Use of Danish Heat Atlas and energy system models for exploring renewable energy scenarios

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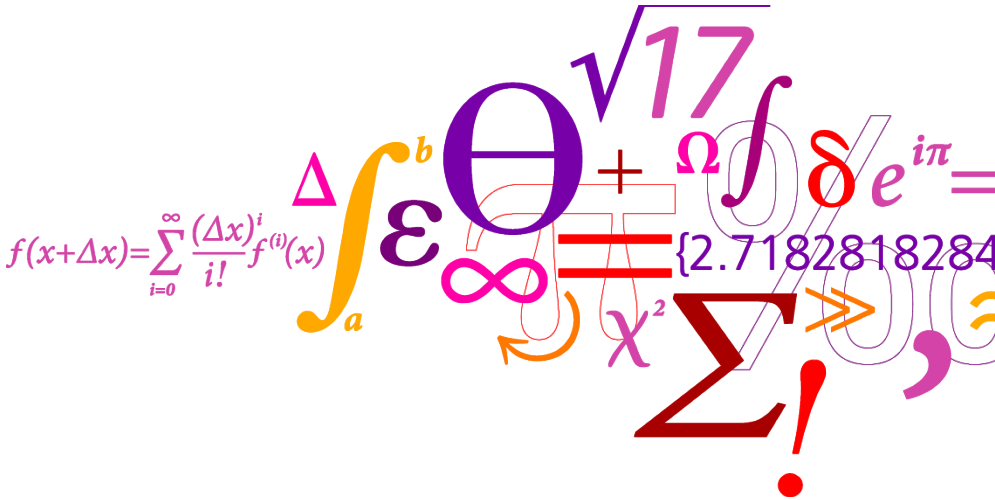

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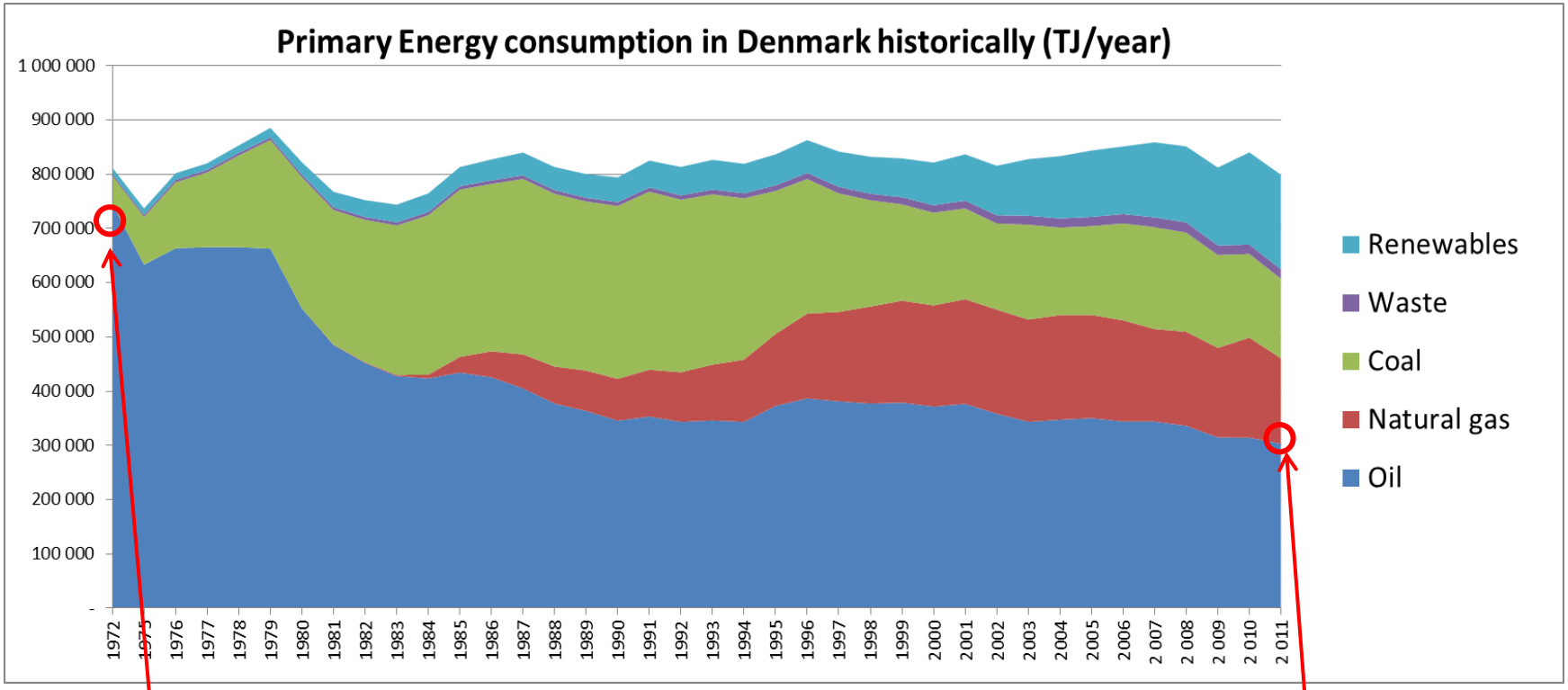
Denmark now and then – example of transition

- Before 1973 Denmark was totally dependent on imported oil – 92% of total primary energy consumption was based on oil
- Increase in oil prices denoted start of energy planning
- Strategies: Energy efficiency improvements and energy saving measures
- Results: Heat demand in buildings reduced by 26% while area increased for more than 50%; share of for covering heat demand in buildings oil reduced from ~90 to ~10 %
- Consequences: Reduced environmental impact
  Reduced impact of changing of oil prices
  Improved security of supply

