PhD project:
Geographical representations of renewable energy systems

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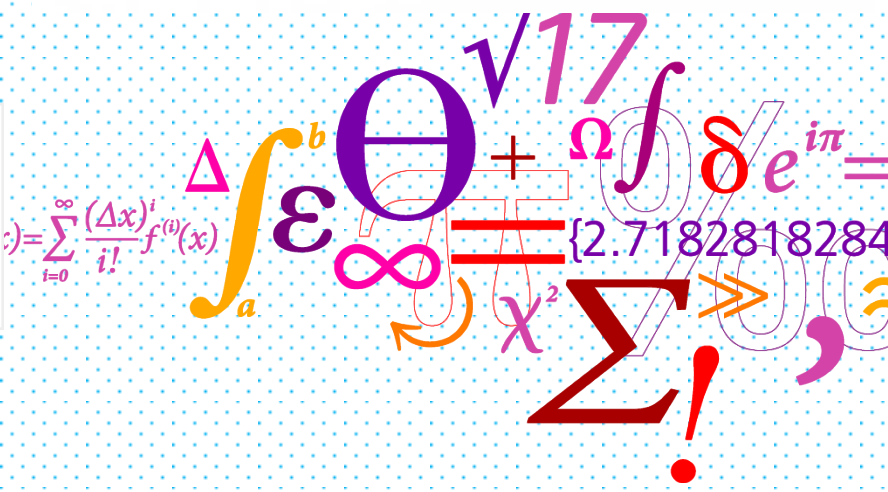
4th Generation District Heating Technologies and Systems



DTU Management Engineering
Department of Management Engineering

PhD project - results

1. Published journal article:

Model for determining geographical distribution of heat saving potentials in Danish building stock in *ISPRS International Journal of Geo-Information* (Special Issue on renewable energy)

2. Journal article in a resubmission phase (in the phase of specific changes):

Danish heat atlas as a support tool for energy system models in Energy Conversion and Management

3. Conference article:

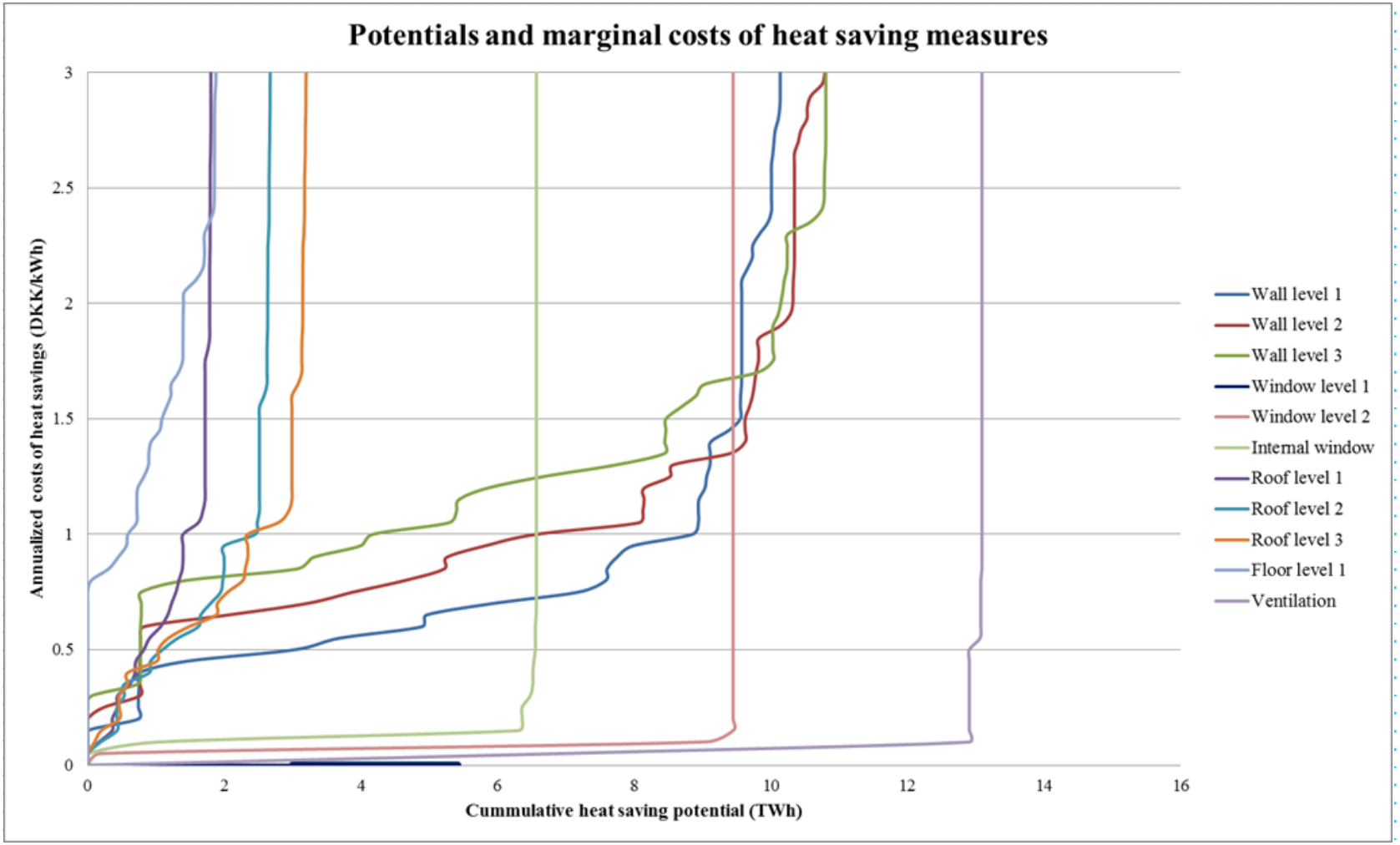
Residential heat pumps in future Danish energy system for 11th International Conference on the European Energy Market (to be submitted before March 17th)

