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Lessons Learned from FiR 1 TRIGA Decommissioning

FiR 1 in the Finnish nuclear energy program



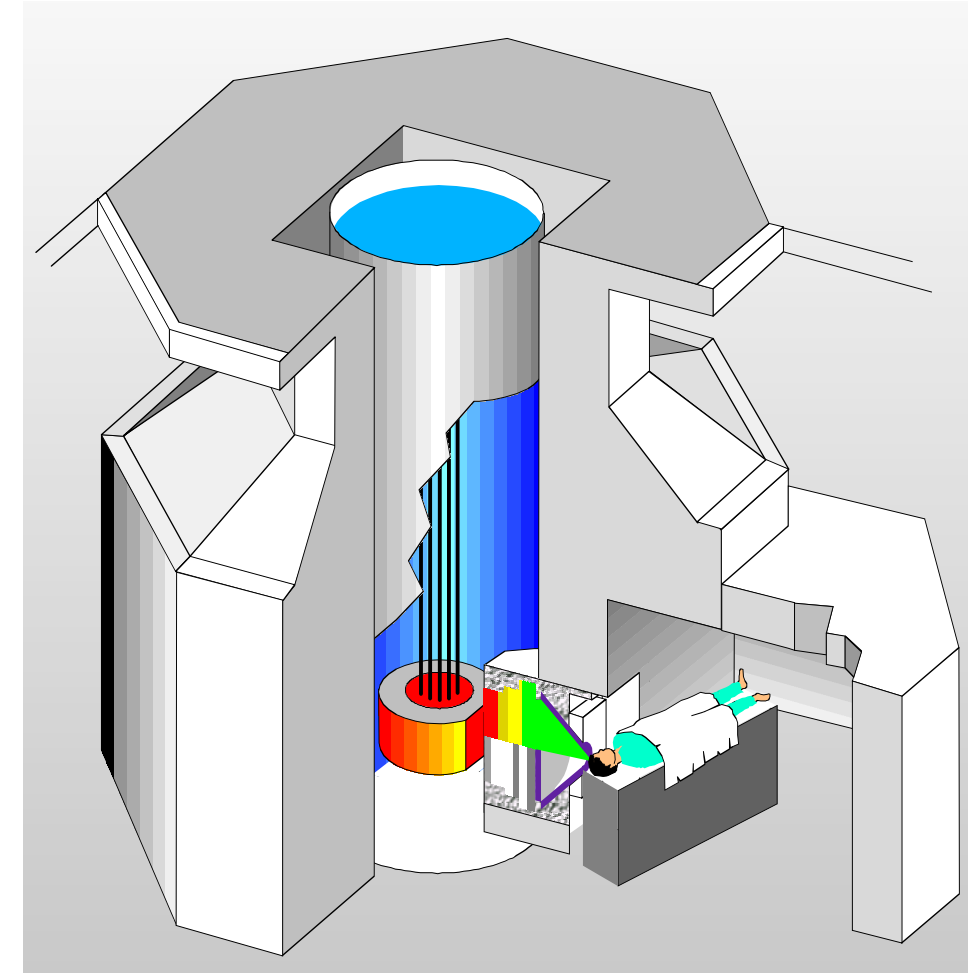
30 May 1960: TRIGA order was signed
by Frederic de Hoffman (General Atomics)
and Minister Pauli Lehtosalo

**31 August 1962: FiR 1
inauguration**
President of the Republic
Urho Kekkonen and
Director of General
Atoms Dr. Frederic de
Hoffman with high level
state and industry
representatives



History of FiR 1 in brief – TRIGA Mark II, 250 kW

- Neutron beam research, activation analysis
- Isotope production, irradiation testing
- Facility for Boron Neutron Capture Therapy
 - BNCT treatments (> 200 patients) in 1997–2012
 - Special materials to be managed in decommissioning
- New “operating license” for decom 2020
- Inventory estimates (excluding fuel):
 - Mass 75 tons, volume 40 m³ (mainly concrete)
 - Activity 3.3 TBq (BNCT moderator and steel > 1 TBq)



