



APIS



Co-funded by  
the European Union

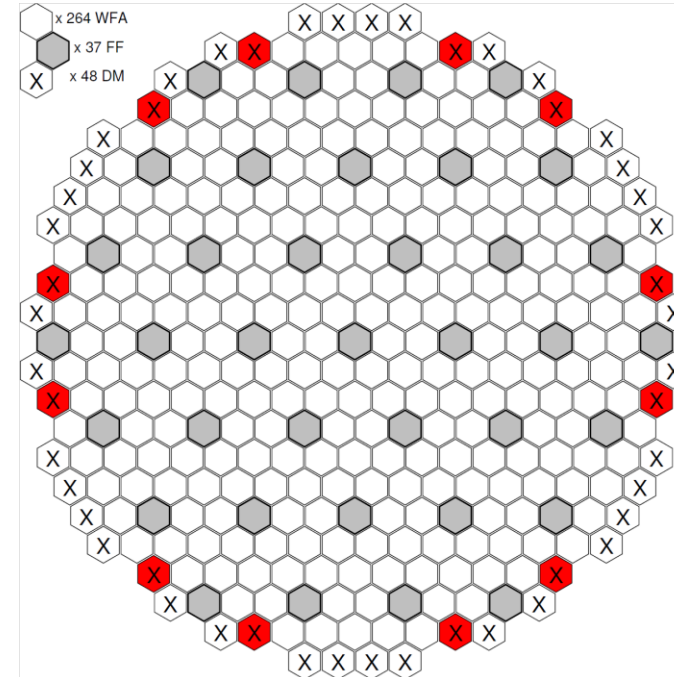
Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or Euratom. Neither the European Union nor the granting authority can be held responsible for them.

# LICENSING OF A NEW FUEL TYPE AT LOVIISA NPP

Henri Rapeli, Fuel Engineer, 15.-19.9.2025

# Loviisa NPP

- Two VVER-440 units (2 x 1500 MWth, 507 MWe)
  - LO1 start-up in 1977, LO2 in 1980
- In February 2023, the Finnish Government granted a new operating license for both units until the end of 2050
- Fuel supplied by TVEL and Westinghouse Sweden Electric (WSE)
  - In November 2022, Fortum and WSE signed an agreement for the design and supply of a new fuel type for Loviisa NPP
- Reactor core consists of 264 fixed fuel elements, 37 control rods (fuel follower + absorber element + intermediate rod), and 48 shielding assemblies located in the core periphery



# Background

- Loviisa NPP's earlier operating licenses were valid until 2027 (Loviisa-1) and 2030 (Loviisa-2), as preparation for the possible extension of the operating licenses, Fortum started a project to diversify the fuel supply of Loviisa NPP
  - As a result, a contract with WSE was reached in 2022
- Fortum used BNFL's (British Nuclear Fuels Limited) NOVA E-3 (fixed) and NOVCA (fuel follower) fuel at Loviisa NPP in the early 2000's
- The new WSE fuel type is called NOVA E-6 (NOVCD) and it's based on the earlier NOVA E-3 (NOVCA) design
- Fuel type NOVA E-5 (NOVCC) was also available
  - Key differences between NOVA E-5 and NOVA E-3: Number of spacer grids increased (7 -> 8), top spacer grid and two bottom grids made from Inconel A718, cladding material optimized ZIRLO
  - Key differences between NOVA E-6 and NOVA E-5: Increased length of pellet stack -> more compatible with resident fuel at Loviisa NPP (NOVCD followers also have a Hf spacer at the top of the pellet stack for power peak mitigation)
- Fortum participates also in the APIS (Accelerated Program for Implementation of secure VVER fuel Supply) program, more on this later

# Timeline of NOVA E-6 (NOVCD) licensing

- Contract signed in November 2022
- Delivery of a non-fuelled NOVA E-5 dummy assembly (stainless steel bars instead of fuel pellets) to Loviisa in 2023
  - The dummy assembly has been irradiated for two cycles, in Loviisa-2 in 2023-2024 and in Loviisa-1 in 2024-2025
  - The dummy was inspected in 2024 during the yearly outages and will be inspected again in 2025-2026 after it is removed from Loviisa-1 reactor during the 2025 outages
- Main part of suitability study completed and approved by the safety authority in summer 2024, additional parts (e.g., seismic analyses) completed in 2025
- First full deliveries of WSE fuel assemblies in 2024
  - Lead test assemblies (12 fixed+6 followers) loaded into Loviisa-2 core in 2024
- Almost a full reload of WSE fuel was loaded into Loviisa-2 core during 2025 outage -> about a quarter of the core is now WSE fuel, full WSE core expected to be reached in 2028



