2013

Pocket Guide to
FINAL DISPOSAL

POSIVA

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FOREWORD

Final disposal of spent nuclear fuel generated in Olkiluoto and Loviisa nuclear power plants, has been prepared in Finland for 30 years. Company tasked for the preparation and the actual implementation of final disposal, Posiva Oy, has compiled the key figures related to the project to be easily available in this pocket guide.

Some disposal-related key figures will change as the project progresses and as the data are specified further according to the amount of fuel disposed of, for example.

The data in the brochure has been updated according to the situation in autumn 2012 so that the figures for the disposal facility volume are based on the current estimate of the amount of spent nuclear fuel (5,440 tonnes of uranium) during the entire lifecycle of existing nuclear plant units and OL3.

POSIVA

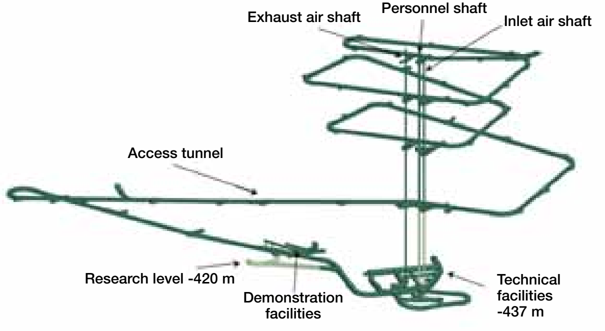
- Established in 1995
- Owners:
  - Teollisuuden Voima Oyj 60 %
  - Fortum Power and Heat Oy 40 %
- The mission of Posiva is to take care of the disposal of its owners' spent nuclear fuel
- Number of staff: 101 (2012)
- Turnover € 67.3 million (2012)

ONKALO site in summer 2012

ONKALO IN FIGURES

- ONKALO is a research tunnel which will be connected to the disposal facilities later.
- ONKALO excavation was launched in 2004 and disposal depth (420 m) was reached in summer 2010.

Length of access tunnel	about 5 km
Incline	1:10
Tunnel dimensions (width x height)	5.5 x 6.3 m
Combined length of shafts	about 1 km
Passenger shaft diameter	4.5 m
Inlet and exhaust air shaft diameters	3.5 m
Total volume of water leaking into ONKALO	37 l/min



FINAL DISPOSAL IN FIGURES

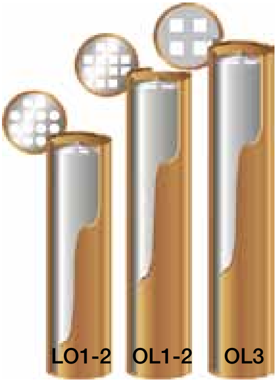
Amount of fuel	5,440 tU
Number of fuel bundles	about 26,000
Number of disposal canisters	about 2,800
Final disposal shaft diameter × height (OL 1-3 tunnels)	3.5 x 4.4 m
Repository volume	about 1.3 million m^3
Total length of disposal tunnels	about 35,000 m
Total length of central tunnels	about 7,000 m
Amount of bentonite in disposal hole (OL1-2)	about 25 tonnes
Repository footprint (bedrock facilities)	1.5 km^2
Disposal canister distance in tunnels (OL1-2 fuel)	about 9 m
Disposal hole diameter × height (OL1-2 fuel)	1.75 x 7.80 m
Electricity consumption of encapsulation and disposal facility	7,600 MWh per year
Canisters for disposal annual average	36

- The disposal budget (2012) is about € 3.5 billion.
- The number of personnel in the encapsulation plant and disposal facility is about 100.
- Fuel bundles are replaced annually in nuclear plants (OL1-2 about 240, LO 1-2 about 200).

FINAL DISPOSAL CANISTER

	LO1-2	OL1-2	OL3
Outside diameter (m)	1.05	1.05	1.05
Total length (m)	3.55	4.75	5.22
Number of fuel bundles (pcs)	12	12	4
Amount of fuel (tU)	1.4	2.2	2.1
Maximum heat output upon disposal	1,370	1,700	1,830
Total weight	18.8	24.5	29.0

- Spent fuel is packed into copper and cast iron canisters, which come in different sizes depending on the fuel bundle size.
- The disposal project uses the following volumes of material for the disposal canisters:
  - About 20,000 tonnes of copper.
  - About 40,000 tonnes of iron and steel parts.



