San Onofre Experience with CISCC

David Victor
Chair
SONGS Community Engagement Panel

June 27, 2019
Who am I?

- Chairman SONGS Community Engagement Panel (CEP)

- Academic
  - Professor at School of Global Policy & Strategy, UC San Diego; Professor of Climate, Atmospheric Science and Physical Oceanography, Scripps Institution of Oceanography
  - Co-leader, UC San Diego Deep Decarbonization Initiative
  - Co-leader, Initiative on Energy and Climate, Brookings Institution

- Heavily involved in US industry and R&D
  - EPRI Board of Directors and Advisory Council
  - INPO Advisory Council
  - 2 National Academy of Sciences panels on future of power sector
Today’s Topics

1. History and decommissioning timeline
2. On-site used fuel management
3. Experience with stress corrosion cracking

Documents: www.songscommunity.com
San Onofre Nuclear Generating Station (SONGS) Plant History

- **Unit 1 (small PWR)**
  - Online January 1968
  - Retired 1992, partially decommissioned
  - Site was semi-remote between SD/LA;
  - California economy grew and location suburbanized

- **Unit 2 (large PWR)**
  - Online Nov ’83; removed Jan ’12

- **Unit 3 (large PWR)**
  - Online April ’84; removed Jan ’12

- **Units 2 & 3**
  - Retired June 7, 2013
Community Engagement Panel (CEP)

- **Role**: Engagement/conduit (not a decision-making body)
- **Formation**: Established voluntarily by SCE in 2014
- **Composition**: 18 leaders in community representing:
  - Local government (neighboring counties and cities)
  - Environmental non-governmental organizations
  - Academia
  - Schools
  - Native Americans
  - Organized labor
  - Business
  - Neighbors (military base and state parks)
  - Emergency response professionals
SONGS Decommissioning Plan
Subject to Change

2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | ... | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | ... | 2040 | ... | 2045 | 2046 | 2047 | 2048 | 2049 | 2050 | 2051

Pre-Decommissioning Work
Fuel in Wet & Dry Storage
CEQA Review

Major Decommissioning Work
All Fuel in Dry Storage

Transfer Fuel Offsite
(Actual Timing Pending Offsite Storage Facility)
NEPA Review
Substructure Removal & Site Restoration
ISFSI Demo
Terminate NRC License

Complete Transfer of Fuel from Wet to Dry Storage
ISFSI-only NRC Requirements Implemented
NRC Partial Site Release
Future milestones are tentative
ON-SITE USED FUEL MANAGEMENT
The Larger Context: Why Long Term Spent Fuel Aging Management at US reactors?
The Original Vision for US Spent Fuel Strategy

- On-site fuel use in reactors
- Cooling in pools
- Packaging, additional cooling (if needed) then transportation to permanent repository
- 1982 Law envisioned 2+ permanent repositories
- After 1982, just one site selected (Yucca mountain, near Las Vegas)
- Yucca mountain highly controversial and not yet (never?) licensed
2018 Inventory
Centralized Used Fuel Resource for Information Exchange (CURIE)
https://curie.ornl.gov/map
Key US SNF Policy Issues
Today

• Restarting Yucca Mountain licensing process
• Opening 2 or more interim storage sites
  – New Mexico and Texas are current candidates
• Funding development of railcars to allow commercial SNF transportation
  – Certification expected next few years
• Funding pilot programs at interim storage sites
• Some startup and other money going into non-Yucca solutions such as “deep borehole”
• Ensuring robust Aging Management Procedures (AMP) for existing SNF Independent Spent Fuel Storage Installation (ISFSI) locations
SONGS Used Fuel Management Strategy

1. Safely manage and store San Onofre’s used nuclear fuel until it is removed from site

2. Promptly offload fuel from pools to dry cask storage
   - Spent fuel is safer in passive dry cask storage
   - Packaged for transportation

3. Support all safe and reasonable options to remove used nuclear fuel from San Onofre site
   - Developing strategic plan to assess the feasibility of relocating spent fuel to an off-site facility

4. Recover used fuel storage costs from DOE
On-site Used Fuel Storage

INITIAL STATE

Spent Fuel Pools
2668 fuel assemblies

Existing ISFSI
50 canisters (1187 fuel assemblies)

EXPANDED ISFSI

73 canisters (2668 fuel assemblies) + existing 50 canisters (1187 fuel assemblies)

29 CANISTERs HAVE BEEN LOADED ONTO THE ISFSI

FUTURE STATE

3855 fuel assemblies in 123 canisters
SONGS Independent Spent Fuel Storage Installation (ISFSI)
Provides Passive Dry Cask Storage for Spent Fuel While On Site

AREVA System
(50 spent fuel canisters)

Holtec System
(73 spent fuel canisters)
Original
AREVA NUHOMS System
Expanded Holtec HI-STORM UMAX System

Corrosion-Resistant Stainless Steel Multipurpose Canister

Stainless Steel Lid

Corrosion-Resistant Stainless Steel Cavity Enclosure Container

Reinforced Concrete Pad (Top/Bottom)
Most Spent Fuel at SONGS Ready for Transportation in Near Term

- Majority of fuel will qualify for transport by 2020
- Remaining fuel qualifies by 2030
- Now is the time to prepare for off-site transportation

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Units 2/3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>33</td>
</tr>
<tr>
<td>AREVA NUHOMS 24PT4</td>
<td>33</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit 1</td>
<td></td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>17</td>
</tr>
<tr>
<td>AREVA NUHOMS 24PT1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Units 2/3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>73</td>
</tr>
<tr>
<td>HOLTEC MPC-37</td>
<td>67</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Decommissioning San Onofre Nuclear Generating Station  Safety | Stewardship | Engagement
SONGS EXPERIENCE WITH CHLORIDE-INDUCED STRESS CORROSION CRACKING
SONGS Experience with CISCC

