Modeling and assessment of
new safety measures for Generation-IV European Sodium Fast Reactor

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  - Results
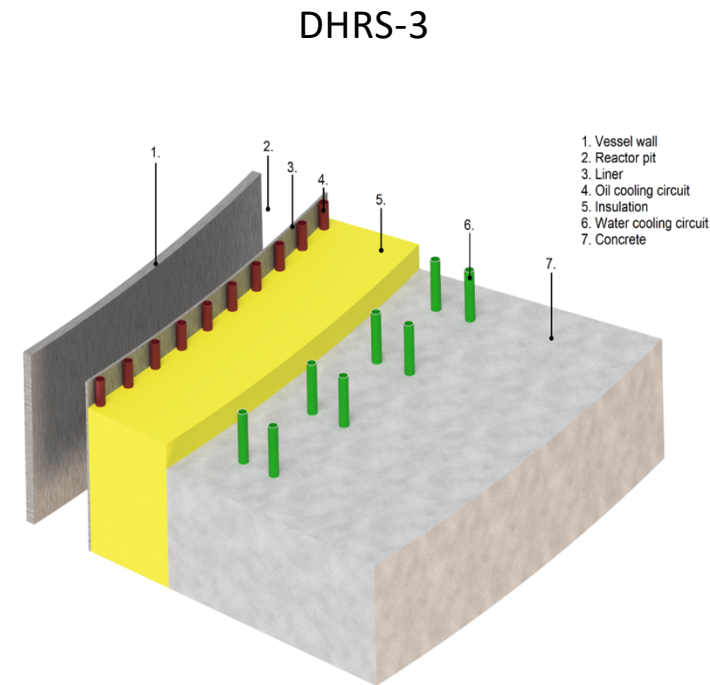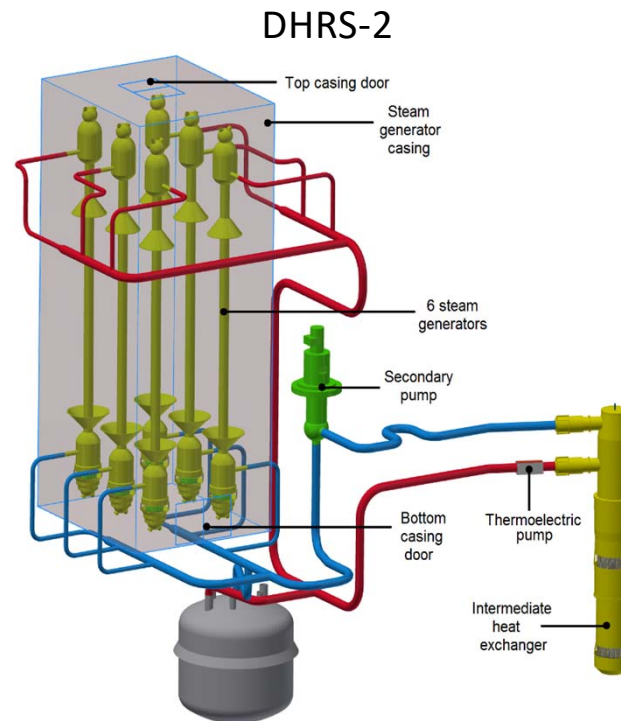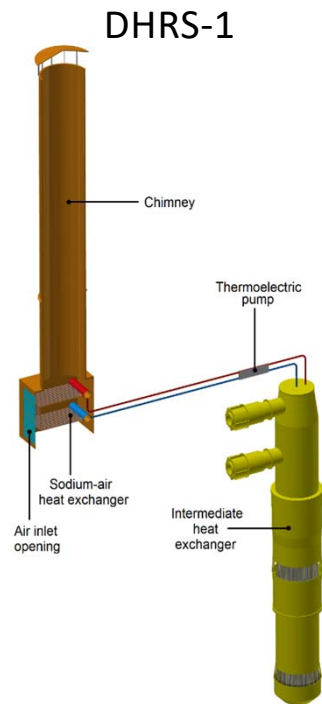- Summary

Focus and objectives of the study

- The main focus of the PhD project is safety assessment of the Generation-IV European Sodium Fast Reactor (ESFR) and the main objectives are:

  - Improve and validate selected modeling methodologies
  - Assess the new safety measures proposed for ESFR
  - Demonstrate the ESFR safety with respect to transient response including design-basis and beyond-design-basis accidents

Research framework

- ## ESFR reactor
  - Pool-type Sodium Fast Reactor
  - Low-void effect core
  - 3 primary pumps
  - 6 intermediate heat exchangers
  - 3 different decay heat removal system
    - 2 passive system
    - 1 active system

