Decommissioning Projects
at the
Nuclear Research Center Karlsruhe

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Executive Director

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Contents of the presentation

- Situation in Germany concerning decommissioning of nuclear facilities
- Overview of the activities of the company EWN and the status of decommissioning of nuclear facilities on the premises of the Karlsruhe research center
- Recommendations of lessons learned
## Research Reactors in Germany with Thermal Outputs of 0.1 MW and more

<table>
<thead>
<tr>
<th>Research reactor</th>
<th>MW&lt;sub&gt;th&lt;/sub&gt;</th>
<th>Operation</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRMZ Mainz (TRIGA)</td>
<td>0.1</td>
<td>1965-1958</td>
<td>in operation</td>
</tr>
<tr>
<td>FRG-1, GKSS Geestacht Research Center</td>
<td>5</td>
<td>1963-1958</td>
<td>decommissioned</td>
</tr>
<tr>
<td>BER-2, Hahn-Meitner Institute Berlin</td>
<td>19</td>
<td>1963-</td>
<td>in operation</td>
</tr>
<tr>
<td>FRJ-2, Jülich Research Center</td>
<td>23</td>
<td>1962-</td>
<td>decommissioned</td>
</tr>
<tr>
<td>FRM-II, University of Munich</td>
<td>20</td>
<td>2003-</td>
<td>in operation</td>
</tr>
<tr>
<td>HD TRIGA II Heidelberg</td>
<td>0.25</td>
<td>1978-1957</td>
<td>dismantled</td>
</tr>
<tr>
<td>FRM, University of Munich</td>
<td>4</td>
<td>1973-1966</td>
<td>decommissioned</td>
</tr>
<tr>
<td>FRH TRIGA, Medical University Hanover</td>
<td>0.25</td>
<td>1978-1966</td>
<td>decommissioned</td>
</tr>
<tr>
<td>FMRB, PTB Braunschweig</td>
<td>1</td>
<td>1967-1995</td>
<td>decommissioned</td>
</tr>
<tr>
<td>FRN, GSF Neuherberg/Munich</td>
<td>1</td>
<td>1972-1982</td>
<td>decommissioned</td>
</tr>
<tr>
<td>FRF-2, University of Frankfurt</td>
<td>1</td>
<td>1977-1983</td>
<td>decommissioned</td>
</tr>
<tr>
<td>RFR, VKTA Rossendorf</td>
<td>10</td>
<td>1957-1991</td>
<td>under dismantling</td>
</tr>
<tr>
<td>FRJ-1, Jülich Research Center</td>
<td>10</td>
<td>1962-1985</td>
<td>under dismantling</td>
</tr>
<tr>
<td>FRG-2, GKSS Geestacht Research Center</td>
<td>15</td>
<td>1963-1995</td>
<td>decommissioned</td>
</tr>
<tr>
<td>NS Otto Hahn (nuclear ship)</td>
<td>38</td>
<td>1968-1979</td>
<td>dismantled</td>
</tr>
<tr>
<td>FR 2, Karlsruhe Research Center</td>
<td>44</td>
<td>1961-1981</td>
<td>in safe enclosure</td>
</tr>
</tbody>
</table>
### Nuclear Power Plants and prototype reactors in Germany, which are currently being decommissioned

