BENEFITS OF DYNAMIC SIMULATION APPLICATIONS TO NEWBUILD NPP PROJECTS

PWR Prague 2026

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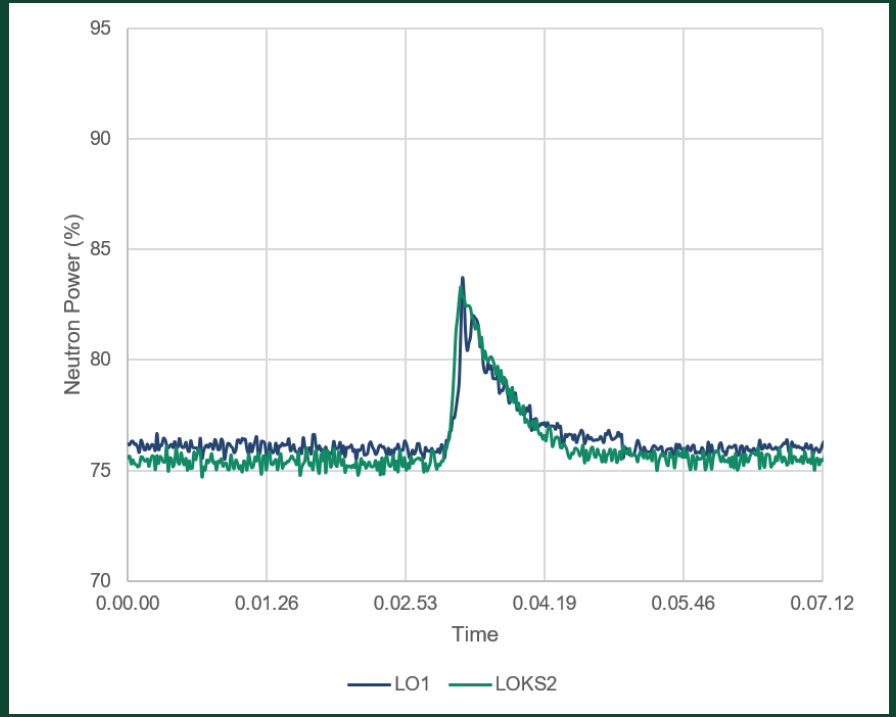
Agenda

- What is dynamic simulation and what are its benefits for newbuild NPP projects?
- Selected case studies
- Key takeaways

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What is dynamic simulation and what are its benefits?

- Dynamic simulation is a method that predicts time-dependent behavior of physical systems, such as power plants. Instead of giving a single static answer, it shows how the system evolves, step by step.
- It's used when time-dependency is of importance:
  - Processes involve feedback loops
  - Conditions change over time
  - The system contains interactions or dependencies (e.g., heat transfer affecting fluid flow)
- Why to use dynamic simulation to support newbuild NPP?
  - It is mandatory (e.g. official safety analysis and use of training simulator for operator training)
  - It ensures on time project execution and confidence in the new design
  - It increases in-house knowledge of the NPP behavior throughout the organization
  - It provides ability to quickly debug and respond to problematic situations



Loviisa NPP (LO1) Power Controller Tuning: comparison between LOKS2 simulation results against LO1 data in case of Primary Coolant Pump stop and restart.

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What is dynamic simulation and what are its benefits?

- Benefits of using dynamic simulation
  - Increased understanding of the plant behavior
  - People education and training
  - Early validation of complete design
    - Validation of interfaces/interactions with other supplier systems
    - Detection of undesired effects
    - Identify optimization margins
- Why put money and effort in dynamic simulation applications?
  - Cost savings
  - Risk reductions
  - Design optimizations



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Apros® overview

- Apros® is a modelling and simulation software for one-dimensional, dynamic modelling of different industrial processes, including their automation and electrical systems
  - Developed by Fortum and VTT Technical Research Centre of Finland
  - Development started 1986
  - Vendor independent code
  - Commitment to continuous development



