Nuclear Decommissioning, a Utility’s Perspective

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Decommissioning
as legal action and time frame

Operation
Post operational Phase

Dismantling or Safe Enclosure
Nuclear Decommissioning, the German case
Nuclear in Germany, the post-Fukushima shock

Immediate and final closure of 8 of 17 nuclear units

that means

8409 out of 20457 MW
Nuclear in Germany, the outlook

NPP > 150 MW

Number of Plants in Operation

*post-Fukushima*: 13th Amendment of Atomic Law

Plants in operation

Plants in decommissioning

Greifswald, Unit 1-5
Gundremmingen, Unit A
Lingen
Muelheim-Kaerlich
Obrigheim
Stade
THTR-300
Wuergassen
Nuclear Decommissioning, key challenges
esp. under German conditions

Operating license: legal framework for multiyear post-operation phase.

Decom. license: required to start dismantling work.

Safety: preservation of vital safety functions in post-operation and dismantling phase
* highly motivated and competent key-staff required,
* under strict regulatory control.

Economics: minimization of cost burden under preservation of adequate safety levels.

Nuclear waste: clear solutions (esp. for final disposal) with significant delays
Nuclear Decommissioning in Germany, the market

The decommissioning market, ...

- in „paper work“ (esp. licensing activities) from now up to around 2025

- in „real“ dismantling activities from 2016 to around 2040

- in waste management solutions incl. final disposal until 2050
Nuclear Decommissioning, European outlook
**EU-27 plus Switzerland, NPP > 150 MW**

Simplified assumptions:
* operating times 60 years
* time frame for decom. and dismantling 25 years
* no multi-decade safe enclosures
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Decommissioning „boom“
around 2035 until 2075
Nuclear Decommissioning,

between proven processes and R&D-needs
Decommissioning, German experiences

NPP Kahl, „yesterday“

... and „today“

In general:
- extensive experiences in all phases of decommissioning since more than 2 decades
- technical feasibility in compliance with safety and radiation protection standards is proven
- necessary technology spectrum is available and was applied effectively several times
- qualified service providers are available
Decommissioning Process

1. Licencing process

... under national responsibility, especially German characteristics
... European harmonisation desirable

R&D:
support for licensing processes:
analyses tools plus improved measurements for the determination of (e.g. RPV) activation levels
Decommissioning Process

2. Dismantling of contaminated systems and components

3. Dismantling of activated components

For both steps
R&D: innovations in existing technologies

e.g. improved/quicker thermal cutting technologies with lower emissions, thus lower dose rates for workers, less secondary waste
Decommissioning Process

4. Dismantling of biological shield

R&D: innovations in existing technologies

- e.g. dust/dose-minimizing optimisations,
- improved robotics,
- diamond wire sawing technologies

5. Dismantling of remaining conventional components

R&D: „none“
Decommissioning Process

6  Final decontamination of buildings and structures

R&D:  progressive/quicker „macro“-measurement techniques, ideally with automisation, innovations in existing „micro“/manual technologies
Decommissioning Process

7 Conventional demolishing of buildings, towards a “green meadow”

R&D: „none“
Bottle neck for economic decommissioning (in Germany)

... waste management at the back-end

(Regulation for)
Radioactive waste treatment, conditioning and packaging for final disposal,

Licensing, exploration, erection and construction of disposal sites

R&D-support, especially for a harmonized (inter)national regulation, desirable
Conclusion

- At least German utilities incl. RWE with a solid expertise in all aspects of decommissioning
- Industrial market for dismantling well established with growing trend
- R&D-challenges in the areas of ...:
  * innovations in existing decommissioning technologies
  * waste treatment towards „readiness“ for final disposal
  * safety criteria for final repositories
Back up
Final Disposal – Volumes and masses

Final disposal volumes of conditioned waste from Decommissioning of all German nuclear power plants ca. 135,000 m³ (equivalent to a cube with an edge length of 51 m)

Example: typical PWR

Mass of radioactive waste for final disposal: ca. 2.5 % of total mass

Total mass of radiologically controlled area: 156.600 t
## Final repository sites Konrad & Gorleben

<table>
<thead>
<tr>
<th>Konrad</th>
<th>Gorleben</th>
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<tbody>
<tr>
<td>Final repository for non-heat-generating waste (low- and intermediate-level waste, also medical waste)</td>
<td>Final repository for heat-generating waste (fuel rods, waste from reprocessing etc.)</td>
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<tr>
<td>• Former ore mine (1957 – 1976)</td>
<td>• Unused salt dome</td>
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<tr>
<td>• Consented for 303,000 m³ of waste packages, sufficient for all non-heat-generating waste from operation and decommissioning</td>
<td>• Begin of selection process from 140 salt domes in the 70ies, Federal government selected Gorleben in 1977</td>
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<td>• Approx. 95% of total waste volume is non-heat-generating</td>
<td>• Exploration 1979 to 1999, moratorium in 2000</td>
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<td>• Planning approval procedure started in 1982</td>
<td>• Moratorium ceased in 2010, next steps:</td>
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<td>• Consent in 2002, last instance in 2007</td>
<td>- exploration continues</td>
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<td>• Costs so far: 1.7 billion €*</td>
<td>- preliminary safety analysis</td>
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<tr>
<td>• Total costs: ca. 2.6 billion €</td>
<td>- international Peer Review</td>
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* Commissioning before 2020 expected

** Commissioning in 2030ies possible

* Utility share: 64.4%
** Utility share: 96.5%