# Nuclear Energy in Finland Operation, projects and licensing

Liisa Heikinheimo Deputy Director General MEAE\*

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Ministry of Economic Affairs and Employment of Finland

## Finland in brief: the coldest country in Europe

#### Area

Situated in northern Europe with an area of 338,432 km<sup>2</sup> of which 72% forest, 10% water, 8% cultivated land.

#### Population

5.5 million, with average density of 18 persons per square kilometre. More than two-thirds of the population reside in the southern third of the country.

### Average temperatures in 2016

Town	Latitude	January	July
Helsinki	60°	-8.8°C	17.8°C
Sodankylä	67°	-18.1°C	16.8°C

#### Economy

In 2016\* GDP totalled  $\in$  214.1 bil., i.e.  $\in$  38,959/capita. In 2014\* services were 70.7%, secondary production 26.5% and primary production 2.8% of the GDP.

#### Structure of industry, Value added gross in production in 2015

Total industry	37.2	100
Mining and quarrying	0.6	1
Forest industry	4.3	12
Chemical industry	4.9	13
Metal industry	16.5	44
Basic metals and metal prod.	3.8	10
Electrical and electronics ind.	5.8	16
Other metal industry	6.9	18
Other manufacturing ind.	5.0	13
Energy supply	4.2	11
Water supply and waste		
management	1.7	5

bil €

0/~

Municipalities with high electricity consumption 2015





## Total energy consumption in 2016\*

1,348 PJ (32.2 Mtoe) 245.0 GJ/capita (5.9 toe/capita)

#### Electricity consumption in 2016\*

85.1 TWh 15,479 kWh/capita

## High energy consumption due to climate, long distances and energy-intensive industry

### Total energy consumption 1975–2016

- Wide energy mix fossil fuels losing ground
- Renewables and nuclear growing; woodbased fuels the most important energy source!

### Final energy consumption by sector 2016

- High seasonality in heating & lighting



# Nuclear energy production: 32 % of electricity produced in Finland (Olkiluoto and Loviisa) in 2018







TVO – OLKILUOTO IN 2018 40 years electricity production, 17 – 20 % of the electricity needs in Finland

## TVO - OLKILUOTO site – OL1, OL2 and OL3

- OL1 and OL2 continuous improvement through modernization projects
- 2018 renewal of operating license till 2038.
- Submission of the license application in January 2017, license in October 2018.

## OL3 - toward commissioning

- Operating license application in 2016. License in 2019 > fuel loading expected in August/September 2019 > start of operating tests with fuel.
- Electricity generation starts in 2019/20.
- All nuclear waste management on one island
- Operating waste repository (VLJ repository at the site)
- Interim storage for spent nuclear fuel (Renewal and extension 2015).
- Final disposal facility for spent nuclear fuel, Posiva / ONKALO in Olkiluoto under construction.



## Loviisa Nuclear Power Plant (Fortum Power and Heat)

Lo1/2: 2 x VVER 505 MW

## Hanhikivi 1 to be built in Pyhäjoki



## Fennovoima Hanhikivi1



- ROSATOM VVER / AES2006, 1200 MW(e) reactor
- Owners Voimaosakeyhtiö Suomi 66 % & ROSATOM 34 %
- Site in Pyhäjoki, Hanhikivenniemi
- Construction license application submitted in 2015
- License handling ongoing (Safety assessment delayed due to the submission of documents), present schedule in 2021.
- Start of operation based on ROSATOM information in 2027/8, based on MEAE estimation around 2030.
- Currently contract with Posiva Solutions for development of spent nuclear fuel waste management solution.
- Automation contract bidding process by ROSATOM ongoing.
- Fennovoima staff about 350 in 2018, project staff from ROSATOM.
- Fennovoima participates to the national research programmes since 2010.
- Fennovoima participates MEAE working groups for national waste management and waste management funding.

## **Existing functions for spent fuel**



- Storage, transport activities and the research tunnel ONKALO in operation.
- ONKALO final depth of 420 metres and length more than 4000 meters.
- First in the world Construction license in 2015 for the final disposal facility, start of construction in 2016.
- Readiness to start the operation for disposal in 2024 (Posiva).



