

# SECURING NUCLEAR SAFETY – A FINNISH VIEWPOINT

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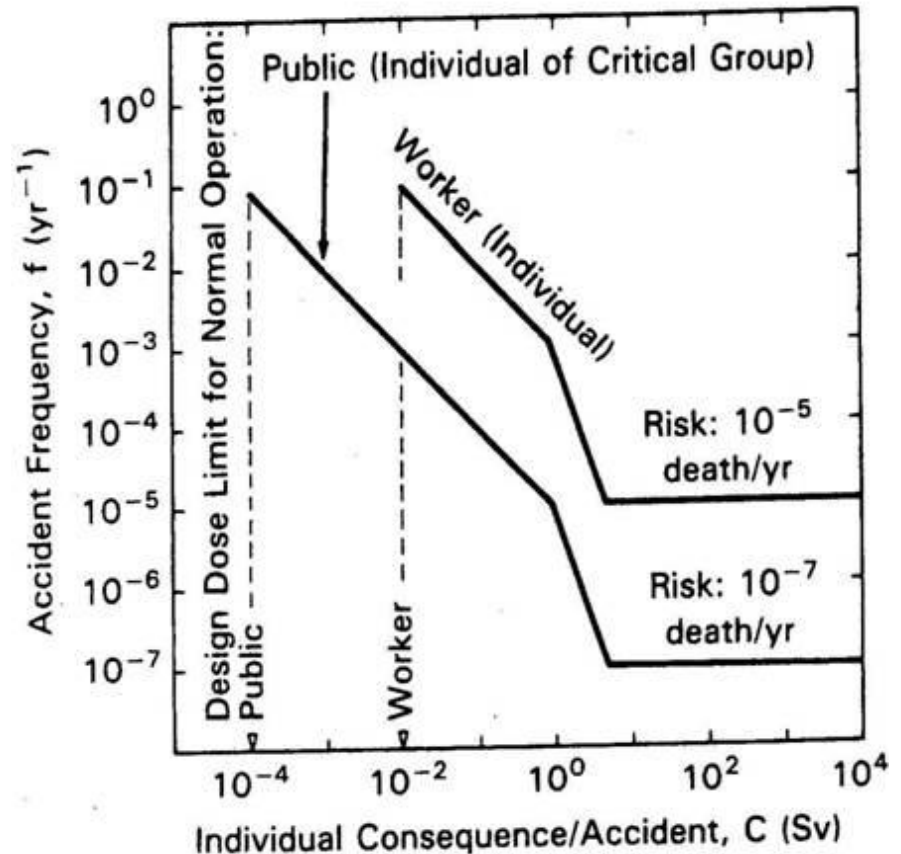
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Efficient and safe use of nuclear energy implies **competence**, continuous **investments** to improve the plants, and proper **attitude** of all stakeholders.

