

Spent Fuel Management in Germany


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Outline:

1. Use of Nuclear Energy
2. Interim Storage of Spent Nuclear Fuel
3. Considerations towards Disposal
4. Conclusions

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1. Use of Nuclear Energy

Legal framework:

- Basic Law (Grundgesetz – GG)**
- Atomic Energy Act (Atomgesetz - AtG)**
- Radiation Protection Ordinance (StrlSchV)**

Until 2011:

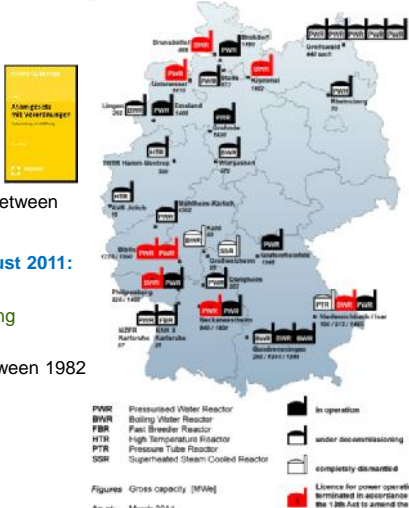
- 17 NPPs (11 PWR + 6 BWR) starting operation between 1975 and 1989 with 21,5 GWe

13th amendment of the Atomic Energy Act in August 2011:

- Immediate shut down of 8 NPPs
 - For 7 NPPs decommissioning and dismantling applications were filed by Oct. 2013
- 9 NPPs (7 PWR + 2 BWR) starting operation between 1982 and 1989 with 12,7 GWe

Further reactor shut down dates:

- Dec 31, 2015, 2017, 2019 one reactor each
- Dec 31, 2021 and 2022 three reactors each



Legend:

- PWR Pressurised Water Reactor
- BWR Boiling Water Reactor
- FBR Fast Breeder Reactor
- HTR High Temperature Reactor
- PTR Pressure Tube Reactor
- SSR Superheated Steam Cooled Reactor

Status:

- In operation
- under decommissioning
- completely dismantled

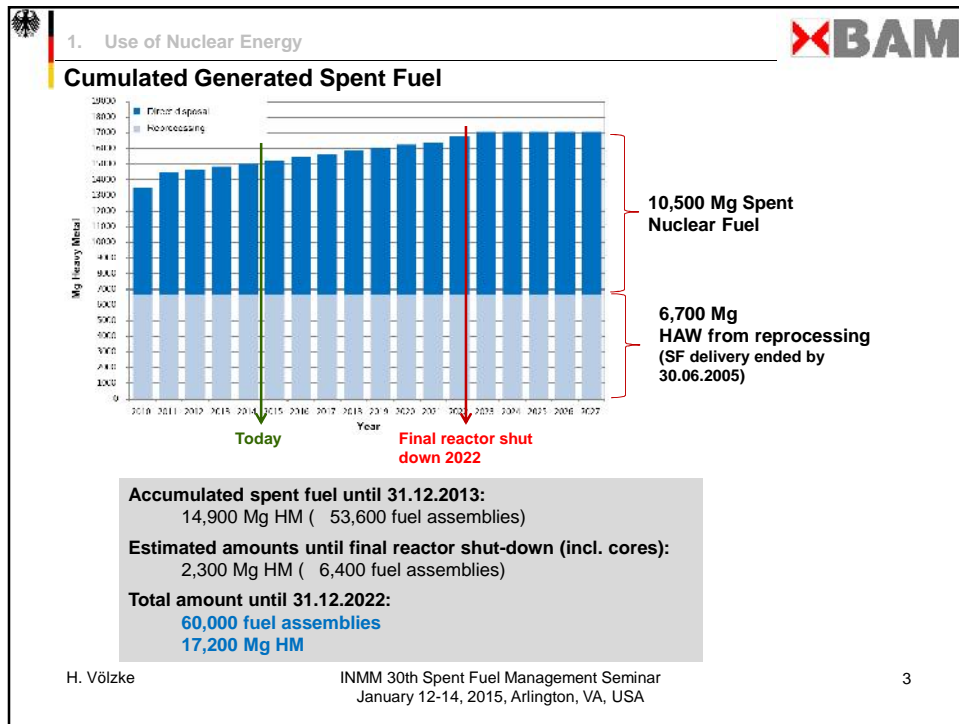
Other:

