Lessons Learned: A Canadian Perspective

Presented by:
Laurie Swami
President and CEO

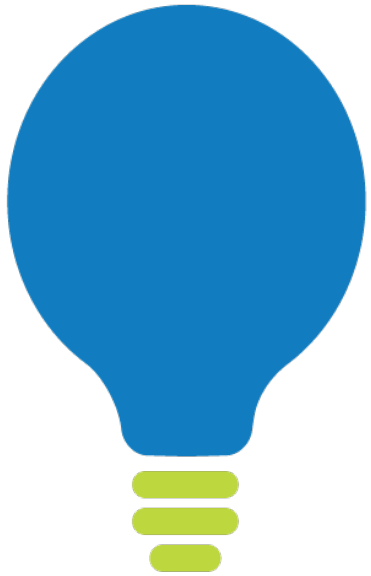
nwmo

NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Canada will ensure the
safe, long-term management
of used nuclear fuel inside
a deep geological repository.

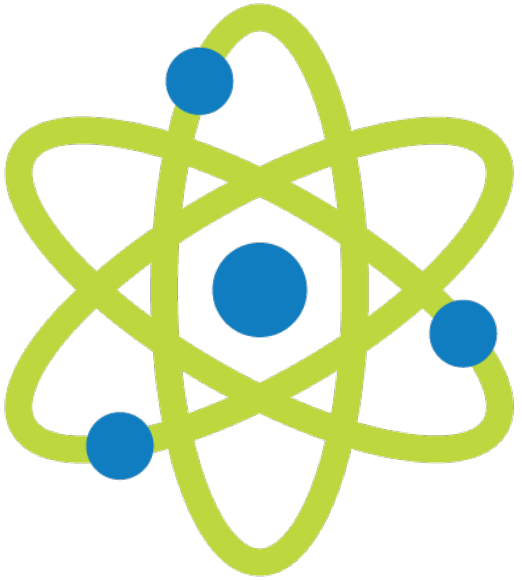
NWMO exists to implement
that plan in a manner that will
protect people and the environment
for generations to come.

How Did We Get Here



Created in 2002

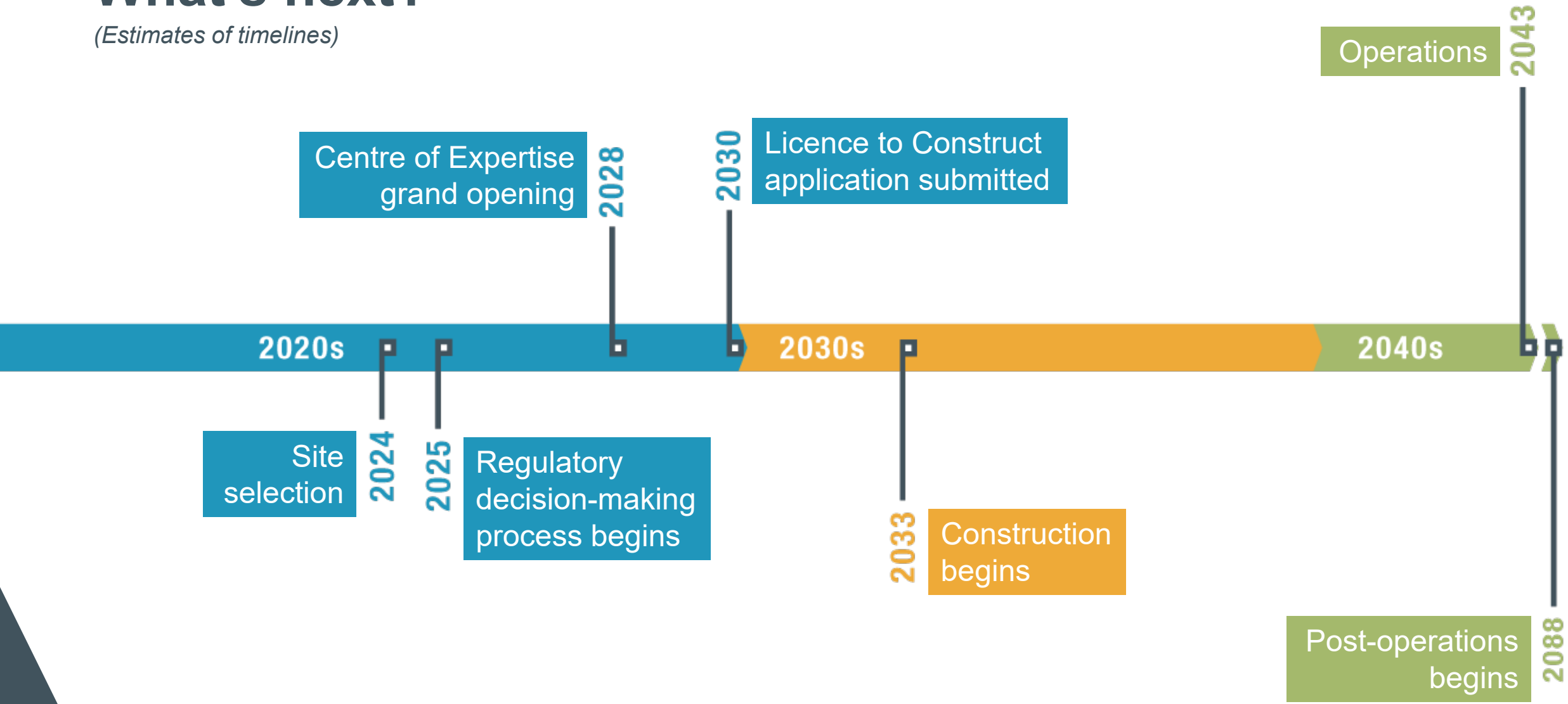
Through dialogue with Canadians and Indigenous peoples, Canada's plan emerged



A non-profit organization funded by waste owners

What's next?

(Estimates of timelines)




1
2
Wabigoon Lake Ojibway Nation-Ignace area
Saugeen Ojibway Nation-South Bruce area

Future Proofing Our Work by Learning From The Past Five Key Lessons

Safety is Critical: Technical Program Evolution

- Early innovation bias
  - Copper coating
  - Smaller Used fuel Containers
- Safety analysis versus building progressive confidence in safety

Engagement Program

- “Learn More” for robust decision making
  - Provide a safe space for open and transparent public dialogue and participation
  - Engage proactively, with purpose
  - Build relationships to achieve a willing coalition

Public Communications

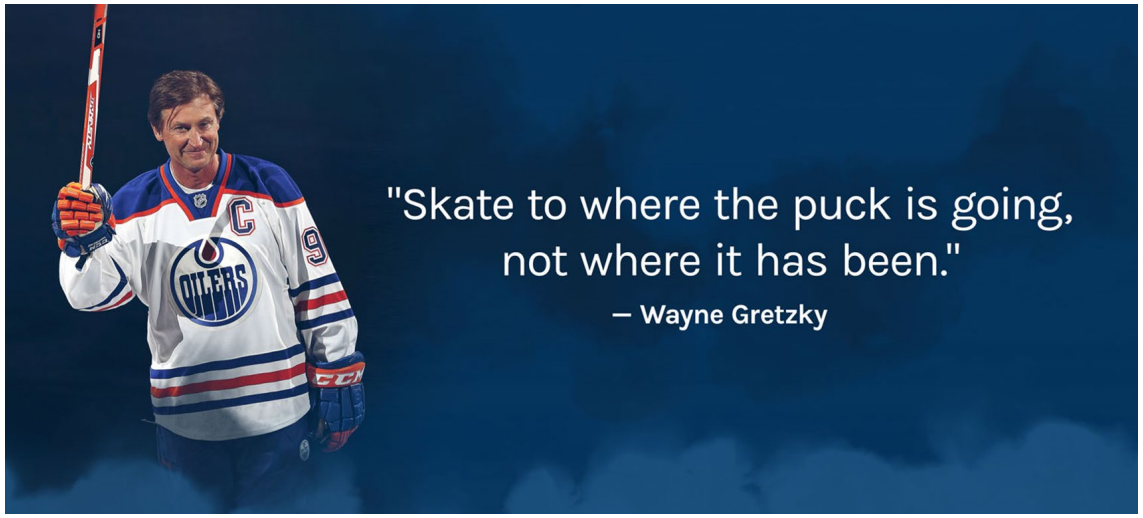
- Future proof your work: keep the long game in mind
  - $26 billion CAD versus $4.5 billion
  - What is the inventory of used fuel or other waste types
- Communicate effectively about risk
  - Used fuel is stored safely, not what you see in the Simpsons
  - Radiation exposure from spent fuel versus other sources

Implementing Organization's Independence from Industry and Government

- Allows the NWMO to make the best decisions in order to site, license and build a DGR
- Not subject to the whims of the government of the day or competing business priorities

Managing Change and Being Ready to Adapt

- Climate Change and the Nuclear Renaissance
- Indigenous rights recognition evolution in Canada
  - UN Declaration on the Rights of Indigenous Peoples
- Being prepared for black swan events, these projects are too long to think it can’t happen to us.



Thank you!

nwmo

EXPERIENCES IN DEVELOPMENT OF DGR FACILITIES : LESSONS LEARNT

Session 1A

Pierre-Marie ABADIE
CEO
Andra

ICGR-7 – 28th May 2024
Busan

Cigéo : HLW and ILW-LL repository

ILW -LL

HLW

designed to be reversible for at least 100 years

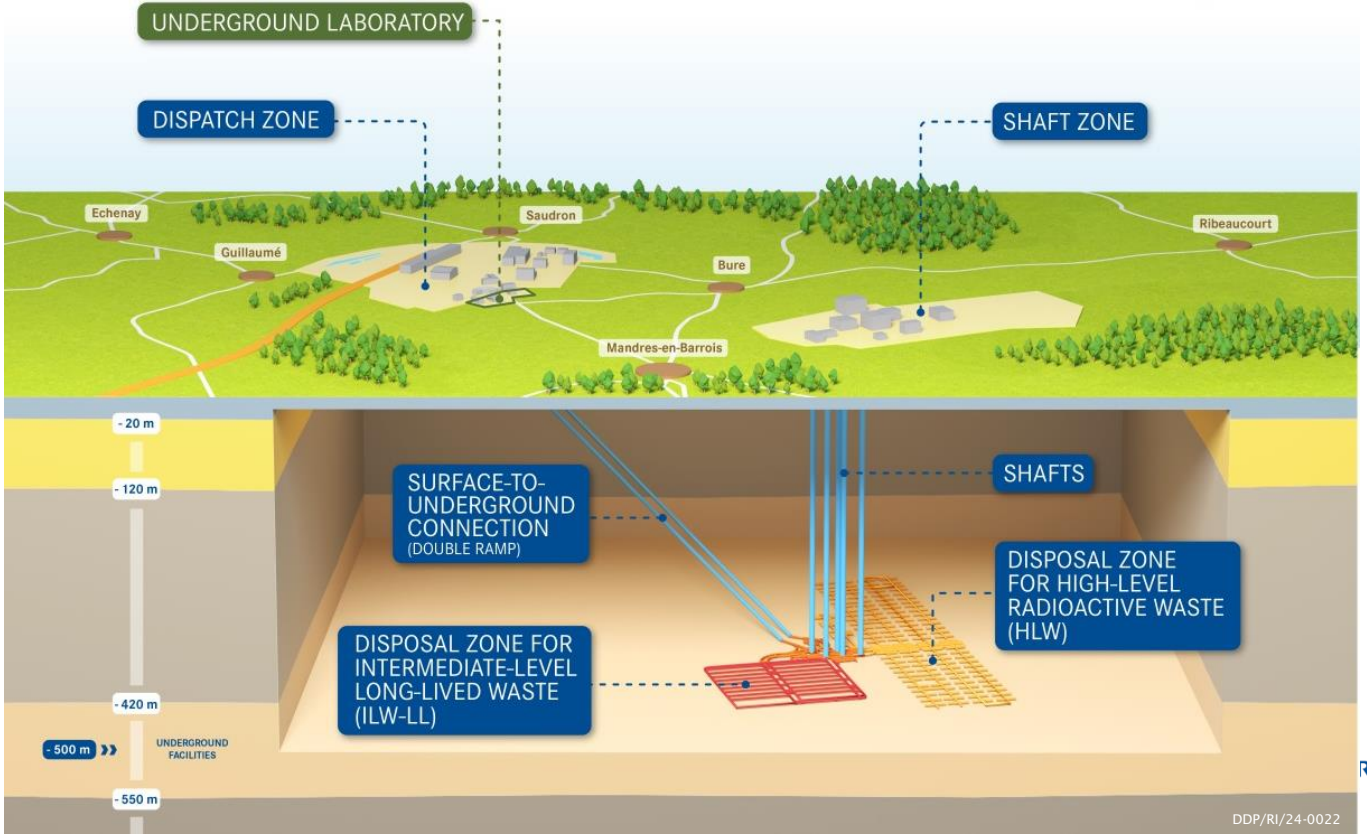
500 Metre depth

15 km² of underground footprint

83 000 m^3 of waste

120 Years of operation

25 Bn Euros



Cigéo : Project specificities

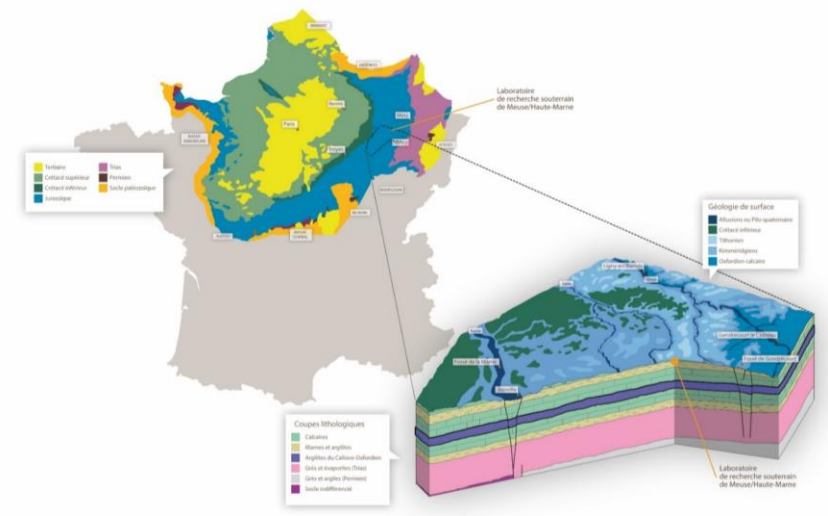
ILW -LL

HLW

- **Inventory :** volume, nature, diversity of waste
- **Fuel reprocessing**
- **Site selection :** Meuse/Haute-Marne district in 1998
  - **Consent-based driven**
  - **Non-nuclearized area**
  - **Sedimentary host rock**
- **Reversible disposal process** over a century **:**
  Progressivity, Flexibility, Adaptability, Retrievability
- **An Industrial Pilot Phase** to test and assess the disposal process and organize the governance of Cigéo
- **New nuclear context**

