Knowledge and Experience on Retrievability of SF/HLW Waste Packages

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Bundesgesellschaft für Endlagerung mbH (BGE)

- German Waste Management Organisation
- Implementer and operator of the Konrad repository, the Morsleben final repository and the Asse mine
- Entrusted with the task of site selection for a repository for heat-generating radioactive waste and spent fuel

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- Subsidiary of BGE (100% shares owned by BGE)
- National and international R&D
- International consulting and engineering in the fields of radioactive waste management, mining, and related subjects
- Assistance in domestic radioactive waste programme

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Regulatory Framework

- Apply to design, further exploration, construction, emplacement operations and decommissioning of a future repository for heat generation radioactive waste
- Stipulate **retrievability as a design criterion**
- Demonstration of technical feasibility, safety and reliability before or during licensing (in a verifiable way)

“During the operating phase up until sealing of the shafts or ramps, retrieval of the waste containers must be possible.”

- **Retrievability** is the planned technical option for removing emplaced radioactive waste containers from the repository mine
- **Retrieval** is the actual action of waste container removal (NEA 2011)

Regulatory framework


Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste

As at 30 September 2010

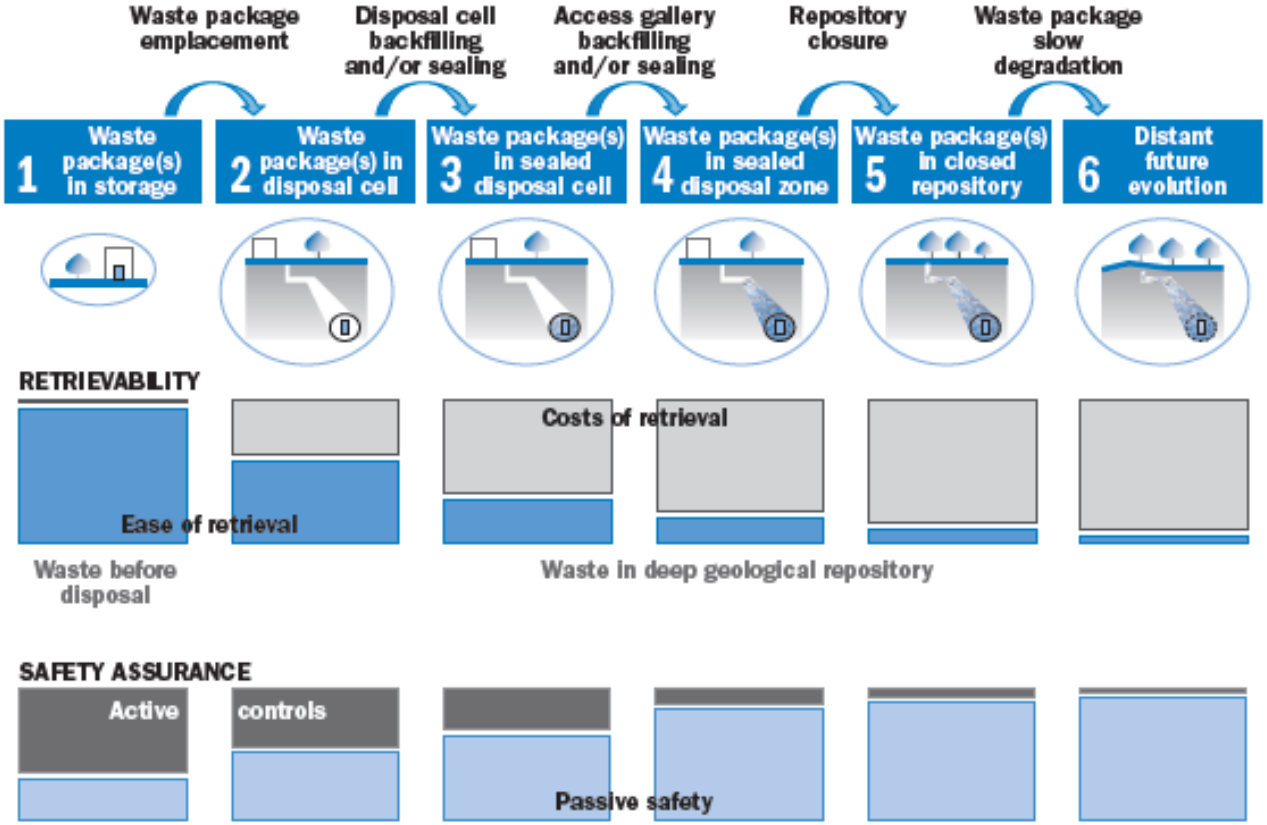
"The number of open emplacement zones should be kept to a minimum. These should be **promptly loaded, then backfilled** and reliably sealed from the mine building."