Model for determining geographical distribution of heat saving potentials in Danish building stock

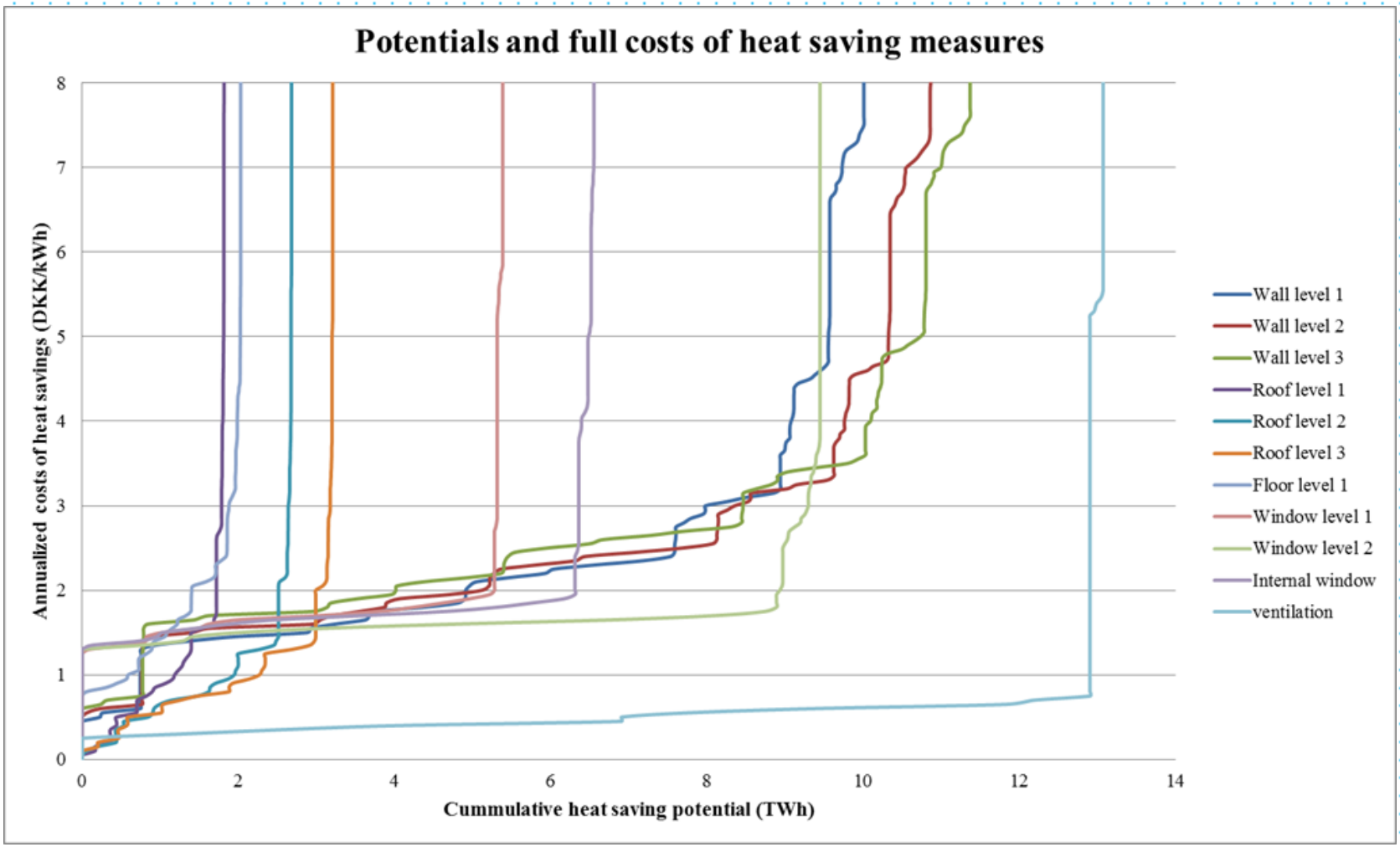
- Calculated current demand for space heating and DHW
- Calculated potentials and costs of heat saving measures within building stock
- Building stock divided in 360 groups depending on construction year, use and temperature region
- 13 levels of heat saving measures
- Marginal and full costs

$$Q_{heat}(c,u,t) = Q_{tr}(c,u,t) + Q_{vent}(c,u,t) - Q_{add}(c,u) + Q_{DHW}(c,u)$$