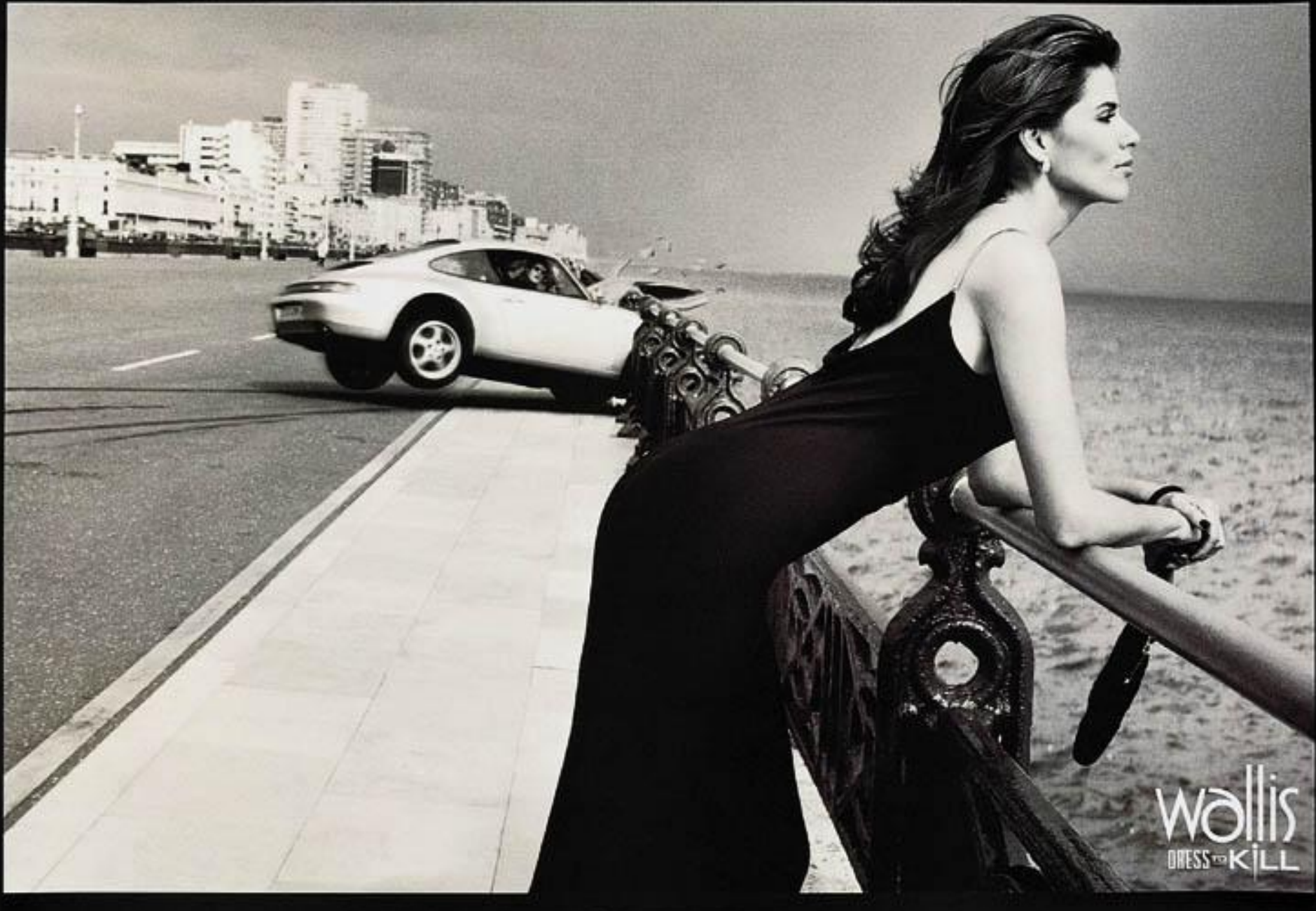
# A procedure in accident analysis

- Hazardous materials and/or threats in general
- Energy sources to release the materials
- Accident scenarios
- Release mechanisms and routes
- Consequences of the accident
- Quantitative risk assessment
- Dispersion models and assessment of effects



Deterministic or  
probabilistic methods

**Risk = probability × consequence**  
**Risk acceptability?**



Wallis  
DRESS TO KILL



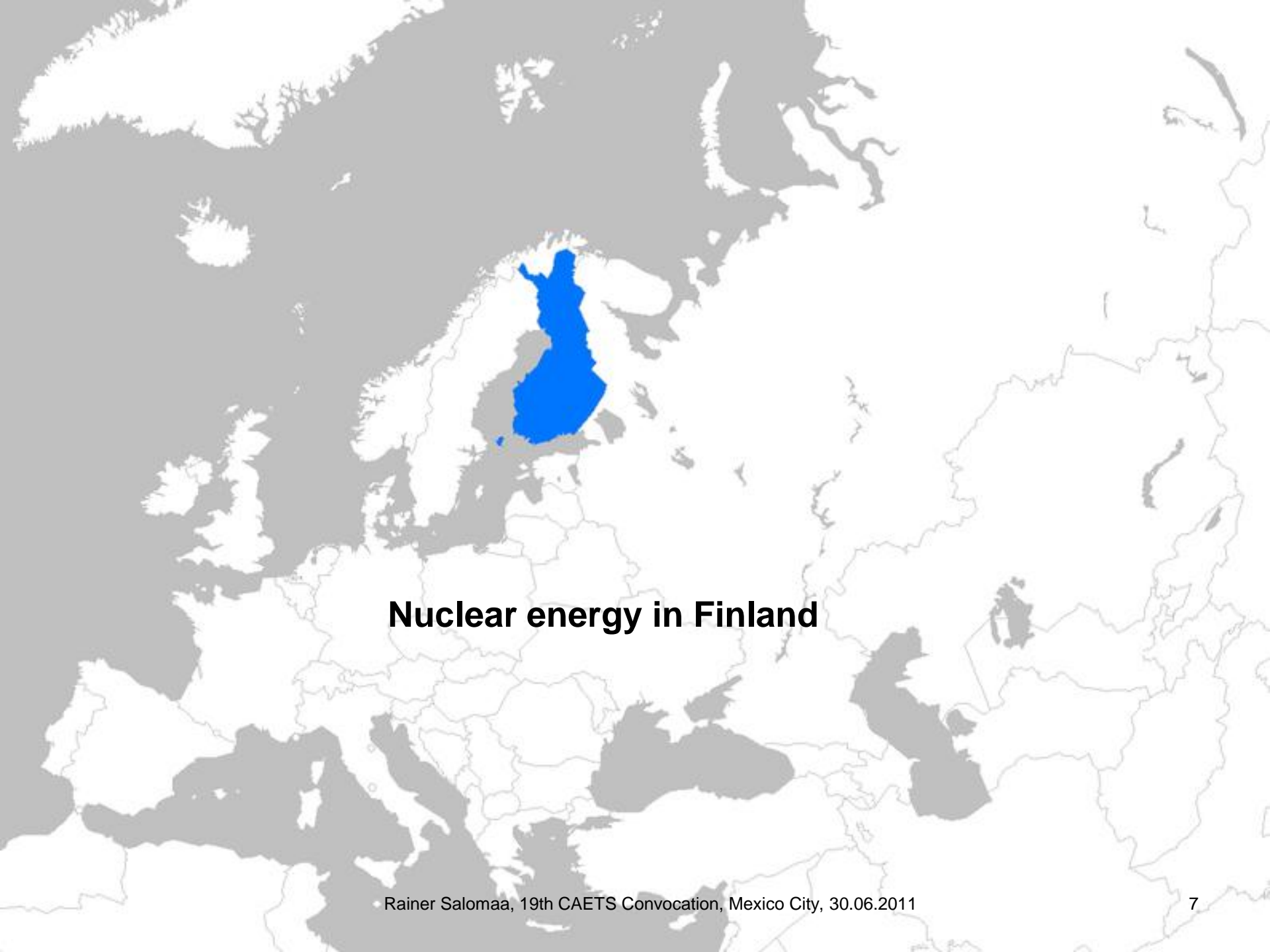
Wallis  
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# Nuclear safety and safety culture

**Nuclear safety** means the achievement of proper operating conditions, prevention of accidents or mitigation of accident consequences, resulting in protection of workers, the public and the environment from undue radiation hazards. **The very complicated interrelations between technology, processes and actors and on the other hand the huge amounts of radioactivity and energy involved makes achievement of acceptable nuclear safety particularly demanding.**

**Safety culture** means the assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, protection and safety issues receive the attention warranted by their significance.

