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ENTRIA

DISPOSAL OPTIONS FOR RADIOACTIVE RESIDUES:
INTERDISCIPLINARY ANALYSES AND
DEVELOPMENT OF EVALUATION PRINCIPLES

Storage of High Level Waste

19th REFORM Group Meeting. Session Introduction: Roles of storage

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Outline

- Storage: An undertaking with limited duration.
- Roles of storage when managing radioactive materials / waste
- Timescales
- Storage options
- Perception of storage

Storage

The holding of radioactive sources, spent fuel or radioactive waste in a facility that provides for their/its containment,
with the intention of retrieval.

… as opposed to disposal:

Emplacement of waste in an appropriate facility
without the intention of retrieval.

…

The term disposal implies that retrieval is not intended; it does not mean that retrieval is not possible.

(IAEA Safety Glossary, 2007)

Therefore, ...

- … storage is always a temporary / interim measure.
- Storage facilities have a limited lifetime (typically decades, up to one century) – both from a technical and a licensing point of view.
- Storage is needed as interim step(s) in every waste management strategy → next slide

Storage as interim step(s) in waste management strategies (variant 1: no reprocessing, “direct” disposal)

- Spent nuclear fuel (SNF) discharged from reactor
- Storage at power plant until heat generation is low enough for transport
- Transport (?)
- Storage (?) at power plant or elsewhere, awaiting encapsulation and disposal
- Transport (?)
- Storage (?) at disposal site awaiting encapsulation
- Encapsulation
- Storage awaiting disposal
- Disposal (so-called „direct disposal“)

Storage as interim step(s) in waste management strategies (variant 2: reprocessing)

- Spent nuclear fuel (SNF) discharged from reactor
- Storage at power plant until heat generation is low enough for transport
- Transport
- Storage at reprocessing plant
- Reprocessing

  Liquid High-level waste (HLW) | Uranium & Plutonium
- Vitrification

  Vitrified HLW
- Storage at reprocessing plant | Storage at reprocessing plant
- Transport | Transport
- Storage awaiting encapsulation | Storage awaiting decision on re-use
- Encapsulation | Re-use or …
- Storage awaiting disposal
- Disposal

Obviously, „storage“ is not the same as „storage“:

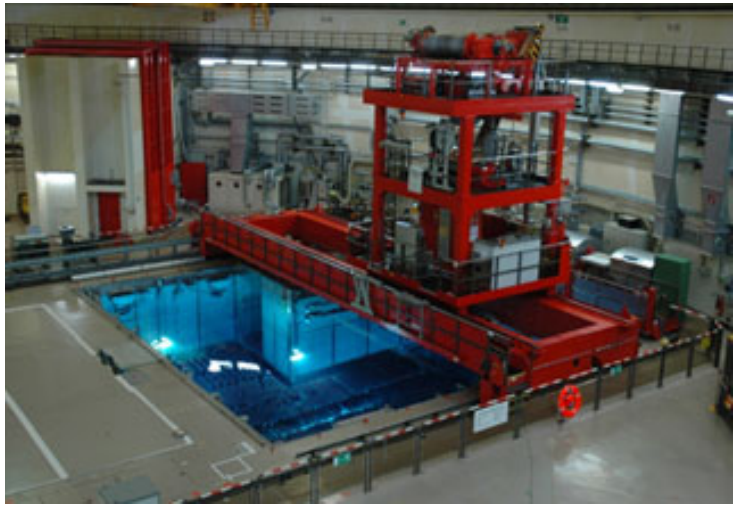
It has a variety of roles / functions within waste management strategies which, inter alia, determine layout and lifetime of storage facilities:

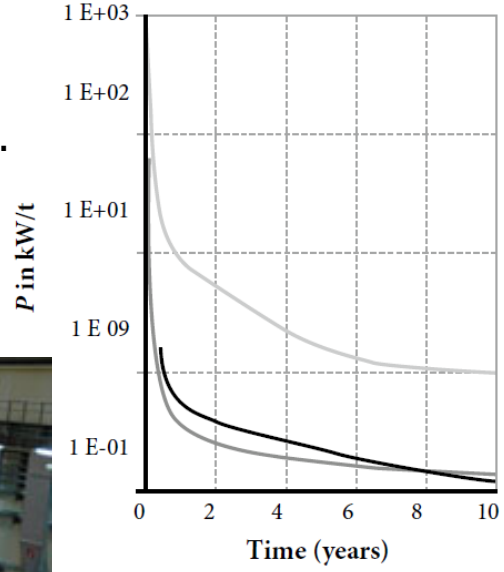
- To allow levels of radioactivity & heat generation to decline before the next step or process can be enacted: decay storage
- To provide stock for an ongoing process, transport step or disposal: buffer storage
- To await a step for which the required facility (e.g. a repository) or transportation capability are not yet available or to await a decision on the next step: interim storage
- To await potential future use (or otherwise) (material not or not yet declared as waste, e.g. U & Pu from reprocessing): strategic storage

see https://www.oecd-nea.org/rwm/reports/2006/nea6043-storage.pdf
note disagreement with IAEA on the use of the term „interim storage“

