May 9, 2011

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
NUCLEAR INNOVATION NORTH	)	
AMERICA LLC	)	Docket Nos. 52-012 & 52-013
	)	
(South Texas Project, Units 3 & 4)	)	

PREFILED DIRECT TESTIMONY OF RICHARD L. EMCH, JR., JEREMY P. RISHEL, AND DAVID M. ANDERSON REGARDING CONTENTION CL-2

Q1. Please state your names, occupations, and by whom you are employed.

A1a. [RLE][1] My name is Richard L. Emch, Jr. I am a Senior Health Physicist employed by the U.S. Nuclear Regulatory Commission (NRC). I have been employed at the NRC for more than 36 years; I joined the U.S. Atomic Energy Commission (AEC) in September 1974. A statement of my professional qualifications is included as Exhibit NRC000005.

A1b. [JPR] My name is Jeremy P. Rishel. I am a Technical Research Scientist employed by Battelle, Pacific Northwest National Laboratory (PNNL). Battelle operates PNNL for the U.S. Department of Energy (DOE). I have been employed at PNNL for 6 years, and prior to that, I worked at Los Alamos National Laboratory (LANL) for nearly 4 years. A statement of my professional qualifications is included as Exhibit NRC000006.

A1c. [DMA] My name is David M. Anderson. I am a Senior Research Economist employed by Battelle, PNNL. Battelle operates PNNL for DOE. I have been employed at PNNL for 16 years, interrupted by 4 years at Washington Mutual Bank headquarters in Seattle. A statement of my professional qualifications is included as Exhibit NRC000007.

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[1] In this testimony, the identity of the witness who supports each numbered paragraph is indicated by the notation of his initials in parentheses.

Q2. Please describe your job duties and responsibilities.

A2a. [RLE] I am currently assigned to the Environmental Technical Support Branch in the Division of Site and Environmental Reviews in the Office of New Reactors. I am responsible for the technical oversight of NRC Staff and contractors involved in the review of the environmental impacts of radiation protection and postulated accidents including Severe Accident Mitigation Alternatives (SAMA) analyses for combined license applications. Severe Accident Mitigation Design Alternatives (SAMDA) analyses are part of the SAMA analyses. In this capacity, I have contributed technical input to every environmental impact statement issued by the NRC in support of combined license applications for new reactors. I have also contributed technically to the NRC's Environmental Assessments that address SAMDA analyses for the Economic Simplified Boiling Water Reactor (ESBWR) design certification and the Aircraft Impact Rule Amendment to the Advanced Boiling Water Reactor (ABWR) design certification.

A2b. [JPR] My current responsibilities at PNNL include (1) assisting the NRC Staff with environmental reviews for nuclear power plant licensing and license renewals in the areas of meteorology, design-basis and severe accidents, and SAMA; (2) assisting in the development and updating of various NRC-related atmospheric dispersion models, including the Radiological Assessment System for Consequence Analysis (RASCAL; NUREG-1887) and PAVAN models; (3) participating in the development of the dust transport (DUSTRAN) dispersion modeling system for the Department of Defense (DOD); (4) performing dispersion modeling in support of environmental assessments for the demolition of decommissioned radiological facilities within DOE; (5) performing meteorological and dispersion modeling to support emergency response at DOE's Hanford Unified Dose Assessment Center; and (6) serving as committee chair for DOE's Consequence Assessment Modeling Working Group under the Subcommittee on Consequence Assessment and Protective Actions.

A2c. [DMA] My current responsibilities at PNNL include (1) assisting the NRC Staff with environmental reviews for nuclear power plant licensing and license renewals in the areas of benefit/cost analysis, need for power analysis, socioeconomic impact assessment, environmental justice impacts, and land use impacts; (2) coordinating amongst these disciplines the assignments of other subject matter experts supporting NRC licensing reviews; (3) drafting updates to NRC guidance in the above listed areas as directed; (4) managing project teams in the area of energy efficiency impact analysis; and (5) performing as a subject matter expert in the above areas on National Environmental Policy Act (NEPA) reviews for other federal agencies including the Department of Energy and US Army Corps of Engineers.

Q3. Please describe your professional qualifications including education, training, work experience, and publications, as it relates to the testimony you are providing.

A3a. [RLE] I received a B.S. in Engineering Physics from Louisiana Tech University in 1973 and a M.S. in Health Physics from Georgia Institute of Technology in 1974. I have been employed by the AEC and the NRC since 1974. I was a supervisor for 15 years in technical specifications, radiation protection, emergency preparedness, design basis accident dose analysis, probabilistic risk assessment, and operating reactor project management. Since early 2002, I have been involved in the review of numerous severe accident mitigation alternative (SAMA) analyses supporting license renewal and combined license applications. I was a technical contributor to over 20 environmental impact statements supporting license renewal applications. In addition, I was one of the authors of LR-ISG-2006-03, “Staff Guidance For Preparing Severe Accident Mitigation Alternatives Analyses,” a license renewal interim staff guidance document endorsing NEI 05-01, Revision A, “Nuclear Energy Institute Severe Accident Mitigation Alternatives (SAMA) Analysis Guidance Document." I was also a Director of the Protective Measures Team at the NRC’s Emergency Operations Center for 15 years.

A3b. [JPR] I received a B.S. (1996) and M.S. (1998) in Meteorology from The Pennsylvania State University. For the past 10 years, I have been involved in the emergency operation centers at both Los Alamos National Laboratory and Hanford, providing consequence assessment modeling support in the event of a chemical, biological, or radiological release. In addition, I am committee chair of DOE's Consequence Assessment Modeling Working Group under the Subcommittee on Consequence Assessment and Protective Actions. As a technical research scientist at PNNL, I support numerous projects and clients, principally in the areas of developing and using atmospheric dispersion codes for emergency response and environmental assessments. In this regard, I support the NRC on the development of atmospheric dispersion models for emergency response (RASCAL) as well as for environmental and safety reviews (PAVAN). I am also a lead reviewer on several EIS's for nuclear reactor license renewal, early site permit (ESP), and COL applications in the areas of meteorology and accidents, which includes SAMDA reviews.

A3c. [DMA] I received an M.S. in Forest Economics from Oregon State University. I have been employed by Battelle, the operator of PNNL from 1991-1997, and currently from 2001 to present. I am a scientist on the technical staff of the Energy and Efficiency Division. I have been conducting economic impact studies for more than 20 years, and I have been involved in assessing baseload power needs associated with nuclear power plants over the previous 4 years. I contributed to the preparation of NUREG-1555, *Environmental Standard Review Plan—Standard Review Plans for Environmental Reviews for Nuclear Power Plants*, and subsequent revisions and have prepared EIS sections on socioeconomics, benefits and costs, need for power, environmental justice and land use for a number of ESP and COL applications.

Q4. Please describe your involvement and responsibilities in connection with the Staff's preparation of the Environmental Impact Statement (EIS) for combined licenses (COLs) for South Texas Project Electric Generating Station (STP) Units 3 and 4.

A4a. [RLE] I was responsible for the technical oversight of NRC Staff and contractors involved in the review of the environmental impacts of radiation protection and postulated accidents, including the SAMA analysis, for the combined license application for STP Units 3 and 4. I helped prepare Section 5.11, “Environmental Impacts of Postulated Accidents,” of the draft and final versions of the EIS for COLs for STP Units 3 and 4. I was also one of the authors of the “Affidavit of Richard L. Emch, Jr. and James V. Ramsdell, Jr. Concerning Finality of SAMDA Conclusions in ABWR Design Certification as Applied to STP Units 3 and 4,” dated July 22, 2010, which was submitted as Staff Attachment 2 in support of the “NRC Staff Motion for Summary Disposition” (ML102030564) of Contention CL-2.

A4b. [JPR] I was not involved in the Staff’s initial review of the COL application or preparation of the EIS. However, I have reviewed the Staff’s work in preparation of my testimony with respect to Contention CL-2.

A4c. [DMA] Other than serving as the subject matter expert for Socioeconomics and Environmental Justice technical areas during the NRC’s initial pre-application visit to the STP site and vicinity, my only involvement has been to peer review environmental impact statement (EIS) sections prior to formal publication by the NRC. I was also one of the authors of the “Affidavit of James V. Ramsdell, Jr. and David M. Anderson, Concerning the Staff’s Review of STPNOC’s Updated SAMDA Evaluation” dated October 7, 2010, which was submitted as Staff Attachment 1 in support of the “NRC Staff Answer to Applicant’s Motion for Summary Disposition of Contention CL-2” (ML102800623).

Q5. What is the purpose of this testimony?

A5a. [RLE, JPR] We are testifying to present the Staff’s views with respect to Contention CL-2, which alleges that there are errors in the severe accident mitigation design alternatives (SAMDA) analysis in the Applicant’s Environmental Report (ER). Specifically, we will discuss the purpose of a SAMDA analysis, describe how such an analysis is performed, and present the results of the Staff’s SAMDA analysis review.

A5b. [DMA] I am testifying to present the Staff’s views with respect to Contention CL-2, which alleges that there are errors in the SAMDA analysis in the Applicant’s ER. Specifically, I will discuss aspects of the Staff's review covering replacement power costs and appropriate inflation accounting.

Q6. Are you familiar with the Contentions CL-2, CL-3, and CL-4 submitted by the Sustainable Energy and Economic Development Coalition, the South Texas Association for Responsible Energy, and Public Citizen (Intervenors) which were subsequently reformulated and admitted by the licensing board as Contention CL-2?

A6. [RLE, JPR, DMA] Yes. We are familiar with the Intervenors' Contentions CL-2, CL-3, and CL-4, (ML093561429) which address the Applicant's quantification of replacement power costs following a shutdown of multiple STP units. These contentions were reformulated by the licensing board as CL-2 and provides:

> The Applicant's calculation in ER Section 7.5S of replacement power costs in the event of a forced shutdown of multiple STP Units is erroneous because it underestimates replacement power costs and fails to consider disruptive impacts, including ERCOT market price spikes.[2]

We are also familiar with Clarence L. Johnson's report, "Review of Replacement Power Costs for Unaffected Units at the STP Site" (2009 Johnson Report) (ML093561431), dated December 21, 2009, submitted by the Intervenors in support of the contentions.

Q7. Did you review or rely on any specific documents in support of your testimony?

A7. [RLE, JPR, DMA] In preparing this testimony we have considered and referenced the following specific documents (with NRC Exhibit numbers noted) in the responses for which we are individually responsible, as indicated by our initials:

<u>Legal Documents:</u>

- [RLE, JPR, DMA] "Intervenors' Contentions Regarding Applicant's Proposed Revision to Environmental Report Section 7.5S and Request for Hearing" (Dec. 22, 2009) (ML093561429) (Contentions CL-2, CL-3, and CL-4). We also reviewed "Review of Replacement Power Costs for Unaffected Units at the STP Site" (ML093561431) (hereafter "2009 Johnson Report"), a report by Clarence L. Johnson submitted in support of Contentions CL-2 through CL-4 as proposed by the Intervenors.

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[2] LBP-10-14 at 30.

- [RLE, JPR] South Texas Project Nuclear Operating Co. (South Texas Project Units 3 & 4), LBP-10-14, 72 NRC __ (July 2, 2010) (slip op.) (consolidating Contentions CL-2, CL-3, and CL-4 into reformulated Contention CL-2).

- [RLE, JPR] “NRC Staff Motion for Summary Disposition” (July 22, 2010) (ML102030564) (seeking summary disposition of Contention CL-2). We also reviewed “Affidavit of Richard L. Emch, Jr. and James V. Ramsdell, Jr. Concerning Finality of SAMDA Conclusions in ABWR Design Certification as Applied to STP Units 3 and 4,” which was submitted in support of the NRC Staff summary disposition motion and included in the same document as Staff Attachment 2.

- [RLE, JPR] “STP Nuclear Operating Company’s Answer Supporting the NRC Staff Motion for Summary Disposition of Contention CL-2” (July 29, 2010) (ML102100609).

- [RLE, JPR] “Intervenors’ Response to Staff’s Motion for Summary Disposition” (Aug. 11, 2010) (ML102230518).

- [RLE, JPR, DMA] “STP Nuclear Operating Company’s Motion for Summary Disposition Of Contention CL-2” (Sept. 14, 2010) (ML102571613). We also reviewed “Joint Affidavit of Jeffrey L. Zimmerly and Adrian Pieniazek” (hereafter “Applicant 2010 Affidavit”) that was submitted in support of the Applicant’s summary disposition motion and included in the same document.

- [RLE, JRP, DMA] “NRC Staff Answer to Applicant’s Motion for Summary Disposition of Contention CL-2” (Oct. 7, 2010) (ML102800623). We also reviewed “Affidavit of James V. Ramsdell, Jr. and David M. Anderson, Concerning the Staff’s Review of STPNOC’s Updated SAMDA Evaluation” that was submitted in support of the NRC Staff’s Answer and included in the same document as Staff Attachment 1.

- [RLE, JPR, DMA] “Intervenors’ Response to Applicant’s Motion for Summary Disposition of Contention CL-2” (Oct. 8, 2010) (ML102820002). We also reviewed “Affidavit in Response to Motion for Summary Disposition” (ML102820005) (hereafter “2010 Johnson Affidavit”) by Clarence L. Johnson submitted in support of the Intervenors’ Answer to the Applicant’s motion.

- [RLE, JPR, DMA] *Nuclear Innovation North America LLC* (South Texas Project Units 3 & 4), LBP-11-07, 73 NRC __ (Feb. 28, 2011) (slip op.) (denying the Applicant’s and Staff’s motions for summary disposition of Contention CL-2).

<u>Exhibits:</u>

- [RLE, JPR, DMA] NUREG/BR-0184, *Regulatory Analysis Technical Evaluation Handbook* (Jan. 1997) (ML050190193) (Exs. NRC00008A and NRC00008B).

- [RLE,JPR] *Technical Support Document for the ABWR*, attachment 1 to NEPA/SAMDA Submittal for the ABWR from J.F. Quirk to R.W. Borchardt (Dec. 21, 1994) (ML100210563) (Exs. NRC00009A and NRC00009B).

- [RLE,JPR] NUREG/BR-0058, Rev. 4, *Analysis Guidelines of the U.S. Nuclear Regulatory Commission* (Sept. 2004) (ML042820192) (Ex. NRC000010).

- [RLE,JPR] NUREG/CR-3568, *Handbook for Value Impact Analysis* (Dec. 1983) (ML062830096) (Ex. NRC000011).

- [RLE,JPR] NUREG/BR-0058, Rev. 2, *Analysis Guidelines of the U.S. Nuclear Regulatory Commission* (Nov. 1995) (ML111180434) (Ex. NRC000012).

- [RLE,JPR] "Final Environmental Assessment by the Office of Nuclear Reactor Regulation, NRC, Relating to the Certification of the US Advanced Boiling Water Reactor Design, Docket No. 52-001," attachment 2 to SECY-96-077, Certification of Two Evolutionary Designs (Apr. 15, 1996) (ML003708129) (Ex. NRC000013).

- [RLE,JPR] Environmental Report for STP, Units 3 and 4, Section 7.3, Rev. 4 (Sept. 2010) (ML102860574) (Ex. NRC000014).[3]

- [RLE,JPR] NUREG/CR-6349, *Cost Benefit Considerations in Regulatory Analysis* (Oct. 1995) (ML103050362) (Ex. NRC000015).

