Scenarios for sustainable heat supply and heat savings in municipalities - the case of Helsingør, Denmark

Local climate action is not only a domain of large cities, but also smaller urban areas that increasingly address climate change mitigation in their policy. The Danish municipality of Helsingør can achieve a substantial CO2 emissions reduction by transforming its heat supply and deploying heat savings. In this paper, we model the heating system of Helsingør, assess it from a simple socio- and private-economic perspective, develop future scenarios, and conduct an iterative process to derive a cost-optimal mix between district heating, individual heating and heat savings. The results show that in 2030 it is cost-optimal to reduce the heating demand by 20–39% by implementing heat savings, to deploy 32%–41% of district heating and to reduce heating-related CO2 emissions by up to 95% in comparison to current emissions. In 2050, the cost-optimal share of district heating in Helsingør increases to between 38 and 44%. The resulting average heating costs and CO2 emissions are found to be sensitive to biomass and electricity price. Although the findings of the study are mainly applicable for Helsingør, the combined use of the Least Cost Tool and modelling with energyPRO is useful in planning of heating and/or cooling supply for different demand configurations, geographical region and scale.
Municipal activities play an important role in national and global CO2-emission reduction efforts, with Nordic countries at the forefront thanks to their energy planning tradition and high penetration of renewable energy sources. In this work, we present a case study of the Danish municipality of Sønderborg, whose aim is to reach zero net CO2 emissions by 2029. Sønderborg has an official strategic plan towards 2029, which we compared with four alternative scenarios to investigate how the municipality could approach its target in the most energy-efficient and cost-effective way while simultaneously keeping biomass and waste consumption close to the limits of the locally available residual resources. We modelled all sectors of the energy system on the municipal scale, applying a broad range of energy conversion technologies, including advanced biomass conversion technologies and reversible electrolysis. We constructed five scenarios, each representing a different energy mix for Sønderborg’s energy system in 2029. We modelled these scenarios using the mixed-integer linear optimization tool Sifre. We compared the results for the five scenarios using four indicators: annual total system cost, total energy system efficiency, annual net system CO2 emissions and total annual biomass consumption. The results show that scenarios with a high degree of electrification perform better on the selected indicators than scenarios with a
high degree of biomass utilization. Moreover, the incorporation of advanced conversion technologies such as electrolysis, fuel cells and methanol production further reduces both the total system cost and net CO2 of the highly electrified energy system. Our sensitivity analysis demonstrates that scenarios with a low biomass consumption and a high degree of electrification are less dependent on changes in energy prices. We conclude that in order to achieve their CO2 emission goals in the most energy-efficient, cost-effective and sustainable way, municipalities similar to Sønderborg should compare a wide range of energy system configurations, for example, scenarios with a high degree of electrification and a limited biomass use.

General information
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Organisations: Department of Energy Conversion and Storage, Department of Management Engineering, Systems Analysis, Energinet.dk
Authors: Sveinbjörnsson, D. Þ. (Intern), Ben Amer-Allam, S. (Intern), Hansen, A. B. (Ekstern), Algren, L. (Ekstern), Pedersen, A. S. (Intern)
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Value Chain Structures that Define European Cellulosic Ethanol Production

Production of cellulosic ethanol (CE) has not yet reached the scale envisaged by the literature and industry. This study explores CE production in Europe to improve understanding of the motivations and barriers associated with this situation. To do this, we conduct a case study-based analysis of CE production plants across Europe from a global value chain (GVC) perspective. We find that most CE production plants in the EU focus largely on intellectual property and are therefore only at the pilot or demonstration scale. Crescentino, the largest CE production facility in Europe, is also more interested in technology licensing than producing ethanol. Demonstration-scale plants tend to have a larger variety of feedstocks, whereas forestry-based plants have more diversity of outputs. As scale increases, the diversity of feedstocks and outputs diminishes, and firms struggle with feedstock provisioning, global petroleum markets and higher financial risks. We argue that, to increase CE production, policies should consider value chains, promote the wider bio-economy of products and focus on economies of scope. Whereas the EU and its member states have ethanol quotas and blending targets, a more effective policy would be to seek to reduce the risks involved in financing capital projects, secure feedstock provisioning and support a diversity of end products.
Value chain structures that define second generation bio-refineries in Europé

**General information**
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Organisations: Department of Management Engineering, Systems Analysis, DTU Climate Centre, Technical University of Denmark, Lund University, NIFU Nordic Institute for Studies in Innovation, Research and Education
Authors: Gregg, J. S. (Intern), Bolwig, S. (Intern), Hansen, T. (Ekstern), Solér, O. (Intern), Ben Amer, S. (Intern), Pladevall Viladecans, J. (Ekstern), Coenen, L. (Ekstern), Klitkou, A. (Ekstern), Fevolden, A. (Ekstern)
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Value chain structures that define second generation bio-refineries in Europé

**General information**
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What is a city?

**General information**
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Authors: Ben Amer, S. (Intern)
Energy system modelling of Nordhavnen, the sustainable urban district of Copenhagen