Forecasted volume of waste :
ILW-LL : ~73 000 m³ → ~ 167 000 packages
60% already produced

HLW : ~ 10 000 m³ → ~ 56 000 packages
40% already produced



Cigéo roadmap from the beginning up to now

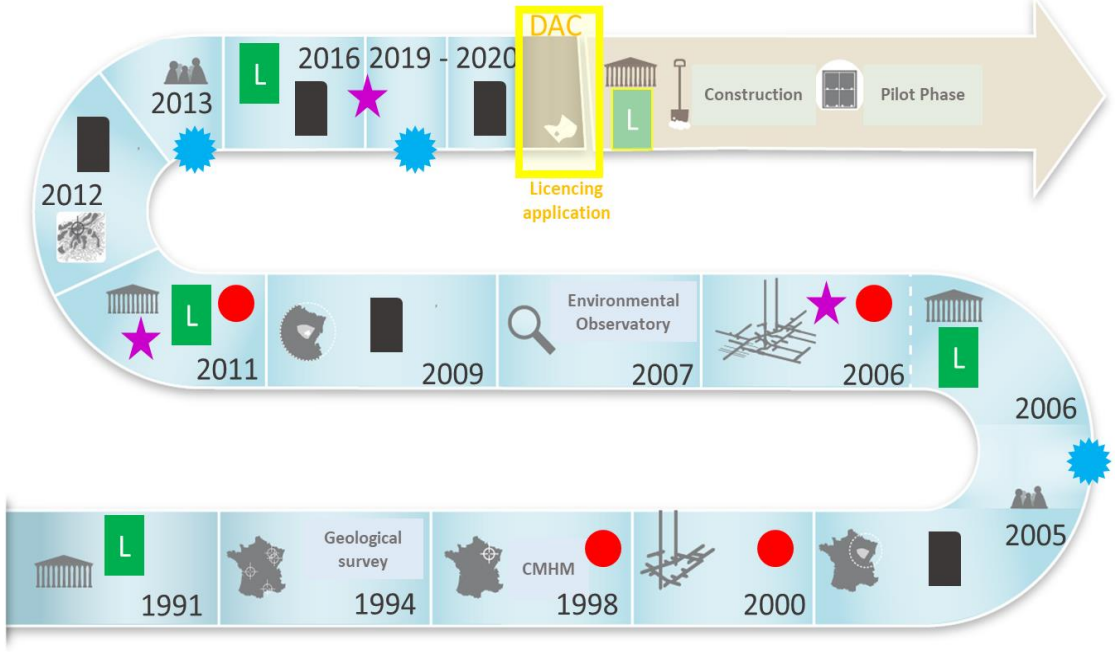
ILW -LL

HLW

→ **A** step-by-step **Roadmap**, with decisional milestones

→ **Safety Case gradual development** supported by an **URL**

→ A continuous and strong **involvement of the French parliament**



Reports (2005, 2009, 2012, 2016, 2020)

Laws
(1991, 2006, 2011, 2016)

International Peer reviews
(2006, 2011,2018)

Public consultation
(2006, 2013, 2021)

URL development

ANDRA

Cigéo licencing : Triple track process started in 2020

ILW -LL

HLW

National project recognition

Final land acquisition allowed

Declaration of **Public Convenience and Necessity**
Submitted in August 2020
Signed and published on **July 8th, 2022**

Urban and environmental procedure

Non-nuclear aspects
Started and on-going

Modification of existing **infrastructures** and natural component
Preliminary works

Nuclear facility licencing

Nuclear facility
Started and on-going

Construction Licence
Submitted in January 2023

ANDRA

On-going programme : Licencing review

Nuclear facility licencing

Review of Construction Licence Application: how does this take place?

The review of the construction licence application could take **three to five years.**

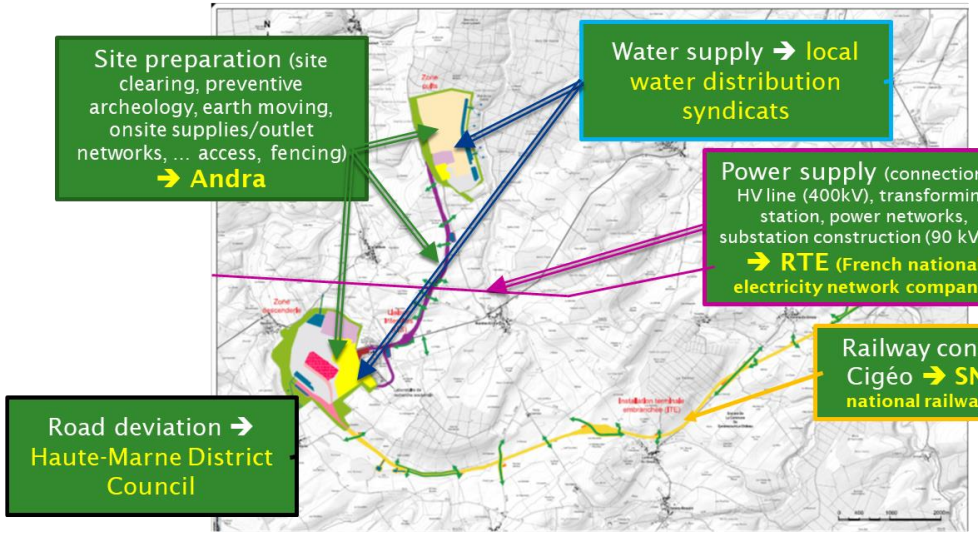
- ✓ Application file submitted OK (January 2023)
- ✓ Review of the completeness of Andra's application by ASN/IRSN OK (June 2023)
- ✓ Inception of detailed technical review with Permanent Experts Groups

Importance to involve all stakeholders on specific topics at the right time

Preparatory works

National project recognition → Urban and environmental procedure

Non-nuclear procedures
Modification of existing infrastructures and natural components of the site :
- Site clearing, preventive archeology, road access, power and water supply, railway connection



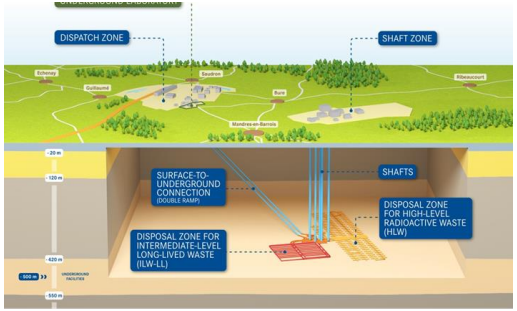
On-going at Andra :

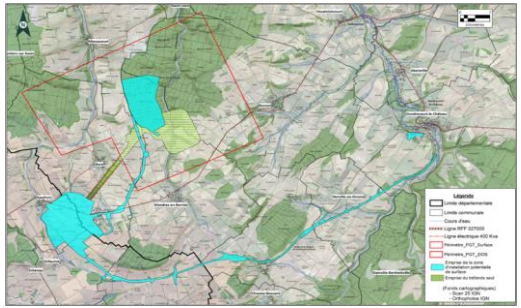
- Processing deliveries of reglementary applications needed to **prepare the site for construction** : Preventive archeology , utilities and supplies…
- To maintain strong **involvement** of the territory and the public
- Involvement of Public Owners (railways, power supply, roads and access'…)

Preparatory works :
- Involvement of numerous entities / companies and numerous authorisations

Final lands acquisition process

National project recognition → Urban and environmental procedure





As nuclear operator, Andra must own the lands for Cigéo :

- **Surface facilities** (shaft and dispatch zones, rail pathway, interzones connecting road…)
- **Underground volumes** for disposal facility , around drifts (ramps, shafts, galleries…)

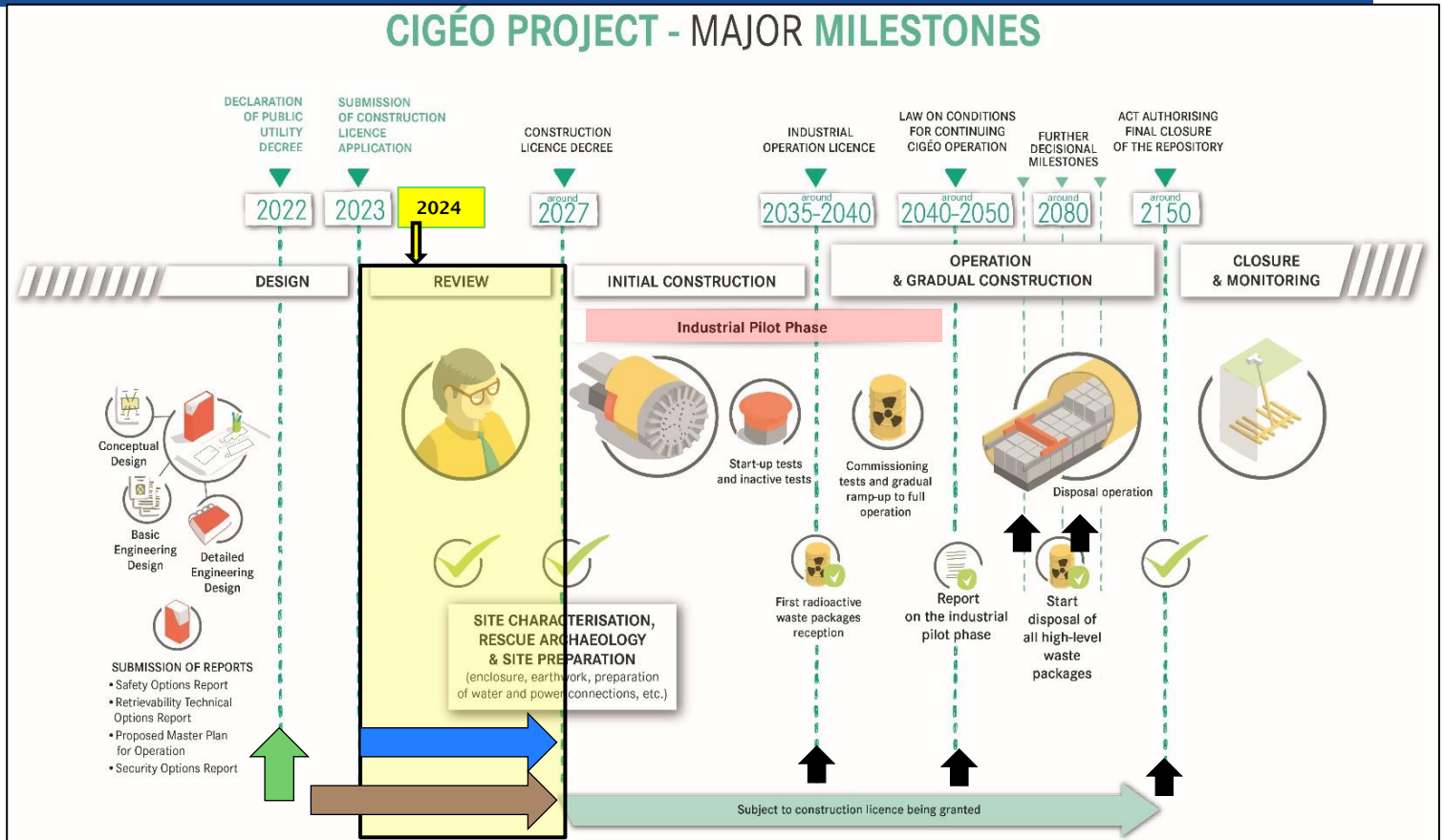
Lands acquired gradually and by a mutual agreement on a consensual basis

In January 2024, expropriation administrative process (prefectures of Meuse and Haute-Marne) to achieve the land acquisition of the latest remaining parcels and the underground area

Andra's properties on lands needed for the construction of the first stage of Cigéo shall be established for the construction license decree (2027-2028)

In January 2024 Andra owns **~20 %** underground rights **~83 %** surface lands

Challenges ahead : Cigéo next steps



National project recognition

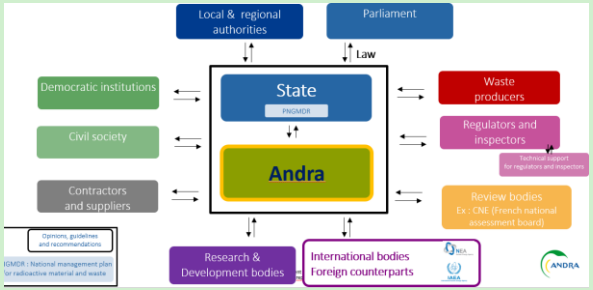
Urban and environmental procedure

Nuclear facility licencing

Future decisions to come

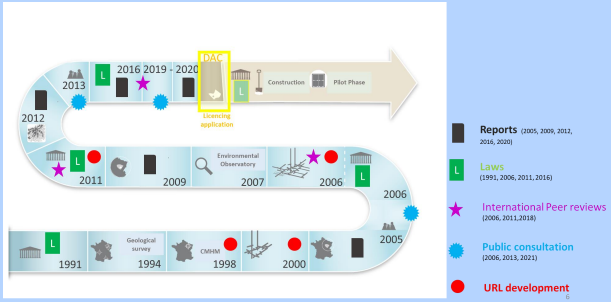
Cigéo, 30 years of development : key-success factors

