ACTIONS TO PROTECT NPPS AGAINST EXTERNAL AND INTERNAL EVENTS AND R&D ACTIVITIES IN FINLAND

International Experts' Meeting on Strengthening Research and Development Effectiveness in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant (IEM-8)

IAEA Headquarters, Vienna, Austria
16–20 February 2015

Liisa Heikinheimo
Head of R&D TVO

CONTENTS

1. Operating NPPs in Finland
2. Renewal of the Finnish YVL guidelines by STUK
3. Examples of measures to protection against external and internal events
4. Safety improvements and reflections to Safety Research – national programme SAFIR
5. Continuous development and R&D

NUCLEAR POWER IN FINLAND 2015

Teollisuuden Voima Oyj, Olkiluoto:

- OL1/2: 2 x BWR 880 MW (1978/1980)
- OL3/EPR 1600 MW (construction 2005)
- OL4 decision in principle in 2010 (max 1800 MW).

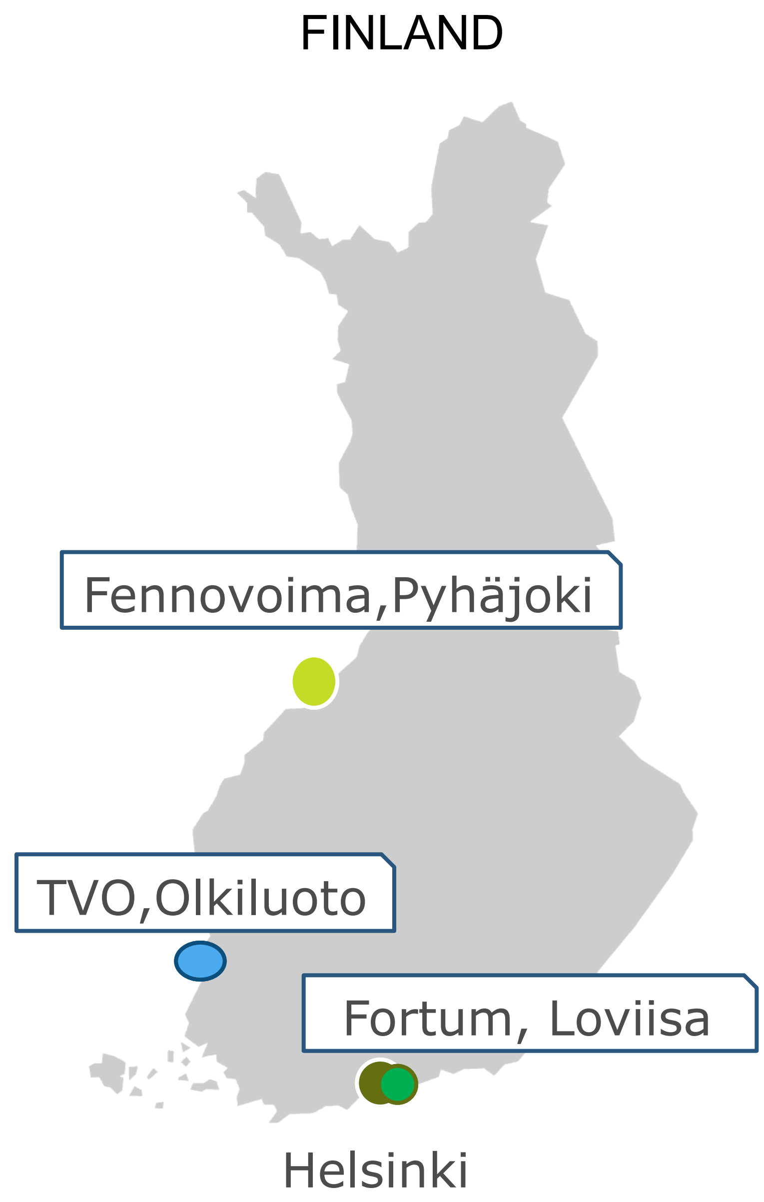
Fortum Power and Heat Oy,

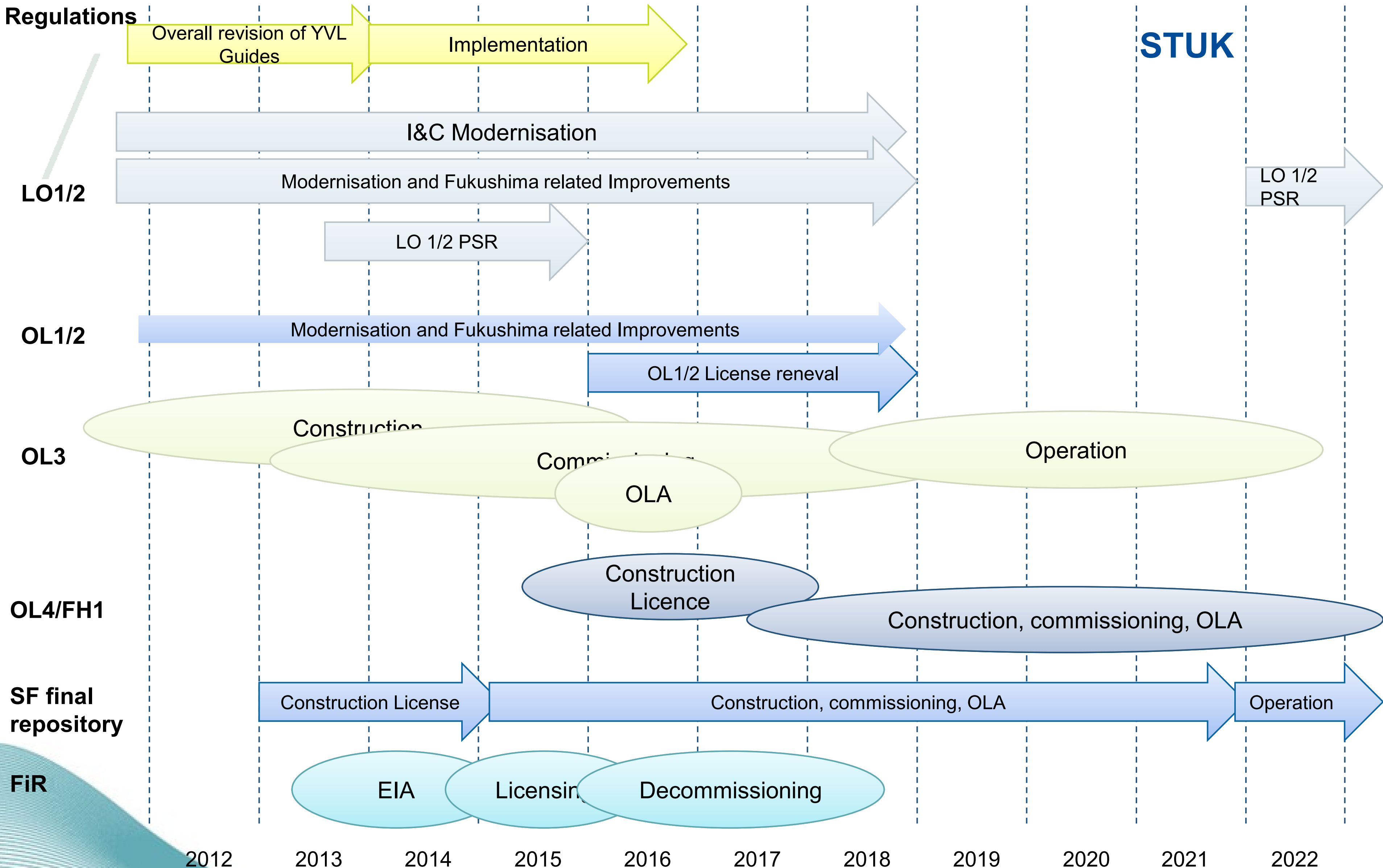
Loviisa (1977/1980):

- Lo1/2: 2 x VVER440 488 MW

Fennovoima Oy, Pyhäjoki:

- FH1 decision in principle in 2010 (max 1800 MW).
- Change of the reactor type approved in 2014: AES-2006, 1200 MW VVER.





Regulations – STUK overview

Renewal of YVL guides by the NUCLEAR safety authority - STUK

45 YVL Guides, 40 renewed in December 2013: Lessons learnt from Olkiluoto 3 and Fukushima

- The main objectives of the YVL Guide revision were to simplify the structure of the collection of nuclear safety rules, harmonise the Guides and apply the lessons of the Olkiluoto 3 project. In addition, the lessons learnt from the Fukushima accident as well as the objectives set for new facilities by the WENRA were taken into account in the project.
- nuclear facilities will be required to withstand more severe natural phenomena and power failures.
- even in the case of a failure, the safety systems of a nuclear facility shall not interfere with each other.
- requirements on management systems have been revised,
- a new Guide on information security has been issued.