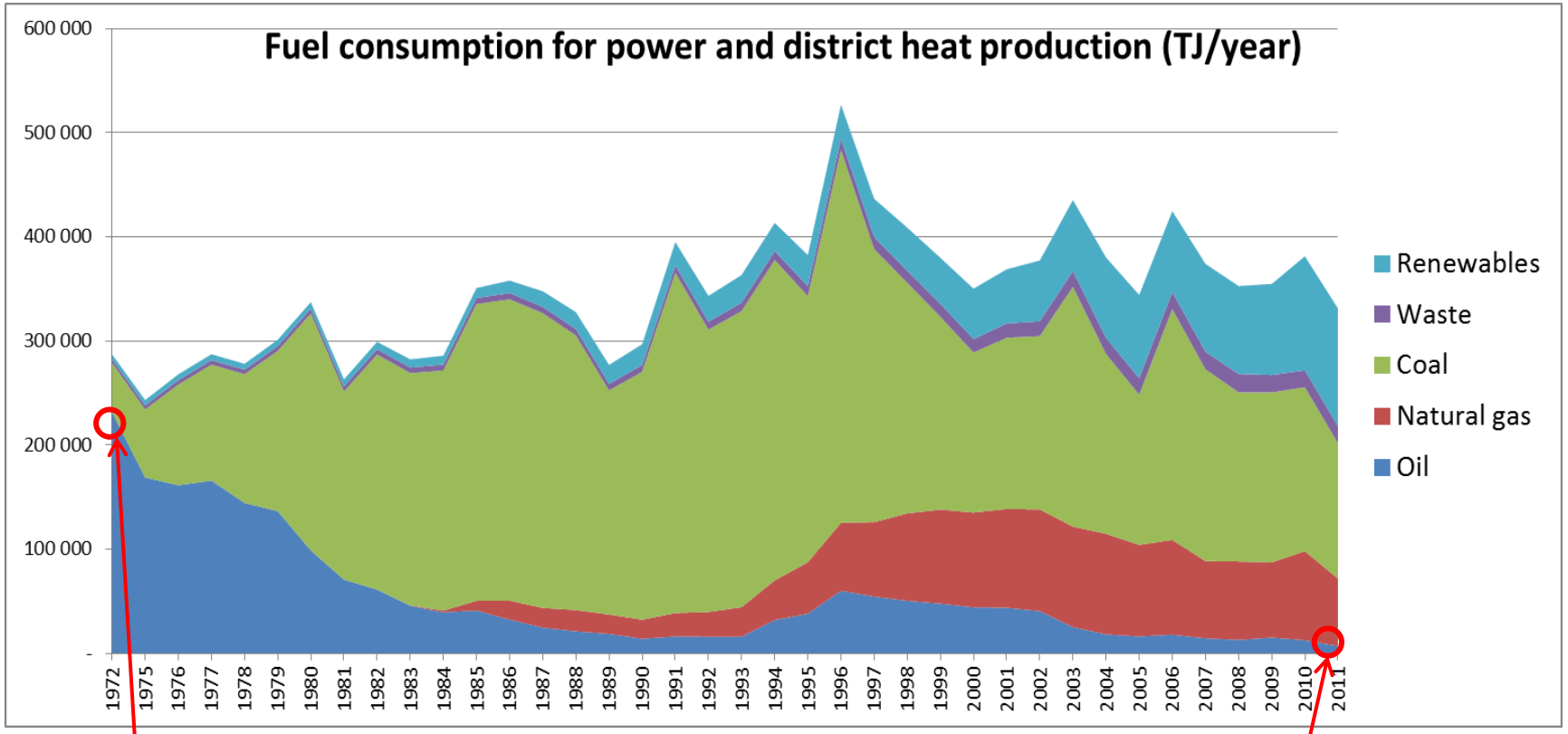
Denmark now and then – example of transition



Oil consumption in 1972

Oil consumption in 2011

Denmark now and then – example of transition



Oil consumption in 1972

Oil consumption in 2011

Denmark now and then – How ?

- Energy efficiency – District heating and CHPs

  52 % of net heat demand is covered by district heating

  76 % of district heat is produced in CHPs

  One third of energy from CHPs is based on renewables

- Energy savings – Reducing heat demand in buildings

  Tightening building regulations

  Aiming at NZEBs

- Denmark goes further – further than EU 2020 goals

  30 % of final energy demand supplied from renewables in 2020

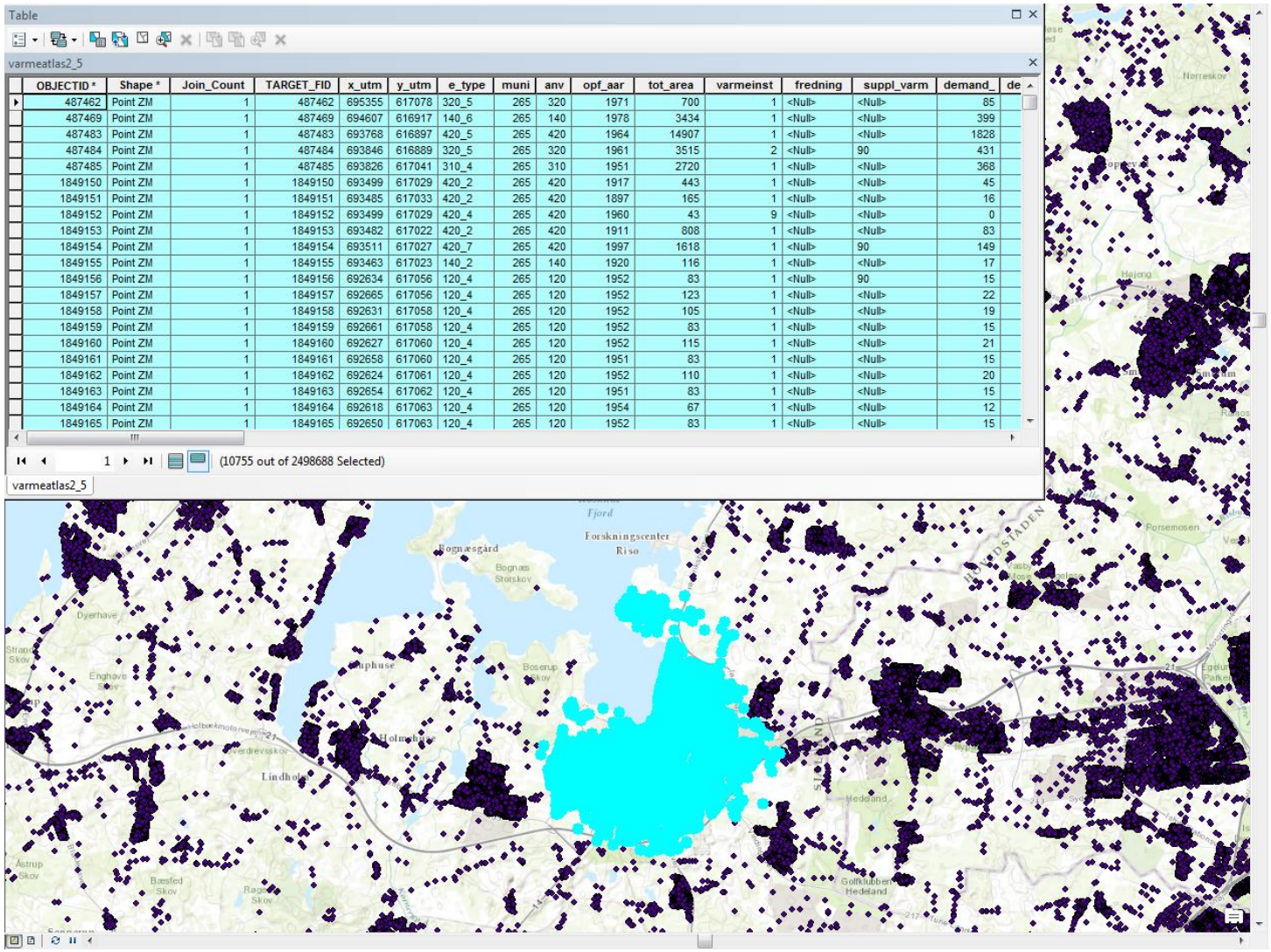
  100 % renewable energy for power and heat production in 2035