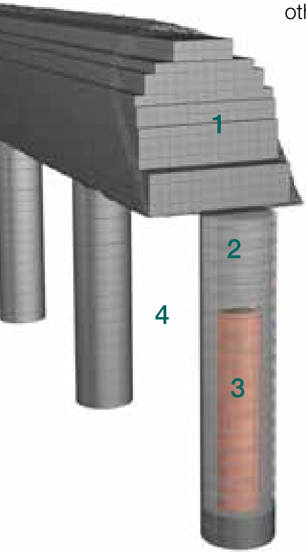
SPENT FUEL

	LO1-2	OL1-2	OL3
Number of fuel bundles, forecast (pcs)	7,752	14,034	3,816
Cooling period (years)	27-38	28-40	37-60
Volume of uranium (tU)	950	2,460	2,030

- Accrual is based on plant lifecycle: LO1-2: 50 years, OL1-2: 60 years, OL3: 60 years.

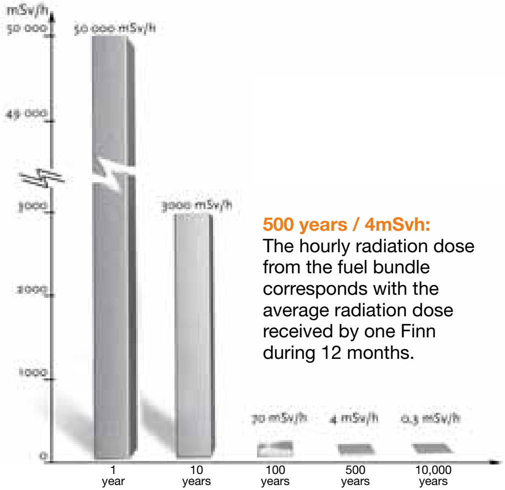
MULTIBARRIER PRINCIPLE

- Different barriers back up each other up and ensure safety.



1. Tunnel filling
2. Bentonite
3. Disposal canister
4. Bedrock

RADIATION OF SPENT FUEL



- Hourly radiation dose (mSv/h) from the spent fuel, measured at one metre from fuel bundle.

RADIATION OF DISPOSAL CANISTER

Fuel cooling time, years	Radiation dose on canister surface mSv/h
40	59
500	0.4
10,000	0.1

TIME SPAN

Posiva submits a construction licence application for the repository.

Olkiluoto is selected as the disposal site by a decision in principle by the Government.

2004

Posiva is established.

2000

The Government's decision in principle on the overall schedule and goal for nuclear waste management, start of geological screening for potential sites for final disposal.

1995

1994

1983

The 1970s

Olkiluoto 1-2 and Loviisa 1-2 nuclear plants are built, nuclear waste management preparations commence.

Closure of the repository.

The 2120s

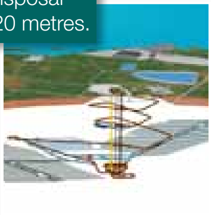
2022

Start of disposal.

2012

2010

ONKALO excavation reaches disposal depth, i.e. 420 metres.



ONKALO excavation commences.

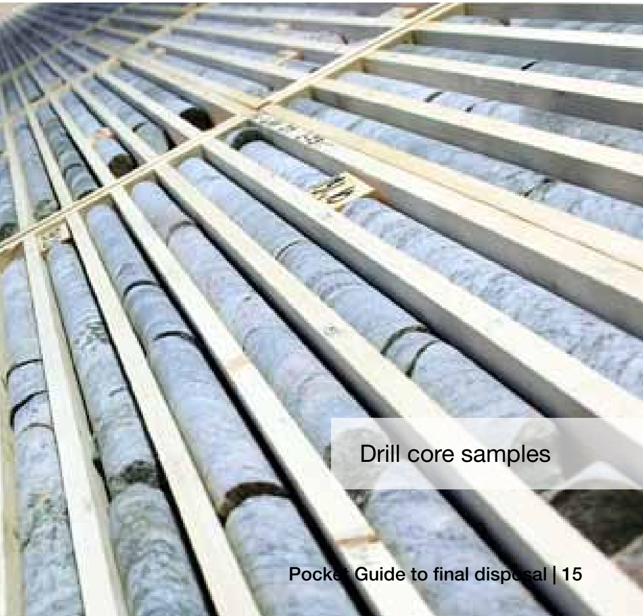
The Parliament forbids the import and export of nuclear waste into and out of Finland.

