Docket No.: A.14-12-007
Exhibit No.:
Date: July 15, 2015
Witness: Donna Gilmore

Joint Application of Southern California Edison Company (U338E) and San Diego Gas & Electric Company (U902E) to find the 2014 SONGS Units 2 and 3 Decommissioning Cost Estimate Reasonable and Address Other Related Decommissioning Issues.	Application 14-12-007 (Filed December 10, 2014)

PREPARED DIRECT TESTIMONY OF DONNA GILMORE

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I.

INTRODUCTION

Q. Please introduce yourself.

A. I am Donna Gilmore. I am founder of SanOnofreSafety.org, an international resource for factual government and scientific information on the serious safety and cost issues found at the San Onofre Nuclear Generating Station. Since the shutdown of the reactors the focus has shifted to spent fuel management issues at San Onofre and elsewhere. Some recent publications include: High Burnup Nuclear Fuel – Pushing the Safety Envelope, January 2014 (co-authored with nuclear physicist Dr. Marvin Resnikoff), Diablo Canyon: Conditions for Stress Corrosion Cracking in Two Years, October 23, 2014, and San Onofre Dry Cask Storage Issues, September 23, 2014.

I have over 30 years experience in information technology project management and systems analysis, including design and implementation of major technology systems for the State of California, and the management of a large mission critical engineering data center.

I frequently participate in NRC and other government meeting on nuclear waste storage issues and related issues, such as material corrosion. I collaborate with nuclear engineers, material engineers and nuclear physicists. My knowledge has become so extensive on the nuclear waste storage issues that I have been invited to speak at numerous venues, including the NRC's November 2014 Annual Nuclear Waste Conference, the Sierra Club November 2014 Summit, and the 2015 California Democratic Convention. I have also made presentations on nuclear waste issues at the California Energy Commission IEPR Nuclear Workshop the California Coastal Commission, and various other venues. I was a member of the Edison CEP Nuclear Waste Workshop.

My statement of qualifications is provided as Attachment A to this testimony.

II.

DRY STORAGE SYSTEM LIFESPAN

Q. What dry storage system does SCE plan to use for spent fuel removed from Units 2 and 3 as part of the decommissioning process?

A. For its proposed dry storage system, SCE plan to use the Holtec HI-STORM UMAX system, including the MPC-37 multi-purpose canisters, Hi-Storm UMAX underground storage modules, the Hi-Track VW on-site transfer cask, and the Hi-Star 190 off-site transportation cask.[1]

The Holtec HI-STORM UMAX Canister Storage System is currently not approved by the NRC for use at San Onofre or other high seismic risk areas.[2]

The HI-STORM UMAX Canister Storage System is not being certified under 10 CFR Part 71 for use in transportation[3]

The HI-STORM UMAX Canister Storage System stores a hermetically sealed canister [MPC-37] containing spent nuclear fuel (SNF) in an in-ground vertical ventilated module (VVM). The HI-STORM UMAX Canister Storage

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[1] Attachment 2, SCE Response to Data Request Gilmore-SCE 047.

[2] Attachment 3, List of Approved Spent Fuel Storage Casks: Holtec International Notice of Final Rule HI-STORM Underground Maximum Capacity [UMAX] Canister Storage System, Certificate of Compliance No. 1040, Federal Register Volume 80, Number 44, March 6, 2015, Pages 12073-12078

[3] Attachment 4, NRC Safety Evaluation Report, HI-STORM UMAX Canister System, April 6, 2015, Docket No. 72-1040, pp 2 - 7 http://pbadupws.nrc.gov/docs/ML1509/ML15093A510.pdf

System is designed to provide long-term underground storage of loaded multi-purpose canisters (MPC) previously certified for storage in CoC No. 1032.[4]

The Hi-Star 190 off-site transportation cask is not approved for use. Holtec has not yet submitted an NRC application for this transportation cask. The Hi-Star 190 transportation cask will be designed to transport the MPC-37 canisters off the San Onofre site to be delivered to some yet to be determined permanent or interim waste storage site. Holtec needs to qualify this to transport high burnup fuel (over 45 GWd/MTU). Otherwise, this fuel cannot be transported.

The MPC-37 planned for San Onofre is a 0.625"(5/8") thick sealed stainless steel welded canister. However, the technical specifications for the MPC-37 state it is 0.5" (½)" thick.[5] It is undetermined if the change in canister thickness will require a license amendment. Each canister holds up to 37 spent fuel assemblies. Each fuel assembly is made up of a bundle of Zirconium clad uranium spent fuel rods that will be highly radioactive for thousands of years.

The MPC-37 is the primary containment for the spent fuel.[6]

The MPC-37 canister is stored in an unsealed underground concrete/steel module. A thick steel and concrete closure lid is bolted to the top of the concrete module.[7] However, the lid has air vents in order to keep the MPC-37 and spent fuel assemblies from overheating. The underground concrete module does not provide protection from all types of radiation, so a leak in the MPC-37 may require the MPC-37 to be replaced. SCE will not share the cost

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[4] Attachment 4

[5] Attachment 5, HI-STORM FW FSAR Non-Proprietary, Revision 2, February 18, 2014, Page 3-39 (ML14052A369) http://pbadupws.nrc.gov/docs/ML1405/ML14052A369.pdf

[6] Attachment 4

[7] Attachment 6, HI-STORM UMAX Canister Storage System (MPC-37, MPC-89), Preliminary SER, Certificate of Compliance No. 1040, Proposed Rule Supporting Information (CoC, Tech Specs, SER) (72-1040) (TAC No. L24664). 9/4/2014, page 6

of this system with the public, but based on their estimates a failure of one canister could costs millions.

