Optimisation of the Thermal Aspects of a Generic High-Level Waste Repository Through Pareto Front Analysis

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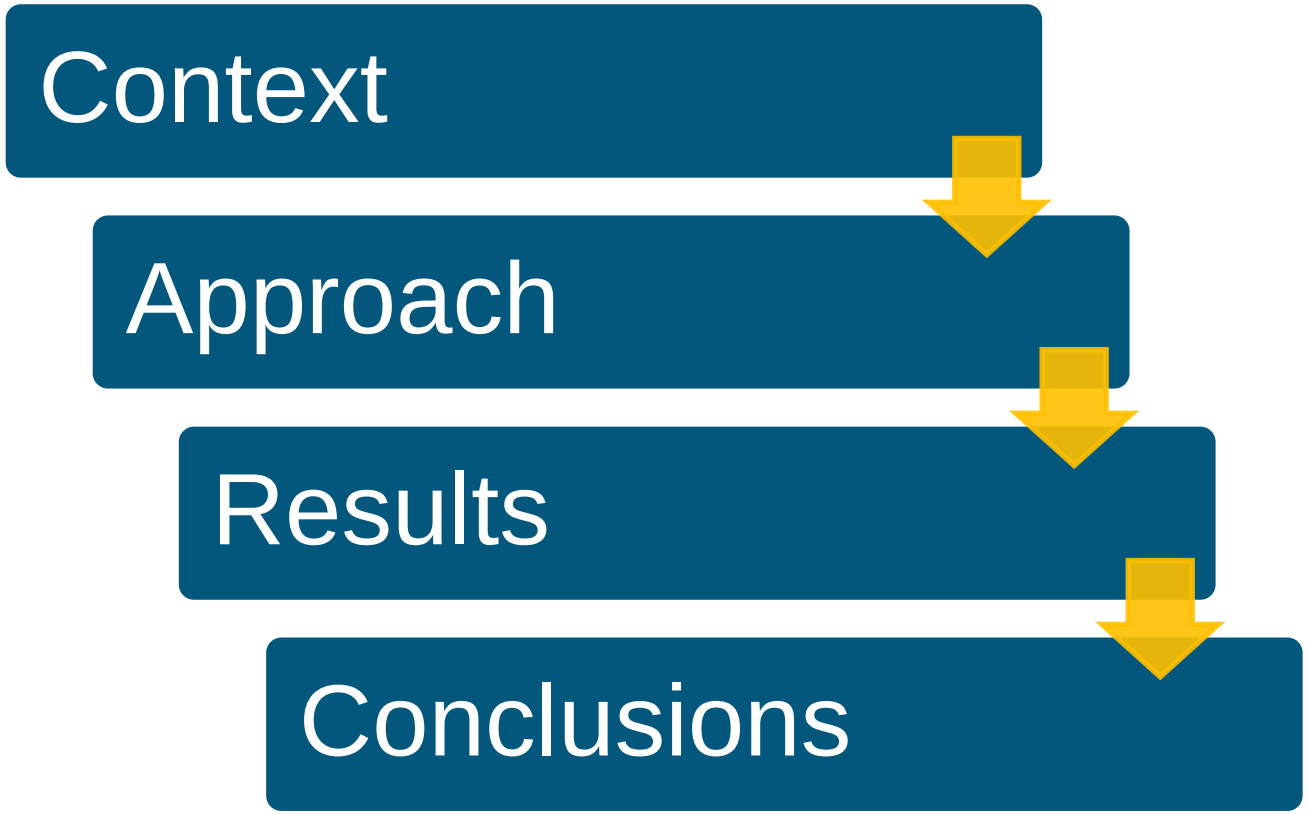
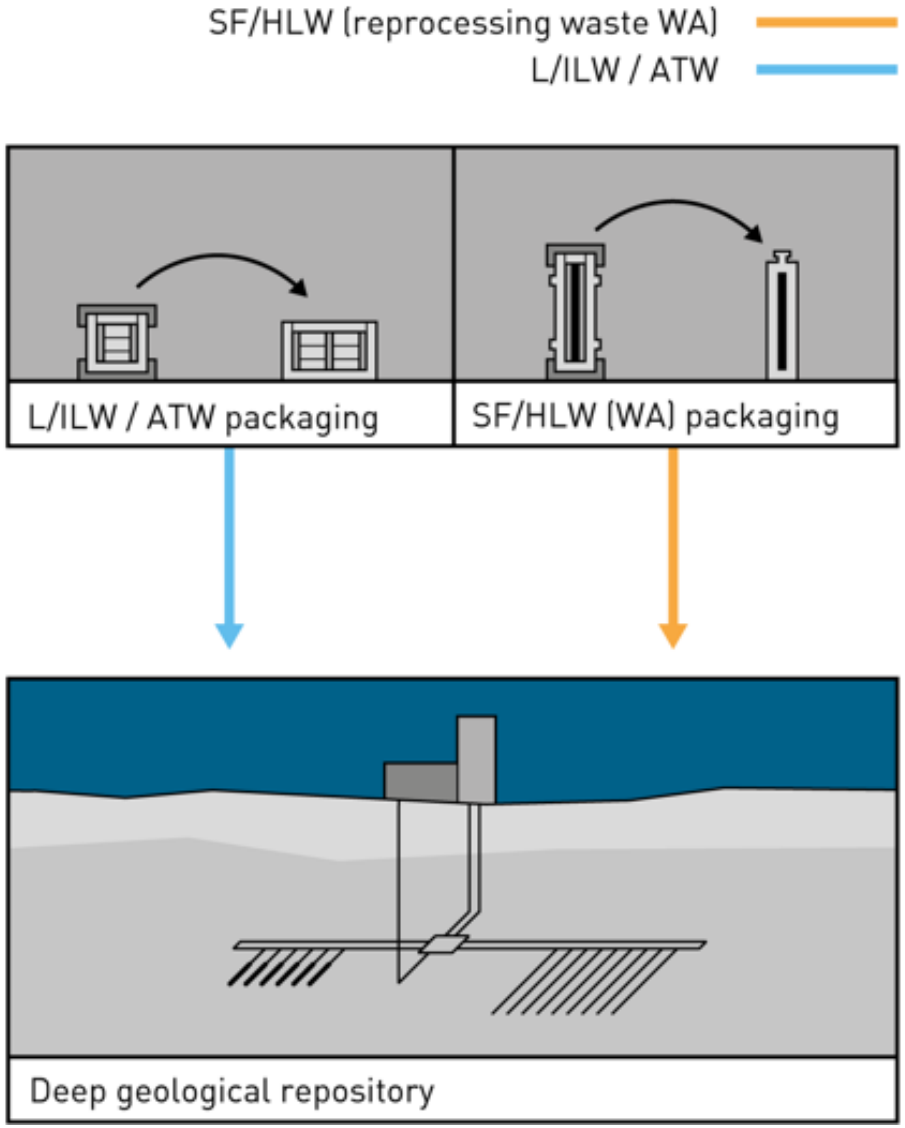
Outline