"Measures taken to secure the options of recovering or retrieval must not impair the passive safety barriers and thus the long-term safety."

"For probable developments, handleability of the waste containers must be guaranteed for a period of 500 years in case of recovery from the decommissioned and sealed final repository"

- **Recovery** is the retrieval of radioactive waste from a final repository as an emergency measure

Comparison with NEA R-Scale



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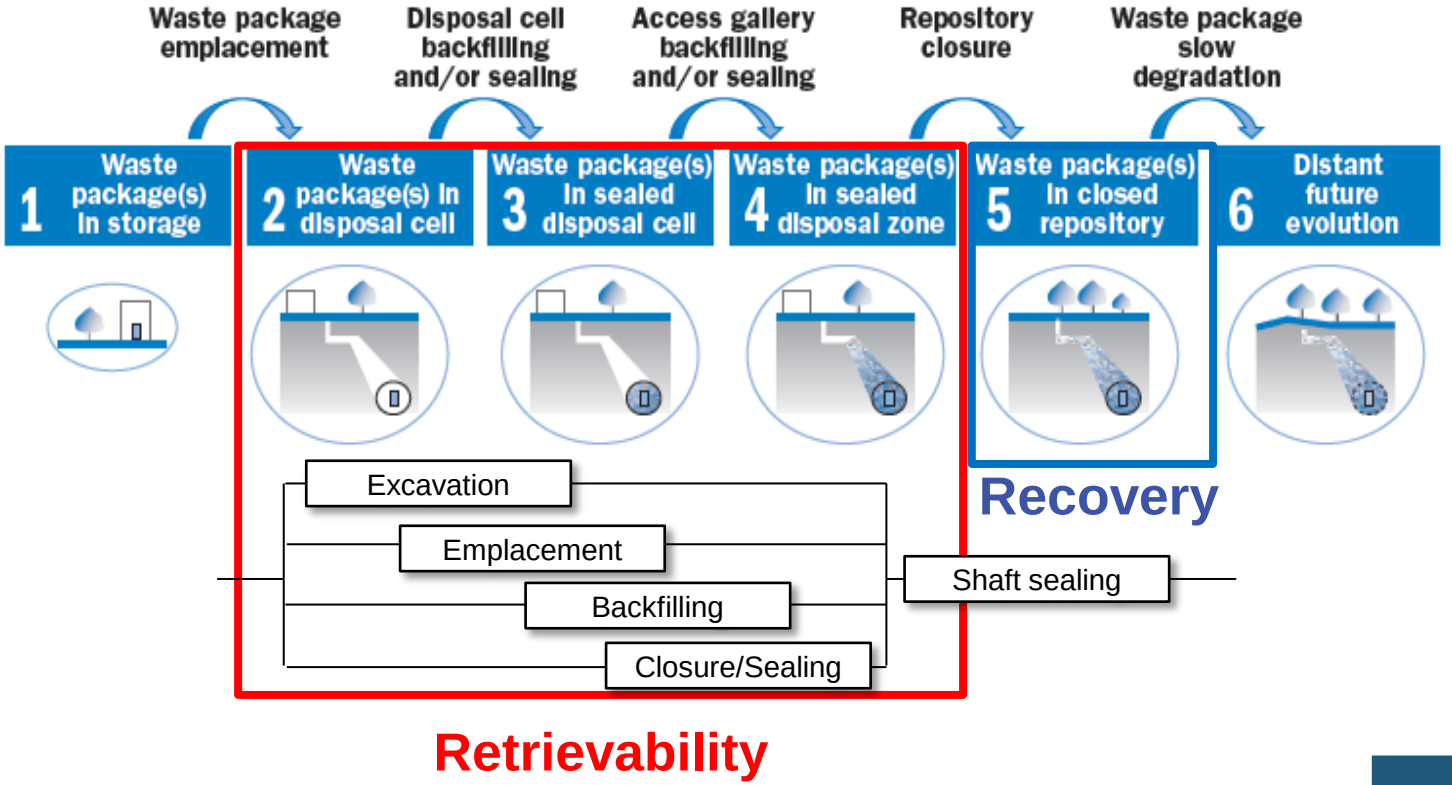
Comparison with NEA R-Scale