- NRC Information Notice – IN 2012-20
- SONGS experienced CISCC in schedule 10 low pressure stainless steel piping (IN 2012-20)
- Marine environment
- CISCC is likely the limiting aging mechanism for SONGS canisters
Why we are focused on the global experience

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS
WASHINGTON, DC 20555-0001

November 14, 2012

NRC INFORMATION NOTICE 2012-20: POTENTIAL CHLORIDE-INDUCED STRESS CORROSION CRACKING OF AUSTENITIC STAINLESS STEEL AND MAINTENANCE OF DRY CASK STORAGE SYSTEM CANISTERS

ADDRESSEES

Extensive Public Attention to these issues

Testimony of Prof. David G. Victor, Chairman of the San Onofre Community Engagement Panel, before the House Oversight and Government Reform Subcommittee on Interior, Energy and Environment
September 26, 2017

Subcommittee Chairman Farenthold, Ranking Member Plaskett, and members of the subcommittee, including Representative Issa and Representative Gomez, thank you for the invitation to testify today about the national problem of storage and disposal of spent nuclear fuel. About 35 years ago Congress laid out a plan for long-term disposal of spent fuel from the country’s nuclear reactors: the Nuclear Waste Policy Act (NWPA) of 1982. Since passage of that law, the government has consistently failed to meet key deadlines to remove spent fuel from the 99 operating commercial reactors at 59 sites around the country. Worse, there are now 17 reactors at 14 sites in 11 states that are no longer operating—reactors, such as at San Onofre in Southern California where the spent fuel will remain stuck onsite long after the rest of the site has been shut down and removed.

Safety of long-term storage in casks: Issues For San Onofre

Report of the Chairman of the Community Engagement Panel of the San Onofre Nuclear Generating Station

David G. Victor
9 December 2014

Los Angeles Times

Nuclear waste has been piling up across America with nowhere to go. Congress needs to act

By DAVID G. VICTOR, DAN STETSON and JERRY KERN JAN 24, 2019 | 3:05 AM
Defense-in-Depth

- Design
- Fabrication
- Operations, Maintenance & Security
- Inspection
- Remediation

Regulatory Oversight

Aging Management
SONGS Dry Fuel Storage Systems

- Required systems licensed for storage and transportation
- Required higher seismic design
- Thicker shell: 5/8-inch vs 1/2-inch (AREVA & Holtec canisters)
- 316L (low carbon) stainless steel (AREVA & Holtec canisters)
- Holtec enhancements to reduce susceptibility to CISCC:
  - Modified weld design to minimize heat input and reduce size of heat-affected zone
  - Over-rolled canister shells to minimize residual stresses
  - Laser peened welds to apply compressive stress to outer surface of welds
- Early development of Holtec Inspection & Maintenance program
Holtec Fabrication Improvement: Peening Canister Welds
SONGS Dry Fuel Storage Systems

- Inspection capability
  - SCE is working with EPRI, vendors, and suppliers
  - Developed robotic inspection capability for Holtec system
  - Qualifying AREVA inspection ring to inspect and characterize indications on AREVA canisters
Qualification of AREVA Inspection Ring Underway

- Qualification for use at SONGS in progress
  - Technical documentation to be final 3Q 2019
- Ring will allow for inspection of full canister shell if needed

Initial inspection with borescope  Secondary use of inspection ring, if needed
AREVA Inspection Ring Assembly
Holtec Canisters Inspections Employed Remote-Controlled Robot and Camera

- Remote-controlled robot
- Reached 99% of shell
  - Lower part of 3-inch-thick base plate not visible

- Measured depth and length of indications
Robotic Inspections of Holtec Canisters

- To understand wear from downloading, inspected 8 canisters
  - Most observed wear was very shallow at 0.000 to 0.005 inches
  - Deepest wear was .026 inches (< thickness of credit card)
  - ASME code conservatively allows for .0625 inches
- SCE’s conclusions (NRC independently verified results)
  - Wear marks are shallow and pose no safety significance
  - Passive oxide layer re-forms to protect from corrosion
  - Canister containment integrity remains robust
  - Inspection & Maintenance program will monitor over time
- Also demonstrated effectiveness of robotic inspections
SONGS Dry Fuel Storage Systems

- Mitigation approaches
  - Potential consequences negligible at ISFSI boundary
    - He overpressure inside canisters
    - No explosive force (dry internals; no Zr fire risk or H2 creation)
    - Confirmed with MPR evaluation
  - Mitigation Options (2 major options)
    - Weld repair: Developing capability to repair canister surface
    - Canister overpack: capability exists; some sites have onsite
# Aging Management Update

<table>
<thead>
<tr>
<th>System</th>
<th>Holtec UMAX</th>
<th>AREVA NUHOMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program</td>
<td>Inspection &amp; Maintenance (I&amp;M)</td>
<td>Aging Management Program (AMP)</td>
</tr>
<tr>
<td>Inspections</td>
<td>8 canisters inspected Spring 2019</td>
<td>Baseline canister inspections forecast 4Q 2021</td>
</tr>
<tr>
<td>Remediation</td>
<td>Evaluating ways to address degraded canister:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1) Robotic weld repair</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2) Encapsulation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3) Transportation cask storage</td>
<td></td>
</tr>
<tr>
<td>License Renewal</td>
<td>Required by 10/15/35</td>
<td>Submitted by vendor to NRC 5/22/19</td>
</tr>
<tr>
<td>Timing</td>
<td>I&amp;M program in place October 2020</td>
<td>AMP in place 4Q 2021</td>
</tr>
</tbody>
</table>
San Onofre Nuclear Generating Station