TECHNISCHE UNIVERSITÄT WIEN

Energy Economics Group

IS THE EUROPEAN ENERGY SYSTEM DECARBONIZATION DRIVING DISTRICT HEATING IN NORWAY?

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The novelty of this work is linking three dimensions

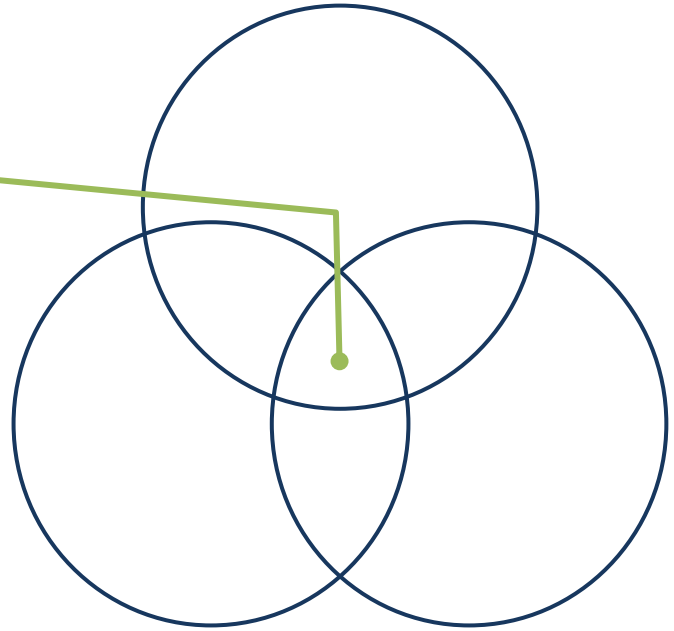
European Levels

Local Levels

A. Trends of the European Energy System

Obtained from results of large-scale energy models

Implement-ability and stress-testing



B. District Heating Network Optimization

Granular representation of both generation units and pipelines

C. Open-Source Data Linkage and Local Characteristics

Highly-spatially resolved input data of heat demand and sources

The core objective of this work

- Understanding the potentials of heat supply via **district heating in Norway** at the regional levels until 2050 **when decarbonizing the European energy system**
- Investigating the cost-optimal network expansion and energy technology dispatch of district heating in each of the **five Norwegian electricity price zones**
- Special focus on the **existing generation and grid infrastructure** allowing to estimate the potential of expanding existing district heating networks from the operator's perspective
- Introducing tailor-made restrictions, constraints and parameters to the optimization testing implement-ability of European decarbonization pathways
- Said parameters include electricity and carbon emission prices, maximum energy technology capacities, and total heat delivered

Why particularly focusing on Norway?

- 80% of the energy demand in the building sector is electricity since the heat sector is **mostly electrified in Norway**
- As a result, **hardly any water-borne heating systems** are available in buildings (which is an additional barrier when switching to district heating)
- Comparatively **low standards** of the existing building stock[1]
- In contrast to most European countries, the renovation of the building stock does not call district heating into question (or its economic viability through decreasing heat density values), but is rather a mandatory element of district heating
- Prices for electricity and district heating are coupled as electricity prices are used as benchmark for the (alternative) heat supply by district heating

[1]A recent study's results indicate a considerable energy saving potential of the Norwegian building stock up to 52% through renovation and retrofitting measures [4].

