

From rock to repository: the iterative process of site characterization and facility design

NWTRB Spring meeting June 9, 2026

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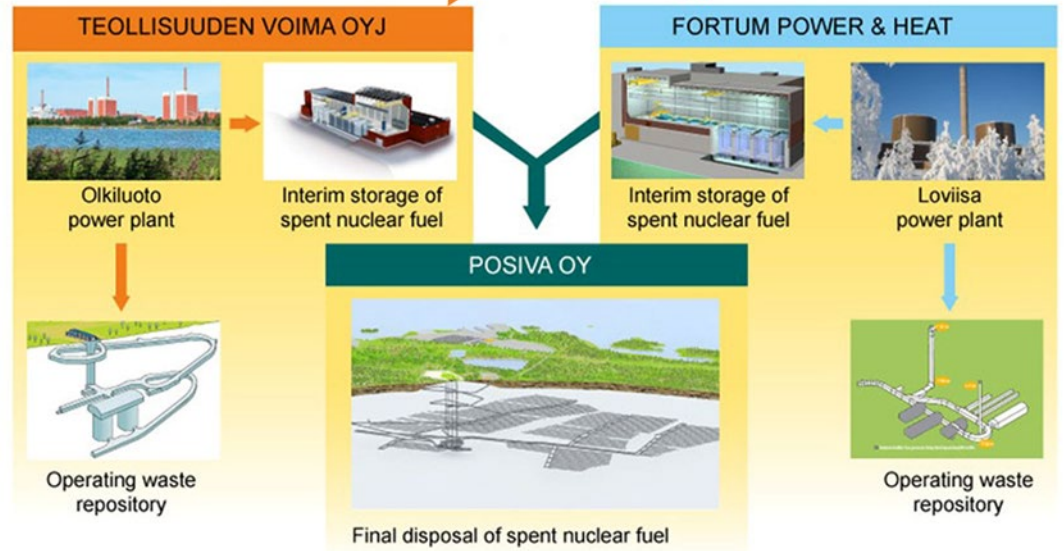
- The Finnish spent fuel disposal program
- Ongoing activities at Olkiluoto
- Iterative site characterization and facility design
- Organisational developments
- Lessons learned
- Take-away points



Main actors involved in spent nuclear fuel disposal



Ministry of Economic Affairs and Employment of Finland



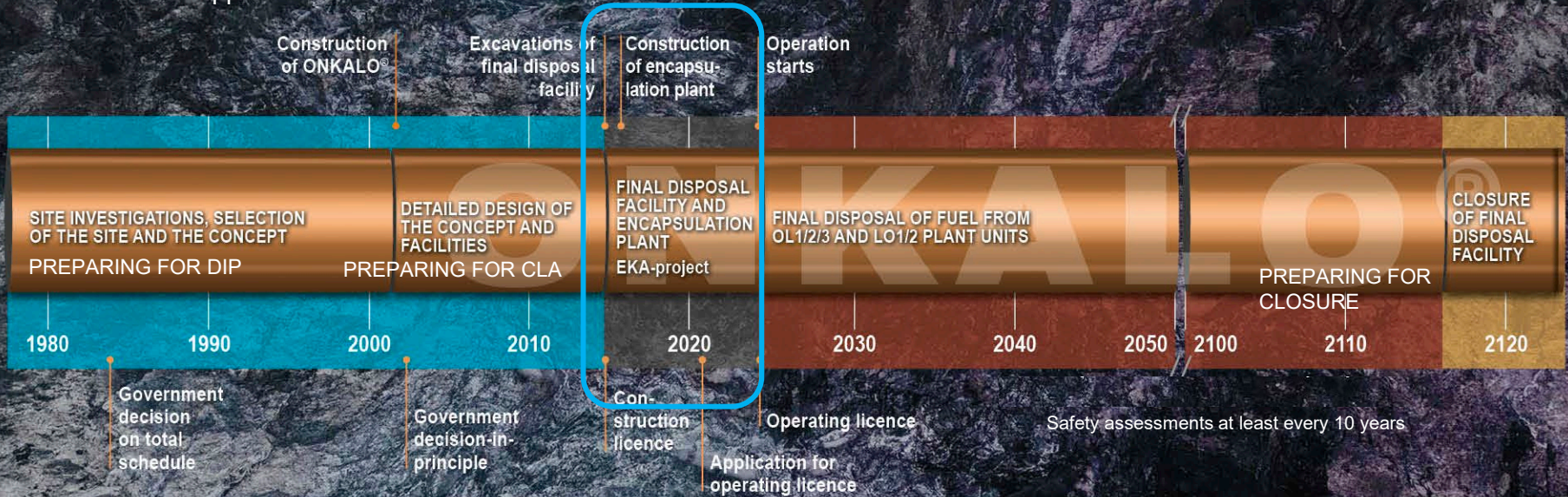
Phase 1. Focus:
Site investigation and selection, disposal concept; preparing first license application