- ## Utilized codes:
  - Autodesk Inventor, CAD software
  - Serpent 2, neutronics Monte Carlo code
  - PARCS, nodal diffusion code
  - TRACE, thermal hydraulics system code
  - Inventor Nastran, Finite Element solver
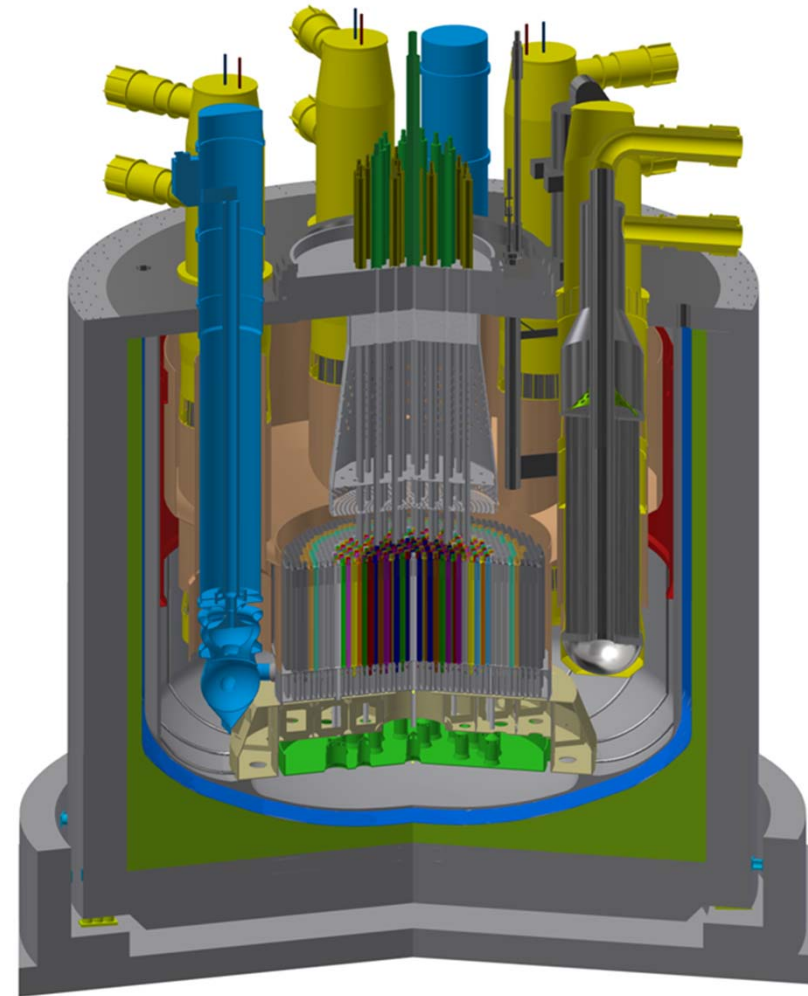
# Protected station blackout (PSBO)-DHRS description

- 3 decay heat removal systems (DHRS) are envisaged in the design
- DHRS-1 and DHRS-2 are passive, whereas DHRS-3 is actively operating
- DHRS-1 and DHRS-2 activation at 600°C IHX inlet temperature

DHRS-1

- Chimney
- Thermoelectric pump
- Sodium-air heat exchanger
- Air inlet opening
- Intermediate heat exchanger

DHRS-2

- Top casing door
- Steam generator casing
- 6 steam generators
- Secondary pump
- Bottom casing door
- Thermoelectric pump
- Intermediate heat exchanger