Introduction into the model

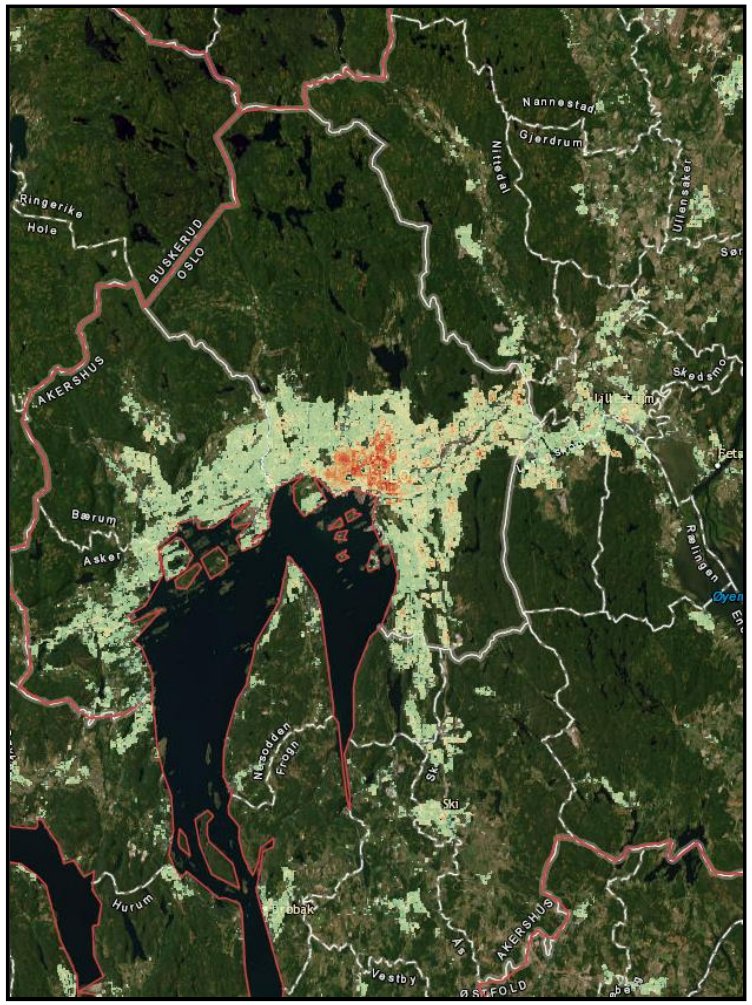
Objective function

- Multi-nodal unit commitment model and build upon two existing models
- Formulated as a mixed integer linear program while the objective function is to minimize the total systems costs z of the district heating network operator
- Key results encompass the optimal investment decision into heat generation technologies and transport pipelines, represented by the value of installed capacity $Cap_{i,t}^{ins}$ per heat infrastructure i and time step t in the optimal case.

Objective function
$$Cap_{i,t}^{*} = \underset{Cap_{i,t}^{ins}}{argmin}\, z$$

Clustering and spatial granularity of the modeling

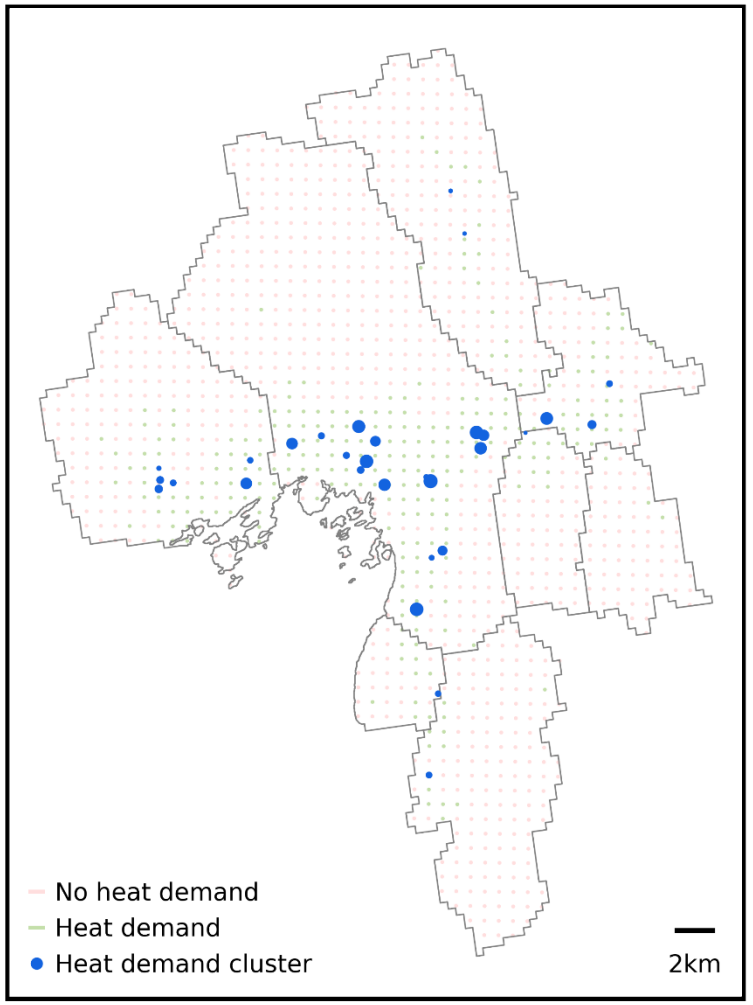
Heat demand at hectar level



Toolbox (hotmaps.eu)