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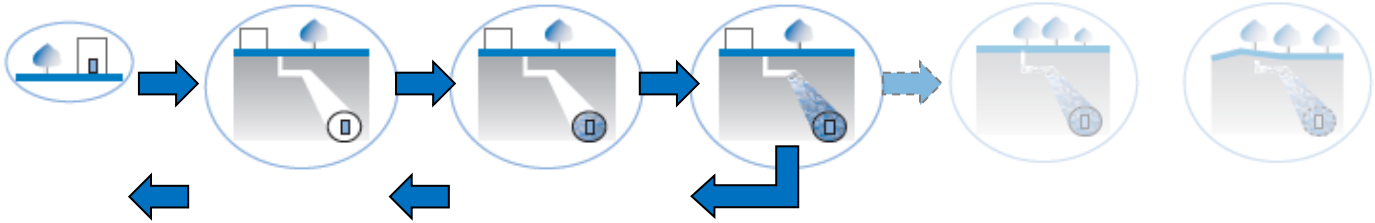
General Retrieval Strategy



➢ **Transfer the waste packages from the passive safety system of the repository back into human care**

“Re-mining”-strategy:

- Emplacement of waste containers, backfilling of cells, and sealing of drifts
- If necessary, conceptual adaptations to repository concept to facilitate retrieval and to improve conditions during potential retrieval period
- In case of retrieval decision:
  - ➢ Create new access drifts to the waste packages by re-excavation of the already backfilled drifts
  - ➢ Expose and remove the waste packages

Relevant Aspects for Implementation

Retrieval concepts and operational processes

- Design of re-excavation concepts with respect to radiation protection
- Design of transport and handling concepts for the retrieved of waste packages

Design and testing of equipment

- Modification of existing equipment to new boundary conditions/new functions
- Development of new retrieval devices
- Preparation of demonstration experiments to prove technical feasibility and reliability

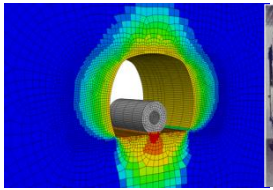
Modifications to repository layout

- Implement technical measures to facilitate retrievability
- Consider future retrieval in the design of the repository layout

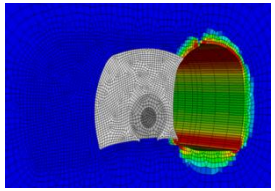
Analysis of thermo-mechanical consequences

- Identify potential timeframe for retrieval
- Analyse geo-mechanical / thermal conditions
- Develop solutions to guarantee workers safety during retrieval

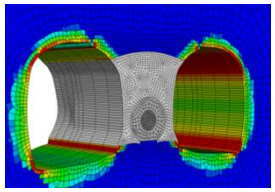
Retrieval Concepts - Example Horizontal Drift Disposal in Rock Salt



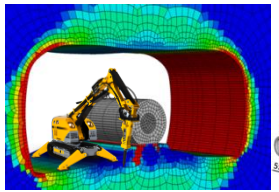
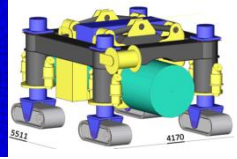

- Blind-ending drifts (17 m²), backfilling of remaining space directly after emplacement
- Re-excavation by road-headers calls for larger diameter to pass POLLUX® cask (5.5 m length, 1.5 m diameter)




- Stepwise excavation of the retrieval drift
- Step 1: small sub drift parallel to emplaced waste packages and between two cross-cuts to establish permanent ventilation