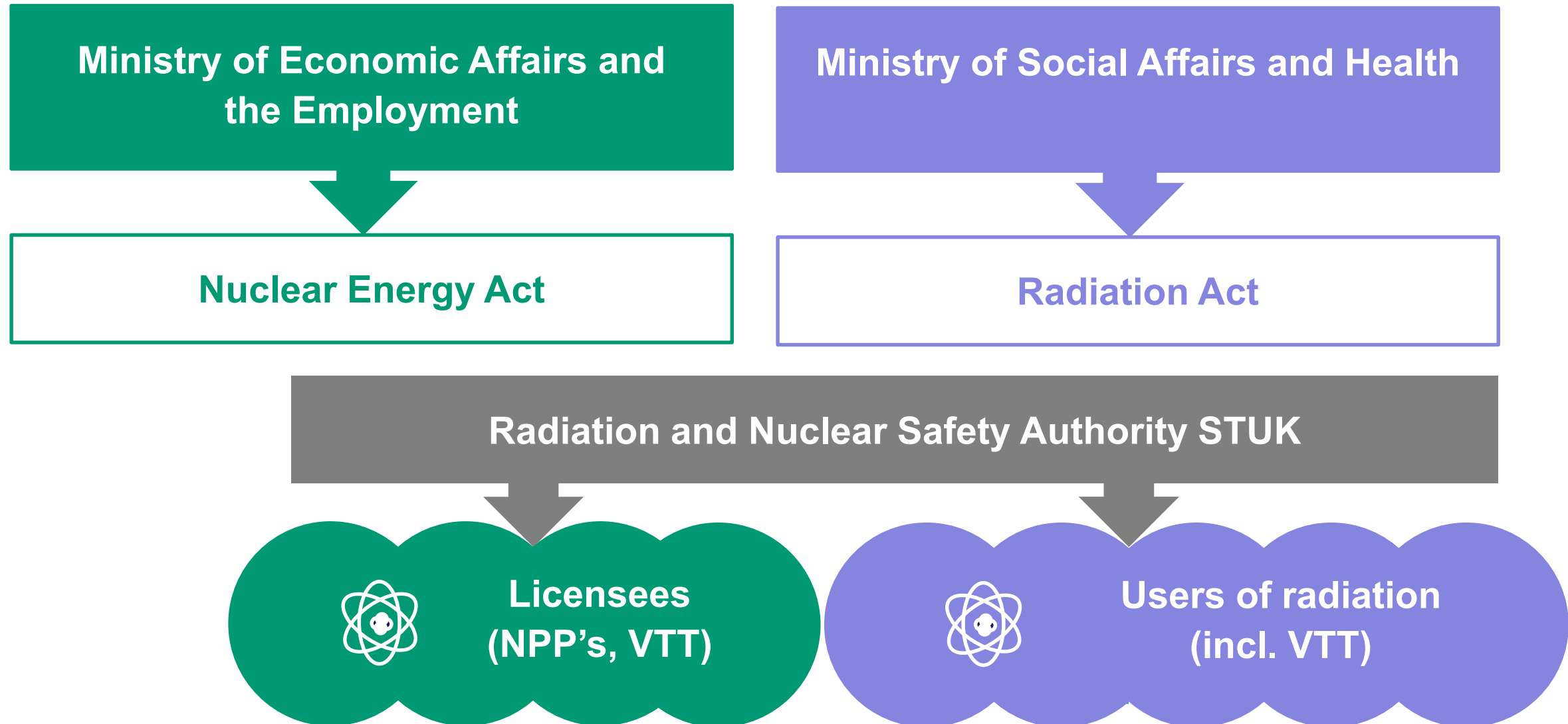
Status of decommissioning

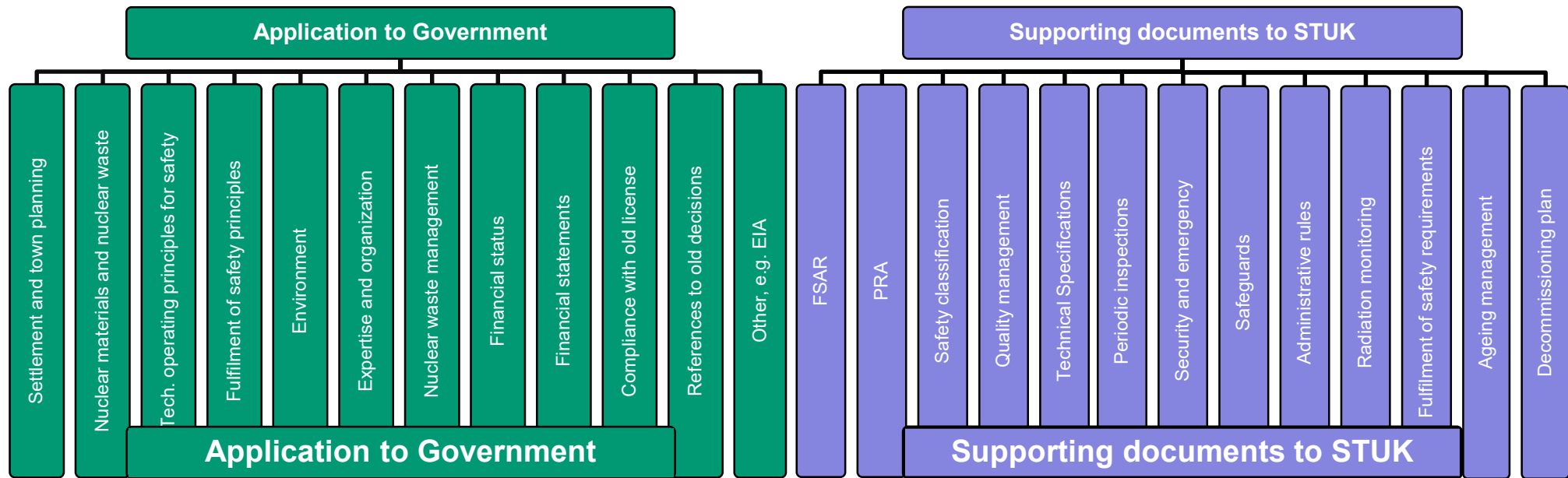
2012	VTT's decision to shut down FiR 1
2013–15	EIA for decommissioning
2015	End of operations
2016	Dismantling planning
2017	License application for decommissioning
	Public hearing → 31.3.2018
	STUK's safety assessment 2.4.2019
<hr/>	
	License expected Q1/2020
2021–24	Dismantling begins, subject to SNF solution

Licensing for decommissioning

Division of duties between ministries

According to the Finnish Radiation Act





Detailed technical reports

Fundamental reports

Delivery of VTT's license application



License application delivered to the ministry on 20 June 2017.
Jorma Aurela and Linda Kumpula (MEAE);
Satu Helynen and Markus Airila (VTT).