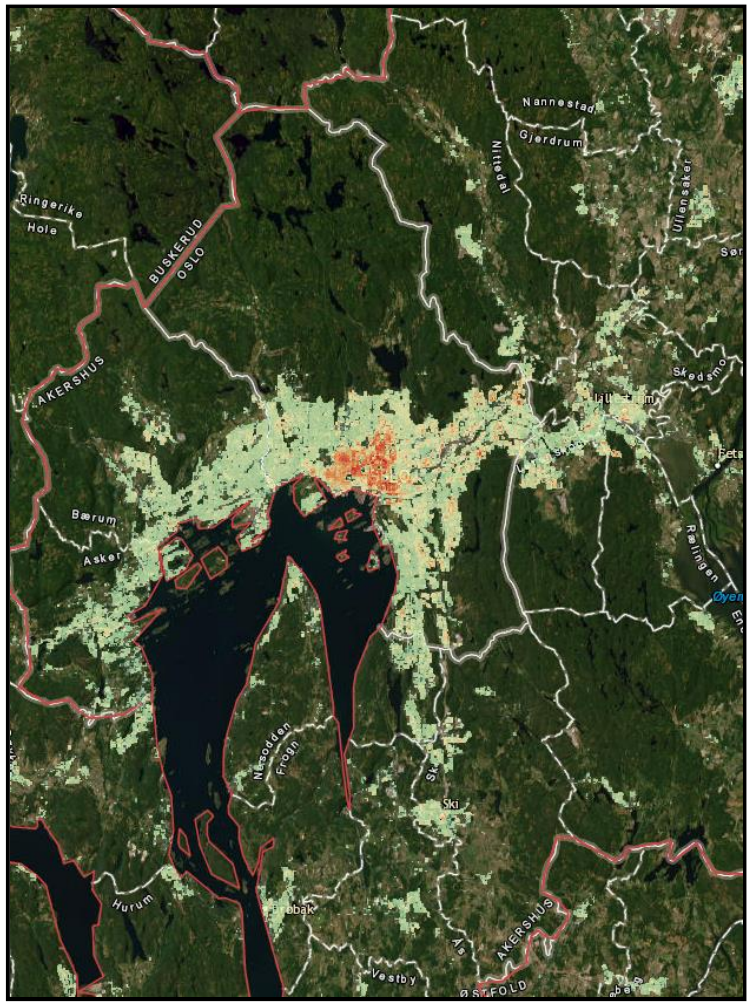
Clustering
Heat
density

Clustered Demand



Clustering and spatial granularity