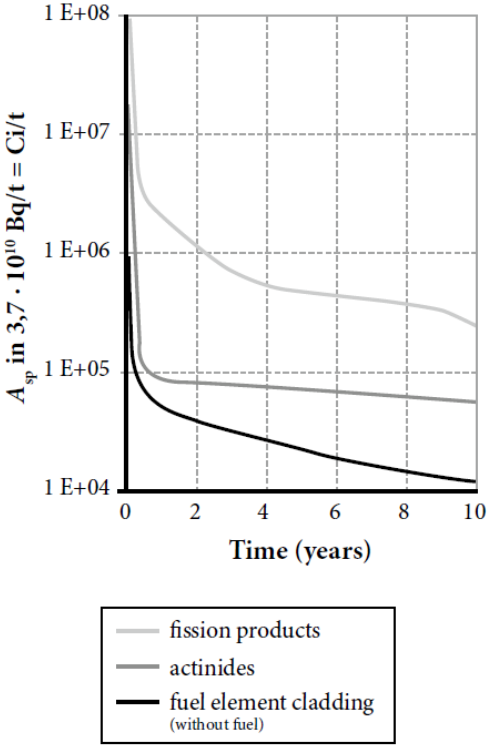
Timescales

- Decay storage: After discharge from reactor typically in cooling ponds at reactor sites. At least several months, typically several years





P: thermal output per mass unit
A_{sp}: specific activity
initial enrichment: 3.5% U=235
burnup: 30,000 MWd/t



sources: http://www.kkw-gundremmingen.de, www.kernenergie.de

Timescales

- Decay storage: After discharge from reactor typically in cooling ponds at reactor sites. At least several months, typically several years
- Buffer storage: days to months
- Interim storage, strategic storage: years to decades
  (note that interim storage might be, at the same time, decay storage)

➢ Our focus: interim storage

- Facilities typically designed and licensed for 20 to 50 years (examples Sweden, Germany)
- License extensions, e.g. periodic license renewal in 20 years increments (US)
- Exception: HABOG (NL): 100 years, with option to extend

source: http://www.kkw-gundremmingen.de

Timescales for interim storage

- There might be reasons to extend the lifetimes originally planned, e.g.:
  - Next step (in most cases: disposal facility) not yet available
  - Intent to wait … what for? → e.g. …
    - R&D to increase confidence in disposal
    - New technological developments (e.g. Partitioning & Transmutation, …)
    - International / multinational solution
    - Developments regarding resource situation – e.g. reprocessing of SNF might become morre desirable
    - Accumulation of inventory
    - Accumulation of funds
  - Lack of political and / or public acceptance for irrevocable solutions
  - Ethically motivated preference for reversible solutions

Timescales for interim storage

- There might be reasons to extend the lifetimes originally planned, …

- Example Germany:
  - Facilities licensed for 40 years
  - ➢ Therefore, licenses will start to expire in the 30ies
  - However, 2013 Site Selection Act foresees completion of site selection in 2031, which …
    - is extremely optimistic, and
    - means that license application, lawsuits, construction, emplacement will be still to come at that time
  - ➢ Therefore, a lifetime extension will be necessary, but …
    - For the time we believe to need (according to current knowledge – take optimistic or pessimistic approach)?
    - For longer, in order allow to wait for … ?

Timescales for interim storage

- There might be reasons to extend the lifetimes originally planned, …

➢ This might result in a state of „indefinite storage“

Challenges of expanded storage

- Ongoing technical challenges (control, refurbishment, renewal)
- Preservation of organisational capabilities and stability
- Continued political and societal commitment
- Economical stability, secure financial resources
- Harder to guarantee with increasing storage time
- Conceivable storage periods considerably shorter than period for which waste presents a hazard and needs to be managed

based on https://www.oecd-nea.org/rwm/reports/2006/nea6043-storage.pdf

Storage options

- Technical options: see ensuing presentation by Köhnke & Reichardt

- Strategic / planning options:
  - Centralised storage
    - At reprocessing plant
    - At disposal site foreseen
    - Elsewhere
  - Decentralised storage
    - At reactor sites
    - Elsewhere

Central versus de-centralised storage: issues

- Practical and economic considerations, e.g. …
  - About proximity to existing sites
    – reactors, reprocessing plants, disposal projects
  - Storage capacity

- Safety and security:
  - Depending on technical (hot cell) and management systems:
    Easier to implement and to maintain at centralised sites or at existing nuclear facilities (but what if these facilities cease to exist?)
  - Vulnerability concerning e.g. terrorist attacs: one or many sites?

