VTT’s role and challenges in nuclear Human Capacity Building in Finland

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Outline

- Background info on Nuclear in Finland and VTT
- Finland’s & VTT’s HCB challenges and VTT Nuclear Energy
- Finland’s & VTT’s means to meet the challenges
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  - Own development projects
  - National ’nuclearization’ course
- Concluding remarks
There are five operating nuclear power plant units in Finland.

Four of them started their operation between 1977 and 1982. The Olkiluoto 1 and 2 BWR units have prolonged operation license to the end of 2038. The Loviisa 1 and 2 VVER units have extension of their operation license to the end of 2050.

The new Olkiluoto 3 (OL3) EPR unit is scheduled to start the commercial operation in April 2023.

With OL3 in operation, 30 % of electricity produced in Finland comes from the TVO’s Olkiluoto NPP and around 10 % from the Fortum’s Loviisa NPP, totalling 40 % of electricity produced in Finland being from nuclear.

In addition, as the first in the world, the final repository ONKALO® at Olkiluoto for spent nuclear fuel should start its operation in 2024.
VTT’s FiR 1 (Triga Mark II) research reactor is in decommissioning.
- All the irradiated fuel from FiR 1 has been returned to US Geological Survey (USGS) TRIGA reactor (GSTR, Denver, Colorado) in early 2021.

VTT’s Low-temperature District heating and desalination Reactor project LDR-50 is moving from conceptual design towards engineering phase.

The technology is expected to enter commercial market in the early 2030’s.

The concept combines conservative LWR technology to innovative passive safety features, taking advantage of low operating temperature and pressure.

VTT’s own funding of 5 M€ granted for 2023-2024.

In addition to technology development, the project has a substantial HCB aspect as ‘the new generation SMR designed by the new generation’.
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- Established in 1942.
- Currently 2213 employees, including 701 doctors and licentiates.
- Approximately 250 persons for nuclear applications, whereof 150 working 100 % for nuclear.
- In nuclear VTT is a Technical Safety and Support Organization (TSO) to the Finnish Regulator STUK.
- VTT also provides support to the nuclear operators in Finland, Fortum and TVO, as well as to the waste management organization Posiva.
- VTT has had these roles from the 1970's.
- Over this time span the aim to have capable and motivated staff has prevailed although the challenges and focus have evolved over the time both due to foreseen developments and external unpredictable events and their consequences.
The 60+ years of operation for NPPs, and a hundred years of operation for the repository are longer than nuclear expert’s professional career of 35 to 45 years from entering the business to retirement.

In addition to the challenge of retirement set by these timelines, part of the skilled staff change their workplace to other nuclear organizations or leave for other disciplines.

- VTT faces this situation pronouncedly due to its role as a research organization that should foster and retain a considerable number of these highly skilled experts.
VTT’s HCB means

- At VTT the Human Capacity Building (HCB) in nuclear takes place primarily via research work in versatile context over the researcher’s career from a trainee to an experienced expert and tutor.

- The major ‘vehicles’ of the HCB are:
  - National research programs,
  - Euratom research projects,
  - VTT’s own strategic projects
  - National ‘nuclearization’ course
Finnish nuclear energy act requires that authorities must have necessary expertise available in Finland.

The state nuclear waste management fund (VYR) directs funds collected from nuclear operators to research organisations through annual calls (~10 M€ volume).
- Investment also in national infrastructure: VTT Centre for Nuclear Safety (CNS).

The national research programs in Nuclear Power Plant (NPP) safety and waste management safety have been a key component in Finland’s and VTT’s Human Capacity Building in nuclear.

Research is done by the young staff in the projects, seniors as tutors.

The new SAFER2022 programme combines the NPP safety and waste management safety tracks.
The number of experts reported was 3,807, which is 522 individuals (16%) more than in the 2010 survey.

The distribution by years of experience has changed from the previous bimodal pattern, concentrating around younger experts.

The proportion of secondary-level vocational qualification-holders is lowest among recent entrants to the sector and highest among the most experienced personnel.
In 2010 VTT faced pronouncedly the same problem that was reflected in the national competence mapping.

Due to the start of the Olkiluoto 3 EPR project in 2005, interest in nuclear had re-emerged and new staff was entering the business.

There had been a stagnation of some 20 to 30 years since the first four units became operational and the average age of the nuclear staff had steadily increased and the ‘first generation’ was about to retire.

Distribution of personnel by experience at VTT Nuclear Energy and comparison with the 2010 competence survey
Total staff at the moment 149, whereof 126 academic, 49 out of them with doctoral degree, the 18 with vocational (technician) background are essential for running the CNS labs.

VTT has had the same challenges in nuclear HCB as those detected at the national level and the national program has been essential in improving the situation.

Due to VTT's role as a research organization, more staff in experienced age quota than in the Finnish nuclear at large.

