2nd International Conference on Smart Energy Systems and 4th Generation District Heating
Aalborg, 27-28 September 2016

Solar heat as centralised or distributed heat supply?

AALBORG UNIVERSITY
DENMARK

4DH
4th Generation District Heating
Technologies and Systems

Presentation contents

4DH
4th Generation District Heating Technologies and Systems

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  - Effects of alternative heat supply options?
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Research questions

- **Solar based heat supply; centralised or distributed?**
- **Effects of alternative options on district heating?**
  - **Identical investment costs for solar collectors and storage**
  - **System servicing the same heat demand**
  - **Buildings specific collectors utilise solar heat directly without distribution losses**
  - **Centralised solar collectors benefit from economy of scale**
  - **Changes in operation within an existing system**
  - **Role of low temperature distribution**

Case study definition

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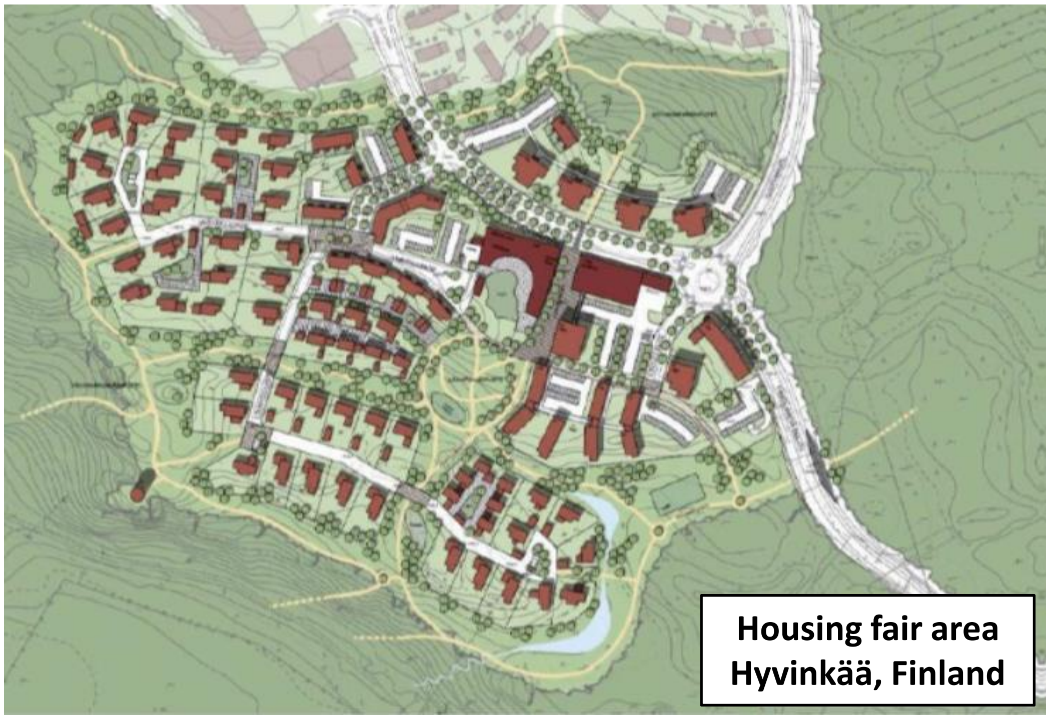
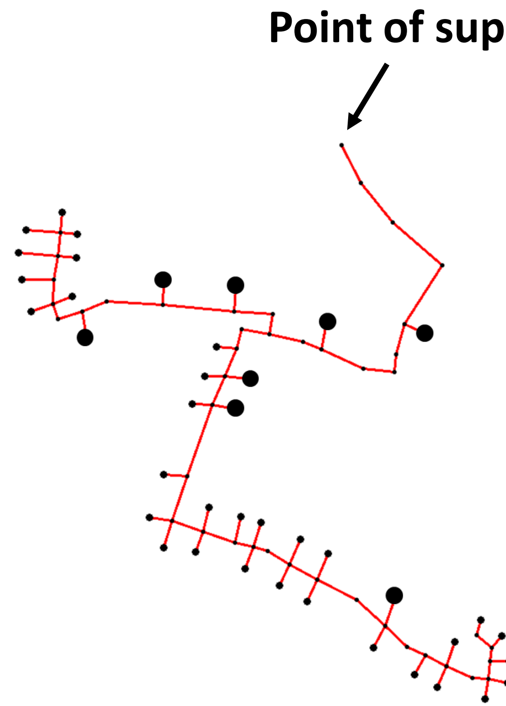
- **Small district heating system in Finland as a case study (1.2 GWh yearly demand, heat density of 0.74 MWh/m)**
- **CHP, boiler and solar collectors (distributed or centralised) as the heat supply options**
- **Supply temperatures for distribution either traditional (outdoor temperature dependent, 115-80 °C) or low (65 °C)**
- **Total of 40 consumers, 32 of which are (distributed option) equipped with solar collectors and an accumulator (6 m^2, ~500 l)**
- **Centralised solar collector with ~50 % more surface area than distributed collectors (due to specific investment costs)**