- Licence for power operation terminated in accordance with the 13th Act to amend the Atomic Energy Act

Figures: Gross capacity [MWe]
As at: March 2014


Source: BMUB, Report of the Federal Republic of Germany for the Fifth Review Meeting in May 2015 (IAEA Joint Convention)
<http://www.bmub.bund.de/en/topics/nuclear-safety-radiological-protection/nuclear-safety/downloads/>

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2. Interim Storage of Spent Nuclear Fuel **XBAM**

Atomic Energy Act (AtG)
Radiation Protection Ordinance (StrISchV).




➔ The storage of nuclear fuel, including spent fuel and radioactive waste with significant contents of fissile material requires (if the proportion of certain uranium and plutonium isotopes exceed the limits specified § 2, para. 3 AtG) a **License under § 6 AtG**.

➔

- § 6 AtG is not a plant license, but a so-called activity-related license.
- The license according to § 6 AtG is a bound decision which means that it is to be granted without discretion if the conditions stated in § 6, para. 2 AtG are fulfilled.

The **licensing authority** in this instance is the **Federal Office for Radiation Protection (BfS)**, while supervision is performed by the competent authority of the respective “Land” (Federal State).

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2. Interim Storage of Spent Nuclear Fuel 

The recommendations of the

- Reactor Safety Commission (RSK) est. 1958,
- Commission on Radiological Protection (SSK) est. 1974,
- **Nuclear Waste Management Commission (ESK)**, est. on June 12, 2008,

play an important role with respect to licensing and supervisory procedures.

➔ These independent expert commissions advise the **Federal Environment Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)** on issues relating to nuclear safety, radiation protection and the management of radioactive waste and spent fuel.

➔  **“Guidelines for Dry Cask Storage of Spent Fuel and Heat-generating Waste”**
 German Waste management Commission (ESK), Revised version of 10.06.2013,
<http://www.entsorgungskommission.de/englisch/downloads/eskempfehlungenesk3011berefassung10062013en.pdf>

“ESK-Guidelines for Periodic Safety Inspections and Technical Ageing Management for Interim Storage Facilities for Spent Nuclear Fuel and Heat-generating Radioactive Waste”
 German Waste management Commission (ESK), Version of 13.03.2014,
<http://www.entsorgungskommission.de/downloads/empfehlungsuz13032014homepage.pdf>

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2. Interim Storage of Spent Nuclear Fuel 

Storage Licenses issued by BfS contain all relevant safety evaluations to satisfy the protection goals

- * safe enclosure * shielding * subcriticality * heat dissipation

under operational and accidental conditions of the specific storage facility and define conditions and requirements for safe and secure operation.

Recent improvements of regulatory guidance were mainly initiated by


- The requirements for the interim storage in **Council Directive 2014/87/EURATOM amending 2009/71/EURATOM** establishing a Community framework for the nuclear safety of nuclear installations, 08 July 2014 (25 June 2009)
 Ę http://ec.europa.eu/energy/nuclear/safety/safety_en.htm
- Ę <http://www.bmub.bund.de/en/topics/nuclear-safety-radiological-protection/nuclear-safety/legal-provisions-technical-rules/eu-adopts-amended-directive-on-nuclear-safety/>
- The **Report on the Radioactive Waste Disposal Safety Reference Levels of the Western European Nuclear Regulators Association (WENRA)** 22 Dec. 2014 Ę <http://www.wenra.org>

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2. Interim Storage of Spent Nuclear Fuel **BAM**

Dry Spent Fuel and HLW Storage Concept
(as defined by ESK guidelines and storage licenses)

- Accident safe dual purpose transport and storage casks
- Valid Type B(U) approval required before loading and during storage to guarantee permanent transportability
- Monolithic thick walled metal cask body
- Vacuum dried and helium filled (800 hPa) cask interior
➔ inert conditions
- Permanently monitored bolted double barrier lid system equipped with metal seals
- Qualified repair concept in case of hypothetical lid failure
- Casks stored inside buildings
- Current storage licenses limited to 40 years