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Organisations: Department of Management Engineering, Systems Analysis, DTU Climate Centre
Authors: Ben Amer, S. (Intern)
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Sustainable district of Nordhavnen – energy system modelling

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Authors: Ben Amer, S. (Intern), Ravn, H. (Ekstern)
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A Value Chain Analysis of Nordic Cellulosic Ethanol Production

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Organisations: Department of Management Engineering, Systems Analysis, DTU Climate Centre, Energy Systems Analysis, Lund University, NIFU Nordic Institute for Studies in Innovation, Research and Education, VTT - Technical Research Centre of Finland
Authors: Bolwig, S. (Intern), Gregg, J. S. (Intern), Klitkou, A. (Ekstern), Wessberg, N. (Ekstern), Hansen, T. (Ekstern), Ben Amer, S. (Intern), Coenen, L. (Ekstern)
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Event: Poster session presented at International Bioenergy Conference, Manchester, United Kingdom.
Scenario modelling as a tool for planning sustainable urban energy systems

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Organisations: Department of Management Engineering, Systems Analysis, DTU Climate Centre, Energy Systems Analysis
Authors: Ben Amer, S. (Intern)
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Publication: Research - peer-review › Paper – Annual report year: 2014

Definition of Smart Energy City and State of the art of 6 Transform cities using Key Performance Indicators: Deliverable 1.2
This report summarises the work undertaken under the EU-FP7 TRANSFORM project for Work Package 1 (part 1): Becoming a Smart Energy City, state of the Art and Ambition. Part 1 starts with a clear outline of each of the participating cities. The work describes the context in terms of climate, energy assets, ambitions, targets and main possibilities in terms of energy efficiency, flows and energy production. After this first step, the work focuses on the description of what a smart energy city is (this report), what the main Key Performance Indicators (KPIs) are that should be met and how this relates to where the current cities and the living labs are. It describes at the same time the current status of city planning, energy planning tools, and existing energy data. The outline should also include information on energy production, energy flows and energy efficiency, where possible. The work will draw largely on existing Strategic Energy Action Plans, Climate Action Plans and planning documents.
This report establishes a definition of smart cities develops Key Elements, Key Performance Indicators and reports on the state of the art regarding the KPIs for the 6 Transform cities. As specified in the Transform proposal, the objective of the evaluation is to identify previous and existing initiatives as a sort of stocktaking on the way to establishing a smart city transformation pathway for each of the participating cities in the Transform project. The definition of a smart energy city and the key performance indicators will be used throughout Transform the guide the work.

General information
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Organisations: Department of Management Engineering, Systems Analysis, DTU Climate Centre, Energy Systems Analysis
Authors: Nielsen, P. S. (Intern), Ben Amer, S. (Intern), Halsnæs, K. (Intern)
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Fostering the use of renewable energies for heating and cooling

The progRESSHEAT project aims at assisting local, regional, national and EU political leaders in developing policy and strategies to ensure a quick and efficient deployment of renewables in heating and cooling networks. The project’s aim is in line with the objectives of the Renewable Energy Directive and the Energy Performance of Buildings Directive that require Member States to develop ambitious policies as regards the use of renewable energy sources and energy efficiency in heating and cooling networks. progRESSHEAT is intended to support the market uptake of existing and emerging renewable electricity, heating and cooling technologies. More specifically, the project helps policy makers develop integrated, effective and efficient policy strategies aimed at achieving a fast and strong penetration of renewable and efficient heating and cooling systems. This includes the analysis of cross-sectoral effects between renewables and energy efficiency measures in industrial heat and cold, waste heat, heating and cooling in buildings and district heating. Together with six local authorities in six target countries across Europe (Austria, Germany, Czech Republic, Denmark, Portugal, Romania), heating and cooling strategies will be developed through a profound analysis of (1) heating and cooling demand and future developments, (2) long-term potential of renewable energies and waste heat in the regions, (3) barriers & drivers and (4) a model-based assessment of policy intervention in scenarios up to 2050. The established local energy advisory tool EnergyPRO will be used for the local studies and further developed to appropriately reflect district heating and cooling. The final versions for the investigated regions will be handed over to the authorities. In the target countries, progRESSHEAT will support the implementation of national heating and cooling plans which have to be released by member states by the end of 2015. The plans will include a policy outlook on how the potentials identified by the comprehensive assessment will be achieved. progRESSHEAT will assist national policy makers in implementing suitable policies with a model-based quantitative impact assessment of local, regional and national policies up to 2050. Policy makers and other stakeholders are strongly considered in the process. They will be offered the opportunity to learn from the experience of other players and gain deep understanding of the impact of policy instruments and their specific design. They are involved in the project via policy group meetings, workshops, interviews and webinars dedicated to policy development assistance, capacity-building and dissemination. The project is supported by the Horizon 2020 programme of the European Union.