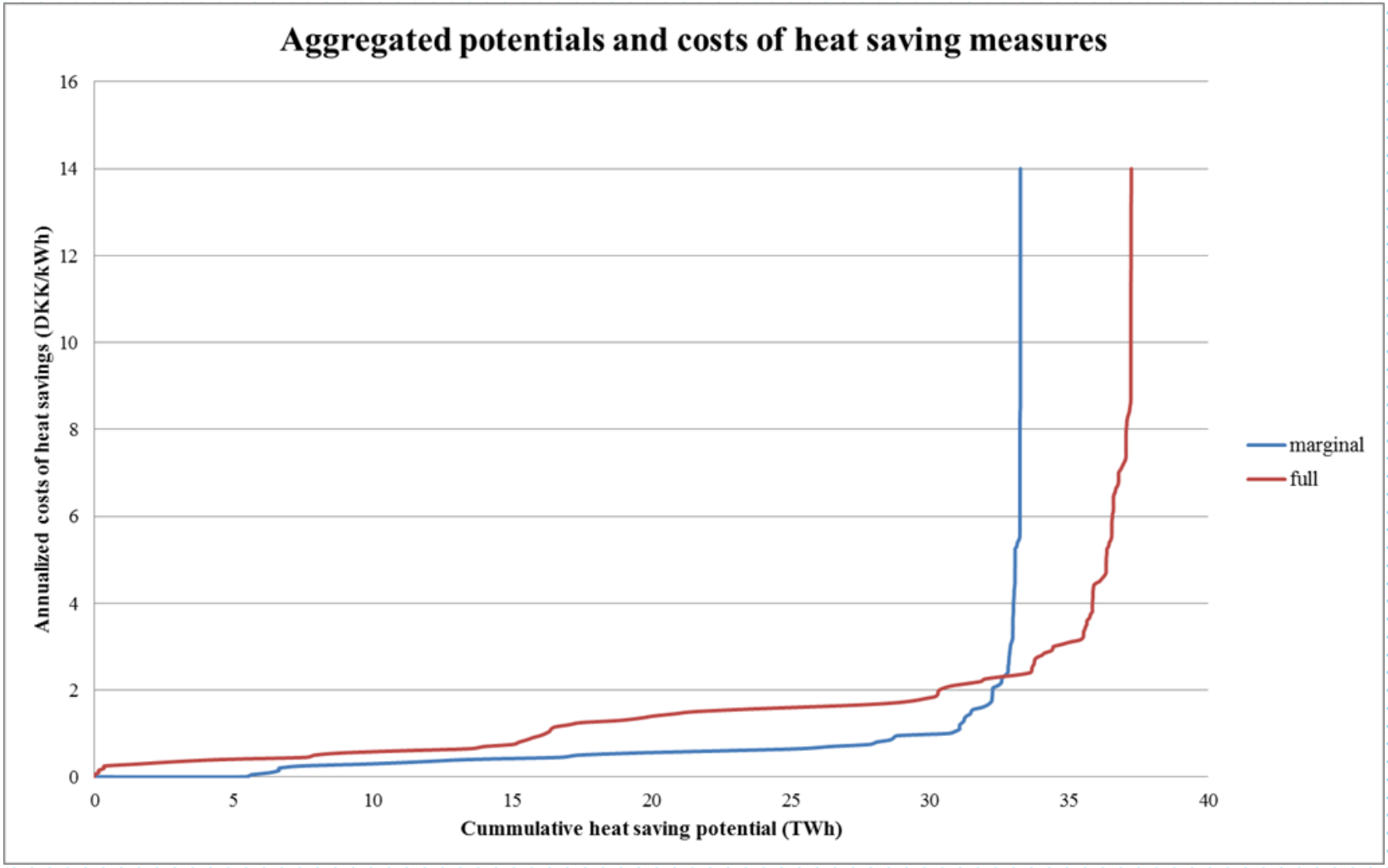
Model for determining geographical distribution of heat saving potentials in Danish building stock – potentials and marginal costs



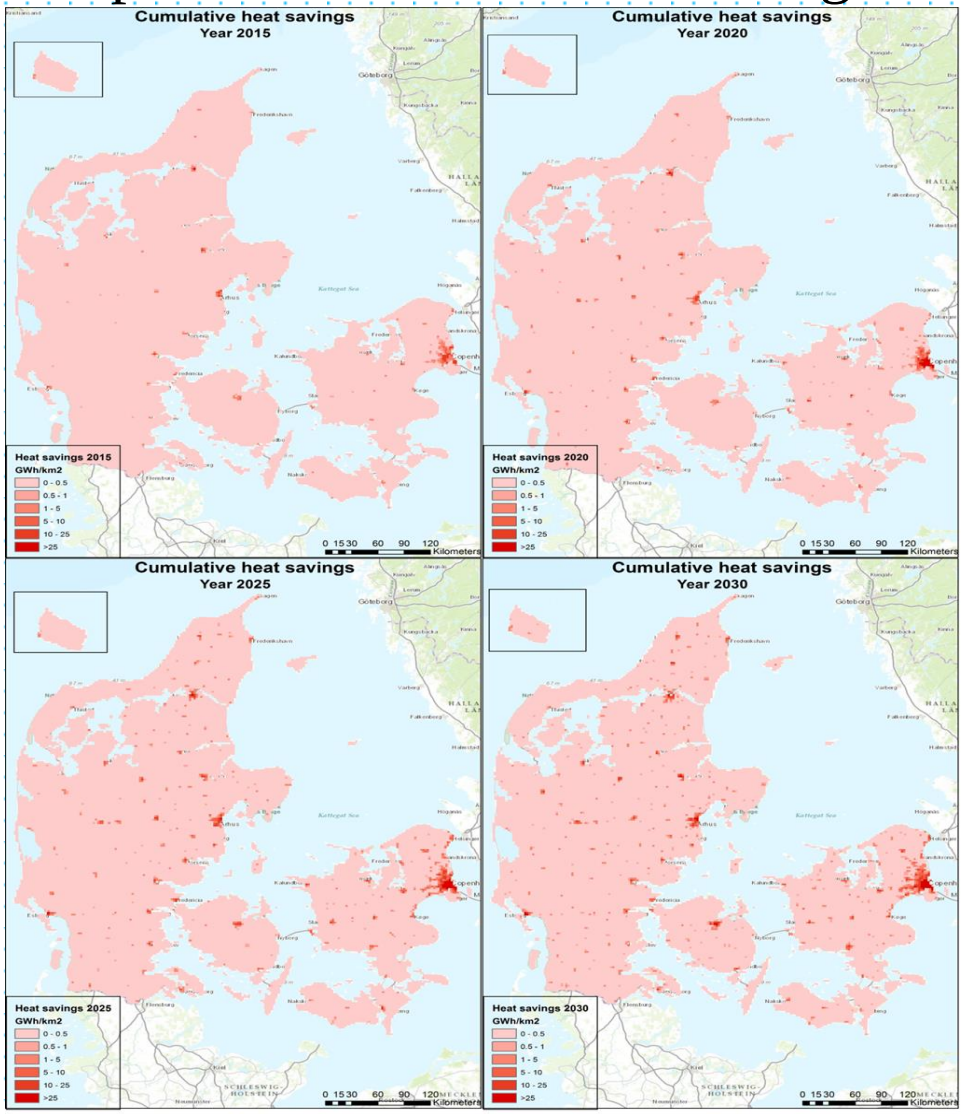
Model for determining geographical distribution of heat saving potentials in Danish building stock – potentials and full costs