Interim Storage Facility at Isar NPP

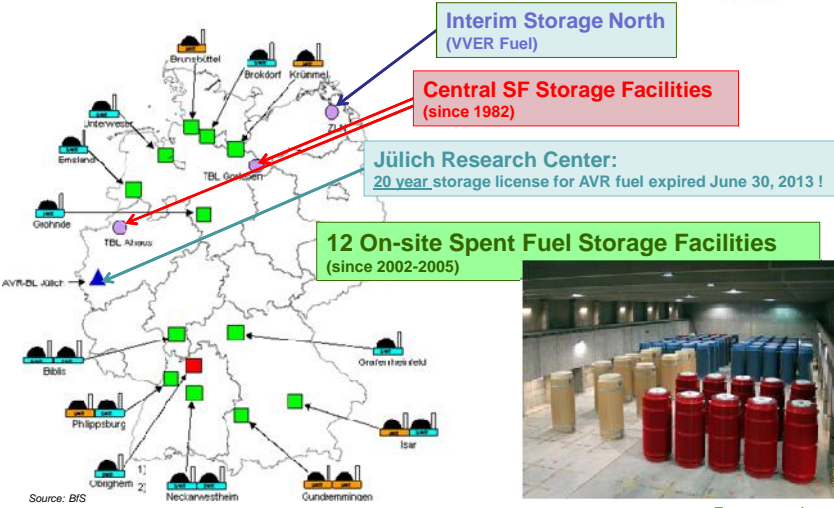


Photos: GNS



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2. Interim Storage of Spent Nuclear Fuel **BAM**



Interim Storage North (VVER Fuel)


Central SF Storage Facilities (since 1982)

Jülich Research Center:
20 year storage license for AVR fuel expired June 30, 2013!

12 On-site Spent Fuel Storage Facilities (since 2002-2005)


Source: BfS

At present 1,000 dual purpose casks of various types are in use for dry storage of SNF and HLW - at 16 storage sites (12 on-site)




Transport and storage casks in the Transport Cask Storage Facility Gorleben (Photo: GNS)

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3. Considerations towards Disposal



Spent Fuel Management Policy and Practices ruled by the Atomic Energy Act (AtG)

Initial concept:

- Centralized interim storage for up to 40 years (Ahaus, Gorleben)
- Pilot Conditioning Plant and deep geological disposal in a salt dome (Gorleben)
- Repository available until 2035

Since 1994 two options: Reprocessing or direct disposal

Since 2005 only direct disposal including subsequent interim storage remained

➔ 12 On-site interim storage facilities + Gorleben + Ahaus + AVR facility Jülich + VVER Interim Storage North

Since 2011 after the Fukushima event

➔ **Phase out decision** shutting down 8 NPPs immediately and the remaining 9 until the end of 2022


„Repository Site Selection Act“ entering into force on July 27, 2013

➔ **Final site selection for a repository until 2031**


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3. Considerations towards Disposal



Change of disposal policy by new „Repository Site Selection Act“ entering into force on 27 July 2013.