Project manager Markus Airila delivering the first set of documents for STUK's review on 30 June 2017.



Antti Rätty delivering the last set of documents for STUK's review on 29 March 2018.

Lessons learned during licensing and initial planning

Evolution of detail in planning

2007: Consultation on potential decommissioning options

Various options
Review of VVO
Suggestions
Experience
decommissioning

2013: Preliminary dismantling plan (Platom)

Available data
Experience
foreign references
One of the

2016: Detailed dismantling planning (BNG)

All specific
Documentation
dismantling
Technical
p.)
VTT preparation
decommissioning

2017 → Refine the detailed dismantling plan (Fortum)

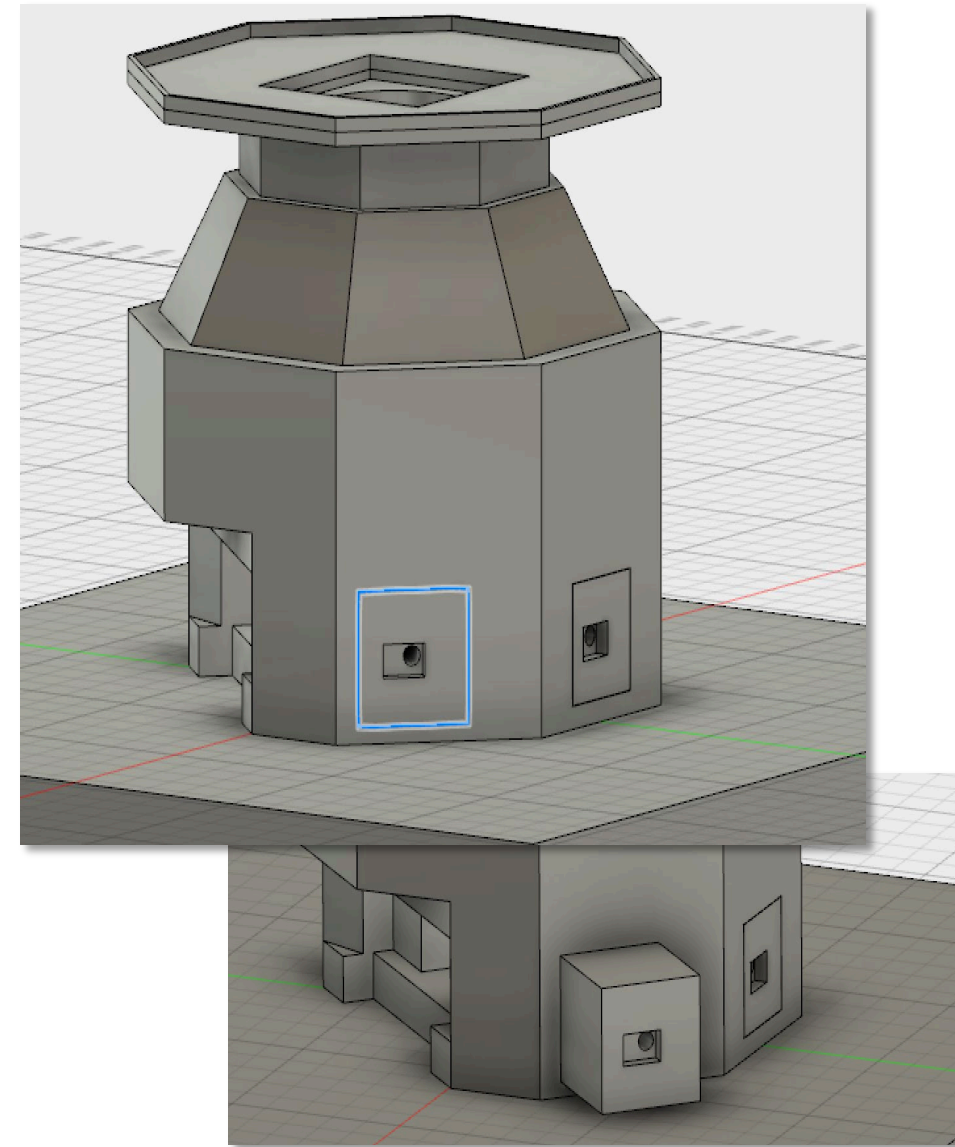
Include all practical considerations:

- Site logistics
- Waste acceptance criteria
- Integrate dismantling, waste management, radiation protection and security operations

