) relative to loading and capital costs. For the spent fuel at potential candidate sites with (PWRs),[33] estimated repacking costs range from $450 million to $978 million.

In the final analysis, before interim storage facilities are licensed the full costs of government ownership of spent nuclear fuel prior to the accepting title before a disposal repository is opened, are necessary to determine the nature and extent of the federal liability. The WCS license should not be issued until Congress is made aware of this potentially very large public expense.

[31] U.S. Department of Energy, Office of Nuclear Energy, Standardized Transportation, Aging, and Disposal (STAD) Canister Design, Presentation to the Nuclear Waste Technical Review Board, June 24, 2015. http://www.nwtrb.gov/meetings/2015/june/jarrell.pdf

[32] Potentially eligible PWR sites include: Rancho Seco (492 assemblies), SONGS 1 (395 assemblies), SONGS 2&3 (3,460 assemblies), La Crosse (333 assemblies), Yankee Rowe (533 assemblies), Connecticut Yankee (1,019 assemblies), Maine Yankee (1,432 assemblies), Zion 1 & 2 (2,226 assemblies), Kewaunee (1,335 assemblies), and Palisades (433 assemblies).

I hereby certify that I have made the foregoing statements under penalty of perjury.

October 23, 2018

Date

Robert Alvarez