  100 % renewable energy system in 2050

Heat Atlas – what is it?

- Bernd Möller, (2008) "A heat atlas for demand and supply management in Denmark", Management of Environmental Quality: An International Journal, Vol. 19 Iss: 4, pp.467 – 479
- GIS based collection of spatially referenced data about 2.5 million buildings in Denmark, along with information about age, area, use, heat installations, conservation status …
- Other information could be added – property value, level of income of inhabitants,…
- Other "thematic layers" could be added – district heating areas and transmission networks, power plants, biomass and solar resources…

Heat Atlas – What does it look like?



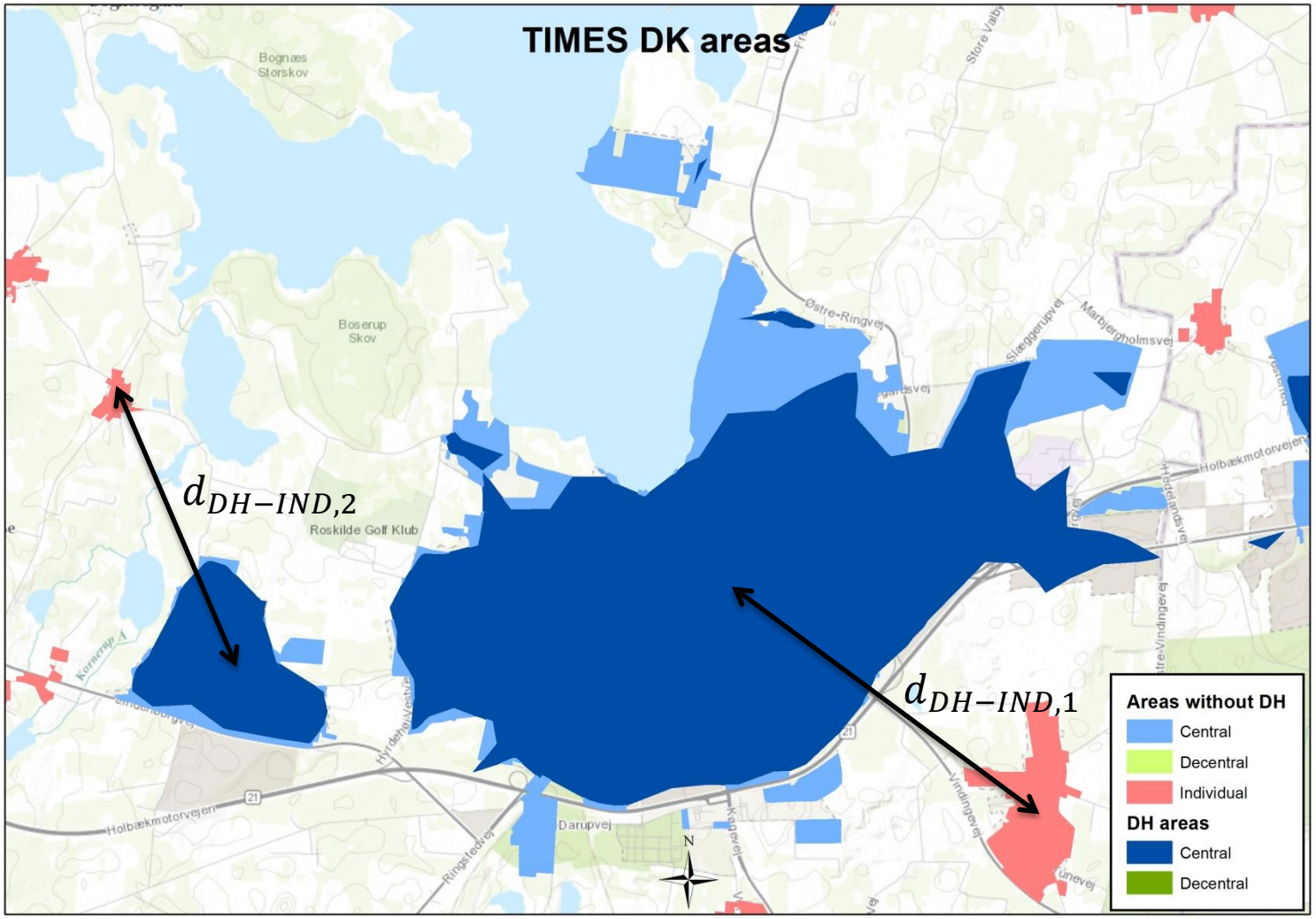
Heat atlas as basis for calculations

- Multiple studies show that gradual expansion of district heating and heat savings in building stock are important aspect towards 100 % renewable energy systems
- Low-temperature district heating in high heat density areas and heat pumps in low heat density areas – heat density analysis can be carried out in GIS
- Heat atlas can deliver basis for analysis of district heating expansion and heat saving calculations – position, age, use, heat demand, source of heating and potentials and costs of heat savings on building level