Dismantling planning 2016–17

Example: cutting of the biological concrete shield

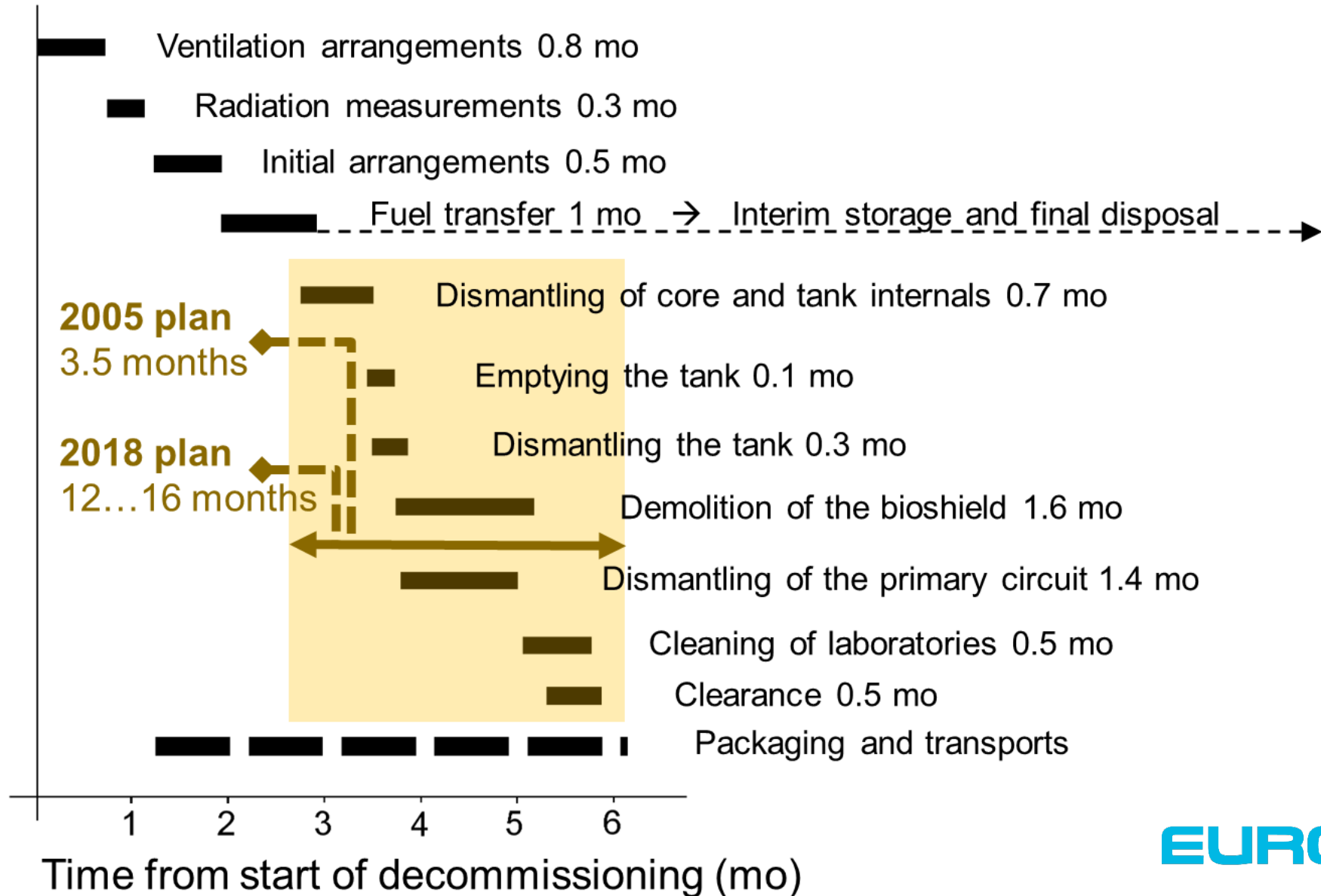
- Competitive tender for planning
 - Relatively high interest, good tenders
 - Selected contractor: Babcock Noell GmbH & Fortum
- Work completed by BNG and reviewed by VTT
 - Practically in schedule (+ 1 month)
 - One small additional work order
 - Domestic regulation, packaging plan and safety classification scheme by Fortum
- The plan forms the basis for...
 - Technical part of the licensing documentation
 - Also supports costing calculations