- [RLE,JPR] Environmental Report for STP, Units 3 and 4, Section 7.2, Rev. 4 (Sept. 2010) (ML102860573) (Ex. NRC000016).

- [RLE,JPR] Environmental Report for STP, Units 3 and 4, Section 7.5S, Rev. 4 (Sept. 2010) (ML102860576) (Ex. NRC000017).

- [DMA] Bureau of Economic Analysis - National Economic Accounts National Income and Product Accounts Table; Table 1.1.9. Implicit Price Deflators for Gross Domestic Product. (retrieved Apr. 21, 2011) (available at http://www.bea.gov/national/nipaweb/TableView.asp?SelectedTable=13&ViewSeries=NO&Java=no&Request3Place=N&3Place=N&FromView=YES&Freq=Year&FirstYear=1991&LastYear=2009&3Place=N&Update=Update&JavaBox=no#) (Ex. NRC000018).

- [DMA] Bureau of Labor Statistics' Producer Price Index for the commodity of "Electric Power" (BLS 2011| Producer Price Index-Commodities: Series Id: WPU054| 2009/1993) (retrieved Mar. 23, 2011) (available at http://data.bls.gov/timeseries/wpu054 by inputting the year range 1993 to 2009) (Ex. NRC000019).

- [DMA] US EIA – Texas Nuclear Profile (Sept. 2010) (available at http://www.eia.doe.gov/cneaf/nuclear/state_profiles/texas/tx.html#_ftnref2) (Ex. NRC000020).

- [DMA] Bureau of Economic Analysis, NIPA Handbook: Chapter 5: Personal Consumption Expenditures (retrieved May 4, 2011) (NIPA Handbook available at http://www.bea.gov/national/Index.htm. Chapter 5 specifically available at http://www.bea.gov/national/pdf/NIPAhandbookch5.pdf) (Ex. NRC000021).

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[3] This testimony and the FEIS are based on the values in Revision 4 of the ER. The NRC Staff reviewed Revision 5 of the ER and concluded that it did not affect the ER sections cited.

- [DMA] Bureau of Economic Analysis, NIPA Handbook: Chapter 6: Private Fixed Investment (retrieved May 2, 2011) (available at http://www.bea.gov/national/pdf/NIPAhandbookch6.pdf) (Ex. NRC000022).
- [DMA] Potomac Economics, Ltd., 2009 State of the Market Report for the ERCOT Wholesale Electricity Markets (July 2010) (available at http://www.puc.state.tx.us/wmo/documents/annual_reports/2009annualreport.pdf) (Ex. NRC000023).
- [DMA] Applicant Document STP_173.xls, "Unit Dispatch – Removing All STP Units" (Sept. 14, 2010) (PDF printout of spreadsheet-excerpts) (Ex. NRC000024).
- [DMA] Applicant Document STP_175.xls, "Unit Dispatch Base Case" (Sept. 14, 2010) (PDF printout of spreadsheet-excerpts) (Ex. NRC000025).
- [DMA] ERCOT Press Release, 2/2/2011 (available at http://www.ercot.com/news/press_releases/2011/nr02-02-11a) (Ex. NRC000029).
- [DMA] Applicant Document STP_174.xls, "Calculations to Support Joint Affidavit" (Sept. 14, 2010) (PDF printout of spreadsheet) (Ex. NRC000030).

Q8. What is a SAMDA analysis?

A8. [RLE, JPR] A SAMDA analysis is a systematic search for potentially cost-beneficial design alternatives to further reduce nuclear power plant severe accident risk. Specifically, a SAMDA analysis compares the cost of a design alternative to its potential benefit in mitigating or eliminating accident risk. A SAMDA analysis uses probabilistic risk assessment (PRA) to consider design improvements and evaluate the change in accident cost risk that would result from those design improvements.

Q9. What is "accident cost risk?"

A9. [RLE, JPR] Accident risk is defined as the probability of an accident times its consequence. In a SAMDA analysis, severe accident consequences are monetized into dollar amounts. Accident cost risk is therefore the probability of an accident times its monetized consequence. A SAMDA analysis seeks design alternatives in which the implementation costs are equal to, or less than, the accident cost risk they avert. SAMDAs that meet this criterion are considered cost-beneficial to implement.

Q10. What are the components of a SAMDA analysis?

A10. [RLE, JPR] A SAMDA analysis uses the cost-benefit methodology described in NUREG/BR-0184, "*Regulatory Analysis Technical Evaluation Handbook*" (Exhibits NRC00008A and NRC00008B) to calculate a "net value," which is the SAMDA's total averted cost risk minus the SAMDA's implementation cost:[4]

Net Value ($) = Total SAMDA Averted Cost Risk ($) – SAMDA Implementation Cost ($)

Averted costs include several monetized offsite and onsite components. Offsite components include averted costs of public exposure and offsite property damage. Onsite components include averted costs of occupational exposure, property damage, and replacement power. Averted costs are weighted by the probability (or frequency) of the accident. The product of the monetized benefit and accident frequency is referred to as the SAMDA's averted cost risk. A SAMDA with an averted cost risk that is greater than or equal to its implementation cost (e.g., the net value is positive) is considered cost-beneficial to implement.

The frequency of a severe accident leading to core damage (i.e., the core damage frequency, or CDF) is determined through a probabilistic risk assessment (PRA). The baseline PRA evaluates possible accident sequences, the associated probability of core damage, and the resulting consequences without implementing any SAMDAs. SAMDA benefits are evaluated by modifying the baseline PRA to account for the effect of the design alternative and then comparing the results of the baseline to the modified PRA.

As an initial screening procedure in SAMDA analyses, it is common to assume that each SAMDA could individually eliminate all probability of a severe accident. In this case, the total SAMDA averted cost risk is referred to as the "maximum averted cost." This conservative assumption over-estimates each SAMDA's benefit, since no one design change can address all possible accident sequences and reduce total accident frequency to zero. In addition, many

[4] NUREG/BR-0184, Sections 4 and 5 (Exs. NRC00008A and NRC00008B).

postulated SAMDAs are mitigative and reduce accident consequences but do not reduce accident frequencies. If the screening procedure were to result in a SAMDA with a positive net value, the calculation would be refined with consideration to the SAMDA's actual risk-reduction potential.

A SAMDA can therefore lead to averted costs by (1) reducing the frequency of an accident, (2) reducing the consequences of an accident, or (3) reducing both the frequency and consequences of an accident.

ABWR DESIGN CERTIFICATION SAMDA ANALYSIS

Q11. Has a SAMDA analysis been conducted on the ABWR design?

A11. [RLE, JPR] Yes, GE Nuclear Energy (GE) conducted a SAMDA analysis as part of its application for design certification under 10 CFR Part 52; the analysis is documented in the *Technical Support Document for the ABWR* (GE 1994 TSD).[5]

Q12. Describe the baseline PRA used in GE's SAMDA analysis.

A12. [RLE, JPR] In the TSD, GE identified the PRA presented in Chapter 19 of the ABWR standard safety analysis report (SSAR) as the baseline PRA for conducting the SAMDA analysis.[6] The baseline PRA identifies the accident sequences, frequencies, and associated consequences from events leading to core damage for the ABWR design. Consequences include offsite population exposure (in person-rem) within 50 miles of a site. The values were calculated using the CRAC2 code (the predecessor to the MELCOR Accident Consequence Code System, or MACCS2) for five representative U.S. sites and then averaged to represent a typical site. Table 1 summarizes the baseline PRA used in GE's SAMDA analysis. Review of Table 1 indicates that the comparatively higher-frequency sequences (NCL and 1) result in

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[5] NEPA/SAMDA Submittal for the ABWR from J.F. Quirk to R.W. Borchardt, attach. 1 (Dec. 21, 1994) (Exs. NRC00009A and NRC00009B).

[6] GE 1994 TSD, attach. A, Section A.2, at 34 (Ex. NRC00009B).

lower population exposure whereas the lower-frequency sequences (6 through 9) result in higher population exposure. The resulting population exposure risk (i.e., the frequency multiplied by the population exposure) is dominated by five accident sequences (NCL, 1, 7, 8, and 9).

Table 1: ABWR Baseline PRA from Accident Sequences Leading to Core Damage.

Accident Sequence[a]	Accident Description[b]	Frequency[a] (per year)	Population Exposure[a] (person-rem)	Population Exposure Risk[c] (person-rem/year)	Cumulative Population Exposure Risk[a] (person-rem/60 years)
NCL	Normal containment leakage to reactor building	1.3E-07	9.60E+03	1.25E-03	0.075
1	Core melt arrested in vessel or in containment with actuation of containment rupture disk	2.1E-08	1.38E+04	2.90E-04	0.017
2	Low pressure core melt with suppression pool bypass and actuation of containment rupture disk	7.8E-11	8.33E+03	6.50E-07	0.00004
3	High pressure core melt with drywell head failure and fire water spray initiation[d]	0.0E+00	3.71E+05	0	0
4	Suppression pool decontamination reduction[d]	0.0E+00	2.06E+05	0	0
5	Large break LOCA without recovery and with actuation of containment rupture disk	7.5E-12	9.34E+04	7.01E-07	0.00004
6	High pressure core melt with drywell head failure and no firewater spray initiation	3.1E-12	2.42E+06	7.50E-06	0.0004
7	Low pressure core melt with drywell head failure and no mitigation	3.9E-10	2.73E+06	1.06E-03	0.064
8	High pressure core melt with early containment failure	4.1E-10	3.20E+06	1.31E-03	0.079
9	ATWS event with drywell head failure	1.7E-10	3.31E+06	5.63E-04	0.034

(a) From GE 1994 TSD, Table 1, at 18 (Ex. NRC00009A).

(b) From GE 1994 TSD, attach. A, Section A.2 (Ex. NRC00009B).

(c) Calculated by multiplying accident frequency (column 3) by population exposure (column 4).

(d) Frequency and risk is listed as 0 in GE 1994 TSD, Table 1, at 18 (Ex. NRC00009A) for this accident sequence. The Staff interprets this to mean that the accident sequence frequency is very small (i.e., less than the lowest frequency listed, 3.1E-12) such that the risks are negligible compared to other accident sequences listed in Table 1.

Table 2 summarizes the total accident frequency and population exposure risk by summing up the individual values for each accident sequence in Table 1. The total population exposure risk is 4.5E-03 person-rem per year, resulting in a total cumulative exposure risk of 0.269 person-rem assuming 60 years of plant operation.

Table 2: Total Accident Frequency and Population Exposure Risk from the ABWR Baseline PRA for Events Leading to Core Damage.

Frequency[(a)] (per year)	**Total Population Exposure[(b)] Risk (person-rem/year)**	**Total Cumulative Population Exposure Risk[(c)] (person-rem/60 years)**
1.6E-07	4.5E-03	0.269

(a) From GE 1994 TSD, Section 3.1, at 12 (Ex. NRC00009A).

(b) Calculated by summing the population exposure risk (Table 1, column 5) for all accident sequences.

(c) From GE 1994 TSD, Table 1, at 18 (Ex. NRC00009A).

Q13. Describe how GE performed the SAMDA analysis.

A13. [RLE, JPR] GE identified 68 potential SAMDAs and then refined the list by removing SAMDAs that were either (1) already part of the ABWR design, (2) not applicable to the ABWR design, or (3) part of another design alternative.[7] The final list (see Table 3, below) contained 21 candidate SAMDAs.[8]

GE then estimated the minimum cost of implementing each SAMDA. In developing the cost estimates, GE used order-of-magnitude costs intentionally biased on the low side, which would favor making the SAMDA cost-beneficial.[9] The costs, referenced in 1991 U.S. dollars, represent the incremental cost that would be incurred at a new plant rather than costs that

[7] GE 1994 TSD, Section 4.3, at 15 (Ex. NRC00009A).

[8] GE 1994 TSD, Table 3, at 22-24 (Ex. NRC00009A).

[9] GE 1994 TSD, Section 4.4, at 15, and attach. A, Section A.1.3.2, at 33 (Exs. NRC00009A and NRC00009B).

would occur for a backfit analysis. Column 2 in Table 3 summarizes GE's SAMDA implementation costs.[10]

GE then estimated the reduction in accident probability (i.e., reduction in core damage frequency, CDF) as a result of implementing each SAMDA; the percent reduction in CDF is listed in column 5 of Table 3 for each SAMDA. It is clear that many of the SAMDAs listed in Table 3—including the lowest cost SAMDAs (i.e., 3c, 7a, and 13a)—are mitigative and result in no reduction of CDF. It is the comparatively higher-cost SAMDA's (e.g., 2a, 9a, 9b) that are preventative and appreciably reduce accident frequency. With the reduction in CDF estimated, GE analyzed averted onsite costs (including onsite cleanup, property damage, and replacement power costs) and averted offsite public exposure associated with implementing each SAMDA. Averted offsite property damage was not considered in GE's SAMDA analysis.[11]

[10] GE 1994 TSD, attach. A, Section A.5 (Ex. NRC00009B).

[11] GE 1994 TSD, attach. A, Section A.1.2, at 32 (Ex. NRC00009B).

Table 3: Summary of GE ABWR Candidate SAMDA Modifications, Implementation Costs, Averted Onsite Costs, Averted Offsite Risks, and Cost/Benefit Ratio.

SAMDA Modification[(a)]	**Implementation Cost**[(b)] **($)**	**Averted Onsite Costs**[(c)] **($)**	**Averted Offsite Risk**[(a)] **(person-rem)**	**Reduction in CDF (%)**	**Cost/Benefit**[(a)] **($/person-rem)**
1a. Severe Accident EPGs/AMGs	$600,000	$0	1.5E-02	0.0%[(d)]	40,000,000
1b. Computer Aided Instrumentation	$600,000	$400	1.0E-02	3.0%[(e)]	59,960,000
1c. Improved Maintenance Procedures/Manuals	$300,000	$1,000	1.6E-02	9.0%[(e)]	18,687,500
2a. Passive High Pressure System	$1,750,000	$6,000	6.9E-02	52.0%[(f)]	25,275,362
2b. Improved Depressurization	$600,000	$1,400	4.2E-02	14.0%[(e)]	14,252,381
2c. Suppression Pool Jockey Pump	$120,000	$200	2.0E-03	2.0%[(e)]	59,900,000
2d. Safety Related Condensate Storage Tank	$1,000,000	$0	1.0E-02	0.0%[(d)]	100,000,000
3a. Larger Volume Containment	$8,000,000	$0	1.5E-01	0.0%[(d)]	53,333,333
3b. Increased Containment Pressure Capability	$12,000,000	$0	1.6E-01	0.0%[(d)]	75,000,000
3c. Improved Vacuum Breakers	$100,000	$0	4.0E-05	0.0%[(d)]	2,500,000,000
3d. Improved Bottom Head Penetration Design	$750,000	$0	5.7E-02	0.0%[(d)]	13,157,895
4a. Larger Volume Suppression Pool	$8,000,000	$0	2.0E-04	0.0%[(d)]	40,000,000,000
5a. Low Flow Filtered Vent	$3,000,000	$0	1.4E-02	0.0%[(d)]	214,285,714
7a. Drywell Head Flooding	$100,000	$0	6.0E-02	0.0%[(d)]	1,666,667
8a. Additional Service Water Pump	$6,000,000	$1,000	1.6E-02	9.0%[(f)]	374,937,500
9a. Steam Driven Turbine Generator	$6,000,000	$5,700	5.2E-02	50.0%[(f)]	115,275,000
9b. Alternate Pump Power Source	$1,200,000	$6,000	6.9E-02	52.0%[(f)]	17,304,348
10a. Dedicated DC Power Supply	$3,000,000	$0	6.9E-02	0.0%[(d)]	43,478,261
11a. ATWS Sized Vent	$300,000	$0	3.0E-02	0.0%[(d)]	10,000,000
13a. Reactor Building Sprays	$100,000	$0	1.7E-02	0.0%[(d)]	5,882,353

14a. Flooded Rubble Bed	$18,750,000	$0	1.0E-03	0.0%[(d)]	18,750,000,000

(a) From GE 1994 TSD, Table 6, at 29-30 (Ex. NRC00009A). (Cost/benefit (column 6) was calculated using the equation from Section 4.2, at 14, of the TSD; GE compared the cost/benefit ratio to a $1,000 person-rem averted standard to determine if a SAMDA was cost-beneficial to implement.)

