

Resilience in operation and design of power and district heating systems

Microgrid Symposium 2026: Special Session on Multi-energy Microgrids

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11/11/2026 VTT – beyond the obvious

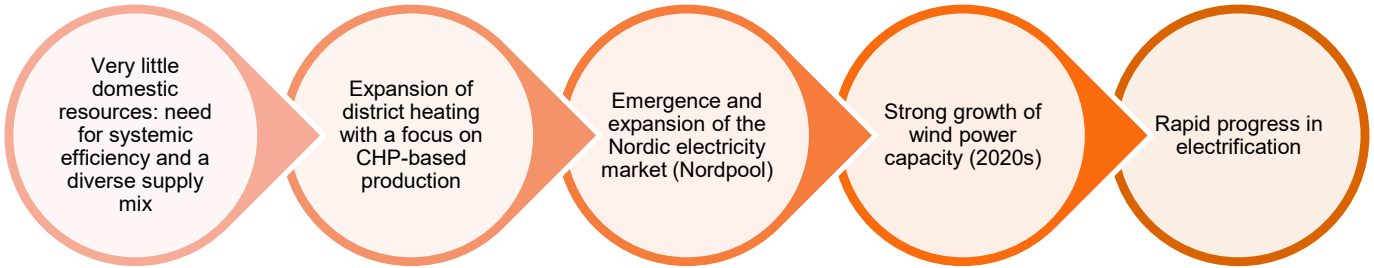
Topics presented

- Background
- Related VTT activities related to the topic
- Resilience in energy research
- Recent work: the concept of shockproof district heating
- Considerations for the future



Background

- Historically, there is a clear division in technology development within the realm of electric engineering and thermodynamics (i.e. the ”turbine” and ”generator” people)
- Finland represents an interesting operational environment regarding the topic



- **The result?** A long tradition of energy systems and smart grids research at VTT

Related VTT activities on the topic

VTT FutureGrid Lab

Multi-purpose platform combining digital and physical dimension of microgrids for grid flexibility and resilience research.

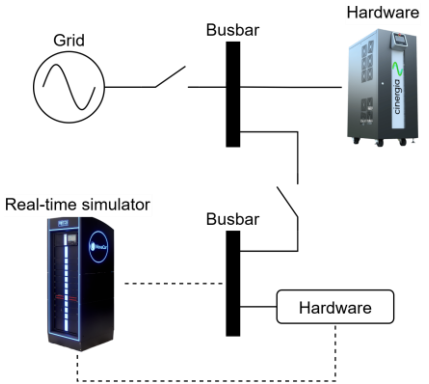


Capabilities

- Safe testing and validation environment for next-generation power grid technologies before real deployment
- Combines physical microgrid + real-time simulation (digital twin) enabling investigation of realistic and large-scale virtual scenarios
- Supports software, hardware, and system-level testing (incl. interoperability, security, resilience)
- Platform for companies, startups, and research actors for validation

Benefits

- Enables risk-free, realistic validation of innovations
- Accelerates deployment of new grid solutions improving grid resilience, flexibility, and security
- Strengthens industry collaboration and competitiveness



Future power grids are developed in | VTT News

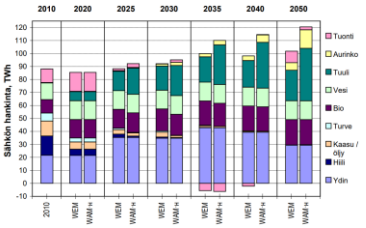
Related VTT activities on the topic

Energy system modelling

Energy transition has far-reaching consequences that go beyond specific sectors; making informed decisions on investments requires modelling-based scenario analysis on different levels of the system, bridging strategic decisions with operational practices.

“energy landscape”

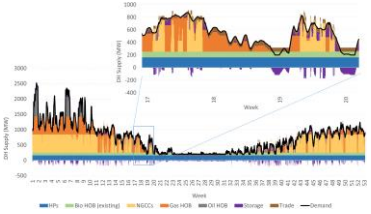
Intersectoral long-term optimisation



Long-term development of the energy sector, considering also the industry, transport, residential and commercial sectors.