Governance and interactions/concertation between stakeholders



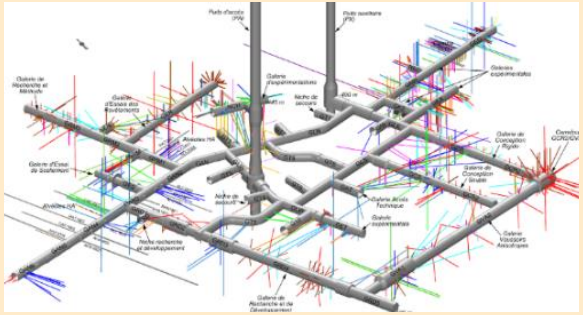
… with a strong territorial involvement

Roadmap and milestones giving time for decisions

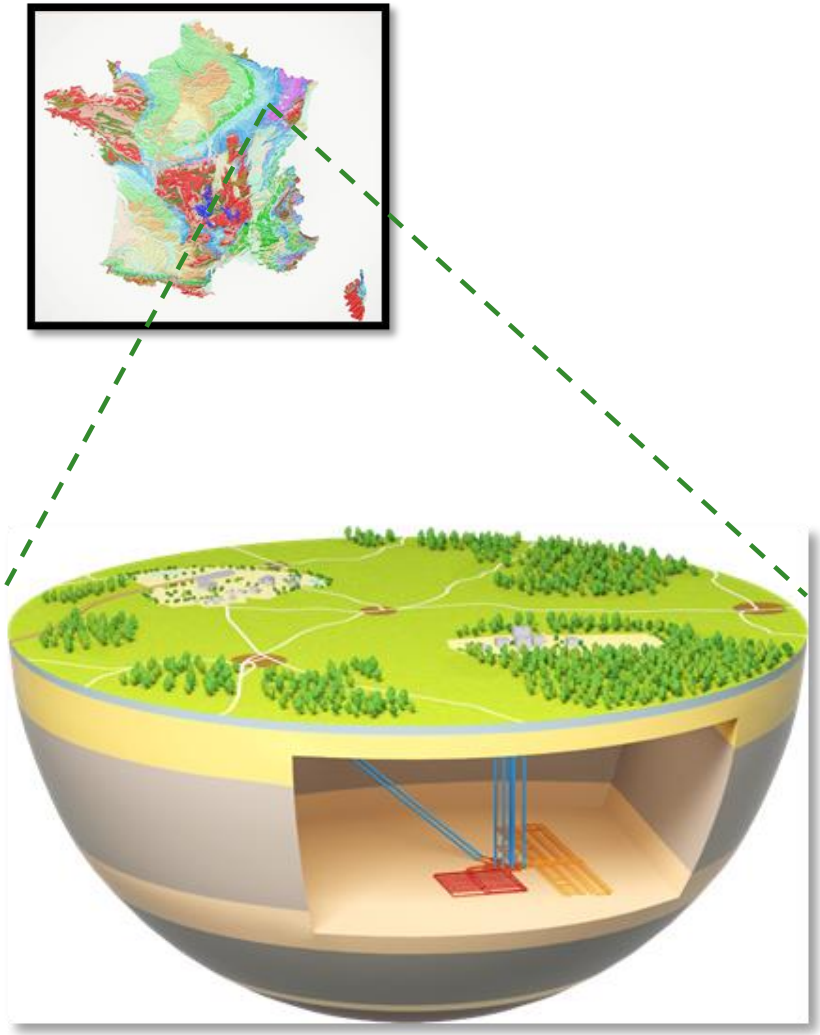


… with 3 Acts allowing pluriannual development plans with **stable funding**

Progressive R&D program providing the scientific basis for each decision milestone



… with a URL in Bure



Thank you

Finland's approach to final disposal of spent nuclear fuel

Ilkka Poikolainen, President and CEO, Posiva Oy

OLKILUOTO

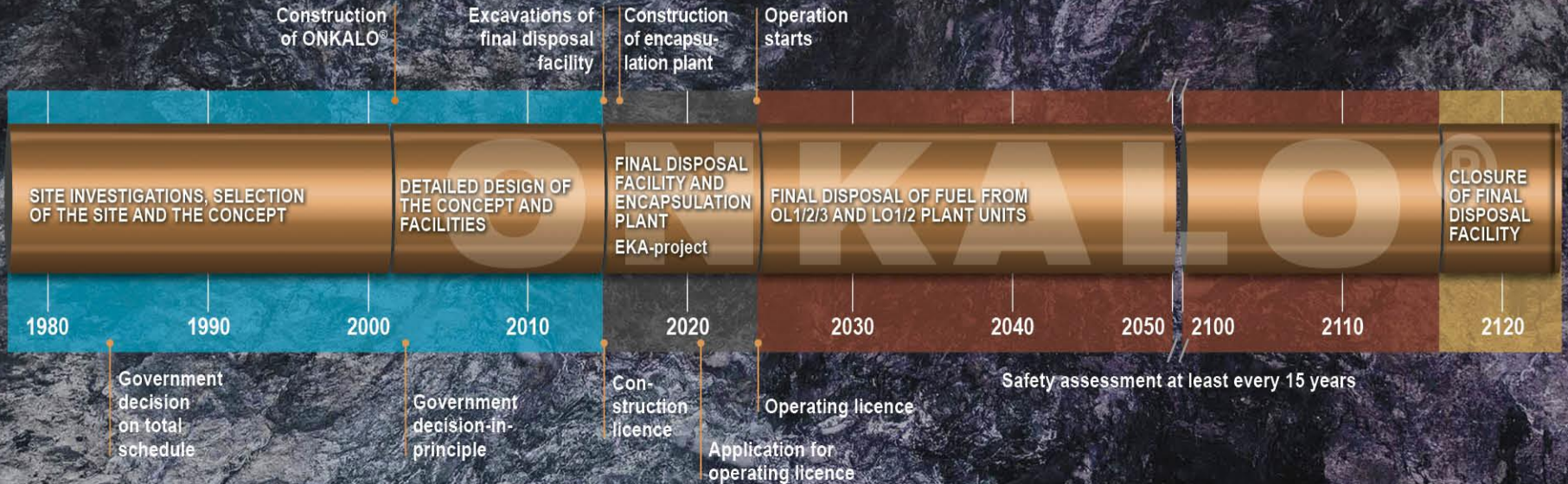
– island that provides entire lifecycle management for nuclear power.

We have a significant role in climate protection as a part of the lifecycle of sustainable nuclear energy

Posiva Oy

- Mission: safe and cost efficient final disposal of spent nuclear fuel of its owners
- A private company owned by Teollisuuden Voima Plc and Fortum Power and Heat
- 90 employees
  - in addition, 100 external person years and 150 construction workers
- Subsidiary Posiva Solutions (est. 2016) sells expertise on the final disposal of SNF
- We have a solution for final disposal of used nuclear fuel

The safe final disposal will be started first in the world in ONKALO®



- Repository capacity is about 3250 canisters
- Depth of the tunnel system -400-450 m
- Construction and operating time approximately 100 years
- Total tunnel length about 50 km

Posiva

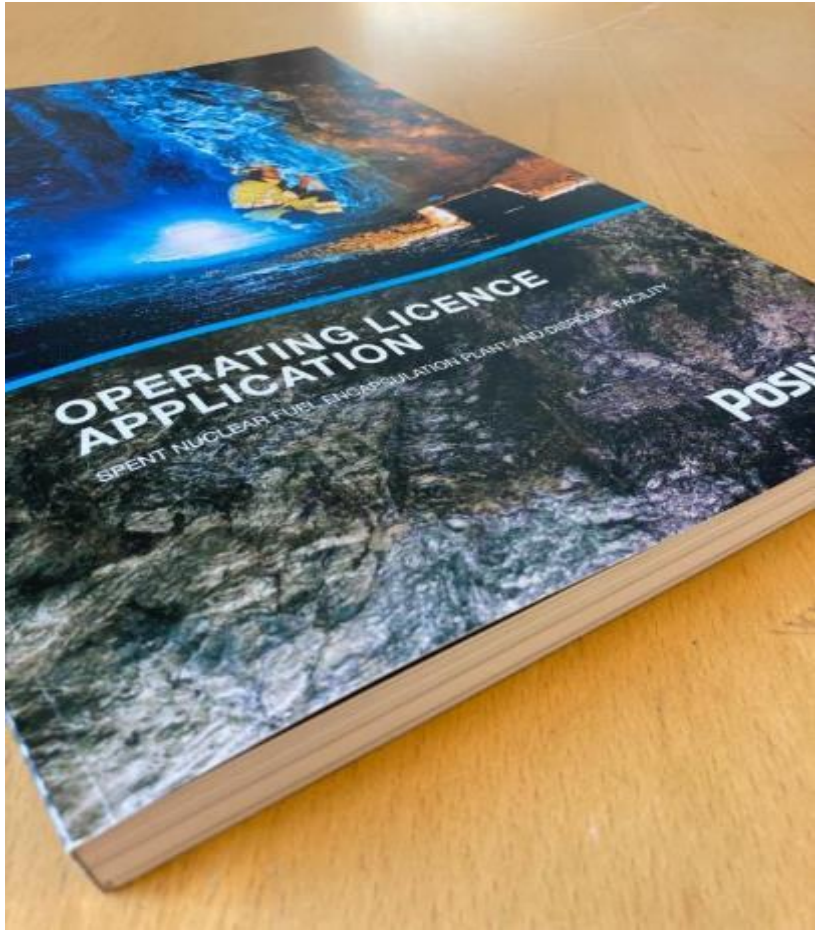
Commissioning is over 80 % completed

- There are about 170 systems or equipment to be commissioned
- Facility Level Commissionings will soon be started – when they have been completed, we will start the Trial Run of Final Disposal in August 2024
- The Trial Run is the final phase of Posiva's preparing for the operation of the DGR. It will be carried out with the methods, procedures, equipment and personnel to be used in the operation phase.
  - **There is also an opportunity to participate and learn how the entire disposal process functions. Discuss with Posiva´s experts and gain insights to benefit own national program**

  => If your company/country is interested in participating the trial run please contact to Posiva Solutions' team

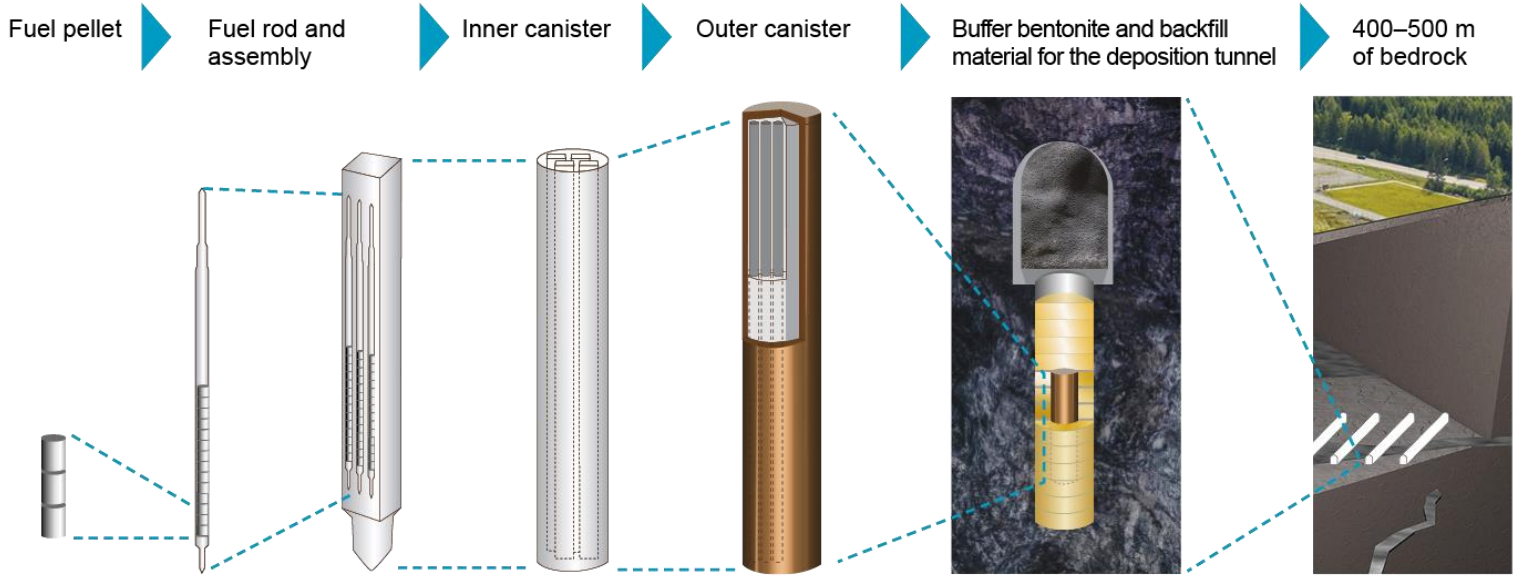
World’s first Operating license application for a DGR was submitted 30.12.2021

- 17 000 pages e-document containing all needed information to grant a permit for a nuclear facility
- H1/2025 considered to be the earliest time to receive the approval to start disposal.



