Pienet modulaariset ydinreaktorit kaukolämpöjärjestelmässä – teknoekonominen mallinnus

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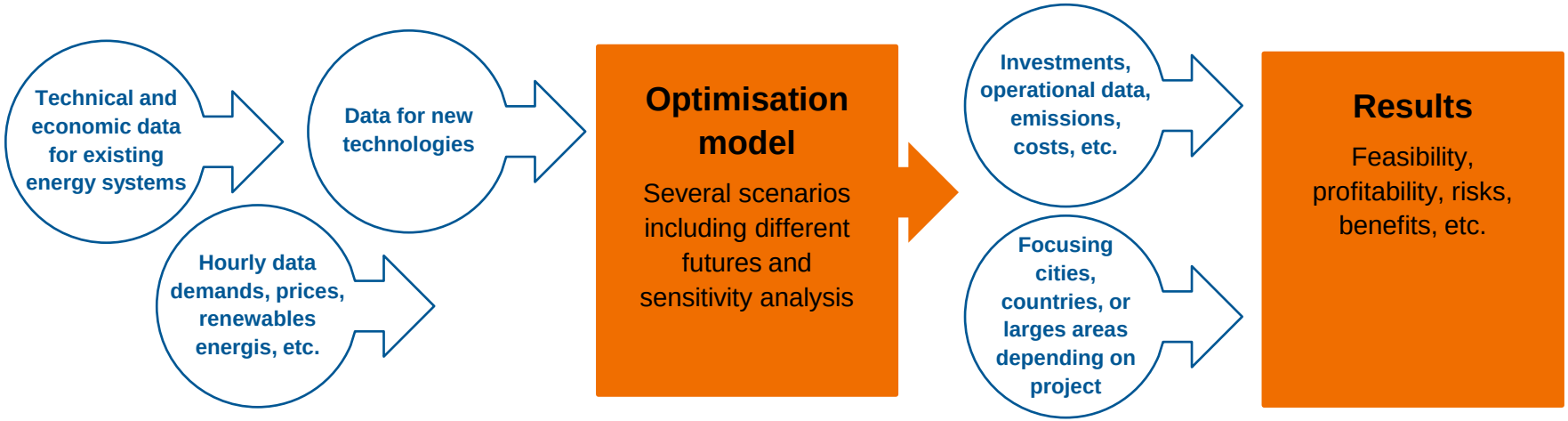
Quick review of our SMR technoeconomic studies

- 2017-2018 Feasibility and cost-assessments of different SMR concepts, early potential estimates, and early company projects
- 2019 Technoeconomic analysis of NuScale and DHR-400 in the Capital region of Finland https://www.researchgate.net/publication/332046309_A_techno-economic_assessment_of_NuScale_and_DHR-400_reactors_in_a_district_heating_and_cooling_grid
- 2022 Comparing SMRs and large heat pumps as options to produce district heating 2022 https://doi.org/10.1016/j.enss.2022.03.001
- 2022 Simulating difficult load following cases with APROS
- 2022 SMRs in Baltic countries https://www.researchgate.net/publication/365038639_Prospects_of_electricity_and_heat-only_SMRs_in_the_Baltic_Region
- 2022 SMRs investment under high fuel price scenarios in Finland https://www.researchgate.net/publication/365038504_Investments_in_Nuclear_Heating_in_Helsinki_Metropolitan_Area_During_Volatile_Energy_Markets
- 2023 Modelling new cities in Finland and new countries in the Northern Europe
- 2023 Larger European collaboration project TANDEM with partners from France, Italy, Czechia.
- 2024 Extending investment and operational analysis to combinations of SMRs and other technologies, modelling the operation of SMRs under weather uncertainty

What we talk about when we talk about energy system modeling?

