

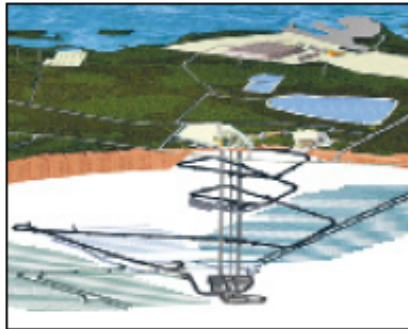


# **Nuclear safety knowhow as a national strategy**

# Content

- The nuclear safety research in Finland
- Competence survey
- The Finnish Nuclear Reactor Safety Research Programme “SAFIR”

# Finnish Nuclear in Nutshell



## WASTE MANAGEMENT:

- Repositories for LLW & MLW in operation at Olkiluoto and Loviisa
- Initial Decision in principle for spent fuel repository at Olkiluoto ratified by Parliament in 2001
- Confirming underground rock characterisation studies underway in ONKALO facility at Olkiluoto



## OLKILUOTO, EURAJOKI

Owner: Teollisuuden Voima Oyj  
 Reactor units 1&2: BWR 2 x 880 MWe (net)  
 Operation started: 1979, 1982  
 Production: 14.2 TWh (2010)  
 Load factor: 93.5 per cent (2010)  
 Under construction  
 Olkiluoto 3: EPR (PWR) 1600 MWe



## HANHIKIVI, PYHÄJOKI

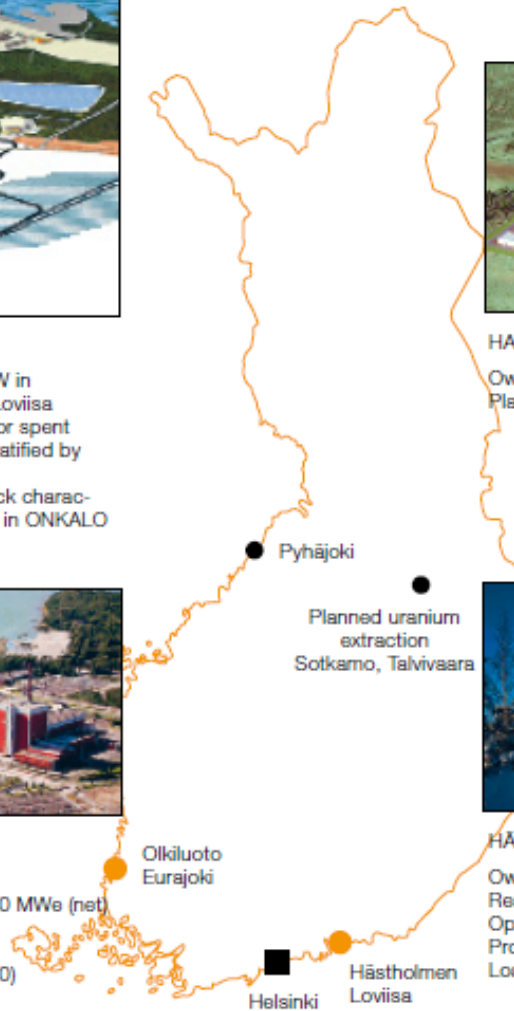
Owner: Fennovoima Oy  
 Planned: Hanhikivi 1

Planned uranium  
 extraction  
 Sotkamo, Talvivaara



## HÅSTHOLMEN, LOVIISA

Owner: Fortum  
 Reactor units 1&2: PWR 2 x 488 MWe  
 Operation started: 1977, 1981  
 Production: 7.7 TWh (2010)  
 Load factor: 91.1 per cent (2010)



# Development of nuclear safety knowhow

- Suitability of the use of nuclear energy was studied in 1950's
- The building of competences started in 1960's
  - International expert exchange programs
  - FiR 1 research reactor in 1961 (TRIGA Mark II)
  - Nuclear safety research at VTT, universities and other stakeholder organizations
  - Building of networks
- Participation in international co-operation
  - NKS
  - OECD/NEA
  - IAEA
- Personnel having experience in the use of nuclear energy existed when NPP programs started in Finland
- Research on nuclear waste management since 1970's