<table>
<thead>
<tr>
<th>NPP unit</th>
<th>MW&lt;sub&gt;e&lt;/sub&gt;</th>
<th>Operation</th>
<th>Plant type</th>
</tr>
</thead>
<tbody>
<tr>
<td>MZFR, Karlsruhe Research Center</td>
<td>58</td>
<td>1965-84</td>
<td>Heavy water-moderated PWR</td>
</tr>
<tr>
<td>KKR, Rheinsberg</td>
<td>70</td>
<td>1966-90</td>
<td>Pressurized water reactor of Soviet design</td>
</tr>
<tr>
<td>KGR-1, Greifswald</td>
<td>440</td>
<td>1973-90</td>
<td></td>
</tr>
<tr>
<td>KGR-2, Greifswald</td>
<td>440</td>
<td>1974-90</td>
<td></td>
</tr>
<tr>
<td>KGR-3, Greifswald</td>
<td>440</td>
<td>1977-90</td>
<td></td>
</tr>
<tr>
<td>KGR-4, Greifswald</td>
<td>440</td>
<td>1979-90</td>
<td></td>
</tr>
<tr>
<td>KGR-5, Greifswald</td>
<td>440</td>
<td>1989-90</td>
<td></td>
</tr>
<tr>
<td>KMK, Mühlheim-Kärlich</td>
<td>1219</td>
<td></td>
<td>PWR, did not take up operation due to court order</td>
</tr>
<tr>
<td>VAK, Kahl</td>
<td>16</td>
<td>1960-85</td>
<td>Boiling water reactor</td>
</tr>
<tr>
<td>KRB-A, Gundremmingen</td>
<td>250</td>
<td>1966-77</td>
<td></td>
</tr>
<tr>
<td>KW L, Lingen</td>
<td>254</td>
<td>1968-77</td>
<td></td>
</tr>
<tr>
<td>HDR, Karlstein/Kahl, green field</td>
<td>25</td>
<td>1969-71</td>
<td></td>
</tr>
<tr>
<td>KWO, Obrigheim</td>
<td>340</td>
<td>1968-2005</td>
<td>Pressurized water reactor (PWR) PWR</td>
</tr>
<tr>
<td>KKS, Stade</td>
<td>640</td>
<td>1972-2005</td>
<td></td>
</tr>
<tr>
<td>KWW, Würgassen</td>
<td>670</td>
<td>1971-95</td>
<td>Boiling water reactor</td>
</tr>
<tr>
<td>KKN, Niederaichbach, green field</td>
<td>106</td>
<td>1972-74</td>
<td>Gas-cooled, heavy water-moderated reactor</td>
</tr>
<tr>
<td>AVR, Jülich</td>
<td>15</td>
<td>1966-88</td>
<td>Gas-cooled high-temperature reactor</td>
</tr>
<tr>
<td>THTR 300, Hamm-Uentrop</td>
<td>308</td>
<td>1984-88</td>
<td></td>
</tr>
<tr>
<td>KNK-II, Karlsruhe Research Center</td>
<td>20</td>
<td>1977-91</td>
<td>Sodium-cooled reactor</td>
</tr>
<tr>
<td>SNR 300, Kalkar</td>
<td>300</td>
<td>No operation</td>
<td>Completely dismantled</td>
</tr>
</tbody>
</table>
### Fuel Element Fabrication Facilities and Reprocessing
(without facilities in large-scale institutions)

<table>
<thead>
<tr>
<th>Location</th>
<th>Fabrication</th>
<th>Operator</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reprocessing facilities (WAK)</td>
<td>Uranium, PU</td>
<td>WAK/FZK</td>
<td>Operation 1972-91 under dismantling</td>
</tr>
<tr>
<td>NUKEM-old, Hanau</td>
<td></td>
<td>Nukem</td>
<td>Operation 1962-88 dismantling completed</td>
</tr>
<tr>
<td>NUKEM 2, Hanau</td>
<td></td>
<td>Nukem</td>
<td>Did not take up operation</td>
</tr>
<tr>
<td>HOBEG, Hanau</td>
<td>Fuel spheres for HTR</td>
<td>Hobeg</td>
<td>Operation 1972-88 dismantling completed</td>
</tr>
<tr>
<td>Uranium processing facility, Hanau</td>
<td></td>
<td>Siemens</td>
<td>Operation 1969-94 dismantling completed</td>
</tr>
<tr>
<td>MOX facility (old), Hanau</td>
<td>Mixed-oxide fuel elements</td>
<td>Siemens</td>
<td>Operation 1969-91 dismantling completed</td>
</tr>
<tr>
<td>MOX facility (new), Hanau</td>
<td></td>
<td>Siemens</td>
<td>Given up during construction (95% completed)</td>
</tr>
<tr>
<td>Fuel element fabrication facility, Karlstein</td>
<td></td>
<td>Siemens</td>
<td>Operation 1982-96, decommissioned, under dismantling</td>
</tr>
<tr>
<td>ANF Lingen</td>
<td></td>
<td>ANF</td>
<td>Operation since 1979</td>
</tr>
<tr>
<td>URANIUM Mines WISMUT</td>
<td>Uranium</td>
<td>WISMUT</td>
<td>Shut down 1991 remediation of the sites, nearly completed</td>
</tr>
</tbody>
</table>
Situation today

Decisions in 1989/90

- fast breeder reactor SNR-300 in Kalkar was not commissioned
- not to construct the industrial reprocessing plant at Wackersdorf

Major amendments of Atomic Energy Act 2002

- Use of nuclear energy is limited (17 NPP in operation today)
  - agreement between utility-companies and government
  - the last NPP will be shut down in 2020

- No new nuclear power station will be constructed
- Reprocessing of nuclear fuel is prohibited after year 2005
The EWN-Group

Task of EWN: decommissioning and waste management of nearly all nuclear facilities belonging to the public.
The EWN-Group

Interim Storage North (ZLN)

Reactor Dismantling

EWN / ZLN GmbH
Greifswald
The EWN-Group

Transport of the Reactor Vessel
The EWN-Group

Dismantling of the High-Temperature Reactor
Situation of the Karlsruhe Research Center

Universität Karlsruhe (TH) + Forschungszentrum Karlsruhe = KIT

Research

WAK Nuclear Plants
Aerial View from the North to the Reactor Decommissioning Projects

FR2

2012

MZFR

2025

2013

KNK
Multipurpose Reactor (MZFR)

1961 – 1965
Construction

1965 – 1984
Operation

1984 – 2012
Dismantling
Compact Sodium Cooled Nuclear Reactor Facility (KNK)