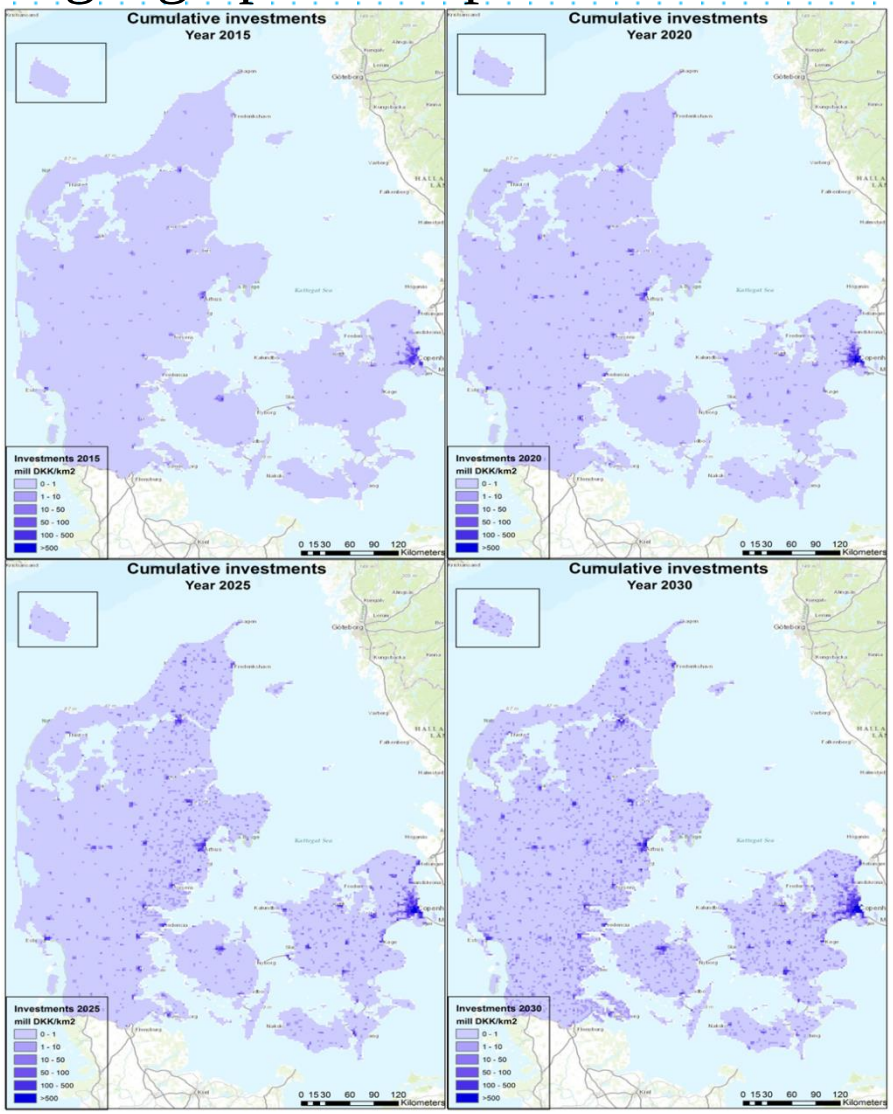


Model for determining geographical distribution of heat saving potentials in Danish building stock – aggregated curves



Model for determining geographical distribution of heat saving potentials in Danish building stock – geographical aspect





Danish heat atlas as a support tool for energy system models

- Presented a method for calculating costs of expanding district heating networks.
- Presented how marginal cost curves of heat savings and DH expansion can be approximated for use in TIMES model for Denmark.
- Presented how heat atlas can be used for visualization of results.