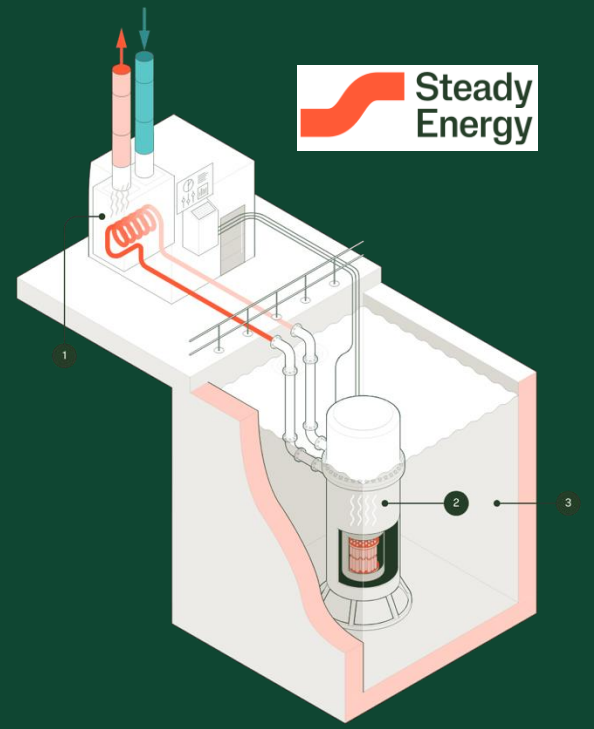
Read the story of Apros® from here: https://www.fortum.com/media/2021/12/story-apros

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Steady Energy leverages simulation for optimal design



- Steady Energy develops LDR-50 small modular reactor (SMR) with a thermal output of 50 MW, designed to operate at around 150°C.
- The reactor is designed to produce heat for district heating, industrial steam production and desalination projects.
- Fortum has used Apros software to create a simulation model of the LDR-50. The model is used to carry out comparison analyses related to the licensing and to solve technical issues related to the functionality and dimensioning of the new plant type.



Feasibility study, Concept development	Newbuild project			Operation	
Preliminary design	Basic design	Detailed design	Commissioning	Solving operational issues	Upgrades and Design modifications

Fortum's modelling expertise is world-class. The combination of deep mastering of modelling tools and practical understanding of nuclear facilities makes their service offering unique. At Steady Energy, we have adopted Apros as a design tool already at an early stage and are developing simulation models further as the design progresses. ***This allows us to quickly arrive at design solutions that both work in practice and meet the licensing requirements.***

- Hannes Haapalahti, CTO, Steady Energy

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Unexpected issues solved with Apros during the OL3 commissioning phase

- Fortum and TVO have developed together a dynamic simulation model for TVO's Olkiluoto 3 plant using Apros software. Model has been utilized for various purposes by TVO.
- Unexpected issues emerged during the commissioning tests when the main feedwater control valve position and steam generator water level oscillated at low partial loads.
- Existing OL3 Apros simulation model with a detailed 3D reactor core was best tool for problem analysis.
- Model accurately reproduced the problematic plant behavior and verified the proposed control parameter changes.
- Based on analysis, TVO demonstrated corrective actions to enable smooth commissioning progress.



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"The use of Apros software and the expertise of Fortum's team were instrumental in helping us reach milestones in the OL3 project. ***Their support allowed us to quickly identify and resolve issues, ensuring the smooth progression of our commissioning phase. This collaboration has been a significant asset to our project's success."***