- Issues related to transports:
  Economics, logistics, acceptance, safety, security

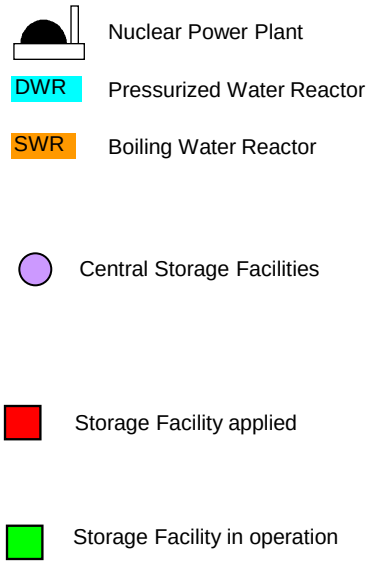
- If a country, such as Germany, frequently changes its strategy,
  it might end up like that … (next slide)

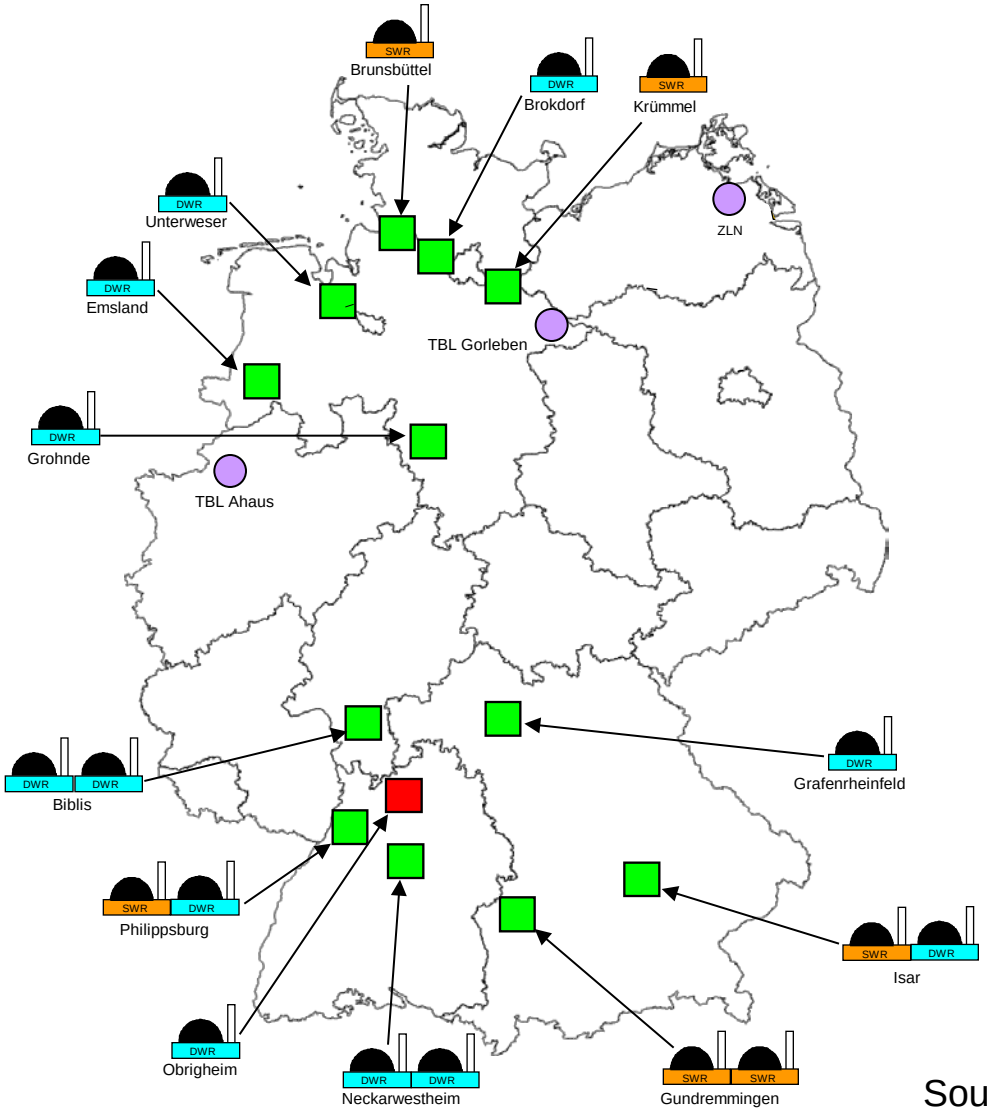
Germany

- Central Storage Facilities
  - Gorleben (TBL-G; 3,800 tons HM) and Ahaus (TBL-A; 3,960 tons HM)
  - Lubmin (ZLN; 585 tons HM) for spent nuclear fuel originating from the nuclear power plants Greifswald and Rheinsberg

- De-centralized Storage Facilities
  - Nuclear fuel storage ponds in the nuclear power plants
  - Jülich storage facility for AVR spent nuclear fuel
  - 12 on-site storage facilities for LWR spent nuclear fuel

Germany





Source: BfS

Finally: Some questions about perception (politicians, media, public)

- One often gets the impression that people can easier live with storage rather than with disposal facilities.
  - Is this impression correct?
  - If so, what are the reasons?
    - Limited lifetime of storage facility?
    - Hesitance to accept irrevocable solutions?
    - Confidence / trust in systems ran by humans rather than in „passively safe“ systems?
    - Others?

Thank you for your attention

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