The HI-STORM UMAX Canister Storage System utilizes the HI-TRAC VW transfer cask to provide a missile and radiation barrier during transport of the MPCs from the fuel pool to the HI-STORM UMAX VVM. The HI-TRAC VW has been previously reviewed and approved for storage activities (CoC No. 1032) and all relevant evaluations are presented in the HI-STORM FW FSAR. Only relevant information necessary to evaluate the interaction between the HI-STORM UMAX VVM and the HITRAC was presented in the HI-STORM UMAX Canister Storage System application[8]

Q. **What dry storage system is SCE currently using for existing spent fuel?**

A. The Areva Transnuclear Horizontal concrete/steel system, with NUHOMS 24PT1-DSC and 24PT4-DSC. The thin (5/8" thick) stainless steel welded canisters are housed in concrete horizontal modules (AHSMs) on two concrete pads. Each canister holds up to 24 spent fuel assemblies. The concrete modules have air vents to provide required cooling of the hot canisters and fuel assemblies.

The February 13, 2014 NRC Inspection Report [page 4][9] shows a total of 51 thin canisters loaded. One canister holds GTCC waste. Attachment 2 provides details on each canister. The first canister was loaded in 2003.

> There were a total of 63 AHSMs on the ISFSI pad. The twelve empty AHSMs will be available for future loading campaigns. The ISFSI pad

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[8] Attachment 4

[9] Attachment 7, San Onofre Nuclear Generating Station, Units 1, 2, 3 and Independent Spent Fuel Storage Installation (ISFSI) Inspection Report, 05000361/2014007, 05000362/2014007, and 07200041/2014001, NRC, February 13, 2014 (ML14045A317)

consisted of two adjacent pad areas designed to hold the AHSMs. The pad was 293 feet in length. The first pad area was 43 feet 6 inches wide and held 31 canisters. The second pad area was 60 feet 6 inches wide and was designed to hold a double row of canisters. The 63 AHSMs currently on the pad were designed for the 24PT1-DSC and 24PT4-DSC canisters, which hold a maximum of 24 spent fuel assemblies. With the 24 assembly canisters, 30 more AHSMs can be added to the current pad for a total of 93 AHSMs. At the SONGS ISFSI, 17 canisters held 395 fuel assemblies from Unit 1 and one canister contained GTCC waste from Unit 1. A total of 17 canisters contained 408 fuel assemblies from Unit 2 and 16 canisters contained 384 fuel assemblies from Unit 3.

Inside the reactors facilities, the Unit 2 spent fuel pool contained 1,318 fuel assemblies and the Unit 3 spent fuel pool contained 1,350 fuel assemblies in wet storage. Each spent fuel pool has the capacity to hold 1,542 assemblies.

Q. Are the Holtec and Areva canister designs used by SCE "thin steel" designs?

A. Both the Holtec MPC-37 and Areva NUHOMS canister designs used by SCE are "thin steel" designs, meaning that they are made of stainless steel with a 5/8" wall thickness.

Thin steel canister technology has been in use less than 20 years. The more mature dry storage technology is the thick metal cask technology, in use over 40 years. Most other countries use thick metal casks up to 20" thick. Japan uses thick steel casks. Germany used ductile cast iron casks. They both house them in reinforced concrete buildings for extra environment protection.

Q. Does the DCE address the lifespan of the dry storage system?

A. The DCE does not specifically address the lifespan of the dry storage system. SCE has stated that "The current SONGS 2&3 decommissioning cost estimate includes provisions for maintaining spent fuel at the station through 2049… the DCE includes maintenance of the facility but not replacement of major components."[10] Thus, the DCE assumes that each element of the dry storage system will have a lifespan that will take it until at least 2049.

For the existing Areva NUHOMS canisters, which were installed beginning in 2003,[11] this constitutes a minimum 46-year required lifespan. Holtec canisters, which the DCE assumes will begin loading in 2019, will require a minimum 30-year lifespan.

Both of these lifespan figures are based on the DCE's assumption that the DOE will begin accepting spent fuel in 2024. Any delay in the DOE's acceptance date will result in an equivalent increase in the number of years of the dry storage system's required lifespan.

Q. What is SCE's claim regarding the lifespan of the Holtec dry storage canisters/casks?

A. SCE claims that all components of the Holtec dry storage system, including the canisters/casks, have a 60 year design life, and "with proper maintenance

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[10] Attachment 8, SCE Response to Gilmore-SCE Question 48

[11] Attachment 7

and monitoring, it is reasonable to conclude that safe storage could continue for 100 years without the use of extraordinary means."[12]

Q. **What are the bases of SCE's claims regarding the Holtec system's lifespan?**

A. SCE's claim that all components dry storage system have a 60-year design life is based on the Hi-Storm UMAX Final Safety Analysis Report (FSAR).[13] Similarly, SCE's claim that the system has a 100-year practical life is based on the claim that "Based on the maintenance program outlined in the FSAR, the Hi-STORM UMAX service life is expected to be at least 100 years."

Q. **Does the Holtec FSAR, which SCE bases its estimate of the dry storage system's lifespan on, consider the likelihood of through-wall cracks at SONGS or similar environments?**

A. The FSAR acknowledges that the MPC (canister) is subject to "Corrosion of the external surfaces of the MPC (stress, corrosion, cracking, pitting, etc) in Long-Term Storage, based on the stainless steel material."[14] However, this assumption is not supported by data I have provided elsewhere in this testimony.