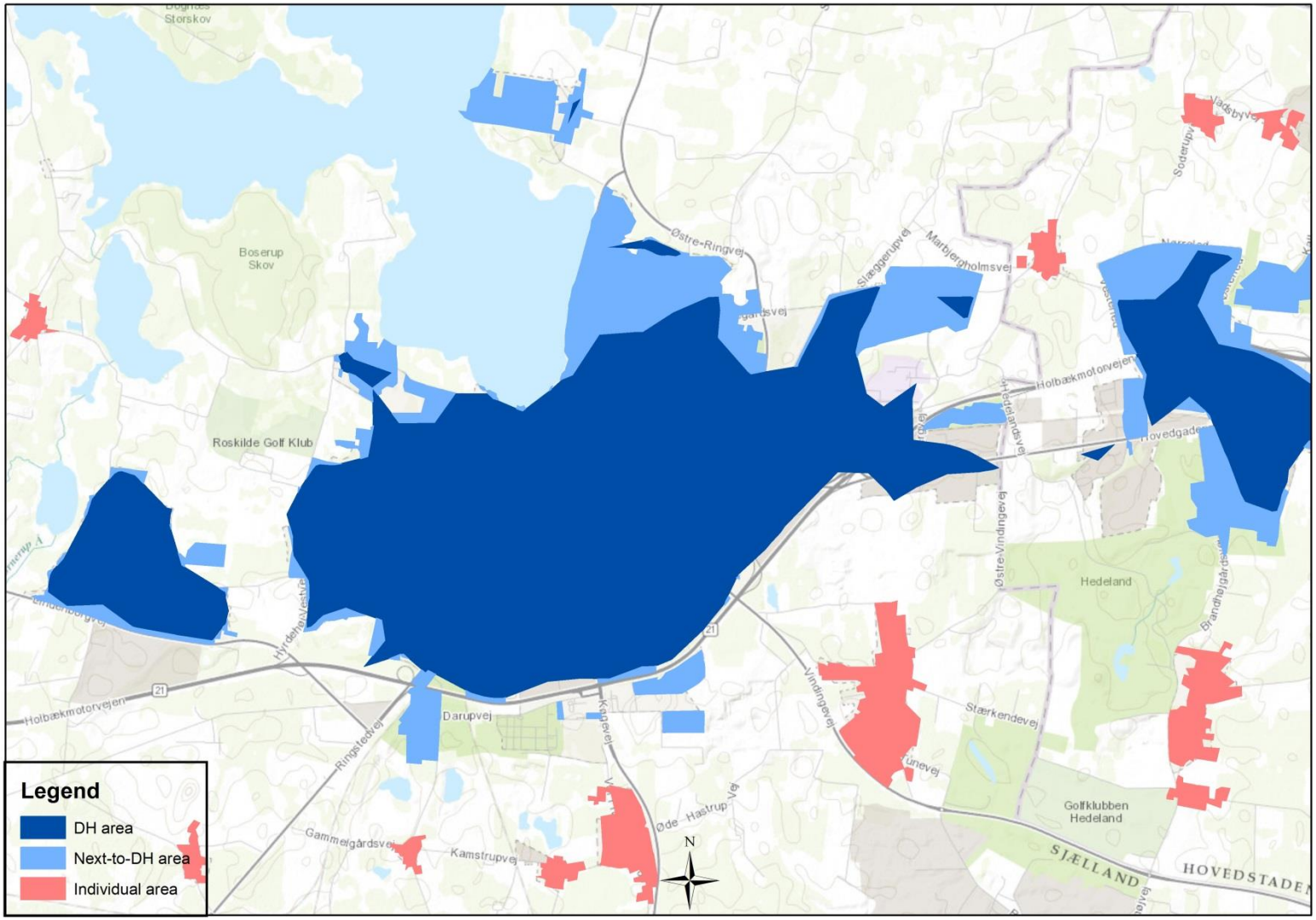
Danish heat atlas as a support tool for energy system models

Areas have been divided on:

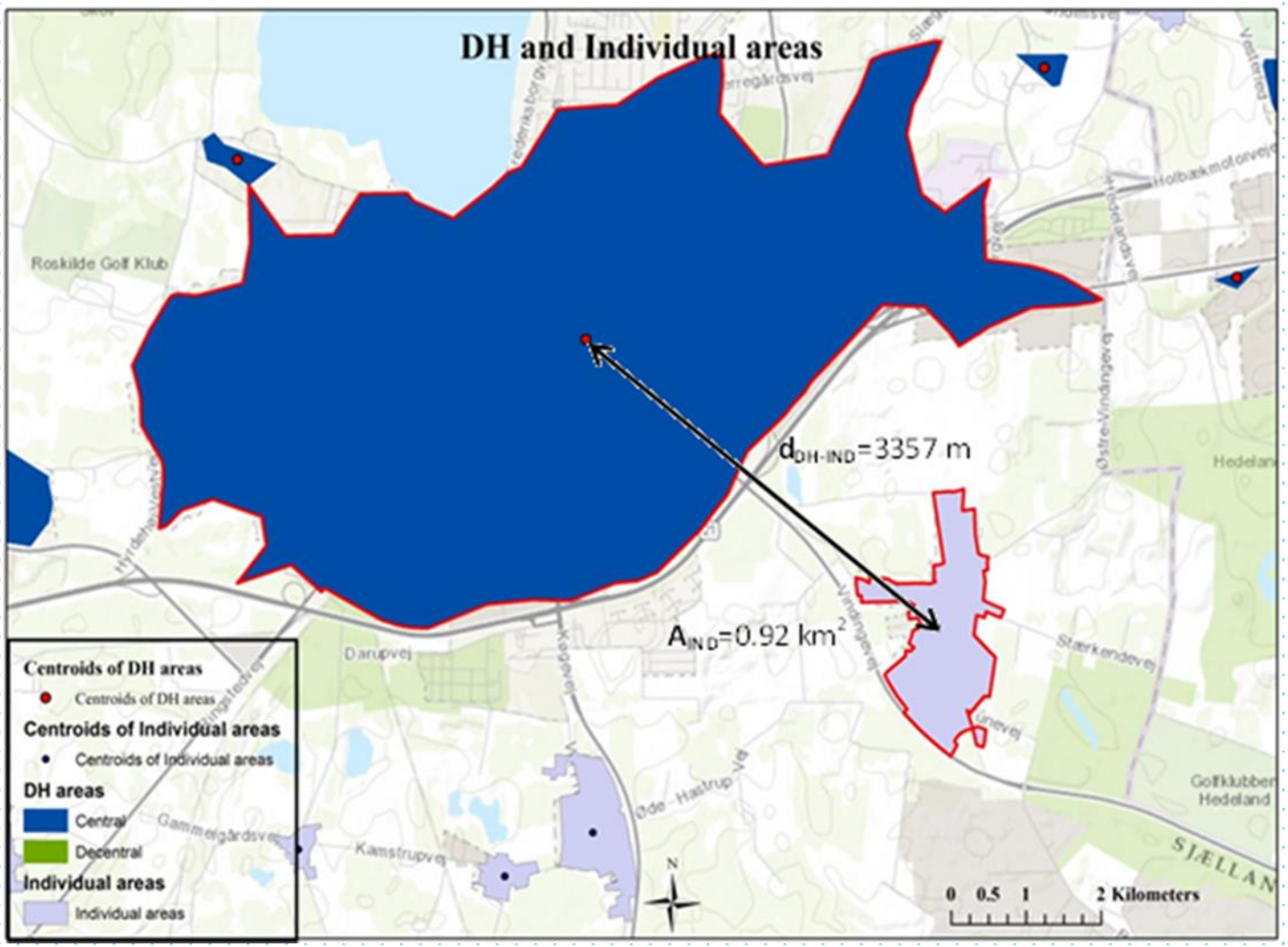
- DH areas
- Next-to-DH areas
- Individual areas