IAEA safety glossary (IAEA Pub 1290)



## **Nuclear energy in Finland**

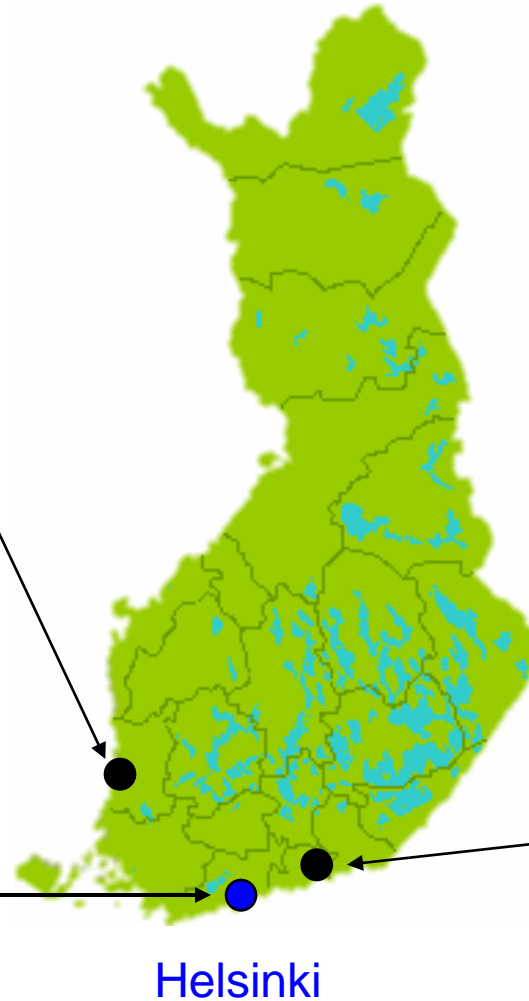
# 25,4% of electricity by nuclear (2008)