- Step 2: similar sub drift on the other site of the emplaced waste packages

- Step 3: removal of the remaining pillar by road-headers (new cross section 32 m²)
- use remote controlled demolition robots to expose the POLLUX®
- Step 4: remove the POLLUX® with modified emplacement device and transfer to surface

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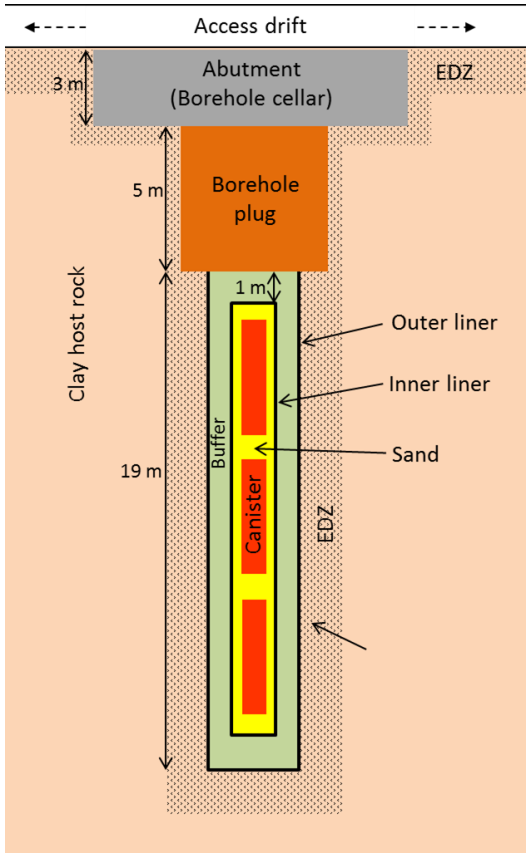
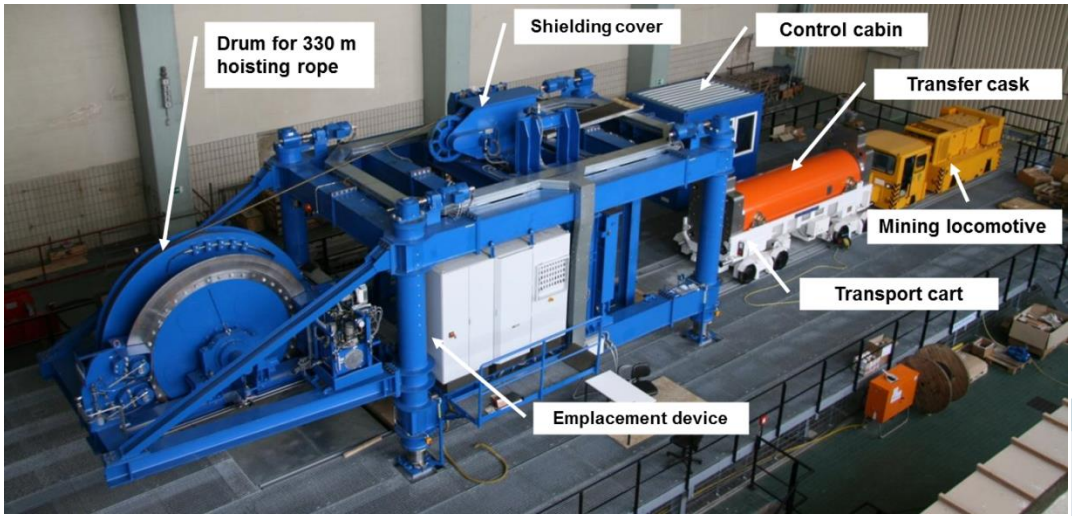
Retrieval Equipment - Example Vertical Borehole Disposal in Clay



- Three unshielded canisters (type BSK-R) per borehole
- Liquid-tight inner steel liner and sand backfill to ensure easy retrieval
- Emplacement and retrieval equipment similar to already tested emplacement device for borehole disposal (originally in salt with boreholes of 300 m depth)