# Scope of poolside inspections of WSE fuel

- As mentioned, the NOVA E-5 dummy assembly will be inspected again during the 2025-2026 operating cycles
  - The dummy assembly and rod bundle will be visually inspected and the vertical positions of the spacer grids will be measured
  - Main objective is to inspect the contact points between fuel rods and spacer grids for signs of grid-to-rod-fretting (GTRF), and to inspect the 3D printed upper and lower flow plates
  - Other inspected/measured quantities are the length, DAF (distance across flats), bow, and twist of the assembly
- Some of the NOVA E-6 (NOVCD) fuel assemblies now loaded into Loviisa-2 will be removed after three operating cycles and some after four cycles
  - One or more of the assemblies irradiated for three cycles will be inspected, as well as of the assemblies irradiated for four cycles

# Work conducted under the APIS program (1)

## Inspection campaign of used old BNFL NOVA E-3 fuel assemblies in 2022-2023

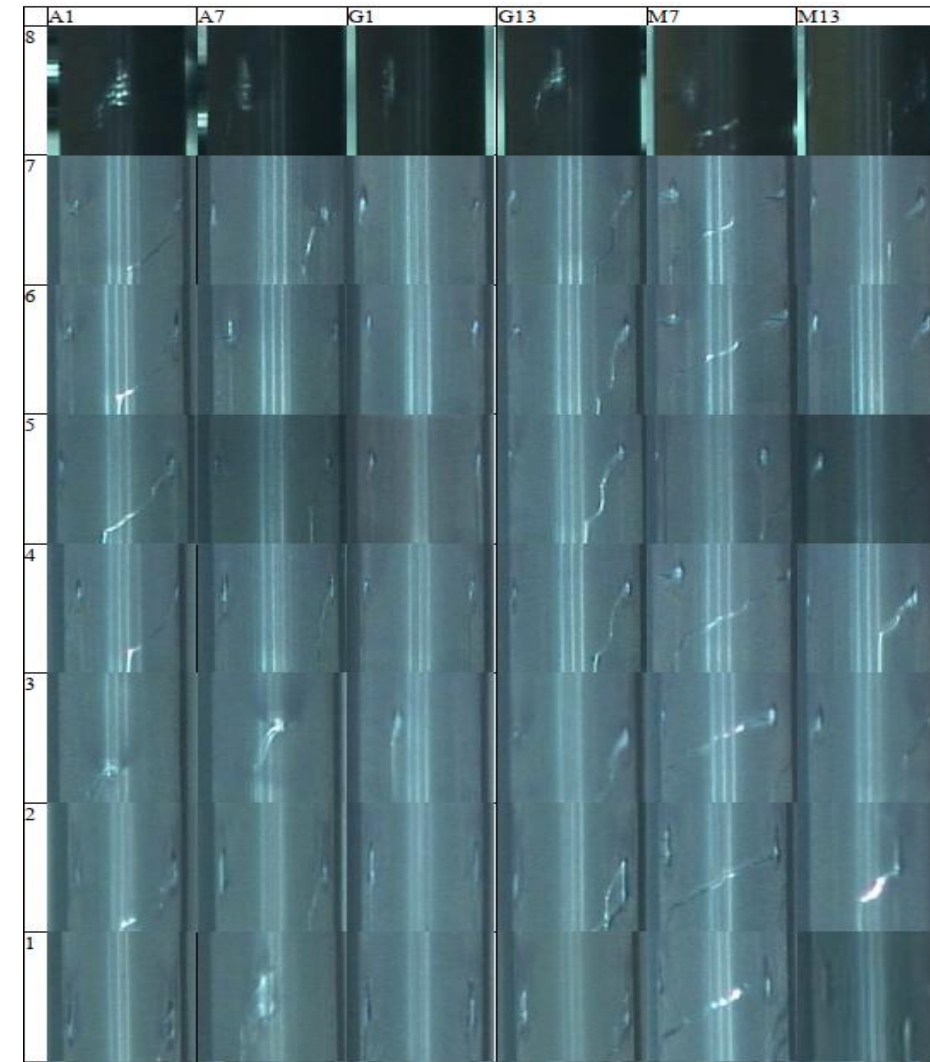
- 12 assemblies (irradiated for three or four cycles) were inspected, mainly to investigate the extent of wear caused by GTRF in the fuel rods (especially corner rods)
  - Significant GTRF wear had been noticed in earlier inspections of a leaking fuel assembly
- Generally the assemblies were in good condition, but some rods did show significant fretting at the locations that are in contact with spacer grids, especially at the lower spacer grids