Q. **Are SCE's claims regarding the dry storage system's lifespan consistent with the Holtec Canisters' NRC License?**

A. No. The NRC plans to only license the Holtec UMAX system for 20 years due to the lack of information to support a 40 year license. The NRC has

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[12] Attachment 8
[13] Attachment 8
[14] Attachment 5

excluded evaluation of any aging issues or other failure mechanisms that may occur after 20 years. [15]

In addition, the NRC has not approved the Holtec HI-STORM UMAX system for San Onofre or other high seismic risk areas. They specifically excluded it from their March 6, 2015 approval for lower seismic areas. The NRC is requiring a NRC License Amendment from Holtec before approving locating this system in high seismic risk areas, such as SONGS. The UMAX system will be approved September 8, 2015 unless adverse comments are received by July 23, 2015. [16] This does not necessarily mean it is approved for San Onofre, since site specific requirements will apply. The NRC stated in the March 6, 2015 lower seismic area UMAX approval:

> <u>Seismic Protection [Page 12075]</u>
>
> Several comments also raised concerns regarding the ability of this CoC system to withstand seismic events, particularly if the system were to be used at specific sites with known seismic activity, such as San Onofre Nuclear Generating Station (SONGS).
>
> <u>Response</u>
>
> The NRC is treating this comment as a significant adverse comment warranting clarification of the record. This rulemaking would add a CoC system to the list of approved spent fuel storage casks in 10 CFR 72.214. The certification provided by this approval does not, in and of itself, authorize use of this system at any specific site. Instead, general licensees (a power reactor that stores spent fuel under a general Part 72

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[15] Attachment 3

[16] Attachment 9, List of Approved Spent Fuel Storage Casks: Holtec International HI–STORM UMAX Canister Storage System, Certificate of Compliance No. 1040, Amendment No. 1, Federal Register, pp 35829- 35833, Vol. 80, No. 120, June 23, 2015

> license) that wish to use this system must first ensure that other applicable requirements are met. (See 10 CFR 72.212).
>
> The seismic design levels of the HI-STORM UMAX Canister Storage System as provided in this CoC are acceptable for most areas in the continental U.S. For locations that have potential seismic activity beyond those analyzed for this system, additional evaluations and certifications may be required before the system may be used in those locations. The NRC is currently evaluating an amendment request to the HI-STORM UMAX Canister Storage System that provides additional analysis intended to ensure the system's integrity during an earthquake with higher seismic demands, including the seismic demands at the location of SONGS. If the NRC approves that amendment request, the amended system could be selected for use at SONGS, provided regulatory requirements are met. [Page 12075]

NRC approval for Amendment 1 is pending public comments. Even if the amendment is approved, San Onofre may require site-specific approvals to use this system.

The NRC plans to only license the Holtec UMAX system for 20 years due to current lack of an aging management plan for longer than 20 years.

Q. Do SCE's claims regarding the dry storage system's lifespan accurately reflect available information about the actual lifespan of the casks?

A. No. There are numerous studies and data that indicate the thin (0.50" and 0.625") stainless steel canisters may begin having through-wall cracks within 17 to 20 years of use, depending on environmental and other conditions, San Onofre being one of the more corrosive environments. For example, the Koeberg plant in South Africa had a similar component with a through-wall crack in 17 years. It was 0.61" thick. It is in a similar environment to San Onofre, on-shore winds, surf and frequent fog. Canisters cannot be inspected for cracks, but all the conditions were found for cracking on a 2-year old Diablo Canyon canister (magnesium chloride salts and a canister temperature low enough for the moisture to dissolve the salt on the canister, which can initiate the corrosion process. According the NRC, once cracks initiate, it can have a through-wall crack in 16 years. The NRC Aging Management program plants to require canisters be taken out of service after a 75% through-wall crack.

According to NRC material engineers:[17]

- 304 and 316 Stainless steels are susceptible to chloride stress corrosion cracking (SCC). [e.g. moist salt air].
    - Sensitization caused by welding increases susceptibility.
    - Crevice and pitting corrosion can be precursors to SCC.
    - SCC is possible with low surface chloride [salt] concentrations
- Welded stainless steel canisters have sufficient through wall tensile residual stresses for SCC
- Several reported cases of Atmospheric SCC of welded stainless steels has been observed in similar components at operating reactors.
    - Component failures in 11-33 years
    - Estimated crack growth rates of 0.11 to 0.91 mm/yr (0.004" to 0.036"/yr)

Q. What is a through-wall crack?

A. A through-wall crack is normally a microscopic crack that travels through the entire wall of the canister. According to a report from the Lawrence Livermore National Laboratory:

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[17] Attachment 10, Aging Management Program Example for Stress Corrosion Cracking, Dunn Darrell S. Dunn, Meeting to Obtain Stakeholder Input on Potential Changes to Guidance for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance, July 14, 2014 , slides 2, 15

> The atmospheric-induced [stress corrosion crack] [SCC] can be divided into 3 model levels, each of which are a condition that needs to be realized before SCC can occur:
>
> 1. Corrosive environment (including chemical environment on the surface of the canister, surface temperature and relative humidity; all of which are influenced by the geographic location of the storage cask)
> 2. Tensile stress (as observed in welded canisters)
> 3. Susceptible material (e.g. 201, 301, 302, 304, 309, and 316 steels)
>
> The three requirements for stress corrosion cracking are present at the weld region of UNF [used nuclear fuel] canisters when chloride-containing salts deposit via deposition of dust during passive cooling. Once SCC is initiated, the environmental conditions need to be evaluated for propagation leading to a through-wall crack [18]

Q. **How do through-wall cracks affect the dry storage system's lifespan?**

A. Through-wall cracks are fatal flaws. According to the NRC a canister cannot be used if it has more than a 75% through-wall crack.[19] Once this condition occurs, the lifespan of the canister is over. There is no repair technology available to adequately repair canisters filled with spent fuel. NRC regulations state that:

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[18] Attachment 11, Input to SNL Report on the Composition of Available Data for Used Nuclear Fuel Storage and Transportation Analysis, M. Sutton, J. Wen, Lawrence Livermore National Laboratory, LLNL-TR-659020, August 19, 2014, PP 3-5 https://e-reports-ext.llnl.gov/pdf/779947.pdf

[19] Attachment 12, NUREG-1927, Rev 1 - Standard Review Plan for Renewal of Specific Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel, revised 6/29/2015 http://pbadupws.nrc.gov/docs/ML1518/ML15180A011.pdf

> Canisters that show evidence of localized corrosion and/or stress corrosion cracking that exceeds acceptance criteria identified in IWB-3640 [over 75% crack depth of wall thickness[20]] are not permitted to remain in service.[21]

Thus, one way of measuring the lifespan of a canister is to looks at when it is likely to develop over a 75% through wall crack. It is important to note that seismic evaluations are done on intact materials. There is no seismic analysis for cracked canisters. The potential for failure of a cracked canister from an earthquake has not been evaluated.

According the Holtec President, Dr. Kris Singh, even microscopic cracks can release millions of curries of radiation and it's not practical to repair them.[22]

Q. What conditions cause through-wall cracks to develop?

A. A paper by Sandia National Laboratories has described the development of through-wall cracks as follows:

> Of primary concern with respect to the long-term performance of the storage casks is the potential for canister failure due to localized corrosion. For most dry cask storage systems, passive ventilation is utilized to cool the casks within the overpacks, and large volumes of outside air are drawn through the system. Dust and aerosols within the air are deposited on the steel canisters, and as the casks cool over time, salts in the dust will deliquesce to form brine on the storage container surface. Under these conditions, localized attack can occur. Chloride-

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[20] Attachment 13, Material Diagnostic of the Pressure Equipment in the Aspects of the New Prescriptions, Ewa Hajewska, et. al, IAE Annual Report 1999, page 32

[21] Attachment 12, NUREG-1927 Revision 1, Page B-8

[22] Attachment 14, Declaration of Donna Gilmore

> induced stress corrosion cracking (CISCC) of welded zones is of special concern, as it a well-documented mode of attack for austenitic stainless steels (including 304SS and 316SS) in marine environments, and many reactors and the onsite interim storage locations are located in coastal areas.[23]
>
> At high container surface temperatures, corresponding to low relative humidities, salts cannot deliquesce and corrosion cannot occur. The actual relative humidity at which deliquescence occurs is controlled by the salt assemblage that is present, and for sea salts, this corresponds to 80-85ºC.[24]

Salt deliquescence can occur on interim storage containers only over a small part of the temperature and relative humidity (RH) range that the storage containers will experience. A reasonable maximum possible absolute humidity is 40-45 g/m3 for sea salts. This corresponds to a maximum temperature of deliquescence of ~85ºC.[25]

Crack initiation at the higher end of the temperature range (up to 80°C) is likely to occur sooner than at ambient temperatures:

> Most austenitic stainless steels vessels and piping plant experience with SCC [stress corrosion cracking] suggests that incidence of SCC rises dramatically when temperatures exceed 55-60ºC. Stainless steel items operating above these temperatures are definitely candidates for preventative measures. Stainless steel equipment operating below 55-

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[23] Attachment 15, Understanding the Environment on the Surface of Spent Nuclear Fuel Containers, Charles R. Bryan and David G. Enos, Sandia National Laboratories, June 2014

[24] Attachment 15 at p. 2

[25] Attachment 16, Data Report on Corrosion Testing of Stainless Steel SNF Storage Canisters, Sandia Lab, September 30, 2013, page V

> 60ºC will not be totally immune to SCC. (Occasional failures have been reported on ambient temperature equipment after 10-15 years of service).
>
> An increase in temperature generally aggravates the conditions for SCC, other conditions being equal. Cracking is more likely to occur at 80ºC proceeding about four times faster at this higher temperature in "wicking" tests compared with 50°C. In tests lasting 10,000 hours each, the maximum chloride concentration to initiate SCC was determined to be about 400 ppm at 20°C and 100 ppm at 100°C. These parameters however will vary with the nature of the specific chloride involved. For example, SCC has been reported at temperatures as low as -20°C in methylene chloride, where the aggressive species was almost certainly hydrochloric acid itself, formed by hydrolysis.[26]

Q. Are the conditions for the development of through-wall cracks present at San Onofre?

A. Yes. All of the conditions for the development of through wall cracks are present at San Onofre.

The existing Areva NUHOMS canisters are made of 316SS (Stainless Steel). 316SS has similar stress corrosion and cracking vulnerabilities to 304SS,[27] the material used in at the Koeberg nuclear plant tank, which had a through-wall

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[26] Attachment 17, Cracked: The Secrets of Stress Corrosion Cracking, Hira Ahluwalia, President of Material Selection Resources Inc. (MSR) Page 3 http://csidesigns.com/flowgeeks/cracked-the-secrets-of-stress-corrosion-cracking/

[27] Attachment 16 at p. V

crack in 17 years. The climate at Koeberg is similar to San Onofre, on-shore winds, surf, and frequent fog.[28]

San Onofre had a pipe failure from stress corrosion cracking, so it definitely has the environmental conditions.[29]

Q. How long does it take for a crack to develop in thin-steel dry storage canisters like those SCE is planning on using?

A. In January 2014, the Electric Power Research Institute (EPRI) spot checked the temperature of a two-year old Diablo Canyon canister and scraped part of the surface of the canister for corrosive particles. EPRI found that the canister had all of the conditions for cracking: the presence of Corrosive Ocean salts (Magnesium Chloride);[30] temperatures low enough for the moisture to cause salt deliquescence.[31] No ones knows if this or any canisters have cracks, since the technology available to inspect for cracks is not available for canisters filled with spent nuclear fuel.