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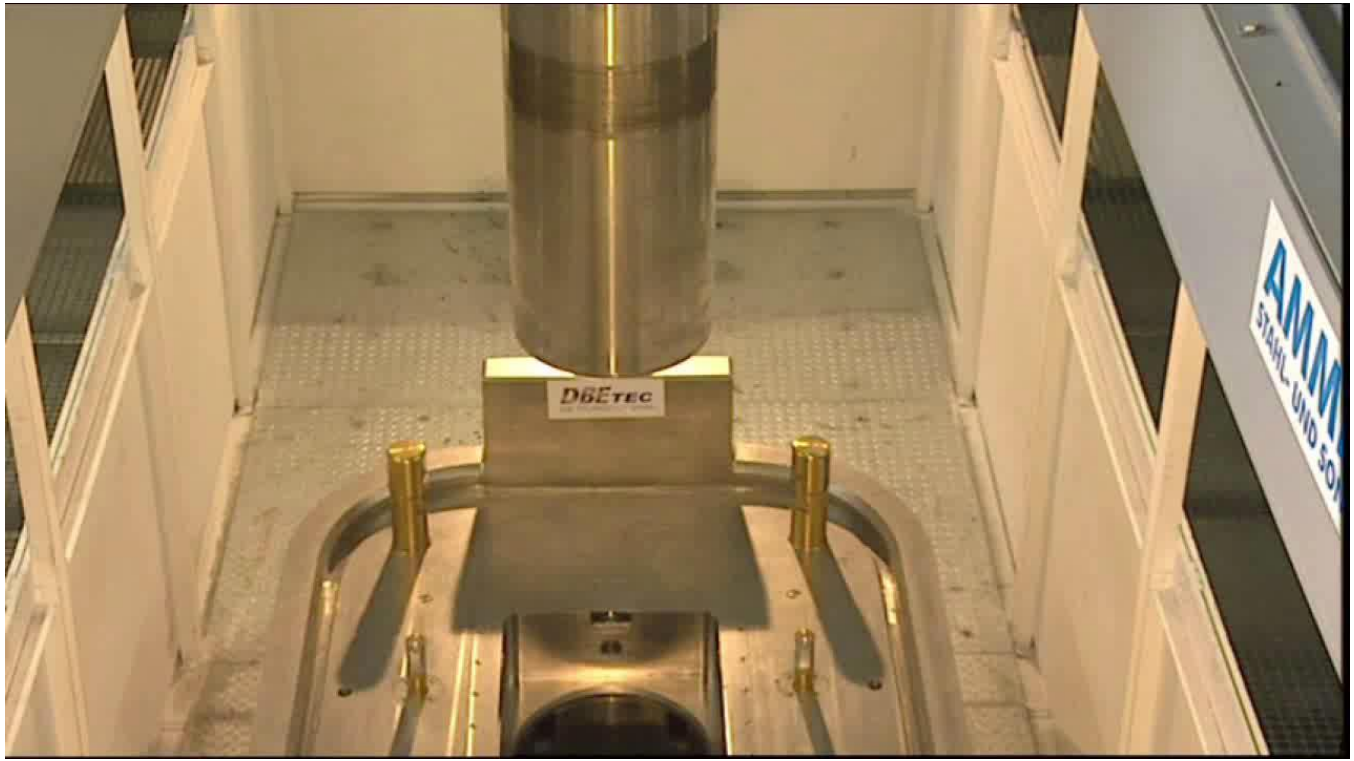


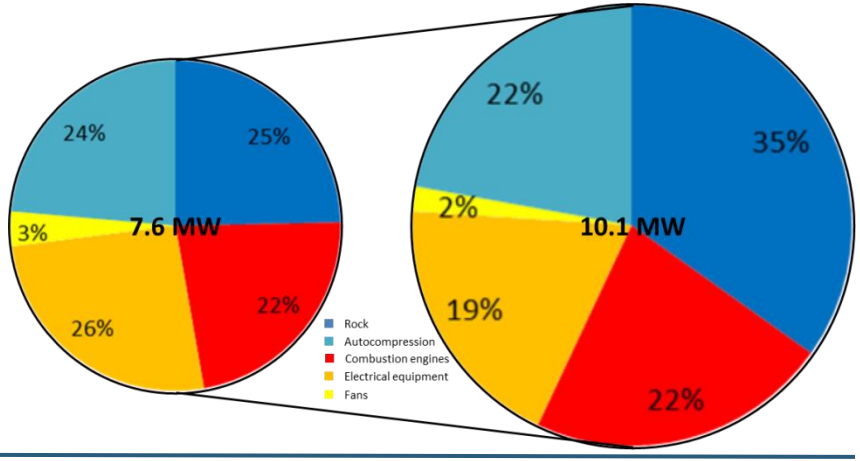
Demonstration of canister retrieval (test facility for borehole disposal of spent fuel canisters with one dummy canister)