Drilling machine

BEDROCK RESEARCH

Number of deep drilling holes in Olkiluoto	57
Total length of drill core samples	about 32 km
Number of ONKALO pilot holes	22
Total length of ONKALO pilot holes	about 2.76 km
Diameter of drill core sample	about 50 mm
Diameter of drill hole	about 76 mm

- The first deep research hole was drilled in Olkiluoto as early as 1989.



Drill core samples

FAQ

Why is the spent fuel not taken abroad?

Finnish law forbids the import and export of nuclear waste into and out of Finland. The producers of nuclear waste, that is, the parties under the nuclear waste management obligation, are responsible for nuclear waste. The power companies TVO and Fortum who are under the nuclear waste management obligation established the company Posiva to take care of the final disposal of its owner companies' spent fuel in the bedrock in Olkiluoto.

What is the intended method for transporting the spent fuel from the Loviisa plants to Olkiluoto? What kinds of arrangements will this require?

There is specific legislation covering nuclear waste transportation. There are strict transport rules: approved containers, a separate licence for every transport, and a requirement according to which each container shall retain its radiation protection characteristics even in the worst-case scenario for an accident. Every transport will be accompanied by the police and a supervisor from the Radiation and Nuclear Safety Authority. Whenever possible, the transportation routes will avoid densely populated areas. The options available include transportation by road, rail and sea, and designated standards have been stipulated for all of these.

Shotcreting in ONKALO

What will happen if the final disposal canisters unexpectedly corrode and start to leak in the repository?

If a final disposal canister corrodes so that there is a hole in it, groundwater may come into contact with the fuel bundles inside the canister. However, the release of radioactive elements is slow since the fuel is in solid form and does not dissolve easily. Release of radionuclides into the bedrock is also prevented by a bentonite buffer surrounding the canister.

Why is copper a suitable material for final disposal canisters?

Copper will endure the anoxic conditions deep inside the bedrock and will not corrode. There have been findings in the natural environment of metallic copper which is many millions of years old and it has retained good protective characteristics.

Have the effects of permafrost and a possible ice age been sufficiently observed in planning the final disposal?

Permafrost and the effects of an ice age on the final disposal solution have been investigated in Finland and other countries. The research results suggest that in Olkiluoto the creation of permafrost and ice and the back and forth movement of the ice sheet will have only a minor effect on the safety of the final disposal.

What would happen if a major earthquake occurred at the final repository?

The likelihood of a major earthquake is very small, but the possibility cannot be completely excluded in the case of long periods of review. That is why the disposal tunnels will be positioned in intact bedrock blocks of Olkiluoto, which means that the impact of earthquakes will be small.

Investigations in Olkiluoto

Research niche
in ONKALO

Is it possible that the waste will contaminate groundwater?

No. The spent fuel is located in the bedrock inside multiple protective barriers. The fuel is encapsulated in a tight copper canister and it is surrounded by a bentonite clay buffer.

Is it possible that something might happen to prevent the final disposal being executed in Olkiluoto?

The suitability of the Olkiluoto bedrock for the final disposal of the spent nuclear fuel has been under investigation since the 1980s. The construction of ONKALO in 2004 has confirmed the understanding of Olkiluoto's suitability for the final disposal of spent nuclear fuel. It is highly unlikely that the decisions concerning the bedrock or technical reasons will be changed.

Is there any intention to mark the final disposal site so that future generations will know of the location?