- **Purpose**: to achieve realistic estimate for operation and investments of SMRs in energy systems including power, heat, H2, etc.
- **Method**: hourly optimisation of energy system by minimising operational cost (or maximizing DH operator profits)



Modelling Northern European energy markets with Backbone

- Built with Backbone open-source modelling framework
  - Open access to model and data.
  - Requires GAMS (licensed linear programming code)
- Enables flexible energy system modelling
  - Multiple energy vectors: electricity, electricity reserves, district heat, hydrogen
  - Storages (electricity, heat, H2)
  - Conversions between grids (e.g. P2X and heat pumps)
  - Can easily change time series years (profiles from certain historical year, but with future demands)
  - Can model a city or region within a country, currently applied for Finnish cities

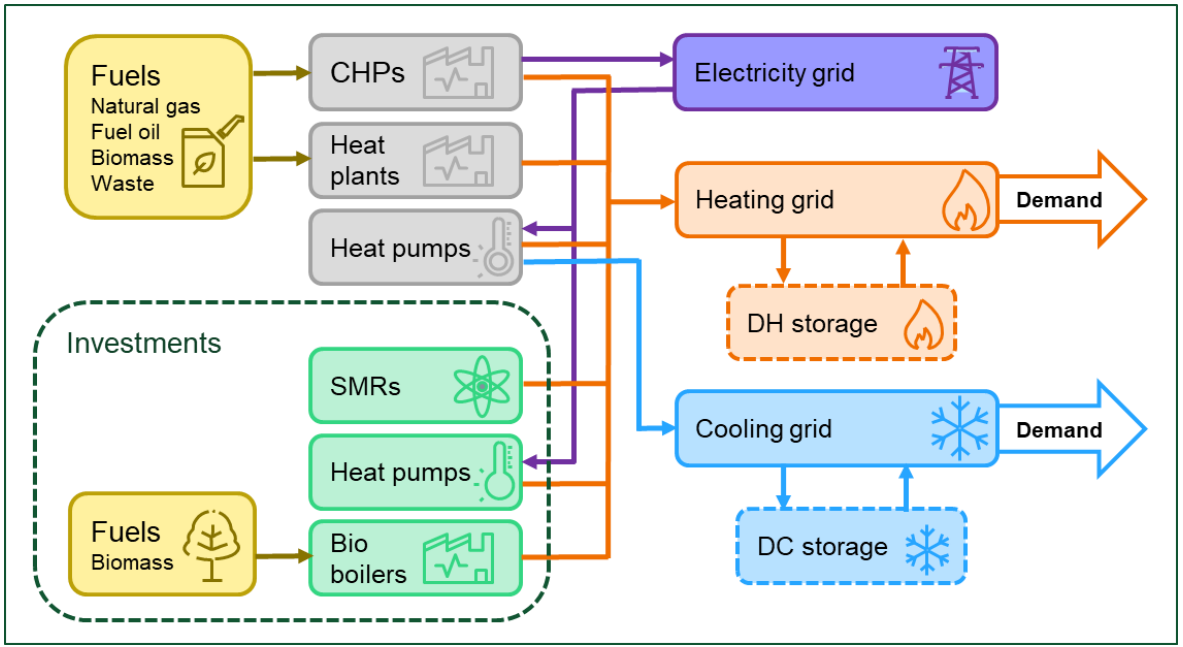
Schematics of city level modelling

Detailed modelling of

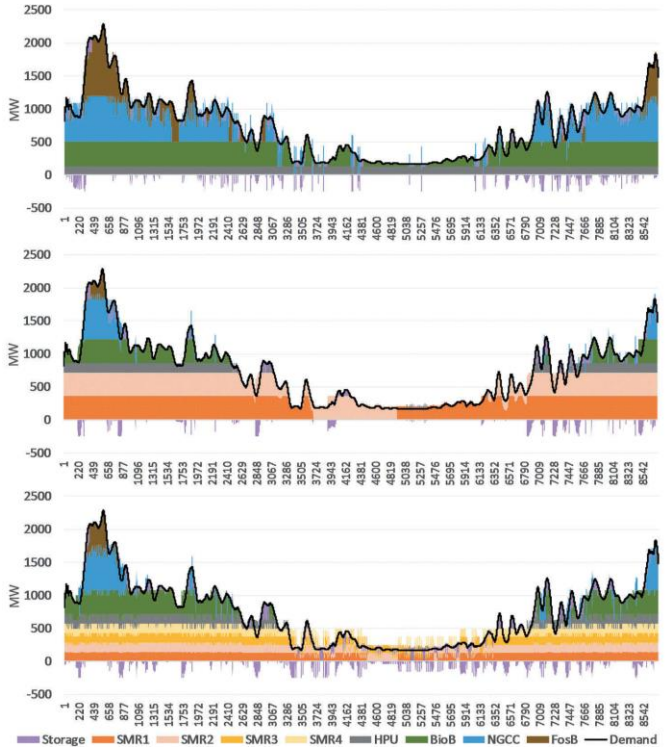
- District heating, district cooling and electricity generation
- Production units
- Storages
- Hourly demands