Olkiluoto 1&2  
BWR 2×880MW  
1979, 1982  
2008: 14.4TWh, 95%

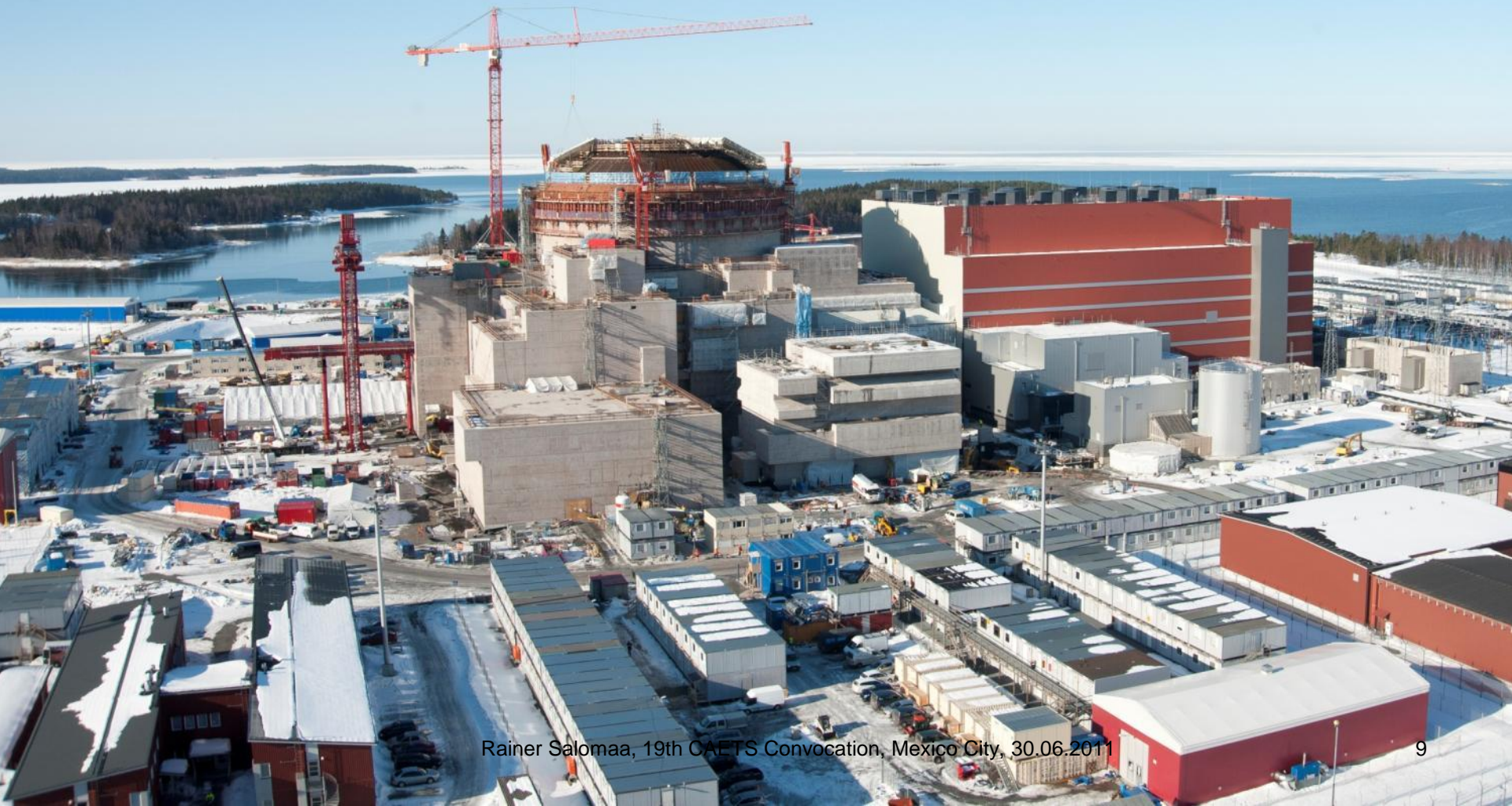


Loviisa 1&2  
PWR 2×488MW  
1977, 1981  
2008: 7,7TWh, 90%

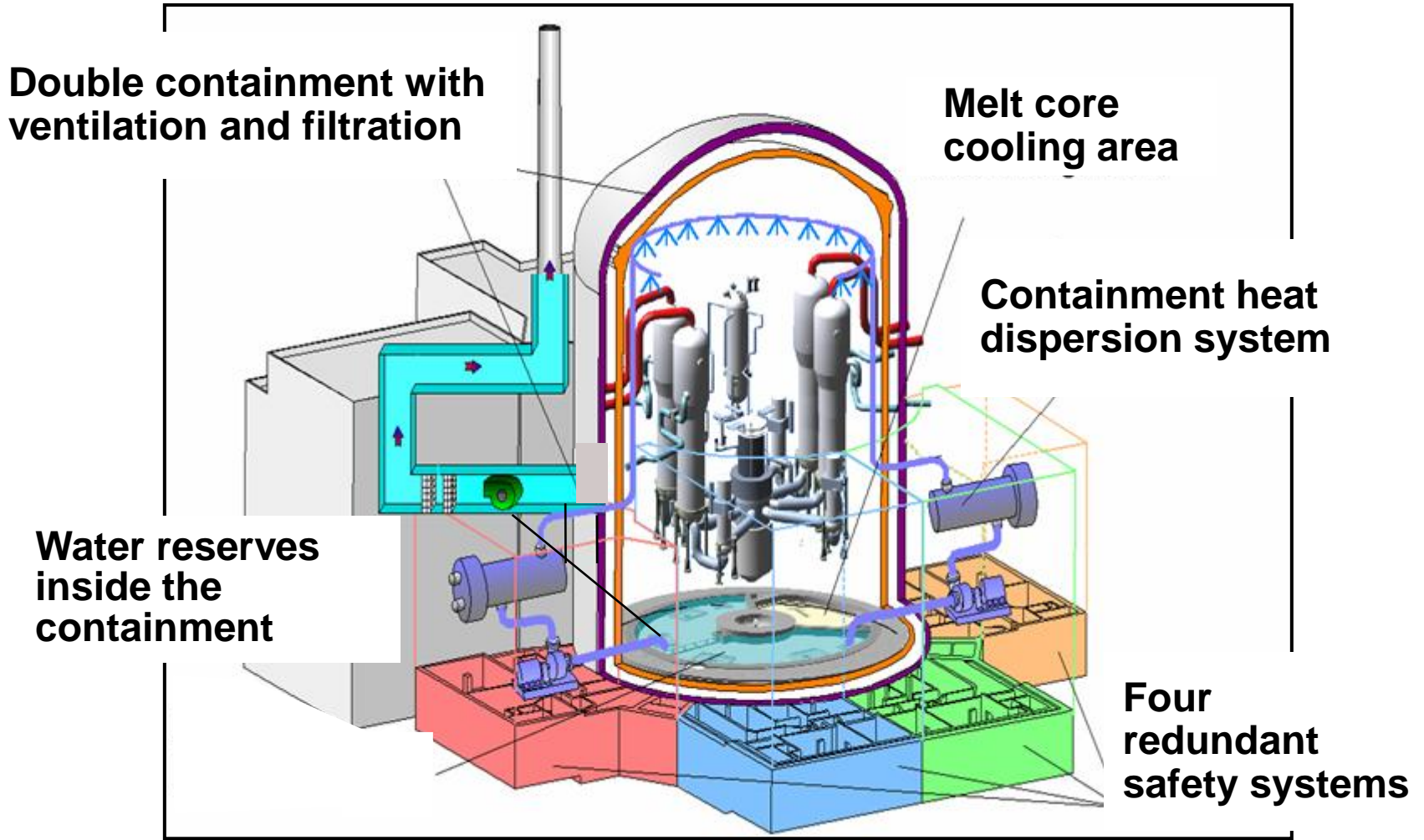


Triga MkII  
1962, Espoo

# The 5th unit under construction Commercial start in 2013



# Main EPR Safety Features



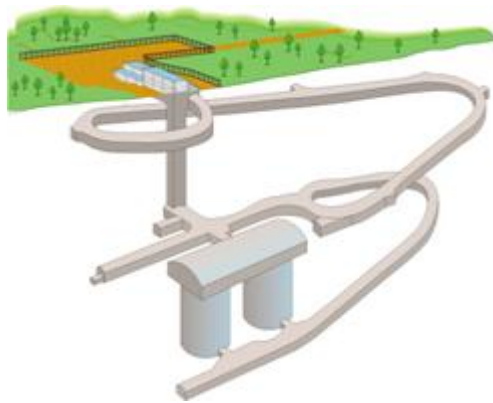
[www.tvo.fi](http://www.tvo.fi)