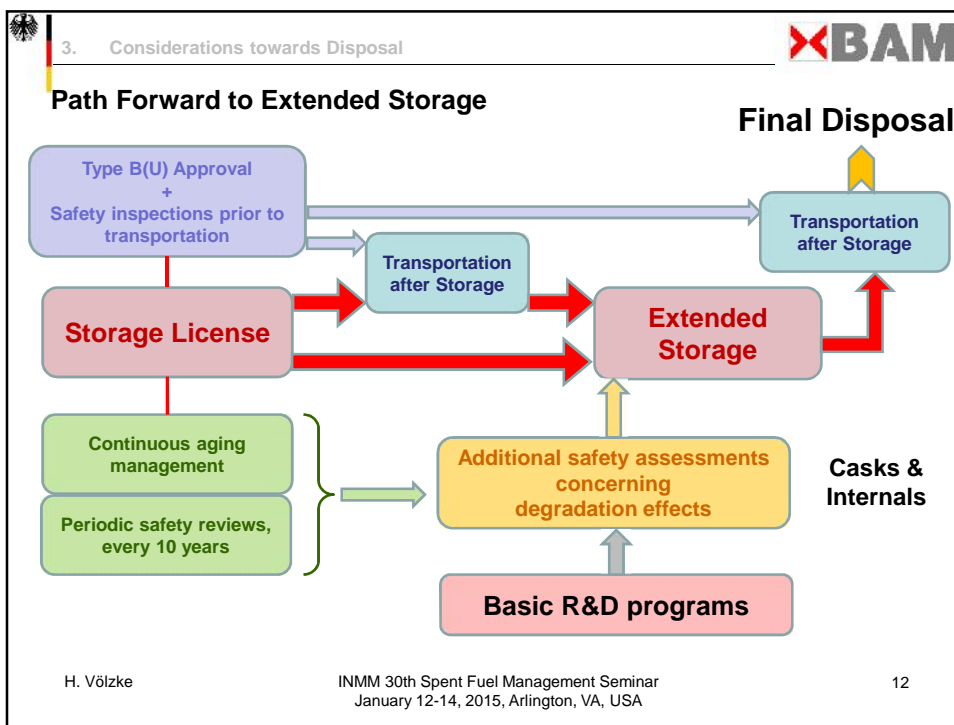
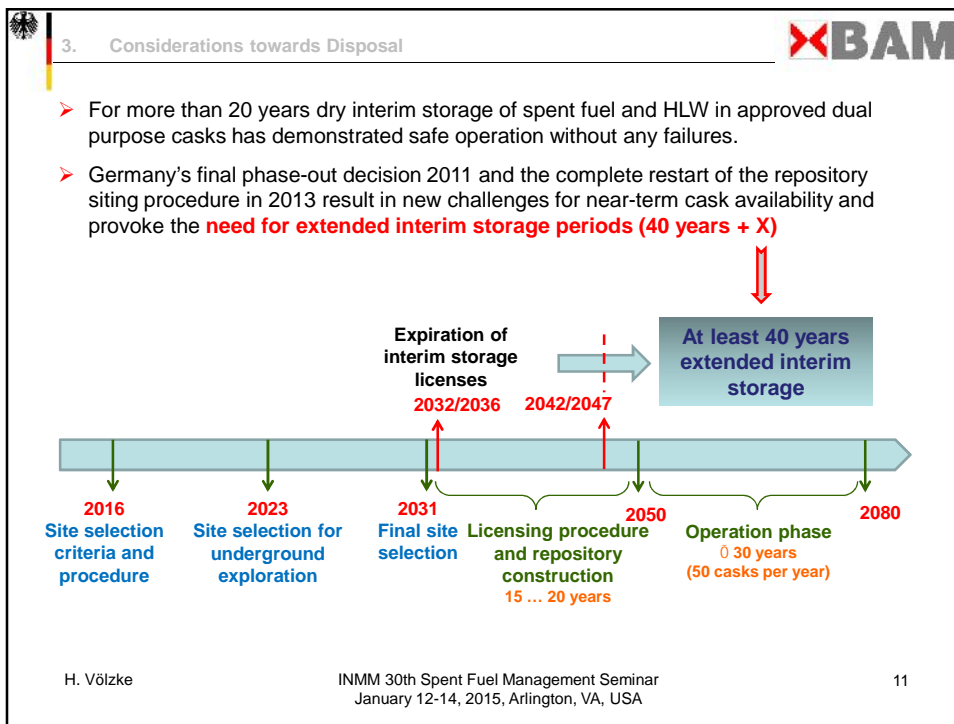
- Site selection procedure will be prepared by a 33 member commission comprising all parts of society:
 - 1 chairman/chairwoman
 - 8 scientists
 - 8 representatives from social stakeholder organizations
 - 8 members from the German parliament (Bundestag)
 - 8 ministers representing the states (“Länder”)
- The commission is to draw up and present proposals concerning i.a. security requirements and geological selection/exclusion criteria by the end of 2015.
- All parts of Germany are taken into consideration for site selection.
- Establishment of a Federal Institute for Nuclear Disposal in 2014/15 responsible for the site selection procedure, site proposals, exploration programs and evaluation criteria.
- Site selection for subsequent underground exploration until 2023
- Repository site selection to be completed by 2031