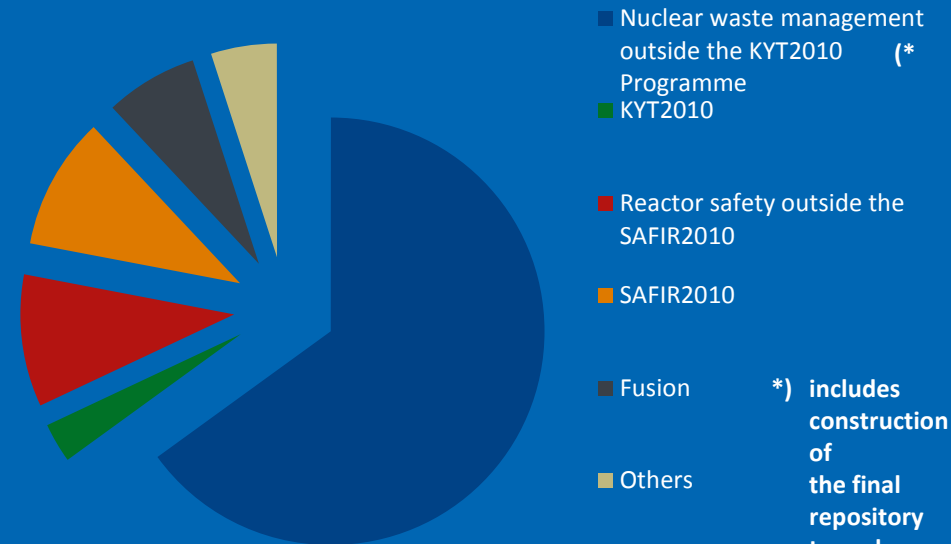
# Nuclear safety as a precondition

## Building a strong domestic expertise from the beginning

- A national ability to use nuclear energy independent of plant vendors
  - Independent assessment of safety by industry
  - Independent assessment of safety by regulatory body
  - ➡ independent decision making
- Principle of continuous improvement
- Importance of research highlighted in legislation

## Ensuring expertise by research

- Typical distribution of nuclear research in Finland, annual volume million 75 euro in 2010