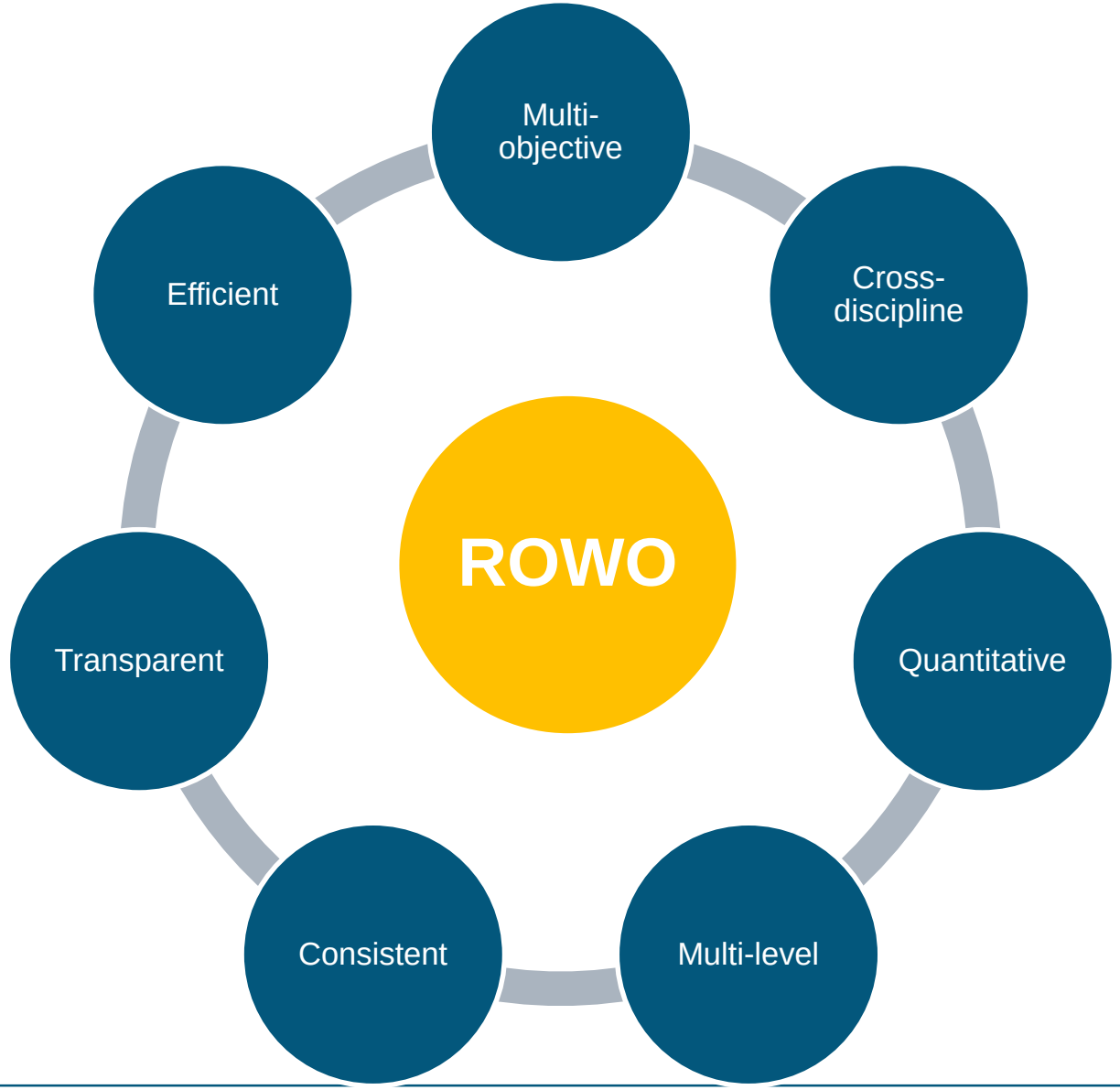
Context – Background and Aims



- General licence application for a deep geological repository for all waste categories in 2024 based on robust repository concepts
- Subsequent optimisation efforts in the period up to construction licence application
- Need for a methodology that identifies, resolves and communicates