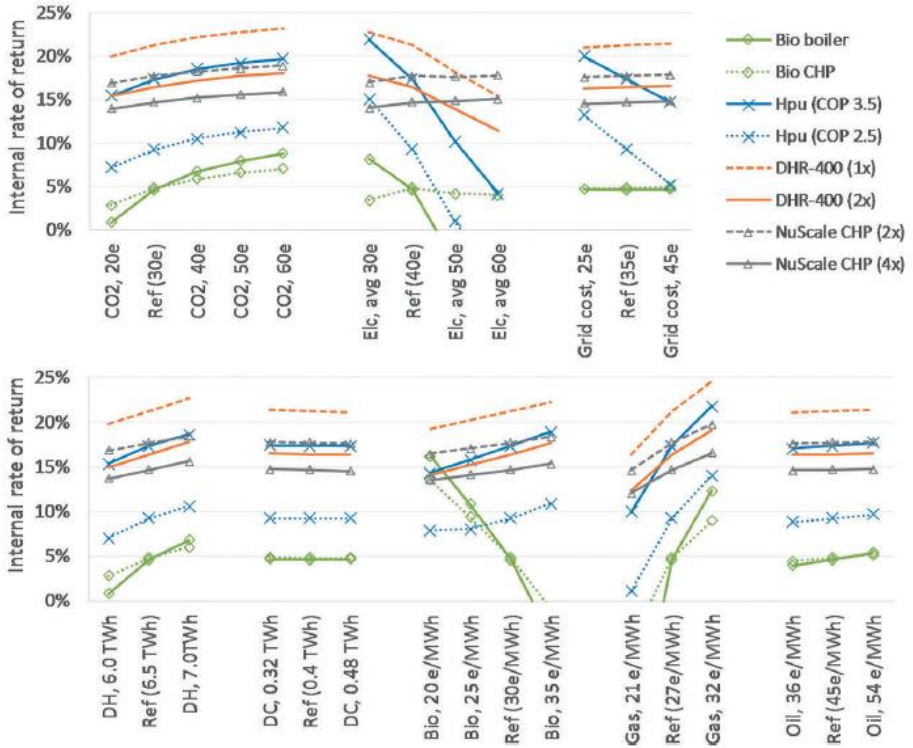
Simplified links to fuel and electricity markets.

Represents how DH operator sees the situation. Maximixes operator profits.