Only safe final disposal is possible

- Multi-barrier principle of final disposal:
  Several engineered barriers and host rock backing up each other ensure long-term safety



Above ground

Encapsulation plant

The systems installed in the fuel handling cell

Welding station

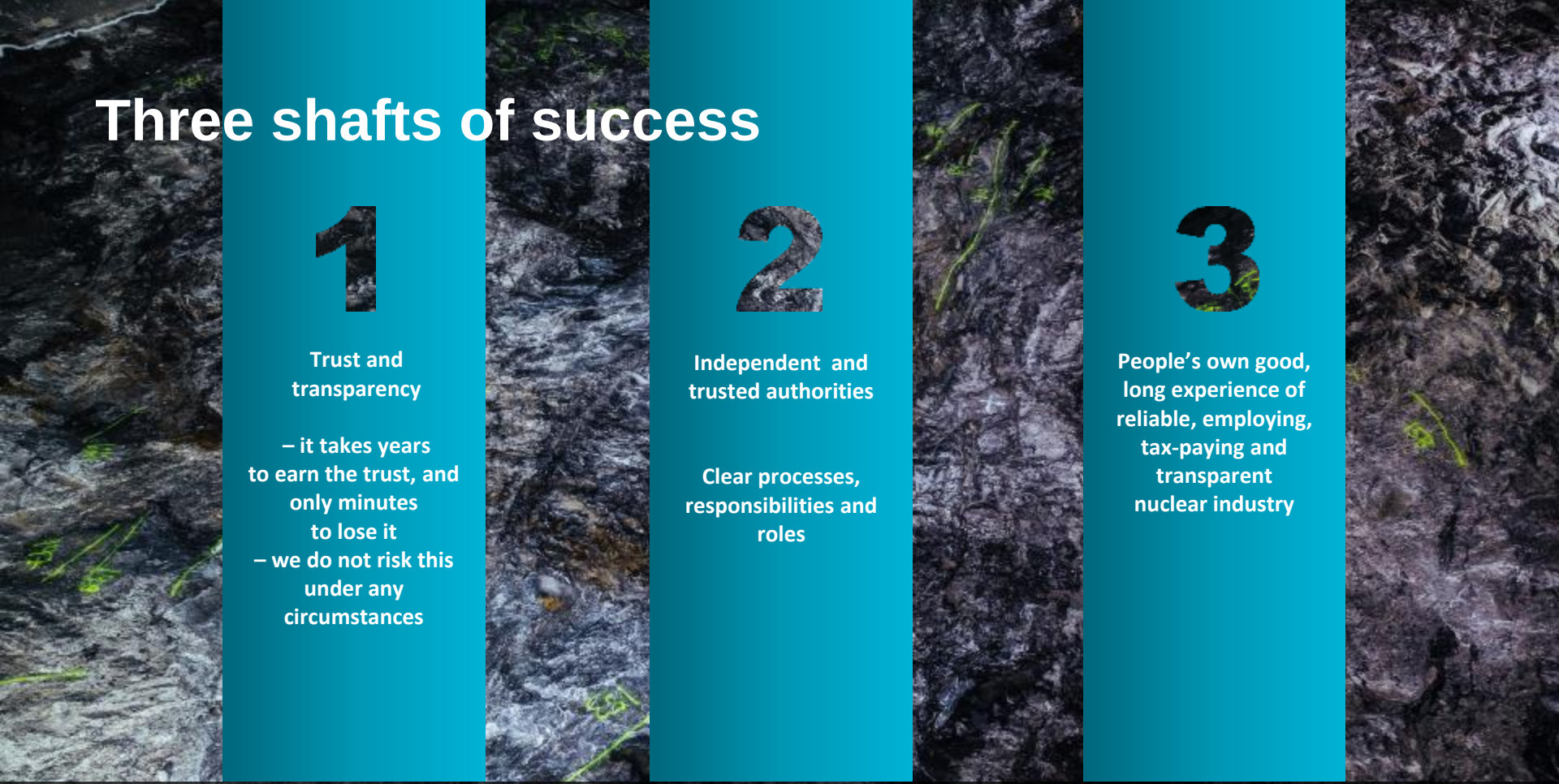
Control room for remote operation

Underground

Final disposal facility

Central tunnel

Three shafts of success



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Trust and transparency

– it takes years to earn the trust, and only minutes to lose it – we do not risk this under any circumstances

2

Independent and trusted authorities

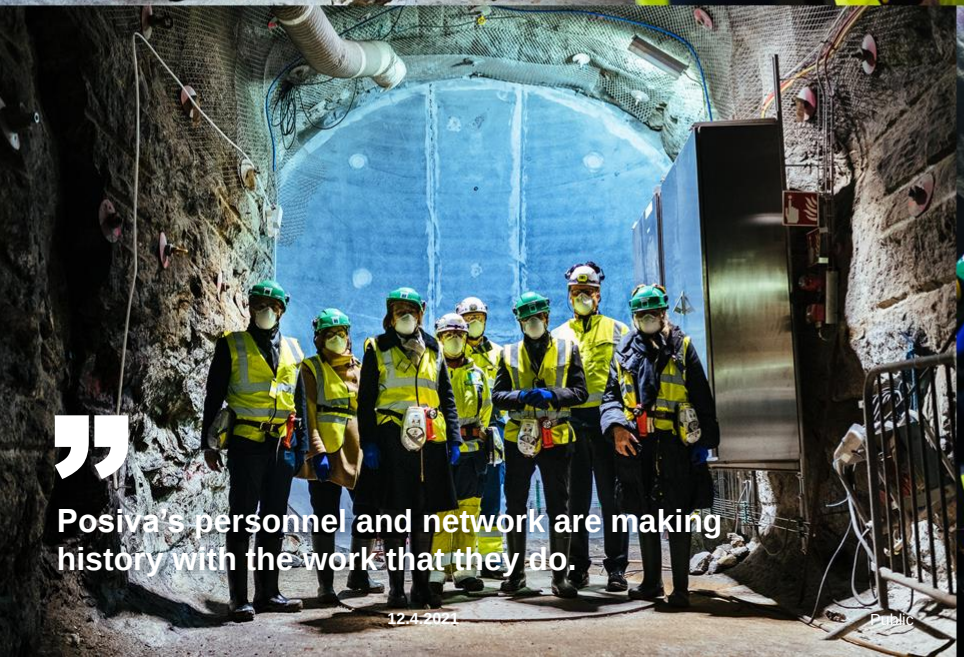
Clear processes, responsibilities and roles

3

People's own good, long experience of reliable, employing, tax-paying and transparent nuclear industry

Public acceptance of deep geological disposal of spent nuclear fuel


Posiva’s ONKALO®
is a game changer.


Posiva’s personnel and network are making history with the work that they do.
12.4.2021
Public


Posiva’s solution for the final disposal of spent nuclear fuel enables the sustainable production of nuclear electricity. A link to IAEA video in here
IAEA Director General Grossi, in November 2020


Rafael MarianoGrossi
2,591 Tweets
Following
3
7
18
Rafael MarianoGrossi @rafaelmgrossi · Dec 1, 2020
Last week I went 450 meters below ground level to visit @Posiva_fi #Onkalo. This is where spent fuel from Finland’s nuclear power reactors will be isolated for thousands of years. A solution for sustainable nuclear energy operation, a game changer! More bit.ly/36q4Eka
RAFAEL MARIANO GROSSI
IAEA Director General
7
41
105


Posiva
Global leader
in final disposal

U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

ICGR 2024: Used Nuclear Fuel and High Level Waste

Mr. Paul Murray, Deputy Assistant Secretary
Spent Fuel & Waste Disposition
U.S. Department of Energy

TIMELINE HISTORY OF DEEP GEOLOGIC REPOSITORY PROGRAM

1950s
Active investigation began on the concept of mined geological repositories for disposal of radioactive waste

1970s
U.S. studied feasibility of reprocessing commercial spent nuclear fuel to extract plutonium; approach later canceled, leaving disposal as primary option for managing radioactive waste.

1980
DOE issued the final environmental impact statement: *Management of Commercially Generated Radioactive Waste.*

1981
DOE issued a record of decision announcing its determination to pursue mined geologic disposal for spent nuclear fuel and high-level radioactive waste.

1982
Congress passed the Nuclear Waste Policy Act, establishing a site-selection process for a geologic repository.

1986
DOE issued environmental assessments for five potential sites; recommended three of the five sites for characterization. President Reagan approved the recommendations.

1987
Congress amended the Nuclear Waste Policy Act to direct DOE to characterize only Yucca Mountain as a potential repository.

1995
DOE issued a notice of intent to prepare the Yucca Mountain Repository environmental impact statement.

1999
DOE issued draft Yucca Mountain Repository environmental impact statement.

2001
DOE issued supplement to the draft environmental impact statement. DOE issued documents relevant to site suitability and a potential site recommendation.

2002
DOE issued final Yucca Mountain Repository environmental impact statement. DOE made site suitability determination and recommendation.

2008
DOE submitted a license application to the Nuclear Regulatory Commission.

2010
Yucca Mountain Repository funding ceased.

Program put on pause.

Program ceased before DOE received construction authorization.

Program ceased before repository emplacement operations began.

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US Stakeholders

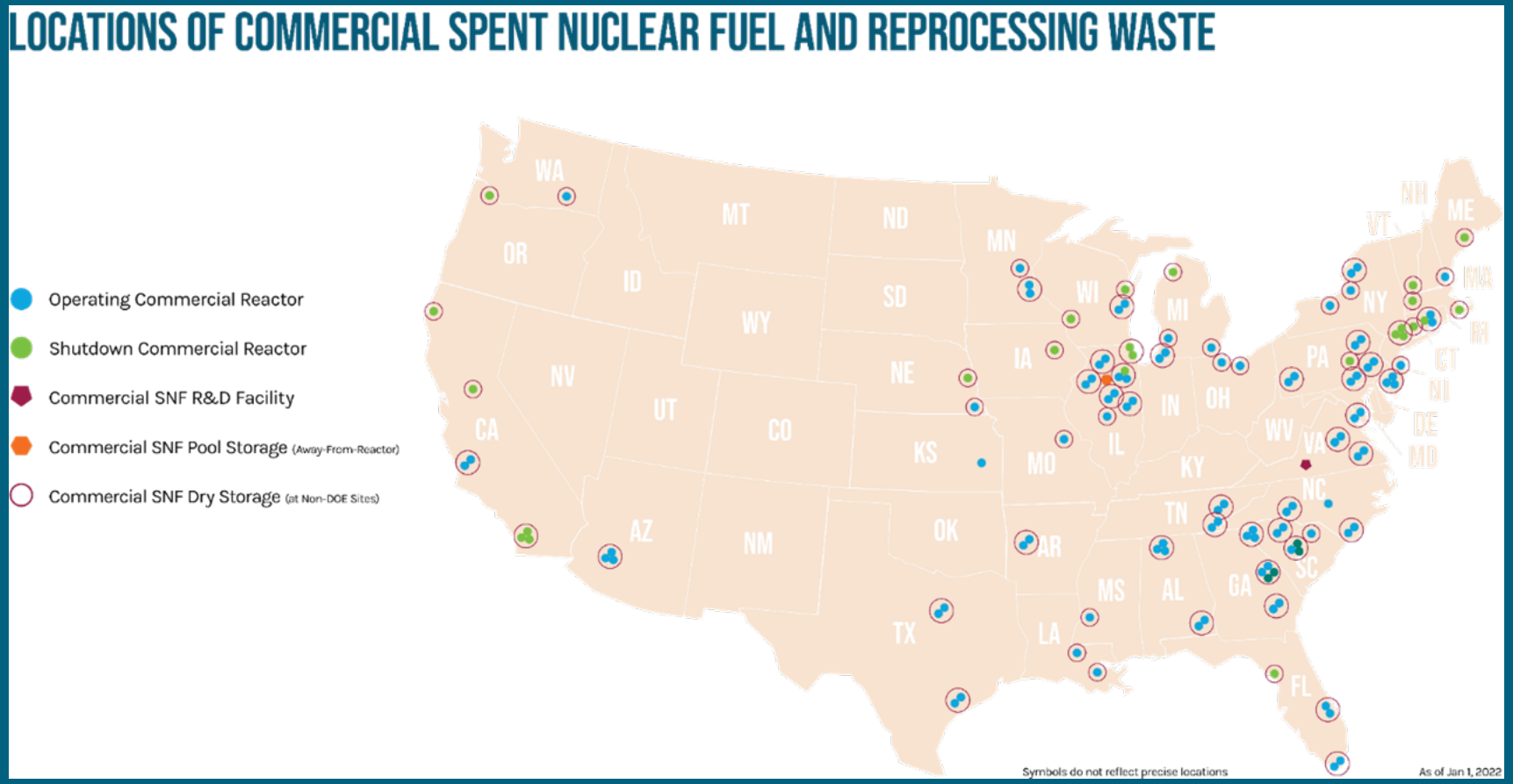
1. Commercial Spent Nuclear Fuel ~ 140,000 tons
2. DOE Environmental Management High Level Waste from:
   - Vitrified HLW from DOE EM clean-up sites.
3. Naval Reactors Spent Nuclear Fuel
4. DOE Spent Nuclear Fuel
5. Advanced Reactors Spent Nuclear

Taxpayer Liability for Spent Nuclear Fuel*

Fiscal Year Ending	DOE's Estimate of Total Liability	Amount Paid from Taxpayer Funded Judgment Fund		DOE's Estimate of Remaining Liability (Total less Amount Paid)
		Cumulative	Annual	
9/30/2023	$ 44.7 Billion	$ 10.6 Billion	$ 500 Million	$ 34.1 Billion
9/30/2022	$ 41.1 Billion	$ 10.1 Billion	$ 1.1 Billion	$ 31.0 Billion
9/30/2021	$ 39.9 Billion	$ 9.0 Billion	$ 400 Million	$ 30.9 Billion
9/30/2020	$ 39.2 Billion	$ 8.6 Billion	$ 600 Million	$ 30.6 Billion
9/30/2019	$ 36.5 Billion	$ 8.0 Billion	$ 600 Million	$ 28.5 Billion
9/30/2018	$ 35.5 Billion	$ 7.4 Billion	$ 500 Million	$ 28.1 Billion
9/30/2017	$ 34.1 Billion	$ 6.9 Billion	$ 800 Million	$ 27.2 Billion
9/30/2016	$ 30.8 Billion	$ 6.1 Billion	$ 800 Million	$ 24.7 Billion
9/30/2015	$ 29.0 Billion	$ 5.3 Billion	$ 800 Million	$ 23.7 Billion
9/30/2014	$ 27.1 Billion	$ 4.5 Billion	$ 800 Million	$ 22.6 Billion

* Source: DOE Nuclear Waste Fund Annual Financial Statement Audit Reports. Over time, these estimates have been based on varying assumptions including when DOE would begin removing commercial spent nuclear fuel from reactor sites. During the ten-year window covered by the table, the date has been pushed out ~ 17 years. In FY 2023, DOE utilized a range approach for "subsequent license renewals" – the numbers in the table above represent the low end of the range.