Updated set of YVL Guides - STUK

There are 40 YVL Guides under five topics (5 more in process):

- A Safety management of a nuclear facility
- B Plant and system design
- C Radiation safety of a nuclear facility and environment
- D Nuclear materials and waste
- E Structures and equipment of a nuclear facility

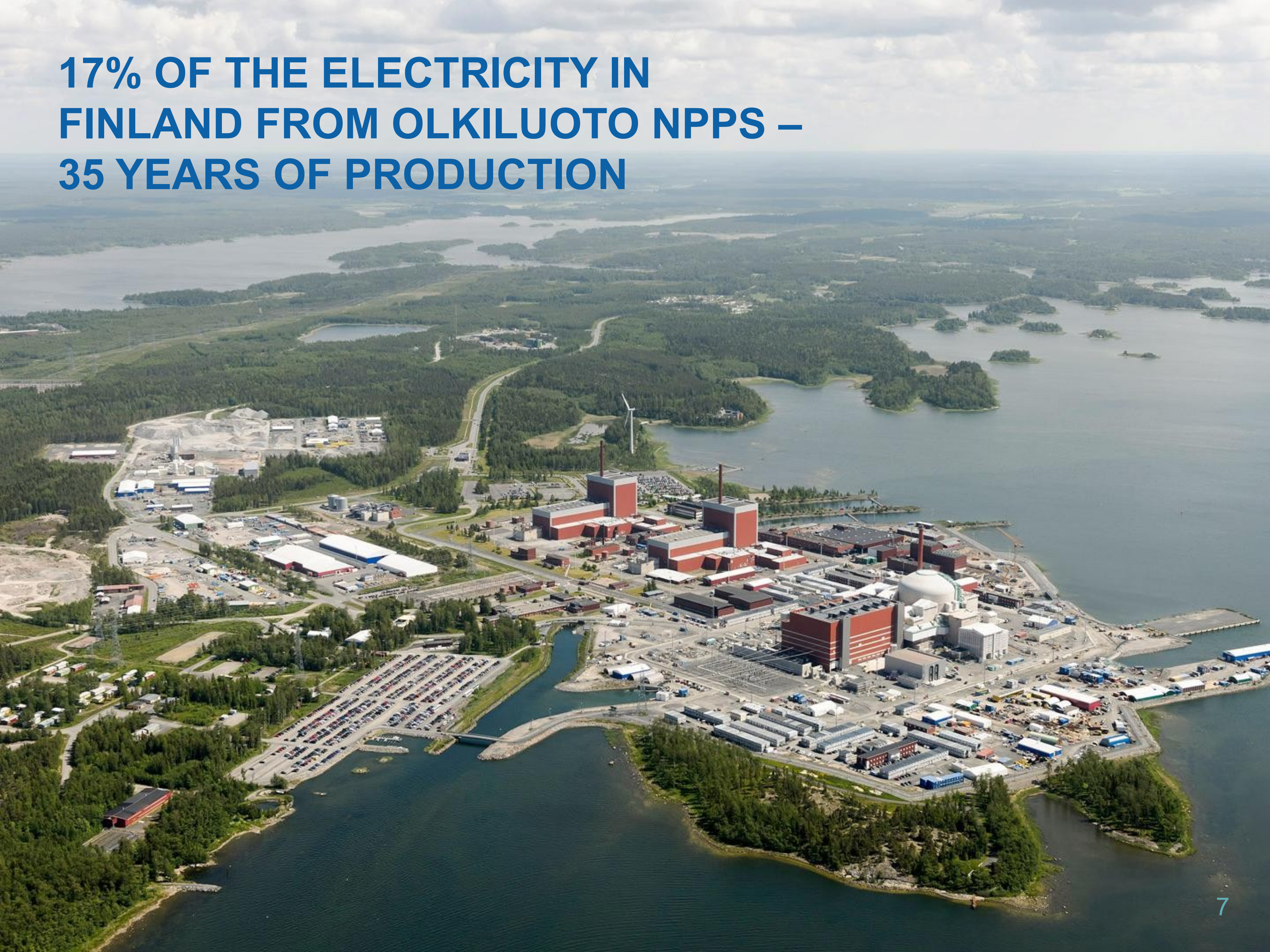
http://www.stuk.fi/julkaisut_maaraykset/viranomaisohjeet/en_GB/yvl/

Especially the Guidelines B1, A7 and C5 include changes that are based on the Fukushima lessons learned:

- B1: Safety design of a nuclear power plant
- A7: Probabilistic risk assessment and risk management of a nuclear power plant
- C5: Emergency preparedness arrangements of a nuclear power plant

- The new requirements in the guidelines will further create needs for new research topics, verification and development of new tools.
- Assessment of fulfilling the 40 new guidelines was due to Dec. 2014 for the operating nuclear power plants.