1966 – 1969 Construction

1971 – 1991 Operation

1991 – 2013 Decommissioning
Future Project: Decommissioning of the Hot Cells (HZ)

2009 – 2012
Dismantling of the first sections
FR 2  Research Reactor

D2O-moderated research reactor
44 MWth (neutron source)
Operation 1961-1981

Dismantling of experimental loops primary and secondary system

Safe enclosure of the reactor block
1991 – 1996

Decision today
complete dismantling
- easy tools for remote dismantling available
- overall costs with dismantling after 30 year much higher
Nuclear Facilities Decommissioning Division at a Glance

- Karlsruhe Multi-Purpose Research Reactor
  - 2012

- Compact Sodium-Cooled Nuclear Reactor Facility
  - 2013

- Central Decontamination Department (HDB)
  - 2080

- Karlstein Superheated Steam Reactor
  - 1998

- Niederaichbach Nuclear Power Plant
  - 1995

- Karlsruhe Reprocessing Plant
  - 2023

- Karlsruhe Research Reactor 2
  - 2025
Fuel Reprocessing Plant WAK

Reprocessing Building

- 2000 t of process equipment dismantled
- out of it 100 t remote controlled
- 1200 t of debris disposed
- 98% of the radioactive inventory (4.8E14 Bq) disposed of as low active waste (interim storage)
Fuel Reprocessing Plant WAK

Reprocessing Building
- 2000 t of process equipment dismantled, out of it 100 t remote controlled
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Reprocessing Building

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**Fuel Reprocessing Plant WAK**

**HLLW-Storage Facilities**
- 60 m³ HLLW, 7.7E17 Bq, 500 kg Uran, 16.5 kg Plutonium
- LAVA in operation
- HWL out of operation (spare storage after maintenance)
- HLLW facilities technically separated
Fuel Reprocessing Plant WAK

Liquid fed ceramic melter
- HLLW feeding rate 10 dm³/h
- Glass production rate 6.7 kg/h
- Joule heating 35 kW
- Glass tank capacity 400 kg
Waste Treatment and Storage at the EWN Group

Mother
EWN GmbH

Subsidiary
AVR GmbH

Subsidiary
WAK GmbH

waste production

NPP Greifswald
NPP Rheinsberg

waste treatment and storage

ZLN Greifswald
Research Center Jülich

final disposal

Gorleben (from 2040+)
KONRAD (from 2014)
ERAM (until 1998)

Research Center Karlsruhe / HDB
ASSE (until 1978)
Waste Management Facilities (HDB)

- Decontamination
- Disassembling
- Compaction
- ILW Handling
Radioactive Waste Processing Paths

- **Solid Wastes**
  - preliminary treatment
  - sorting/crushing/decontamination
    - casting/filling
    - compaction
    - drying
  - solidification/cementation
  - vitrification
  - packaging
  - intermediate storage
    - repository storage of non-heat-generat. waste
    - repository storage of heat-generat. waste
  - disposal paths
    - unlimited reuse
    - melting

- **Liquid Wastes**
  - incineration
  - evaporation
  - repository storage of non-heat-generat. waste
  - disposal paths
    - melting

Repository GORLEBEN
Repository KONRAD
Waste Management Facilities (HDB)

Product Control

Interim Storage
Contents of the presentation

- Situation in Germany concerning decommissioning of nuclear facilities
- Overview of the activities of the company EWN and the status of decommissioning of nuclear facilities on the premises of the Karlsruhe research center
- Recommendations of lessons learned
Preparing D&D Work

First Step:
- Complete recording of the nuclide inventory
  (nuclide composition / level of contamination)
- Documentation of construction and building
  (e.g. installation)

Second step:
- Upgrade of safety barriers
  (no spread of contamination outside and to the staff)
- Upgrade of ventilation systems including control systems of
  released radioactivity
- Upgrade of cranes
D&D Strategies

- Complete decommissioning including waste management
- Partitioning of the whole decommissioning project in different parts (manageable duration), each with own license
- Basic rules for D&D:
  - as simple as possible
  - if possible, using standard tools for dismantling
If possible, waste management on site

Necessary waste management facilities:

- Treatment of liquids (evaporation, cementation)
- Possibilities for decontamination and release of materials
- Cementation of concentrates and solid waste
- Super compaction
- When indicated, facility for drying (increases long time stability of the waste)
- Existence of adequate and proofed mobile facilities
Basic Conditions for Waste management

- Possibilities for clearance
  (to be established by authorities)

- Safe interim storage
  (even for longer periods of time)

- Final disposal
Waste Management

Immediate packing of the waste using

- Drums

- MOSAIK containers

- Containers (stackable and stable)
Summary

- Germany has a lot of D&D experiences
- Experience of the Karlsruhe Decommissioning projects and of waste management can be used for smaller nuclear facilities and laboratories

I wish you a pleasant week with a lot of impressions and information which are useful for your own decommissioning projects