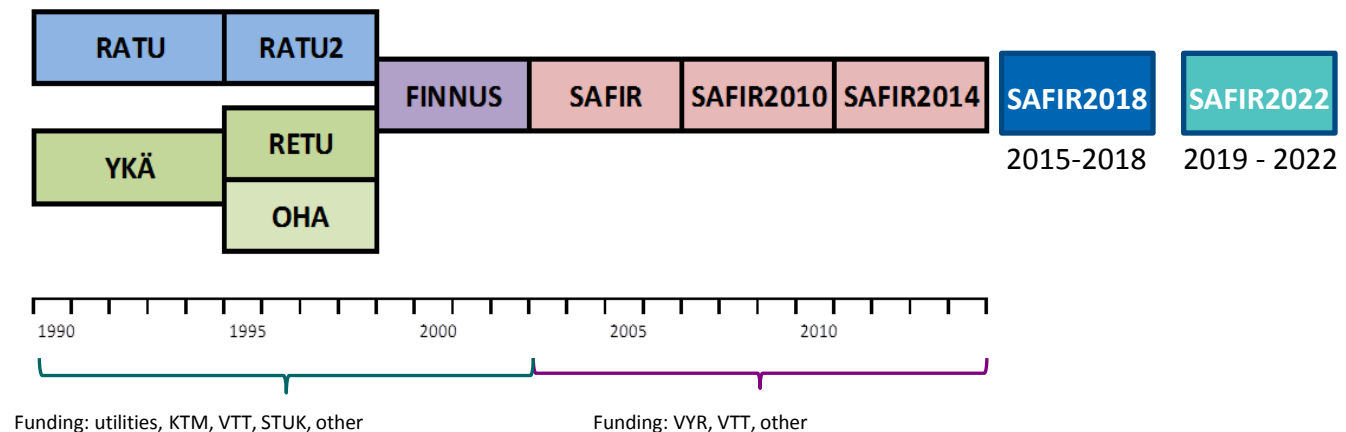


- International co-operation NKS, OECD/NEA, IAEA, EU

# Conduct of the research in safety programs

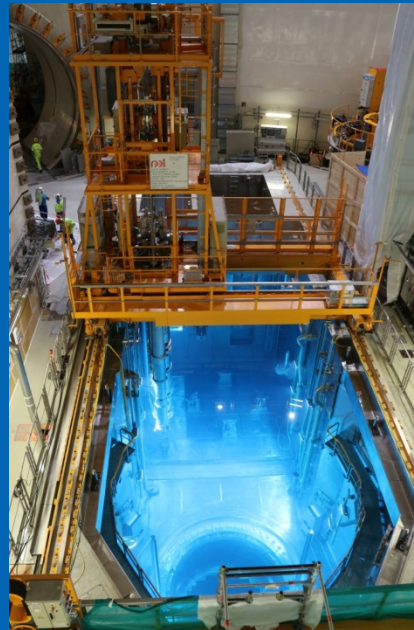
- the funding for the nuclear safety research has been ensured by Nuclear Energy Act since 2003
- the goal of the research is to ensure availability of know how and expertise
- funding is collected from the licensees (based on the thermal power of the reactor (SAFIR) or the amount of nuclear waste (KYT))
- amount of the funding is checked every few years, change of the act is needed to implement changes

National nuclear safety research programs 1990 - 2022



# Survey of competences

- In 1993 Parliament did not approve the DiP for a new NPP; decrease of interest
- Generation change and organizational surveys
- DiPs for new build
  - In 2002 DiP for OL3
  - In 2010 DiPs for OL4 and FH NPPs
    - Parliament's statement that the knowledge and infrastructure must be secured
  - MEAE Committee on competence
    - MEAE competence survey in 2012
      - recommendations
    - MEAE Nuclear Energy Research Strategy in 2014
    - MEAE Competence survey update in 2017





# Future needs for expert, Master's degree about 2000 out of 4000

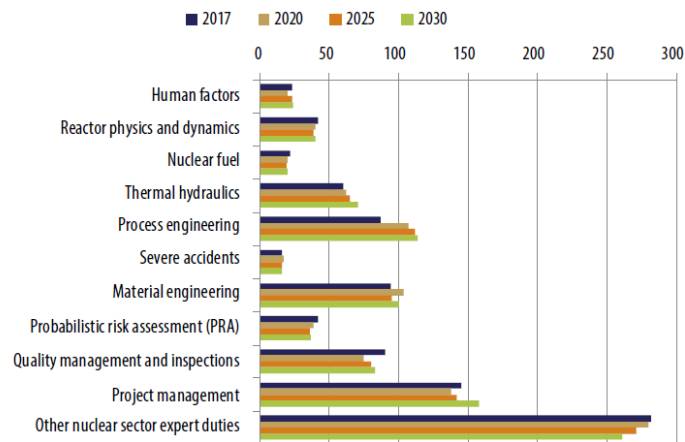
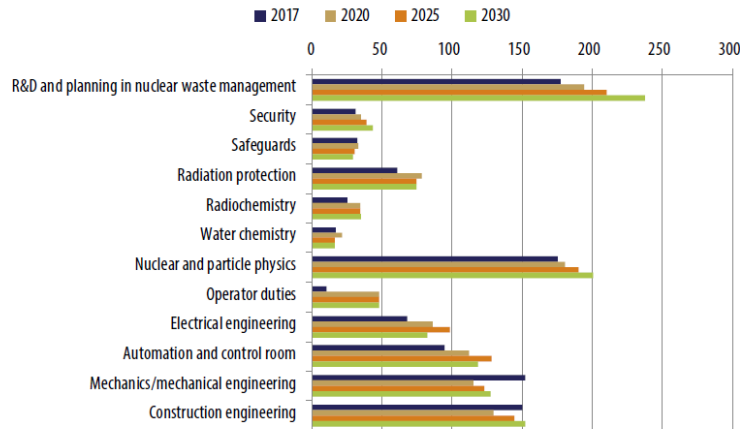
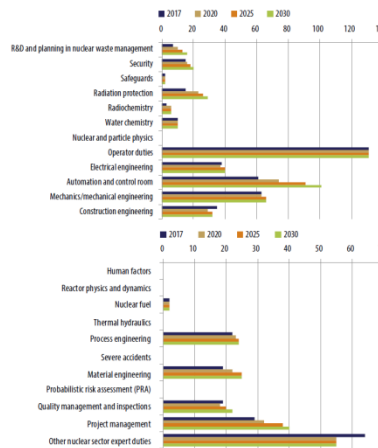
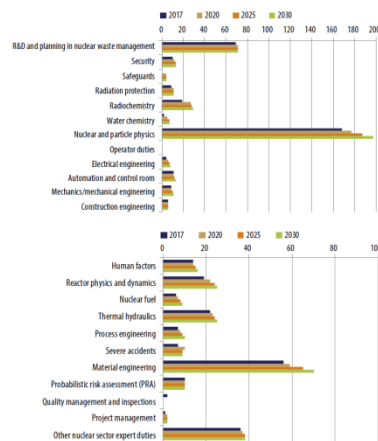