(b) From GE 1994 TSD, attach. A, Section A.5 (Ex. NRC00009B). (GE's estimated minimum cost is in 1991 dollars.)

(c) From GE 1994 TSD, attach. A, Section A.5 (Ex. NRC00009B). (Averted onsite costs include economic loss of the facility, direct accident costs (including onsite cleanup), and replacement power costs; it does not include averted onsite exposure. GE assigned $0 averted onsite costs to SAMDAs that are primarily mitigative; these SAMDAs do not reduce accident probability and therefore do not contribute to averted onsite costs.)

(d) Reduction in CDF from GE 1994 TSD, Section A.4 (Ex. NRC00009B). (In some cases, GE did not explicitly list the reduction in CDF as 0 for some SAMDAs that have $0 averted onsite cost. However, in Section A.1.3.1, at 33, of the TSD, GE did note that it only estimated averted onsite costs for SAMDAs that reduce CDF. Therefore, where GE stated a SAMDA had $0 averted onsite cost, but did not explicitly provide a reduction in CDF, the Staff assumed a value of 0.)

(e) Reduction in CDF from GE 1994 TSD, Section A.4 (Ex. NRC00009B).

(f) Reduction in CDF was not explicitly provided by GE in Section A.4 of the TSD; the value was estimated by the Staff for the purposes of this testimony. From NUREG/BR-0184 (Section 5.7.6, at 5.41) (Ex. NRC00008B), averted onsite costs (V_{op}) can be calculated by estimating the reduction in accident frequency (ΔCDF) and the onsite property damage (U) that includes cleanup, replacement power, and repair/refurbishment costs ($V_{op} = \Delta CDF * U$).

Rearranging this equation as $U = V_{op}/\Delta CDF$, the NRC Staff calculated the value of U for SAMDAs listed in Table 3 where both an averted onsite costs (V_{op}) and a reduction in CDF (ΔCDF) were provided in the TSD (i.e., SAMDAs with footnote "e" in Table 3). For example, for SAMDA 2b, the V_{op} of $1,400 divided by the ΔCDF of 14% results in a value of $10,000 for U ($1,400/0.14=$10,000). The calculated values for U ranged from $10,000 for SAMDAs 2b and 2c to $13,333 for SAMDA 1b, with an average value of about $11,500. NUREG/BR-0184 does not provide guidance on how the value of U may vary from accident to accident, but for large-scale core melt accidents, the NRC Staff assumed the value of U would be relatively constant for a given reactor design. By taking a SAMDA's averted onsite cost (column 3) and dividing it by $11,500, the Staff was able to estimate the reduction in CDF for SAMDAs with a non-zero value of averted onsite cost (for example, for SAMDA 2a, averted onsite cost of $6,000 ($V_{op}$) divided by $11,500 (U) results in a ΔCDF of 52%).

GE estimated averted onsite costs for SAMDAs that reduce accident frequency; mitigative SAMDAs were not credited with averting onsite costs because they do not reduce accident frequency.[12] Onsite costs included replacement power at $0.013/kW-h differential cost, cleanup at $2 billion, and economic loss of the facility at $1 billion.[13] Column 3 in Table 3 lists the averted onsite costs for each SAMDA.

GE evaluated averted offsite public exposure by considering each SAMDA's effectiveness in reducing exposure (in person-rem) to a population within 50 miles of a typical site using the same methods described to estimate population exposure in the baseline PRA. The benefit of a particular SAMDA was defined to be its reduction in population exposure.[14] Column 4 in Table 3 summarizes the averted offsite population exposure risk calculated by GE for each candidate SAMDA assuming 60 years of operation.[15]

With the SAMDA components calculated, GE proceeded to evaluate the costs and benefits of each of the 21 candidate modifications. GE performed the evaluation by calculating a cost/benefit ratio:[16]

$$\text{Cost/benefit ratio} = \frac{\text{SAMDA Implementation Cost (\$)} - \text{SAMDA Averted Onsite Cost (\$)}}{\text{SAMDA Averted Offsite Exposure (person-rem/plant life)}}$$

From the above definition of the cost-benefit ratio, the averted onsite cost (Table 3, column 3) for each SAMDA is subtracted from its implementation cost (Table 3, column 2), thereby making the SAMDA appear more cost-effective.

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[12] GE 1994 TSD, Section A.1.3.2, at 33 (Ex. NRC00009B).

[13] GE 1994 TSD, Section A.1.3.2, at 33 (Ex. NRC00009B).

[14] GE 1994 TSD, Section A.1.2, at 31 (Ex. NRC00009B).

[15] GE 1994 TSD, Table 6, at 29-30 (Ex. NRC00009A).

[16] GE 1994 TSD, at 14 (Ex. NRC00009A).

Column 5 in Table 3 summarizes the cost/benefit ratio for each SAMDA. GE compared the cost-benefit ratio to a $1,000 per person-rem averted standard for offsite exposure to determine if the SAMDA was cost-beneficial; SAMDAs with a cost-benefit ratio less than or equal to the $1,000 person-rem standard would be considered cost-beneficial to implement.

Q14. What were the results of GE's SAMDA analysis?

A14. [RLE, JPR] GE compared the cost-benefit ratio for each SAMDA (Table 3, column 5) with the $1,000 per person-rem standard for averted offsite exposure and determined that none of the 21 SAMDAs were cost effective to implement.[17] From GE's analysis, SAMDA 7a (Drywell Head Flooding), is the closest to being cost-beneficial. However, its cost-benefit ratio is approximately 1,667 times larger than the $1,000 per person-rem standard for averted offsite exposure. Furthermore, with regards to replacement power cost considerations, this SAMDA is purely mitigative and results in no reduction in CDF and therefore no reduction in averted onsite costs. As Table 3 shows, many of the SAMDAs, including the lowest-cost SAMDAs (i.e., 3c, 7a, and 13a), are mitigative and result in no averted onsite costs. SAMDA 2b (Improved Depressurization), with a cost-benefit ratio that is approximately 14,252 times larger than the $1,000 person-rem standard, is the SAMDA closest to being cost-beneficial that would have an impact on averted onsite costs, albeit small.

GE concluded that because the total cumulative offsite exposure risk from the baseline PRA (0.269 person-rem/60-years) was already small, the maximum justifiable cost for a SAMDA would need to be less than $269.[18] GE concluded that no SAMDAs are cost-beneficial given the low residual risk of the ABWR design.[19] Table 4 summarizes the maximum averted costs from GE's SAMDA analysis.

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[17] GE 1994 TSD, attach. A, Table A-7, at 62 (Ex. NRC00009B).

[18] GE 1994 TSD, Section 4.6, at 16 (Ex. NRC00009A).

[19] GE 1994 TSD, Section 5.0, at 16 (Ex. NRC00009A).

Table 4: Summary of Maximum Averted Costs from GE's SAMDA Analysis.

	GE 1994 TSD Maximum Averted Costs ($)
Maximum Averted Offsite Costs[(a)]:	$269
Maximum Averted Onsite Costs[(b)]:	$6,000
Total Maximum Averted Costs:	$6,269

(a) Assumes a maximum averted 0.269 person-rem exposure over a non-discounted, 60-year period with a $1,000 per person-rem conversion factor; offsite property damage is not considered.

(b) Averted onsite costs include replacement power, site cleanup, and economic loss of the facility; it does not include monetized averted onsite exposure. The largest averted onsite cost is $6,000 (from SAMDAs 2a and 9b, Table 3).

Q15. Does GE's SAMDA analysis consider replacement power costs?

A15. [RLE, JPR] Yes, as noted earlier, GE estimated replacement power costs for SAMDAs which reduce core damage frequency.[20] Replacement power costs were combined with economic loss of the facility and onsite cleanup costs; the combined value is GE's estimate of averted onsite cost and is reported Table 3, column 3, for each SAMDA.[21] Many of the SAMDAs listed in Table 3—including the lowest-cost SAMDAs—have no averted onsite cost (i.e., the averted onsite cost is $0). GE considered these SAMDAs to be mitigative. Mitigative SAMDAs reduce accident consequences, for example, by reducing the accident source-terms. Mitigative SAMDAs do not reduce core damage frequency (i.e., accident probability, Table 3 column 5) and therefore are not beneficial at averting onsite costs, including replacement power costs.

Q16. Is GE's SAMDA analysis consistent with current guidance related to SAMDA analysis?

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[20] GE 1994 TSD, attach. A, Section A.1.3.2, at 33 (Ex. NRC00009B).

[21] GE 1994 TSD, attach. A, Section A.5.7.1, at 50 (Ex. NRC00009B).

A16. [RLE, JPR] GE's analysis is generally consistent with current guidance related to SAMDA analysis; the guidance related to cost-benefit considerations is documented primarily in NUREG/BR-0184 and NUREG/BR-0058, Revision 4, *"Analysis Guidelines of the U.S. Nuclear Regulatory Commission"* (Exhibit NRC000010). However, since these documents were published after GE's SAMDA analysis, there are some notable differences:

- GE presents the results of its SAMDA analysis in the form of a cost/benefit ratio, whereas NUREG/BR-0184 calculates a net value.[22] The cost/benefit ratio is similar to net value and differs only in functional form. To perform the net value calculation, a standard conversion factor (in $/person-rem) is needed to monetize the averted offsite exposure benefit (person-rem) into dollars ($). The individual cost components are then summed and the resulting sign of the net value indicates whether a SAMDA might be cost-beneficial (positive = cost-beneficial, negative = not cost-beneficial). Using GE's method, the cost/benefit ratio for each SAMDA is instead compared to the standard conversion factor for offsite exposure to determine if the SAMDA is cost-beneficial; SAMDAs with a cost-benefit ratio less than or equal to the conversion factor would be considered cost-beneficial.
- GE compared the results of its cost-benefit ratio to a $1,000 per person-rem standard for averted offsite exposure benefit, whereas NUREG/BR-0184[23] and NUREG/BR-0058[24] recommend $2,000 per person-rem. At the time GE published the TSD, a $1,000 per person-rem averted offsite exposure was considered standard; precedents for its use had been established in NUREG/CR-

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[22] NUREG/BR-0184, Sections 4.3, 4.4, and 5 (Exs. NRC00008A and NRC00008B).

[23] NUREG/BR-0184, Section 5.7.1.2, at 5.26 (Ex. NRC00008B).

[24] NUREG/BR-0058, Revision 4, Section 4.3.5, at 31 (Ex. NRC000010).

3568, "*Handbook for Value Impact Analysis*."[25] In 1995, NUREG/BR-0058 Revision 2[26] (and its subsequent revisions), recommended the use of a $2,000 per person-rem conversion standard. The $2,000 per person-rem value is considered in NRC's Environmental Assessment (EA) relating to the certification of the ABWR design (NRC 1996 EA)[27] as well as the Applicant's site-specific SAMDA analysis documented in its ER.[28]

- GE did not consider offsite property damage in its SAMDA analysis.[29] However, offsite property damage is considered in the NRC 1996 EA[30] as well as the Applicant's site-specific SAMDA analysis documented in its ER.[31]
- GE did not consider averted onsite exposure in its SAMDA analysis. However, averted onsite exposure is considered in the Applicant's site-specific SAMDA analysis documented in its ER.[32]
- GE used an 8% discount rate to present value when calculating averted onsite costs[33] and conservatively did not discount monetized offsite exposure costs.[34]

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[25] NUREG/CR-3568, Section 3.2.2, at 3.15 (Ex. NRC000011).

[26] NUREG/BR-0058, Rev. 2, Section 4.3.3, at 22 (Ex. NRC000012).

[27] "Final Environmental Assessment by the Office of Nuclear Reactor Regulation, NRC, Relating to the Certification of the US Advanced Boiling Water Reactor Design, Docket No. 52-001," Section 3.5.5, at 13 (Ex. NRC000013). The NRC 1996 EA is attachment 2 to SECY-96-077, Certification of Two Evolutionary Designs (Apr. 15, 1996).

[28] STP 2010 ER, Rev. 4, Section 7.3.3, at 7.3-3 (Ex. NRC000014).

[29] GE 1994 TSD, Section A.1.2, at 32 (Ex. NRC00009B).

[30] NRC 1996 EA, Section 3.5.5, at 13 (Ex. NRC000013).

[31] STP 2010 ER, Rev. 4, Section 7.3.3, at 7.3-3 (Ex. NRC000014).

[32] STP 2010 ER, Rev. 4, Table 7.3-1, at 7.3-3 (Ex. NRC000014).

[33] GE 1994 TSD, Section A.1.3.2, at 33 (Ex. NRC00009B).

[34] GE 1994 TSD Section A.1.3.3, at 33 (Ex. NRC00009B).

Discounting is used to compare amounts of money that would be expended at different times. NUREG/BR-0184[35] and NUREG/BR-0058[36] recommend the use of a 7% real discount rate and, for sensitivity analysis, a 3% discount rate. Both discount rates are considered in the NRC 1996 EA[37] as well as the Applicant's site-specific SAMDA analysis documented in its ER.[38]

Q17. Was the GE analysis reviewed by the NRC Staff?

A17. [RLE, JPR] Yes, the NRC Staff evaluated GE's SAMDA analysis as part of the design certification for the U.S. ABWR design under Subpart B to 10 CFR Part 52. The NRC Staff's review is documented in the NRC 1996 EA and resolves environmental issues concerning SAMDAs on a generic basis for the ABWR design.[39] 10 CFR Part 52, Appendix A, Section VI.B.7 resolves environmental issues concerning SAMDA for any application that references the U.S. ABWR design whose site parameters are within those specified in the TSD.

Q18. Describe the NRC Staff's review of the GE SAMDA analysis.

A18. [RLE, JPR] In the NRC 1996 EA, the NRC applied bounding assumptions to GE's SAMDA analysis to determine if the resulting conclusion—there are no cost-beneficial SAMDAs for the U.S. ABWR design—was acceptable.

The NRC reviewed the 21 candidate SAMDAs identified by GE and found the set to be a reasonable range of design alternatives. The NRC noted that although the SAMDA list was not all inclusive, the benefits of any additional SAMDAs would unlikely exceed the benefits of the

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[35] NUREG/BR-0184, Section B.2.1, at B.2 (Ex. NRC00008B).

[36] NUREG/BR-0058, Rev. 4, Section 4.3.5, at 32 (Ex. NRC000010).

[37] NRC 1996 EA, Section 3.5.5, at 13 (Ex. NRC000013).