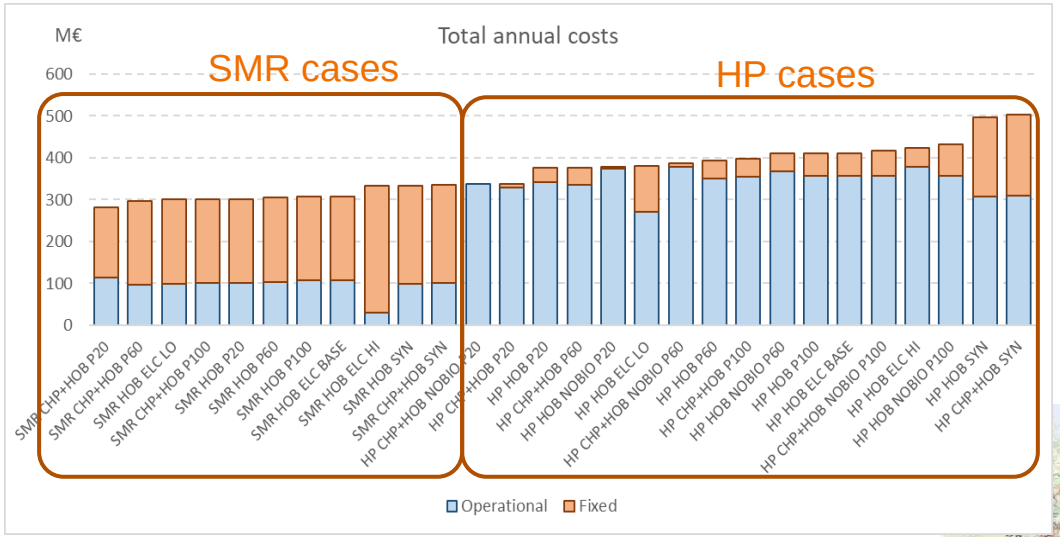


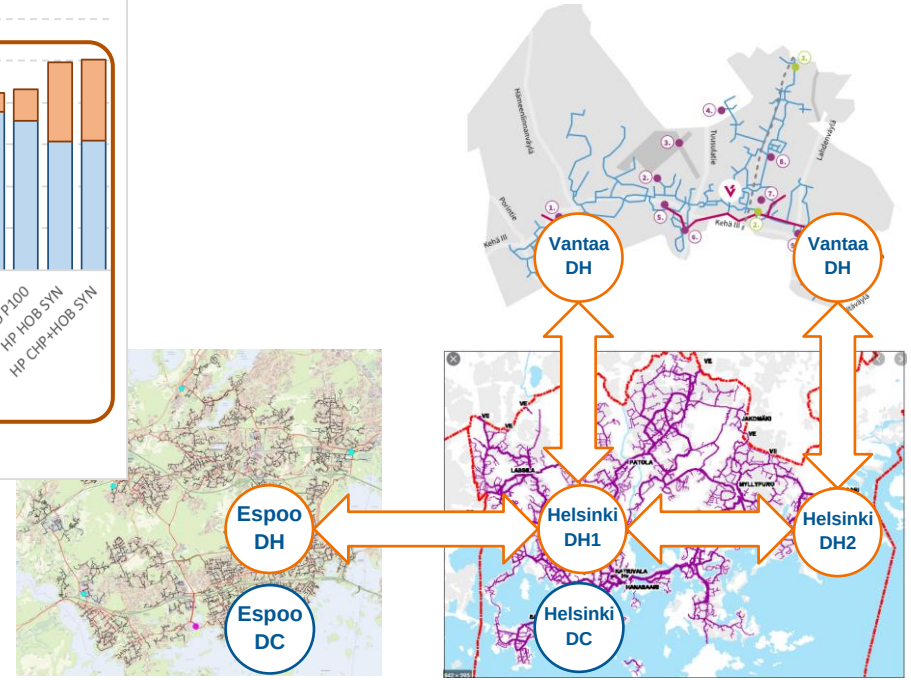
Case study: NuScale and DHR-400 reactors in a district heating and cooling grid