- Juha Poikolainen, Head of Nuclear Safety Design, TVO

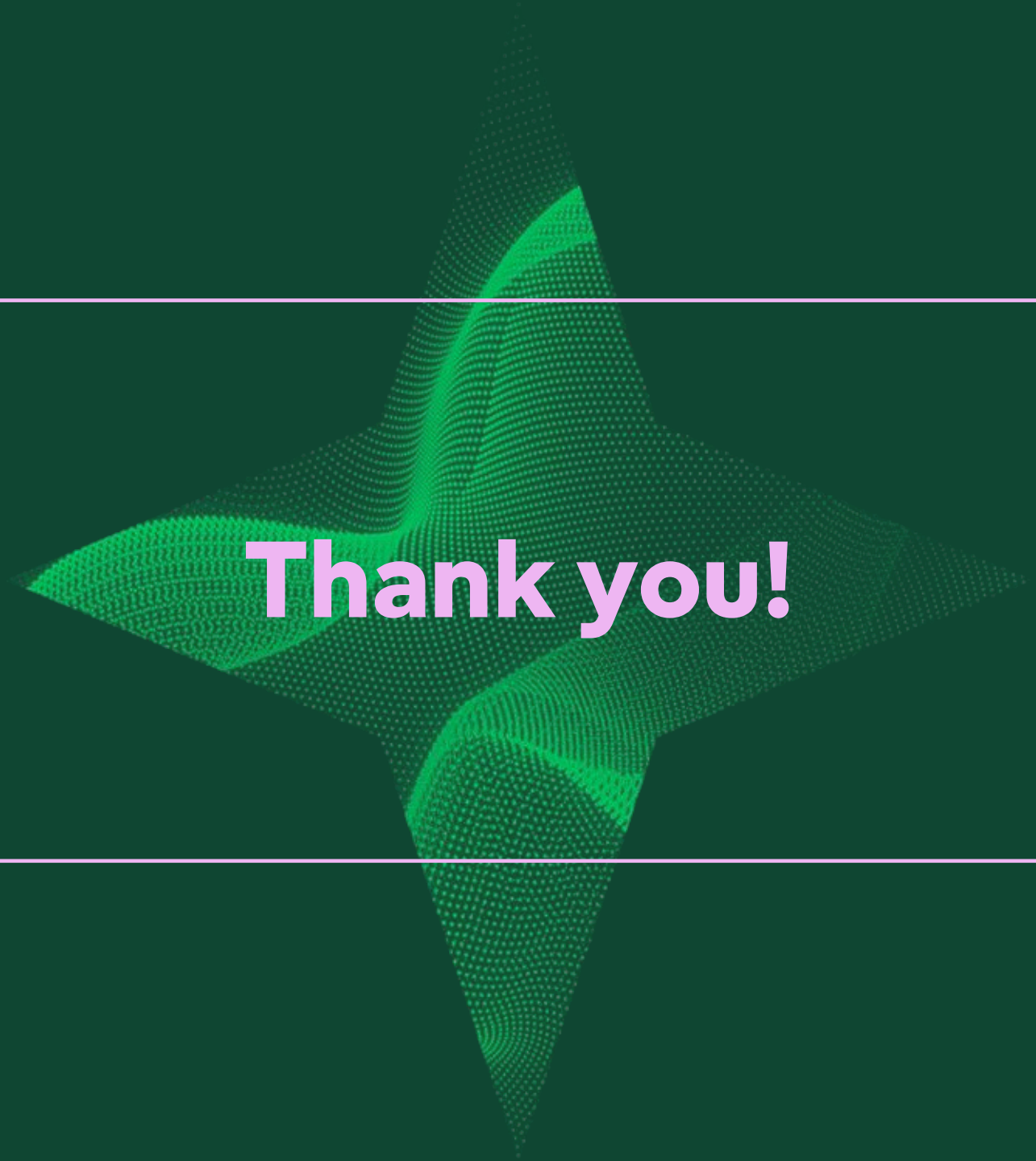
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KEY TAKEAWAYS

Dynamic simulation creates value throughout plant lifecycle

- Simulation is an investment best done early and proactively
- Simulation improves quality and reliability in design
- Strong simulation expertise in own organization is a valuable asset

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Thank you!

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