[38] STP 2010 ER, Rev. 4, Section 7.3.3, at 7.3-3 (Ex. NRC000014).

[39] NRC 1996 EA (Ex. NRC000013).

modifications that GE considered and any alternative improvements would not likely cost less than the least expensive SAMDAs already identified.[40]

With regards to SAMDA costs, which included averted onsite costs, the NRC noted some inconsistencies in GE's cost estimates. For example, some of the lower-cost SAMDAs were considerably less than what NRC Staff expected (making them appear more cost-beneficial), whereas some of the higher-cost SAMDAs were higher than expected (making them appear less cost-beneficial). For the higher-cost SAMDAs, NRC noted that even if the cost estimates were reduced by a factor of ten, the resulting SAMDA analysis would not result in any cost-beneficial design alternatives. Therefore, given the uncertainties in developing precise implementation costs, NRC found GE's SAMDA cost estimates to be reasonable.[41]

With regards to averted offsite costs, the NRC did not analyze each SAMDA's potential for risk reduction, as was done in GE's TSD. Instead, the NRC Staff applied a bounding assumption—each SAMDA could individually eliminate all the risk from severe accidents. This conservative assumption over-estimates each SAMDA's benefit, since no one design change can address all possible accident sequences.[42] For each SAMDA, the NRC assumed a maximum averted exposure benefit of 1 person-rem over a 60-year plant life; this screening value is nearly four times higher than the total offsite exposure (0.269 person-rem) calculated by GE in the baseline PRA (see Table 2). Using GE's least expensive SAMDA of $100,000 (see Table 3, column 2), the resulting cost-benefit ratio was calculated to be $100,000 per person-rem; this value is 100 times more than the $1,000 per person-rem standard used by GE for determining if a SAMDA is cost-beneficial.

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[40] NRC 1996 EA, Section 3.4, at 8 (Ex. NRC000013).

[41] NRC 1996 EA, Section 3.5.3, at 10-11 (Ex. NRC000013).

[42] NRC 1996 EA, Section 3.5, at 9 (Ex. NRC000013).

Table 5 summarizes the maximum averted costs included in the NRC's base review of GE's TSD. For completeness, the $6,000 maximum averted onsite cost associated with SAMDAs 2a and 9b from GE's TSD (Table 3) is included; the NRC did not make adjustments to GE's averted onsite costs.

Table 5: Summary of Maximum Averted Costs from the NRC's EA SAMDA Review.

	NRC EA Maximum Averted Costs ($)
Maximum Averted Offsite Costs[(a)]**:**	$1,000
Maximum Averted Onsite Costs[(b)]**:**	$6,000
Total Maximum Averted Costs:	$7,000

(a) Averted public exposure assumes a bounding assumption of 1 person-rem, over a non-discounted, 60-year period with a $1,000 per person-rem conversion factor. Offsite property damage is not considered in the ABWR EA base review.

(b) For completeness, combined averted onsite cost from SAMDAs 2a and 9b (Table 3) of GE's TSD is included; the NRC did not make adjustments to GE's averted onsite costs.

Q19. Did the NRC consider current SAMDA guidance when conducting its review of the TSD for the ABWR design certification?

A19. [RLE, JPR] Yes, the NRC's review included further consideration of more recently available guidance, including the use of alternative cost-benefit criteria presented in NUREG/BR-0058, Revision 2, "*Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission"* and NUREG/CR-6349, "*Cost-Benefit Considerations in Regulatory Analysis"* (Exhibit NRC000015). Specifically, the NRC considered a $2,000 per person-rem standard conversion factor[43] for offsite dose exposure and an additional $3,000 per person-rem supplement to account for offsite property damage.[44] The NRC applied different discount rates, including a 7% real discount rate and a 3% sensitivity discount rate.[45]

Q20. What were the results of the NRC Staff review with regards to these additional considerations?

A20. [RLE, JPR] Even with further consideration of the cost-benefit criteria in NUREG/BR-0058 and NUREG/CR-6349, the NRC Staff concluded based on significant margins

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[43] NRC 1996 EA, Section 3.5.5, at 13 (Ex. NRC000013) (per NUREG/BR-0058, Revision 2, Section 4.3.3, at 22 (Ex. NRC000012)).

[44] NRC 1996 EA, Section 3.5.5, at 13 (Ex. NRC000013) (per NUREG/CR-6349, Section 4.1.5, at 4-8 (Ex. NRC000015)).

[45] NRC 1996 EA, Section 3.5.5, at 13 (Ex. NRC000013) (per NUREG/CR-6349, Section 3.2.1, at 3-2 (Ex. NRC000015)).

in the analysis, that no SAMDAs were cost-beneficial for the ABWR design.[46] Although the maximum averted costs were higher, the NRC Staff noted that the actual risk reduction from the lower-cost SAMDAs (e.g., 7a Drywell Head Flooder in Table 3) was considerably less than the maximum risk reduction assumed in the screening analysis.[47] Therefore, the NRC Staff agreed with GE's conclusion that none of the SAMDAs considered were justified based on cost-benefit considerations.[48]

APPLICANT'S SAMDA ANALYSIS IN ER SECTIONS 7.3 AND 7.5S

Q21. Has the Applicant conducted a SAMDA analysis for an ABWR design at the STP site?

A21. [RLE, JPR] Yes, the Applicant updated GE's generic SAMDA analysis to include site-specific characteristics to verify that the conclusion— there are no cost-beneficial SAMDAs for the ABWR design—remained valid for the STP site. The Applicant's SAMDA analysis is documented in Sections 7.3 and 7.5S of its ER.

Q22. Describe the Applicant's analysis.

A22. [RLE, JPR] The Applicant updated the risk estimates in GE's baseline PRA (Tables 1 and 2) to include STP site-specific land-use, population, and meteorological data. The Applicant used the MELCOR Accident Consequence Code System (MACCS2) code to estimate the mean accident consequences, including offsite population exposure and property damage, within a 50-mile radius of the STP site for each accident sequence listed in Table 1. The total site risk is determined by multiplying the accident consequence by its frequency and summing the results. Table 7 lists the total offsite population exposure risk and property damage cost risk for the STP site. The total population dose risk for the STP site (4.3E-03

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[46] NRC 1996 EA, Section 3.5.5, at 13 (Ex. NRC000013).

[47] NRC 1996 EA, Section 3.5.5, at 13 (Ex. NRC000013).

[48] NRC 1996 EA, Section 3.6, at 14 (Ex. NRC000013).

person-rem/year,[49] Table 7) is less than the risk (4.5E-03 person-rem/year, Table 2) calculated by GE for a generic site. A similar comparison of offsite property damage risk cannot be made because GE did not consider offsite property damage risk in its analysis.[50]

Table 7: Total Frequency, Population Exposure Risk, and Property Damage Risks from ABWR Severe Accidents at the STP Site for Events Leading to Core Damage.

Frequency (per year)[(a)]	**Population Exposure Risk (person-rem/year) [(b)]**	**Property Damage Risk ($/year)[(b)]**
1.6E-07	4.3E-03	2.6

(a) From GE 1994 TSD, Section 3.1, Pg 12 (Ex. NRC00009A).

(b) From Table 7.2-3 of STP ER, Revision 4 (Ex. NRC000016).

The Applicant used the cost-benefit methodology in NUREG/BR-0184 to calculate averted offsite and onsite costs. Similar to the screening methodology used by the NRC in the EA, the Applicant assumed that each SAMDA could individually eliminate all the risk.[51] This conservative assumption over-estimates each SAMDA's benefit, since no one design change can address all possible accident sequences. Table 8 provides a summary of the averted costs calculated by the Applicant for one ABWR using a $2,000 per person-rem monetization factor for population exposure, a licensing period of 40 years, and discount rates of 7% and 3%.

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[49] STP 2010 ER, Rev. 4, Table 7.2-3, at 7.2-10 (Ex. NRC000016). Note: the STP FEIS (NUREG-1937, Table 5-17, at 5-103 (Ex. NRC00003C)) lists the value as 4.24E-03; the difference is insignificant. Footnote 4 to Paragraph 13 of the "Affidavit of Richard L. Emch, Jr. and James V. Ramsdell, Jr. Concerning Finality of SAMDA Conclusions in ABWR Design Certification as Applied to STP Units 3 and 4," Staff Attachment 2 to the "NRC Staff Motion for Summary Disposition" (July 22, 2010) indicates: "Note that the ER value of 4.3×10^{-3} person-rem/yr is the highest value of estimates for 1997, 1999, and 2000. The staff value is an average for the 3 years."

[50] GE 1994 TSD, attach. A, Section A.1.2, at 32 (Ex. NRC00009B).

[51] STP 2010 ER, Rev. 4, Section 7.3.3, at 7.3-3 (Ex. NRC000014).

Table 8. Summary of Maximum Averted Costs for a Single ABWR Unit at the STP site.

	7% Discount Rate[(a)] ($)	3% Discount Rate[(a)] ($)
Maximum Averted Offsite Costs:		
Public Exposure	$66	$158
Property Damage	$20	$48
Maximum Averted Onsite Costs:		
Occupational Exposure	$68	$140
Cleanup/Decontamination	$2,300	$4,700
Replacement Power	$4,400	$7,400
Total Maximum Averted Costs:	$6,900	$12,500

(a) From Table 7.3-1 on page 7.3-5/6 of STP ER, Revision 4 (Ex. NRC000014). Present value (2007 dollars) assuming maximum averted offsite risk (Table 7), with a $2,000 per person-rem monetization factor for population exposure, and a licensing period of 40 years.

Q23. What was the conclusion of the Applicant's analysis relative to cost-beneficial SAMDAs at the STP site?

A23. [RLE, JPR] The Applicant compared the site-specific total maximum averted costs in Table 8 with the SAMDA implementation costs from GE's analysis (Table 3, column 2) and concluded that, based on GE's estimated minimum SAMDA implementation costs, there are no cost-effective design alternatives.[52] In reality, the lowest-cost SAMDAs in Table 3 only address a small fraction of the maximum averted risk assumed in the Applicant's analysis. Furthermore, as noted earlier, the lowest-cost SAMDAs in Table 3 are primarily mitigative and would result in little-to-no averted onsite cost if implemented.

Q24. Did the Applicant consider in its SAMDA analysis the effects on other units at the STP site from a severe accident at one of the proposed ABWR units (STP Units 3 or 4)?

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[52] STP 2010 ER, Rev. 4, Section 7.3.3, at 7.3-3 (Ex. NRC000014).

A24. [RLE, JPR] Yes, in Section 7.5S.5 of the ER, the Applicant included additional averted onsite costs, including replacement power costs, resulting from the temporary shutdown and decontamination of the other units at the STP site from a severe accident at one of the proposed units.[53] The Applicant's motion for summary disposition included an affidavit that made further adjustments to replacement power cost to address specific contentions raised by the Intervenors.[54]

Q25. What was the effect of the factors considered in ER Section 7.5S.5 on the Applicant's conclusions relative to cost-beneficial SAMDAS at the STP site?

A25. [RLE, JPR] In Section 7.5S.5 of the ER, the Applicant further modified the benefit of each SAMDA by increasing the averted onsite costs to include occupational exposure, cleanup, and replacement power costs of the other units. In total, the Applicant considered averted onsite costs from four units—two units that are existing (STP Units 1 and 2) and the two units that are proposed (STP Units 3 and 4). The severe accident was assumed to occur at one of the proposed units (STP Units 3 or 4).

For replacement power costs, the Applicant assumed that cleanup and refurbishment for STP Units 1 and 2 would take two years, and the other ABWR unit that did not experience a severe accident would take six years to restart based on past experience at Three Mile Island Unit 1 (TMI-1) after the accident at TMI-2.[55] The Applicant relied on guidance in NUREG/BR-0184 to develop averted cost estimates. Short-term replacement power costs were estimated

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[53] STP 2010 ER, Rev. 4, Section 7.5S.5 (Ex. NRC000017).

[54] Joint Affidavit of Jeffrey L. Zimmerly and Adrian Pieniazek, ¶¶ 31 through 74 (Sept. 14, 2010) (hereafter "Applicant 2010 Affidavit").

[55] STP 2010 ER, Rev. 4, Section 7.5S.5, at 7.5S-6 (Ex. NRC000017).

using a $310,000 per day (1993 dollars) cost estimate for a reference 910 MWe reactor;[56] the cost was scaled to the appropriate power level for each STP reactor.

The averted onsite costs estimates for the other units were added to the single-unit ABWR costs listed in Table 8; the results are listed in Table 9 for both a 7% and 3% discount rate. Averted offsite costs are the same, in either case, since only one ABWR unit is assumed to have an accident. Baseline risk used to calculate maximum averted costs in Table 9 is defined by the STP site-specific estimates in Table 7.

The Applicant compared the site-specific total maximum averted costs in Table 9 with the SAMDA implementation costs from GE's analysis (column 2, Table 3) and concluded that, based on GE's estimated minimum SAMDA implementation costs, there are no cost-effective design alternatives—even with the additional consideration of averted onsite costs for multiple units.[57]

As Table 9 indicates, replacement power costs are the single-largest contributor to maximum averted costs. The estimates are based on 1993 estimates of replacement power costs from NUREG/BR-0184.[58]

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[56] STP 2010 ER, Rev. 4, Section 7.5S.5, at 7.5S-7 (Ex. NRC000017) (see also NUREG/BR-0184, Section 5.7.7.1, at 5.51 (Ex. NRC00008B)).

[57] STP 2010 ER, Rev. 4, Section 7.5S.5, at 7.5S-7 (Ex. NRC000017).

[58] NUREG/BR-0184, Section 5.7.7.1, at 5.51 (Ex. NRC00008B).

Table 9. Summary of Maximum Averted Costs Considering Multiple Units at the STP Site.

	7% Discount Rate ($)	3% Discount Rate ($)
Maximum Averted Offsite Costs[(a)]:		
Public Exposure	$66	$158
Property Damage	$20	$48
Maximum Averted Onsite Costs[(b)]:		
Occupational Exposure	$418	$730
Cleanup/Decontamination	$5,117	$9,816
Replacement Power[(c)]	$7,756	$12,263
Total Maximum Averted Cost:	$13,377	$23,015

(a) From Table 7.3-1 on page 7.3-5/6 of STP ER, Revision 4 (Ex. NRC000014).

(b) Maximum averted onsite costs assume a severe accident at an ABWR unit (STP Units 3 or 4) impacting operations at the other ABWR unit as well as STP Units 1 and 2. Values are from Tables 7.3-1 (Ex. NRC000014) and 7.5S-2 (Ex. NRC000017 at 7.5S-9/10) of STP ER, Revision 4. Costs are determined by adding like costs listed in Table 7.3-1 with like costs in Table 7.5S-2.

(c) Replacement power costs in 1993 dollars.[59]

Q26. Did the Applicant later update its SAMDA analysis in ER Sections 7.3 and 7.5S to account for inflation?

A26. [RLE, JPR] In support of its summary disposition motion, the Applicant updated the analysis to 2009 dollars by escalating the costs by a factor of 1.45, based on the Bureau of Labor Statistics producer price index-commodities.[60] Table 10 presents the maximum averted cost estimates for the STP site with the replacement power costs updated to 2009 dollars.

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[59] Applicant 2010 Affidavit, Table 1, at 10 (or ¶ 23).

[60] Applicant 2010 Affidavit, at 11 (or ¶ 28).

