

PhD project:

Geographical representations of renewable energy systems

PhD Student: Stefan Petrovic,
DTU Management Engineering
System Analysis Division
Energy System Analysis section



Supervisor: Kenneth Karlsson,
Senior Scientist, DTU
Management Engineering



Co-Supervisor: Bernd Möller,
Associate professor, Department
of Development and Planning,
Aalborg University



4th Generation District Heating Technologies and Systems

Focus of my research

- Planning of sustainable energy systems is influenced by technical, environmental, social, economic and demographic factors.
- In one sentence: Focus in my research is improvement in strategic planning by using energy system modelling tools in combination with GIS.
- In two sentences: My research is focusing on upgrading and geographically referencing renewable energy and saving potentials including residential, industrial, transportation and tertiary sector. These data will be used as input for different sustainable energy scenarios, including costs and environmental impacts.

- Spatially referenced data including energy demand, supply, energy savings potentials, renewable energy resources, social and demographic factors associated investment and operation costs will create **Energy Atlas**.

Focus of my research

Research questions:

- Which elements should be added to spatial GIS databases in order to improve its role in strategic planning?
- How can use of Energy Atlas together with energy system modelling tools improve strategic planning?
- What kind of aggregation procedure should be applied on data in spatial GIS databases so that these data can be used in Danish, temporal energy system models?
- How should data from national, temporal energy systems models be disaggregated so that these data can be used in detailed spatial GIS databases?
- Which investment, environmental, technological and social, scenario describes the optimal pathway for developing of 4th Generation District Heating Technologies and Systems?

Focus of my research

In form of a drawing:

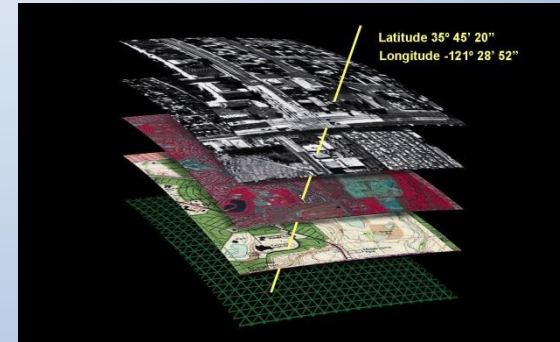


Heat Atlas in GIS

adding new layers

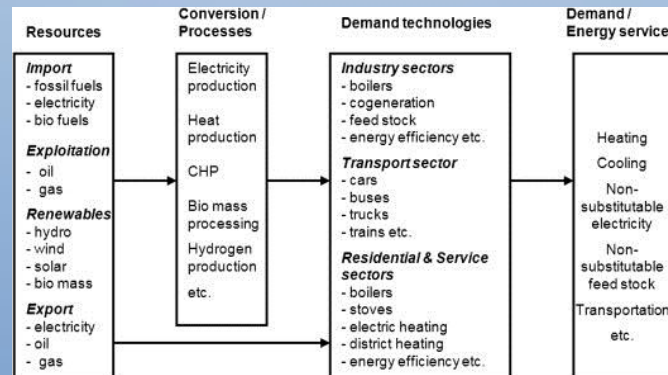


Heat savings potentials
 Energy potentials
 (wind, solar, biomass)
 Sources
 Demands