Q. Once a crack initiates, how long can it take to go through-wall?

A. Due to the limited time these thin canisters have been in use and the inability to inspect them for cracks, the NRC studied failure of similar components at

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[28] Attachment 18, The Pacific Energy Center's Guide to California Climate Zones, October 2006, Zone 7 pp. 1 - 4

[29] Attachment 19, NRC Information Notice 2012-20: Potential Chloride-Induced Stress Corrosion Cracking of Austenitic Stainless Steel and Maintenance of Dry Cask Storage System Canisters, November 14, 2012 , Page 1 and 2

[30] Attachment 20, FY14 DOE R&D in Support of the High Burnup Dry Storage Cask R&D Project, William Boyle, DOE, NWTRB Meeting, August 6, 2014 (slide 12)

[31] Attachment 21, Update on In-Service Inspections of Stainless Steel Dry Storage Canisters, EPRI, Keith Waldrop, Senior Project Manager, Presented by John Kessler, Program Manager, NEI-NRC Meeting on Spent Fuel Dry Storage Cask Material Degradation, January 28, 2014 (Diablo slides 17-19)

nuclear power plants. Power plant operating experience with stress corrosion cracking of stainless steel shows estimated crack growth rate of up to 0.91 mm (0.036 inch)/year for cold metal.[32] . Hotter metal, such as spent fuel dry storage canisters, will have increased crack growth rate.[33]

The NRC has stated that once a crack initiates it can go through-wall in 16 years:

> Based on estimated crack growth rates as a function of temperature and assuming the conditions necessary for stress corrosion cracking continue to be present, the shortest time that a crack could propagate and go through-wall was determined to be 16 years after crack initiation.[34]

At the Koeberg South Africa plant, a 304L stainless steel refueling water storage tank (RWST), developed a crack 15.5 mm (0.61 inch) deep within 17 years, which is deeper than the thickness of most U.S. canisters (0.61 inch vs 0.5 to 0.625 inch thick).[35] The Koeberg tank required dye penetrant testing (PT) to reveal cracks. This cannot be done with canisters filled with spent fuel.

> Koeberg is a seawater-cooled, 2 x 920 MW Pressurized Water Reactor plant, with a three-loop Framatome nuclear steam supply system. Koeberg is situated 30 km North of Cape Town, South Africa, on the Atlantic coast. Koeberg have detected numerous externally initiated cracks, some through-wall, on seamed piping of safety related systems, the refueling storage water tanks and cast valves of both units. The tanks, piping and valves are manufactured out of austenitic stainless

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[32] Attachment 22, Chloride-Induced Stress Corrosion Cracking Tests and Example Aging Management Program, Darrell S. Dunn, August 5, 2014, Slide 9 https://sanonofresafety.files.wordpress.com/2013/06/8-5-14-scc-rirp-nrc-presentation.pdf

[33] Attachment 17, p. 3

[34] Attachment 23, NRC Meeting Summary of August 5, 2014, Public Meeting with the Nuclear Energy Institute on Chloride Induced Stress Corrosion Cracking Regulatory Issue Resolution Protocol

[35] Attachment 19, pp. 1 – 2

> steel grade 304L and the systems typically operate at temperatures below 50 C. Metallurgical assessment of the cracks concluded it to be transgranular stress-corrosion cracking (SCC) associated with the marine environment (chlorides), susceptible material (304L) and stresses associated with cold forming, welding and casting shrinkage. The cracking was almost exclusively initiated through surface pitting of the components. The problem presented a challenge in that a vast number of components were affected by SCC and due to the largely subsurface nature of the cracking the inspection method had to include grinding of all the pipe surfaces to allow use of dye penetrant testing (PT) to reveal cracks. This paper describes the background to the problem, the inspection method, the morphology and the recovery strategy.[36]

Koeberg is located in a similar corrosive marine environment as San Onofre: on-shore winds, surf and frequent fog. The Koeberg container crack depth was 0.61”. The San Onofre canisters are 0.625” thick.

San Onofre started loading canisters with spent fuel in 2003. If San Onofre canisters have experience similar to Koeberg, that means a canister at San Onofre could start releasing radiation into the environment as early as 2020 (5 years from now).

III.

CONCRETE DEGRADATION

Q. What is concrete degradation?

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[36] Attachment 24, Environmentally induced transgranular stress-corrosion cracking of 304L stainless steel components at Koeberg, Basson, J.P. (Eskom, Koeberg Nuclear Power Station, Melkbosstrand, Cape Town (South Africa)); Wicker, C. (TSI, Koeberg Nuclear Power Station, Melkbosstrand, Cape Town (South Africa))

A. Concrete degradation is concrete aging that may affect the function of the concrete structure, including steel reinforcements.

Q. Does the DCE address concrete degradation?

A. No, in its response to Gilmore-SCE Data Request 119, SCE admitted that "the DCE did not specifically consider concrete degradation."[37]

Q. Has the NRC raised concerns regarding concrete degradation in dry storage systems like the proposed Holtec system?

A. Yes. The Holtec dry storage system is composed of an underground concrete structure, with the surface exposed. The thin steel canister is loading into modules in the underground system and a vented bolted top is added.

I attended (via teleconference) NRC's Expert Panel Workshop on Degradation of Concrete in Spent Nuclear Fuel Dry Cask Storage Systems, February 24-25, 2015, where technical experts identified numerous unresolved concrete aging management problems, even more with below ground systems (such as the Holtec UMAX dry storage system due to limited inspection capability, moisture and numerous chemical reactions with concrete, with near the ocean being a significant factor). The NRC is just now started to evaluating aging management issues with the concrete structures, of which there are many.