“systems operation”

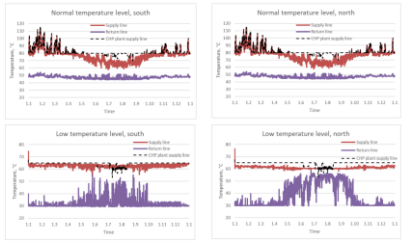
Energy systems optimisation



Operational aspects of current and potential future energy system; e.g. mechanisms of sector-coupling, electricity prices.

“stakeholder perspective”

Site or actor-specific optimisation or simulation



Stakeholder-perspective for assessing the techno-economic feasibility solutions, including reserve markets.

DHC and buildings

Relevance of the heating and cooling sector is great, representing ~50 % of final energy consumption. DHC systems need to considered taking the whole value chain point of view. The end-user measures (in buildings) are in key role.



Resilient and response buildings

Integrating energy efficiency, digital intelligence and resilience to ensure continuous operation, lower costs and improved occupant wellbeing in all situations.



Living labs

Co-create, test and validate innovations in real-world environments and partners, accelerating development, reducing risk and ensuring solutions deliver real impact.



Circularity for the built environment

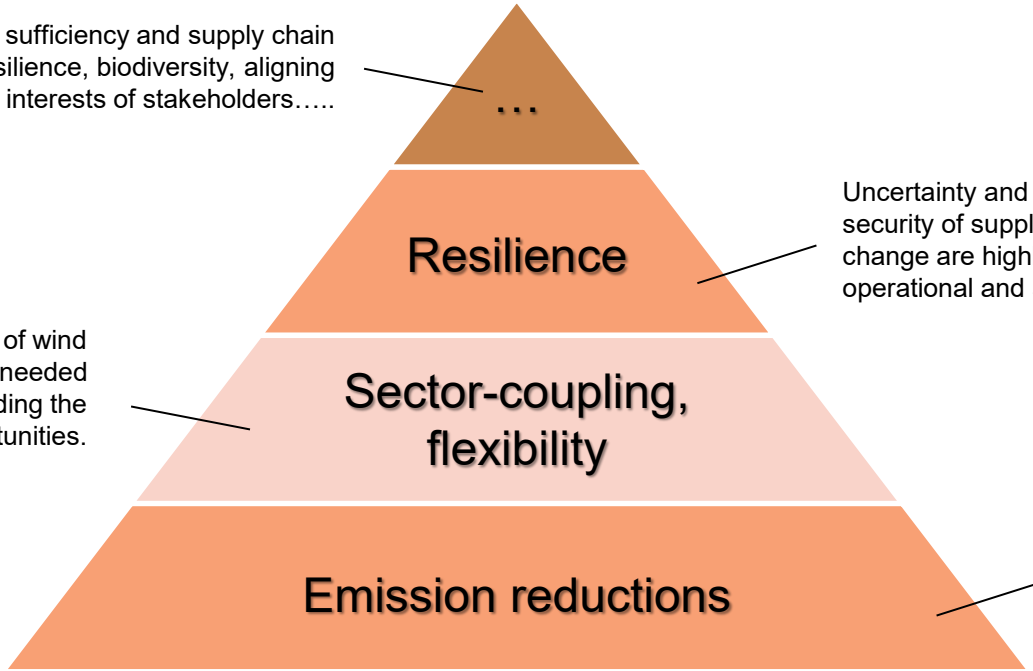
data-driven optimisation of buildings and materials to extend lifecycle, costs and emissions reductions, and support sustainable, high-value use of assets across their entire lifecycle.



Sustainable building materials

develop and validate low-carbon, durable and circular materials to reduce emissions and ensure long-term performance and safety in buildings and infrastructure.