Energy Atlas in GIS

*Representing results
 from Energy System
 models*

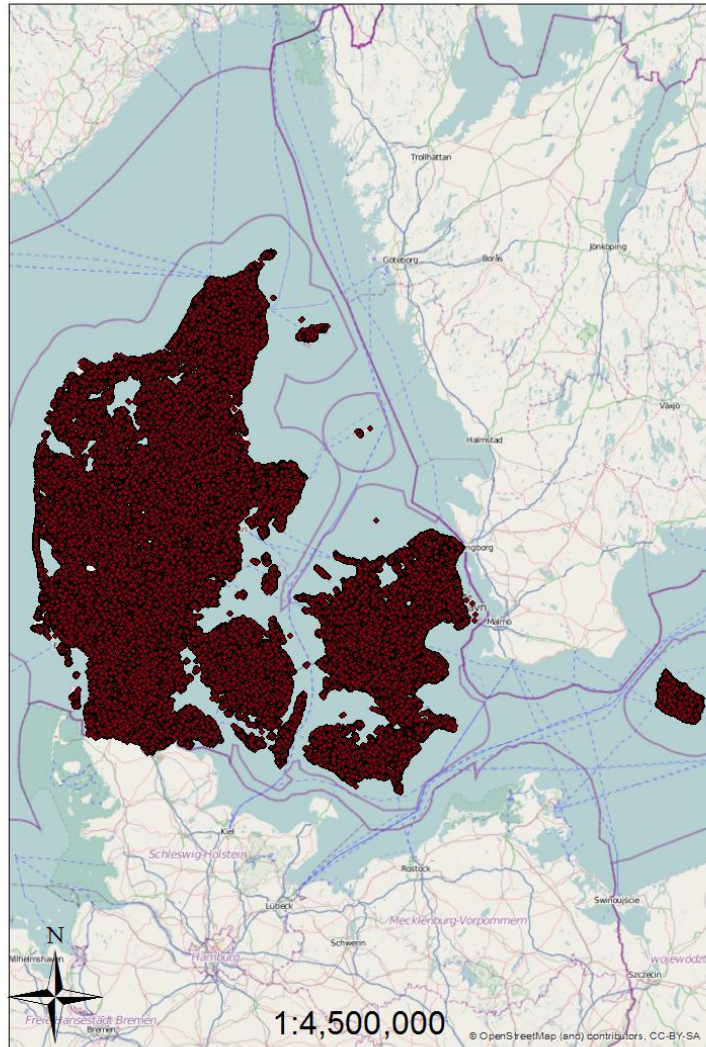


Energy System model

*Inputs to Energy
 System models*



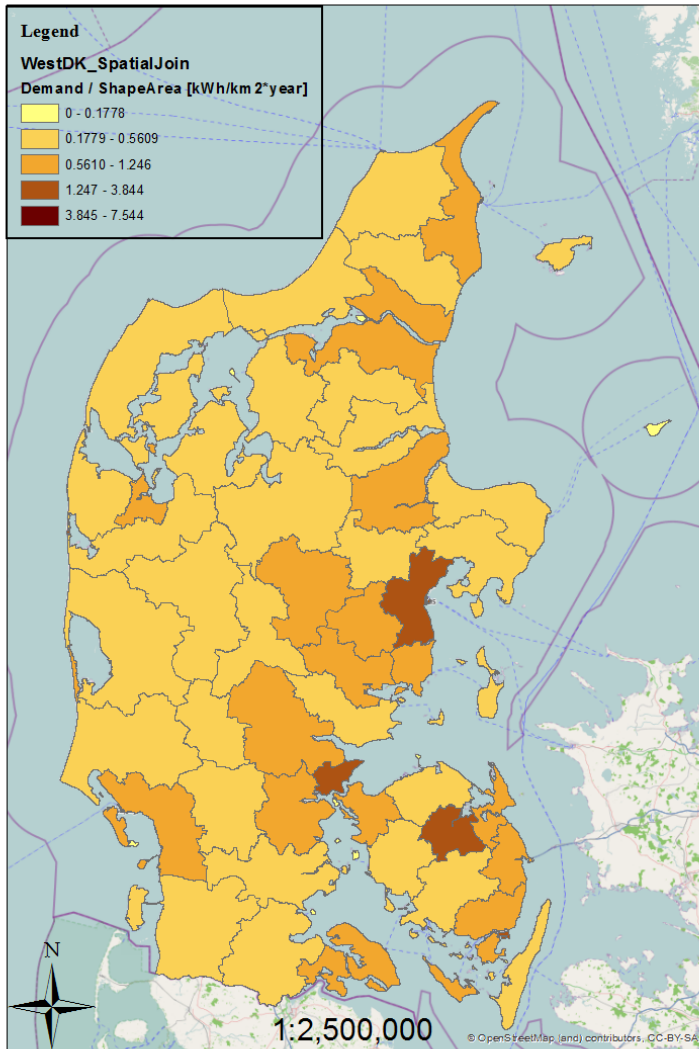
Focus of my research



Heat atlas

Contains spatially referenced data about 2,5 million buildings in Denmark including heat consumption, building area, type of heating, building age, type of building ...