The NRC does not know how soon these degradations can happen and would not hazard a guess. They are just starting to evaluate these issues. They made a point of saying cost isn't their issue, so they do not consider replacement or

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[37] Attachment 25, SCE Response to data request Gilmore-SCE 119

repair costs, only safety. (Concrete is not an issue in thick steel or ductile cast iron casks, since they do not use concrete for containment.)[38] [39]

At the July 14, 2014 NRC meeting, the presentation by NRC outlined some of the areas of concern with concrete aging that can result in functional failure of the concrete: cracking, loss of material (spalling, scaling), expansion cracking, loss of bond, and loss of or reduction in strength (change in mechanical properties).

The NRC has identified a number of aging mechanisms that could affect concrete/steel dry storage systems (including the Holtec or Areva systems at SONGS), including:[40]

- Chemical attack such as with Chlorides (Cl) as typically found in marine environments or sulfates [SO_4] that occur widely in everyday life in the water, ground and air, such as sulfates that occur as microscopic particles resulting from fossil fuel combustion. They increase the acidity of the atmosphere and form acid rain. With the San Onofre dry storage system located adjacent to I-5, this may be a significant risk factor.
- Aggregate reactions/expansion
- Corrosion of embedded steel
- Leaching of Ca(OH)2 → CaCO3
- Long-term settlement
- Gamma/neutron irradiation

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[38] Attachment 26, Official Transcript of Proceedings, NUCLEAR REGULATORY COMMISSION, Expert Panel Workshop on Degradation of Concrete in Spent Nuclear Fuel Dry Cask Storage Systems, February 24, 2015, Pages 335-351

[39] Attachment 26 pp. 138-161

[40] Attachment 27, NRC Generic Concrete Aging Management Program, Ricardo D. Torres, July 14, 2014, Slide 3

- High temperature dehydration

Q. Does technology currently exist for monitoring concrete degradation?

A. According to a November 2014 report by Xihua He, et. al.:

> Concrete degradation monitoring methods are well developed and have sufficient sensitivity to detect degradation before physical deterioration begins. However, these methods also have limitations, such as being labor intensive and limited to interrogation depths of 10 cm [4 in] or requiring access to the interior surfaces. Embeddable sensors have been developed and are commercially available; however, significant effort would be required to install these sensors in existing DCSSs. In addition, determining an optimized location for sensor placement may require analysis or knowledge of susceptible areas for degradation.[41]

Q. How does concrete degradation impact the dry storage system's lifespan?

A. Concrete degradation can shorten the dry storage system's lifespan. However, the NRC does not have information on how soon these degradation mechanisms might occur – short term or long term.

IV.

RELIANCE ON UNPROVEN ACTIVITIES/TECHNOLOGIES: CHILLERS

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[41] Attachment 28, Available Methods for Functional Monitoring of Dry Cask Storage Systems, Xihua He, et.al., Executive Summary, page ix

Q. **Does the DCE assume that SCE will rely on novel, unproven activities or technologies in the SONGS decommissioning?**

A. No, the DCE's assumptions do not include the use of novel, unproven activities or technologies, and the DCE does not state that the risks for delays or additional costs associated with unproven activities or technologies have been included in the cost estimate.

Q. **Do SCE's actual decommissioning plans rely on the use of novel, unproven activities or technologies?**

A. Yes. SCE plans to change the cooling system for the spent fuel pools, relying on air chillers instead of ocean water to keep the spent fuel assemblies cool. If they are not cooled adequately, even a partial boil-off of the water below the level of the assemblies can cause a critical failure of the system.

SCE has requested a Coastal Permit to changing the cooling system from ocean water to cooling the water with air chillers. However, there is no evidence that this technology will work or can be maintained for the thousands of fuel assemblies that currently require constant cooling to avoid boil off. There is nothing in the DCE that addresses this new cooling system or the cost if this system fails and must revert back to ocean cooling.

SCE has provided the Coastal Commission a list of three decommissioned nuclear facilities that previously used chillers to cool their spent fuel islands: Rancho Seco, Maine Yankee, and Maine Yankee. None are comparable to San Onofre.

Rancho Seco only used chillers for only three years. They only have 493 fuel assemblies and no high-burnup fuel (over 45GWd/MTU) and the fuel had cooled for many more years than San Onofre's fuel, so the demand for cooling was much less than San Onofre's needs. They are also not located in a corrosive marine environment. From its start in 1975 to the permanent shutdown in 1989 Rancho Seco only had a total equivalent of 6 full power years.[42]

On August 21, 2002, Rancho Seco completed placing all 493 spent fuel assemblies in dry storage at the onsite Independent Spent Fuel Storage Installation (ISFSI), licensed under 10 CFR Part 72.[43]

Rancho Seco fuel assembly burnup maximum is 38.2 GWd/MTU.
Rancho Seco Facility and Independent Spent Fuel Storage Installation (ISFSI)[44]

San Onofre has 2776 spent fuel assemblies (SFA) in the pools. Maximum burnup is 52 GWd/MTU. Unit 2 contains 1426 SFA (1318 + 108 of these with zero burnup) and Unit 3 contains 1350 SFA. Of these, 31 fuel assemblies were reported to the Department of Energy (DOE) as damaged (failed); 15 in Unit 2 and 16 in Unit 3.[45] [46]

Maine Yankee rejected using chillers for their spent fuel pool island. "This system involves the use of a chiller (air conditioner) to remove heat. The system was rejected because: A. High initial cost. B. Still requires water or air cooled condenser, and C. Complex equipment and controls to maintain."[47] Maine Yankee is a pressurized water reactor (825 MWe) last