# Nuclear waste management in Finland

## Olkiluoto Power Plant



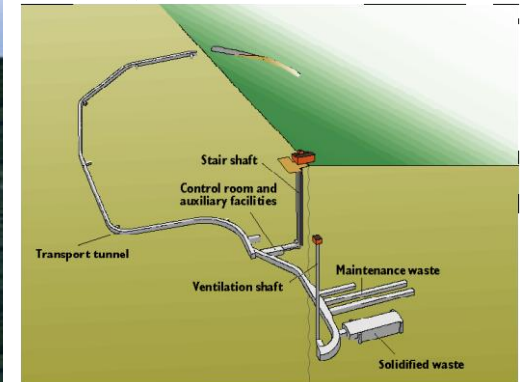
Operational waste  
TVO



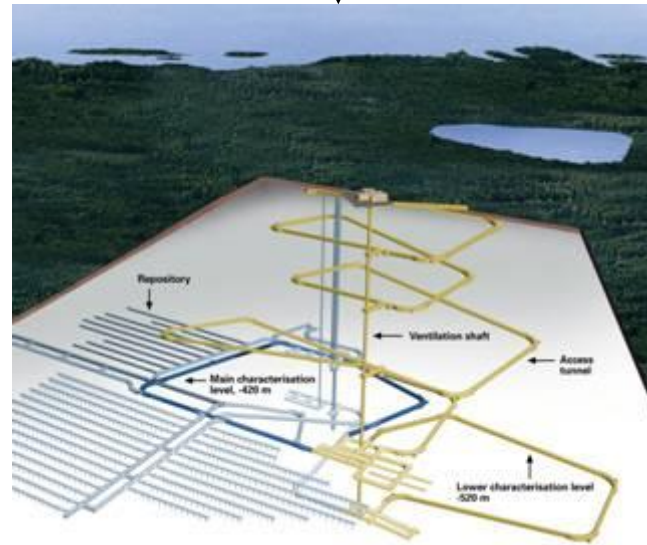
## Loviisa Power Plant



Operational waste  
Fortum

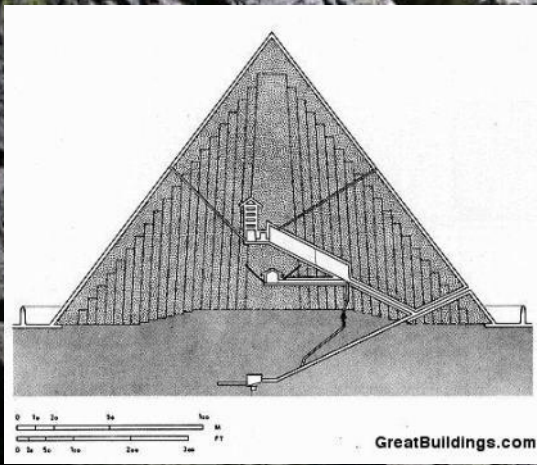


Spent fuel  
Posiva



[www.posiva.fi](http://www.posiva.fi)

**Construction licence in 2012, disposal start in 2020**



Posiva Oy/ Jussi Partanen

All energy sources have their pros and cons. The mandatory **Environmental Impact Analysis** (EIA) discusses the risks and benefits.

The objective of the Nuclear Energy Act of Finland is to keep the use of nuclear energy in line with **the overall good of society**, and in particular to ensure that the use of nuclear energy is safe for man and the environment and does not promote the proliferation of nuclear weapons. **Decision-in-principle**.

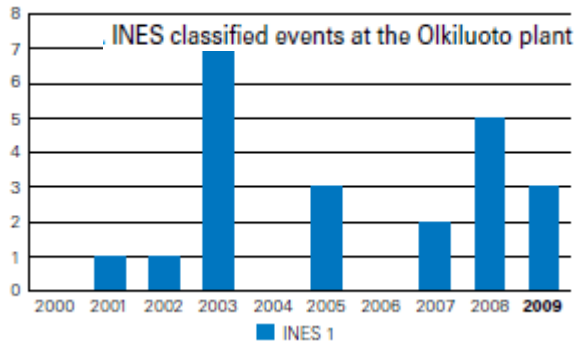
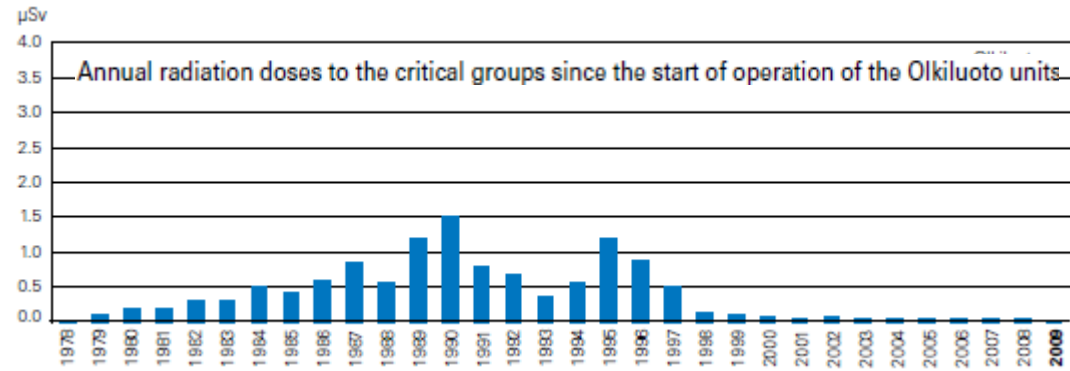
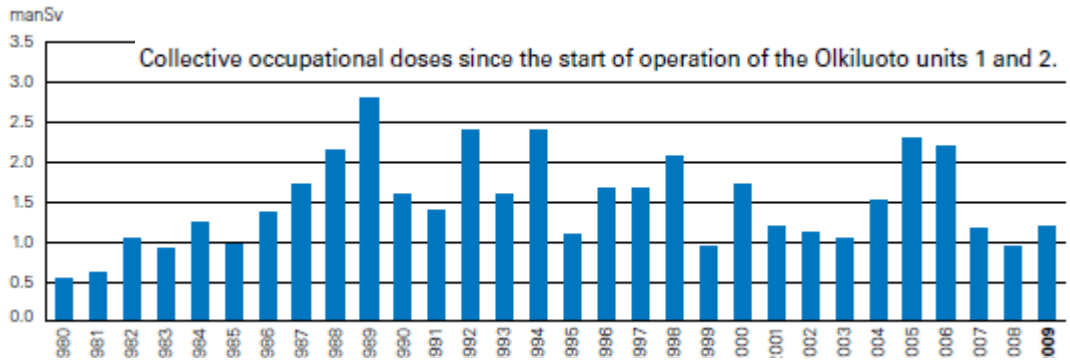
The Nuclear Act states that "the safety of nuclear energy use shall be maintained at as high a level as practically possible". Safe operation means also efficient electricity production and therefore All the stakeholders have a common goal for **continuous safety improvements**.

Finnish regulations are up to date and **the regulator STUK is independent and powerful**. The licensee has the responsibilities.