of the modeling

Heat demand at hectar level



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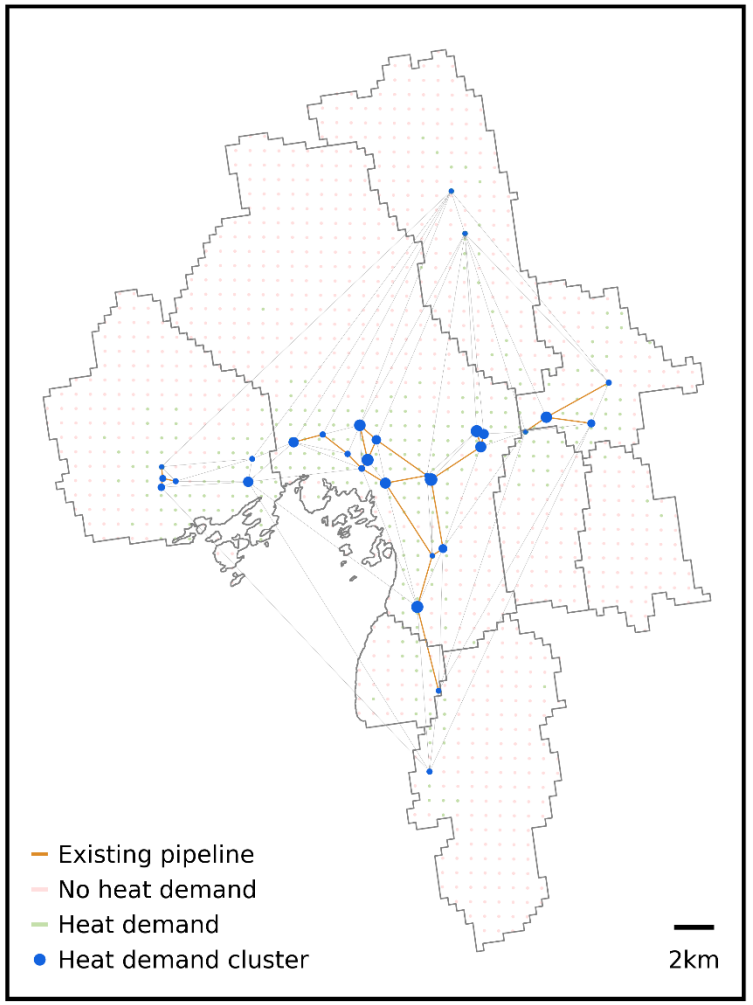
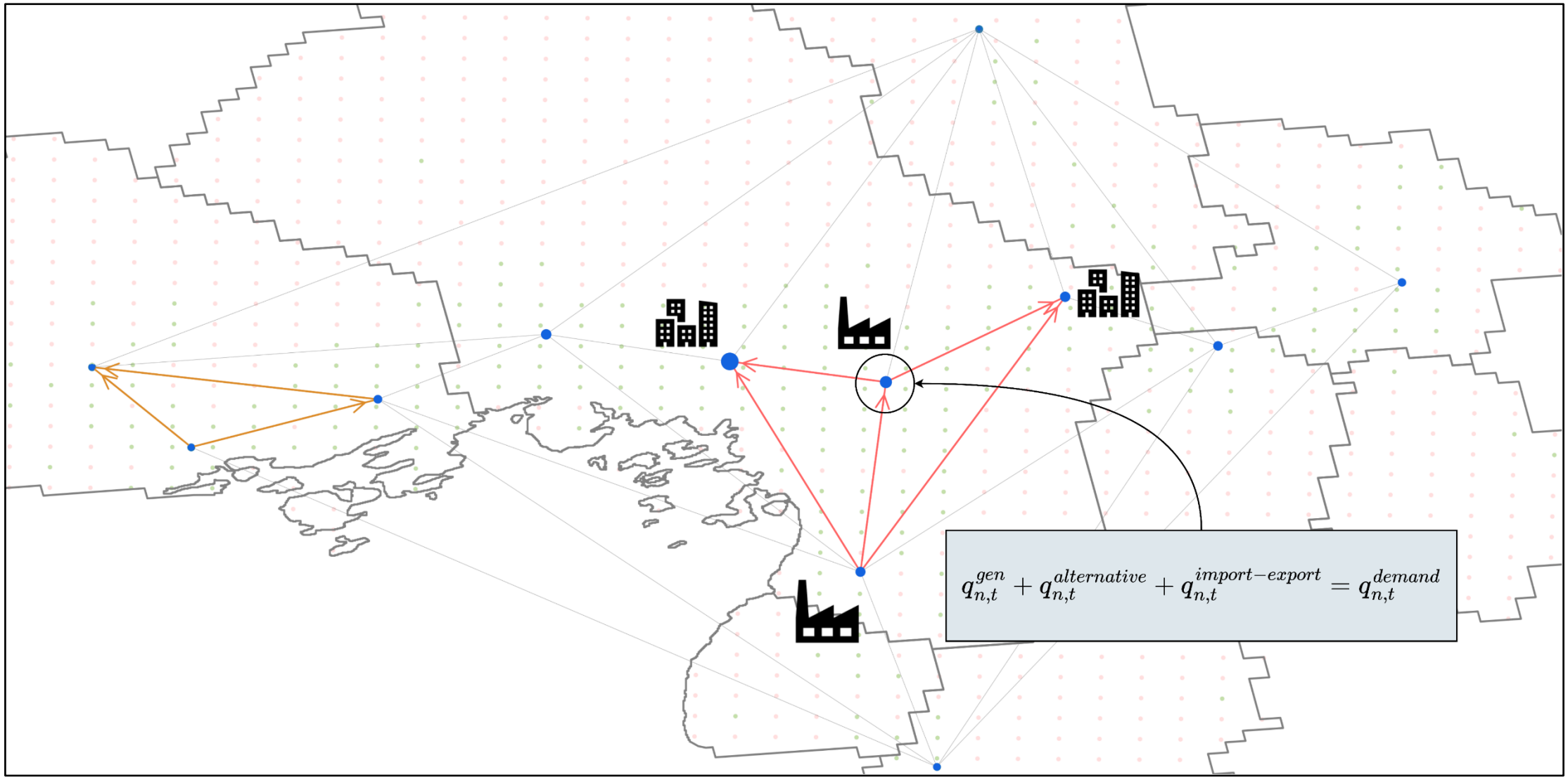
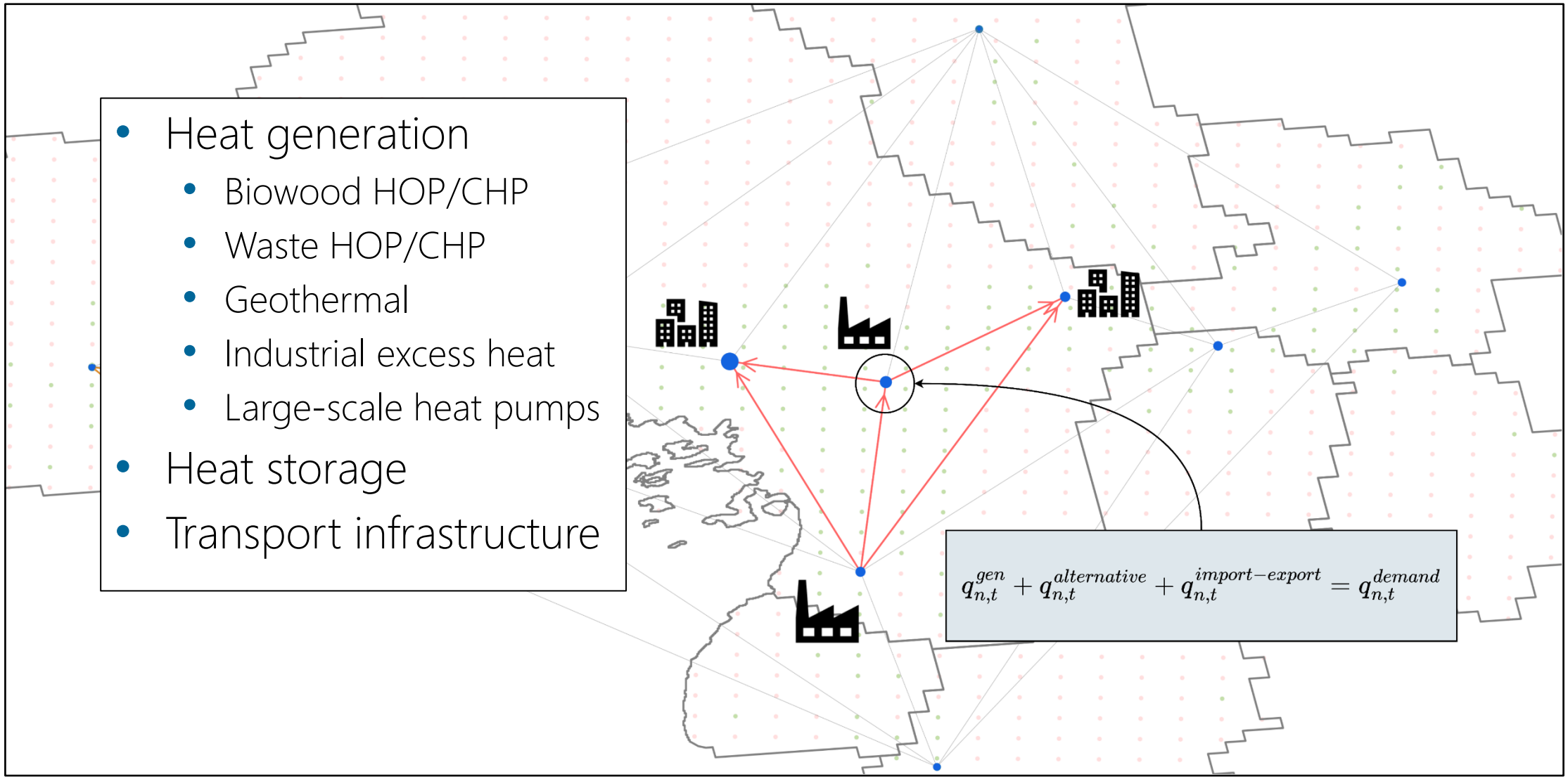