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[42] Attachment 29, Rancho Seco NRC Inspection Report, August 31, 1999, page 11
[43] Attachment 30 - ML032260147 - Rancho Seco Post Shutdown Decommissioning Activities Report, Amendment 4, 7/31/2003, Page 3
[44] Attachment 31 - NRC Inspection Report 05000312/2013007 and 07200011/2013001, August 22, 2013, Attachment 2 Loaded Canisters at Rancho Seco ISFSI
[45] Attachment 32 - Unit 2 San Onofre Reactor Data (DOE Form GC-859 Schedule C) https://sanonofresafety.files.wordpress.com/2013/06/songs-4702-masterfromformgc859.pdf
[46] Attachment 32A – Unit 3 San Onofre Reactor Data (DOE Form GC-859 Schedule C)
[47] Attachment 33 - Conceptual Project Assessment, Spent Fuel Pool Island Project, CPA NO. 97-42, October 1997, P. 9

operated in December 1996. After final defueling, the fuel pool housed 1432 assemblies.

V.

SPENT FUEL POOL RETIREMENT RISKS

Q. What are SCE's current plans for the spent fuel pools?

A. The DCE indicates that SCE plans to destroy the spent fuel and transfer pools once the pools are empty.[48]

Q. What risks are associated with SCE's plan do destroy the spent fuel pools?

A. Spent fuel pools are the only viable method to remediate a failed canister.[49] Chrystal River recognizes this and plans to retain their pools until the fuel is removed from the site:

> Contingency plans are required to maintain the ability to unload canisters and/or repackage the fuel for transport. It is for this reason that DEF plans to maintain the spent fuel pool in a recoverable condition, the cost of which was included in the analysis of the dry storage option.[50]

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[48] Decommissioning Cost Estimate, Page 5.

[49] Attachment 34 - A Project Concept for Nuclear Fuels Storage and Transportation, June 15, 2013, Page 38

[50] Attachment 35 - From PSC Staff to Commission Docket No. 140113-EI - Petition for approval to construct an independent spent fuel storage installation and an accounting order to defer amortization pending recovery from the Department of Energy, by Duke Energy Florida, Inc. , December 4, 2014 Page 4

Holtec President Dr. Kris Singh has admitted that it is not feasible to repair damaged canisters that are loaded with spent fuel:

> "…It is not practical to repair a canister if it were damaged… if that canister were to develop a leak, let's be realistic; you have to find it, that crack, where it might be, and then find the means to repair it. You will have, in the face of millions of curies of radioactivity coming out of canister; we think it's not a path forward…
>
> "…A canister that develops a microscopic crack to precisely locate it… And then if you try to repair it… the problem with that is you create a rough surface which becomes a new creation site for corrosion down the road. ASME Sec 3. Class 1 has some very significant requirements for making repairs of Class 1 structures like the canisters, so I, as a pragmatic technical solution, I don't advocate repairing the canister."[51]

In SCE's response to Data Request Gilmore-SCE 079, SCE asserts that repairing damaged thin wall canisters is possible, but that tools to repair these canisters still need to be developed.[52] SCE's position is at odds with its own vendor's statements regarding the infeasibility of repairing damaged canisters and the dangers of creating new sites for future corrosion.

Q. Are these risks adequately accounted for in the DCE?

A. The DCE does not address the potential risks and risk-related costs associated with SCE's plan to dismantle the spent fuel pools, nor does it address the

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[51] Attachment 14

[52] Attachment 36 - SCE Response to Gilmore-SCE 079

additional risks associated with SCE's failure to develop contingency plans for dealing with damaged canisters.

VI.

RELIANCE ON SPECULATIVE TECHNOLOGIES FOR INSPECTION

Q. Are the DCE's schedule and cost estimates based on the assumption that all decommissioning activities will be conducted with currently available technology?

A. Yes, Assumption 3 of the DCE specifically states that a key assumption for the DCE is that "The decommissioning will be performed using currently available technology."[53]

Q. Do SCE's actual decommissioning plans rely on technology that is not currently available for inspecting the spent fuel canisters?

A. A November 2014 report by Xihua He, et. al. outlines the many challenges to develop inspection and monitoring technology or to adapt existing technology to the thin canisters and their concrete overpacks/casks.

> …Substantial advancement in technology may be necessary for methods that are not presently designed or packaged for field use…
>
> …No suitable method was identified for detecting and monitoring of atmospheric deposition of solid chloride-containing salts that may lead to degradation of safety significant SSCs, such as welded stainless steel canisters used in the majority of DCSSs…

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[53] Decommissioning Cost Estimate, Assumption 3, p. A-1 - 26

> …Stress corrosion cracking sensors are limited. Surrogate sensors, which are an instrumented SCC coupon, have been developed for condition monitoring in field applications. Significant advancement and qualification testing would likely be necessary to use the sensor for DCSS monitoring. Other methods, such as fiber optic sensors or crack propagation sensors, have significant limitations (e.g., unknown temperature and radiation tolerances). Fiber optic sensors appear to be the only direct method of monitoring the actual component of interest. Implementation of this type of system would be challenging, given the temperatures and radiation near the canister surface. Such an application also would need to consider the possible detrimental effects of attaching a sensor to the canister surface…
>
> …Monitoring the canister internal environment poses several challenges because of high temperatures, radiation, and accessibility difficulty…[54]

VII.

2024 DOE WASTE ACCEPTANCE DATE

Q. **Does the DCE rely on the assumption that the DOE will begin accepting spent fuel in 2024 and complete by 2049 for its schedule and cost estimates?**

A. Yes. The DCE specifically identifies the DOE 2024 spent fuel acceptance date as one of its "key assumptions."[55]

Q. **What is SCE's basis for this assumption?**

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[54] Attachment 28, page ix

[55] Decommissioning Cost Estimate, Assumption 4, p. 23.