conflicts of interest in the entire Swiss waste management system

➢ Development of a repository optimisation workflow (ROWO) in the framework of RD&D

Context – Requirements on the ROWO



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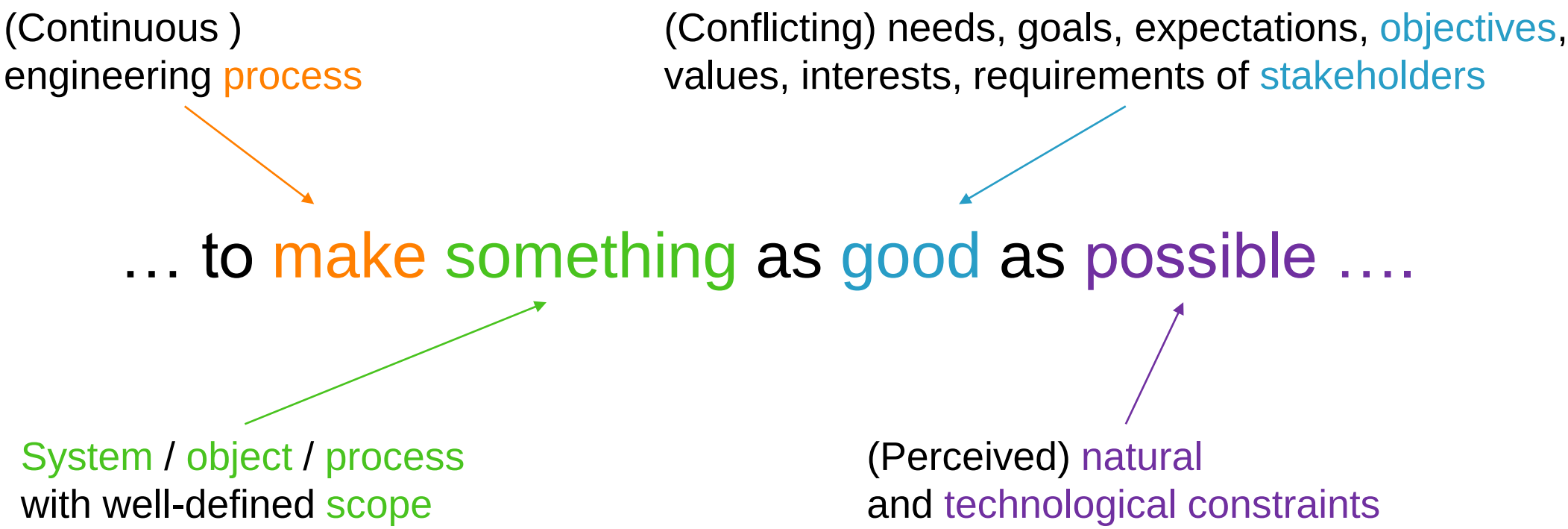
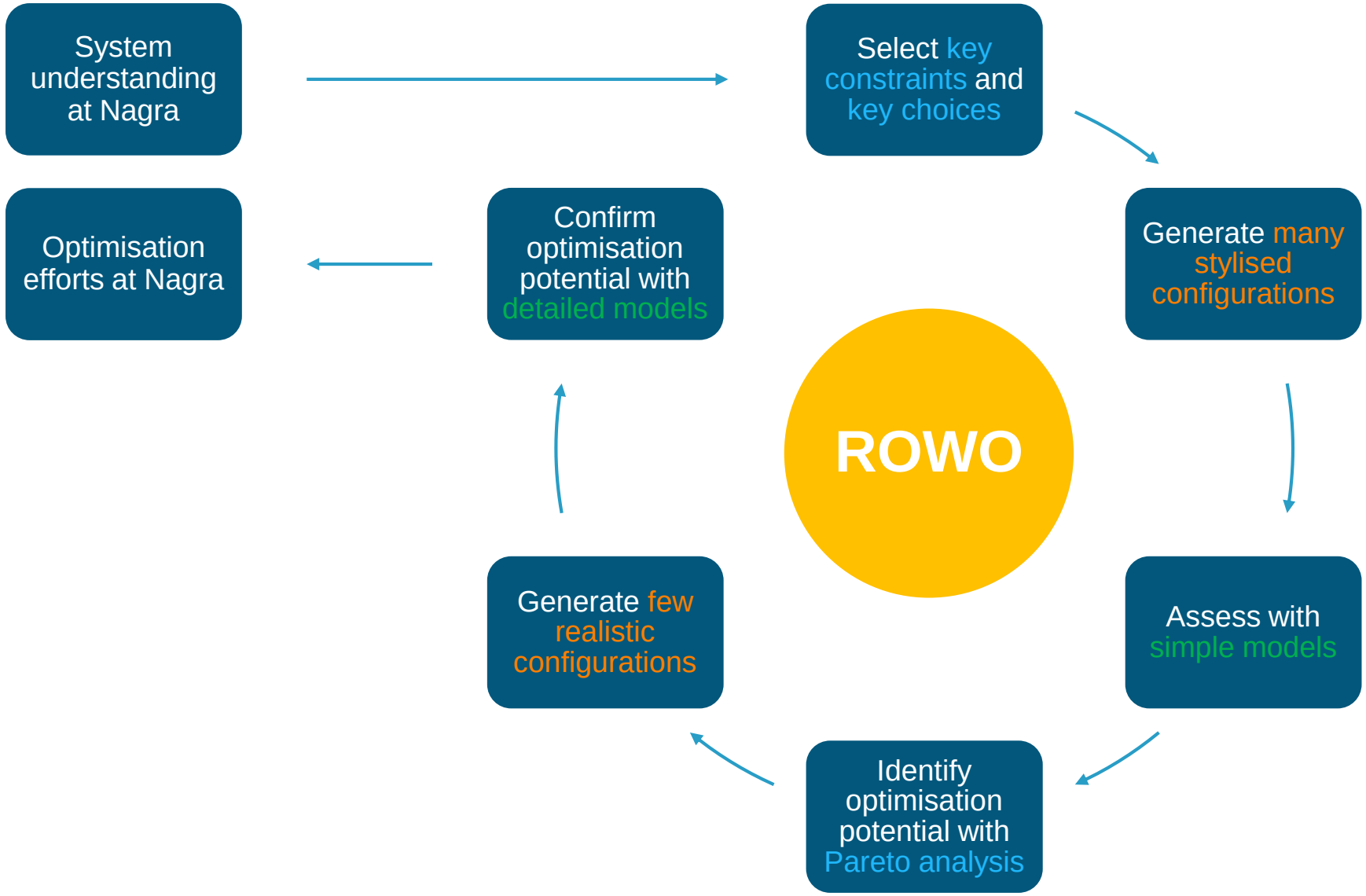
Approach – Aspects of Optimisation

