Regulatory Lessons to be Drawn from Industry Experience in Managing Material and Waste from Nuclear Decommissioning

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Dr. Charlotta E. Sanders
Senior Project Manager
Outline of Presentation

• Introduction of WNA
• Overview of Waste Management & Decommissioning (WM&D) Working Group Report
• An ERA of Decommissioning?
• Decommissioning Strategy
• Inventory
• Radioactive Waste Hierarchy
• Transportation
• Economics
• Global Updates
• Key Takeaway Items
WNA - A Strong Global Network of Members

Europe | 62 members
Austria, Belgium, Bulgaria, Czech Republic, Finland, France, Germany, Hungary, Italy, Luxembourg, Netherlands, Poland, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom

Russia and Central Asia | 14 members
Afghanistan, Kazakhstan, Russia, Uzbekistan

Americas | 45 members
Argentina, Bolivia, Brazil, Canada, USA

Africa and Middle East | 10 members
Egypt, Israel, Jordan, Kenya, Namibia, South Africa, United Arab Emirates

Asia-Pacific | 52 members
Australia, Bangladesh, China mainland and Taiwan, India, Indonesia, Japan, Singapore, South Korea

183 member companies
43 countries
Our Mission

We work with industry

We inform and communicate on nuclear energy

We train the leaders of tomorrow

We drive global action towards the Harmony goal
We develop industry positions on the issues that matter through our Members Groups

**Working Groups**

- **Fuel Cycle Working Groups**
  - Fuel Report
  - Sustainable Used Fuel Management
  - Transport
  - International Network for Safety Assurance of Fuel Cycle Industries

- **Plant Performance Working Groups**
  - Cooperation in Reactor Design Evaluation & Licensing
  - Supply Chain
  - Capacity Optimization
  - Waste Management & Decommissioning

- **Cross-Cutting Working Groups**
  - Radiological Protection
  - Law
  - Economics
  - Security

**Advisory Groups**

- Advisory Panel
- Communication Group
In February 2019, the WM&D Working Group published a report on the *Methodology to Manage Waste from Nuclear Decommissioning*.

The objective of this guidance report is to:

- Bring together key knowledge and expertise regarding management of material and waste
- Provide guidance to those facing new decommissioning challenges

An Era of Decommissioning?

- Following an increase of new build activity between 1960 to the early ’90s, an Era of Nuclear Decommissioning is dawning.
- International Energy Agency expects a “wave of retirements of ageing nuclear reactors” and an “unprecedented rate of decommissioning” – between 2014 and 2040.

Source: IAEA
An Era of Decommissioning?

- However, “many Member States … consider nuclear power as a proven, clean, dispatchable and economical technology that is expected to play an increasingly important role in improving energy supply security and mitigating climate change” (IAEA Status & Prospects 2017).
- 28 countries are interested in introducing nuclear power.
  - In 13 countries with a power program, these are either constructing new ones or actively completing previously suspended construction projects.
  - 16 countries have plans or proposals for building new reactors.

Source: Hartford Courant
An Era of Decommissioning?

- Even with projected nuclear new build projects, we have entered into an ERA of decommissioning.
  - Example: All of Germany’s reactors will be closed by the end of 2022 and Belgium’s will be closed by the end of 2025.

- The Era of Nuclear Decommissioning:
  - Potential drop in the number of operating reactors.
  - Decommissioning and waste management fund crunch.
  - Increased pressure on waste disposal/repository site access.
Challenge: Immediate or Deferred Dismantling

- Decisions on large-scale decommissioning and waste management projects have potentially far-reaching consequences on the local, regional and even national level.
- The major influences on determining the decommissioning strategy and the end states are normally outside the control of the plant operator.
<table>
<thead>
<tr>
<th>Cost Factors</th>
<th>Risk Factors</th>
<th>Regulatory Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>High cost due to the radioactive inventory</td>
<td>Higher radiological risks during dismantling and waste processing.</td>
<td>Regulator and stakeholder interface and approach is known and can be planned for</td>
</tr>
<tr>
<td>Lower lifetime costs &amp; minimal care and maintenance.</td>
<td>Funding requirements forecast over a shorter term with increased predictability.</td>
<td></td>
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<tr>
<td>Utilization of existing staff with key knowledge</td>
<td>Good knowledge and inventory processed to lower risk forms</td>
<td></td>
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<td>Potential cost benefits if limited alternative construction space for new build.</td>
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## Deferred Dismantling