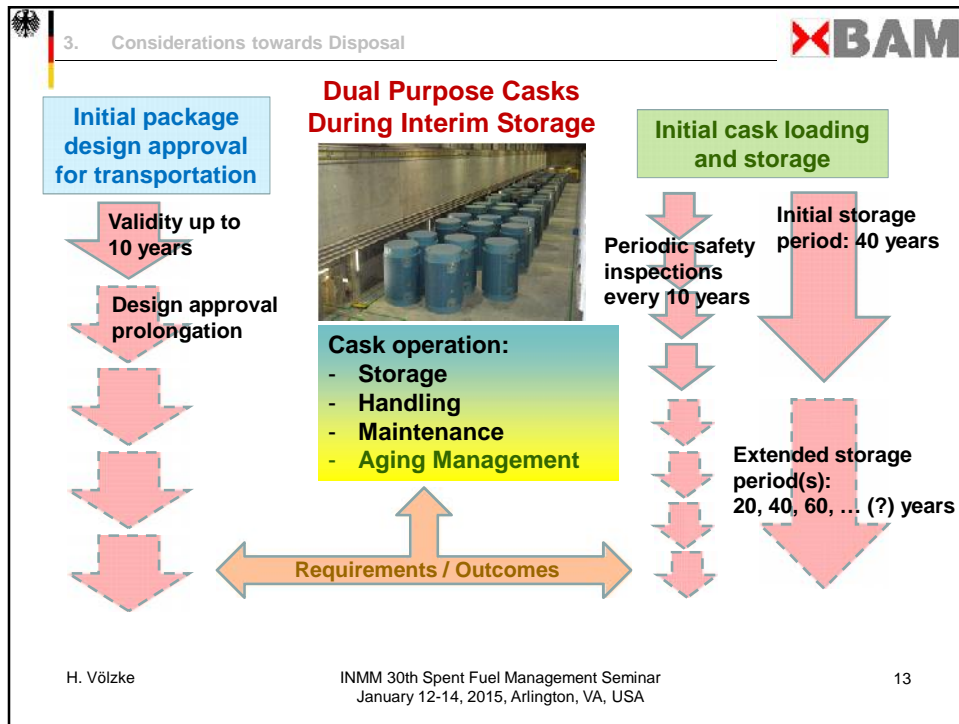
The final site selection is followed by licensing procedure and construction of the repository

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4. Conclusions **BAM**

- For more than 20 years dry interim storage of spent fuel and HLW in approved dual purpose casks has demonstrated safe, secure, reliable, and flexible operation without any failures.
- Germany's final phase-out decision 2011 and the complete restart of the repository siting procedure in 2013 result in new challenges for near-term cask availability and provoke the need for extended interim storage periods.
 - ➔ Extended storage periods of 80 years or even more are most likely
- Storage and transportation (after storage) are closely linked
 - ➔ Further improvement of the regulatory framework gives valuable support
 - ➔ Aging management issues should be addressed in a holistic approach
- Additional safety demonstrations and material data for the long-term concerning casks and inventory will be required in the future and should consider both storage and transportation needs.
- First R&D initiatives have already been started by BAM focussing on metal seals, polymers for neutron shielding, and elastomer seals.

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4. Conclusions 

➤ **Other challenges comprise**

- ➔ **Additional storage licenses (and transport design approvals) concerning**
 - All specific fuel data (PWR and BWR) from remaining NPP operation
 - Storage of defect fuel assemblies
 - HLW return from UK to other on-site storage facilities instead of Gorleben
- ➔ **60 – 80 dual purpose casks to be manufactured and loaded annually during the next decade**
- ➔ **Decommissioning and dismantling of NPPs and finally separate operation of all storage facilities**
- ➔ **Knowledge management during phase out and beyond nuclear power plant operation is a major issue**
- ➔ **R&D needs concerning suitable cask designs for disposal taking into account various host rock formations, the existing cask fleet and potential fuel conditioning/repacking needs.**

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