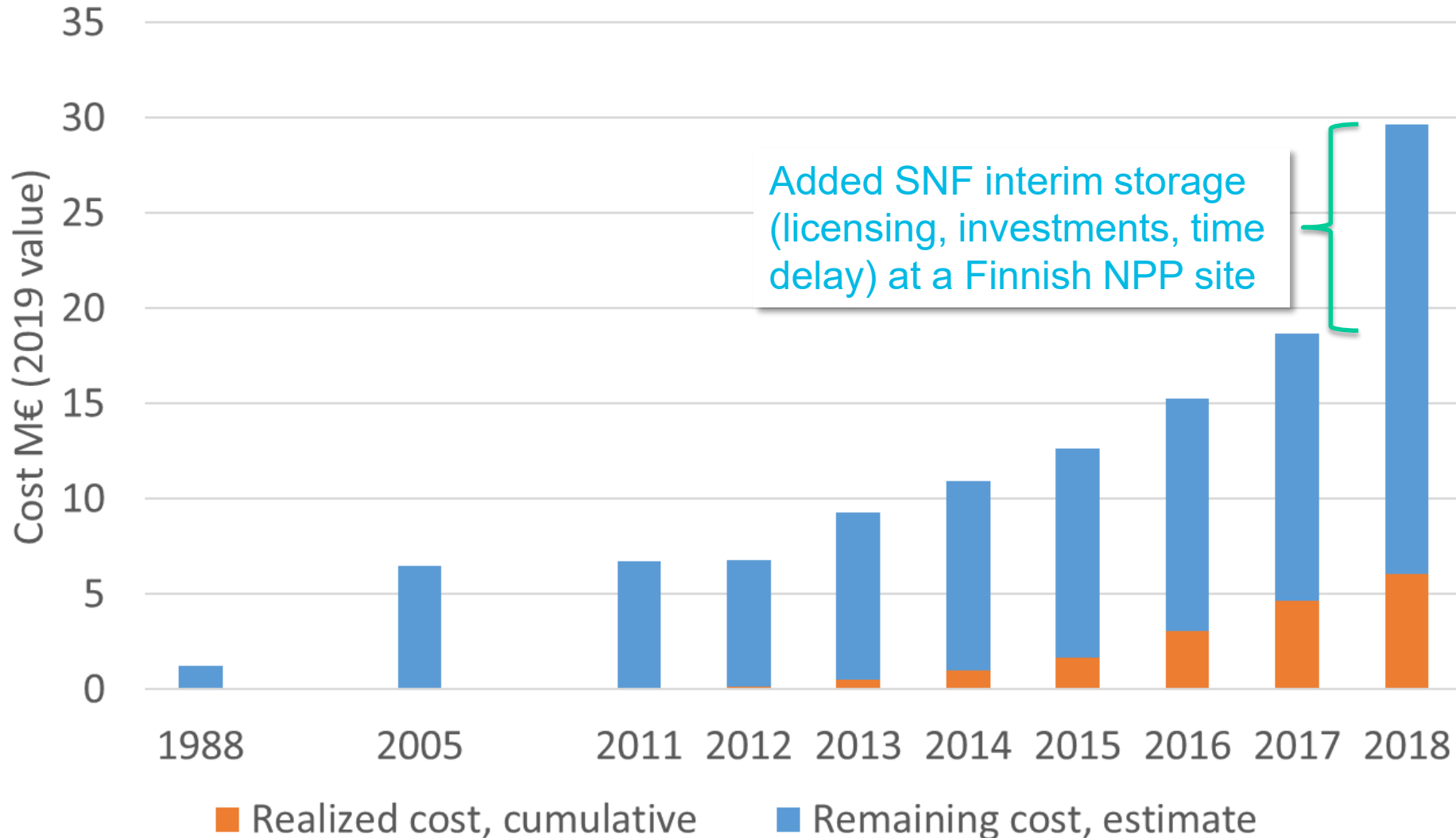
Babcock Noell GmbH

Evolution of detail in planning

Comparison 2005 vs 2018 plan



Cost estimate evolution 1988–2018



Summary of lessons learned

First nuclear facility to be decommissioned in Finland

- **Impact on national regulation and practices**
 - Interpretations of specific requirements (safety goals and practice)
 - MEAE and STUK used FiR 1 experiences in development of legislation
- **Experience gained in the project organization**
 - Active owner in dismantling planning projects
 - In-house experience in inventory modelling and measurements
- **Adapting organization to decom**
 - Retained all operating personnel + key recruitments
 - Safety culture assessment 2018 – recommendations being implemented
- **Main challenge: uncertainty over waste solutions at shutdown**
 - Licensing: long preparation and review
 - Planning: slow convergence of plans (lack of fixed boundary conditions)

See also

VTT's info pages on the decommissioning project

<http://www.vttresearch.com/services/low-carbon-energy/nuclear-energy/decommissioning-of-finlands-first-nuclear-reactor>

Decommissioning license application (Website of the Ministry)

<http://tem.fi/en/vtt-technical-research-centre-of-finland-ltd-s-licence-application-for-decommissioning>