Table 10. Summary of Maximum Averted Costs Considering Multiple Units at the STP Site with 2009 Replacement Power Costs.

	7% Discount Rate ($)	**3% Discount Rate ($)**
Maximum Averted Offsite Costs[(a)]:		
Public Exposure	$66	$158
Property Damage	$20	$48
Maximum Averted Onsite Costs[(b)]:		
Occupational Exposure	$418	$730
Cleanup/Decontamination	$5,117	$9,816
Replacement Power[(c)]	$11,323	$17,903
Total Maximum Averted Cost:	$16,944	$28,655

(a) From Table 7.3-1 on page 7.3-5/6 of STP ER, Revision 4 (Ex. NRC000014).

(b) Maximum averted onsite costs assume a severe accident at an ABWR unit (STP Units 3 or 4) impacting operations at the other ABWR unit as well as STP Units 1 and 2. Values are from Tables 7.3-1 (Ex. NRC000014) and 7.5S-2 (Ex. NRC000017 at 7.5S-9/10) of STP ER, Revision 4. Costs are determined by adding like costs listed in Table 7.3-1 with like costs in Table 7.5S-2.

(c) Replacement power costs are escalated by a factor of 1.45 based on the Bureau of Labor Statistics producer price index-commodities.[61]

Q27. Is the Applicant's analysis consistent with current NRC SAMDA analysis guidance?

A27. [RLE, JPR] Yes, the Applicant's base SAMDA analysis documented in Section 7.3 of the ER follows the methods described in NUREG/BR-0184 for estimating averted onsite and offsite costs and the resulting net value. To calculate averted costs, the Applicant applied a bounding assumption—each SAMDA can individually eliminate all probability of a severe accident—consistent with NRC Staff's screening analysis in the ABWR EA review. This conservative assumption over-estimates each SAMDA's benefit, since no one design change can address all possible accident sequences and reduce total accident frequency to zero. Therefore, the averted cost risk used in the Applicant's SAMDA analysis is the maximum

[61] Applicant 2010 Affidavit at ¶¶ 28-30.

averted cost risk, not an actual averted cost risk that might be achieved by implementing a given SAMDA.

NRC STAFF'S SAMDA ANALYSIS IN THE STP EIS

Q28. How did the Staff perform its SAMDA review in the STP EIS?

A28. [RLE, JPR] In the EIS,[62] the Staff limited its review to a determination of whether or not the Applicant's site characteristics were within the site parameters specified in GE's TSD. The TSD does not contain a specific list of site parameters. However, the population dose risk is given as 4.5E-03 person-rem per year for a generic site (see Table 2). The population dose risk is based on site characteristics, including meteorological conditions and population distribution, and the Staff considered it the appropriate site parameter for purposes of comparison.

Q29. What were the results of the Staff review?

A29. [RLE, JPR] The Staff independently reviewed and confirmed the STP site-specific dose risk presented in the Applicant's ER and listed in Table 7. The Staff concluded that the STP site-specific dose risk was bounded by the 4.5E-03 person-rem per year value (see Table 2) considered in the GE 1994 TSD for the ABWR design certification. The Staff concluded[63] that environmental issues related to SAMDAs were therefore resolved by rule.

Q30. Why is the Staff offering testimony on the Applicant's SAMDA analysis and Contention CL-2?

A30. [RLE, JPR, DMA] The Staff is expanding its analysis to address the issues raised by the Intervenors in Contention CL-2 regarding the STP site-specific SAMDA analysis.

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[62] NRC FEIS 2011 (NUREG-1937), Section 5.11.3, at 5-111 to 5-113 (Ex. NRC00003C).

[63] NRC FEIS 2011 (NUREG-1937), Section 5.11.3, at 5-113 (Ex. NRC00003C).

NRC STAFF'S SAMDA ANALYSIS TO ADDRESS CONTENTION CL-2

Q31. Has the NRC Staff conducted its own SAMDA analysis to address the issues raised by Contention CL-2?

A31. [RLE, JPR] Yes.

Q32. What is the basis for the NRC SAMDA analysis?

A32. [RLE, JPR] The NRC reviewed the Applicant's SAMDA analysis in the ER, and used it as the basis for the Staff's review of issues related to Contention CL-2. The NRC confirmed the Applicant's site-specific risk estimates (Table 7) and reviewed the averted cost calculations with consideration of regulatory guidance (i.e., NUREG/BR-0148). In some instances, the Staff differed with estimated averted costs in the Applicant's site-specific SAMDA analysis.

Q33. How does the NRC SAMDA analysis differ from that of the Applicant?

A33. [DMA] The Staff's SAMDA analysis differs from the Applicant's in three areas. However, the bottom line conclusions do not change and are in agreement with the Applicant's findings. The three areas include the inflation scaling of SAMDA implementation costs, the inflation scaling of short-term replacement power costs, and the capacity (availability) factor assumption applied to nuclear units. Each of these points will be discussed in more detail in the answers to the next seven questions.

One difference stems from the treatment of inflation and the associated scaling of dollar values from 1991 or 1993 to 2009. There are essentially two levels of analysis that might be valid depending on the application. A cursory level of analysis would suggest that roughly accounting for inflation between the early 1990's and present day would be sufficient. Under this approach, applying a readily available and widely used inflation index such as the Consumer Price Index might be sufficient to create an inflation scaling factor. This approach is valid for making rough comparisons of general price trends observed over time – especially for costs faced by consumers or households.

Because this Contention deals directly with the plausibility of potentially cost-beneficial SAMDAs, the Staff employed a more detailed consideration of inflation in the analysis. To the degree that one would expect inflation rates to vary by type of cost, it is useful to consider alternative inflation indices that are more narrowly targeted to the specific type of expenditure being considered in the analysis.

Q34. Describe the factors the NRC Staff uses to adjust SAMDA implementation costs.

A34. [DMA] The Staff believes that the Bureau of Economic Analysis' Gross Domestic Product Implicit Price Deflator for Nonresidential Structures (BEA 2010| National Income and Product Accounts Table 1.1.9|) is a more appropriate index to use to adjust the cost of SAMDAs for inflation because SAMDAs relate to structural alternatives in plant design and the GDP deflators are more specific to private capital investment than other inflation indexes such as the Consumer Price Index or the Producer Price Index. Although some SAMDAs are not purely structural in nature, such as training programs or software, the Staff believes that such SAMDAs also would be treated as part of the expected costs covered by the full capital investment in the project. Based on these considerations, the Staff would scale the 1991 dollar values associated with SAMDAs reported in NUREG/BR-0184 by a factor of 2.25 to arrive at costs expressed in 2009 dollars. The factor is determined by dividing the target year index value by the source year index value. For the Implicit Price Deflator for Gross Private Domestic Investment in Nonresidential Structures[64] the calculation is 122.187/54.287, which equals 2.25. Therefore, the cost of the lowest cost SAMDA would be adjusted for inflation from $100,000 in 1991 dollars by multiplying by the factor above to arrive at a cost of $225,000 in 2009 dollars.

Q35. Describe the inflation factors the NRC Staff uses to adjust replacement power costs.

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[64] Bureau of Economic Analysis - National Economic Accounts National Income and Product Accounts Table; Table 1.1.9. Implicit Price Deflators for Gross Domestic Product, Line 10. (The relevant columns are 1991 and 2009) (retrieved Apr. 21, 2011) (Ex. NRC000018).

A35. [DMA] The Staff believes that the Bureau of Labor Statistics' Producer Price Index for the commodity of "Electric Power" (BLS 2011| Producer Price Index-Commodities: Series Id: WPU054|) is the appropriate index to use to adjust the cost of short-term replacement power for inflation because in the short term power would be purchased on the market to replace the lost resources at STP. The Producer Price Index is intended to reflect the inflation in prices faced by producers at the wholesale level. The need for short-term replacement power would imply that power producers such as the Applicant would need to acquire electric power on the wholesale market just like any other commodity. Based on these considerations, the Staff would scale the 1993 dollar values associated with short-term replacement power costs reported in NUREG/BR-0184 by a factor of 1.40 to arrive at costs expressed in 2009 dollars, as explained below.

Q36. Why do the NRC Staff's adjustments for inflation differ from the factor used by the Applicant?

A36. [DMA] The Applicant reports using the BLS Consumer Price Index to scale 1991 dollar values associated with SAMDAs by a factor of 1.58 to arrive at costs expressed in 2009 dollars.[65] The Applicant reports using the BLS Producer Price Index to scale the 1993 dollar values associated with short-term replacement power costs adapted from NUREG/BR-0184 by a factor of 1.46 to arrive at costs expressed in 2009 dollars.[66] The Staff's inflation adjustment factors do not agree with the Applicant's factors. This is apparent in the case of SAMDA costs because different inflation indices were used. As for the inflation adjustment made for replacement power costs, the Staff cannot reconcile the Applicant's application of the Producer Price Index to arrive at a factor of 1.46 for the 1993:2009 adjustment. By the Staff's accounting, that factor should be 1.40, which is slightly different. The factor is determined by dividing the

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[65] Applicant 2010 Affidavit at ¶ 30.

[66] Applicant 2010 Affidavit at ¶ 29.

target year index value by the source year index value. For the Producer Price Index for the Electric Power commodity the calculation is 180.0/128.6,[67] which equals 1.40.

Q37. Would using the NRC Staff's adjustments for inflation instead of the Applicant's make it more or less likely that a SAMDA would be considered cost-beneficial? Why?

A37. [DMA] The Staff's inflation adjustments have two effects. First, the cost of the least costly SAMDA would be $225,000 instead of $158,000 as estimated by the Applicant. The effect would be that it would be less likely that there would be a SAMDA that would be considered cost-beneficial. The adjustment to replacement power costs leads to an increase in the cost of replacement power, which has the effect of reducing the gap between maximum averted cost and the least cost-beneficial SAMDA, making it more likely that there would be a SAMDA that would be considered cost-beneficial. In this sense, the two effects somewhat offset. However, the Staff's use of the 1.40 factor, compared to the Applicant's use of the 1.46 factor, would have the effect of reducing this gap by slightly less than if the 1.46 factor were used.

Q38. Do the Applicant's estimates of the replacement power costs include an adjustment for capacity factor?

A38. [DMA] The Applicant's estimates of the replacement power costs in Table 10 reflect the suggested average capacity factor of 60%-65% referenced from NUREG/BR-0184. The Applicant does not adjust this value in its analysis.

Q39. Why do the NRC Staff estimates of replacement power costs include a capacity factor adjustment?

A39. [DMA] The Staff adjusts the suggested average capacity factor referenced from NUREG/BR-0184 to account for more recent experience reported by the Energy Information Administration which suggests that STP Units 1 and 2 operated at a combined capacity factor of

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[67] Bureau of Labor Statistics' Producer Price Index for the commodity of "Electric Power" (BLS 2011| Producer Price Index-Commodities: Series Id: WPU054| 2009/1993) (retrieved Mar. 23, 2011) (Ex. NRC000019).

at least 90 percent in 2010.[68] This adjustment is necessary to reflect the true need for replacement capacity availability based on current operations. Relying on the suggested 60%-65% range reported in NUREG/BR-0184 would understate the amount of capacity needed to replace power from STP, given current operating capacities.

Q40. What effect would an adjustment for capacity factor have on the Applicant's values for replacement power costs?

A40. [DMA] The adjustment is applied as a simple multiplier derived by dividing 90% by 60% to get a value of 1.5. In cost terms, failing to make this adjustment understates the cost of replacement power reported in Table 11 by approximately $5,429 at a 7 percent discount rate to $8,584 at a 3 percent discount rate.

Q41. Has the NRC Staff considered the factors raised by the Intervenors regarding inflation scaling?

A41. [DMA] Yes.

Q42. The Intervenors would use a refined Core Index of Personal Consumption Expenditures to adjust SAMDA costs. Is this reasonable, and if not, why not?

A42. [DMA] The Staff believes that using an inflation index based on personal consumption expenditures is not a valid approach to scaling the costs of SAMDAs. While such indices contain rich product detail, ultimately they reflect retail inflation faced by persons and households,[69] not inflation associated with large-scale capital expenditures like those of nuclear power plant construction. SAMDAs are design modifications to a nuclear power station and would not include items typically purchased by persons or households. As such, the Staff believes that the proper inflation index to use for scaling SAMDA costs should be one that is reflective of private capital investment. The Staff identified the Bureau of Economic Analysis' Gross Domestic Product Implicit Price Deflator for Nonresidential Structures as the appropriate

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[68] US EIA – Texas Nuclear Profile, at 2 (Sept. 2010) (Ex. NRC000020).

[69] Bureau of Economic Analysis, NIPA Handbook: Chapter 5: Personal Consumption Expenditures, at page 5-2. (retrieved May 4, 2011) (Ex. NRC000021)

index. This index is designed to reflect inflation associated with costs of large buildings and other structures and all related systems.[70]

Q43. How would Table 10, above, which describes the results of the Applicant's SAMDA analysis, change if the Staff's adjustments for inflation scaling and capacity factor were incorporated?

A43. [DMA] Table 11 provides results of the Staff's analysis, based on addressing the differences noted. This table also provides the basis for comparison of the Intervenors' claims in further answers below.

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[70] Bureau of Economic Analysis, NIPA Handbook: Chapter 6: Private Fixed Investment, at 6-3, Table 6.1 (retrieved May 2, 2011) (Ex. NRC000022).

Table 11. Summary of Maximum Averted Costs Considering Multiple Units at the STP Site with 2009 Replacement Power Costs, Capacity Factor Adjustment, and Proper Inflation Scaling.

	7% Discount Rate ($)	3% Discount Rate ($)
Maximum Averted Offsite Costs[a]:		
Public Exposure	$66	$158
Property Damage	$20	$48
Maximum Averted Onsite Costs[b]:		
Occupational Exposure	$418	$730
Cleanup/Decontamination	$5,117	$9,816
Replacement Power[c]	$16,288	$25,752
Total Maximum Averted Cost:	$21,909	$36,504

(a) From Table 7.3-1 on page 7.3-5/6 of STP ER, Revision 4 (Ex. NRC000014).

(b) Maximum averted onsite costs assume a severe accident at an ABWR unit (STP Units 3 or 4) impacting operations at the other ABWR unit as well as STP Units 1 and 2. Values are from Tables 7.3-1 (Ex. NRC000014) and 7.5S-2 (Ex. NRC000017 on page 7.5S-9/10) of STP ER, Revision 4. Costs are determined by adding like costs listed in Table 7.3-1 with like costs in Table 7.5S-2.

(c) Based on guidance from NUREG/BR-0184. Replacement power costs are escalated by a factor of 1.40 based on the Bureau of Labor Statistics producer price index-commodities[71] and do not reflect ERCOT pricing.

ISSUES RAISED BY THE INTERVENORS IN CONTENTION CL-2

Q44. Did the Applicant adjust its SAMDA analysis to address the issues raised by the Intervenors in Contention CL-2 regarding the calculation of replacement power costs?

A44. [DMA] In support of its summary disposition motion, the Applicant also examined a number of other factors related to replacement power costs to determine if these factors would cause any SAMDAs to potentially be cost-beneficial. Additional factors considered included:

[71] Bureau of Labor Statistics' Producer Price Index for the commodity of "Electric Power" (BLS 2011| Producer Price Index-Commodities: Series Id: WPU054| 2009/1993) (Ex. NRC000019).