17% OF THE ELECTRICITY IN FINLAND FROM OLKILUOTO NPPS – 35 YEARS OF PRODUCTION

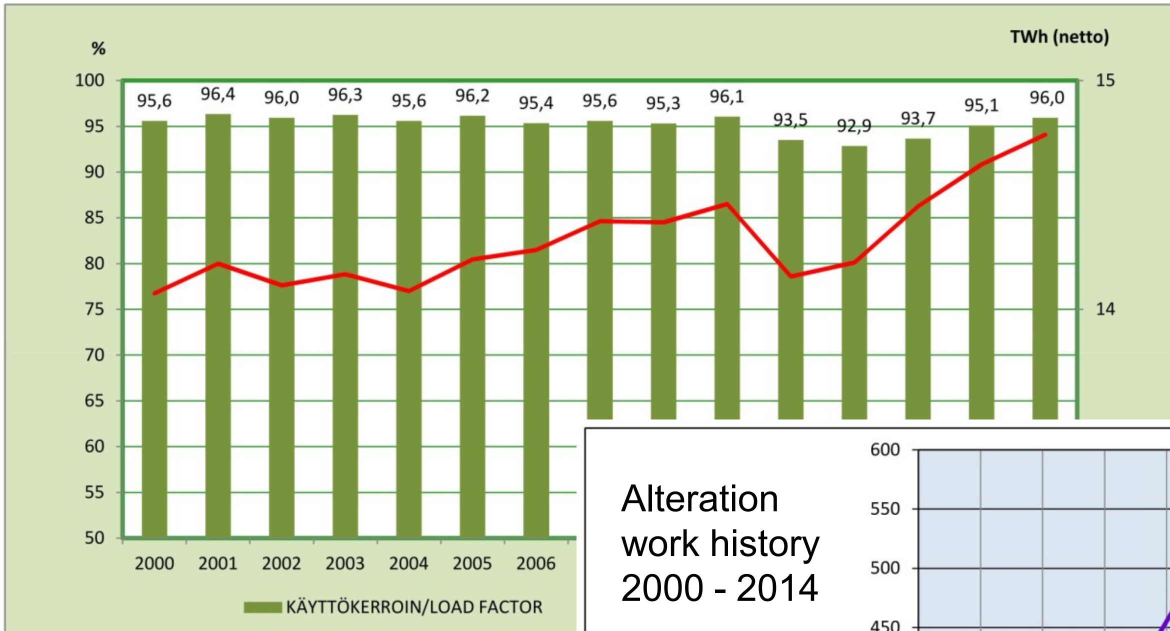


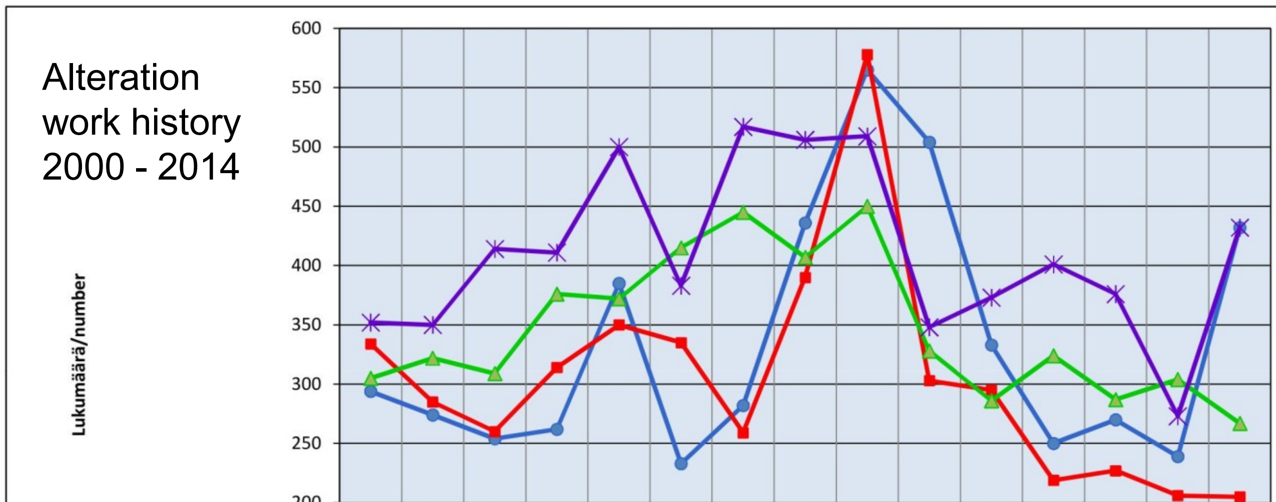
TVO – TOWARDS 2020 AND CONTINUOUS WORK TO IMPROVE THE SAFETY

- OL1 ja OL2 – continuous improvements and modernisations. **2018 operation license renewal.**
- OL3 – automation testing and assembly. **Preparations for the operation license and PTO.**
- OL4 – the DiP will be in force till June 2015.
- Waste management on one island, Olkliluoto.

TVO

OL1 + OL2 AVERAGE LOAD FACTORS AND PRODUCTION - CONTINUOUS WORK TO IMPROVE THE PERFORMANCE AND FOR MAINTENANCE



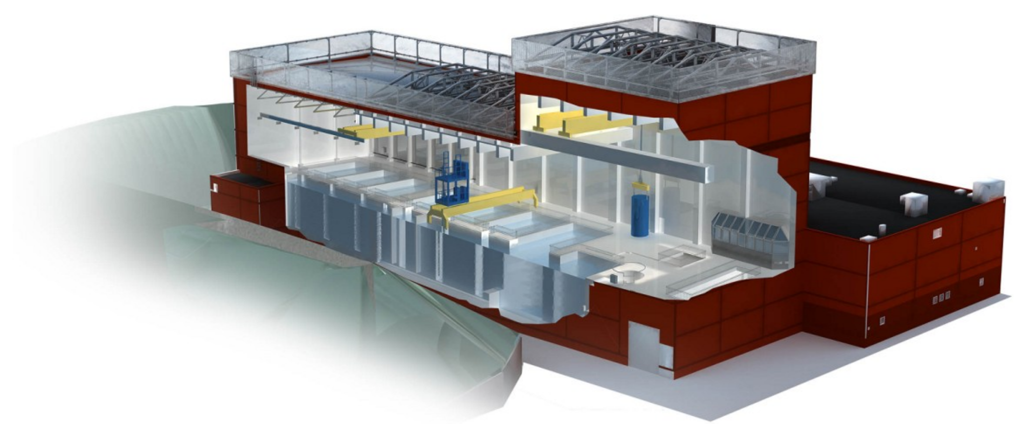


	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Dokumentoituja/Documented	294	274	254	262	385	233	282	436	565	504	333	250	270	239	432
Asennettu/Installed	334	285	260	314	350	335	259	390	578	303	295	219	227	206	205
Suunniteltu/Planned	305	322	309	376	372	415	445	407	450	328	286	324	287	304	267
Uudet työt/New work	352	350	414	411	500	383	517	506	509	348	373	401	376	273	432

TVO

MAJOR IMPROVEMENTS AT OL1/OL2/KPA

- High and low pressure pumping to RPV both in detail design phase
- Ensuring fire water feeding
- Spent fuel interim storage improvements – ensuring the heat removal and integrity.
- Ensuring sufficient diesel fuel availabilty in long term accident situations
- Increasing the amount of Mobile equipment
- Ensuring fresh water supply in case of multi-unit accident .



MAJOR IMPROVEMENTS AT OL1/OL2/KPA…

FIRE WATER FEEDING

- Ensuring the water feed in long lasting events
- Feeding established at KPA and OL1, OL2 will be completed in 2015.
- Water level measurement in fuel pools in progress.

FLOODS , SEISMIC AND EXTREME WEATHER EVENTS

- Strengthening KPA structures against flooding
- Oil accidents, preparedness improved.

AUXILIARY FEED WATER SYSTEM (system 327) MODIFICATIONS

- Loss of seawater HEX will not furher cause an immediate loss of the auxiliary feed water system – done at OL1 and ready at OL2 in 2015. Will improve in the core damage frequency (CDF).
- Steam and hydrogen outlet in case of severe accident from the reactor hall. Work in planning phase.

REMOVAL OF DECAY HEAT IN CASE OF LOSS OF AC

- Pumping of demi-water with high pressure turbine-pump in the reactor for 2½ h-3 h. To enable primary pressure decrease to 5 bars.
- In case no electricity is available till this, pumping of fire water with normal pumps will follow. Modifications in planning phase.