Phase 2. Focus:
ONKALO® and preparing Construction License Application

Phase 3. Focus:
Constructing the disposal facility and preparing the Operating License Application

Phase 4. Focus:
Operation of the facility and further development of the disposal system

Phase 5. Focus:
Preparing and closure of the facility



Complete Nuclear Waste Management on one island – Olkiluoto, Finland

Interim storage for spent fuel

Spent nuclear fuel brought from the plant unit cools down in water pools

Final disposal of spent nuclear fuel ONKALO®

The commissioning is ongoing and the application for operating license has been submitted 30.12.2021

Repository for operational waste (LILW repository)

Repository for low and intermediate-level radioactive Waste, in operation since 1992

Final disposal of the decommissioning waste of the power plant

Reservation for the radioactive decommissioning waste of the power plants



Above ground:

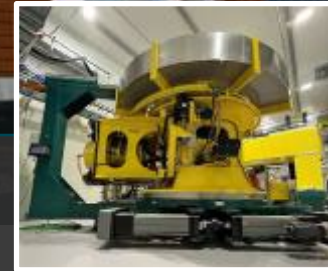
Encapsulation plant – ready.



The systems installed
in the fuel handling cell



Control room
for remote
operation



Welding
station

Deposition hole

HVAC works



Deposition tunnel



Maintenance hall

Underground:

**Final disposal facility – ready.
Equipment – some of them are
still in the testing phase.**

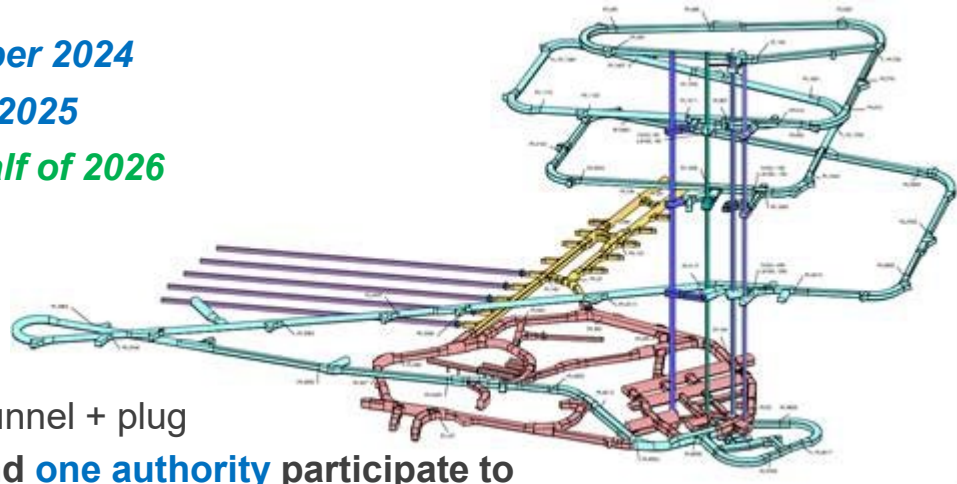


Central tunnel

Trial Run of Final Disposal started in 8/2024

The Trial Run is the final phase of Posiva's preparing for the operation of the deep geological repository. It will be carried out with the methods, procedures, equipment and personnel to be used in the operation phase. It includes:

- fuel transports: **finished in September 2024**
 - encapsulation: **finished in January 2025**
 - final disposal **starts during first half of 2026**
 - retrieval of a "damaged" canister back to the encapsulation plant: **finished in January 2025**
 - 5 canisters + clay components+ 70 m tunnel + plug
- Six waste management organizations and one authority participate to learn how the entire disposal process functions, to discuss with Posiva's experts and to gain insights to benefit own national program. One can still come along!**