Heat atlas for analysis of expansion of district heating

- Utilizes waste heat, adds flexibility to energy system with increasing share of wind power
- But it has high investment costs and high transmission losses
- GIS can be used to delineate DH areas, Next-to-DH areas and Individual areas and to find the costs of connecting these areas

Heat atlas for analysis of expansion of district heating



Heat atlas for analysis of expansion of district heating

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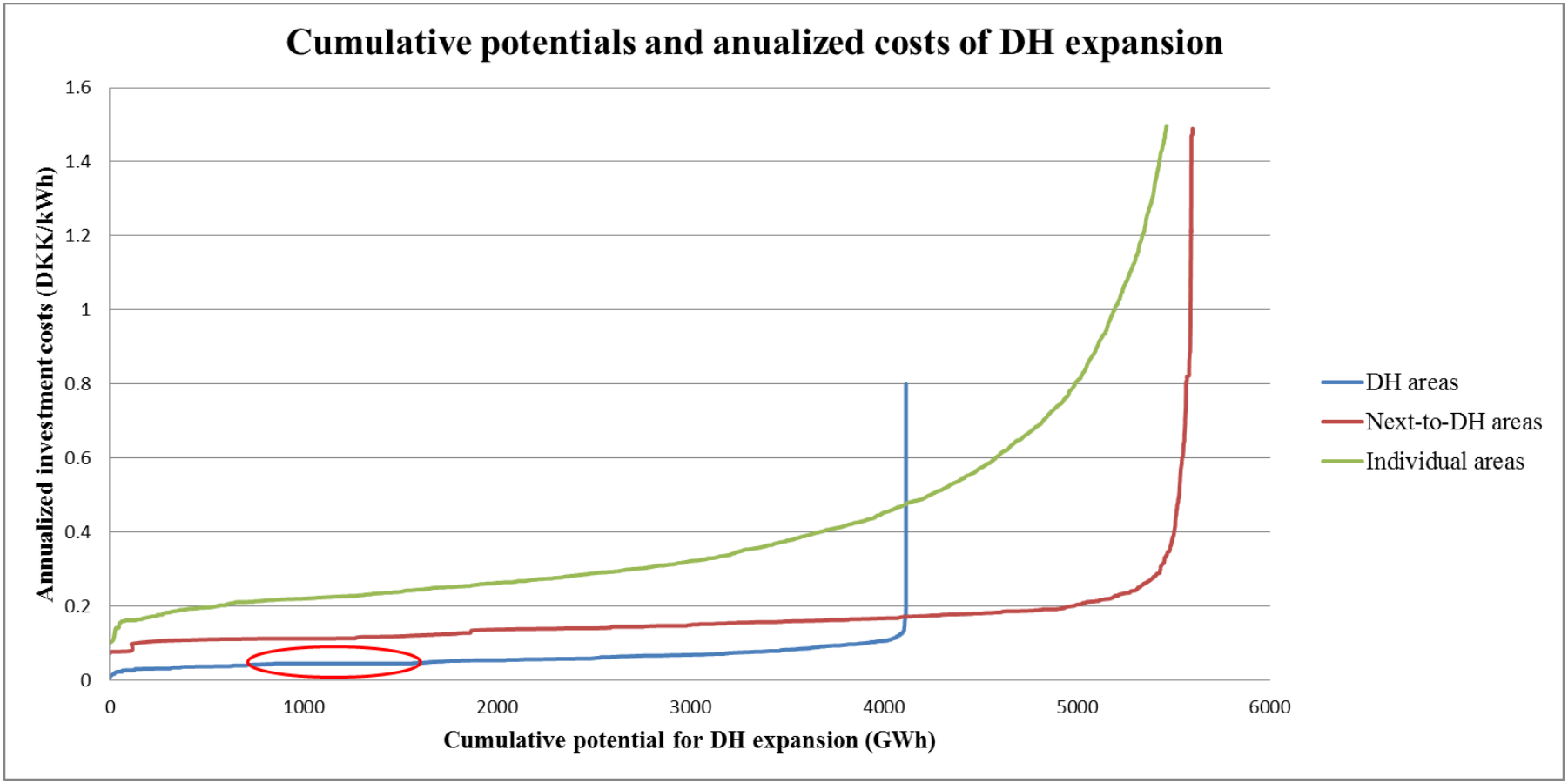
- But it has high investment costs and high transmission losses
- GIS can be used to delineate DH areas, Next-to-DH areas and Individual areas and to find the costs of connecting these areas
- Cost of connecting certain area to district heating:

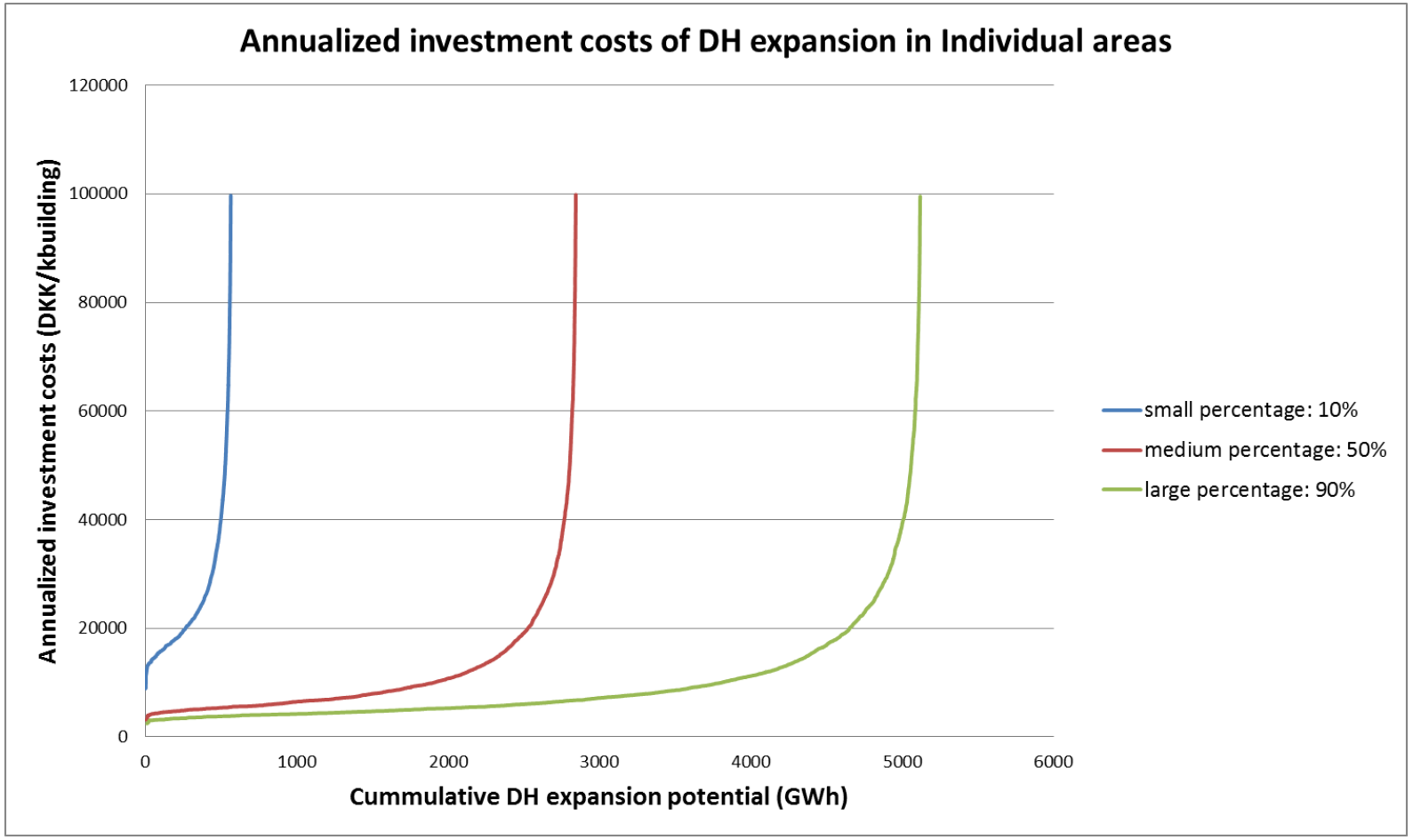
$$C = C_{TR} + C_{DIST} + C_{CONN} =$$
$$c_{TR} \cdot d_{DH-IND} + c_{DIST} \cdot A + \left(c_{CONN,s} + c_{HE,s}\right) \cdot n_s + \left(c_{CONN,m} + c_{HE,m}\right) \cdot n_m + \left(c_{CONN,l} + c_{HE,l}\right) \cdot n_l$$

- Costs of transmission, distribution and connection infrastructure are included
- GIS and heat atlas made possible to include information about area, demand, distances, heat demand and number of buildings

Heat atlas for analysis of expansion of district heating - result



Heat atlas for analysis of expansion of district heating - result



Heat atlas for analysis heat savings in building stock

- Heat atlas contains information about age, use, area of buildings
- Data about physical building properties are taken from reports made by SBi and DTU Byg
- Calculations are done in 3 steps:

1. Calculating current heat demand

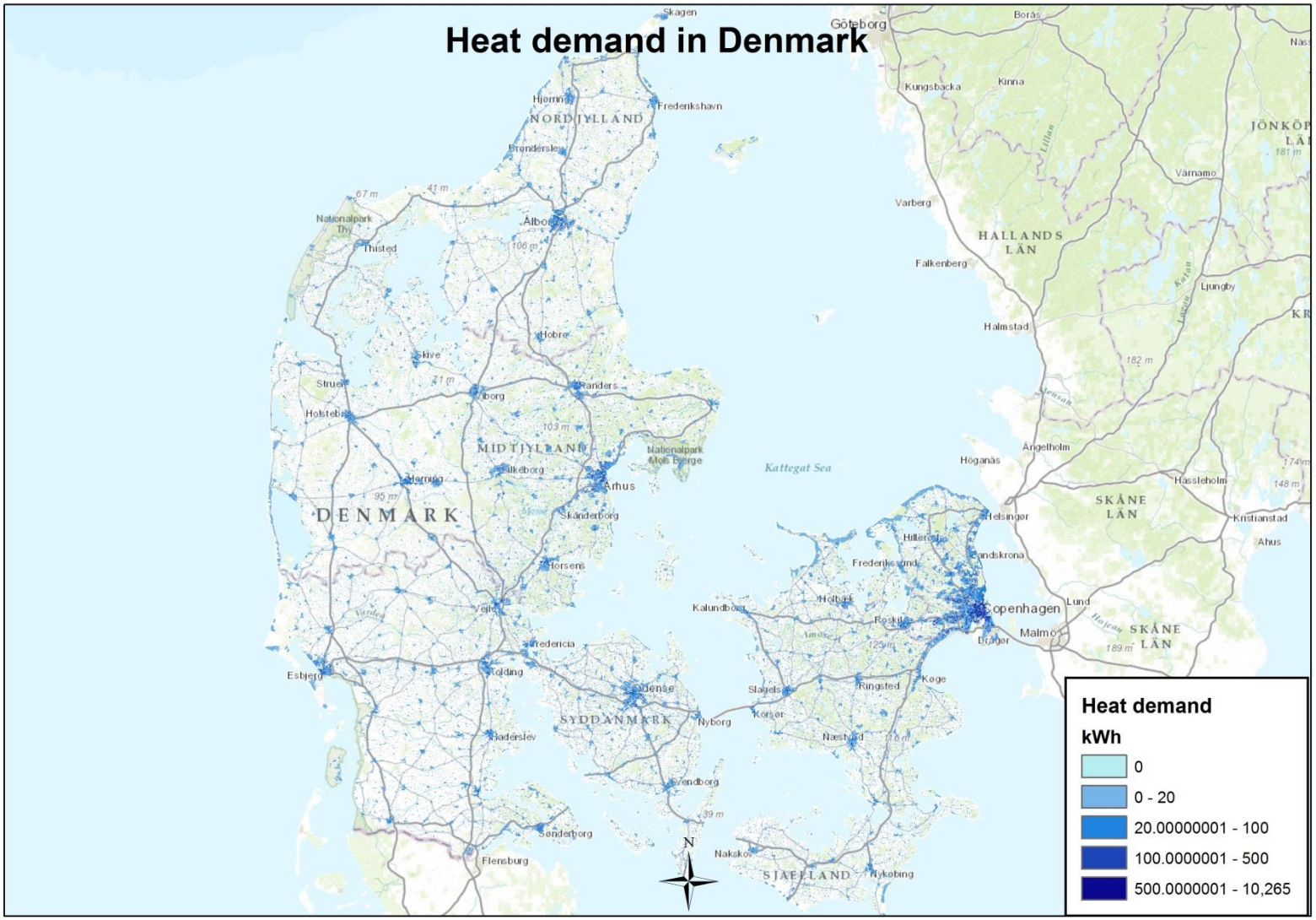
$$H_{dem} = H_{env} + H_{ven} + H_{dhw} - H_{sol} - H_{int}$$