NOG SAFETY & ENVIRONMENT PROJECTS:

- Reconstitution of design bases for severe accident mitigating systems and strategies
- Production and handling of non-condensable gases during severe accidents
- Hydrogen leakage to the reactor building during a severe accident:
  - Identify H2 possible **leakage paths, evaluate flow paths and concentration spots in RB**
  - Provide a methodology for “hydrogen walk downs” in order to assess hydrogen transport and distribution in the reactor building
  - Perform a “hydrogen walk down”
  - Evaluation of an analysis tool, e.g. FAI FATE – CFD model
  - Identify **suitable counter measures, e.g. usage of blow-off panels, ventilation, PAR etc.**
- Design margins and acceptance criteria – Core stability.

Safety assessment results

- Fortum's nuclear power plants in Finland and Sweden have high safety level and Fortum's knowhow in nuclear safety is internationally recognized.
- Loviisa NPP has been heavily modified already in the design phase, e.g. containment and safety systems.
- Safety level has been improved throughout the plant lifetime by plant modifications. For example, new systems have been installed to mitigate the severe accidents.
- Immediate need for additional safety upgrades was not identified.
- Safety margins against external hazards are sufficient.
- During the safety assessment a few issues were raised where safety level could be increased even further.

Fortum

Cooling towers

- Two cooling towers for each of the plant units, one for reactor and one for fuel pools
- Designed by Fortum except the heat excangers
- Heat exhanger designer and manufacturer: GEA EGI Contracting/Engineering Co. Ltd
- Initiating event: Loss of ultimate heat sink.
- Safety class: Non-classified
- Installations are ready, last commissioning tests late summer / early autumn 2015.