bey^ond

the obvious

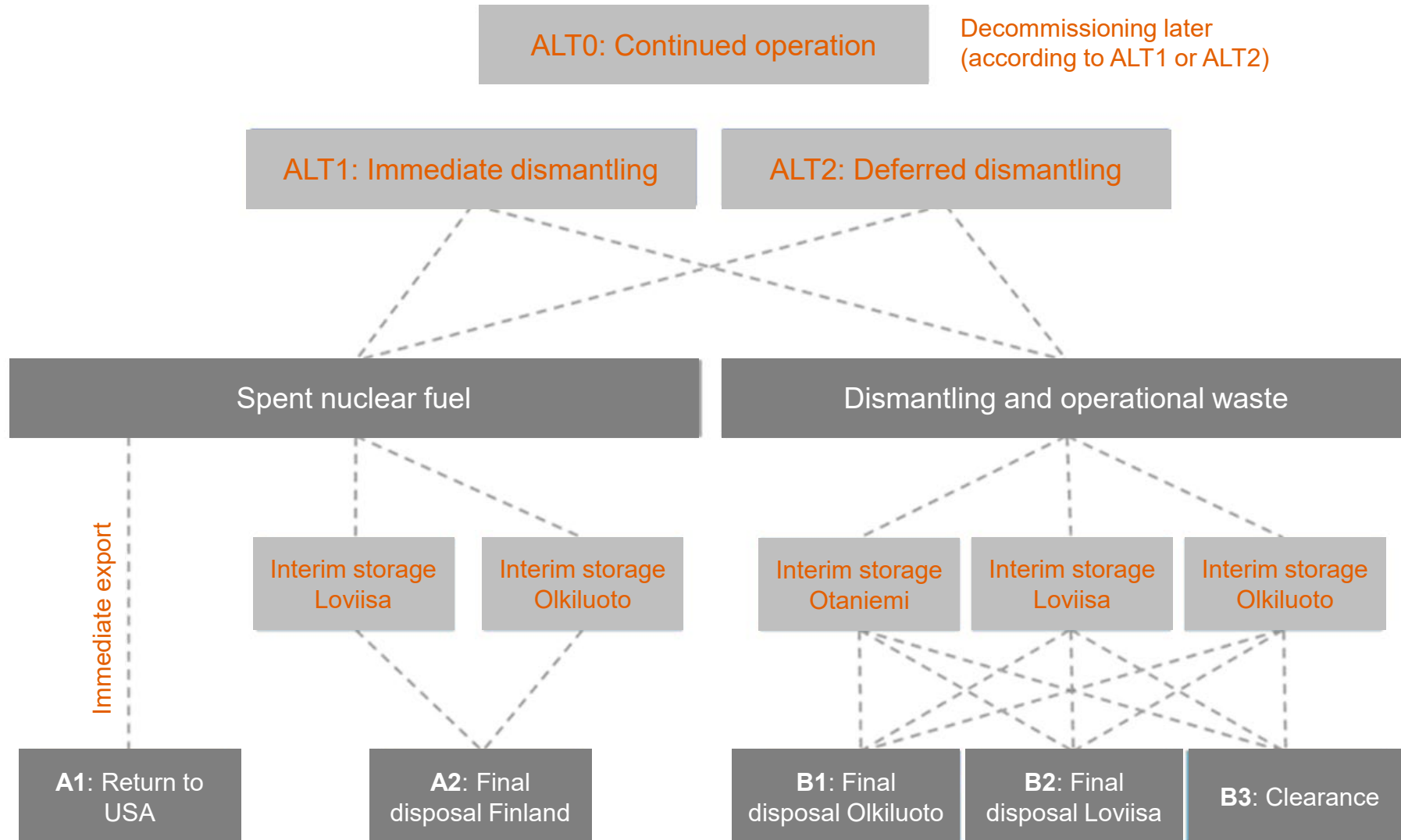
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Options for nuclear waste management

FiR 1 Environmental Impact Assessment 2013–15



Path forward Alternatives

SNF interim storage option

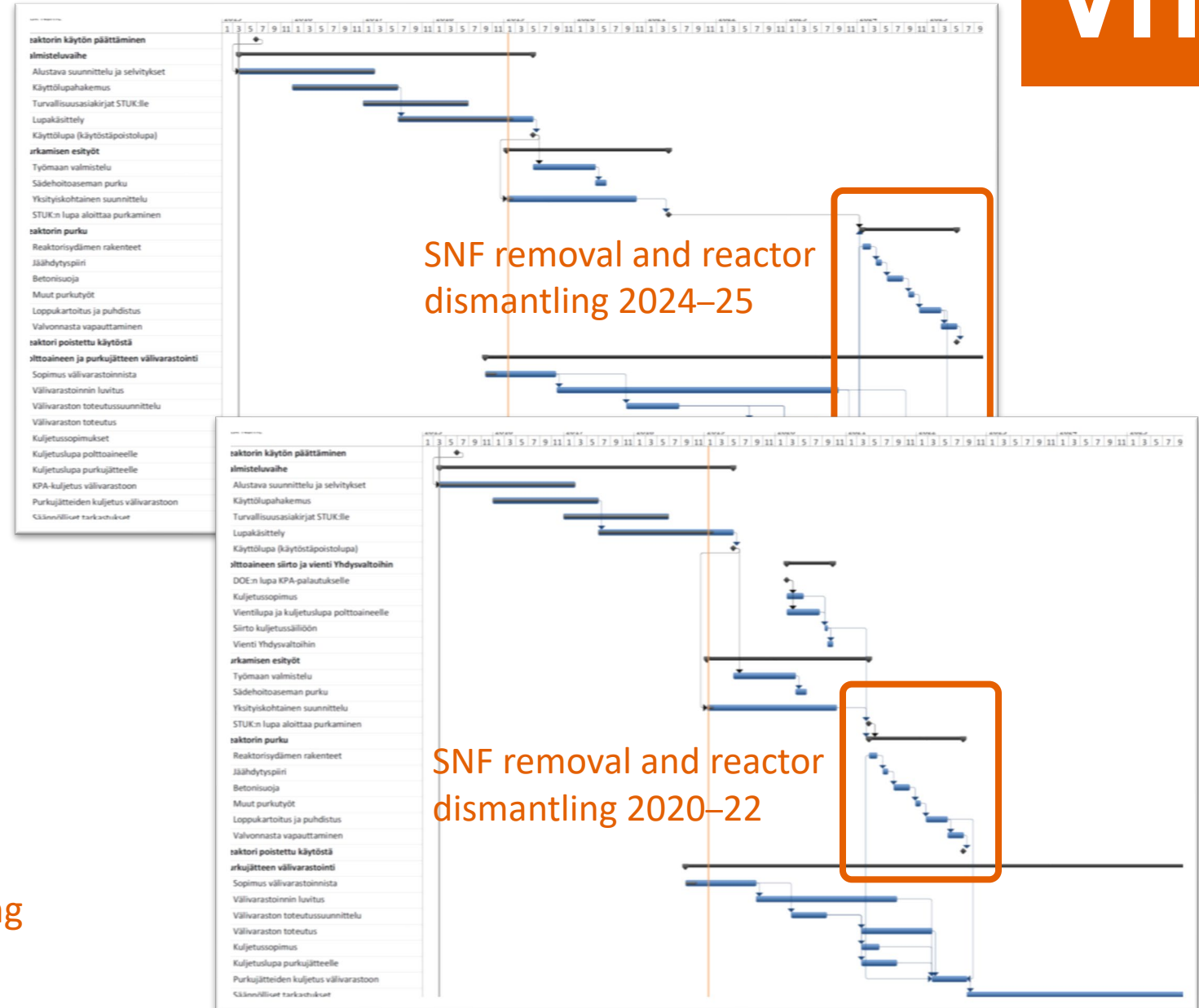
- Contract with domestic NPP operator
- Licensing + investments → + 2–3 years
- Final destination: USA or Finland