Heat balance and existing network



Heat balance and existing network

- Heat generation
  - Biowood HOP/CHP
  - Waste HOP/CHP
  - Geothermal
  - Industrial excess heat
  - Large-scale heat pumps
- Heat storage
- Transport infrastructure

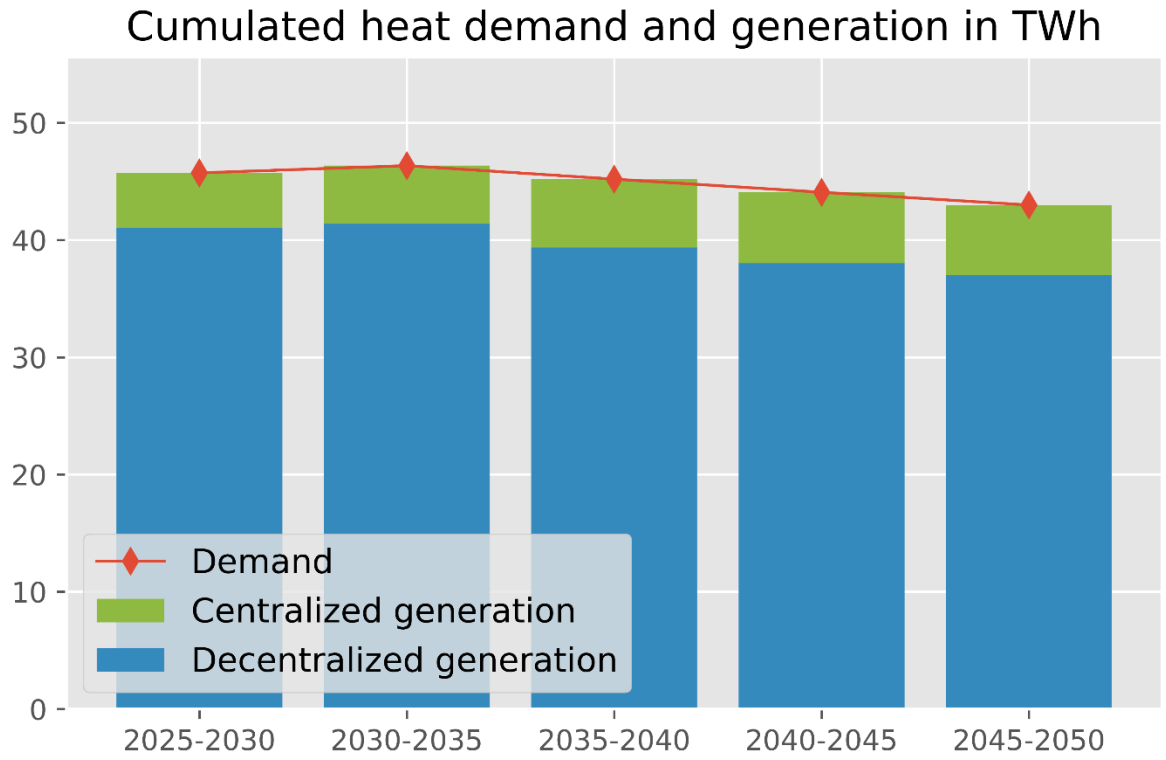


$$q_{n,t}^{gen} + q_{n,t}^{alternative} + q_{n,t}^{import-export} = q_{n,t}^{demand}$$