2. Calculating heat savings for different elements of building envelope

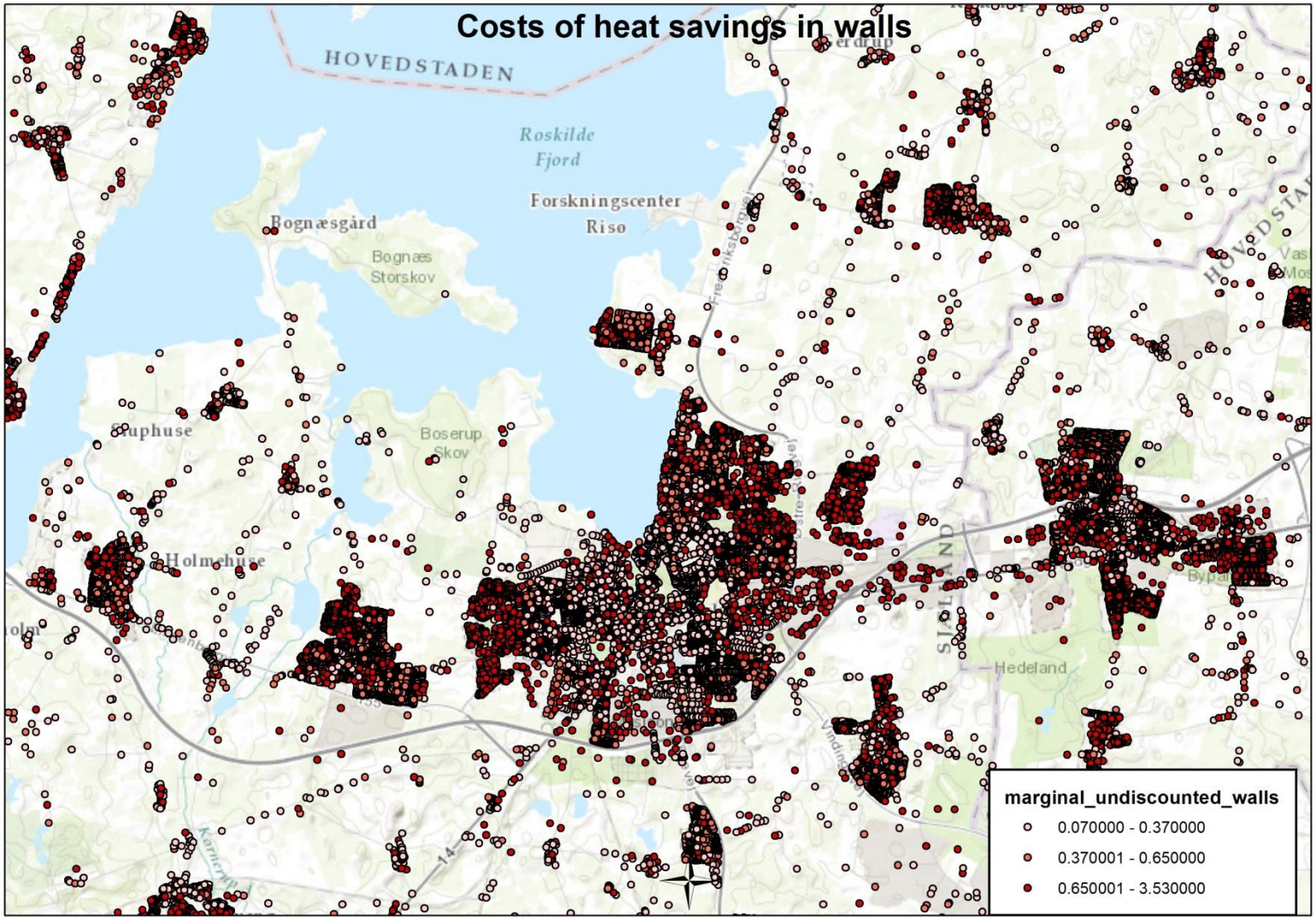
$$SAV_{env} = \sum_{m} \sum_{elem} \left(u_{elem,old} - u_{elem,new}\right) \cdot A \cdot f_{elem} \cdot \left(t_{ind} - t_{out,m}\right) \cdot d_m \cdot k_{24} \cdot k_{elem,t}$$