U.S. Spent Nuclear Fuel In Context



1958
United States began using commercial nuclear power

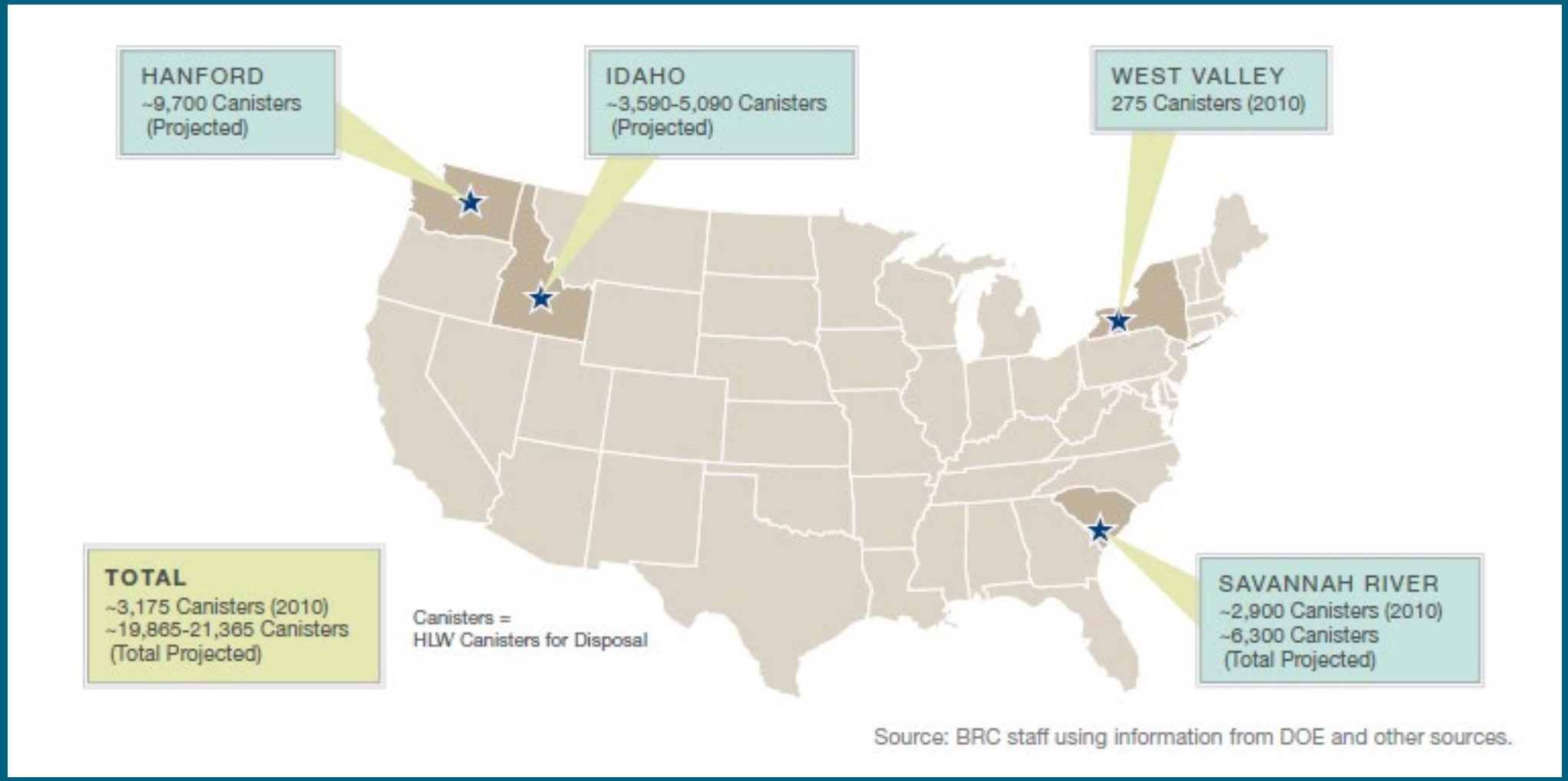
2023
93 operating commercial reactors at 53 nuclear power plant sites in 28 states

- 20 nuclear power plants have shut down
- 90,000+ metric tons of spent nuclear fuel

End of Current Fleet
United States estimated to have ~140,000 metric tons of spent nuclear fuel

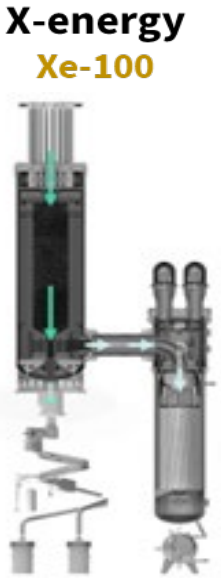
Who is responsible for the management of SNF?

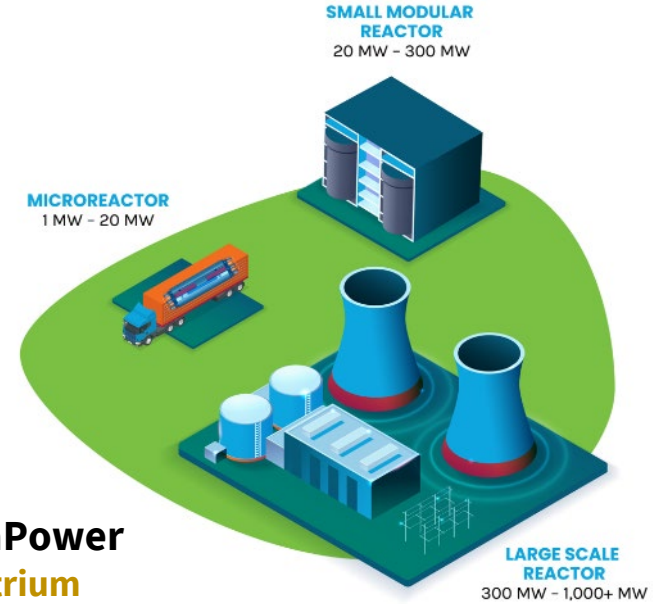
DOE SNF and HLW



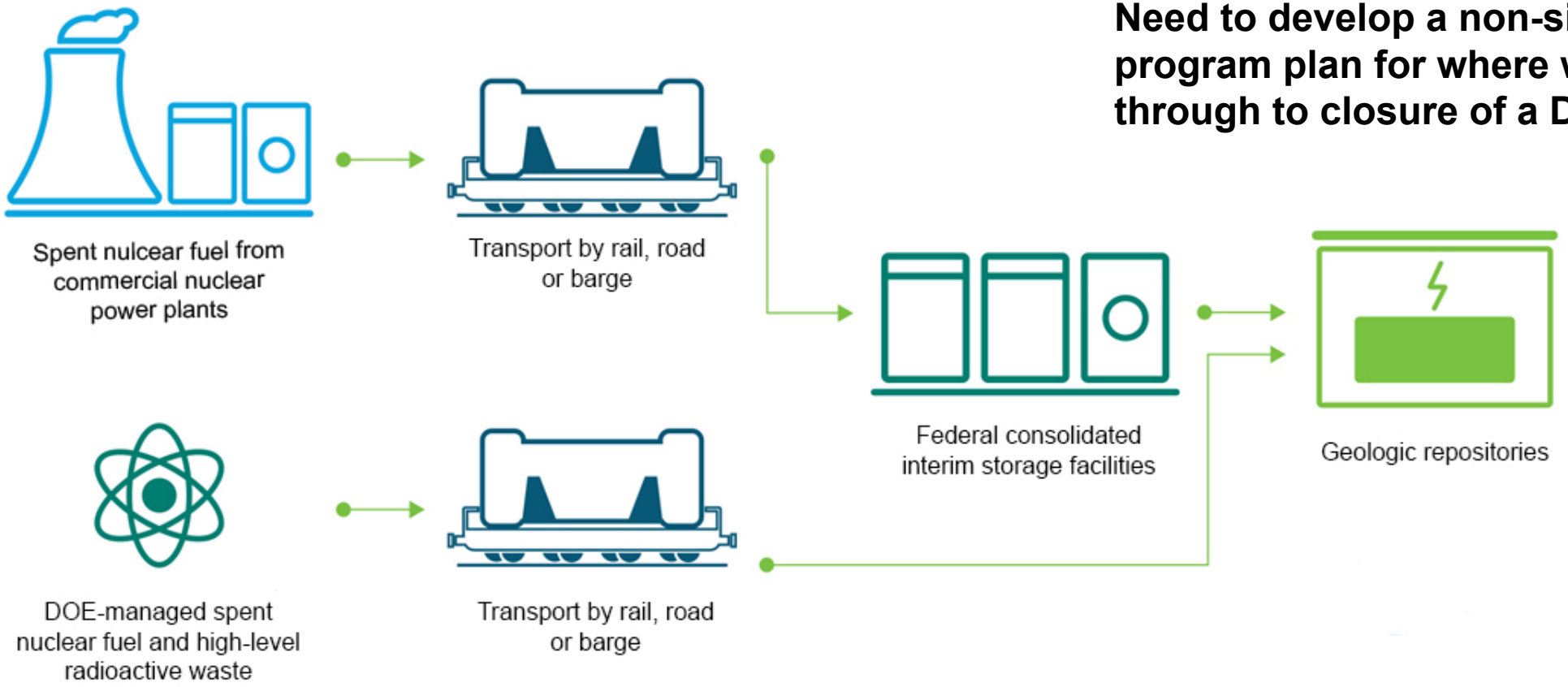
Considering Waste Management for Advanced Reactors

- NRC License Approach
- DOE's integrated project team on back-end management of advanced reactors
- Technical assessment of storage, transportation, and disposal
- Preliminary cost assessments/comparison





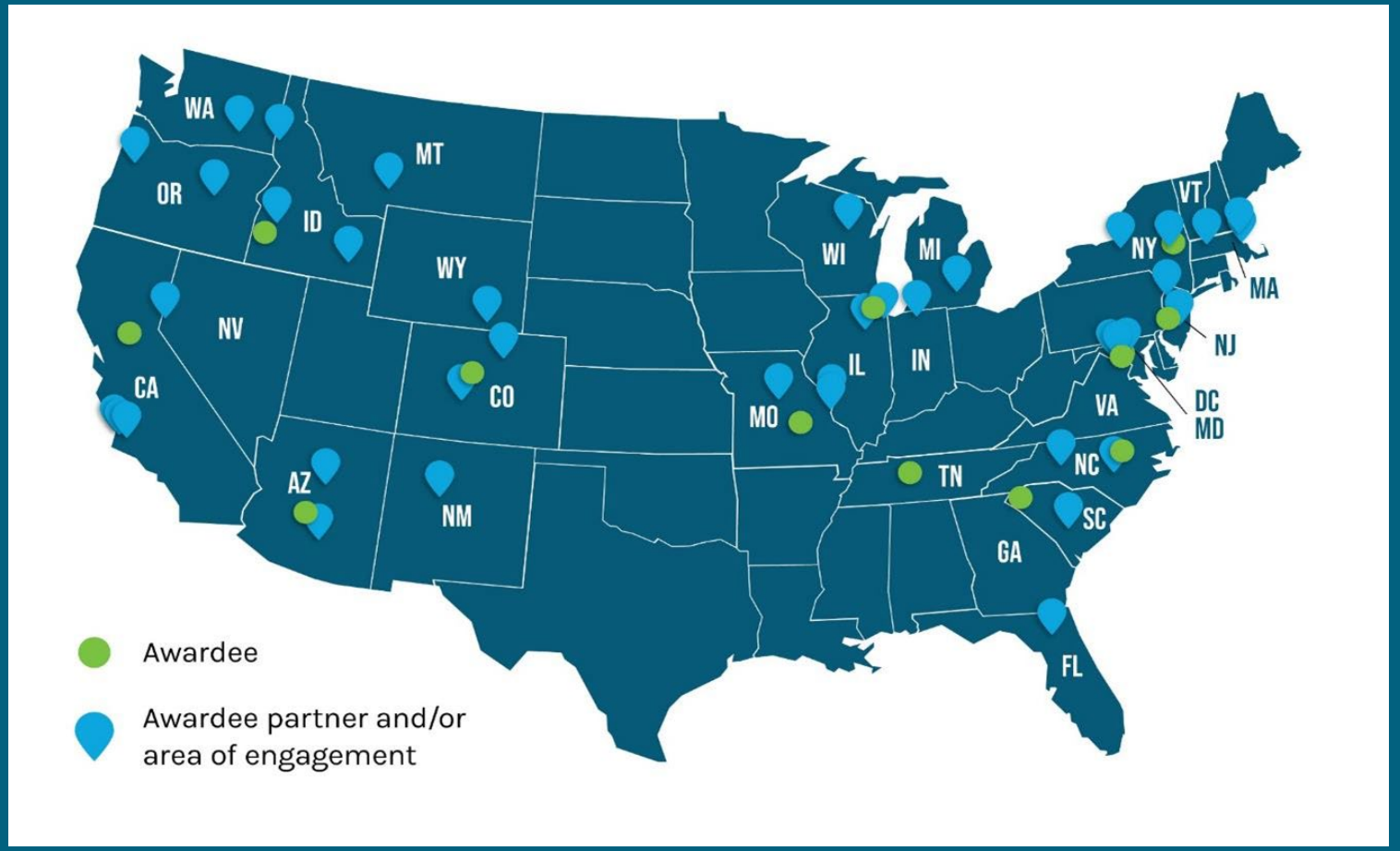
Integrated Waste Management System



Need to develop a non-site specific program plan for where we are today through to closure of a DGR?