$$C = C_{TR} + C_{DIST} + C_{CONN} =$$
$$= c_{TR} \cdot d_{DH-IND} + c_{DIST} \cdot A + \left(c_{CONN,s} + c_{HE,s}\right) \cdot n_S + \left(c_{CONN,m} + c_{HE,m}\right) \cdot n_m + \left(c_{CONN,l} + c_{HE,l}\right) \cdot n_l$$

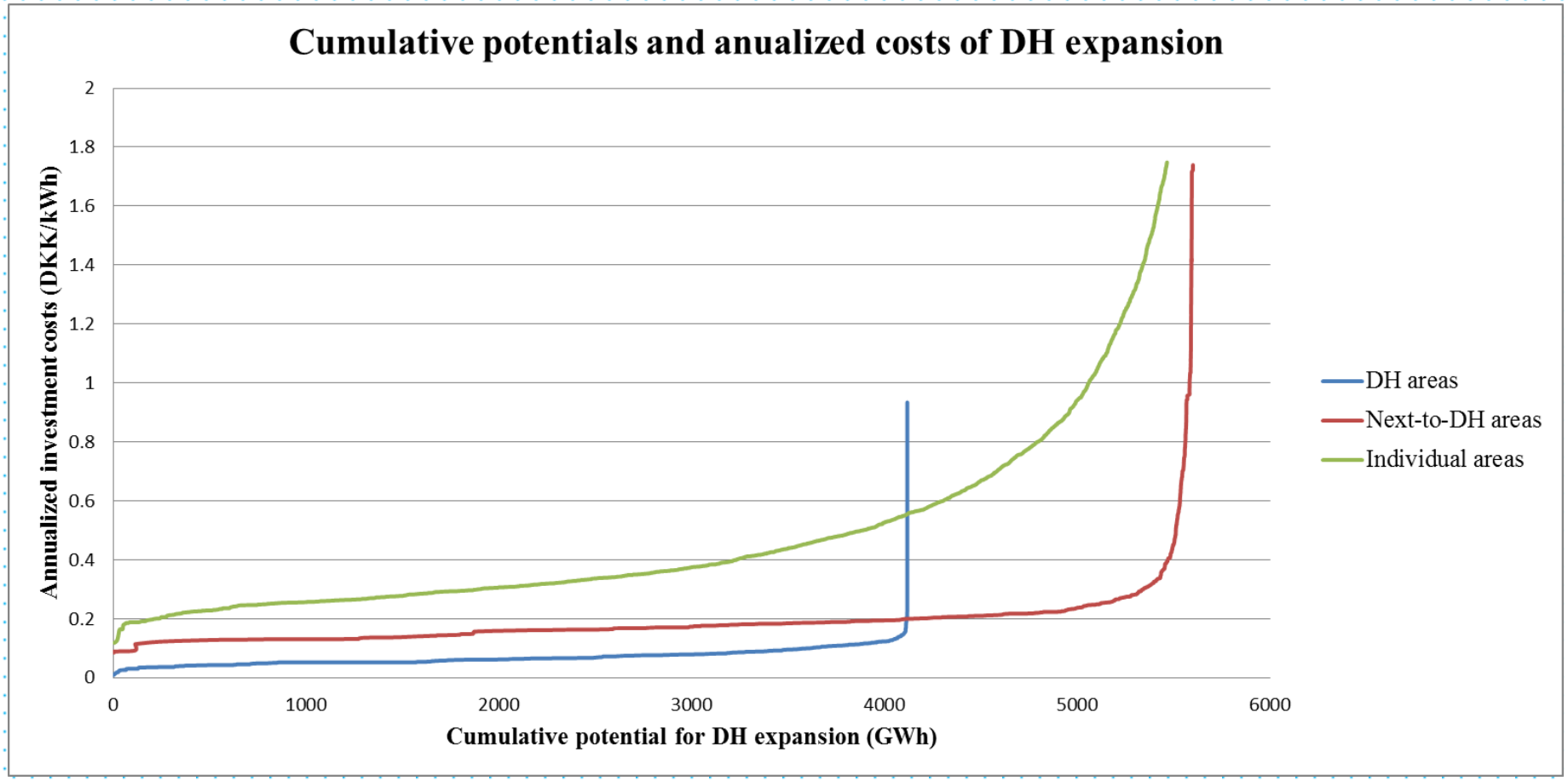
Danish heat atlas as a support tool for energy system models – DH expansion