DHRS-3

1. Vessel wall
2. Reactor pit
3. Liner
4. Oil cooling circuit
5. Insulation
6. Water cooling circuit
7. Concrete

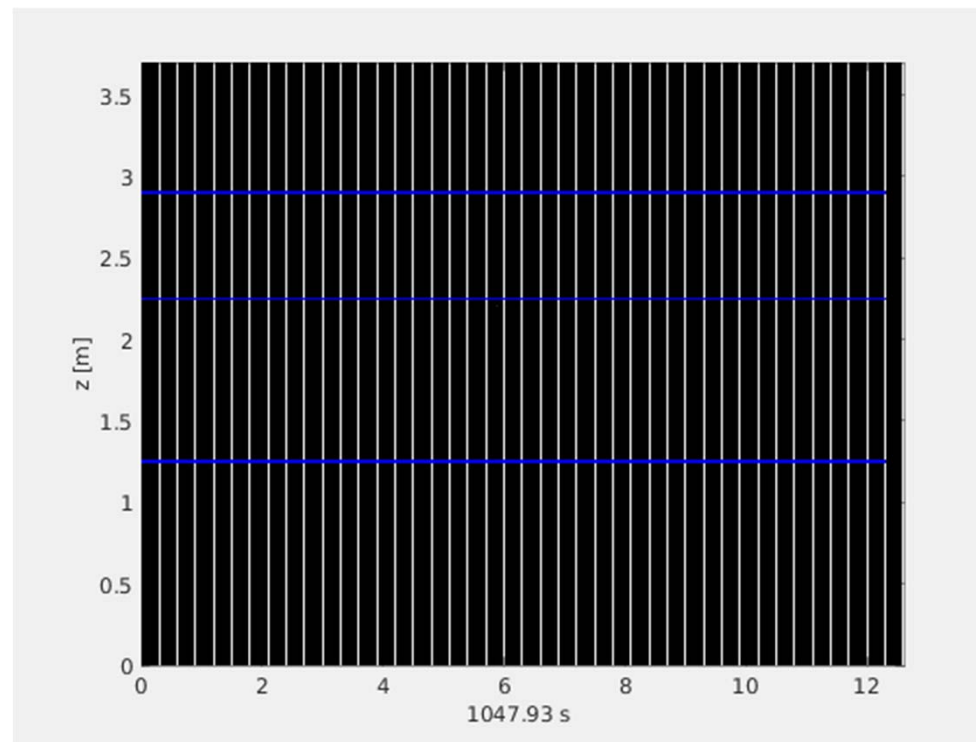# Protected station blackout (PSBO)-DHRS results

- Fukushima like accidental condition to ensure the safe shutdown of the reactor under such conditions
- Initiator event is a loss of electrical power supply
- Control rod insertion is ensured (protected scenario)
- All pumps (primary, secondary and tertiary) are gradually stopped in the reactor
- DHRS systems are initiated at 600°C IHX inlet temperature

DHRS-1 performance assessment
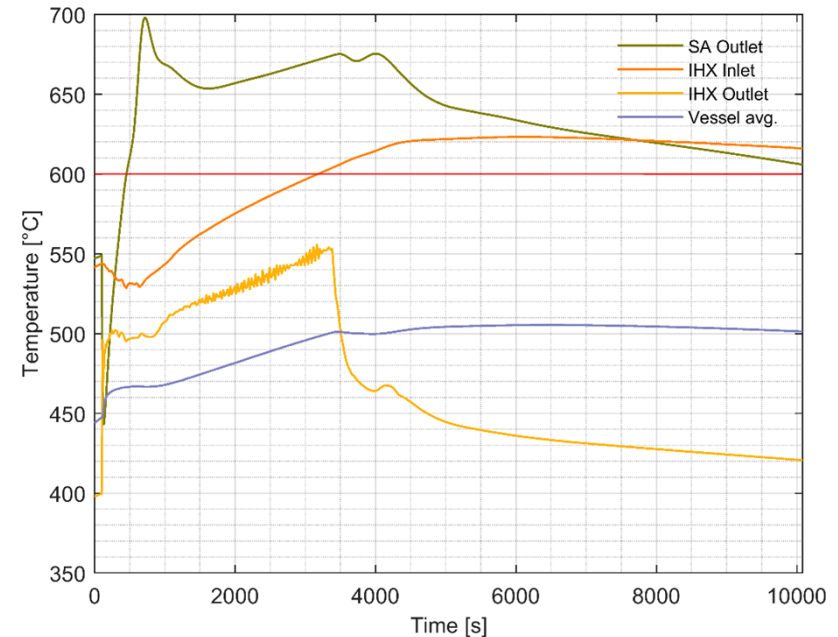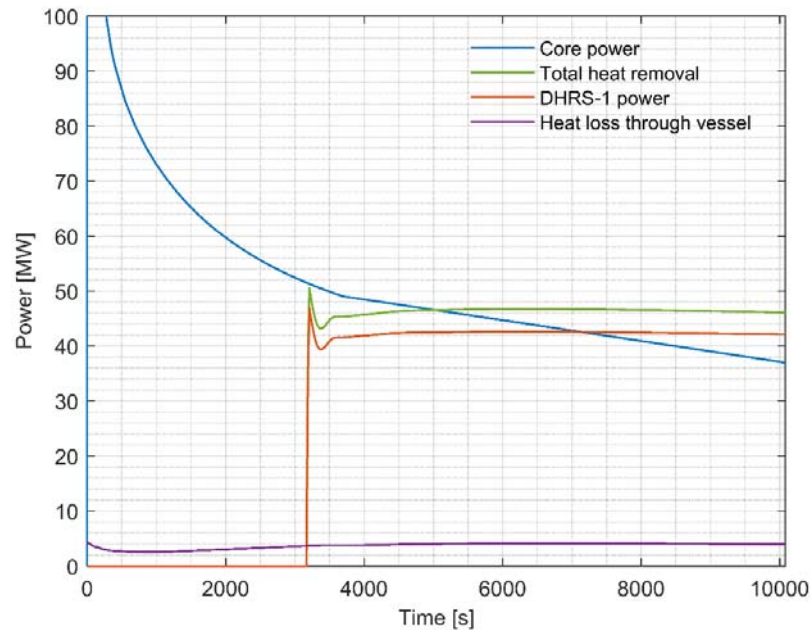
Unprotected loss of flow (ULOF)-TRACE model