- Dictionary definition of optimisation:



Approach – Repository Optimisation Workflow (ROWO)



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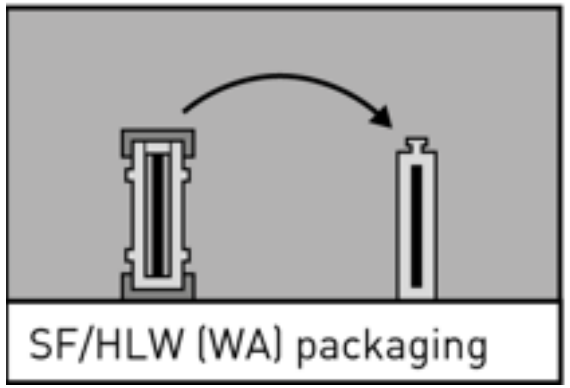
Example Application

- Generic repository for high-level radioactive waste
- Consideration of spent fuel (SF) and vitrified high-level waste (HLW)
- Optimisation with regard to
  - TH evolution post-closure
  - total cost

Key Factors – Pre-disposal Waste Management

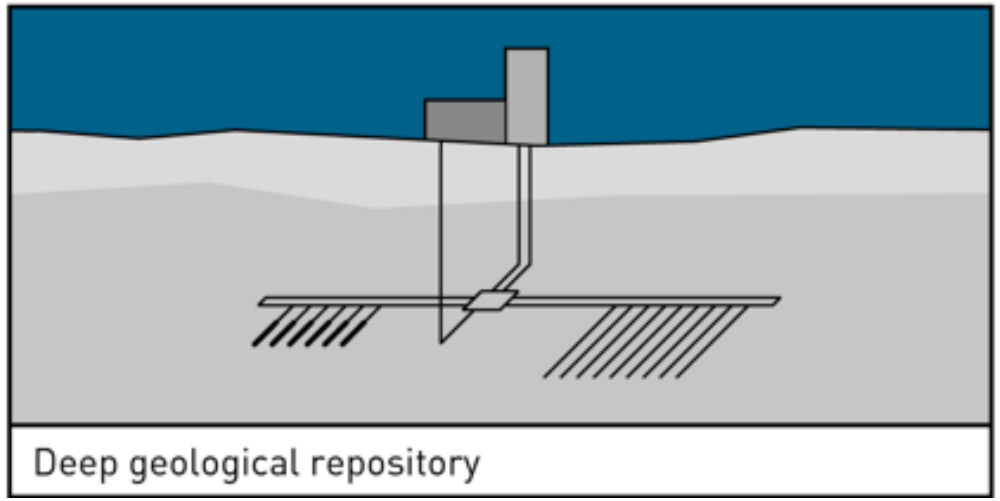
- Key constraints
  - number and characteristics of individual SF assemblies and HLW flasks
  - characteristics and location of existing nuclear facilities
  - characteristics of existing transport infrastructure
  - unit prices for pre-disposal activities and facilities