SNF direct return option

- Return to USA as soon as Idaho opens: 2020? 2021?
- Readiness to start dismantling in 2021

Selection of path?

- Preparation for transport to USA ongoing
- Preparations for interim storage: soon



Spent nuclear fuel return to USA

Idaho National Laboratory

FiR 1 fuel is US origin → Belongs to the US DOE foreign research reactor fuel return programme

Several batches of similar fuel already collected

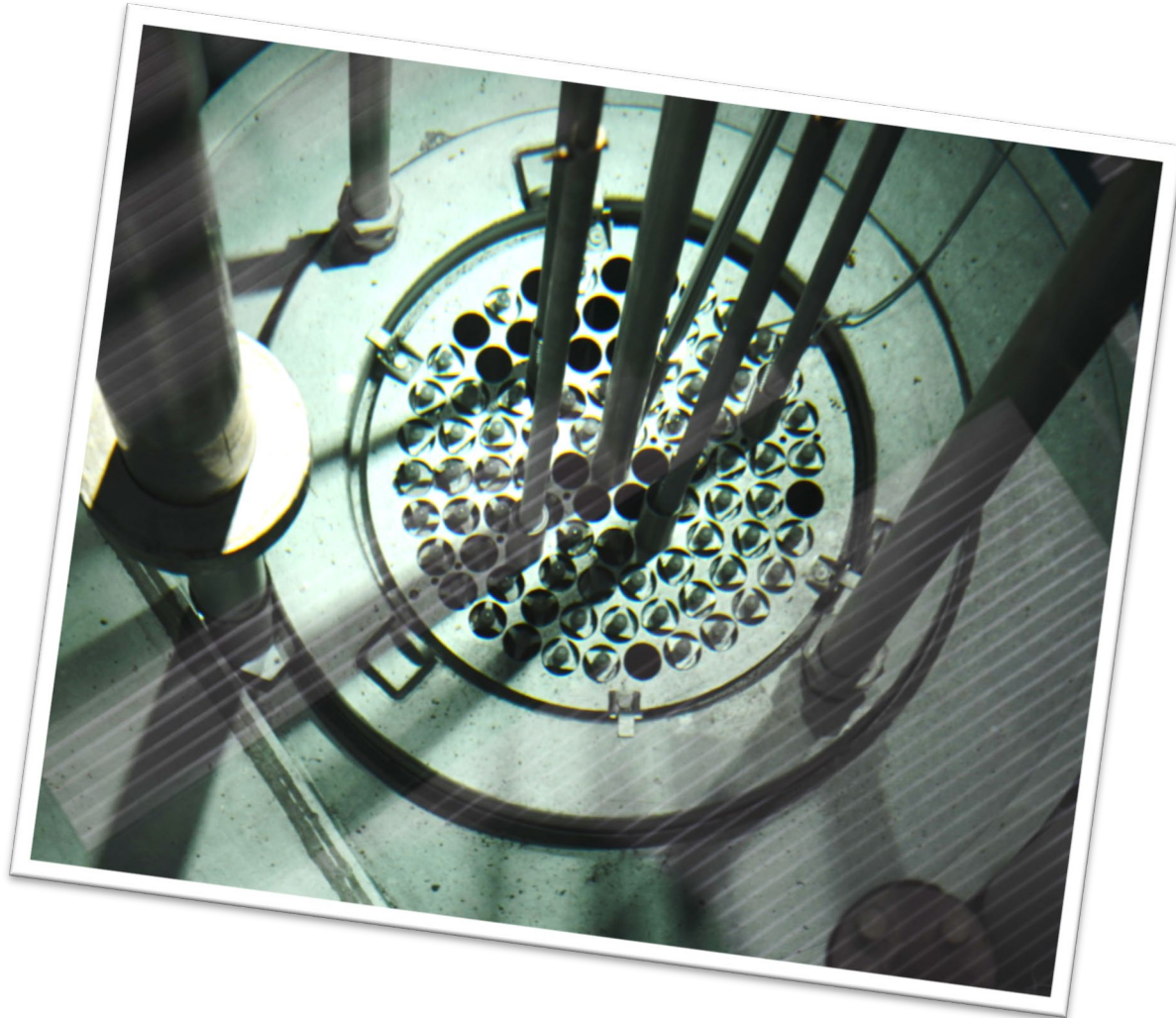
Finnish Nuclear Energy Act recognizes FiR 1 as an exception → export allowed