3. Calculating costs of heat savings (marginal and full)

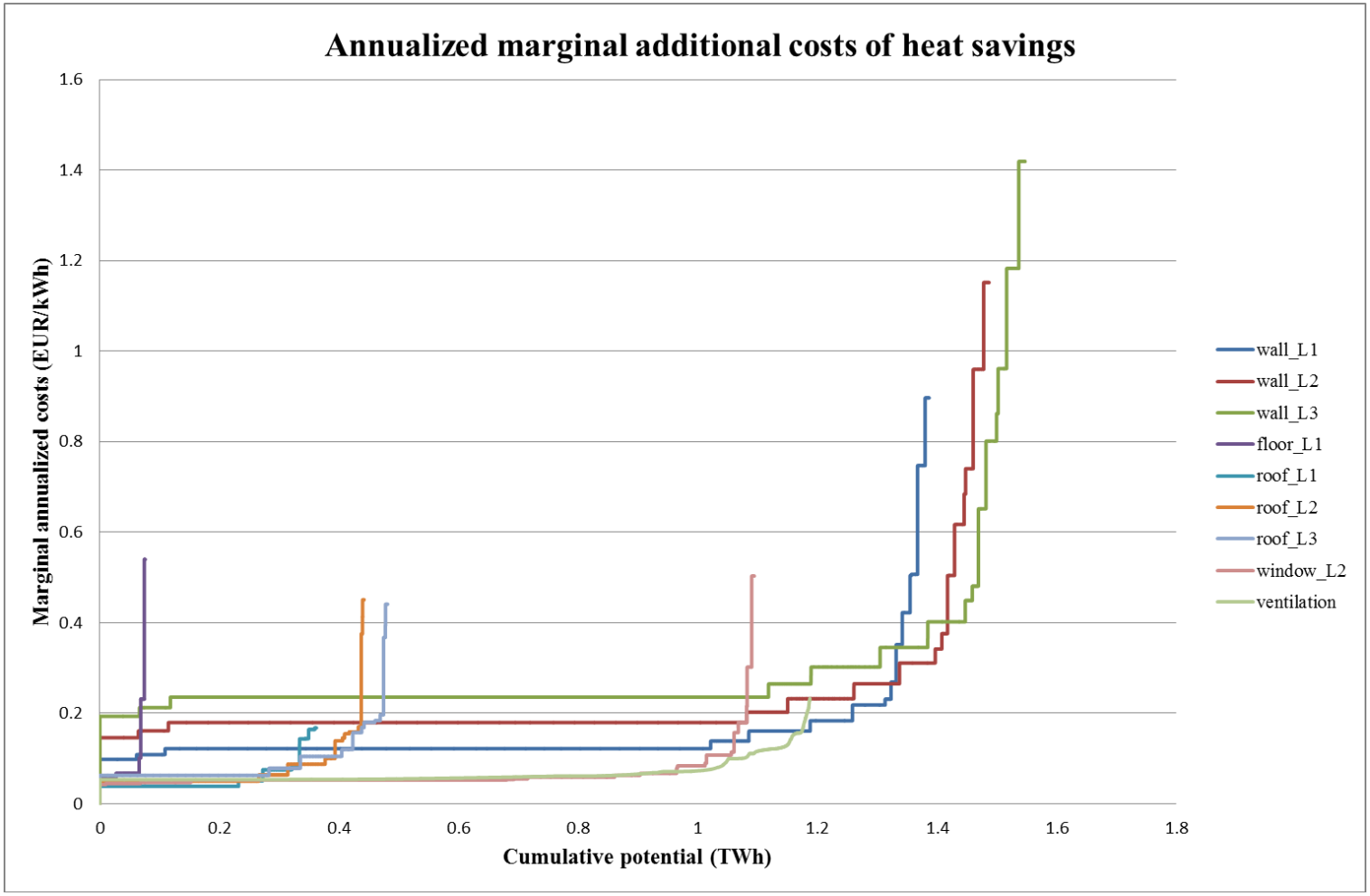
Map of heat demand



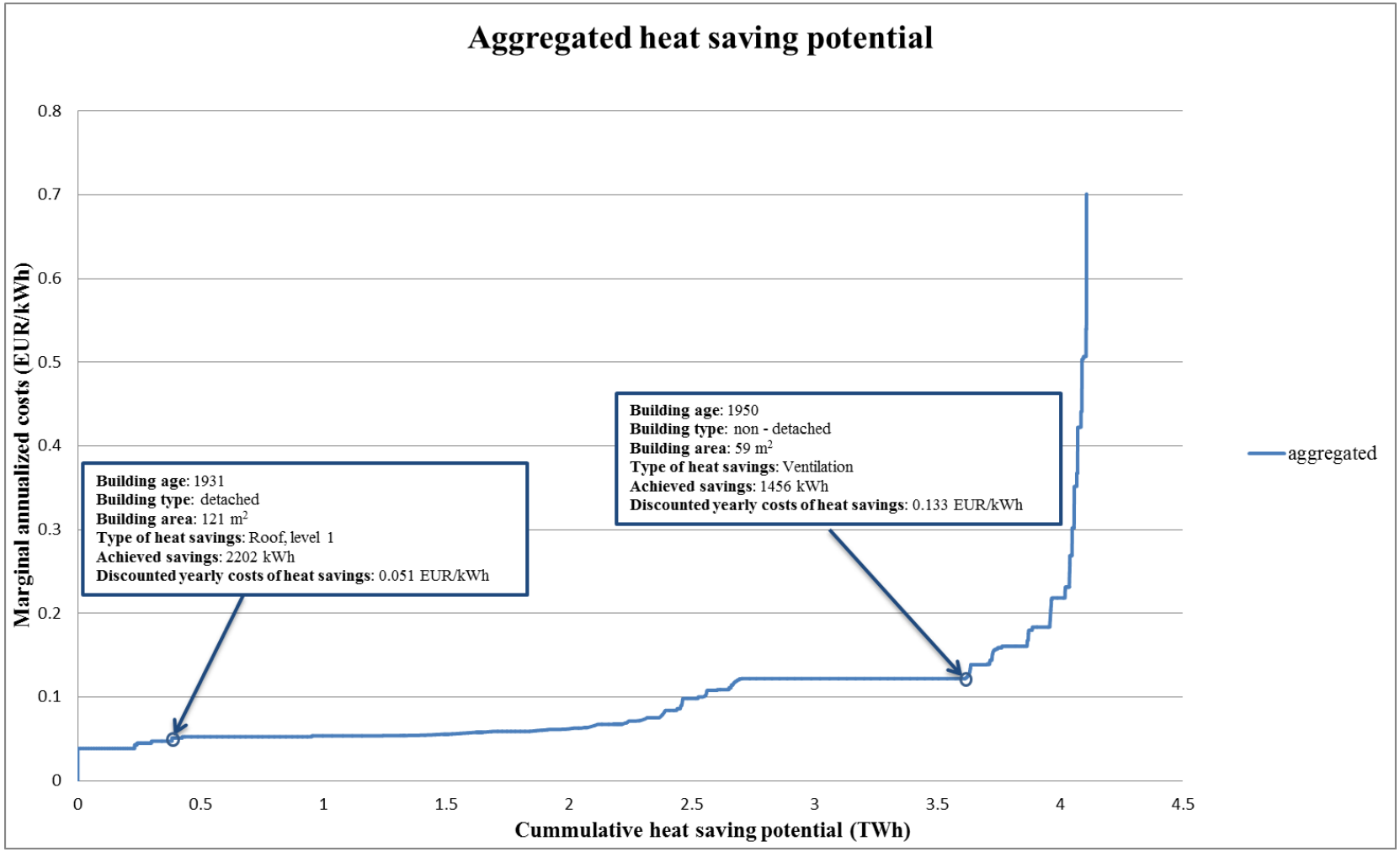
Map of costs of heat savings



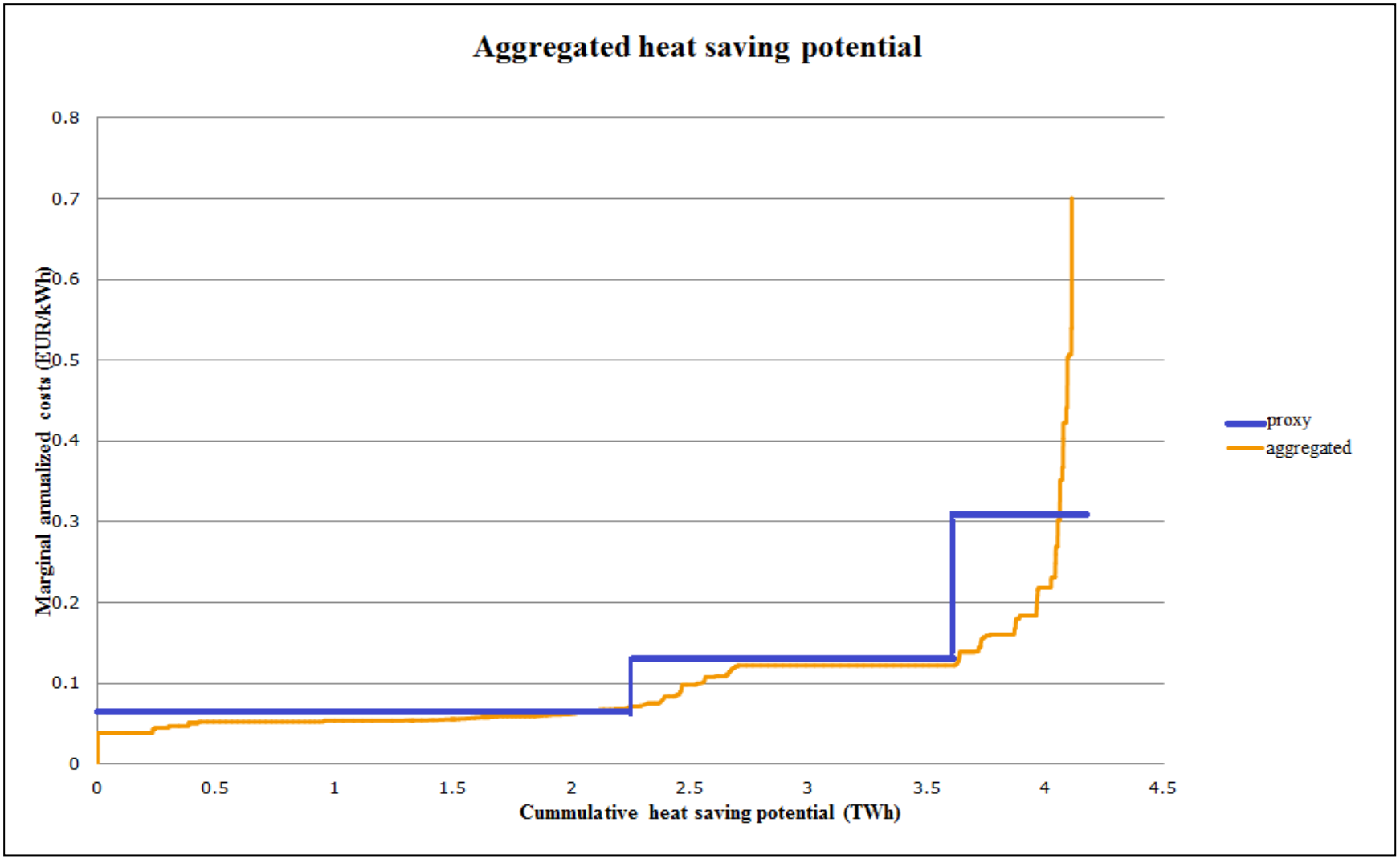
Heat atlas for analysis heat savings in building stock - results



Heat atlas for analysis heat savings in building stock - results



Heat saving curves as inputs to TIMES model for Denmark



Heat atlas – resume

- Heat atlas is useful as data container, pre-analysis tool and as tool for spatially representing results
- Could be improved by adding information about power plants, transmission facilities, energy resources, but social parameters would also be useful (number of inhabitants, their age, level of income,…)

Thank you for your attention

Questions and answers

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