Figure 3.2 Number of experts with Master's degree in 2017 and estimated future demand in 2020, 2025 and 2030 by area of competence. All respondents.

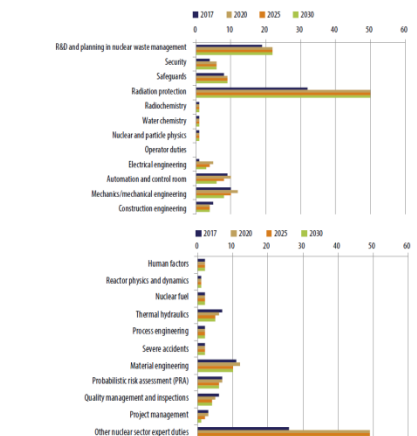
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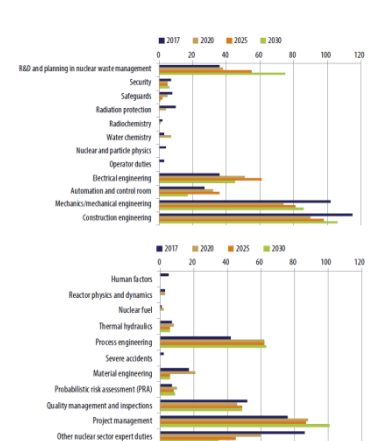
## Power companies



## Research institutes and universities



## Public sector (STUK, MEAE)



## Other industry



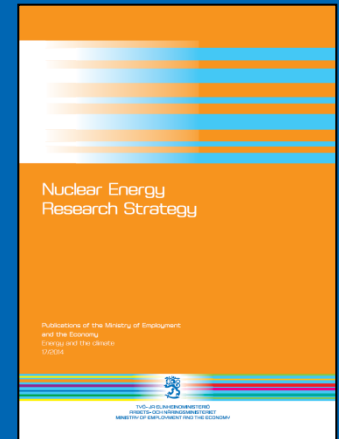
# Nuclear safety research in Finland

The Finnish Nuclear Energy Research Strategy to 2030 was published 2014

- Safety research has a key role in competence building in Finland

**VISION FOR THE NUCLEAR ENERGY RESEARCH STRATEGY:**

*Internationally high-quality Finnish expertise and research will secure the safe, sustainable, and competitive use of nuclear energy and promote business opportunities.*



1. Broad scope national programmes, according to national target and significance
2. High scientific level, international competitiveness and visibility
3. Active participation to international programmes, multidisciplinary national co-operation
4. A broad and comprehensive national doctoral programme network
5. Building, maintaining, and utilising infrastructure requires coordination at the national level
6. From research to innovations, growth and internationalization of business
7. Proposal to establish an advisory committee on nuclear energy research and use of nuclear energy