<table>
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<tr>
<th>Cost Factors</th>
<th>Risk Factors</th>
<th>Regulatory Factors</th>
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</thead>
<tbody>
<tr>
<td>Preparation for care and maintenance</td>
<td>Deterioration of plant</td>
<td>Regulator and stakeholder requirements may change</td>
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<tr>
<td>Long term site management</td>
<td>Loss of knowledge and skills</td>
<td></td>
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<td>Lower dismantling cost</td>
<td>Closure of waste routes</td>
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<tr>
<td>Potential loss of value associated with the plant footprint.</td>
<td>Difficulty forecasting future economic conditions</td>
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In decommissioning VLLW is the main concern due to the expected large volume.

European Union radwaste inventory prior to the large decommissioning programs:

- ~90% Very low-level and low-level waste
- ~10% Intermediate-level waste
- ~0.2% High-level waste

Waste Categories per Volume

3.3 million m³

13
<table>
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<th>The Radioactive Waste Hierarchy</th>
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<tr>
<td><strong>Avoidance</strong></td>
</tr>
<tr>
<td><strong>Re-use</strong></td>
</tr>
<tr>
<td><strong>Recycling</strong></td>
</tr>
<tr>
<td><strong>Reclassification</strong></td>
</tr>
<tr>
<td><strong>Volume reduction</strong></td>
</tr>
<tr>
<td><strong>Disposal</strong></td>
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</tbody>
</table>
Transportation

- Transport of radioactive waste is frequently perceived to be problematic
- Generally not the case for solid waste, especially not for VLLW/LLW
- Transports are governed by specific internationally agreed regulations
- Standard sea containers can be used for most contaminated materials
- When implementing external treatment or disposal of large components, an efficient transport plan must be in place
- Regulator dialogue and stakeholder confidence is crucial
Decommissioning costs

- Time schedule is the main cost driver
- Waste management is a typical bottle neck
- Early fuel and efficient component and waste evacuation is crucial

Source: EPRI, Decommissioning Costs, #1023025
Before consent for decommissioning work to go ahead is given, an environmental impact assessment must be considered.

The regulation was updated in 2018 - The Nuclear Reactors (Environmental Impact Assessment for Decommissioning) (Amendment) Regulations 2018 – Statutory Instrument No. 834
In 2018, 21 nuclear power and early demonstration reactors were in decommissioning.

Oyster Creek ceased operations in late 2018 with Three Mile Island Unit 1 and Pilgrim permanently stopping power operations in 2019.

Additionally, operators in the U.S.A. have expressed their desire to cease operations of numerous reactors through the 2020’s.
In 2015, decisions were taken by plant owners to phase out the four oldest operating nuclear power reactors during the period 2017 – 2020.

Following decisions taken by the plant owners to permanently shutdown four reactors, licensees in Sweden are facing new challenges in the area of human resources.
Global Updates – Canada

- This regulatory document provides an overview of the framework for decommissioning nuclear facilities in Canada.
Global Update – Germany

- The German legal framework does not provide regulations specific to decommissioning. Decommissioning was integrated in the nuclear legislation.
FANR continues to focus on development of regulations and guides for the safety of waste management.

In 2015, they issued FANR-REG-21 “Decommissioning of Facilities” setting the safety requirements for all aspects of planned facility decommissioning from the siting and design of a facility to the termination of the license.
Key Takeaways

- Decommissioning strategy should be **clearly defined early** in decommissioning planning.
- **Time management, segregation, clearance/recycling and volume reduction** are key parameters for a successful decommissioning project.
- Ensure that waste handling and treatment/clearance never become bottle necks.
- **Early removal** of fuel, large components and waste will shorten decommissioning schedule and cut costs.
- Do not generate a waste without a defined outlet.
- The decommissioning landscape is and will undergo rapid change over the coming decades, as more and more sites speedily enter the decommissioning phase.
Thank you for your Attention

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