The experience years distribution is currently quite even, peaking in the group 10 to 20 years of professional experience.
Finnish national research programmes on waste management - evolution of funding and main deliverables
Finnish national research programmes on NPP safety - evolution of funding and main deliverables
National programme’s contributing to VTT’s HCB

- VTT is and has been the major research partner in the national programmes, also responsible for the coordination of the programmes.
National programmes contributing to VTT’s HCB
- combined VTT figures for SAFIR2022 & KYT2022

VTT has ~ 150 persons working 100% for nuclear
A particular element of VTT’s HCB in reactor safety during the recent years has been the development of VTT’s Kraken Core Physics Computational Framework that started in 2017.

The Framework is largely developed within the SAFIR2022, but it contains elements outside the national program as well.

The Kraken development has involved approximately 10 young researchers, with 3 Masters Thesis completed and 2 Doctoral Thesis about to complete.
Importance of Euratom research projects for VTT’s HCB

- Euratom research projects have been by volume (funding) as important or even more important for VTT as the national programmes.

- However, when summing up the available data on the person months in the national research programmes SAFIR20222 and KYT20222 and that for VTT’s Euratom projects for 2019 to 2022, it turned out that the national programmes have a major share.

- In the Euratom projects the role of more experienced researchers in pronounced, as the projects should present the highest level of expertise available.

- Yet, HCB is an essential element also in the Euratom projects.
Own developments – Apros since 1986

- Apros is a dynamic simulation software/environment and Apros® is a registered trademark of Fortum and VTT Technical Research Centre of Finland Ltd.

- Over the decades the development of Apros has been a significant tool of VTT’s HCB.

- Hundreds of Master’s thesis, scientific journal and conference articles have been produced on Apros. For instance, the Aalto University’s Aaltodoc provides information on 113 academic theses related to Apros, 86 of them Master’s Thesis and the rest Licentiate and Doctoral Theses.

- Apros is an example of project that had a significant effect on the HCB in-house during the first decades, but is now more significant as a tool of HCB outside VTT.

- At the moment Apros development team at VTT Nuclear Energy includes:
  - 3 senior members with over 20 years of experience
  - 2 intermediate members with over 5 years of experience
  - 2 junior members with less than 5 years of experience.

- There are hundreds of Apros users worldwide. In 2019 there were over 500 Apros installations in 27+ countries (plant designers, suppliers and operators, research institutes, universities and safety authorities.)
VTT’s Low-temperature District heating and desalination Reactor project LDR-50 is moving from conceptual design towards engineering phase.

The project is our most important current strategic development, taking place entirely with VTT’s own funding. VTT granted 5 M€ for the development for the period 2023-2024.

The project involves 30 to 40 young researchers, with average age of the group being ‘slightly over’ 30 years (info from the project manager).

The project has produced as ‘by-product’ 3 Master’s Thesis and at least one Doctoral Thesis is in the making.

3D visualisation of refuelling operation for the LDR-50 district heating reactor. Illustration by Prof. Jaakko Leppänen, VTT.
The course was started when OL3 construction began, and it became evident that we need a lot of new people into the industry.

- An important factor for the participants is also getting to know people from other organizations.

- Consists of six periods, each with a duration of four days.

- The course is organized in a collaborative manner.
  - All organisations in the nuclear field participate: the regulator, licensees, main consulting companies and VTT.

- Approximately 100 lecturers who are the best experts in their fields and 80 yearly participants.
  - VTT has on average 15 lecturers and 10 yearly participants.
  - The participants typically have a few years experience from the field.

- In 2023 we have the 20th edition/year of the course.
The challenge of keeping the competent staff

- Typically, at VTT an expert participates in the national program, EU project(s) as well as VTT's own projects and commercial projects. Thus, when an experienced expert leaves VTT, it is not only from one function, but it addresses all.

In 2021 we had 14 new and 21 left, making the change percent as 24 %
In 2022 we had 26 new and 17 left, making the change percent as 29 %
Concluding remarks

- National programmes have had the most significant effect on VTT’s HCB in nuclear during the past 20 years.
  - This situation is foreseen to continue.

- In the Euratom projects the role of more experienced researchers is pronounced, as the projects should present the highest level of expertise available.
  - Yet, HCB is an essential element also in the Euratom projects.

- LDR-50 is the most significant VTT Nuclear Energy strategic development at the moment in the technical sense, but it is also very significant in the HCB of the new generation.

- VTT faces the constant exit problem as by definition the retired persons are very experienced ones, but also the most of others leaving are from the experienced end.
References/Sources


- Current Status and On-Going Development of VTT’s Kraken Core Physics Computational Framework, energies-15-00876-v2.pdf


Acknowledgements

The authors would like to thank the following VTTers for help in collecting the data:

• Ms Jaana Päivärinta and Ms Suvi Järvinen, VTT Project Finance
• Ms Anneli Klinga, VTT Human Resources
• Dr Jari Hämäläinen, Director of SAFER2022
• Dr Aku Itälä, KYT2022 Programme Engineer
• All BA45 Research Team Leaders
Demand for experts is estimated to decrease slightly in the near future, followed by a slight upturn. The previous survey (OTR2010) predicted a clear growth.

Demand for personnel is estimated to be 3,981 in 2030, which is 5% higher than the number of personnel in 2017.

The number of Master’s degree-holders should increase by 190 individuals, i.e., 10% on the current level.