A. SCE's basis for this assumption is that SCE assumed that the DOE would start accepting spent fuel in 2024 in SCE's 2012 Songs 2 & 3 Decommissioning Cost Estimate, and that "DOE has not provided any new, definitive, or binding information regarding the opening of a permanent deep geologic repository, or a schedule for commencing to accept spent fuel."[56] In response to Gilmore-SCE Question 63, SCE stated: "The DOE has provide no other information upon which to base a different assumption."[57]

Q. Is this assumption consistent with the actual status of DOE waste storage projects?

A. The assumption is inconsistent with the actual status of DOE waste storage projects. The DOE's current plans for waste storage are set forth in the DOE Office of Nuclear Energy's January 2013, nuclear waste strategy. This strategy involves the construction of a "pilot-scale" interim waste storage facility, to be opened by 2021, a larger interim waste facility to be opened by 2025, and a permanent waste storage facility to be opened by 2048.[58]

This project has been put on hold indefinitely. On April 22, 2015 the House Appropriations Committee defunded the DOE's integrated waste strategy, instead approving $175 million for DOE and NRC to continue the Yucca Mountain licensing process.[59]

The Yucca Mountain project has been plagued by controversy, and has not been approved by the NRC. It is unclear whether Yucca Mountain will ever

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[56] SCE-01, p. 14

[57] Attachment 37 - SCE Response to Gilmore-SCE Question 63

[58] Department of Energy, Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste, January 2013, pp. 5-8.

[59] H.R. 2028, H.Rept. 114-91

be approved. In light of Congress' decision to de-fund the DOE nuclear waste strategy in favor of Yucca Mountain, the Congressional Research Service stated:

> Given the delays resulting from the ongoing shutdown of the nuclear waste program, longer on-site storage is almost a certainty under any option. Any of the options would also face intense controversy, especially among states and regions that might be potential hosts for future waste facilities.[60]

Q. **Has SCE projected additional costs associated with a later acceptance date?**

A. Yes. In its response to data request Gilmore-SCE 109, SCE stated: "In June 2014, SCE calculated that a 10-year delay from the assumed 2024 start date for the removal of the spent fuel from the SONGS site by the DOE would increase decommissioning costs by approximately $133 million."[61]

VIII.
DRY STORAGE SYSTEM COST

Q. **What is the DCE's projected cost for the dry storage system?**

A. In response to Gilmore-SCE Data Request 054, SCE has identified 12 DCE budget categories that constitute the cost of the Dry Storage system. The total cost of these 12 budget categories is over $405 million.[62]

Q. **What is the DCE's basis for its dry storage system cost estimate?**

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[60] Attachment 38 - Civilian Nuclear Waste Disposal, RL33461, Mark Holt, Congressional Research Service, April 24, 2015, Page 30

[61] Attachment 39 - SCE Response to data Request Gilmore-SCE 109

[62] Attachment 40 - SCE Response to data request Gilmore-SCE 54

A. EnergySolutions did not independently estimate the cost of the dry storage system for the DCE. Rather, EnergySolutions accepted the DCE cost figure provided to it by SCE and treated this figure as an assumption. DCE Assumption 21 states that "The costs for ISFSI construction and transfer of spent fuel form Units 2 & 3 to dry storage were developed by SCE and furnished to EnergySolutions."[63]

Q. How did SCE calculate the dry storage system cost figure provided to EnergySolutions?

A. SCE provided EnergySolutions with the cost figure referenced in DCE exhibit 21 in an email dated January 27, 2015, which was provided in response to data request Gilmore-SCE 070.[64] In this email, SCE employee Robert Munger replies to EnergySolutions' request "E" for "Currently available plans and projected costs, if any, for transfer of spent fuel into dry storage" as follows:

> The cost to move to storage includes not only the cost of the canisters and modules, but other activities such as inspection of fuel, characterization of fuel and trash, development of loading plans, processing of CEA's for storage in the canisters. The current estimated costs for this scope of work is bounded by $265,000,000 based upon vendor proposals.[65]

Similarly, Munger replies to EnergySolutions' request "E" for "currently available plans and associated costs, if any, for the expansion of the existing ISFSI required for spent fuel transfer to dry storage" as follows:

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[63] DCE Assumption 21, p. 25

[64] Attachment 41, SCE Response to Data Request Gilmore-SCE 070

[65] Attachment 42

> The estimated cost for the design and construction of the ISFSI to include a new hardened security post meeting the anticipated changes to NRC rules for ISFSI security and additional security requirements is bounded by $35,000,000 based upon vendor proposal.

The $265,000,000 figure provided by SCE to EnergySolutions "was based on the highest value from the rough order of magnitude proposals that were provided by three vendors, and a rough order of magnitude estimate of the SONGS oversight for the project."[66]

Similarly, the $35,000,000 figure provided by SCE to EnergySolutions "was based on the highest value from the rough order of magnitude proposals that were provided by three vendors."[67]

IX.

DECOMMISSIONING COST ESTIMATE BASIS

Q. Is the DCE based on information regarding actual decommissioning costs?

A. SCE has admitted that the DCE is a "conceptual estimate." At the time the DCE was developed, "no detailed engineering studies for any of the decommissioning work had been performed, no procurement activities had commenced, and no contracts had been signed… Therefore, the level of planning in the DCE… did not meet the threshold for a 'Detailed Estimate' as defined in the budgetary literature."[68]

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[66] Attachment 43 - SCE Response to Gilmore-SCE 139.
[67] Attachment 44 - SCE Response to Gilmore-SCE 140.
[68] Attachment 45 - SCE Response to Gilmore Q. 67

Q. Does this conclude your rebuttal testimony?

A. Yes.