Return programme currently halted (delays in processing of legacy waste in Idaho)

Environmental analysis and decision on programme extension until 2029 was published in May 2019



103 spent fuel elements



Detailed calculation on dismantling waste

Relatively small inventory and volume

Highest material-wise calculated activities

Steel (Fe-55, Ni-63, Co-60) 1,9 TBq

- Rotary specimen rack 1,7 TBq

Fluental 1,3 TBq

- H-3 >> 99%

Estimate on total inventory, excluding spent fuel:

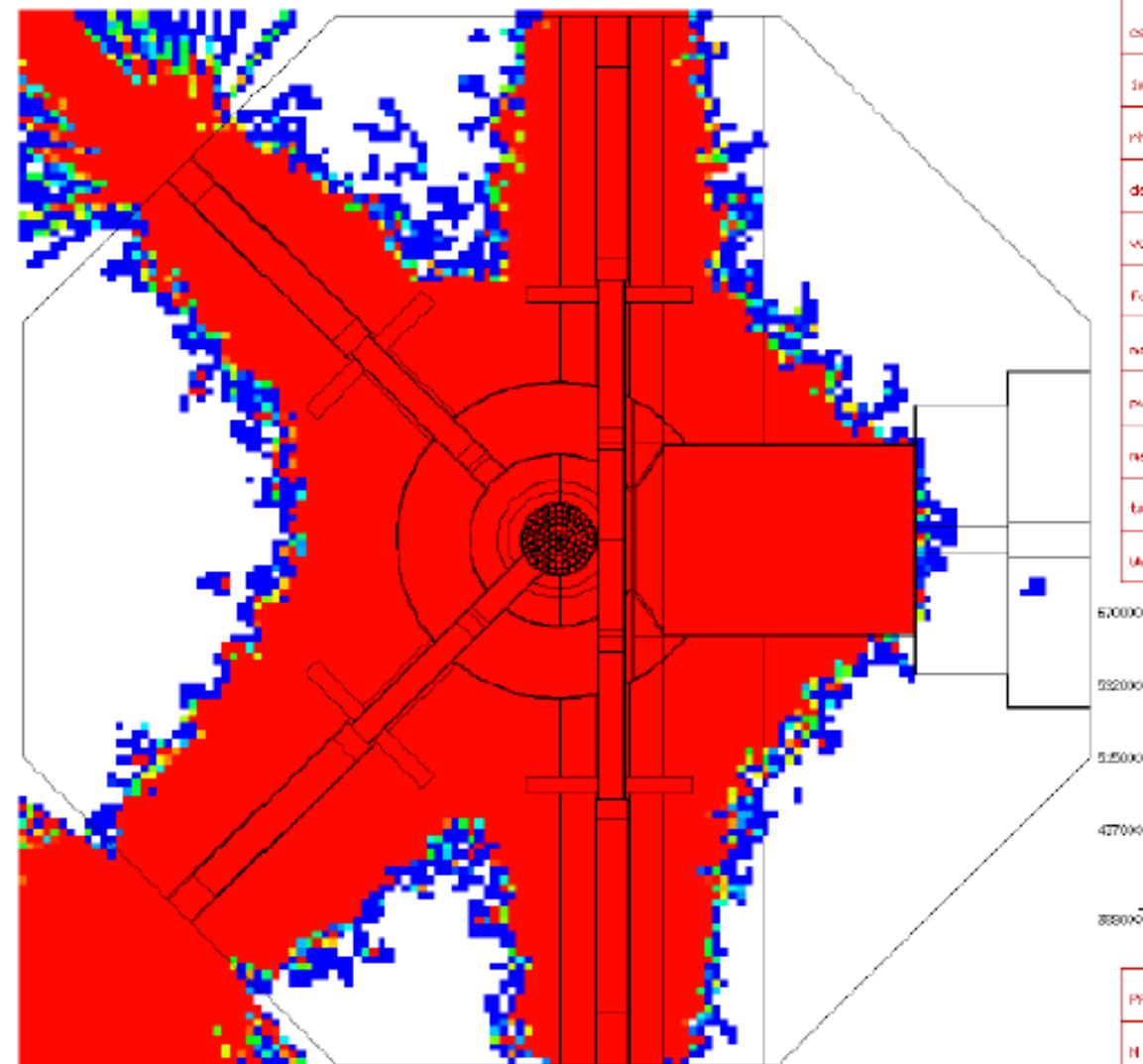
Less than 5 TBq

= ca. 1 / 40 000 of Loviisa NPP inventory

Estimate on volume of dismantling waste:

100 m³

(as packed for interim storage)





30.6.2015

Otakaari 3 / Rakentajanaukio



Permanent shutdown and maintenance

From 30.6.2015

- Reactor core was made subcritical and control instrumentation locked
- Core decay heat < 1 W
- Maintenance of safety functions
 - Manning (offices) during office hours
 - Safety, security and emergency preparedness functions remain fully operational
 - All responsible roles in the operating organization (approved by STUK) are maintained