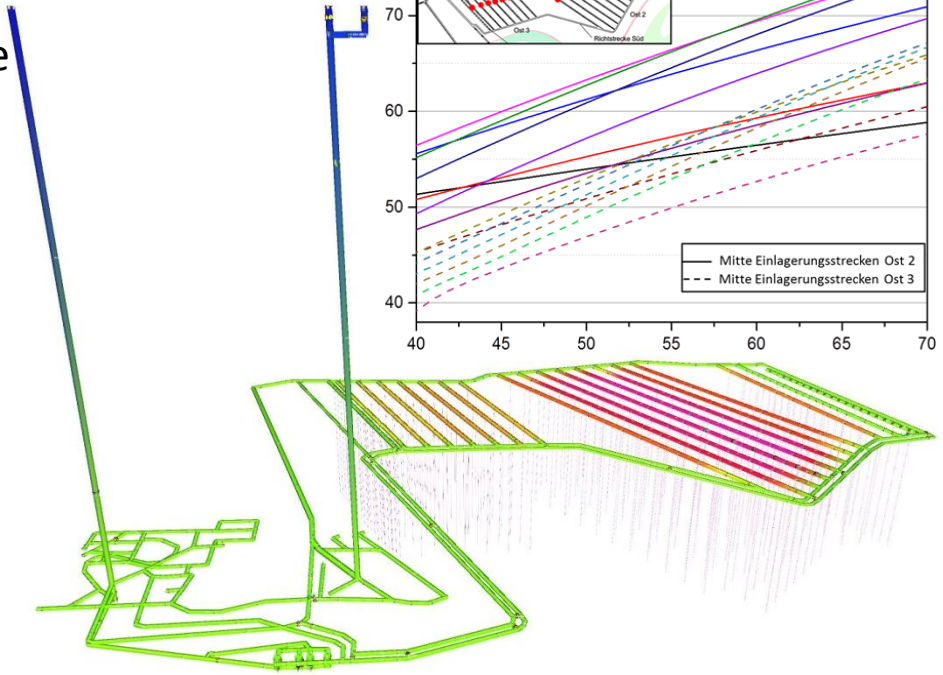
Retrieval Equipment - Example Vertical Borehole Disposal in Clay

Suction device for sand removal (same dimensions as canister, circulating airflow inside borehole), first pilot tests for air intake

