



CITIES

Centre for IT Intelligent Energy Systems

Energy Supply Modelling in cities: A Case Study of Sønderborg Municipality

Motivation

Denmark has established the target of becoming independent of fossil fuels in the electricity and heating sectors by 2035 and of becoming fully independent of fossil fuels on a net annual basis by 2050. Such targets can only be met with a strong policy making, not only on a national level but also on more local administration levels. Most municipalities in Denmark have established their own vision and targets for making their energy systems more sustainable. Among these is the municipality of Sønderborg in Southern Denmark, which is used as a case in this demo project.

Sønderborg has the ambitious goal of reaching a CO₂ neutral energy system by the year 2029. Along with other partners the municipality has formed the ProjectZero vision and formed a company called ProjectZero A/S (also referred to as the ProjectZero secretary) to help facilitate this transition. The ProjectZero secretary is a partner both in the CITIES project and in this demo project. Sønderborg's climate goals and the collaboration with ProjectZero are important reasons for choosing Sønderborg municipality as a case. The municipality's energy system also has a suitable scale for a study of this kind; it is simple enough to allow for detailed modelling of the system while at the same time being sufficiently complex to represent an interesting energy system case on a city level in Denmark.

Objective

The aim of the demo project is to develop, model and evaluate scenarios for Sønderborg's energy system in 2029 in order to identify ways of increasing the efficiency and integration of the system while minimizing CO₂ emissions and socioeconomic costs. As a part of this, possibilities for the introduction of new energy conversion technologies in the system, such as heat pumps, biogas production, thermal gasification, electrolysis, biogas methanation and transport fuel synthesis will be investigated.

Methodology

In this demo project, the energy system of Sønderborg municipality is modelled using the techno-economic energy system modelling tool *Sifre*, developed by Energinet.dk. *Sifre* is a mixed-integer linear optimization model which optimizes the hour-by-hour operation of the

defined energy system. The model has a modular layout, meaning that an energy system with any number of energy conversion units and connections between these can be defined and modelled in a flexible way. Among the model outputs are the total system operation costs, greenhouse gas emissions, the hour-by-hour energy flows between all modules in the system and model-generated prices of these energy flows.

The model takes the whole energy system into account, i.e. the electricity, heating, gas and transport sectors and the interplay between them. Municipal and national data series on renewable energy generation profiles, energy conversion capacities, energy consumption profiles, energy price profiles etc. are used as inputs in the model. Energinet.dk and ProjectZero are vital partners in the project and help with supplying reliable data. In line with the CITIES project description, WP1 investigates the magnitudes and patterns of energy consumption (demand) in the different sectors of the system while WP2 focuses on the requirements for energy generation, conversion, transmission and storage (supply). On the supply side, the possibilities for integrating new technologies such as thermal gasification of biomass, hydrogen production by high-temperature electrolysis, upgrade (methanation) of biogas and synthetic transport fuel (methanol, DME) production will be investigated. On the demand side, the potential for flexible energy consumption will be looked into, especially in connection with heat pumps (domestic and large-scale) and electric vehicle charge/discharge.

Multiple different scenarios for energy supply capacities and technologies in Sønderborg municipality will be modelled and optimized against the identified energy demand. The results from these modeling scenarios will then be evaluated and compared in order to identify the most cost and energy efficient solutions for a CO₂ neutral Sønderborg in 2029.

In this kind of regional-scale energy systems modeling, it must also be kept in mind that Sønderborg municipality is not an island system, but an integrated part of the Danish and European energy system and markets. The modelling results for Sønderborg's energy system will therefore be put into context with and compared with the status and plans for the greater energy system outside Sønderborg's boundaries.

Partners

- CITIES WP1 (DTU Management Engineering)
- CITIES WP2 (DTU Energy)
- Energinet.dk
- ProjectZero

Deliverables

- An optimization model of Sønderborg's energy system in 2029.
- Report on different scenarios for Sønderborg's energy system in 2029.
- Results and data for usage as inputs in more generic energy supply models for cities.

Time frame

January 2015 – June 2016 (estimated)

Contact person

Dadi Sveinbjörnsson, postdoc at DTU Energy, dasv@dtu.dk.