Consent-based Siting Consortia

- On June 9, 2023, DOE selected geographically and institutionally diverse awardees to serve as information, engagement, and resource hubs, referred to as consent-based siting consortia. The consortia will foster community discussion and capture feedback on interim storage of spent nuclear fuel.
- Locations identified represent principal investigators, partners, or communities that will participate in the awards. DOE is not looking for volunteer communities to host interim storage facilities in this stage of the consent-based siting process. As such, the locations identified do not represent locations being considered for a consolidated interim storage facility for commercial spent nuclear fuel.



CONSENT-BASED SITING CONSORTIA PROGRESS

Consent-based siting consortia support DOE's efforts to facilitate inclusive community engagement and elicit public feedback on consent-based siting, management of spent nuclear fuel, and federal consolidated interim storage. The 12 awardees are comprised of various organizations to help reach communities across the country and remove barriers to participate in DOE's consent-based siting process. **Awardees have made significant progress in carrying out community engagement activities and providing direct grants to communities wanting to learn more.**

30 Consortia Public/Media Engagements Held

21 New Team Members Brought into the Consortia Effort

3 Community Sub-Grant Programs Issued

20 Information Resource Projects

9 Government Engagements Held (Tribal, State, Local, Federal)

Progress: DOE's Consent-Based Siting Process General Timeline

Progress: Consent-Based Siting Consortia Timeline

Updates reflect activities from September 2023 up to mid-March 2024.

To learn more about these metrics, please visit energy.gov/ne/consent-based-siting-consortia or send an email to consentbasedsiting@hq.doe.gov

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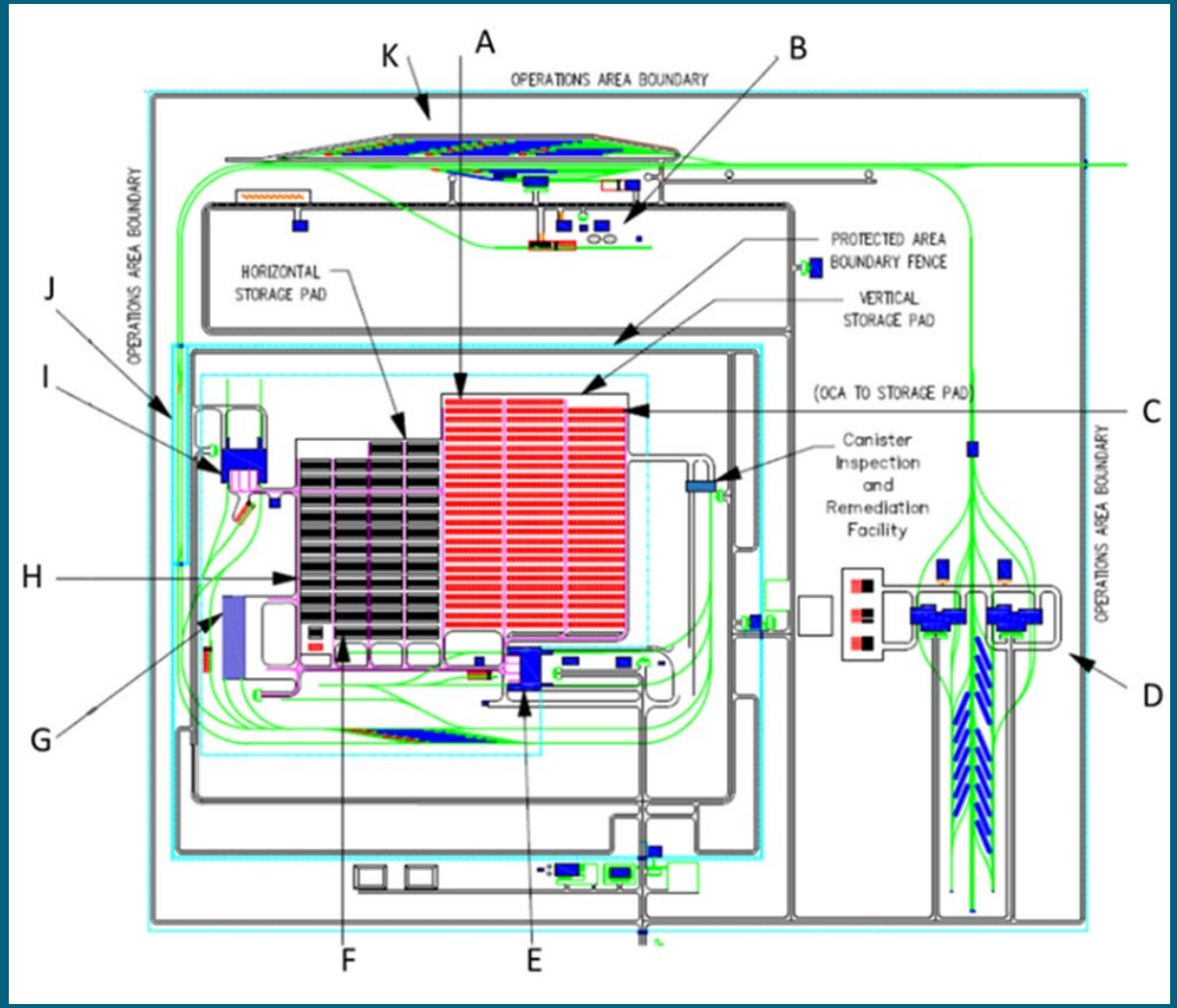
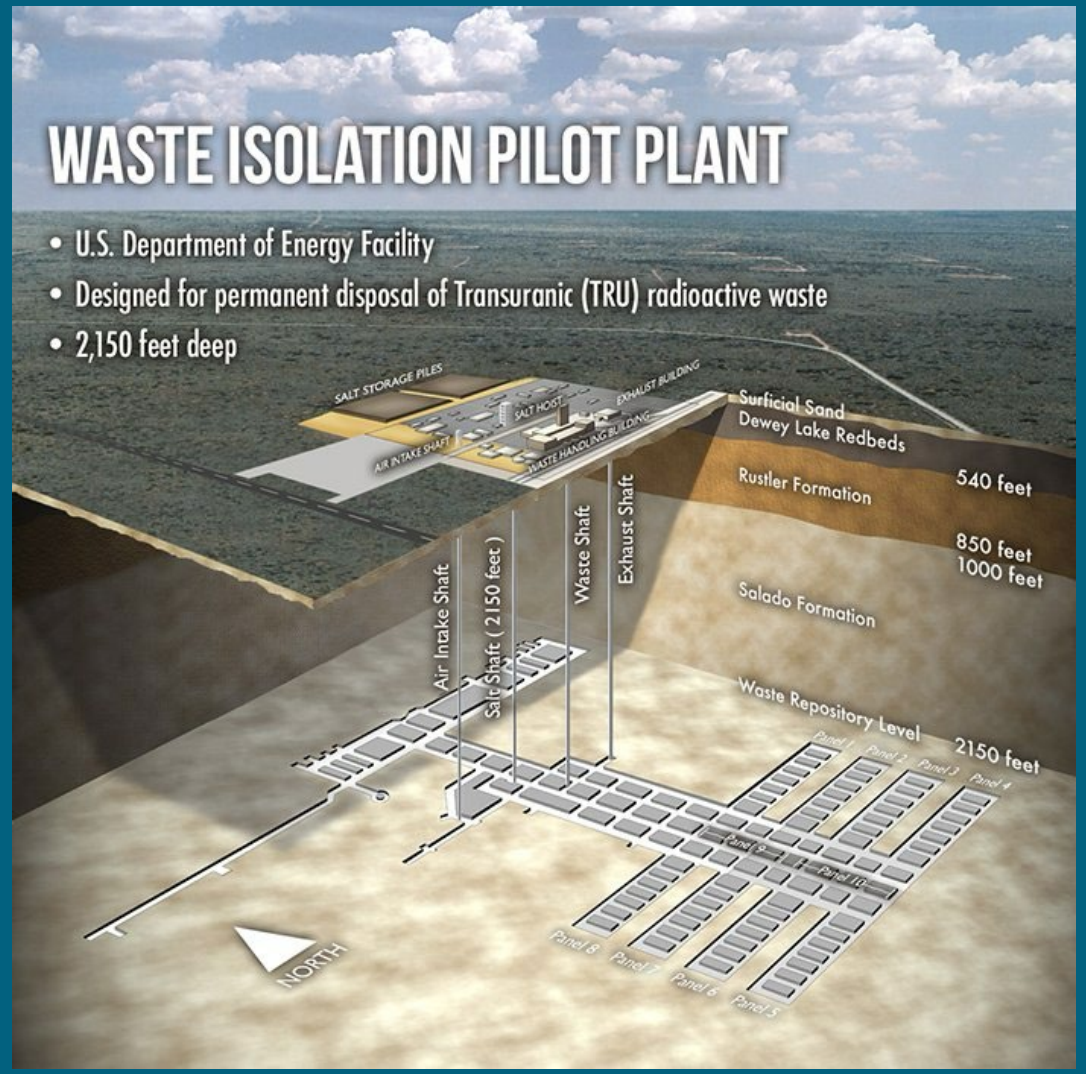
Consolidate Federal Interim Storage

- Design proceeding on schedule.
- Capacity to take SNF from the shut down reactor sites.
- Capacity can be increased to accommodate additional SNF.
- Liabilities estimate assumes start of operations in 2038. Any later will increase the nations liabilities.
- Operational 2038-2042.




IDOX 030001

Waste Isolation Pilot Plant



- The **facility**'s disposal rooms are nearly a half mile, or 2,150 feet, below the surface.
- For 25 years operated by DOE Environmental Management for the disposal Transuranic Waste from clean-up of the weapons sites.
- Recently granted a permit extension for a further 15 years of operation.
- Approximately 96 percent of the total volume of waste to be disposed at WIPP will be contact-handled TRU waste. The remaining 4 percent will be remote-handled TRU waste.

Repository Program

- Nuclear Waste Policy Act.
- Continue to support international R&D related related to generic repository model.
- Evaluating sending DOE Engineers and managers to work on international programs.
- Build capability in US industry to support the start of a future program.
- Collaborate with EM on lessons learned from WIPP and the search for second repository.

U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

Questions

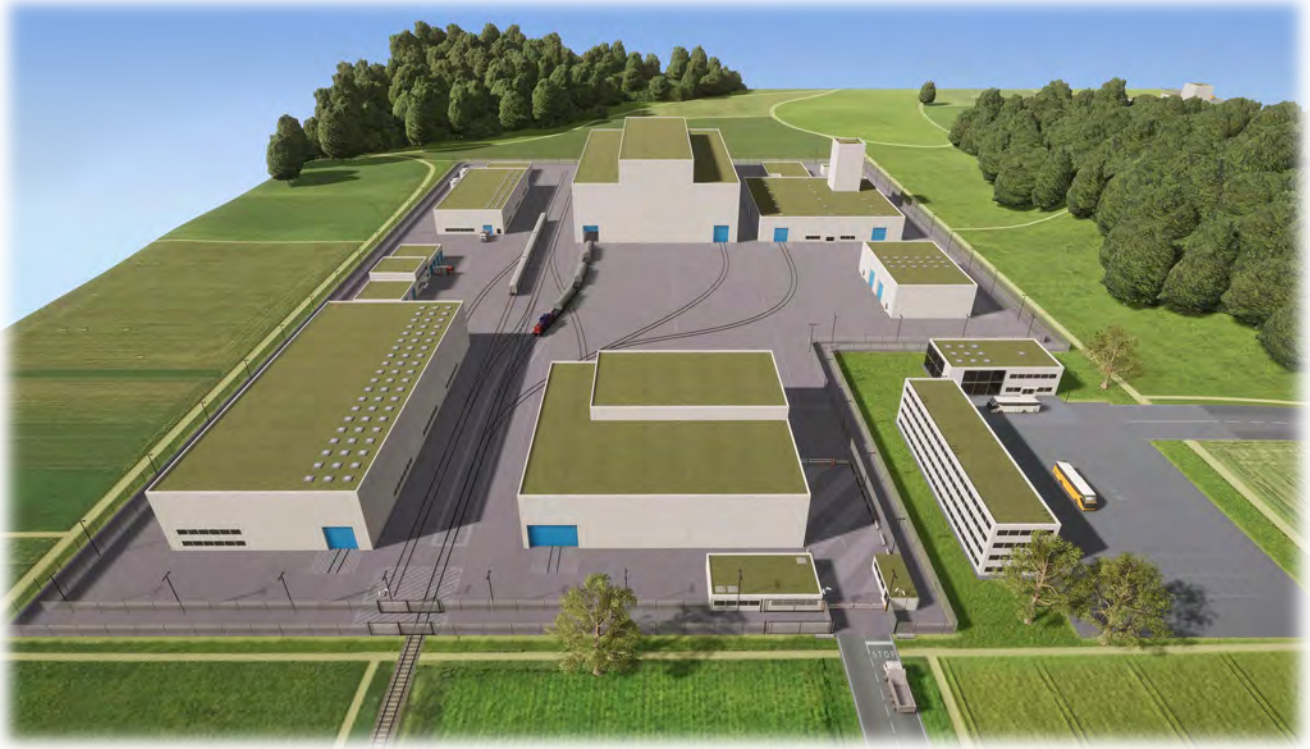
Development of a DGR: The Swiss Case

7th International Conference on Geological Repositories (ICGR-7)