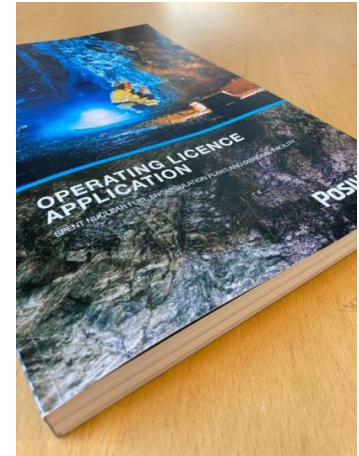


Challenges of different nature

- Geological disposal facilities for high-level radioactive waste present challenges of different nature
 - **Socioeconomical issues** related to the siting of a disposal facility for long-lived hazardous waste
 - **Multi-generational** implementation timeline
 - High-level waste facilities which are built deep underground are **new types of facilities**
 - **One-of-a-kind** facilities that require the development of **country- and host rock-specific requirements**
 - Several sources of **laws and requirements** to be fulfilled
 - **Technically complex system** to be managed with the right **competences**, evolving over time

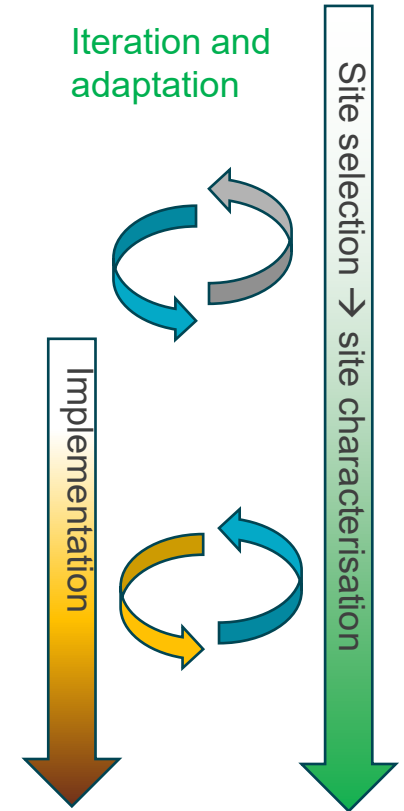
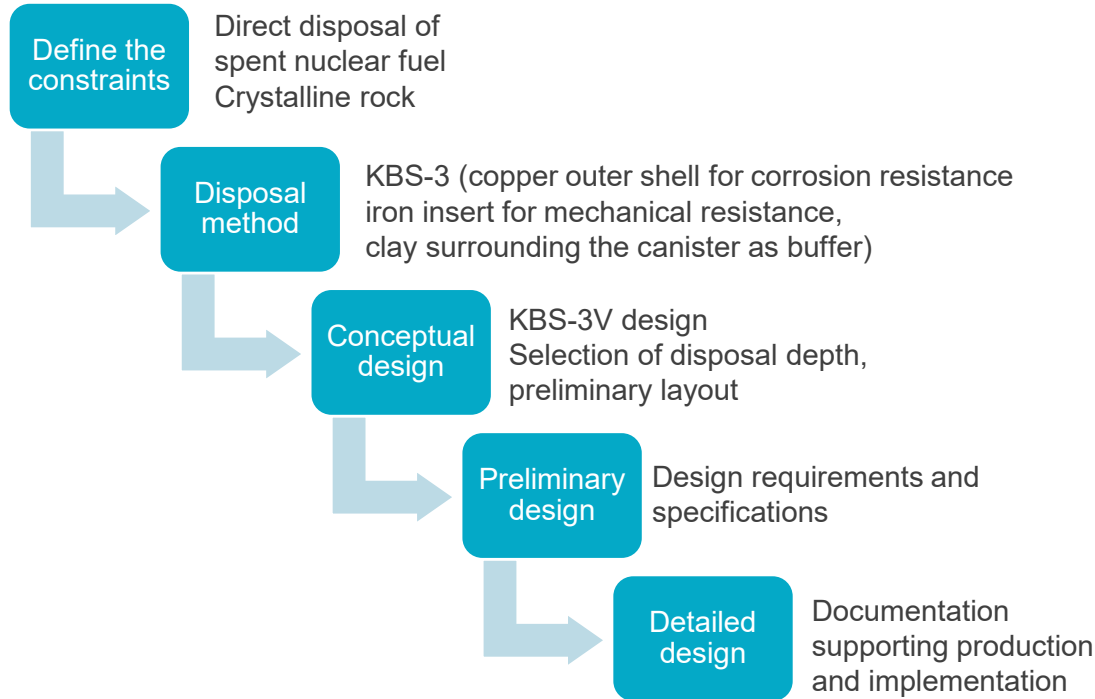


Ratification of the siting decision by the Finnish Parliament on May 18, 2001



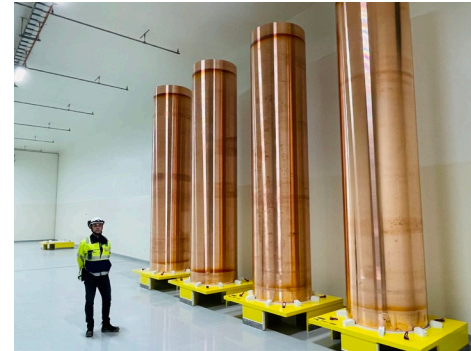
World's first Operating licence application for a spent nuclear fuel disposal facility, submitted in 2021