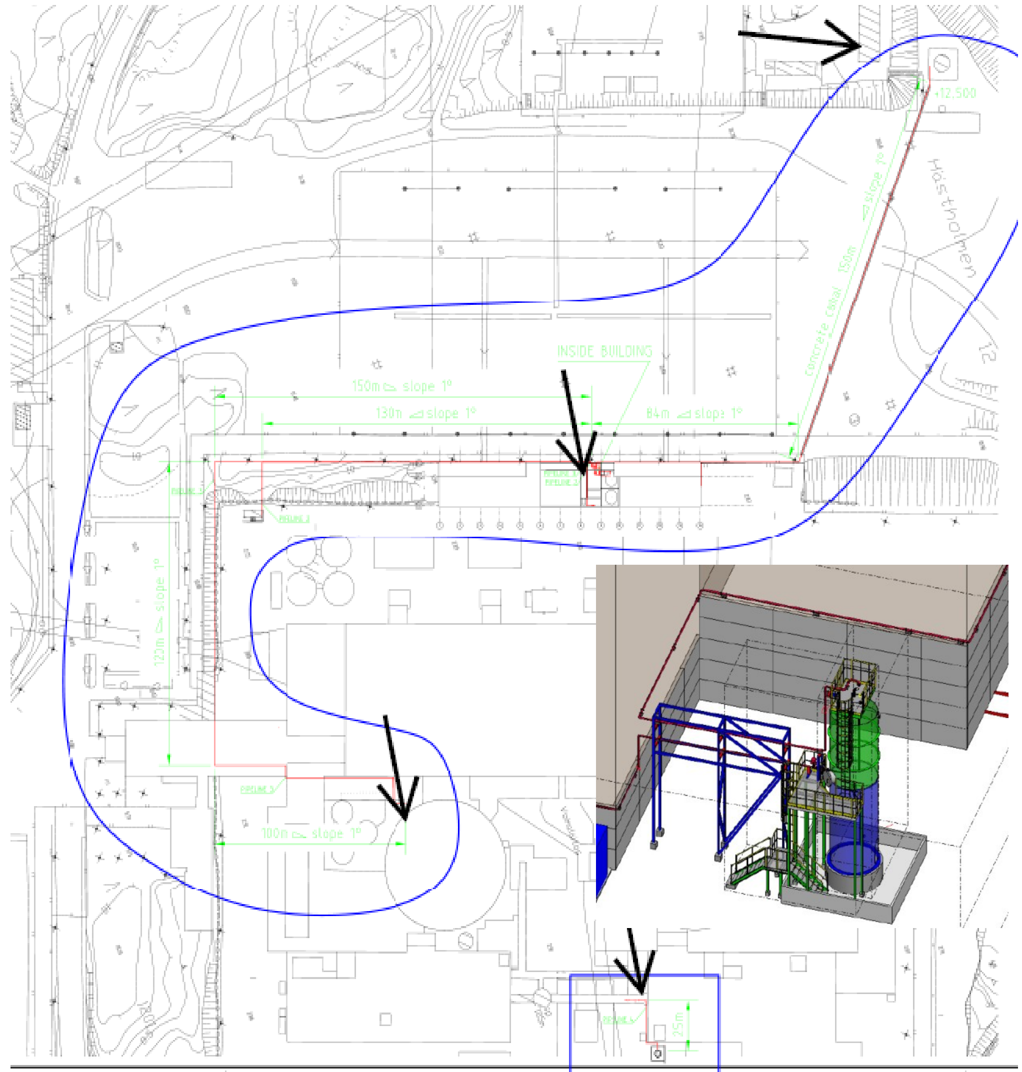
Fortum

Ultimately high sea water level

- A seismic tsunami like the one in Fukushima is not relevant for the Gulf of Finland
- Plant shutdown preparation will be started if the sea water level reaches level +1,75 m. The plant will be shut down if the sea water level reaches level +1,95 m. Power plant yard level is at +3,00 m.
- Sea water level clearly exceeding level +3,00 m long enough would result in widespread loss of safety system and safety functions.
- Fortum will install higher gates to sea water channels to prevent spreading of water inside the plant in shutdown states with open sea water system piping. Current gates reach level +2,00 m and new gates will reach level +3,00 m. Two of four gates have been renewed.
- New assessments of possible sea water level have been launched with Finnish Meteorological Institute..
  - Preliminary results indicate higher levels with higher frequencies than anticipated before due to change in climatic conditions.
- Additional protections againts high sea water level in auxiliary emergency feedwater system have been implemented.

Diesel fuel distribution

- New tank
- Distribution piping
- Refuelling stations
- Implementation 2016



SAFIR2014 programme 2011-2014

SAFIR2014

Finnish Nuclear Energy Act 53§:

The objective of the SAFIR2014 research programme is to develop and maintain experimental research capability, as well as the safety assessment methods and nuclear safety expertise of Finnish nuclear power plants, in order that, should new matters related to nuclear safety arise, their significance can be assessed without delay.

SAFIR 2014 - 9 research themes and 42 projects:

1. Man, organisation and society
2. Automation and control room
3. Fuel research and reactor analysis
4. Thermal hydraulics
5. Severe accidents
6. Structural safety of reactor circuits
7. Construction safety
8. Probabilistic risk analysis
9. Development of research infrastructure

Special topics announced in the calls:

- International co-operation
- **Impact of Fukushima accident**

Impact of Fukushima accident on SAFIR2014

SAFIR2014

Fukushima induced research topics:

Extension of existing topics and new safety issues

- Initiating events: external hazards, multiple events
- Design of NPPs: seismic events, cliff edge effects (loads, integrity of safety functions after extreme loads)
- Accident mitigation: deterministic and probabilistic assessment of long lasting accidents, heat removal, hydrogen issues, release of fission products
- Safety of the entire fuel life cycle, esp. storage of spent fuel.

- http://safir2014.vtt.fi/ and http://safir2018.vtt.fi/

Impacts of Fukushima accident on SAFIR2014 research activities

SAFIR2014

Man, organisation and society:

- Review of lessons learned from reported events (e.g. Fukushima) which have design as a contributing factor

Fuel research and reactor analysis:

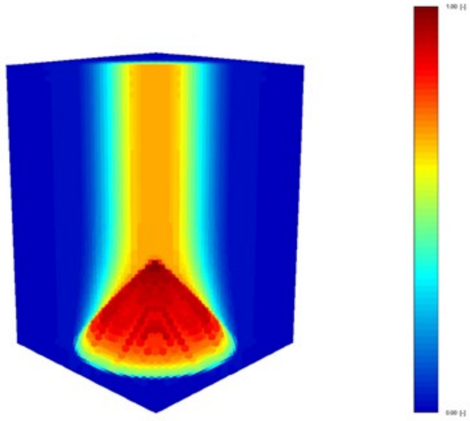
- Development of tools and methods to enable an informed assessment of the distribution of radionuclides in various fuel microstructures

Thermal hydraulics:

- OECD/PKL3 project: ”Fukushima” test scenario

Severe accidents:

- Estimation of the radiation doses caused by the Fukushima accident in the environment of the Fukushima Dai-ichi power plant using VTT’s ARANO model
- OECD/NEA Benchmark Study of the Accident at the Fukushima Daiichi Nuclear Power Plant (BSAF) Project Co-operation.
- Investigation of liquid metal, liquid oxide slag and salt liquid/solid phase interactions with CHEMSHEET
- Development of MELCOR models of the Fukushima accident
- Development of an analysis tool for studies of loss of coolant accidents spent fuel pools in the reactor building.