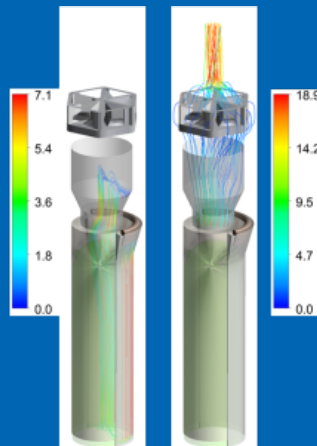


# SAFIR2018



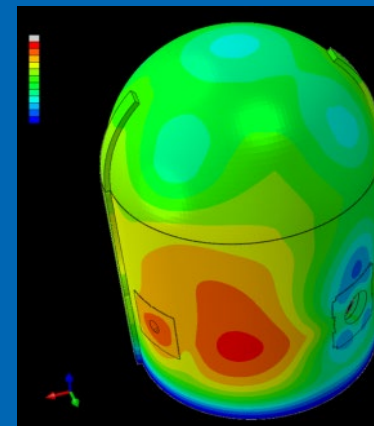
## Plant safety and systems engineering

- Overall safety throughout the life cycle of nuclear power plants
- Operational resilience
- Management principles and safety culture
- PRA and Defence-in-Depth (DiD)
- Safety assessment of automation (I&C) and electric systems
- Extreme weather conditions.



## Reactor safety

- Experimental and computational methods for ensuring the safety requirements
- Thermal-hydraulic problems, CFD methods
- Reactor core safety analyses
- Fuel behaviour studies, reactor dynamics
- Severe accidents and fission product transport
- Uncertainty and sensitivity analyses.

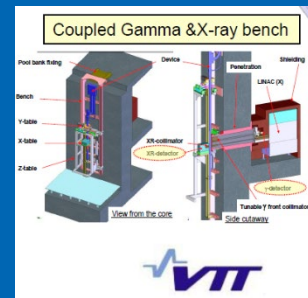
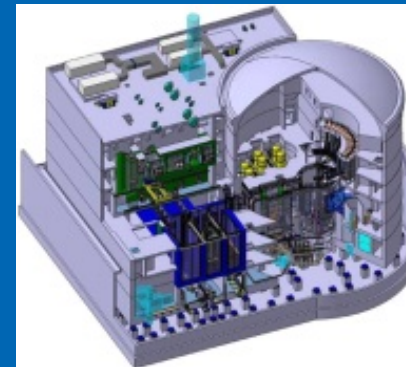
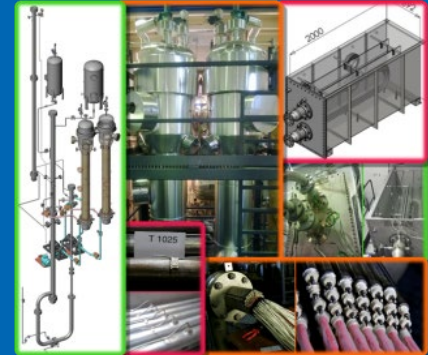
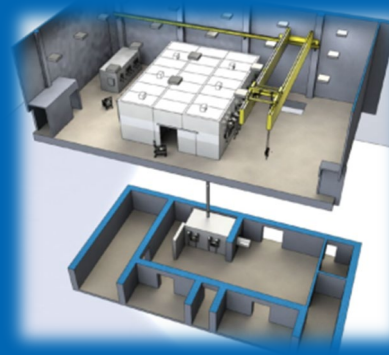


## Structural safety and materials

- Support of the long-term and reliable use of nuclear power plants
- Integrity of barriers and material issues
- Aging phenomena of structures and equipment
- Experimental and numerical methods for external event assessment
- Fire risk evaluation.