The law says that the state will be responsible for the final disposal location once the final disposal has been acceptably carried out. At the same time, the information about the final disposal will be entered into the applicable registries. However, safe final disposal must be based on the principle that the final disposal location need not be monitored, and the information on it need not be maintained. According to existing plans, the final disposal will take about 100 years, so if the aim is to consider marking the site for other reasons, there is a lot of time to develop the method.

GLOSSARY

Bentonite, bentonite buffer

Bentonite is a naturally occurring type of clay, created as a result of the alteration of volcanic ash. A special feature of bentonite clay is its swelling as a consequence of moisture (wetting). Bentonite is designed to be used as a buffer material.

Burn-up (specific burnup)

The total amount of energy generated in the fuel per unit of mass. When the burnup increases, the residual heat production increases, and fuel must be cooled for a longer time prior to final disposal.

Canister, copper canister

A technical release barrier intended for the disposal of spent fuel bundles and built of a copper overpack, and a cast iron insert.

Cooling time

The time during which the thermal output of spent fuel has decreased to the level required by the disposal requirements.

Demo facilities, demonstration facilities (in ONKALO)

Test tunnels excavated according to the disposal requirements.

Drill core sample

A rock sample obtained from the rock by drilling. The sample can be used for determining the rock type consistency and fracturing, for example.

EBS (Engineered Barrier System)

Technical release barriers in the disposal facility, such as the canister, bentonite buffer and tunnel backfill.

EDZ (Excavation Damaged Zone)

A broken zone caused by tunnel excavation.

EIA

Environmental Impact Assessment, which investigates the impact of major projects on the environment.

Final disposal

The long-term isolation of spent fuel from living nature and the human habitat.

Fuel assembly, fuel bundle

The fuel bundle of a nuclear power plant comprises fuel rods which contain nuclear fuel.

KBS-3V and KBS-3H

The technical solution of final disposal. According to the 3V principle, canisters are placed vertically in the bedrock, and horizontally in the 3H solution.

Multibarrier principle

The isolation of spent fuel from living organisms with several independent release barriers so that no radioactive substances enter the organic nature in any circumstances.

NDT (Non-Destructive Testing)

An inspection method which does not break the substance, such as X-ray.

Nuclear waste

A nuclear power results in low-level and intermediate-level waste as well as highly radioactive spent nuclear fuel. Low- and intermediate-level waste is disposed of in final repository located in power plant areas. At the moment, spent fuel is stored in spent fuel pools located in power plant areas, and will be later disposed of in the Olkiluoto bedrock.

OL1-3, LO1-2

Olkiluoto and Loviisa nuclear power plants (OL1, Olkiluoto 1).

ONKALO

An underground rock characterisation facility for the final disposal of spent nuclear fuel.

Fuel bundle

Pilot hole

A hole drilled in the rock surrounding ONKALO. The hole is for obtaining information for excavation planning and implementation, for example.

PL (pole number)

The figure indicates the distance (in metres) from the tunnel mouth.

Release barriers

The purpose of release barriers is to keep radionuclides within the final disposal system. Technical release barriers: canisters, bentonite buffer and tunnel backfill. The bedrock is a natural release barrier.

RSC (Rock Suitability Classification)

A procedure for developing and defining the suitability of the bedrock for final disposal panels, tunnels and holes.

RTD (Research, technical design and development of disposal operations)

Final disposal has been researched and developed in Finnish conditions since the 1970s and the research and development is still continuing.

Spent nuclear fuel

Radiated fuel, removed from the reactor, the burnup of which is too high to be re-used in the reactor.

Subcritical

A system which does not sustain a chain reaction. In all circumstances, the disposal canister must remain subcritical, i.e. no chain reactions may occur in it.

Technical rooms (ONKALO)

The technical facilities comprise parking and service garages, rescue facilities, the elevator centre and canister reception facility.

Total volume of water leakage

Volume of water leaking to ONKALO from the bedrock, litres per minute.

VLJ

Low- and intermediate-level radioactive waste, created in nuclear plant operations, such as activated ion-exchange resins used for purification of process water and contaminated plastics, clothes, tools etc. during maintenance work.

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