27-31 May 2024 in Busan, Korea

Annatina Müller-Germanà, PhD,

Head of International Affairs and Research, Staff of the Directorate, Swiss Federal Nuclear Safety Inspectorate ENSI



Introduction…

EUROPE

Produced by the Cartographic Research Lab
University of Alabama

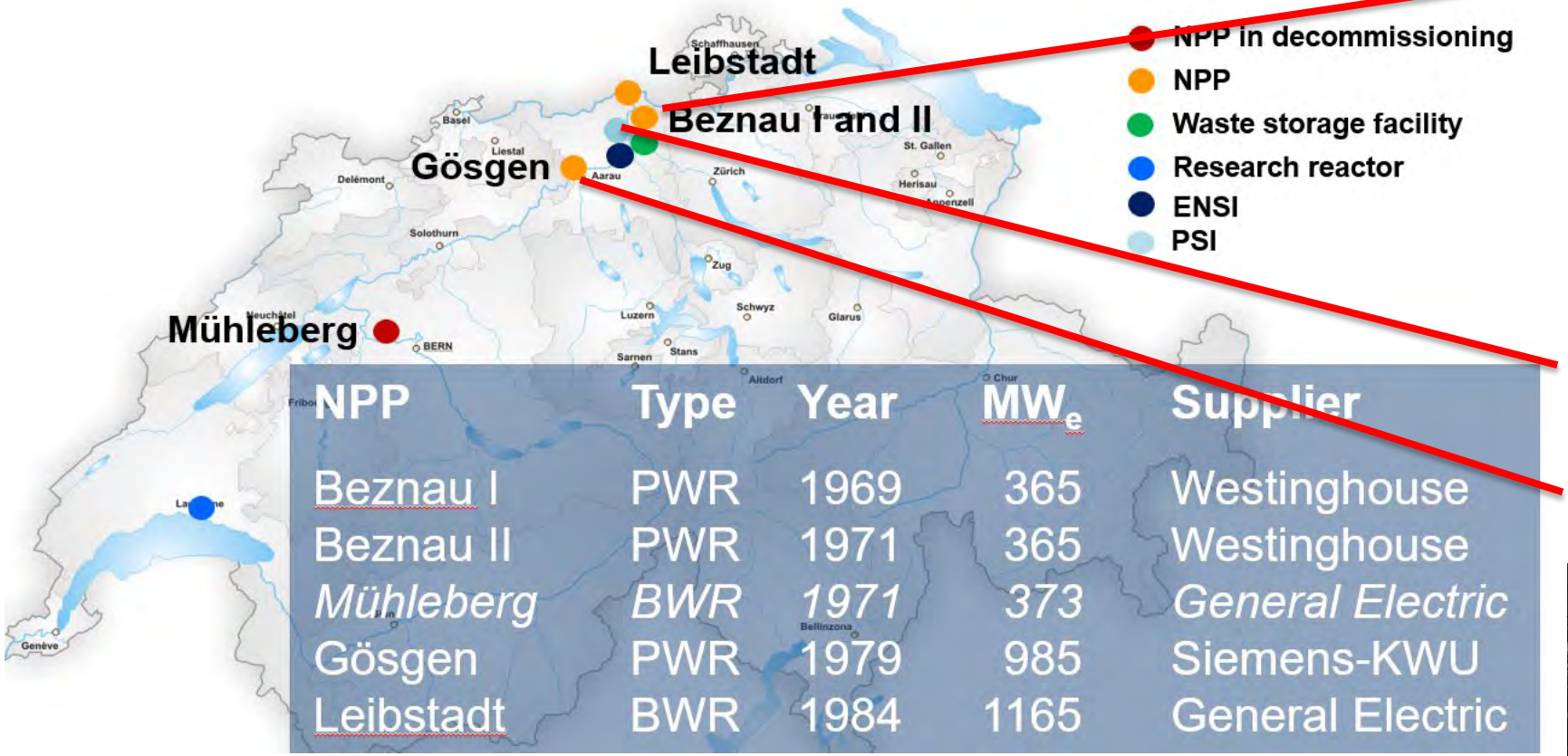
Switzerland – «A special case»

- **Federal State structure**: 26 cantons divided into more than 2'300 communes
- Population of **8.5 million** people
- **4 national languages**: German, French, Italian and Romansh
- **Direct Democracy**: Popular initiatives and referendums

ENSI: the Swiss independent regulator for nuclear safety and security

- The Swiss Federal Nuclear Safety Inspectorate ENSI is the national regulatory body with responsibility for nuclear safety and security of the Swiss nuclear facilities.
- ENSI's supervision covers the whole life of a facility and related activities with oversight over projecting, siting, designing, operation of a facility until its decommissioning and the (final) disposal of radioactive waste.

Swiss Nuclear Facilities



NPP	Type	Year	MW_e	Supplier
Beznau I	PWR	1969	365	Westinghouse
Beznau II	PWR	1971	365	Westinghouse
Mühleberg	*BWR*	*1971*	*373*	*General Electric*
Gösgen	PWR	1979	985	Siemens-KWU
Leibstadt	BWR	1984	1165	General Electric

ZWIBEZ Interim storage facility at Beznau NPP

Central Storage Facility ZZL

Federal Storage Facility BZL

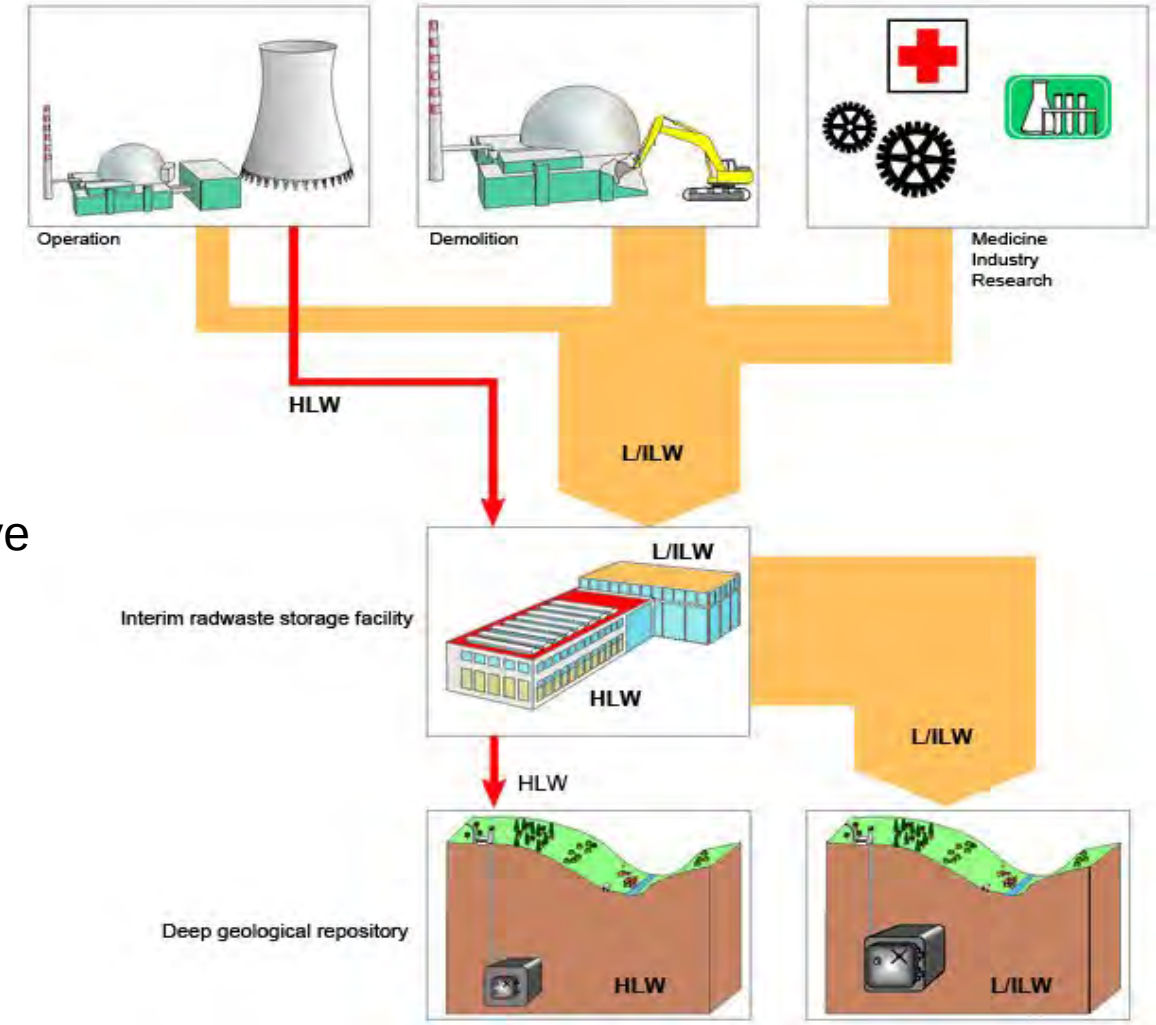
Nasslager Gösgen Wet Storage Facility

Nuclear Waste Management in Switzerland

HLW: High-level radioactive waste

LL-ILW: Long-lived intermediate-level radioactive waste

L/ILW: Short-lived low- and intermediate-level radioactive waste



Idea of Deep Geological Repository in Switzerland

- A method that allows the **radioactive waste to be kept away from human living environments in the long term** – i.e. for many millennia.

- In Switzerland, the **Nuclear Energy Act NEA** stipulates that radioactive waste has to be stored in deep geological repositories.

- The Expert Group on Disposal Concepts for Radioactive Waste (EKRA), set up in 1999, concludes that storage in deep geological repositories represents **the only safe option for long-term storage**.

- **Similar concepts** are also followed **in other countries** (e.g. USA, France, Finland)

Two Repositories for Radioactive Waste

- A **combined repository** is planned, involving **two physically separate storage areas** for HLW and L/ILW which use **one common facility on the surface**.

The **storage of L/ILW** begins **earliest in 2035**.

The **storage of HLW** begins **approx. in 2045** due to its interim storage period of 40 years.

Sectoral Plan (2008)

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

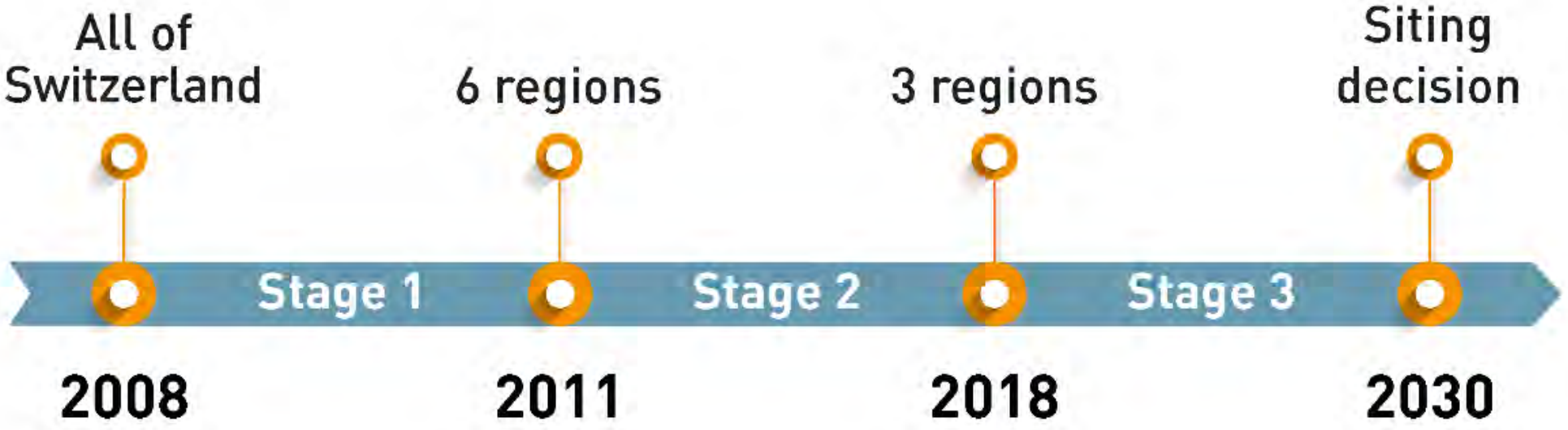
Department of the Environment,
Transport, Energy and Communications DETEC
Swiss Federal Office of Energy SFOE
Legal Services and Safety Division

2 April 2008

This translation is intended for information purposes only. It has no legal force.