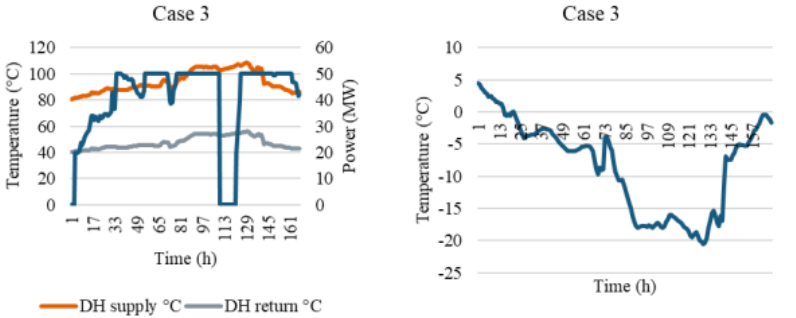


Case study: SMRs in the Finnish Metropolitan DH system





Thermal-Hydraulic Analysis of Difficult Load Following Cases



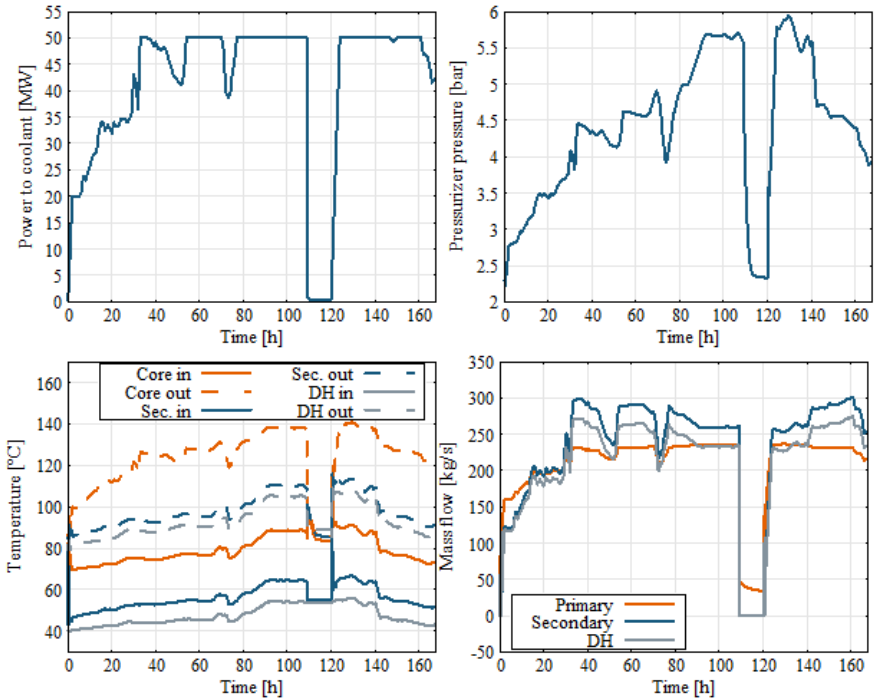
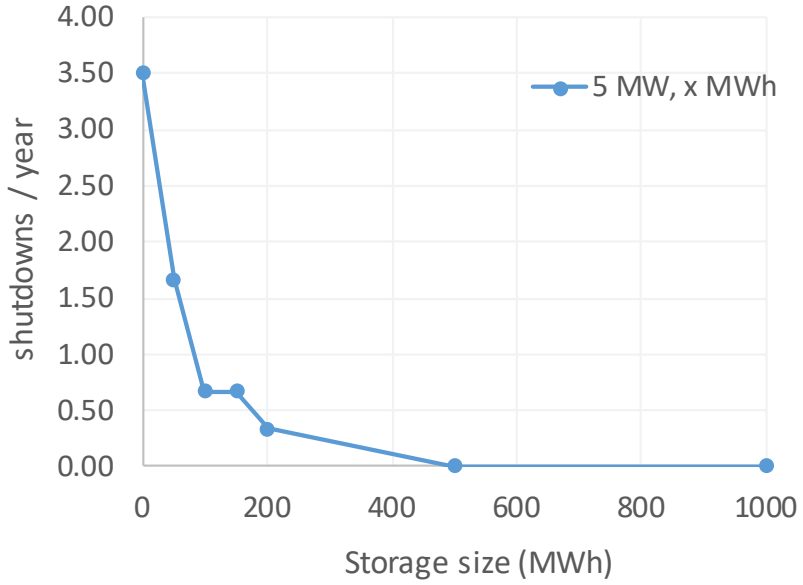
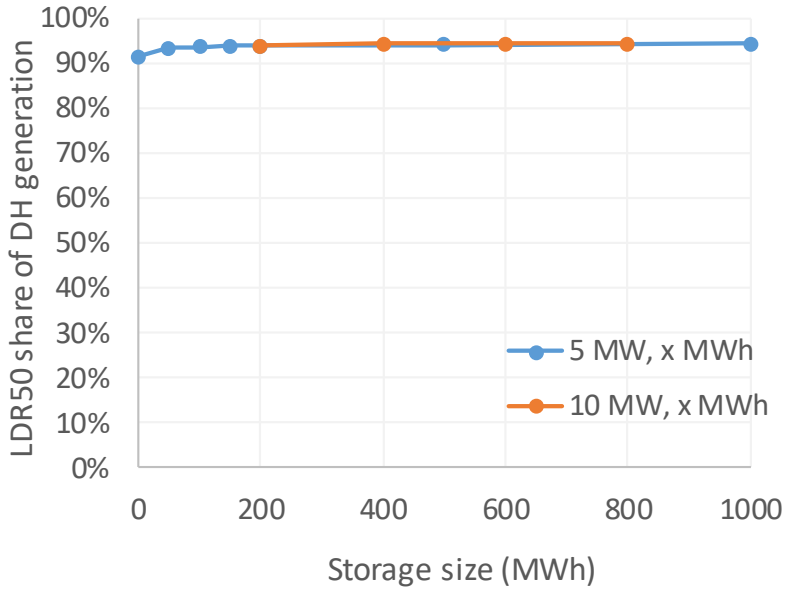


Figure 9 Case 3: Reactor power, primary pressure, temperatures and mass flows during the time series.

Case study: Very small DH system





SMR technoeconomic studies at VTT

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26/01/2024 VTT – beyond the obvious