- Increasing replacement power costs by an additional factor of 1.68 to account for the difference between the replacement power costs in Table 10 and replacement power costs based on 2009 Electric Reliability Council of Texas (ERCOT) pricing data,[72]

- Alternately, increasing replacement power costs by a factor of 4.0 to reflect the highest, historical ERCOT pricing data, which occurred in 2008,[73]

- Considering potential market effects and related consumer impacts from the loss of power from the STP site,[74]

- Considering the potential for price spikes from the loss of power from the STP site,[75] and

- Considering the possibility of a grid outage.[76]

The Applicant concluded that none of these factors considered, alone or in combination, would be sufficient to cause the least expensive SAMDAs in Table 3 to be considered potentially cost-beneficial.

I. Using Replacement Power Costs Specific To The ERCOT Region

Q45. You said that the Applicant incorporated ERCOT pricing data into its SAMDA analysis. Would this use of ERCOT pricing data be in lieu of the use of the replacement power costs values in NUREG/BR-0184?

A45. [DMA] Yes.

Q46. You said that the Applicant incorporated 2009 ERCOT pricing data into its analysis. Can you explain further how the Applicant did this?

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[72] Applicant 2010 Affidavit at ¶ 33.

[73] Applicant 2010 Affidavit at ¶ 38.

[74] Applicant 2010 Affidavit at ¶ 43.

[75] Applicant 2010 Affidavit at ¶ 60.

[76] Applicant 2010 Affidavit at ¶ 66.

A46. [DMA] The Applicant scaled the replacement power costs ($/MWh) adapted from NUREG/BR-0184 to 2009 dollars, then determined the difference between that value and the equivalent cost of power based on 2009 ERCOT pricing data.[77] The Applicant determined that the scaled replacement power costs adapted from NUREG/BR-0184 are $20.72 per MWh, and the 2009 ERCOT average balancing price for the Houston Zone was $34.76 per MWh. Dividing $34.76 by $20.72 yields a factor of 1.68, by which the Applicant multiplied the risk-weighted cost of replacement power to scale from NUREG/BR-0184 values to ERCOT values.

Q47. What was the Applicant's basis for using 2009 ERCOT prices as opposed to ERCOT prices for some other year?

A47. [DMA] The Applicant justified the use of 2009 ERCOT prices as being the most recent available, and suggested that as long as SAMDA costs and replacement power costs are from the same year, the use of current or historical pricing data "removes much of the speculation from the SAMDA evaluation."[78]

Q48. Do you agree with the Applicant's reasoning?

A48. [DMA] The Applicant's approach is reasonable to a point. However, the Staff believes that while it is reasonable to use the most recent cost data available, it is also reasonable to use the most representative cost data available, as well. Those two may not necessarily agree with each other.

Q49. What would the value for replacement power costs in Table 11 be if 2009 ERCOT prices were incorporated into the analysis? What would be the value for maximum averted costs?

A49. [DMA] The values in Table 11 reflect the Staff's scaling to account for a modern nuclear power capacity factor. As a result, the price increased to $29.81 per MWh, based on the NUREG/BR-0184 guidance. Thus, if the 2009 ERCOT Houston Zone average balancing

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[77] Applicant 2010 Affidavit at ¶ 33.

[78] Applicant 2010 Affidavit at ¶ 34.

price[79] of $34.76 were used, instead of the 29.81 per MWh price, the cost of replacement power in Table 11 would be multiplied by a factor of 1.17 ($34.76/$29.81) – increasing replacement power costs $2,706 at a 7 percent discount rate to $4,279 at a 3 percent discount rate. The revised maximum averted cost would be $24,615 at a 7 percent discount rate to $40,783 at a 3 percent discount rate.

Q50. You said that the Applicant performed an alternate calculation using 2008 ERCOT pricing data. Can you explain further how the Applicant did this?

A50. [DMA] Recalling Answer 46, the Applicant estimated the 2009 price to be $20.72 per MWh, based on application of the NUREG/BR-0184 guidance. The Applicant scaled its price used in the 2009 analysis ($20.72 per MWh) based on the Houston Zone average balancing price for 2008 ($82.95 per MWh). Dividing $82.95 by $20.72 yields a factor of 4.00.[80] It then multiplied replacement power costs calculated using the NUREG/BR-0184 guidance by 4.00 to scale to 2008 ERCOT prices for the Houston Zone.

Q51. Did the Applicant state whether 2008 or 2009 values should be used? What was the Applicant's basis for its claim?

A51. [DMA] The Applicant argues that 2008 prices are anomalous in the context of annual average prices since deregulation began in 2002 in Texas.[81] The Applicant indicates that 2009 prices are more recent[82] and that conclusions of the SAMDA analysis are not affected by using either 2008 or 2009 prices.[83]

Q52. Do you agree with the Applicant's reasoning?

A52. [DMA] Yes.

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[79] Potomac Economics, Ltd., 2009 State of the Market Report for the ERCOT Wholesale Electricity Markets, at 1, Footnote 9 (July 2010) (Ex. NRC000023).

[80] Applicant 2010 Affidavit at ¶ 38.

[81] Applicant 2010 Affidavit at ¶ 37.

[82] Applicant 2010 Affidavit at ¶ 32.

[83] Applicant 2010 Affidavit at ¶ 38.

Q53. What would the value for replacement power costs in Table 11 be if 2008 ERCOT prices were incorporated into the analysis instead of 2009 ERCOT prices? What would be the value for maximum averted costs?

A53. [DMA] The values in Table 11 reflect the Staff's scaling to account for generating capacity and for modern nuclear power capacity factor (e.g. dispatch availability factor). As a result, the price increased to $29.81 per MWh. Thus, if the 2008 Houston Zone average balancing energy price of $85.02[84] were used, the cost of replacement power in Table 11 would be multiplied by a factor of 2.85 ($85.02/$29.81) – increasing replacement power costs by $30,171 at a 7 percent discount rate to $47,704 at a 3 percent discount rate. The revised maximum averted cost would be $52,080 at a 7 percent discount rate to $84,208 at a 3 percent discount rate. Because these values are less than the $225,000 lowest-cost SAMDA, the Staff concludes there is no cost-beneficial SAMDA.

Q54. The Intervenors claim that replacement power costs should be based on forecasted ERCOT prices, not 2009 ERCOT prices, which they claim are unrepresentative. Are these claims reasonable, and if not, why not?

A54. [DMA] Replacement power costs should be based on the costs of acquiring wholesale power in the region affected by the loss of the STP units. In this case that is the ERCOT region. The Staff believes it would not be reasonable to base the analysis on cost data acknowledged to be anomalous in the context of all available data. While it might provide a conservative basis for analysis to use data reflecting anomalously high or low wholesale prices, the Staff believes that for the SAMDA analysis, the Applicant should provide the most representative data available and support that selection of data with reasoning indicating why it should be viewed as the most representative data.

The Staff believes that the relative position of nuclear power in the ERCOT dispatching order would not change whether the analysis is based on recent-to-current average prices for a

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[84] The $82.95 value the Applicant used must be scaled to a 2009 equivalent value using the BLS Producer Price Index for Electric Power (Ex. NRC000019) (the factor is 1.025 (2009/2008 or 180.0/175.6=1.025)). As a result the 2008 price is $85.02 per MWh in 2009 dollars.

plant coming online today, or based on forecast prices for a plant coming online in 2020, for example. The Staff believes that forecast prices could be used for this analysis, but that would require the forecasting of SAMDA costs to a matching future year. The Applicant also noted, and the Staff agrees, that this approach could introduce unneeded speculation.[85] The Staff would not expect any effect on the conclusions of the analysis.

The Intervenors claim that by relying on ERCOT's 2009 average balancing energy prices, the resulting cost of replacement power has been biased on the low side. This claim is based on the fact that 2009 ERCOT prices were substantially lower than 2008 prices and previous year prices. They also claim that regional market price effects have been ignored by relying on the NUREG/BR-0184 guidance. Ultimately, in response to the Applicant's joint affidavit describing the use of 2008 ERCOT prices, the Intervenors agree that the approach used by the Applicant to rely on ERCOT 2008 prices was "not unreasonable"[86] as that approach reflects a period of elevated natural gas prices.

Q55. Would the use of ERCOT prices be consistent with NRC guidance?

A55. [DMA] Use of the ERCOT data would not be inconsistent with NRC guidance, but is not explicitly suggested. The Staff believes that use of ERCOT data provides a case for a reasonable sensitivity analysis to determine the effect of alternative average price scenarios on replacement power costs. Ultimately, however, extremely high and purely speculative average prices would be required before replacement power costs would rise to a level sufficient to impact the conclusions of the SAMDA analysis.

Q56. What should be the bases for estimating replacement power costs?

A56. [DMA] Replacement power costs should be based on the costs of acquiring wholesale power in the region affected by the loss of the STP units. NUREG/BR-0184 terms

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[85] Applicant 2010 Affidavit at ¶ 34.

[86] 2010 Johnson Affidavit at ¶ 9.

these "short-term" replacement power costs, which would reflect the costs of acquiring wholesale power to replace power taken offline by an event at a nuclear power plant that would cause other units at the same site to come offline, similar to the Three Mile Island accident. This acquired electric power would not require a long-term commitment to build new generation resources, as the unaffected units would be expected to eventually return to service.

Q57. Has the NRC Staff used these bases for estimating replacement power costs in its analysis?

A57. [DMA] Yes.

II. <u>Market Effects And Related Consumer Impacts</u>

Q58. How did the Applicant incorporate market effects into its SAMDA analysis in its summary disposition motion?

A58. [DMA] The Applicant developed a simplified spreadsheet model of economic dispatch in the ERCOT region. The model is fully described and documented in the Applicant's Affidavit.[87] The Applicant identified the cost characteristics of the alternative types of electricity generation resources available in the ERCOT region. Economic dispatch means the Applicant has identified the market entry costs of specific technologies based on public data sources. Thus, if the wholesale price remains below the market entry price, the technologies with costs above the hourly wholesale price cannot be dispatched economically. As demand increases by the hour of the day, the wholesale price increases to attract the marginal resource into the market to satisfy the increasing demand.

Q59. Is including market effects in estimating replacement power consistent with NRC guidance?

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[87] Applicant 2010 Affidavit at ¶¶ 47-53. Accompanying this description of the analysis, the Applicant also provided two spreadsheets (Applicant Document STP_173.xls, "Unit Dispatch – Removing All STP Units" (Sept. 14, 2010) (PDF printout of spreadsheet-excerpts) (Ex. NRC000024) and Applicant Document STP_175.xls, "Unit Dispatch Base Case" (Sept. 14, 2010) (PDF printout of spreadsheet-excerpts) (Ex. NRC000025)). These spreadsheets contain the simplified dispatch model referred to in the Staff's testimony. The Staff adapted these spreadsheets for its analysis by modifying values on the "Unit Costs&Availability" tab (page 2 of the exhibits) and observing the resulting impact on the ERCOT average balancing energy price at the bottom of the hourly model output in the "Load and Dispatch" tab (page 6 of the exhibits).

A59. [DMA] NUREG/BR-0184 guidance was written at a time when the utility industry was much more regulated. The effects caused by having merchant generators in a market area are not reflected in that guidance. Thus current guidance does not call for consideration of market effects specifically in replacement cost estimation. The Staff believes that conducting sensitivity analyses to address potentially influential factors would be a reasonable expectation for any SAMDA analysis.

Q60. The Intervenors claim that the Applicant has not properly incorporated market effects in its estimate of replacement power costs. What are the market effects that the Intervenors claim have not been properly incorporated?

A60. [DMA] The Intervenors claim that some assumptions of the Applicant's dispatch model are questionable.[88] Specifically, they question the assumed capacity factor for wind generation of 24.5 percent as being somewhat high, and recommend that a value closer to 9 percent would be more realistic. They claim the model's treatment of ancillary service pricing to be overly simplistic, but provide no further explanation. They also question the assumption of perfect competition reflected by setting hourly prices equal to marginal prices, as this assumption ignores the implications of market power being wielded strategically.

Q61. Is the Intervenors' claim reasonable, and if not why not?

A61. [DMA] The Intervenors' argument is based on questioning model assumptions that ultimately have little effect on replacement power costs. However, the Staff does not find the questions regarding these assumptions unreasonable. Realism of the simplified dispatch model would be improved by adjusting the wind capacity factor downward as the Intervenors suggest. In testing this, the Staff found that reducing the entire fleet of wind resources to a 9 percent capacity factor (a 63.3% reduction) resulted in a 2.0 percent change in average annual

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[88] 2010 Johnson Affidavit at ¶ 10.

balancing prices estimated by the simplified dispatch model. The effects of this adjustment are fully discussed in Answer 63 below.

Ancillary services are used to protect the electric system from unforeseen events such as unplanned generator outages, load forecast error, and wind forecast error, by maintaining reserve capacity that is responsive to such changes in the load.[89] Their impact on average balancing energy prices is illustrated in the figure on page 3 of the "2009 State of the Market" report.[90] These prices are embodied in the hourly marginal prices provided in the Applicant's simplified dispatch model. Even significant changes in these prices would have only a negligible effect on overall average prices.

Assumptions regarding exercising of market power cannot be handled reliably in a simplified spreadsheet model of economic dispatch using publically available data. However, the Staff believes that the ERCOT pricing data already reflect the effects of market power being wielded, as it reasonably can be assumed that this behavior is understood to occur in a deregulated market such as ERCOT.

Q62. Did the Staff review the Applicant's approach to incorporating ERCOT market effects into the analysis? What are the results of this review?

A62. [DMA] The Staff reviewed the dispatch model provided by the Applicant. The Staff was able to scale average marginal prices such that the results described by the Applicant could be replicated. The model permits the user to alter any underlying assumptions in order to examine any alternative dispatching and pricing outcomes desired.

The Staff did find that the Applicant's simplified dispatch model fails to account for 177 hours of the expected 8760 hours of load and cost data. As a result, over 2 percent of the

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[89] Potomac Economics, Ltd., 2009 State of the Market Report for the ERCOT Wholesale Electricity Markets, at 29 (Ex. NRC000023).

[90] Potomac Economics, Ltd., 2009 State of the Market Report for the ERCOT Wholesale Electricity Markets, at 3 (Ex. NRC000023).

expected hours in a year are missing. Electricity consumption could be understated by about that much as a result. Further, the average marginal cost is probably overstated by some small amount as the missing hours have not been factored into that average. Note that the majority of the missing hours are from the 11pm hour, and thus the Staff would expect that marginal costs in that hour would pull the overall average marginal cost down only fractionally from what the Applicant reported. The Staff did not attempt to populate the missing hours with representative data, as it is not expected that doing so would noticeably alter any results or conclusions of the analysis.

For the sake of completeness and consistency, the Staff made one additional initial minor adjustment to the Applicant's model to reflect the average capacity factor for nuclear power that the Staff used to adjust the NUREG/BR-0184 analysis to account for modern nuclear power operating experience as discussed in Answer 39. The simplified dispatch model used an average capacity factor of 88.5 percent, which the Staff modified to 90.0 percent consistent with recent operating experience at STP. This change had no meaningful effect on the average balancing energy price estimated by the model.

Q63. What would be the incremental impact of considering ERCOT market effects on replacement power costs in Table 11, in addition to using 2008 ERCOT prices? What would be the value for maximum averted costs?