Case study area (Hyvinkää, Finland)





Scenarios investigated

- **Heat supply combinations studied**
  - **Boiler**
  - **Boiler, CHP**
  - **Boiler, CHP + solar collectors on roof-tops (distributed)**
  - **Boiler, CHP + solar collector field (centralised)**

  - **Other combinations and/or different designs (in terms of capacities) possibly included if reasonable**

Methods and tools

Case study and scenario definition

System specification, assumptions used, decision on scenarios to be investigated

Simulations and modelling

Realistic heat demand both heating and DHW (IDA ICE, Apros), solar collector model (Matlab), district heating network simulation (Apros), priority based operation of heat supply (MS Excel)

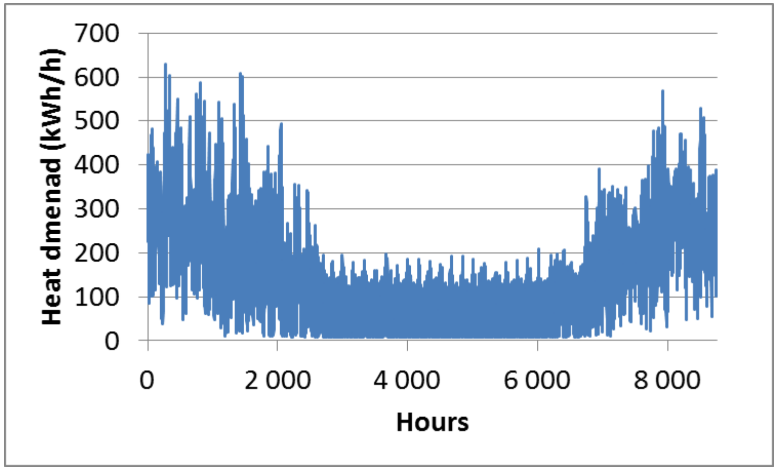
System level evaluation

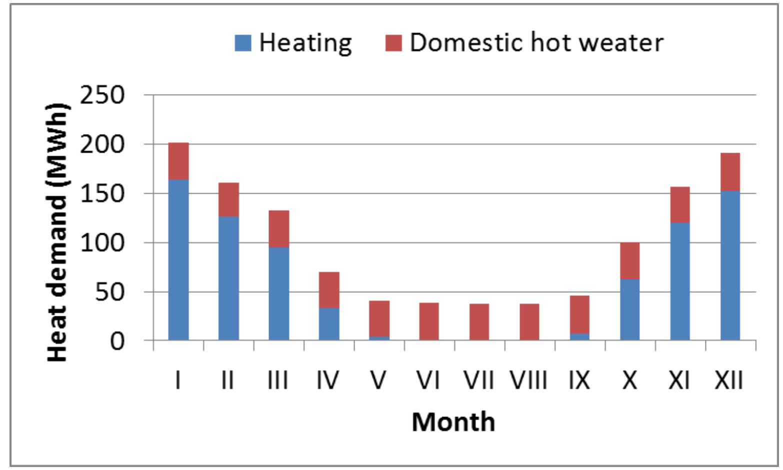
Energy efficiency evaluation for representative 1 year period, used in economic analysis for 20 years of operation