Focus of my research

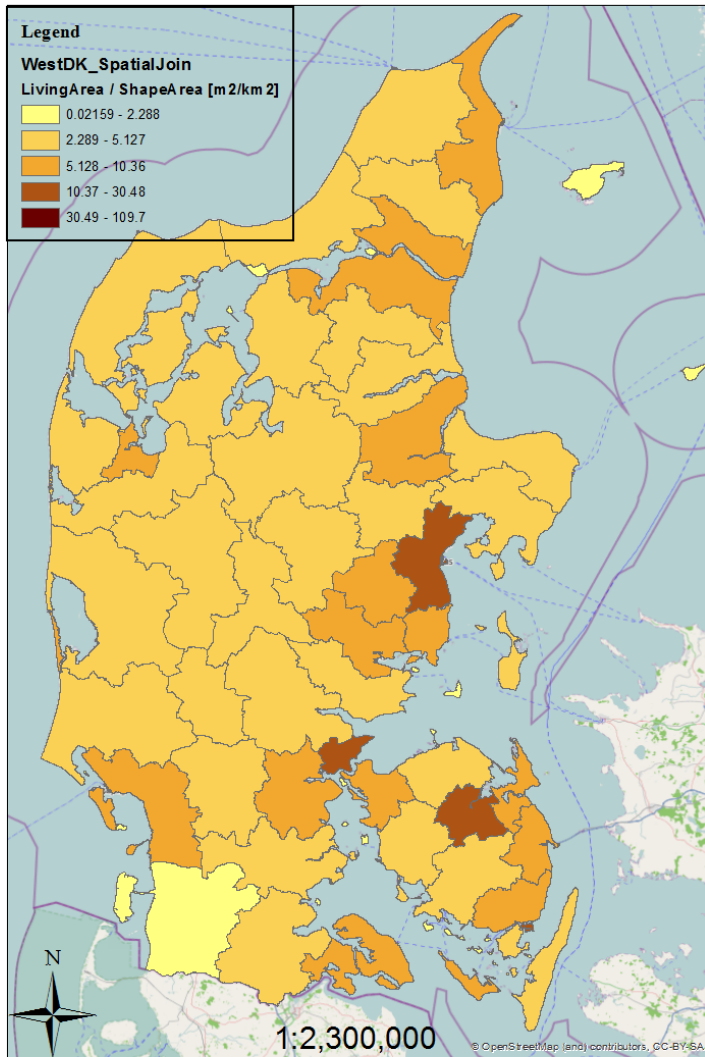


Heat Demand in communes in West Denmark normalized on commune area; only residential buildings are included.

This map is obtained by spatially joining Heat Atlas with map of communes in Denmark.

Joining rule used was SUM.