A63. [DMA] Starting with the 2008 Houston Zone average balancing energy price of $85.02,[91] the Staff followed the method described[92] by the Applicant to run the dispatch model. The Staff scaled the market entry prices of each generation technology represented in the Applicant's model such that the resulting average balancing energy price would equate to the

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[91] See Answer 53 for a discussion of this average balancing energy price.

[92] Applicant 2010 Affidavit at ¶ 52.

2008 Houston Zone average balancing energy price of $85.02.[93] Then, the Staff removed all STP generating units from availability for dispatch in the model. The resulting average balancing energy price rose by $4.29 to $89.31 per MWh.[94] As a result, the cost of replacement power would be multiplied by a factor of 1.05 ($89.31/$85.02) – increasing replacement power costs by $2,344 at a 7 percent discount rate to $3,706 at a 3 percent discount rate. The revised maximum averted cost would be $54,424 at a 7 percent discount rate to $87,914 at a 3 percent discount rate. Because these values are less than the $225,000 lowest-cost SAMDA, the Staff concludes there is no cost-beneficial SAMDA.

Accounting for the Intervenors' suggested reduction in wind capacity factor as discussed in Answer 61 above has the following effect. Based on 2008 ERCOT prices and market effects discussed above, the annual average balancing price would rise by $1.78 to $91.09 per MWh.[95] The cost of replacement power would be further multiplied by a factor of 1.02 ($91.09/$89.31) – further increasing replacement power costs by $973 at a 7 percent discount rate to $1,538 at a 3 percent discount rate. The revised maximum averted cost would be $55,397 at a 7 percent

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[93] See Answer 53 for derivation of this value. See also Staff Document - NRC-Staff-modified STP_175.xls, "Unit Dispatch Base Case – Modified to Use 2008 ERCOT Prices and 90 Percent Capacity Factor for Nuclear" (May 9, 2011) (PDF printout of spreadsheet-excerpts) (Ex. NRC000026) The staff adapted this spreadsheet for its analysis by modifying values on the "Unit Costs&Availability" tab (page 2 of the exhibit) and observing the resulting impact on the ERCOT average balancing energy price at the bottom of the hourly model output in the "Load and Dispatch" tab (page 6 of the exhibit).

[94] See Staff Document - NRC-Staff-modified STP_173 – no wind adjustment.xls, "Unit Dispatch – Removing All STP Units – Modified to Use 2008 ERCOT Prices and 90 Percent Capacity Factor for Nuclear" (May 9, 2011) (PDF printout of spreadsheet-excerpts) (Ex. NRC000027) The staff adapted this spreadsheet for its analysis by modifying values on the "Unit Costs&Availability" tab (page 2 of the exhibit) and observing the resulting impact on the ERCOT average balancing energy price at the bottom of the hourly model output in the "Load and Dispatch" tab (page 6 of the exhibit).

[95] See Staff Document - NRC-Staff-modified STP_173 – with wind adjustment.xls, "Unit Dispatch – Removing All STP Units – Modified to Use 2008 ERCOT Prices, 90 Percent Capacity Factor for Nuclear, and 9 Percent Capacity Factor for Wind" (May 9, 2011) (PDF printout of spreadsheet-excerpts) (Ex. NRC000028) The staff adapted this spreadsheet for its analysis by modifying values on the "Unit Costs&Availability" tab (page 2 of the exhibit) and observing the resulting impact on the ERCOT average balancing energy price at the bottom of the hourly model output in the "Load and Dispatch" tab (page 6 of the exhibit).

discount rate to $89,452 at a 3 percent discount rate. Because these values are less than the $225,000 lowest-cost SAMDA, the Staff concludes there is no cost-beneficial SAMDA.

Q64. The Applicant also addressed the impact of market effects on consumers based on Intervenors' concerns.[96] What did the Staff estimate would be the incremental impact of considering the consumer impacts of ERCOT market effects on replacement power costs in Table 11, in addition to those addressed above? What would be the value for maximum averted costs?

A64. [DMA] The Applicant used an approach[97] to estimate the consumer impacts and the Staff adopted the Applicant's approach to this question. As covered in Answer 63, based on 2008 ERCOT prices, the annual average balancing price would rise by $4.29 to $89.31 per MWh to account for the loss of all units at the STP site. Adding the effect of reducing the wind capacity factor in the simplified dispatch model, the annual average balancing price would rise by $1.78 to $91.09 per MWh. The total impact is found by multiplying this total price increase ($6.07 per MWh) by the total annual consumption of electricity in ERCOT of 336,053,224 MWh, as provided by the simplified dispatch model.[98] This yields the total impact of this price increase of $2,039,843,070. Multiplying by the CDF (1.56×10^{-7} per year), the risk-weighted value becomes $318.22 per year. The Applicant accounted for a 40-year life and assumed the period of higher prices would last 6 years.[99] The Staff also used these values in its calculations. Based on these inputs, the total incremental effect on the cost of replacement power is $76,372 ($318.22 * 40 * 6). The revised maximum averted cost would be $131,768 at a 7 percent discount rate to $165,824 at a 3 percent discount rate. Because these values are less than the $225,000 lowest-cost SAMDA, the Staff concludes there is no cost-beneficial SAMDA.

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[96] Applicant 2010 Affidavit at ¶¶ 56-59.

[97] Applicant 2010 Affidavit at ¶¶ 57-58.

[98] Applicant Document STP_173.xls, "Unit Dispatch – Removing All STP Units" (Ex. NRC000024) (page 6 of exhibit).

[99] Applicant 2010 Affidavit at ¶ 57.

III. Price Spikes

Q65. In their contention, the Intervenors claimed that the Applicant's conclusions related to consumer impacts of price spikes are understated. How did the Applicant address price spikes in its summary disposition motion?

A65. [DMA] Price spike effects are embedded in the resulting average balancing energy prices that are an output from the Applicant's simplified dispatch model. In other words, based on the 2009 State of the Market report for ERCOT, price spikes have the effect of raising average balancing energy prices by 10-20 percent over the 2006-2009 period.[100] Therefore the impact on replacement power costs can be simulated in the Applicant's simplified dispatch model by simply scaling the marginal prices of the generation resources in ERCOT by an additional assumed percentage increase. As such, the effects of the spikes are not understated.

Q66. Is addressing price spikes consistent with NRC guidance related to replacement power cost estimates?

A66. [DMA] NUREG/BR-0184 guidance was written at a time when the utility industry was much more regulated. The effects caused by having merchant generators in a market area are not reflected in that guidance. Thus current guidance does not call for consideration of price spikes in replacement cost estimation.

Q67. Is the Applicant's method of addressing price spikes reasonable, and if so, why is it reasonable?

A67. [DMA] Yes. The Applicant's simplified model permits the user to alter marginal prices to fit any set of assumptions. The resulting impact on average balancing prices can be observed.

Q68. How do the Intervenors suggest that price spikes be addressed in estimating replacement power costs?

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[100] Potomac Economics, Ltd., 2009 State of the Market Report for the ERCOT Wholesale Electricity Markets, at 7, Figure 6 (Ex. NRC000023).

A68. [DMA] The Intervenors do not make a specific suggestion about how price spikes should be incorporated in to the SAMDA analysis. They do suggest, as does the Applicant, that price spikes had a 20 per cent upward effect on average balancing prices in 2008.

Q69. Given your responses to the previous questions, did the Applicant adequately account for the impacts of price spikes?

A69. [DMA] The Staff believes the Applicant adequately accounts for the impacts of price spikes on the cost of replacement power.

Q70. Has the NRC Staff considered the effects of price spikes in its estimation of replacement power costs?

A70. [DMA] Yes. The impact of price spikes is built into the simplified dispatch model provided by the Applicant.

Q71. How were these effects addressed in the NRC Staff replacement power cost estimates?

A71. [DMA] The Staff validated the Applicant's simplified economic dispatch model, where actual ERCOT hourly prices for 2009 can be observed. According to ERCOT, price spikes resulted in an 18 percent increase in average balancing prices in 2009.[101] These effects are built into the construction of the model using ERCOT 2009 hourly prices, as stated by the Applicant.[102] The Staff also examined the effect of an additional 20 percent impact on marginal prices, above the 20 percent already accounted for when populating the model with 2008 ERCOT marginal prices, similar to the Applicant's approach.[103]

Q72. What would be the incremental impact of considering the effects of ERCOT price spikes on replacement power costs in Table 11, in addition to consideration of ERCOT 2008 Average Balancing Energy Prices and market effects? What would be the value for maximum averted costs?

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[101] Potomac Economics, Ltd., 2009 State of the Market Report for the ERCOT Wholesale Electricity Markets, at 7, Figure 6 (Ex. NRC000023).

[102] Applicant 2010 Affidavit at ¶¶ 60-61.

[103] Applicant 2010 Affidavit at ¶ 64.

A72. [DMA] Starting with the 2008 Houston Zone average balancing price of $85.02,[104] adjusted for ERCOT market effects to $91.09[105] including reduced wind capacity factors, the Staff scaled marginal prices by an additional 20 percent in the simplified dispatch model with all 4 STP units removed from availability. The total impact is found by multiplying this total price increase ($18.22 per MWh) by the total annual consumption of electricity in ERCOT of 336,053,224 MWh, as provided by the simplified dispatch model.[106] This yields the total impact of this price increase of $ 6,122,469,674. Multiplying by the CDF (1.56×10^{-7} per year), the risk-weighted value becomes $955.11 per year. The total incremental effect on the cost of replacement power is $38,204. The revised maximum averted cost would be $169,973 at a 7 percent discount rate to $204,028 at a 3 percent discount rate. Because these values are less than the $225,000 lowest-cost SAMDA, the Staff concludes there is no cost-beneficial SAMDA.

IV. Grid Outages

Q73. In Contention CL-2, the Intervenors claimed that the Applicant's SAMDA analysis in its ER fails to account for the effects of a potential loss of the ERCOT grid triggered by shutdown of the STP units. What are the loss-of-grid impacts which the Intervenors suggest had not been accounted for?

A73. [DMA] The Intervenors claim that the loss of all four STP units simultaneously could increase the likelihood of controlled or uncontrolled outages on the ERCOT grid. They acknowledge a very low probability of such events, but suggest that the magnitude could be substantial, citing the California energy crisis of 2000-2001 and the Northeast United States blackout of 2003 as "extreme examples." [107]

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[104] See Answer 53 for discussion of this average balancing price.

[105] See Answer 64.

[106] Applicant Document STP_173.xls, "Unit Dispatch – Removing All STP Units" (Ex. NRC000024) (page 6 of exhibit).

[107] 2009 Johnson Report at 7.

Q74. Is addressing grid outages consistent with NRC guidance related to replacement power cost estimates?

A74. [DMA] No. No guidance is provided suggesting such events be considered in SAMDA analysis.

Q75. How did the Applicant account for these impacts in the analysis it provided in support of its summary disposition motion?

A75. [DMA] The Applicant provides a numerical assessment of the potential impact of the loss of the ERCOT grid triggered by the loss of all four units at the STP site.[108] The Applicant reasons that the probability of loss of the ERCOT grid is "far less than 0.1." Cumulating the probabilities of an accident at one of the STP units leading to shutdown of the other 3 units, followed by the loss of the ERCOT grid equates to "far less than 10^{-8} per year" chance of such an event.[109] In spite of the remote and speculative nature of such an event, the Applicant concluded that were such an event to happen, the total value of lost load would be approximately $3.42 Billion using the 24 hours of August 4, 2009 (a time of peak electricity usage). It then compared that amount to the $10 Billion in estimated damages attributed to the 2003 Northeast blackout. Adopting the larger of the two numbers for its SAMDA analysis, the Applicant concluded that a $10 Billion disruption caused by the ERCOT grid going down for 24 hours would amount to a $156 per year contribution to replacement power costs, when the cumulative probabilities are applied.[110]

Q76. Is the Applicant's method of addressing grid outages reasonable, and if so, why is it reasonable?

A76. [DMA] The Applicant's analysis of the impact of the loss of the ERCOT grid is not unreasonable. However, the Staff believes that the significant range in estimated costs

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[108] Applicant 2010 Affidavit at ¶¶ 71-73.

[109] Applicant 2010 Affidavit at ¶ 71.

[110] Applicant 2010 Affidavit at ¶ 73.

(assuming between 3 and 10 billion dollars) available to the Applicant illustrates the extremely speculative nature of such an event. Further, the Staff believes that events with such low probabilities of occurrence would be remote by any measure. The Applicant picked an acknowledged artificially high probability of occurrence in an attempt to be conservative. The Staff is not aware of a reliable estimate of the probability of loss of grid for any region.

The Staff also notes recent events in Texas where during a winter weather event of unseasonably cold temperatures (Feb 1-4, 2011), ERCOT declared a grid emergency and imposed rolling blackouts on the ERCOT grid.[111] Of note, this event did not result in the loss of the ERCOT grid for a 24-hour period, and it corresponded to a period where extremely cold weather occurred during a period of traditionally low demand. Many generators were offline for scheduled maintenance.

Regardless of this recent event and other more extreme events cited by the Intervenors, the Staff believes that attempting to factor such events into replacement power costs for the SAMDA analysis would require consideration of events that are remote and speculative and, by definition, would contribute only minor influence on the risk-weighted cost of replacement power, even under very conservative assumptions.

Q77. What would be the incremental impact of considering the effects of grid outages for replacement power costs in Table 11, in addition to consideration of ERCOT 2008 Average Balancing Energy Prices, market effects, and price spikes? What would be the value for maximum averted costs?

A77. [DMA] The Staff adopted the Applicant's approach[112] to illustrate the potential impact. The total impact is found by multiplying the reported $10 Billion impact from the 2003 Northeast blackout by an assumed 10 percent probability of occurrence, then multiplying by the CDF (1.56×10^{-7} per year). The risk-weighted value becomes $156 per year. The total

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[111] ERCOT Press Release, 2/2/2011 (Ex. NRC000029).

[112] Applicant 2010 Affidavit at ¶¶ 73-74.

incremental effect on the cost of replacement power is $6,240. The revised maximum averted cost would be $176,213 at a 7 percent discount rate to $210,268 at a 3 percent discount rate. Because these values are less than the $225,000 lowest-cost SAMDA, the Staff concludes there is no cost-beneficial SAMDA.

SUMMARY OF THE RESULTS

Q78. What is the result of the NRC Staff SAMDA analysis?

A78. [DMA, JPR, RLE] Based upon the above considerations, the NRC Staff updated the Applicant's averted onsite costs to account for all concerns raised by the Intervenors. The results of the Staff's SAMDA analysis review are presented in Table 12.

Table 12. NRC Staff Summary of Maximum Averted Costs Considering Multiple Units at the STP Site with Replacement Power Costs and All Intervenor Concerns (2009 dollars).

	7% Discount Rate ($)	**3% Discount Rate ($)**
Maximum Averted Offsite Costs[(a)]:		
Public Exposure	$66	$158
Property Damage	$20	$48
Maximum Averted Onsite Costs[(b)]:		
Occupational Exposure	$418	$730
Cleanup/Decontamination	$5,117	$9,816
Replacement Power	$170,592	$199,516
Total Maximum Averted Cost:	$176,213	$210,268

(a) From Table 7.3-1 on page 7.3-5/6 of STP ER, Revision 4 (Ex. NRC000014).

(b) Staff estimates based on Table 11 estimates with additional power considerations and adjusted scaling.

Q79. From the NRC Staff's review, has the Staff identified any SAMDAs that are cost-beneficial?