Resilience in energy research



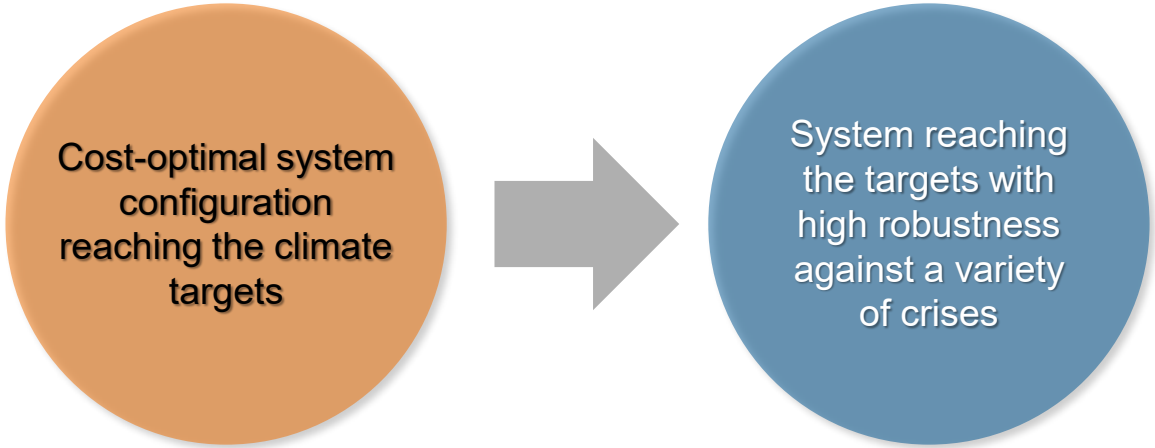
Material sufficiency and supply chain resilience, biodiversity, aligning interests of stakeholders…..

Uncertainty and lack of stability, concerns security of supply and adaptation to the climate change are highlighting the need for both operational and strategic resilience.

To cope with increasing shares of wind and solar power, flexibility is needed with the sector-coupling expanding the related opportunities.

Emission reduction the main driver and objective for energy related research, still representing the cornerstone of development.

Objective of energy systems modelling redefined



”All swans are black in the dark”; the importance the energy system modelling higher than ever, and technological solutions enhancing resilience sought after.

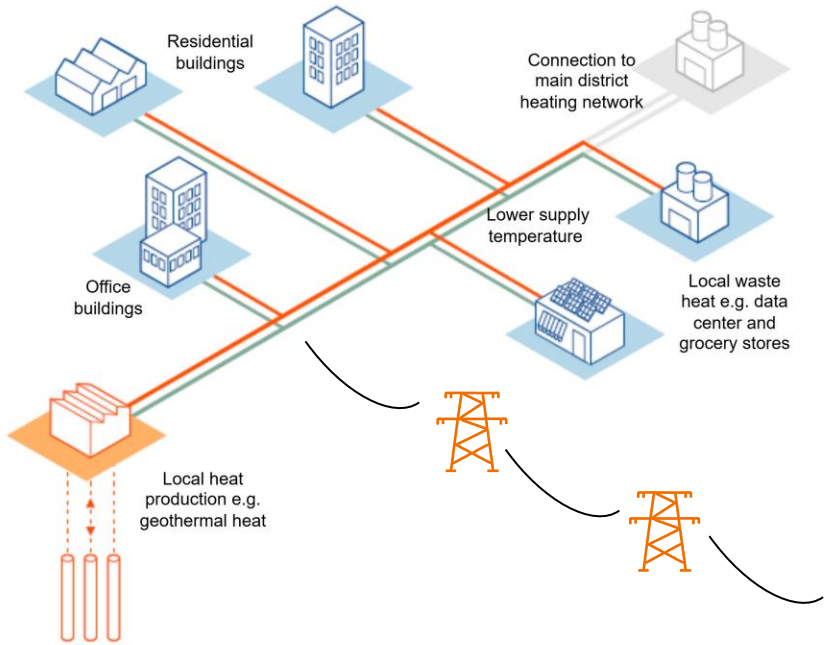
Concept of a ”shockproof DH” system

Case study

- An isolated municipality with DH and limited grid connection; how to cope with a prolonged power outage? If buildings are not heated, they would be damaged likely beyond repair (a concrete motivation)
- Combining heating (DH) and grid perspectives

Topics for study

- Quantifying minimum power and heating demands
- Grid forming capabilities, operating a DH system as “cells”
- Solutions for ”distributing scarcity”
- Energy storages and local generation capacity
- Control systems and physical devices adapting
- Operation in “resilience” and “normal” modes
- Operational choices/solutions vs. strategic perspective



Future considerations

Overall objective

- Strengthening the links between the systemic needs and the technology development

More specific targets

- Utilising our models for assessment of systemic resilience (with a systematic approach)
- Developing concepts, solutions and technologies enabling island-based management of a unified energy system including both electric and (district) heating systems
- Broadening the scope of strategic resilience into critical raw materials and their supply chains
- Stakeholder roles and their decision-making in overall society; pairing solutions with implementation pathways – including potential business models and role of regulations
- More significant emphasis on climate change adaptation in our overall research

beyond

the obvious

Thank you!

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