Focus of my research

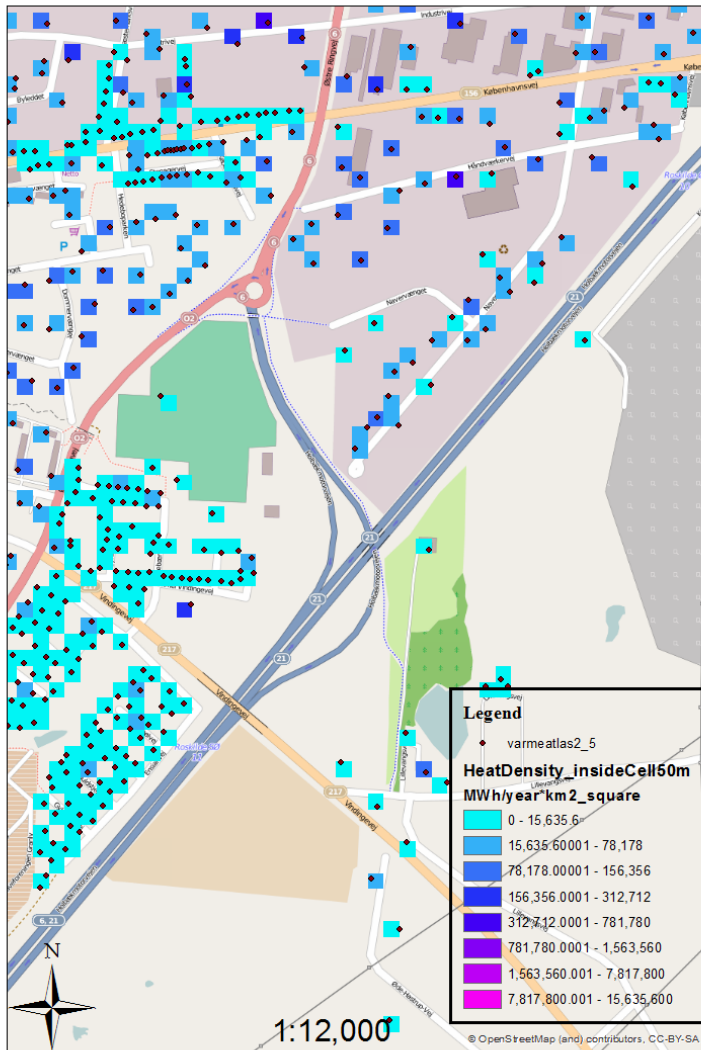


Total Building Area in communes in West Denmark normalized on commune area; only residential buildings are included.

This map is obtained by spatially joining Heat Atlas with map of communes in Denmark.

Joining rule used was SUM.

Focus of my research



Heat Demand attribute converted from point to raster type using Point to Raster Conversion.

Raster square size is 50 m.

Heat Demand of all buildings inside 50 m square is summed.

How does my research fit into the 4DH concept

Scientific objective of 4DH: Establishing platform for coherent development of 4DH technologies and systems in which synergy is created between development of grids and components, house installations, DH production and system integration, **planning and implementation tools and methodologies**.

Societal objective of 4DH: Further the understanding of **role of DH in the design of future national energy system** seen in light of EU 2020 and Danish 2050 goals.

Generating knowledge in 4DH:

Development of **coherent spatial databases, data infrastructures and energy planning tools based on GIS**.

Energy system analysis tools, methodologies and theories to conduct scenarios of future sustainable energy systems in order to identify role of DH systems and technologies.

At Energy Systems Analysis there is lot of experience in working with Balmorel (model of Denmark exist) and TIMES (model of Denmark is being build).

How does my research fit into the 4DH concept

Objective of 4DH is achieving synergy:

- Between disciplines – geography, energetics, economy, environmental science, engineering, computer science.
- Between organizations – universities, DH companies, industry and consultancies.

Results that I could present at some of the next meetings:

- New layer in Energy Atlas, or
- link between GIS and energy systems modelling tool.

How can I collaborate with private partners

I would like to receive data from partners, especially in tabular or in form of spatial databases (electricity and heat consumptions, building characteristics, demographic factors), but other forms will be valuable.

Spatial databases along with results from energy system models could be beneficial for consultancies in starting phases of their projects regarding expansion DH, improving energy efficiency, utilising renewable energy resources.

Ringkøbing-Skjern Kommune could serve as a test region, where theoretical conclusions could be verified.

How do I see collaboration with other PhD students in 4DH

Data collection – I will use data for creation of Energy Atlas; We should make joint data container that will be available to all project participants.

Data collection – data should be thoroughly described and it should be clear whether data is publicly available.

Joint papers – good idea for similar PHD projects, match-making could be done by supervisors or by PhD students themselves.

PhD projects similar to *Geographical representations of renewable energy systems*:

- 2.1 Energy Scenarios for Denmark
- 2.5 The role of district heating in the Chinese energy system
- 3.1 Strategic energy planning in a municipal and legal perspective
- 3.3 Geographical representations of heat demand, efficiency and supply (Twin Project)

Thank you for your attention