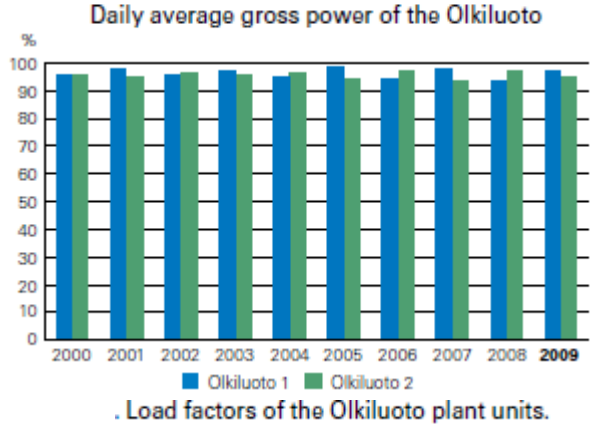
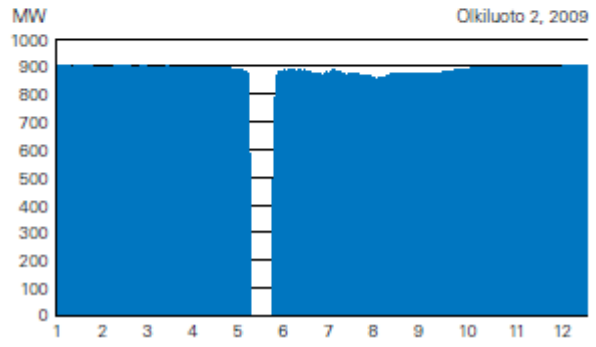
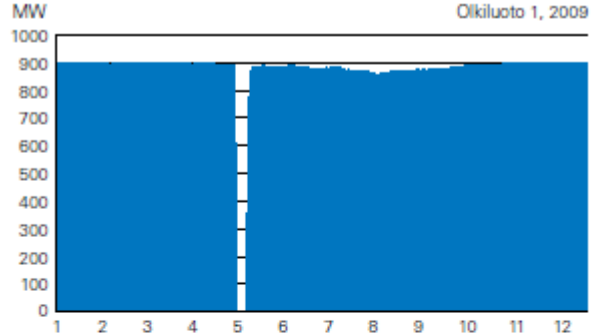
TVO/Hannu Huovila

# Some indicators of OI1 and OI2



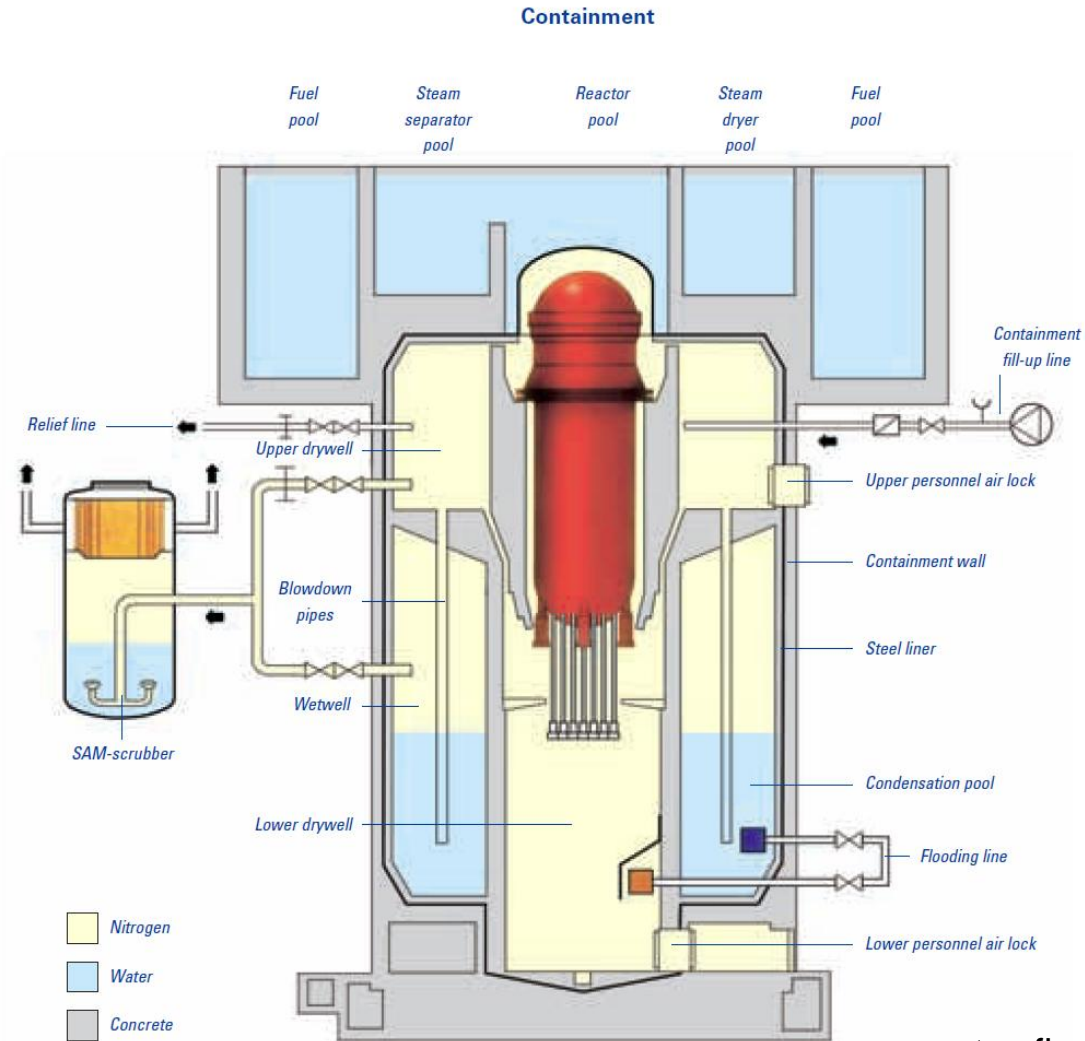
INES 1 = anomaly with safety significance

Source: STUK-B129



# Modernization and modification projects in TVO

- "Always as good as new"
- Modernization and reactor uprating:
  - 660 → 710MW 1983-1984
  - 710 → 840MW 1995-1998
- Turbine plant modernization
  - 840 → 860 MW 2005-2006
  - Turbine efficiency increase
  - 860 → 880 MW 2010-2011
- Construction of interim storage for spent fuel (KPA) 1984-1987
- Low- and intermediate level waste repositories 1988-1992
- **Containment filtered venting system (SAM) 1986 -1989**
- Plant-identical training simulator at Olkiluoto 1988-1990
- Impacts from Fukushima?