Preliminary results

Electricity price development according to EMPIRE results

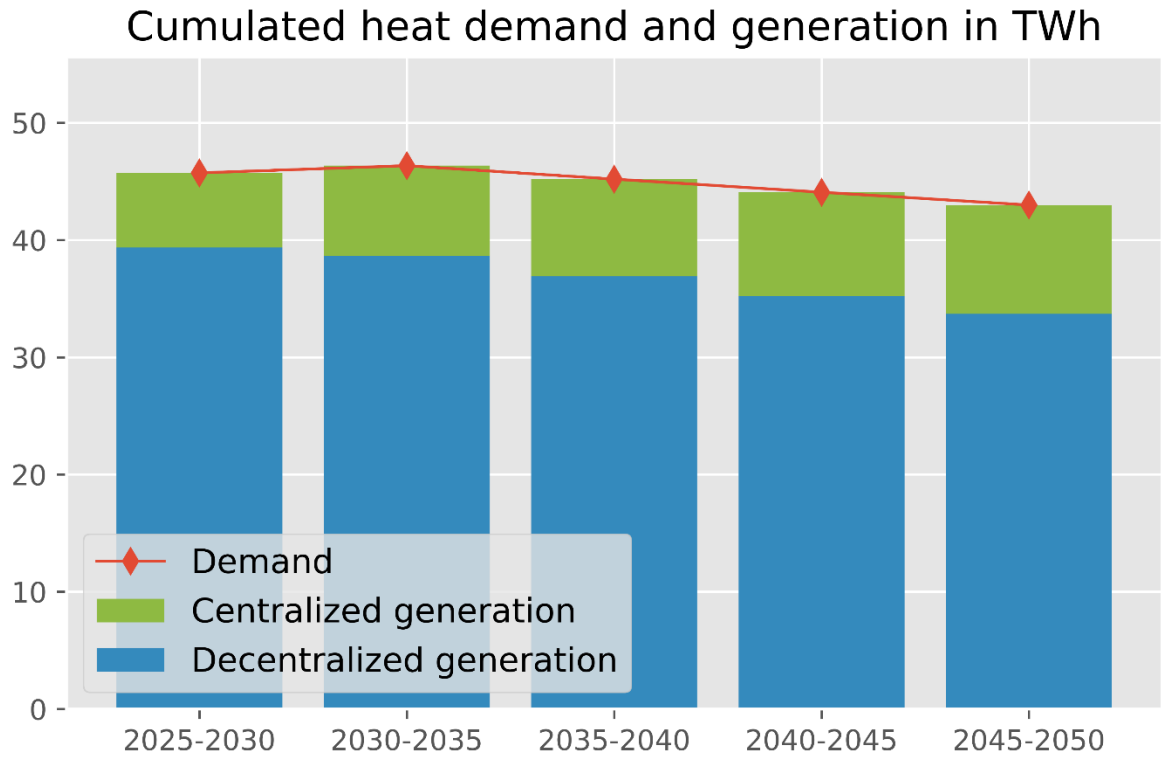
- Existing district heating infrastructure is being used
- No extension of transport pipelines -> current network is sufficient
- Minor increase in generation portfolio:
  - 10% in 2025
  - 14% in 2050



Preliminary results

Higher increase of electricity prices -> $\Delta p_{elec} = 65\ ^{€}/_{a}$

- Extended pipeline network
  - Strengthen existing pipelines
  - Develop new areas to supply
- Significant increase in generation portfolio:
  - 10% in 2025
  - 22% in 2050



Outlook and future work

- Application of the approach to the five different Norwegian electricity price zones
- Assess the shift from decentralized electrified heating to district heating
  - Estimate the reduction of required investments into electricity distribution grid given a further electrification of the mobility / transport sector in Norway
  - Quantification of the potential of the flexibility provided by district heating networks for the electricity sector and power markets
  - Examine the costs for building renovation and the consequent demand reduction in building heating
  - Analysis on the electricity price needed for triggering more investments into DH
  - Integration of the changing electricity demand into the large-scale model to estimate the influence on the electricity price