- Key choices
  - duration of interim storage / emplacement start
  - strategy for waste packaging
  - location of waste packaging
  - number / capacity of waste and bulk material shipments

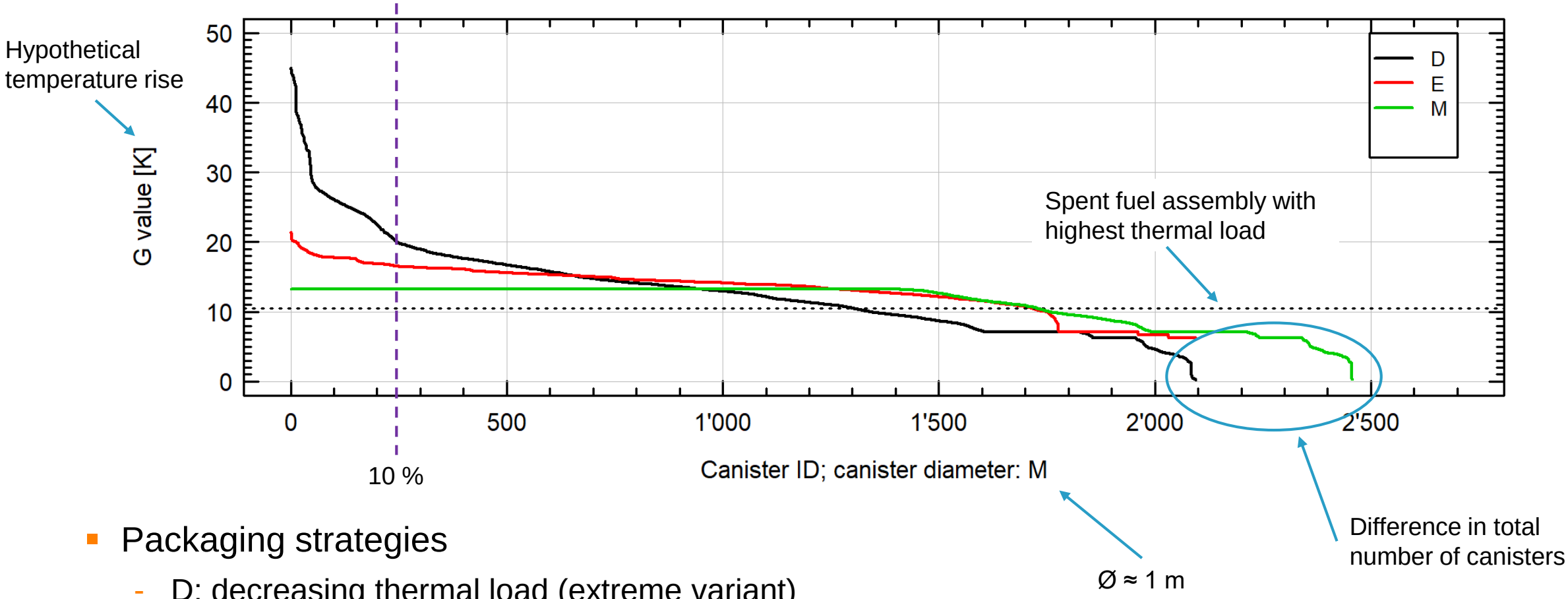


Key Factors – Repository Implementation

- Key constraints
  - available space underground
  - in-situ thermal, hydraulic and mechanical conditions and characteristics
  - technology & materials available
  - good engineering practices / rules
  - unit prices for implementation activities and facilities
- Key choices
  - potential canister positions
  - assignment of loaded canisters to potential canister positions
  - canister emplacement order
  - canister emplacement rate