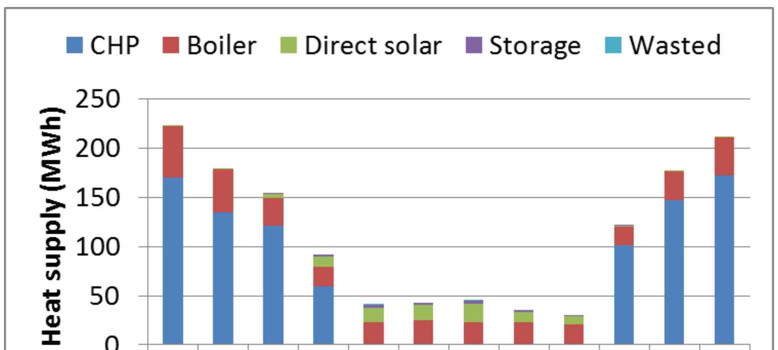
Results and conclusions

Analysing results of evaluation process, both from energy and economics perspective

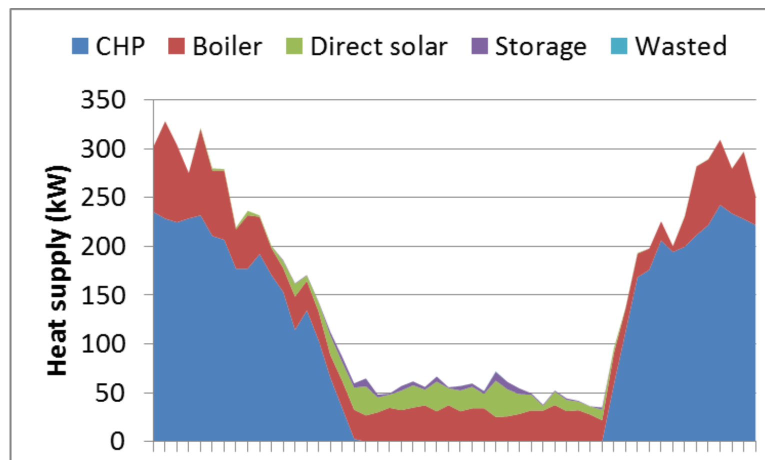
Result examples (65 °C, centralised)