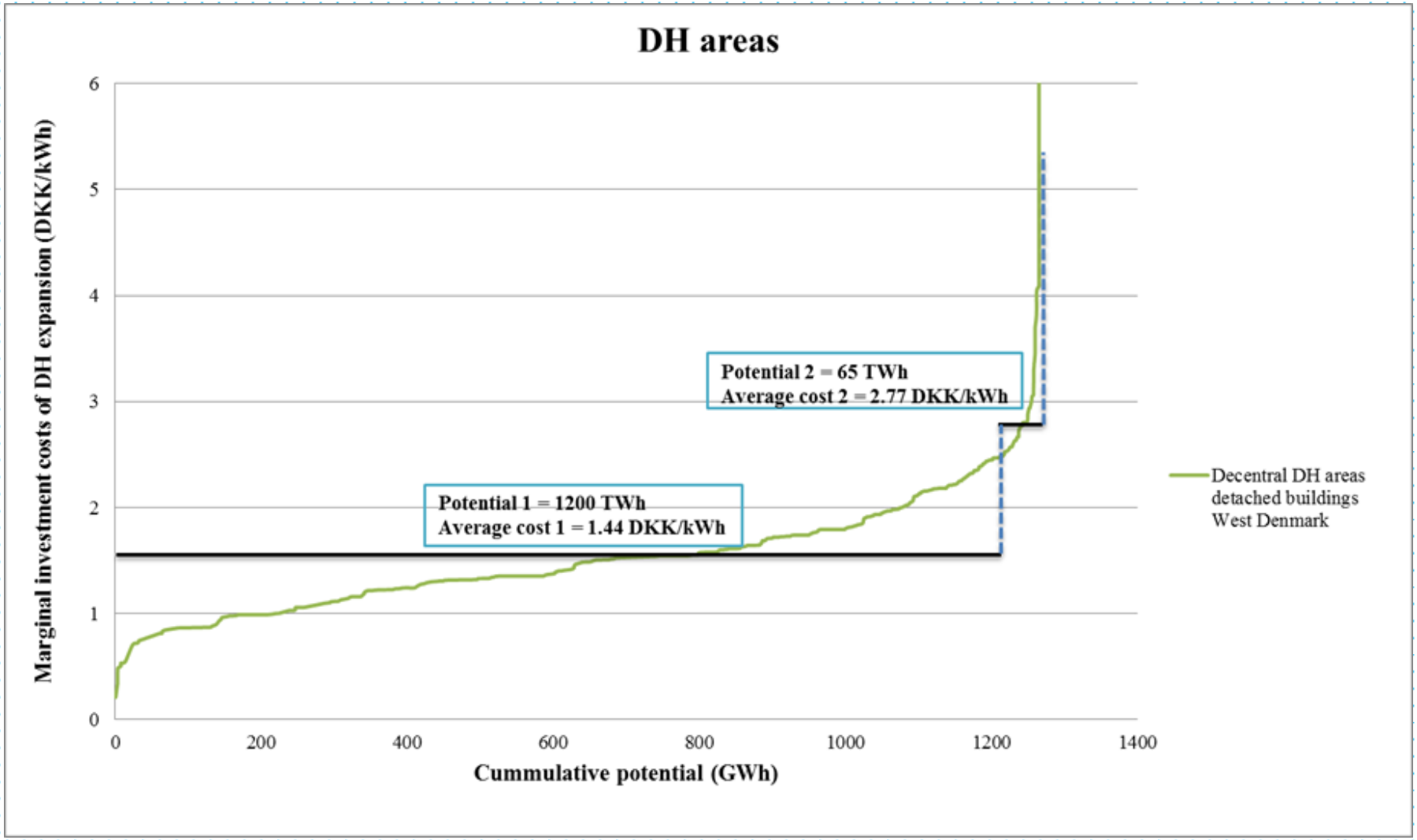
Danish heat atlas as a support tool for energy system models – DH expansion



Danish heat atlas as a support tool for energy system models – DH expansion



Danish heat atlas as a support tool for energy system models – approximation of curves