Department of Management Engineering
Systems Analysis
Vienna University of Technology
Fraunhofer Institute for Systems and Innovation Research ISI
Institute for Resource Efficiency and Energy Strategies - IREES GmbH
OÖ Energiesparverband
ee energy engineers GmbH
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Instituto de Engenharia Mecanica e Gestao Industrial - INEGI
Agentia Pentru Management ul Energiei si Protectia Mediului Brasov - ABMEE
City of Litomerice
Energy Cities, the European association of local authorities in energy transition
Period: 01/03/2015 → 01/10/2017
Number of participants: 6
Acronym: progRESSHEAT
Project participant:
Karlsson, Kenneth Bernard (Intern)
Münster, Marie (Intern)
Petrovic, Stefan (Intern)
Kitzing, Lena (Intern)
Ben Amer-Allam, Sara (Intern)
Salvucci, Raffaele (Intern)

Relations
Related projects:
Geographical representations of renewable energy Systems
Strategic research centre for 4th Generation district heating technologies and systems
Urban energy transitions and quality of life

Department of Management Engineering
Period: 01/12/2013 → 30/11/2017
Number of participants: 3
Phd Student:
Ben Amer-Allam, Sara (Intern)
Supervisor:
Gregg, Jay Sterling (Intern)
Main Supervisor:
Nielsen, Per Sieverts (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Activities:

Modelling tools for energy planning and energy system integration
Period: 2 Nov 2016
Sara Ben Amer-Allam (Invited speaker)
Department of Management Engineering
Systems Analysis
DTU Climate Centre

Related event
EERA JP Energy Integration
02/11/2016 → 04/11/2016
Kgs. Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

Modelling of low-carbon district heating: lessons learnt from a Danish and a Czech case
Period: 28 Sep 2016
Sara Ben Amer-Allam (Speaker)
Department of Management Engineering
Systems Analysis
DTU Climate Centre

Related event
2nd International Conference on Smart Energy Systems and 4th Generation District Heating
27/09/2016 → 28/09/2016
Aalborg, Denmark
Activity: Talks and presentations › Conference presentations

Energy modelling with energyPRO - results and lessons learnt from progRESs HEAT project
Period: 13 Sep 2016
Sara Ben Amer-Allam (Invited speaker)
Department of Management Engineering
Systems Analysis
DTU Climate Centre
Related event

Energy Cities’ District heating fact-finding mission to Denmark
13/09/2016 → …
Frederiksberg, Denmark
Activity: Talks and presentations › Conference presentations

Scenarios for sustainable heat supply in cities - case of Helsingør, Denmark
Period: 7 Sep 2016
Sara Ben Amer-Allam (Speaker)
Department of Management Engineering
Systems Analysis
DTU Climate Centre

Related event

11th Conference on Sustainable Development of Energy, Water and Environment Systems
04/09/2016 → 09/09/2016
Lisbon, Portugal
Activity: Talks and presentations › Conference presentations

A comparison of tools for energy planning
Period: 24 May 2016 → 25 May 2016
Sara Ben Amer-Allam (Invited speaker)
Department of Management Engineering
Systems Analysis
DTU Climate Centre
Centre for IT-Intelligent Energy Systems in Cities

Description

Speaker and panel member
Links:

Related event

3rd General Consortium Meeting of the CITIES project
24/05/2016 → 25/05/2016
Lyngby, Denmark
Activity: Talks and presentations › Conference presentations

Progressive heating and cooling: progRESsHEAT project in Helsingør, Denmark
Period: 10 Nov 2015
Sara Ben Amer-Allam (Speaker)
Department of Management Engineering
Systems Analysis
DTU Climate Centre

Related event

The role of Nordic municipalities and regions in the green transition: Energy festival
10/11/2015 → …
Copenhagen, Denmark
Activity: Talks and presentations › Conference presentations

**Modelling scenarios for sustainable urban energy systems**
Period: 23 Feb 2015
Sara Ben Amer-Allam (Speaker)
Department of Management Engineering
Systems Analysis
DTU Climate Centre
Centre for IT-Intelligent Energy Systems in Cities

**Related event**

**Smart Sustainable Cities Seminar at NTNU**
23/02/2015 → 24/02/2015
Trondheim, Norway
Activity: Talks and presentations › Conference presentations

**Groningen Energy Summer School 2014**
Period: 19 Aug 2014 → 29 Aug 2014
Sara Ben Amer-Allam (Participant)
Department of Management Engineering
Systems Analysis
DTU Climate Centre

**Description**
University of Groningen Energy Summer School 2014

**Related event**

**Groningen Energy Summer School 2014**
18/08/2014 → 29/08/2014
Groningen, Netherlands
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

**Association of European Schools of Planning PhD Workshop 2014**
Period: 5 Jul 2014 → 8 Jul 2014
Sara Ben Amer-Allam (Participant)
Department of Management Engineering
Systems Analysis
DTU Climate Centre
Energy Systems Analysis

**Related event**

**Association of European Schools of Planning PhD Workshop 2014**
05/07/2014 → 08/07/2014
Delft, Netherlands
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.