# Research infrastructure

- Nuclear Energy Act amendment 2016 special funding for infrastructure in SAFIR and KYT programs
  - VTT Centre of Nuclear Safety, Hot Shells
    - Main focus before end of 2020
  - LUT thermal hydraulic test facility
    - Main focus after 2021
  - JHR test programme preparation
- TEKES/Business Finland, VTT, Power companies
  - Jules Horowitz Research Reactor (JHR) in France with Finnish share 2%
  - In-kind contribution
    - MeLoDIE biaxial in-reactor creep device for fuel cladding studies
    - Gamma scanning/X-ray tomography benches and collimators for both underwater and hot cell measurements
- FiR Research Reactor in decommissioning phase



# International Co-operation in SAFIR

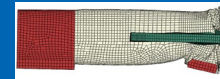
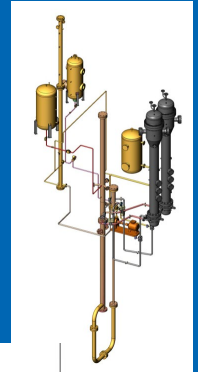
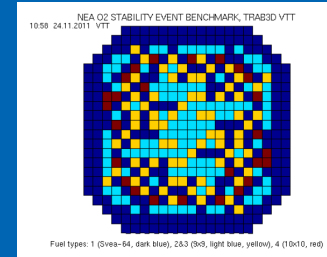
Almost all projects have international contacts:

- OECD/NEA experimental projects and database projects, NEA working groups, Halden project co-operation, Jules Horowitz Research Reactor (JHR)
- EU networks and projects, NUGENIA
- Co-operation with universities and research institutes
- Co-operation with nuclear industry and safety authorities abroad
- Nordic co-operation: NKS, NORTHNET, Energiforsk, Swedish regulatory body (SSM)

SAFIR2018 was evaluated in 2018 by an international expert group lead by prof. John Carroll from MIT.

- The scientific and technical quality is very high
- Capabilities are strong, etc...
- Report available at

<http://urn.fi/URN:ISBN:978-952-327-325-2>



John S. Carroll, MIT Sloan School of Management (Chair)  
Jacques Giovanola, Emeritus Professor Ecole Polytechnique Federale de Lausanne  
Board Member, Swiss Federal Nuclear Safety Inspectorate  
Xu Cheng, Karlsruhe Institute of Technology  
Timo Okkonen, Reqrīs Oy

## Mission

*“National nuclear safety research aims at high national nuclear safety assessment capability. It develops and creates expertise, experimental facilities as well as computational and assessment methods for solving future safety issues in close cooperation with competent international partners.”*

## Vision

*“The SAFIR2022 research community is a vigilant, internationally recognised and strongly networked competence pool that carries out research on topics relevant to the safety of Finnish nuclear power plants on a high scientific level and with modern methods and experimental facilities.”*

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[FRAMEWORK PLAN](#)
[ORGANISATION](#)
[MATERIAL](#)
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### The Finnish Research Programme on Nuclear Power Plant Safety 2019 - 2022

National nuclear safety research aims at high national nuclear safety assessment capability. It develops and creates expertise, experimental facilities as well as computational and assessment methods for solving future safety issues. International cooperation is essential in the research projects.

The objective of SAFIR2022 is in accordance with Chapter 7a of the Finnish Nuclear Energy Act that is intended to ensure that, should new matters related to the safe use of nuclear power plants arise, the authorities possess sufficient technical expertise and other competence required for rapidly determining the significance of the matters.

**Topical**

The members to the Management Board and steering groups have been nominated.

The final seminar of SAFIR2018

The final seminar of the SAFIR2018 research programme will take place on **21-22 March 2019 at Hanasaari (Espoo)** and as a webinar. More information will appear on SAFIR2018 website <http://safir2018.vtt.fi/>. If you did not receive an invitation to the interim seminar in 2017 and would like to participate, please send an email to [jari.hamalainen@vtt.fi](mailto:jari.hamalainen@vtt.fi).

#### Updatings

January 10, 2019  
Links to previous programmes.

October 31, 2018  
Site launched.