www.tvo.fi

# Improvements in the Loviisa NPP

- Considerable changes from the original Soviet VVER440/230 design to satisfy western safety standards (containment, ECCS)
- Layout deficiencies, fire protection, RPV embrittlement,
- SAM refurbishments
- Improvements in heat transfer, electricity, etc.
- Plant simulations, PRA studies, Apros simulator
- PLEX and digital I&C
- Operating license for 2027 and 2030 (50 years) with safety reviews at 2015 and 2023



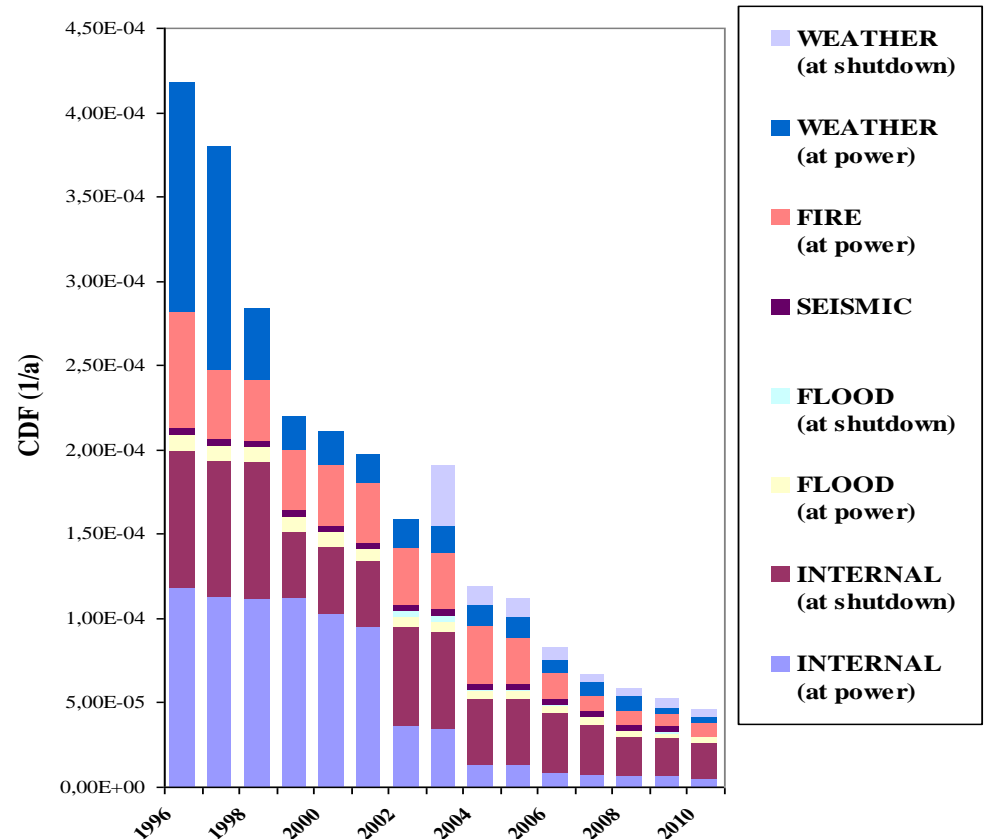
[www.fortum.com](http://www.fortum.com)

# Loviisa PRA

## Loviisa 1 Risk distribution

(Not included: Fire at shutdown states)

- PRA levels 1 and 2
- Power, shutdown
- Seismic, weather, flooding, fire
- Living-PRA
- PRA is an efficient tool for priority
- PRA covers only the considered scenarios and therefore SAM and conservative beyond-DBA analysis are needed



www.fortum.com

Lessons from TMI-2 and Chernobyl induced many plant improvements including severe accident management. Extreme weather conditions were already considered. September 11th lead to the double containment of newbuilds.

Has something been forgotten? Fukushima induced the present stress tests for all European power plants including Olkiluoto and Loviisa.