A79. [RLE, JPR, DMA] No. By the Staff's estimation, the least costly SAMDA ranges between 7-28 percent above the total maximum averted costs, depending on choice of discount rate. In other words, after consideration of all the Intervenors' concerns, the Staff concludes that the least costly cost-beneficial SAMDA still costs at least 1.07 (3 percent discount rate) to 1.28 (7 percent discount rate) times more than the total maximum averted cost.

Q80. Would you summarize the results of the NRC Staff's SAMDA review?

A80. [RLE, JPR, DMA] Table 13 summarizes maximum averted offsite and onsite cost estimates from the Applicant's and Staff's SAMDA screening analyses discussed in this testimony. Costs are reported for the 7% discount rate. The Applicant's and Staff's screening analyses are based on maximum averted costs using site characteristics for the STP site. For comparison, the lowest-cost SAMDA from GE's TSD (Table 3, column 2) is also included.

The last column in Table 13 provides the ratio of the lowest-cost SAMDA to the total maximum averted cost from the Applicant's and Staff's SAMDA screening analyses; a potential cost-beneficial SAMDA would have a ratio less than 1.0. It is clear that, even with the additional replacement power costs for the other units and consideration of various market factors contributing to price escalation, there are no potential cost-beneficial SAMDAs for the STP site.

Table 13. Comparison of Maximum Averted Costs with Minimum SAMDA Costs from SAMDA Screening Analyses Discussed in the Testimony.

SAMDA Analysis	Maximum Averted Offsite Costs ($)	Maximum Averted Onsite Costs ($)	Total Maximum Averted Costs ($)	Minimum SAMDA Cost[(a)] ($)	Minimum SAMDA Cost/Total Max Averted Cost
STP ER 7.3[(b)]	$86	$6,768	$6,854	$100,000	14.6
STP ER 7.5S[(c)]	$86	$13,291	$13,377	$100,000	7.5
Applicant 2010 Affidavit[(d)]	$86	$109,655	$109,741	$158,000	1.4
NRC Staff Review[(e)]	$86	$21,823	$21,909	$225,000	10.3
NRC Staff Review[(f)]	$86	$54,338	$54,424	$225,000	4.1
NRC Staff Review[(g)]	$86	$55,311	$55,397	$225,000	4.1
NRC Staff Review[(h)]	$86	$131,682	$131,768	$225,000	1.7
NRC Staff Review[(i)]	$86	$169,887	$169,973	$225,000	1.3
NRC Staff Review[(j)]	$86	$176,127	$176,213	$225,000	1.3

(a) From Table 3; the lowest-cost SAMDA (7a, $100,000 in 1991 dollars) is used as the minimum SAMDA cost in the screening analysis. In the Applicant Affidavit, the SAMDA cost is adjusted to 2009 dollars using a factor of 1.58.[113] The NRC Staff review uses an adjustment factor of 2.25 to escalate to 2009 dollars.

(b) From Table 8, 7% discount rate.

(c) From Table 9, 7% discount rate.

(d) From Applicant's Affidavit at Paragraph 74.

(e) From Table 11, 7% discount rate.

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113 Applicant 2010 Affidavit at ¶ 74.

(f) Consideration of 2008 ERCOT prices in Answer 53, 7% discount rate.

(g) Consideration of 2008 ERCOT prices and ERCOT market effects in Answer 63, 7% discount rate.

(h) Consideration of 2008 ERCOT prices, ERCOT market effects, and consumer impacts in Answer 64, 7% discount rate.

(i) Consideration of 2008 ERCOT prices, ERCOT market effects, consumer impacts, and ERCOT price spikes in Answer 72, 7% discount rate.

(j) Consideration of 2008 ERCOT prices, ERCOT market effects, consumer impacts, ERCOT price spikes, and loss of the ERCOT grid in Table 12, 7% discount rate.

Q81. The largest maximum averted cost value in Table 13 is $176,213 (last row in Table 13). Could you briefly summarize the extent to which this value is a conservative estimate of maximum averted costs?

A81. [RLE, JPR, DMA] The largest maximum averted cost ($176,213) includes several assumptions that were used to conservatively estimate the value, including:

- [RLE, JPR] The total accident risk is conservatively assumed to be reduced to zero by a single SAMDA; that is not possible.
- [RLE, JPR] Averted onsite costs include the costs for cleanup and replacement power costs for the three co-located units (existing STP Units 1 and 2 and 3 or 4).
    - Averted onsite cleanup costs for the unaffected units, which do not experience core damage, are conservatively assumed to be 30% of the costs for the affected unit, the unit that experiences core damage.[114]
    - Averted onsite replacement power costs conservatively assumes replacement power is required for two years at STP Units 1 and 2 and six years at STP Units 3 or 4, even though these units would likely not be damaged or significantly contaminated and would likely be ready, physically, to restart within a matter of months (most of the total CDF is for accident sequences where the containment remains intact).
- [DMA] Averted onsite replacement power costs include ERCOT market effects, consumer impacts, price spikes, and grid outage. Conservative inputs and assumptions affect the analysis in several ways. The dispatch model was calibrated to the highest historical prices for the traditionally highest-priced zone of ERCOT. These prices embed all price spikes in a given year; however, the further assumption of additional 20-percent price spikes was added to the

[114] STP 2010 ER, Section 7.5S.5, at 7.5S-6 (Ex. NRC000017).

historically high average prices. Finally, the additional impact of the potential loss of the ERCOT grid was assumed to have a 10 percent probability, in the absence of any authoritative estimate of such a probability.

Q82. If, on initial screening, a SAMDA appeared to be cost-beneficial, would the SAMDA analysis be refined?

A82. [RLE, JPR] Yes, the screening analysis conservatively assumes that the lowest-cost SAMDA can reduce the total accident CDF to zero. This bounding assumption overstates each SAMDA's risk-reduction potential. Therefore, the SAMDA analysis would be refined if the screening procedure resulted in a potential cost-beneficial SAMDA.

Q83. If a refined SAMDA analysis were to be performed, what refinements would be made?

A83. [RLE, JPR] If the screening analysis resulted in a potentially cost-beneficial SAMDA, the PRA would be examined to estimate the actual reduction in core damage frequency that could be realized by implementing the SAMDA. The SAMDA analysis documented in GE's TSD, and summarized in Tables 3 of this testimony, performs an individual SAMDA analysis by estimating the actual risk-reduction expected as a result of implementing each SAMDA. Because the refined analysis would consider the SAMDA's actual risk-reduction potential, the total averted cost would always be less than the total maximum averted cost assumed in the screening analysis. Additionally, estimated SAMDA costs would be refined to more accurately reflect actual costs. As previously noted, the minimum estimated SAMDA costs used in GE's TSD were conservatively biased towards making a SAMDA cost-beneficial.[115] The minimum cost estimate would be revised to account for expected SAMDA implementation costs and these costs would likely be higher and therefore make any SAMDA less cost-beneficial to implement.

Q84. Did the Staff attempt to refine the SAMDA analysis?

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[115] GE 1994 TSD, attach. A, Section A.1.3.2, at 33 (Ex. NRC00009B).

A84. [RLE, JPR] Yes, the screening analysis summarized in Table 13 conservatively assumes that the lowest-cost SAMDA (7a, Table 3) reduces the CDF by 100%, thereby resulting in the maximum averted costs listed in Table 13. In the TSD, GE analyzed the actual risk-reduction potential of each SAMDA; column 5 in Table 3 lists the reduction in CDF for each SAMDA. The lowest-cost SAMDAs, including 7a, 3c, and 13a, are mitigative and provide no reduction in CDF. Therefore, these SAMDAs result in $0 averted onsite costs (Table 3, column 3), not $176,127 as Table 13 suggests. Assuming these SAMDAs are capable of achieving the maximum averted offsite cost of $86, the ratio of the SAMDA's cost ($225,000) to its averted cost ($86) becomes 2616, not 1.3 as Table 13 suggests. In fact, this same conclusion applies to all SAMDAs in Table 3 that have no reduction in CDF.

Q85. Did the Staff attempt to further refine the SAMDA analysis for the SAMDAs that do reduce CDF?

A85. [RLE, JPR] Yes, the Staff further refined its analysis to consider all other SAMDAs listed in Table 3 that do reduce CDF and therefore avert onsite costs.

Q86. What were the results of the Staff's refined analysis?

A86. [RLE, JPR] As noted above, the averted costs listed in Table 13 conservatively assume that the lowest-cost SAMDA can address all possible accidents sequences and reduce the total accident frequency (i.e., the CDF) to zero. In reality, a SAMDA can only reduce a fraction of the total CDF. In the TSD, GE estimated the actual reduction in CDF that could be expected if each SAMDA were implemented; column 5 in Table 3 lists these values. Many of the SAMDAs listed in Table 3—including the lowest-cost SAMDAs (i.e., 3c, 7a, and 13a)—are mitigative and result in no reduction of CDF. It is the comparatively higher-cost SAMDA's (e.g., 2a, 9a, 9b) that are preventative and appreciably reduce accident frequency.

Several of the averted cost components that are calculated using the methodology in NUREG/BR-0184—including averted replacement power costs[116]—require a reduction in accident CDF in order for there to be any averted cost. As noted above, the Applicant's and Staff's screening analyses conservatively assume 100% reduction in CDF. Table 14 is a subset of the SAMDAs included in Table 3 and lists only those SAMDAs that reduce actual accident CDF; these are the only SAMDAs that are relevant to issues related to replacement power cost considerations in Contention CL-2 because they are the only SAMDAs that lead to a reduction in CDF and therefore averted power costs.

Of the eight remaining SAMDAs listed in Table 14, only four SAMDAs (2b, 9a, 9b, and 2a) appreciably reduce the CDF (column 2) to more than 10% of the total CDF. The maximum reduction in CDF is approximately 50%, which is 2 times less than the 100% maximum reduction assumed in the screening analyses. Furthermore, the implementation costs (column 6) associated with these SAMDAs are higher—by as much 60 times greater than the lowest-cost SAMDA (SAMDA 7b, $225,000) used in the screening analysis. Table 14 lists the actual offsite, onsite, and total averted costs (columns 3, 4, and 5 respectively) that could be expected if these SAMDAs were implemented; the values are significantly less than the Staff's maximum values assumed in the screening analysis (last row, Table 13) because the actual CDF reduction is significantly less than the maximum (i.e., 100%) reduction assumed in the screening analysis. The last column in Table 14 provides the ratio of the SAMDA cost to the total actual averted cost; a cost-beneficial SAMDA would have a ratio less than 1.0. SAMDA 9b, with a ratio of 29.3, is the closest SAMDA to being cost-beneficial. Clearly, when the analysis is refined by considering the actual CDF-reduction potential of each SAMDA with respect to the SAMDA's cost, the SAMDAs become even less likely to be cost-beneficial to implement. On this basis, the NRC Staff concludes that in fact there are no cost-beneficial

[116] NUREG/BR-0184, Section 5.7.6.4, at 5.46 (Ex. NRC00008B).

SAMDAs for the STP site, even with the additional consideration of averted onsite cleanup and replacement power costs from other power units.

Table 14: Summary of GE ABWR Preventative SAMDA Modifications that Lead to a Reduction in CDF.

SAMDA[a]	CDF Reduction %	Actual Averted Offsite Cost[b] ($)	Actual Averted Onsite Cost[b] ($)	Total Actual Averted Cost[b] ($)	Implementation Cost[c] ($)	Implementation Cost/Actual Averted Cost
2c Suppression Pool Jockey Pump	2.0%[d]	$2	$3,523	$3,525	$269,550	76.5
1b Computer Aided Instrumentation	3.0%[d]	$3	$5,284	$5,287	$1,349,100	255.2
8a Additional Service Water Pump	9.0%[e]	$8	$15,851	$15,859	$13,497,750	851.1
1c Improved Maintenance Procedures/Manuals	9.0%[d]	$8	$15,851	$15,859	$672,750	42.4
2b Improved Depressurization	14.0%[d]	$12	$24,658	$24,670	$1,346,850	54.6
9a Steam Driven Turbine Generator	50.0%[e]	$43	$88,064	$88,107	$13,487,175	153.1
9b Alternate Pump Power Source	52.0%[e]	$45	$91,586	$91,631	$2,686,500	29.3
2a Passive High Pressure System	52.0%[e]	$45	$91,586	$91,631	$3,924,000	42.8

(a) From GE 1994 TSD, Table 6, at 29-30 (Ex. NRC00009A) (Includes only SAMDAs that result in a reduction in CDF).

(b) Calculated using the actual CDF (column 2) and the Staff's maximum averted cost estimates (last row, Table 13).

(c) From GE 1994 TSD, attach. A, Section A.5 (Ex. NRC00009B) (GE's estimated minimum cost escalated by a factor of 2.25 to 2009 dollars).

(d) Reduction in CDF from GE 1994 TSD, Section A.4 (Ex. NRC00009B).

(e) Reduction in CDF estimated by Staff using the method described in Table 3, footnote "f."

May 9, 2011

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
NUCLEAR INNOVATION NORTH AMERICA	)	
LLC	)	Docket Nos. 52-012 & 52-013
	)	
(South Texas Project, Units 3 & 4)	)	

AFFIDAVIT OF RICHARD L. EMCH, JR.,
CONCERNING PREFILED TESTIMONY REGARDING CONTENTION CL-2

I, Richard L. Emch, Jr., do declare under penalty of perjury that my statements in the "Prefiled Direct Testimony of Richard L. Emch, Jr., Jeremy P. Rishel, and David M. Anderson Regarding Contention CL-2" and my statement of professional qualifications (Exhibit NRC000005) are true and correct to the best of my knowledge and belief.

Executed in Accord with 10 CFR § 2.304(d)
Richard L. Emch, Jr.
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Executed at Rockville, MD
this 9th day of May 2011

May 9, 2011

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
NUCLEAR INNOVATION NORTH AMERICA	)	
LLC	)	Docket Nos. 52-012 & 52-013
	)	
(South Texas Project, Units 3 & 4)	)	

AFFIDAVIT OF JEREMY P. RISHEL
CONCERNING PREFILED TESTIMONY REGARDING CONTENTION CL-2

I, Jeremy P. Rishel, do declare under penalty of perjury that my statements in the "Prefiled Direct Testimony of Richard L. Emch, Jr., Jeremy P. Rishel, and David M. Anderson Regarding Contention CL-2" and my statement of professional qualifications (Exhibit NRC000006) are true and correct to the best of my knowledge and belief.

Executed in Accord with 10 CFR § 2.304(d)
Jeremy P. Rishel
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Executed at Richland, WA
this 9th day of May 2011

May 9, 2011

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
NUCLEAR INNOVATION NORTH AMERICA	)	
LLC	)	Docket Nos. 52-012 & 52-013
	)	
(South Texas Project, Units 3 & 4)	)	

AFFIDAVIT OF DAVID M. ANDERSON
CONCERNING PREFILED TESTIMONY REGARDING CONTENTION CL-2

I, David M. Anderson, do declare under penalty of perjury that my statements in the "Prefiled Direct Testimony of Richard L. Emch, Jr., Jeremy P. Rishel, and David M. Anderson Regarding Contention CL-2" and my statement of professional qualifications (Exhibit NRC000007) are true and correct to the best of my knowledge and belief.

Executed in Accord with 10 CFR § 2.304(d)
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Executed at Richland, WA
this 9th day of May 2011