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#### SAFIR2022 Extranet

User name and password needed

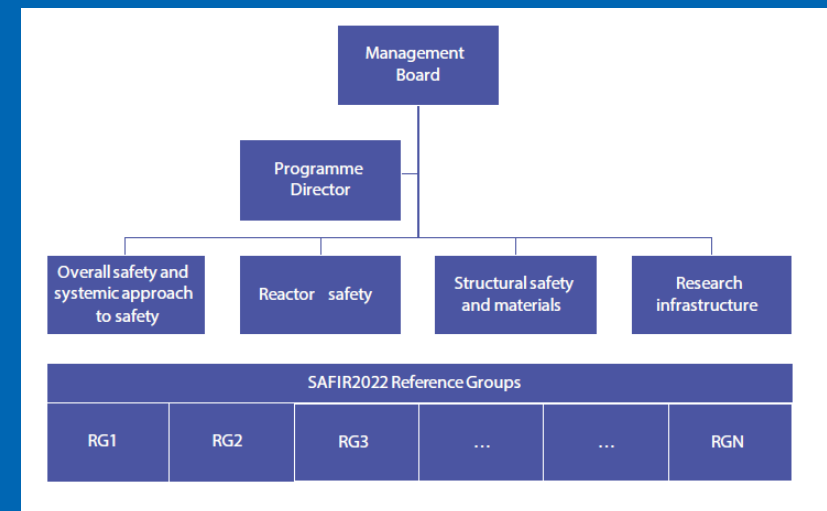












# SAFIR2022 overarching goals 2022 and 2026

1. Nuclear safety assessment capability building \*)
2. Overall safety and systemic approach to safety \*)
3. Validated tools for reactor and nuclear power plant analysis
4. Nuclear fuel and its lifecycle from reactor to final disposal \*)
5. Ageing phenomena and the integrity of barriers
6. Severe accidents
7. External hazards
8. Nuclear safety in a changing environment

\*) common topic with KYT2022

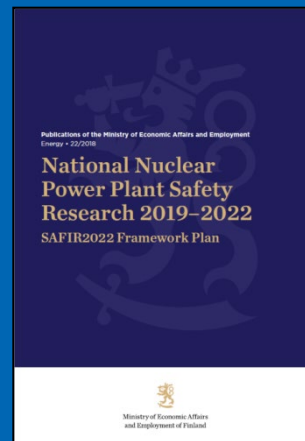


SÄTEILYTURVAKESKUS  
STRÅLSÄKERHETSCENTRALEN  
RADIATION AND NUCLEAR SAFETY AUTHORITY



From very good  
to excellent!

SAFIR2018



SAFIR2022

- innovative projects
- excellence projects
- and ...

# Experience from the national nuclear safety research programs

- the Finnish nuclear safety programmes have been found as a good way of ensuring the national expertise
  - clear goals presented in framework programme
  - organization is a modern network
  - on-line transfer of know how
  - stability in financing => increase of interest
- **STUK and TSO support**
  - research programme ensures that expertise is available
  - the research programme has an important role in competence building at STUK
- **most of the experts in the field (STUK, NPPs, TSO organizations) have been qualified to the nuclear safety work in the research programmes**



Programme	Volume, M€	Volume, person years	Total number of publications	Academic degrees		
				Dr.	Lic.	M.Sc.
YKÄ 1990-1994	15,4	168	318	6	5	10
RATU 1990-1994	8,2	76	322	1	3	3
RETU 1995-1998	9,8	107	405	3	2	2
RATU2 1995-1998	7,5	60	280	3	4	11
FINNUS 1999-2002	14,4	130	564	6	2	18
SAFIR 2003-2006	19,7	148	545	6	1	17
SAFIR2010 2007-2010	27,5	197	866	8	1	31
SAFIR2014 2011-2014	40,1	279	1244	12	2	27
SAFIR2018 2015-2018	29,6	209	1095	18	0	26
<b>Total</b>	<b>172,2</b>	<b>1374</b>	<b>5639</b>	<b>63</b>	<b>20</b>	<b>145</b>