### Olkiluoto spent fuel transport

## ONKALO, excavation started in 2004

## **Nuclear Waste Management in Finland**





## **POSIVA - FINAL DISPOSAL FACILITY** ONKALO and underground repository for the spent nuclear fuel



from research project towards implementation

# Posiva's program has progressed already for 40 years



## **ONKALO** site in 2020's

ZOSIVA



2019-03-13

Kaukonen Kari

CE PAS

Public

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## Final disposal facility project proceeds

- Canister hoist raise boring about to finish
- Full-scale In Situ System Test (FISST) proceeds
  - Copper canister with heating and instrumentation installed in June 2018
  - Buffer installed in July 2018
  - Backfilling is about to finish
  - Plug installation early 2019
- Encapsulation plant main equipment suppliers have been selected and engineering/licensing is ongoing
- Production planning for the first production phase (45 years) is ongoing
- Start of encapsulation plant construction in summer 2019.



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# FISST-installations, canister and bentonite buffer components

2019-03-13

Kaukonen Kari



### Canister installed June 29th 2018

Buffer installed July 23rd 2018



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# Encapsulation plant – decision to start the construction works in 2019



6. Canister hoist

Vuorio Petteri

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**Overall safety and systemic approach to safety:** Overall safety and systemic approach to safety includes a wide range of overarching nuclear safety research topics, as well as topics affecting the nuclear power plant as a whole.

**Reactor safety:** Reactor safety research focuses on the development of experimental and computational analysis methods aimed to ensure that a nuclear facility and its systems are able to implement the safety requirements set for them.

**Structural safety and materials:** The aim of the research on structural safety and materials is to increase knowledge that supports long-term and reliable use of the nuclear power plants, particularly with respect to matters involving the integrity of barriers and material issues that affect the reliability of the safety functions.

**Research infrastructure development:** Domestic infrastructure and experimental research are vital for the maintenance and enhancement of national competences, as well as for leveraging international experimental capabilities for national needs.

#### SAFIR2018 in 2015-2018

- The total volume of research was 29,6 M€, 209 person years
- The funding organisations: the Finnish State Nuclear Waste Management Fund (VYR) with 17,7 M€, VTT with 6,4 M€, LUT University, Aalto University, NKS, SSM, Halden Reactor Project, TVO, Fennovoima, Fortum, others.
- In addition, VTT Centre for Nuclear Safety equipment and laboratory projects were funded by jointly SAFIR2018 and KYT2018, which increases the total funding to 46,4 M€.
- 1095 publications and other reports including 166 scientific journal articles and 236 conference articles
- 44 higher academic degrees, 18 doctors.

#### SAFIR2022 in 2019

- The total volume of research is 6,7 M€: 32 research projects and 42 person years.
- In addition, funding for the VTT Centre for Nuclear Safety projects jointly by SAFIR2022 and KYT2022 is 6,2 M€.
- Research: overall safety and organisation, plant level analysis, reactor and fuel, thermal hydraulics, mechanical integrity, structures and materials, severe accidents, research infrastructure.



The new VTT Centre for Nuclear Safety has hot cells for research and testing of radioactive structural materials from nuclear power plants.

CFD model of VVER-440 pressurizer.

For details, see SAFIR2022 and SAFIR2018 websites <u>http://safir2022.vtt.fi</u> and <u>http://safir2018.vtt.fi</u> (the final report of SAFIR2018 available).

# Finnish Research Programmes on Nuclear Waste Management KYT2018 and KYT2022

- Research is divided into interacting main topics: (1) safety, (2) feasibility, and (3) acceptability of nuclear waste management with safety as the most central
- Research infrastructure development since 2016
- Funding from State Nuclear Waste Management Fund and research organisations
- Coordination at VTT

#### KYT2018 in 2015-2018

- 4-year budget 11,6 M€, 32 research and infra projects, 100 person-years
- 13 public seminars
- 71 peer-reviewed articles, 215 conference papers, 36 academic degrees (12 doctors)
- International review 2017
- Research organisations: VTT, Aalto University, Geological Survey of Finland, Universities of Helsinki, Jyväskylä, Eastern Finland, Tampere, Tampere University of Technology, Numerola Oy

#### KYT2022 in 2019

- Annual budget 2,1 M€, 30 research and infra projects, 24 person-years
- Safety on nuclear waste most central research topic
- As new topics, for instance decommissioning, and overall safety in nuclear waste management
- Research organisations: see KYT2018



#### Further information:

- KYT2018: <u>http://kyt2018.vtt.fi/en/</u>
- KYT2022: <u>http://kyt2022.vtt.fi/en/</u>, under completion



## Thank you!