Impacts of Fukushima accident on SAFIR2014 research activities

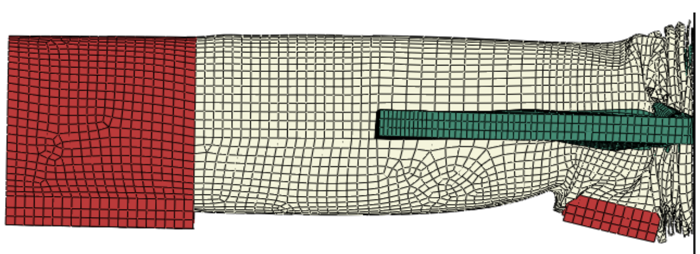
SAFIR2014

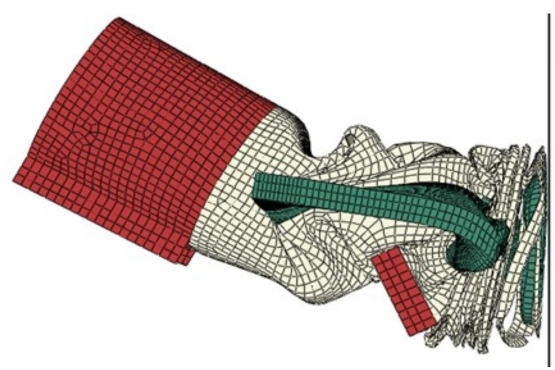
Construction safety:

- External impacts and Seismic safety of nuclear power plants: targets for research and education (SESA)

Probabilistic risk assessment:

- More detailed studies of the occurrence of natural hazards: very rapid changes of Baltic Sea level (meteotsunamis), ice storms (very intensive freezing rain), excess snowfall cases and hurricane scale wind speeds.

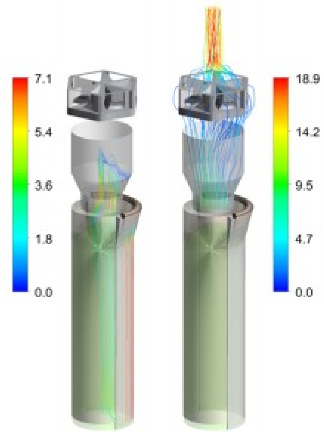




New programme 2015-2018

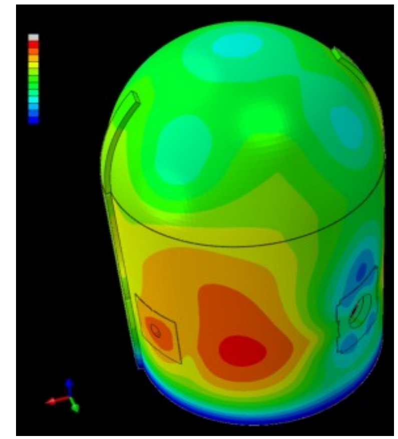
Plant safety and systems engineering

- Wide interdisciplinary research area covering the interfaces between operations and technologies
- Operation of the plant as a whole
- Design principles, defence-in-depth
- Operating processes, information model and documentation of safety justification
- Human and organisational performance, I&C, PRA applications etc.



Reactor safety

- Goal to ensure the experimental facilities, computational methods, and skilled experts
- The methods should enable independent assessment of the supplier's and licensee's proposals
- Thermal hydraulics, reactor dynamics, severe accidents , PRA, electric systems etc.



Structural safety and materials

- Safe long term use of the plants
- Research on the management of the ageing of materials and structures
- New materials, manufacturing, and structural engineering
- Life cycle management and extension
- Probabilistic and deterministic design (RI-ISI).

WHAT HAS BEEN LEARNT?

1. The principle of ’further improving the safety’ is correct, and one has to have necessary means and resources available
2. One has to be prepared for severe accidents
3. Core damage frequency (CDF) and large release frequency (LRF) have to be continuously diminished to find out the most efficient means at the time in question
4. Harmonizing and presuming international requirements is essential
5. All the learnings from accidents have to be utilized – analyse, learn and adopt, including R&D co-operation and forums.

TVO

Acknowledgements for the material used in the presentation:

- Mr Mika Harti and Mr Harri Tuomisto, Fortum
- Mr Mikko Lemmetty and Mr Janne Wahlman, TVO

TVO

THANK YOU