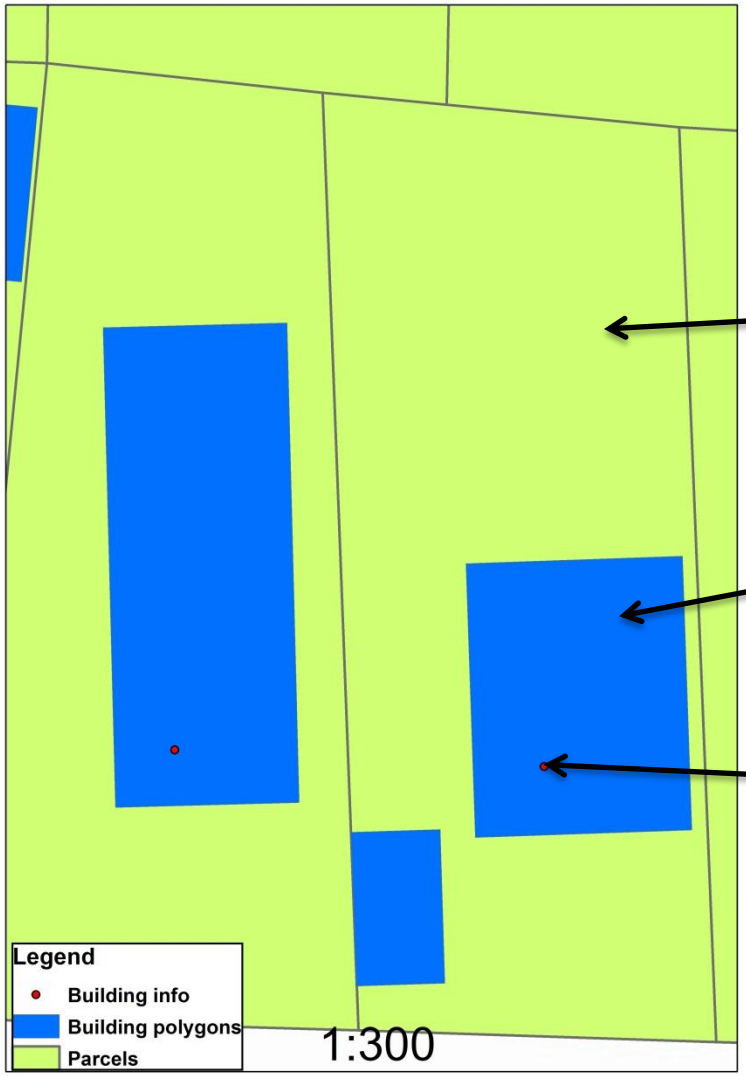


Residential heat pumps in future Danish energy system

- Introduced variable COP factors for ASHPs and GSHPs.
- Converted spatial constraints related to GSHP to energy constraints.
- Explored the role of residential heat pumps until 2050 using TIMES model for Denmark.

Residential heat pumps in future Danish energy system – spatial constraints

$$W_h = P_{h,spec} \cdot A_{av} \cdot k_{area} \cdot T_{flh} \cdot \frac{COP_{av}}{COP_{av} - 1}$$



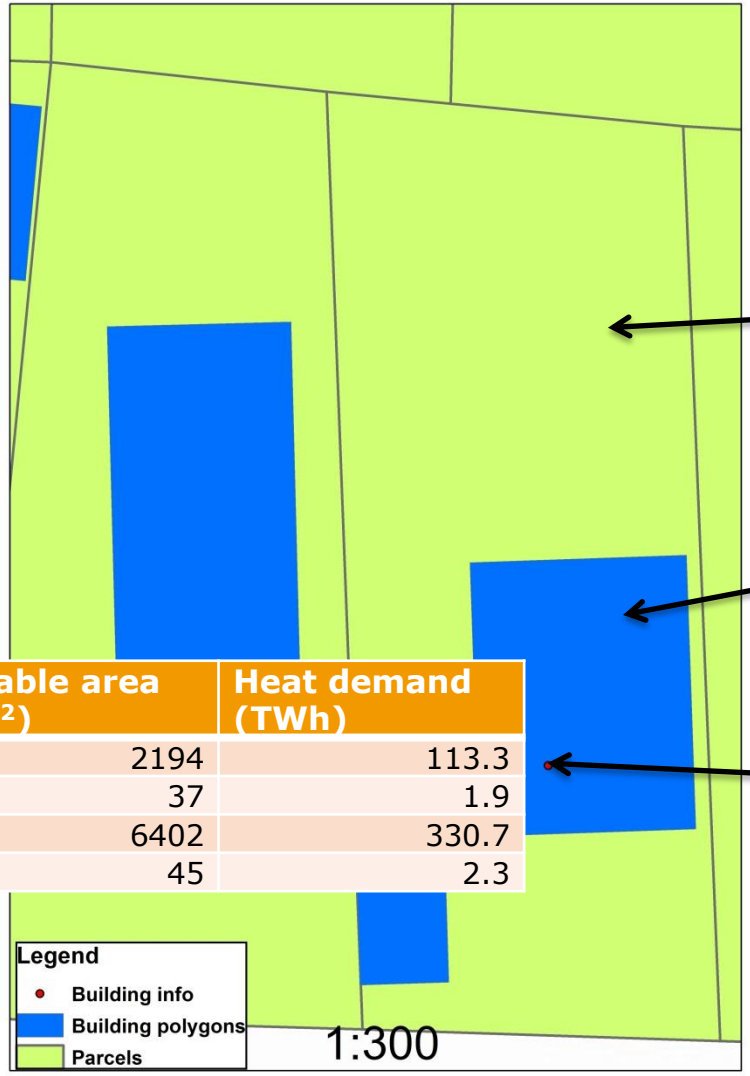
Available parcel area (green)

Building's ground area (blue)

Information about building (red point)

Residential heat pumps in future Danish energy system – spatial constraints

$$W_h = P_{h,spec} \cdot A_{av} \cdot k_{area} \cdot T_{flh} \cdot \frac{COP_{av}}{COP_{av} - 1}$$



Available parcel area (green)

Building's ground area (blue)

Information about building (red point)

Region	Building type	Useable area (km²)	Heat demand (TWh)
East	Detached	2194	113.3
East	Multi-storey	37	1.9
West	Detached	6402	330.7
West	Multi-storey	45	2.3

Thank you for your attention

Questions and answers

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