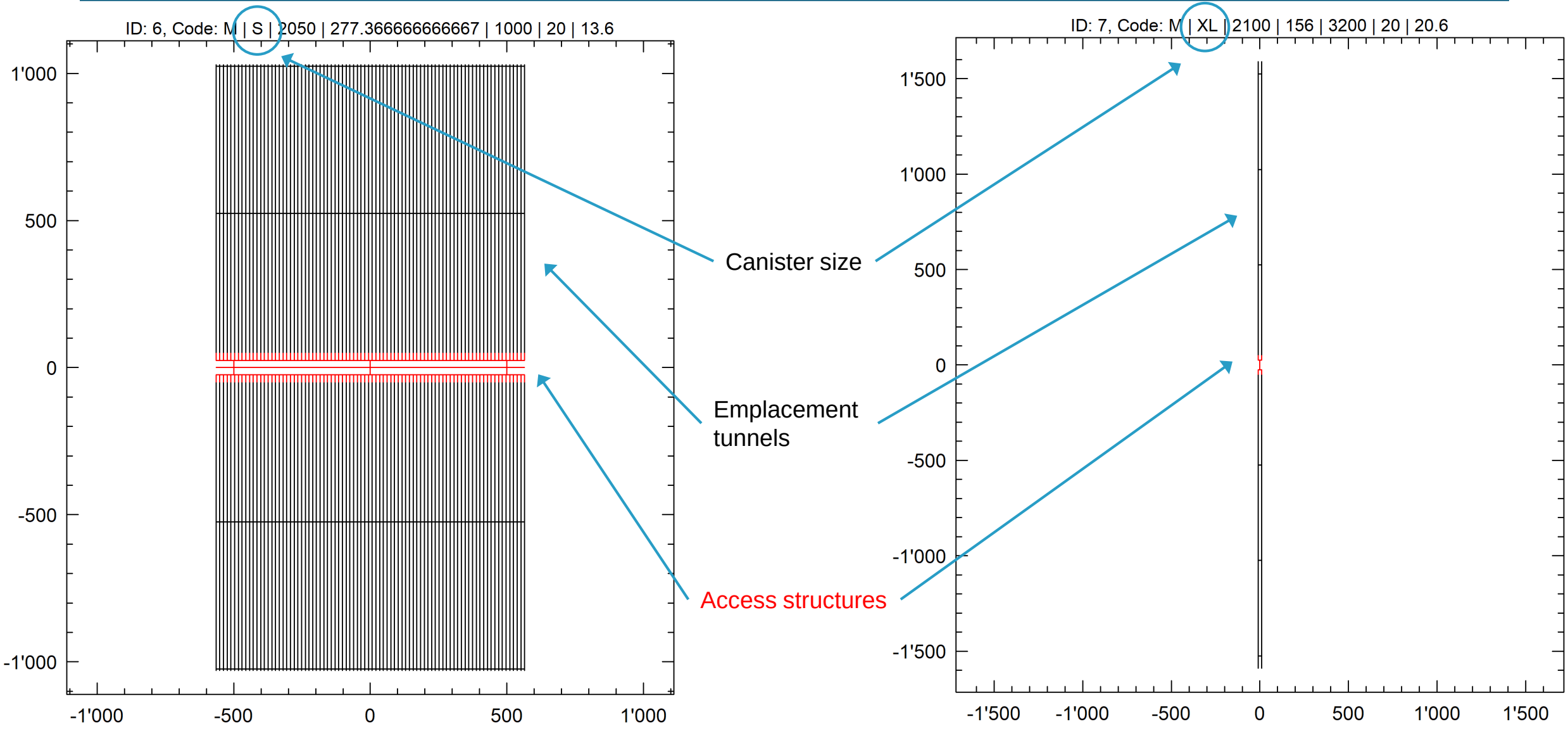


SF/HLW Thermal Characteristics and Packaging Strategies



- Packaging strategies
  - D: decreasing thermal load (extreme variant)
  - E: balanced thermal load
  - M: maximum thermal load (current approach, 1,500 W)

Example Stylised Configurations



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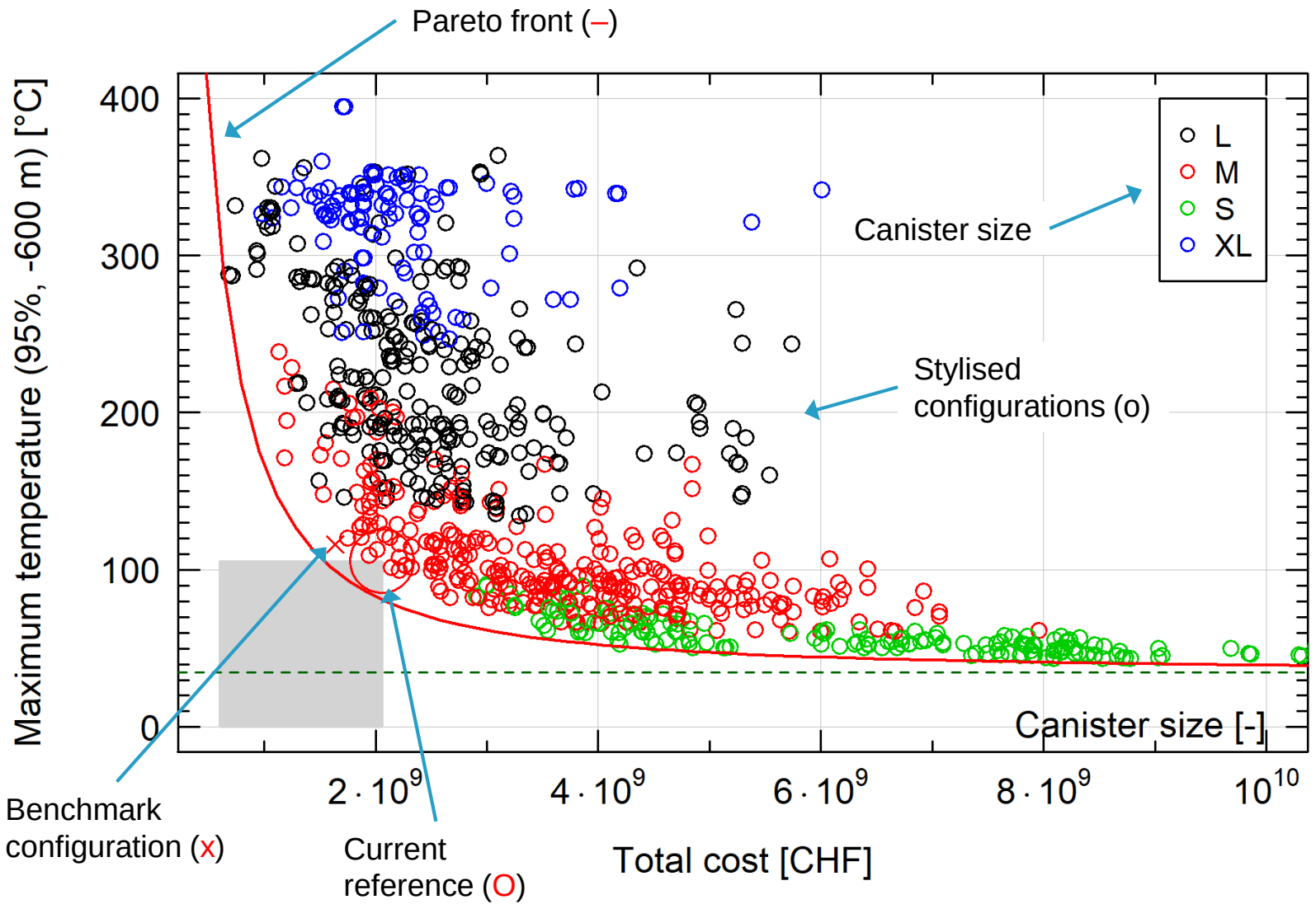
Pareto Analysis