Iterative site characterization and facility design



Plan for safety and sustainability

- Changes aim at achieving a **robust and streamlined design** that can be **reliably** and **sustainably implemented**
 - Meets the **safety** requirements
 - Less tailor-made and **more “off-the-shelf”** components
 - More **well-established production** processes
 - **QA/QC methods** that can be **reliably implemented**
- A **robust and streamlined design** implies
 - Less sensitivity to small changes in production parameters
 - Less sensitivity to human error and human factors
 - Less uncertainties in the “as-implemented” state
- A **robust and streamlined design** fosters **safety** and **sustainability**



Plan for iteration and adaptation

- For deep geological repository programmes, **knowledge** and **experience** grows at an increasingly fast pace as the programme evolves
- This steep learning curve calls for **iteration** and **adaptation**
 - **Changes** are to be **expected** during various phases of the licensing process
 - Particularly during **implementation** and **commissioning** of the DGR
 - Technical feasibility (implementability)
 - Economical feasibility (sustainability)



Plan for organizational developments

- Waste management organizations operate over **several decades**
- Such long-term programs require **adapting management style over time**
- There have been **7 major organisational changes within Posiva**
 - from **site selection process**
 - to the choice of the **Olkiluoto site**
 - from **underground characterization**
 - to **preparation for construction**
 - from **construction and detailed design**
 - to **production and operation**
- Each phase had different **organization(s)** and **competence profile(s)**
 - Started from natural sciences, nuclear and construction engineering
 - Evolved to include business management and industrial engineering



Lessons learned over four decades

- The DGR design development process is **iterative** and **adaptive**
 - In the early phase of the program, it is acceptable to use assumptions as long as they are clearly labeled as such so they can be checked later
 - The design evolves to incorporate new knowledge from the site and implementation experience
- Due to iteration and adaptation, **changes are part of the process**
 - Changes aim at achieving a robust and streamlined design that can be reliably and sustainably implemented
- **Requirements management** is important particularly during the **early phases** and during **optimization**
 - Requirements are **country-** and **host-rock specific**
 - Requirements are developed **iteratively** to achieve a **robust** and **streamlined** solution
 - Requirement changes should be managed for **transparency**, **traceability** and **knowledge management**
 - A **requirements management system** is a useful tool for
 - designing the facility, its infrastructures and managing the interfaces
 - optimizing the facility design and processes to enhance safety and sustainability
 - communicating to internal and external stakeholders

Lessons learned over four decades (cont.)

- In an endeavour lasting several decades, the **organization** and **management style** needs to be **adaptive**
 - Key aspects:
 - Management of long-term transitions
 - Balance in-house vs. outsourced expertise
 - Knowledge management & information sharing
 - Iterative way of working
 - International collaboration
- A strong **safety culture** and **communication skills** are needed from the implementer
 - To safely implement changes and to communicate them
 - To foster transparency and traceability
- Implementing a new type of facility implies a **steep learning curve** for the implementer and all stakeholders
 - **Dialogue** and **mutual learning** is key among
 - the implementer and the regulator
 - there are several other category of stakeholders
 - all of them are important




Take-away points

- Plan for safety and sustainability
- Plan for iteration and adaptation
- Plan for organizational development
- Mutual learning and dialogue with all stakeholders is essential



*Lessons learned are available via **Posiva Solutions** integrating Posiva's expertise with good practices and lessons learned from decades of international cooperation*


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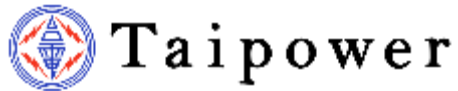
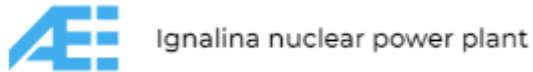
www.posiva.fi



An aerial photograph of a rugged, mountainous landscape. The terrain is characterized by steep, rocky slopes and a winding road that snakes through the valley. A river or stream is visible, flowing through the lower part of the scene. The overall color palette is dominated by dark blues, greys, and earthy tones, suggesting a high-altitude or mountainous environment. The text 'Posiva' is overlaid in the center, with a vertical bar below the letter 'v'.

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Posiva Solutions' Reference Clients



Our client satisfaction survey average result 2016-2024

4.7 / 5