# Work conducted under the APIS program (2)

## WSE NOVA E-5 dummy assembly inspections in 2024

- One of the key points in the irradiation of the dummy assembly was to learn about the GTRF performance of the NOVA E-5 assembly compared to the BNFL NOVA E-3 assemblies
- General condition of the assembly was good, and no abnormal observations were made
- Six corner rods were lifted and inspected for fretting marks in places where the rods are in contact with spacer grid dimples and springs
- No indications of excessive wear was found, as expected after just one irradiation cycle
- As mentioned before, the dummy assembly will be inspected again in 2025-2026, after its removal from Loviisa-1 in 2025



# Work conducted under the APIS program (3)

## Research regarding the ADOPT pellets in 2024-2025

- Fortum conducted an economical evaluation on the implementation of WSE's ADOPT (Advanced Doped Pellet Technology) pellets
  - Key design changes are larger grain size and increased density
  - A more in-depth evaluation was conducted using ADOPT pellets with slightly larger diameter (ADOPT-B)
- The implementation of the ADOPT pellets can generate economical benefits as it would allow decreasing the fresh fuel feed that is loaded yearly to the reactors
  - On the other hand, decrease of fresh feed would require irradiating some assemblies for five cycles, and current burnup limits would likely need to be increased
  - The average enrichment of the fixed fuel assemblies would also have to be increased



# Work conducted under the APIS program (4)

## CFD calculations regarding the pressure loss coefficient (PLC) of the NOVA E-5 fuel assembly

- Fortum conducted CFD calculations in 2023 to assess the differences in the PLC between the newer NOVA E-5 design and the older NOVA E-3 design
  - The fuel actually in use at Loviisa NPP, NOVA E-6, is very similar to the NOVA E-5 with respect to the PLC
  - Goal was to verify that the NOVA E-5 (and by extension the NOVA E-6) design is hydraulically compatible with Loviisa reactor cores and the resident fuel
  - Main difference between NOVA E-3 and NOVA E-5 with respect to PLC is that NOVA E-5 has one more spacer grid
  - Calculations only considered the rod bundle, as this was the part of the assembly that was changed the most between NOVA E-3 and NOVA E-5
- Result was that the NOVA E-5 has ~8 % smaller PLC than the NOVA E-3, even though the NOVA E-5 has the additional spacer grid
  - The spacer grid of NOVA E-5 was designed to minimize pressure losses, without these design features, PLC of the NOVA E-5 was calculated to be ~2 % larger compared to NOVA E-3



# Summary

- Fortum licensed during the years 2022-2025 a new fuel type for Loviisa NPP, WSE's NOVA E-6 (fixed) and NOVCD (fuel follower)
  - NOVA E-6 (NOVCD) lead test assemblies were loaded to Loviisa-2 in 2024
  - Almost a full reload batch was loaded to Loviisa-2 in 2025
- The new design is based on WSE's NOVA E-5 (NOVCC) design, which is based on BNFL's NOVA E-3 (NOVCA) design
  - BNFL's NOVA E-3 (NOVCA) fuel was used in Loviisa NPP in the early 2000's
- Fortum has conducted research in many different areas under the APIS program related to the licensing process of NOVA E-6 (NOVCD)
  - Fuel inspections (old BNFL assemblies and the NOVA E-5 dummy)
  - CFD calculations related to the PLC of the new fuel design
  - Economic evaluation of the ADOPT pellets