- 42 channel boiling model is used with TRACE (1/12th of the reactor)
- The current model is used with point kinetics
- The influence of the sodium plenum is analyzed
- Around 60s of boiling is simulated currently

- Clad melting with the reference model but no power runaway
- A sensitivity study is being conducted on certain design parameters such as:
  - Assembly outlet geometry
  - The influence of gagging scheme
  - Sodium plenum effect
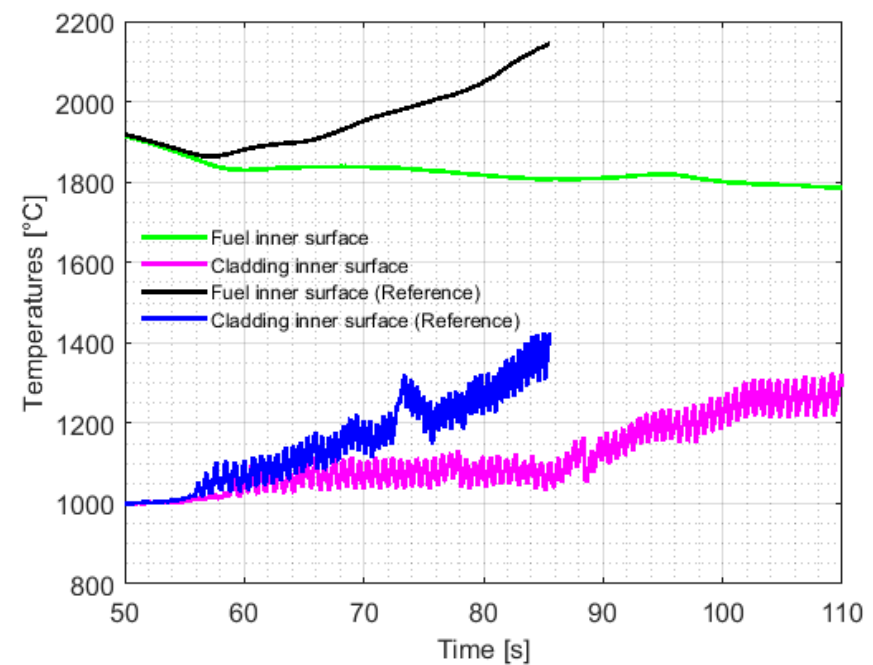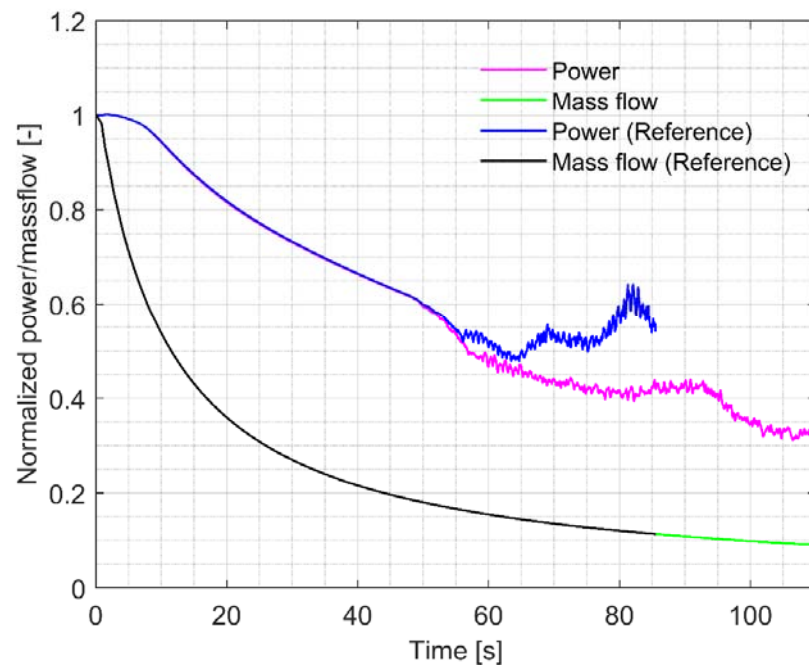
Summary

- The ESFR has been modeled with different simulation tools, such as TRACE, PARCS and Serpent 2

- The reactor behavior is being analyzed under protected (PSBO) and unprotected conditions (ULOF)

- Proposed new DHRS are evaluated under PSBO conditions

- Sensitivity of reactivity components and design parameters are being assessed

- Certain design modification proposals are made based on the simulation results

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Thank you for your attention!