IEA NEA Nuclear Workshop
Update of the Nuclear Energy Technology Roadmap

Nuclear Decommissioning
Andreas Ehlert, January 2014
Decommissioning market is emerging and may reach up to EUR 20-30 bn cumulated until 2030 in Europe

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>E.ON plants¹</td>
<td></td>
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<tr>
<td>External plants</td>
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</tbody>
</table>

1 Based on extrapolation of historic approach to decommissioning with EON
2 Incl. other plants in Germany and 2-3 out of 10 plants that go after shut down into immed. dismantling in Belgium, Switzerland, Finland, France, Bulgaria, Czech Rep., Lithuania, Slovakia, UK
3 Incl. other plants in Germany and 1 out of 10 plants that go after shut down into immediate dismantling in Belgium, Finland, France and Switzerland

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Nuclear Decommissioning, Andreas EHLERT, EON January 2014
Point of departure: A nuclear decommissioning project is structured along 6 phases, duration 12yrs in Germany

1. Steering (planning / management)
2. Post operations
3. Service operations
4. Dismantling
5. Waste handling
6. Demolition

- End of commercial operations
- Removal of fuel elements
- Release from nuclear legislation
- „Green field“

- 3 – 5 years
- 10 years
- 2 years
E.ON gained substantial experience in the direct dismantling of Stade und Würgassen NPP

<table>
<thead>
<tr>
<th>Immediate dismantling ongoing</th>
<th>Immediate dismantling planned</th>
</tr>
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<tbody>
<tr>
<td><strong>NPPs</strong></td>
<td><strong>Isar I / Unterweser</strong></td>
</tr>
<tr>
<td>Shut down</td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>2011 / 2011</td>
</tr>
<tr>
<td>Start of dism.</td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>2018e / 2018e</td>
</tr>
<tr>
<td>Dism. duration</td>
<td></td>
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<tr>
<td>15 yrs. (ongoing)</td>
<td>10 yrs. (planned)</td>
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</tbody>
</table>

**Examples**

- Unplanned shut down (start of decom. from revision)
- Planned shut down on short-term notice (fuel transports and storage)
- Execution based on “small step approach” (dismantling, regulation)
- Dismantling approach based on critical path assessment
- Build-up of experience, decom. technology and process know-how
- Planning started during operations phase, know-how transfer ensured

**Capacity (MW)**

- **Würgassen**
  - 640
  - BWR
  - Decom. 2014 completed (exp.) w/o civil demolition

- **Stade**
  - 640
  - PWR
  - Decom. 2014 completed (exp.) w/o civil demolition

- **Isar I / Unterweser**
  - 878 / 1.345
  - BWR / PWR
  - Post operations (KKI/KKU)

**Capacity (MW)**

- **Type**
  - **Status**
  - Decom. 2014 completed (exp.) w/o civil demolition
**New Situation needs significant Change on all levels within a Nuclear Utility Organization**

<table>
<thead>
<tr>
<th>Operation</th>
<th>Decommissioning</th>
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</thead>
<tbody>
<tr>
<td>Highest focus on safety and quality on operation and maintenance (e.g. preventive)</td>
<td>Highest focus on safety and quality for non-commercial/post/residual operation</td>
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<tr>
<td>Fundamental safety functions (protection goals) are control reactivity, fuel cooling and to confine radioactive material</td>
<td>No more generation contribution, permanent checking and testing of requirement and measures</td>
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<td>Well known working environment</td>
<td>One-Time activities</td>
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<tr>
<td>High radiological inventory (nuclear risk)</td>
<td>Protection goal is to confine radioactive material (move to industrial risk)</td>
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<tr>
<td>Continuous and extensive training of staff for safe operation</td>
<td>Changed focus of organization to project orientation</td>
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<td>Commitment of staff towards long-term operation, fixed employment with routine objectives</td>
<td>Dynamic „Dismantling of organization“ with visible end of employment</td>
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</table>

**Preserve – Maintain – Invest**

**Shut-down – Reduction – Change**

Source: EON’s view and IAEA Tecdoc 1702, 2013: RINDAHL, Halden
We see four major areas for further technological development and improvements:

1. **RPV* and RPV internals**
   - Improve standardization
   - Reuse equipment
   - Simplify tools
   - Improve automation

2. **Waste treatment and recycling**
   - Improve automation of tools
   - More flexible remote controlled tools
   - “Intelligent tools to measure decontamination success”

3. **Decontamination & release measurement of surface**
   - Improve automation in currently personal intensive work
   - Improve techniques for decontamination
   - Leverage based on total amount of surface

4. **Disposal requirements**
   - Allow disposal of entire components
   - Improve disposal capacity for med /low active waste
   - Adjust release limits
   - Develop recycling options
   - Improve standardization

*) RPV = Reactor pressure vessel