- Pareto analysis identifies the limits of the design space (Pareto front)
- Nagra's current reference configuration is close to the Pareto front
- "Better" configurations with similar TH performance but smaller cost identified
- Confirmation with detailed models (benchmark)

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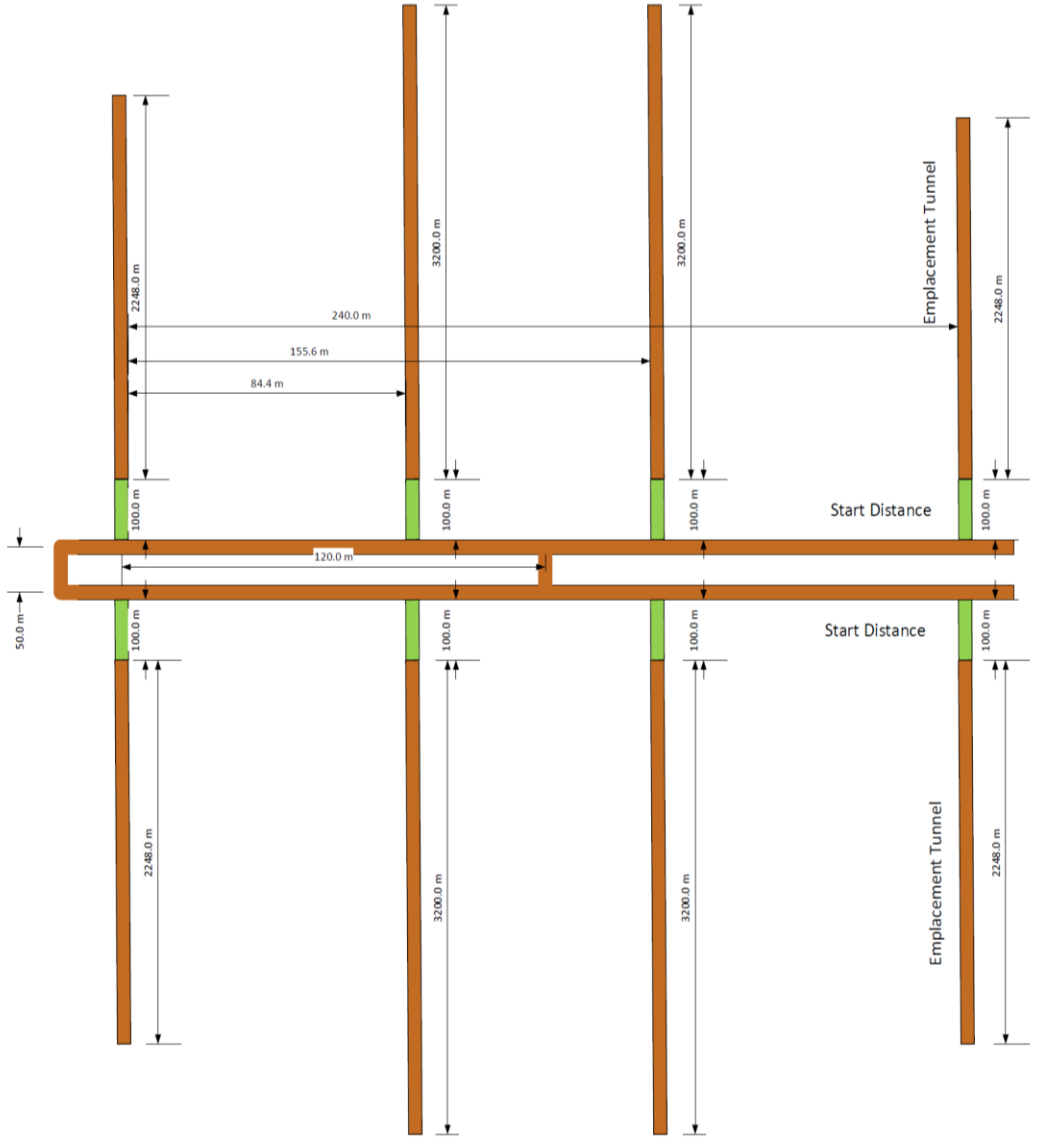
(More) Realistic Configuration for Benchmark