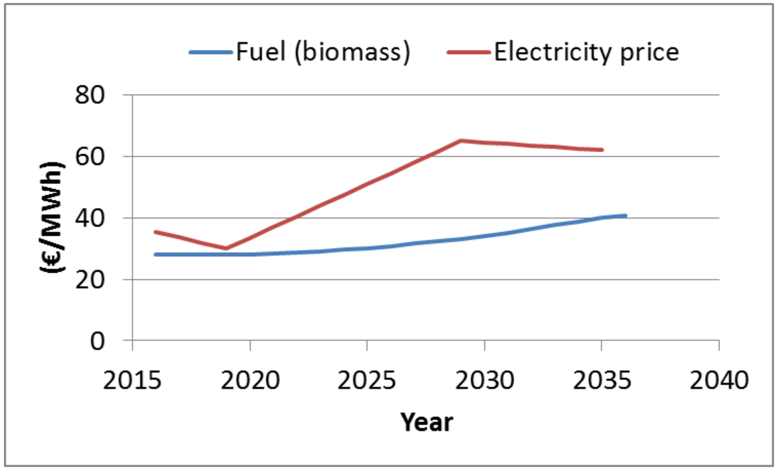


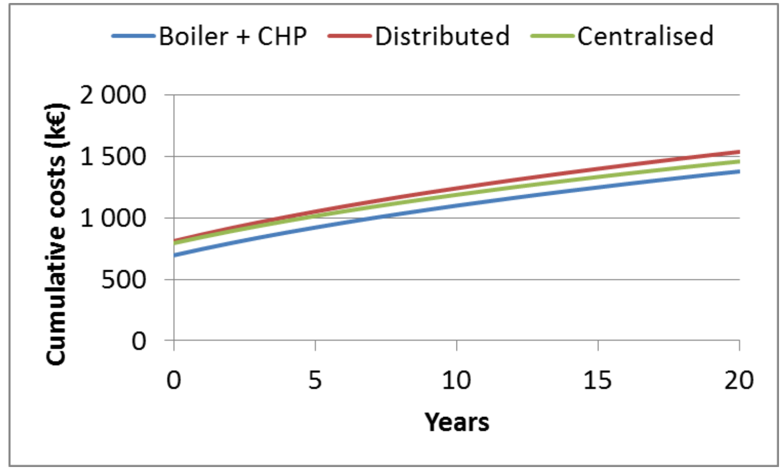


Network simulation results utilised; heat losses, return temperatures.



Result examples (economics)





Boiler efficiency	75%
Total efficiency (CHP)	85%
Electrical efficiency (CHP)	20%
Discount rate	6%
Maintenance (% of investment)	
CHP	2.5%
Boiler	5.0%
Solar collectors	1.0%

- **2015 Spot prices (FI) used as a hourly, year-long electricity price profile**
- **Only heat supply considered, distribution network excluded as an investment**
- **Centralised 5 % better than distributed, but due to investment cost boiler + CHP the best option**
- **System with centralised solar panels 2.6 % more cost efficient, than boiler + CHP only**

Preliminary conclusions

- **Solar collectors suitable for dwellings and LTDH**
  - **Dwellings: 90 MWh/year, 0.47 MWh/m^2**
  - **Centralised (115-80 °C): 80 MWh/year, 0.27 MWh/m^2**
  - **Centralised (65 °C): 99 MWh/year, 0.33 MWh/m^2**
- **Centralised collectors can (potentially) handle surplus**
  - **Dwelling specific collectors lose 30 % of energy, even if using 3.0-3.5x larger storages than in centralised option**
- **Economics**
  - **Centralised collectors cost effective, improve the system but not enough compared to boiler + CHP option**
  - **Investment costs decisive, low electricity price plays a part**

Next steps

- **Different solar collector/storage dimensioning**
  - **More solar output could be reasonable**
- **Optimisation for more efficient utilisation of storage**
- **Distributed solar collector output calculated in more detail**
- **Sensitivity analysis on cost parameters**
- **More detailed distribution temperature dependency for boilers and CHP output**

Thank you!

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Abstract

Ambitious greenhouse gas (GHG) emission reduction targets set by EU pose a significant challenge for the energy systems in member countries. District heating as an energy efficient solution for heat supply and distribution can potentially play a major part on a European level for meeting these targets. One key issue concerning district heating itself is the efficient integration of renewable energy sources to existing systems. The focus of this study is on introducing solar heating to an existing district heating system either as distributed or as centralized design of solar collectors.

The paper investigates alternative combinations of heat sources including boilers, combined heat and power (CHP) plants, centralized solar collectors and distributed solar collectors by performing a techno-economic analysis. Moreover, the effect of reducing the supply temperature level in different choice of heat sources is studied. Traditional, outdoor dependent supply temperature level (115-80 °C) and constant low supply temperature level (60 °C) are considered.

Study is made on system level point of view and in terms of energy efficiency and economics using a sample period for a one year for representative energy analysis and 20 year period for long term economic analysis. The distributed and centralised solar collector designs have been defined with same investment costs, but different capacities based on their respective unit costs (€/kW). This approach is used in order to ensure results contributing on finding the most cost-efficient way for integrating renewable energy sources in an existing district heating system.

Heat demand in residential buildings consisting of heating and domestic hot water consumption, alternative sources of heat and district heating network itself are all modelled by individual, dedicated models in order to provide realistic input data for the techno-economic analysis.

Investigation is based on a case study of a small, local district heating system with an annual heat consumption of 1.2 GWh, heat demand density of 0.74 MWh/m located in Finland.

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