# Fukushima and stress tests

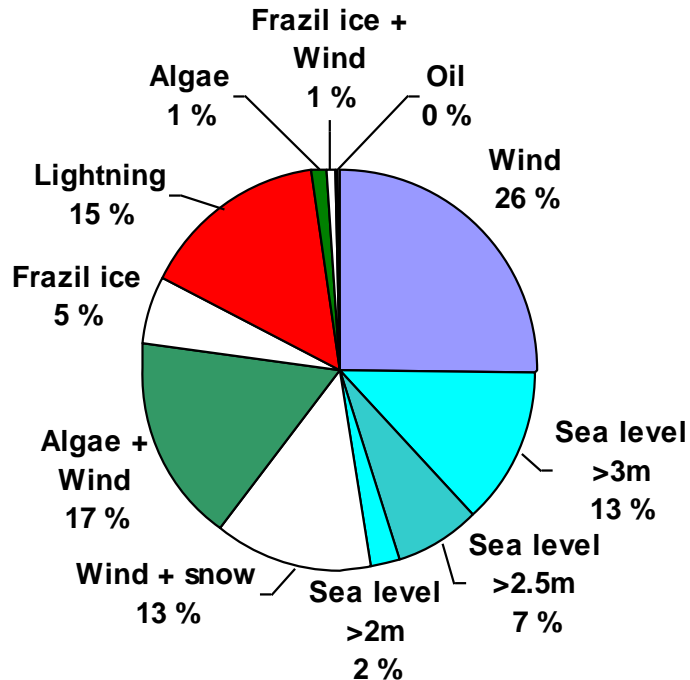




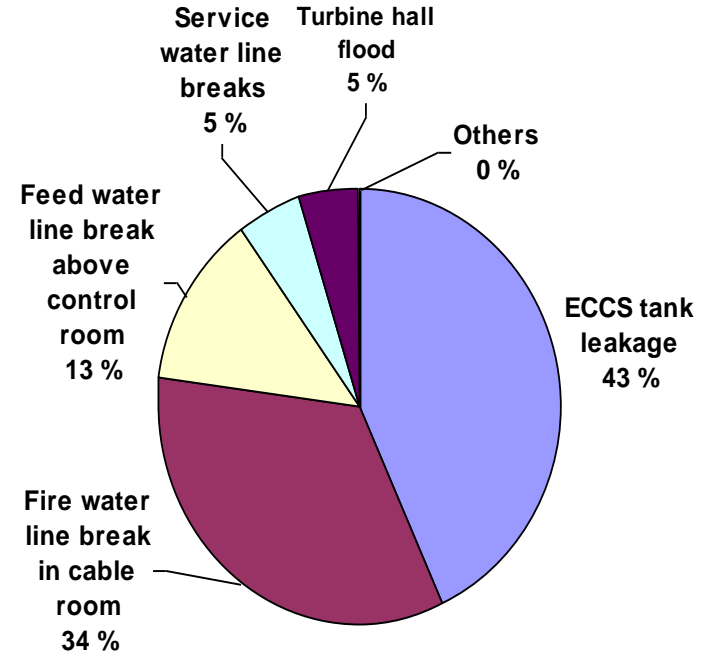
# Weather and floods



Extreme weather conditions  
 Anticipated in Loviisa NPP  
 Estimated core damage  
 frequency  $3 \times 10^{-6}/a$



Weather risks at power in Loviisa



Flood risk at power in Loviisa

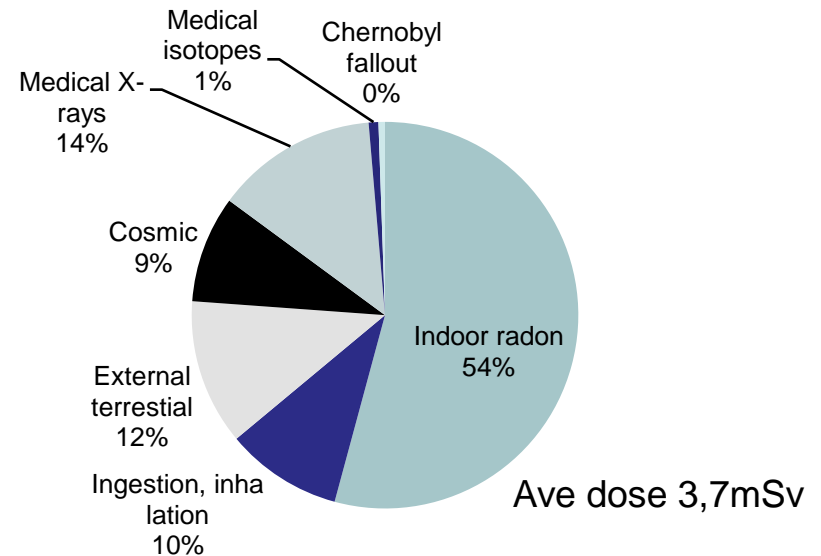
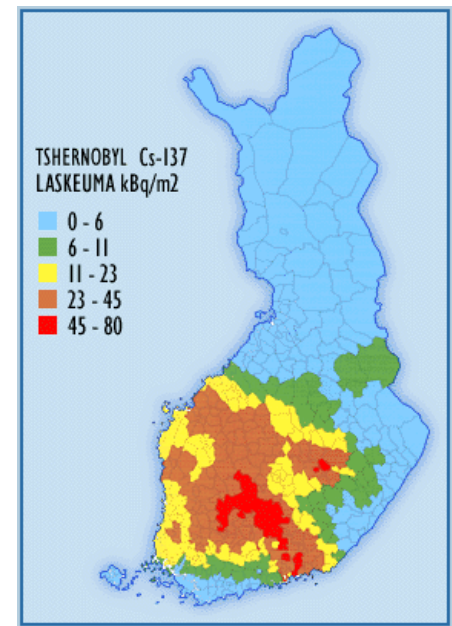
Finns die because of bad habits: smoking, eating and drinking. Indoor radon is the most important factor concerning radiation.

Chernobyl has had measurable effects.

Neighboring NPPs in Kola, Sosnovy Bor, Forsmark, and Oskarshamn.

# Death risks of Finns (1997)

Cause	Deaths/year
Smoking	8000
Unhealthy food	8000
Alcohol	900
Traffic accidents	400
Air pollution (traffic)	300
Intoxication	500
Indoor radon	300
Pollution (energy)	100
Solar (UV radiation)	100
Mutagens (drinking water)	100
Carbon monoxide	50
Chernobyl	5



Jouko Tuomisto, ALARA 1/1997.

[www.stuk.fi](http://www.stuk.fi)

Primarily nuclear safety relies on humans. The devices are designed and fabricated by humans and they are operated by humans. That implies considerable challenges to nuclear safety.

# The challenge: human factors

- Safety culture
- Organisations, competence and attitudes
- Public tolerance, political decision making
- Proliferation, terrorism
  
- Human resources: how to recruit and train new talented people.
  - Real things to do (modernisation, newbuild)
  - Include frontiers (Gen4, fusion, transmutation)
  - Efficient collaboration (R&D and E&T)
  - Long term visions and plans
  - Innovations, cross-disciplinary thinking
  - Knowledge transfer

# Conclusions

- Nuclear safety requires attitude, competence and resources
  - In normal operation nuclear energy is a viable solution.
  - Nuclear waste problem can have a consistent solution. Safety case?
  - Nuclear incidents and even anticipated accidents may still occur. R&D
  - Severe accidents must be excluded. R&D
  - Nuclear energy means a very long commitment implying strong changes of the environment during the next hundred years.
- 
- Up to date regulations and a strong regulator assure safe operations.
  - Continuous improvement of the plants - even EPR
  - Proliferation, security etc. are open problems
  - Functional infrastructure exists; increase collaboration.
  - Knowledge transfer, risk of deterioration of international R&D.
  - Consistent resources for R&D and E&T must be allocated.



Thank You!

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