Sectoral Plan for Deep Geological Repositories

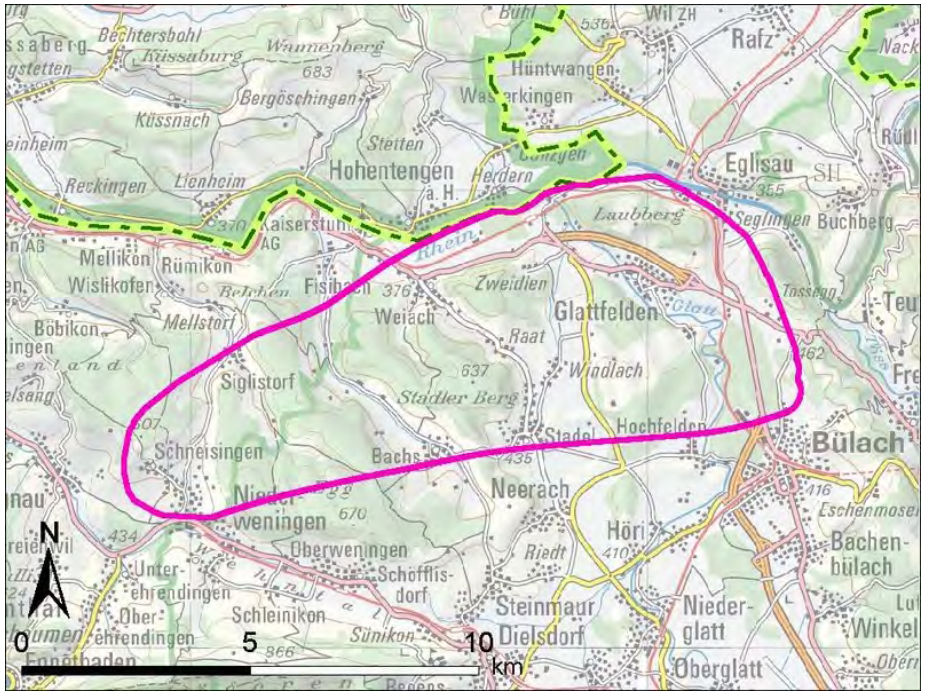
Conceptual Part



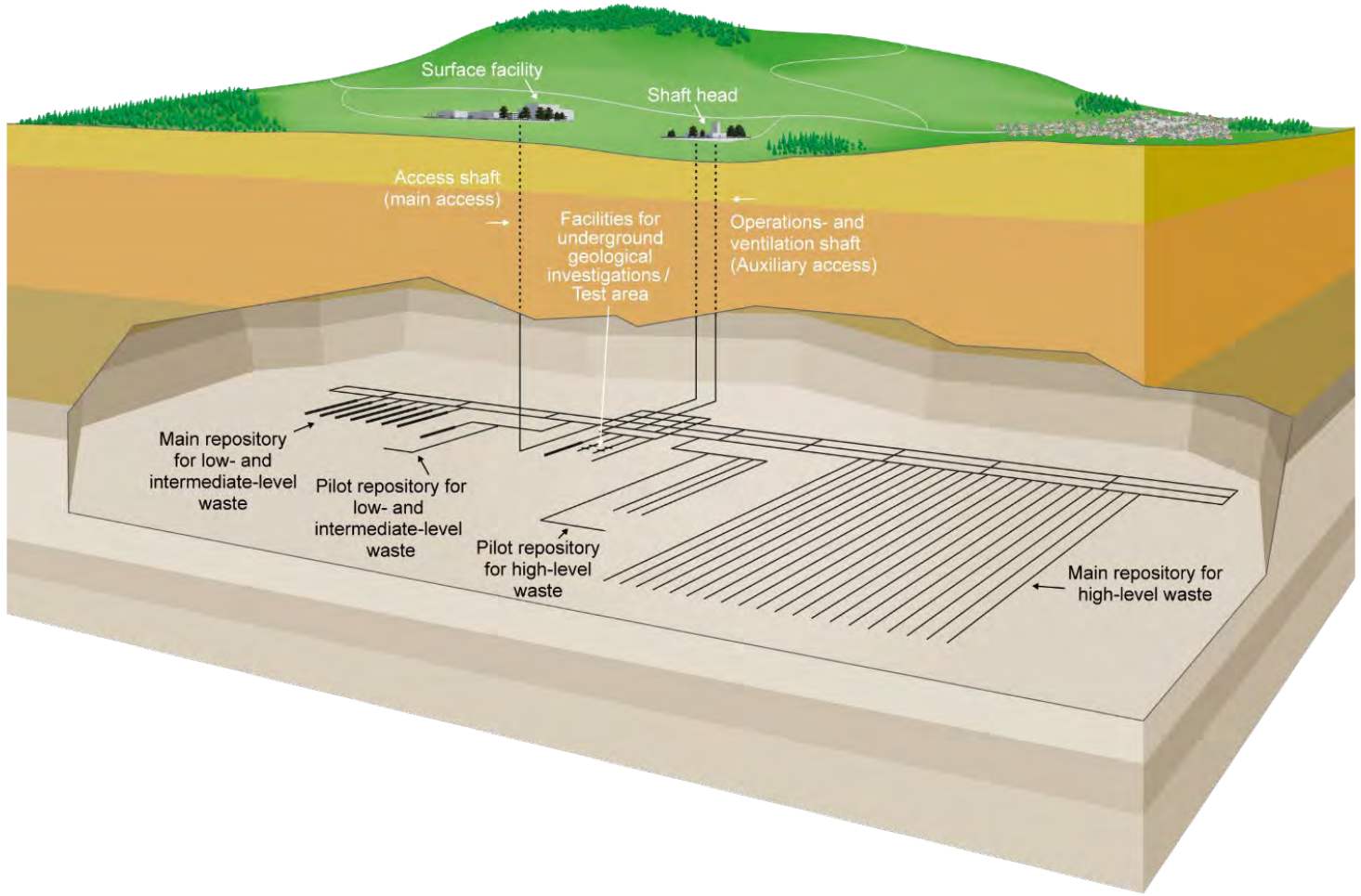
The Site Selection by the Swiss National Cooperative for the Disposal of Radioactive Waste (NAGRA)

September 2022: Nagra presents the site for a deep geological repository

- The site of Nördlich Lägern has been selected by Nagra for a deep geological repository and the current Central Interim Storage Facility for Radioactivity Waste (Zwilag) for a packing facility.
- As soon as Nagra submits the licence applications, most likely in 2024, ENSI will be tasked to review them.
- According to Nagra, the geological subsoil in Nördlich Lägern offers the greatest geological barrier effect, the best stability of the rock strata and a high degree of flexibility for the layout of the underground repository compared with Jura East and Zurich Northeast.



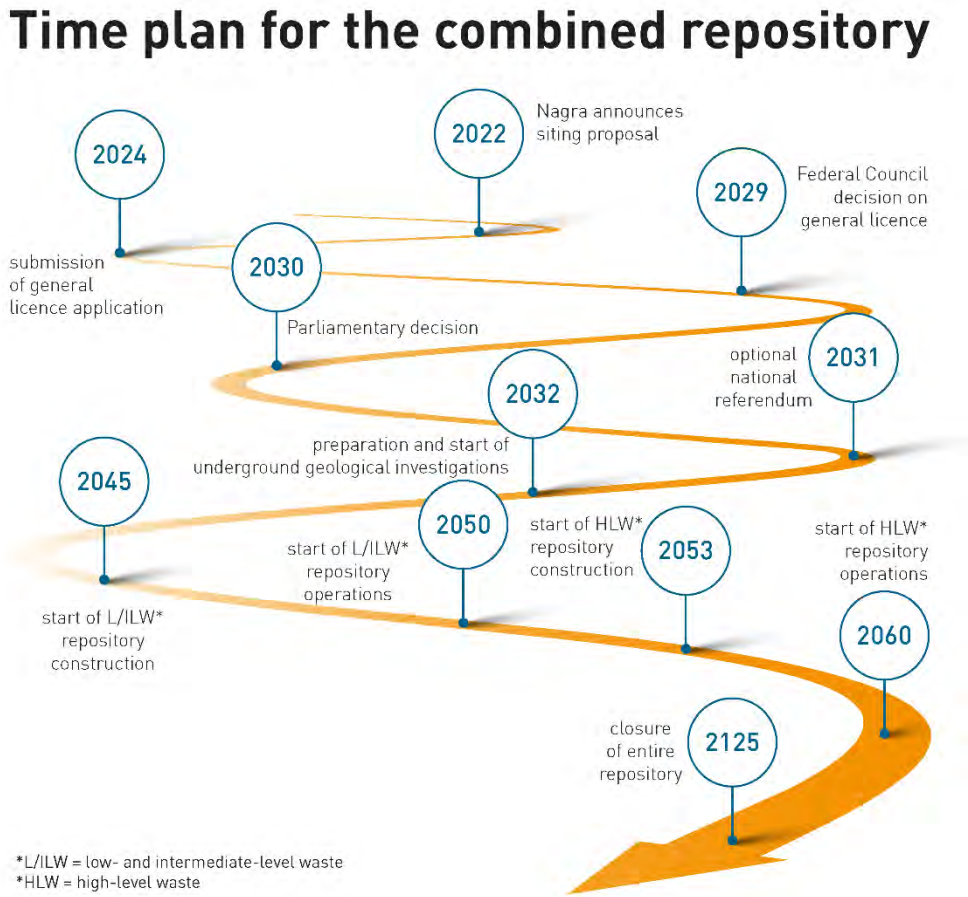
Proposed Disposal facilty (HLW and LILW) 2022



Geological Repositories: Siting Process

Repository facility

- Nagra proposed a joint repository for LILW and HLW
- ENSI-Review 2025-2026
- Government decision expected by 2029



Stakeholder Confidence: Technical Forum Safety

Sectoral plan stipulates exchange with stakeholders:

15 Technical Forum on Safety

Main function: Discusses and answers technical and scientific questions on safety and geology from the public, the communes, the siting regions, organisations, cantons and public bodies of affected neighbouring countries

15.1 Collects and structures incoming questions

15.2 Defines the procedure for processing and answering questions and brings in external experts if necessary

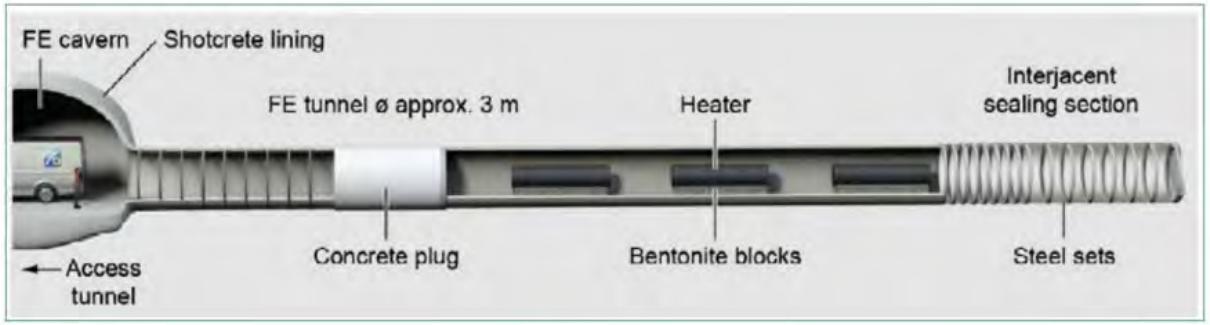
15.3 Ensures that the answers to questions are documented traceably, publishes answers and provides regular information on the processing stage of questions

15.4 Can itself raise and answer technical and scientific questions

Membership (≈ 40):
Federal/cantonal experts, German and Austrian experts, NGOs, representatives of siting regions.
Status: 178 Questions received (answers on web)

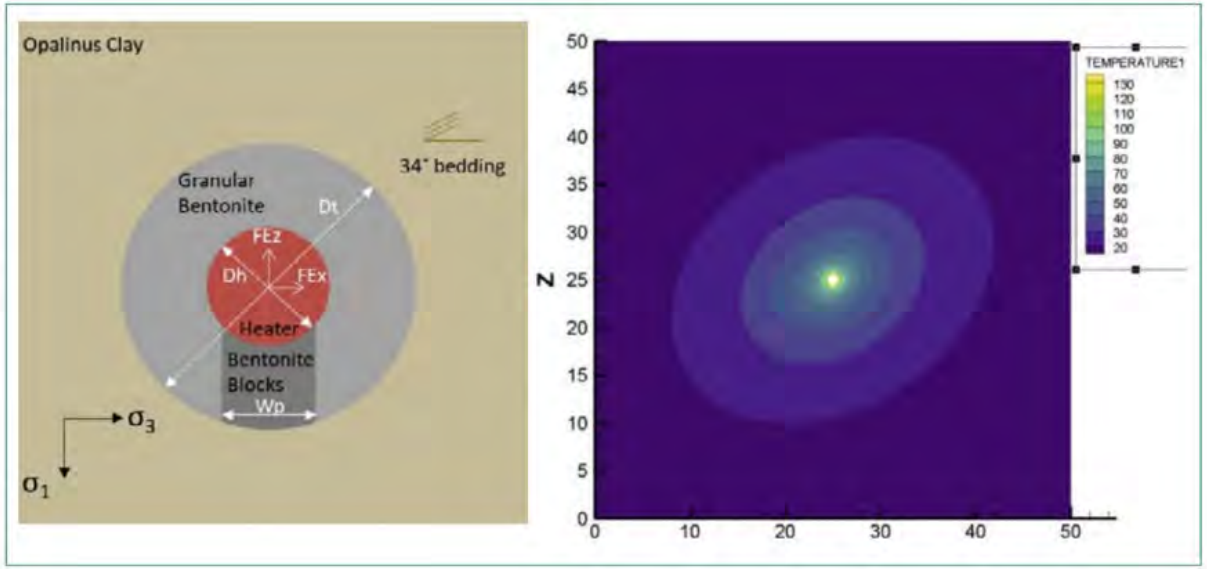
Stakeholder Confidence: Independent Research

Abbildung 46: *Schematische Darstellung des FE Tunnels. Quelle: NTB 15-02*



Nagra-Experiment

Abbildung 47: *Schematische Darstellung des 2D Modells für Schritt 1 (links, ENSI) und beispielhafte Darstellung der anisotropen Temperaturausbreitung (rechts, ENSI).*



ENSI-Numerical modelling of experimental results → Safety Case Review

Summary (Development of DGR)
Key elements

- Importance of respected technical expertise (implementer /regulator)
- Regulator and implementer act according to their roles in a predefined process
- Transparent procedure for all parties involved
- Constant exchange with stakeholders, openness to their questions
- National political structures and culture play a significant role in success of development for DGR

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Eidgenössisches Nuklearsicherheitsinspektorat ENSI
Inspection fédérale de la sécurité nucléaire IFSN
Ispettorato federale della sicurezza nucleare IFSN
Swiss Federal Nuclear Safety Inspectorate ENSI

Thank you very much for your attention!
Questions?

More information can be found on:

www.ensi.ch/en

twitter.com/ENSI_CH/

www.linkedin.com/company/489423/

www.youtube.com/user/ensitube