- Long emplacement tunnels
  - favour heat dissipation into the rock
- Packaging strategy E
  - balanced thermal load (–)
- Canister positioning
  - "hot" canisters within the outer emplacement tunnels
  - Canister and tunnel spacing tailored to thermal load

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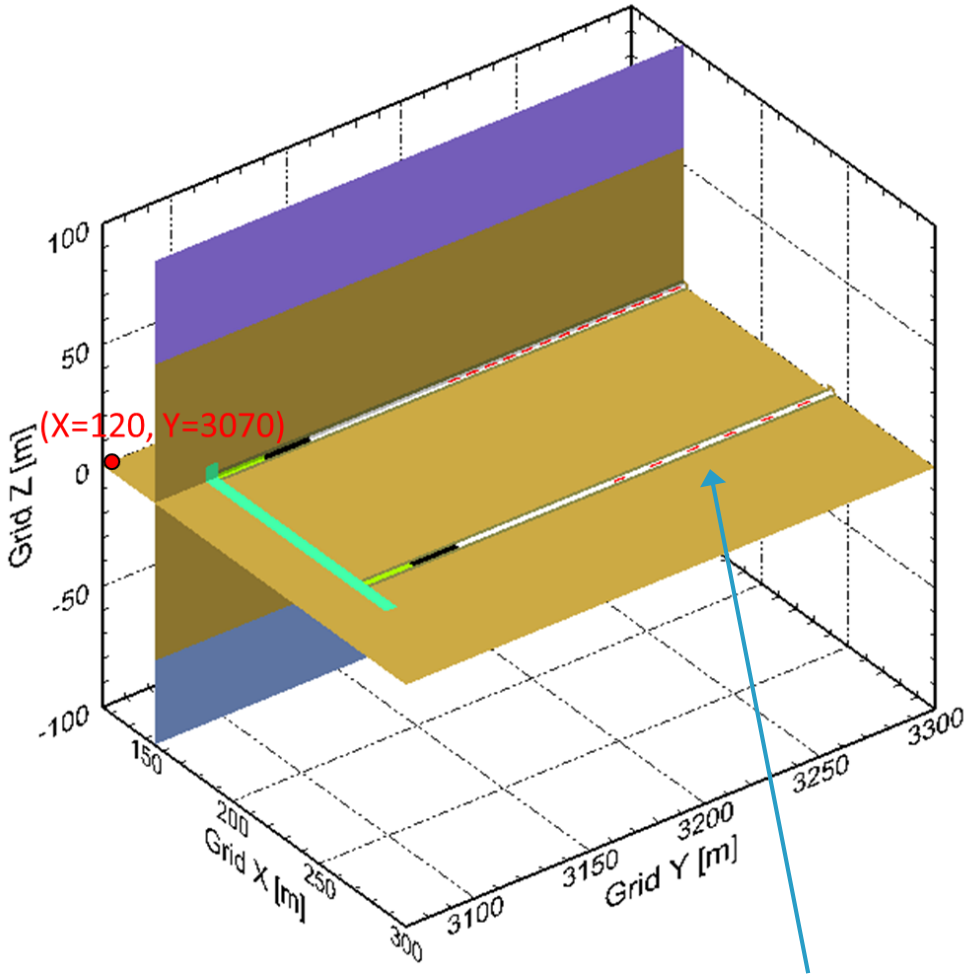
Detailed Assessment of Benchmark Configuration



Enhanced canister spacing for "hot" canisters

- Detailed numerical calculations with TOUGH3 by INTERA
  - similar TH performance as Nagra's current reference configuration
- Detailed cost estimation with cost study framework
  - cost savings for repository part confirmed
  - cost savings for packaging part yet to be confirmed

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Conclusions

- Repository optimisation workflow (ROWO) developed and tested
- ROWO in line with main requirements
- Major conflict of interest and substantial optimisation potential identified
- Results (partly) confirmed with detailed benchmark studies
- Next steps within RD&D setting
  - additional natural and technological constraints
    - generic setting ► selected site and location of packaging facility
    - logistics of implementation process (packaging, transport, construction, operation, closure)
  - additional stakeholder objectives and associated indicators
    - e.g. criticality, environmental impact, radiation dose, monitoring, waste retrieval
    - development of additional ROWO proxy models
  - comprehensive benchmarking

thank you
for your attention

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