Expected Conditions – Example Vertical Borehole Disposal in Salt

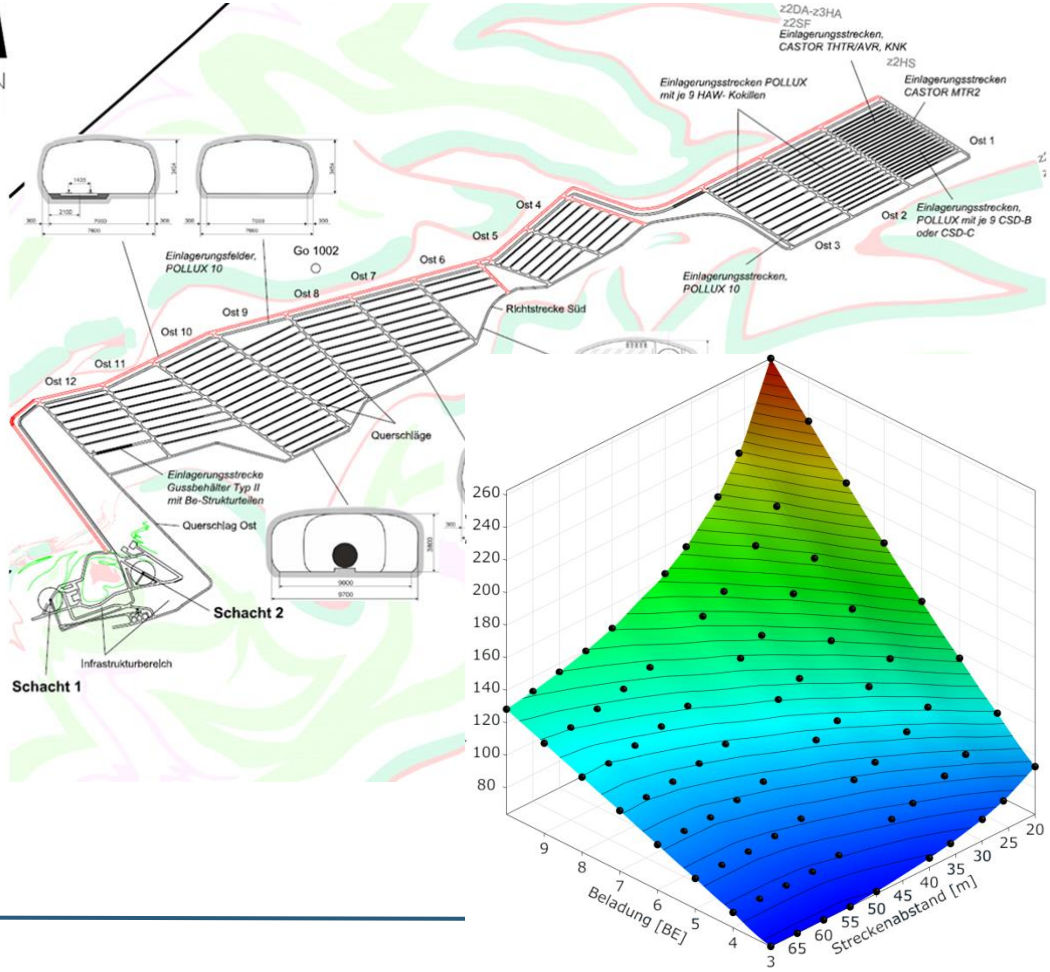
- Heat generation of the waste increases rock temperature after emplacement and during potential retrieval period
- Re-excavation in hot rock conditions → additional technical cooling during excavation needed (up to 1,5 MW)
- Re-excavation in nuclear zone/controlled zone → sucking ventilation instead of more comfortable blowing ventilation preferred





Layout Modifications – Example Drift Disposal Salt

- Minimization of excavations and long-term related safety distances no longer relevant for the layout → additional access drifts to improve re-excavation
- Variation of spacing between emplacement drifts allow optimization of temperature conditions during retrieval
- Cross-section of the retrieval drift has to be considered for pillar design/drift distance



Summary and Conclusions

- Retrievability is a licensing requirement for a German HLW and SF repository
- Retrievability corresponds to the transfer of the waste packages from passive safety system of the repository back into human care
- Retrievability is compatible with safety concept for HLW and SF repository in salt and clay formations in Germany
- Technical feasibility, safety, and reliability of all retrieval concepts and techniques have still to be demonstrated
- Currently, waste package management plan after retrieval does not exist (e.g. interim storage facility, storage and transport containers, etc.)

Many thanks…

…to my colleagues for their contributions to the R&D projects

ASTERIX	Effects of safety requirement retrievability on existing repository concepts and requirements on new concepts
ERNESTA	Development of technical concepts for the retrieval of waste packages with heat-generating waste and spent fuel from repositories in salt and clay formations

…and to the Federal Ministry for Economic Affairs and Energy (BMWi) and the Project Management Agency Karlsruhe (PTKA) of the Karlsruhe Institute of Technology (KIT) for funding the R&D projects on retrievability in Germany

PTKA
Projektträger Karlsruhe
Karlsruher Institut für Technologie

Bundesministerium
für Wirtschaft
und Energie

Thank you for your attention!

BGE TECHNOLOGY GmbH