Technical University of Denmark



Benefits of Integrating Geographically Distributed District Heating Systems

Dominkovic, Dominik Franjo; Baekovi, I.; Sveinbjörnsson, Dadi Þorsteinn; Pedersen, Allan Schrøder; Krajai, G.

Publication date: 2016

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):

Dominkovic, D. F., Baekovi, I., Sveinbjörnsson, D. Þ., Pedersen, A. S., & Krajai, G. (2016). Benefits of Integrating Geographically Distributed District Heating Systems [Sound/Visual production (digital)]. 29th International Conference on Efficiency, Cost, Optimization, Simulation and Environmental Impact of Energy Systems, Portorož, Slovenia, 19/06/2016

DTU Library

Technical Information Center of Denmark

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

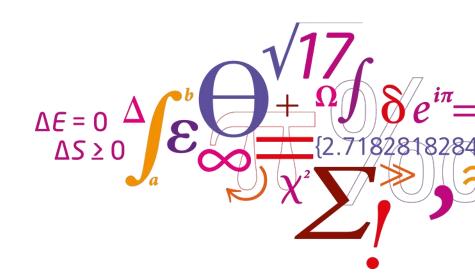
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.



Benefits of Integrating Geographically Distributed District Heating Systems

<u>Dominik Franjo Dominković*</u>, I. Bačeković, D. Sveinbjörnsson, A.S. Pedersen, G. Krajačić

ECOS coference Portorož 21 June 2016



DTU Energy

Department of Energy Conversion and Storage

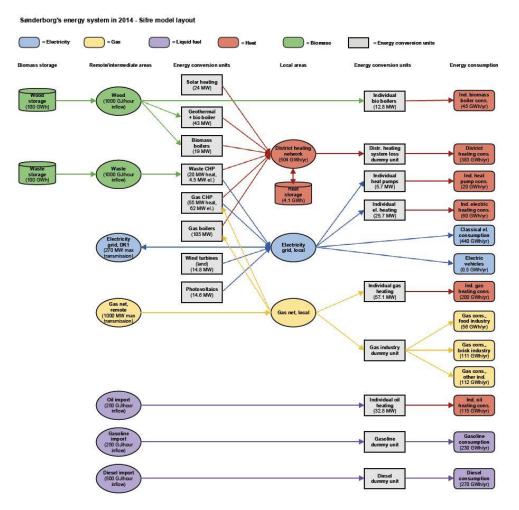


Outline

- Sønderborg the current status of DH systems
- Model description
- Description of indicators used for evaluation
- Case study description
- Results
 - Model validation
 - Results of the case study for the current state of the system
 - Results of the case study for the energy system in 2029
- Conclusions

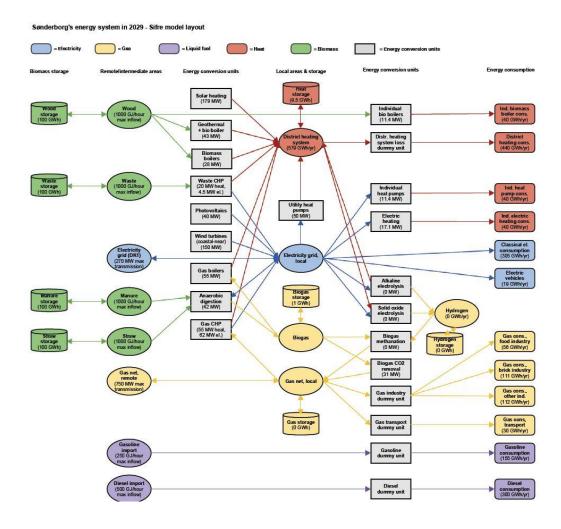


Sønderborg – energy system in 2014



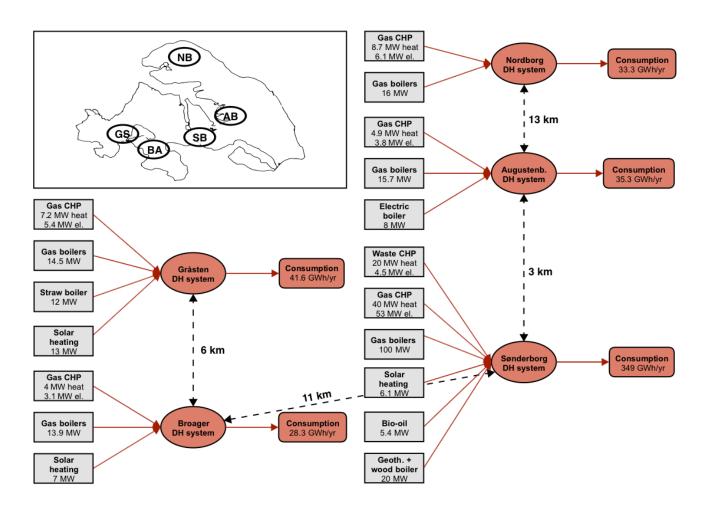


Sønderborg – anticipated energy system in 2029





Sønderborg – DH systems





Connecting DH systems – the model

- Linear continuous optimization model
- Objective function: to minimize total annual socio-economic costs
 - Levelized investment costs, fixed and variable O&M, fuel costs and import/export of different energy carriers
- Possibility of using CO2 and biomass consumption cap
- Exogenous variables:
 - Demand for different types of fuel
- All sectors included in calculation (power, heating, gas and mobility)



Indicators

- Economic: the total annual socio-economic costs
- Technical: CO2 emissions (calculated post-optimization)
- Feasibility of interconnections: NPV, IRR, dynamic payback time
 - NPV sum of all the payments (positive and negative) related to the investment
 - IRR discount rate at which NPV is equal to zero
 - Dynamic payback time time needed for NPV of income to cover the investment



Case study

• Population: 75,000

• Area: 496 km²

• Carbon neutrality by 2029

• 5 different DH systems

TOTAL FINAL ENERGY CONSUMPTION	CONSUMPTION (GWH/YR)	CO2 EMISSIONS (KTON/A)
DISTRICT HEATING	488	42
INDIVIDUAL HEATING	438	104
ELECTRICITY	442	158
(CLASSICAL)**		
PROCESS ENERGY	270	64
TRANSPORT	510	133
TOTAL	2148	500 (528.57)*

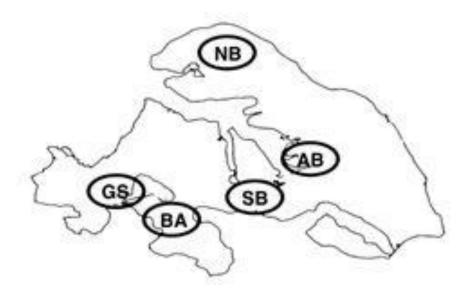


DH systems

DH PRODUCTION BY NETWORK*	INSTALLED CAPACITY (MW)	PRODUCTION (GWh/YEAR)	STORAGE CAPACITY [m³]
SØNDERBORG	201.5	349.0	4000
GRÅSTEN	46.7	41.6	8500
AUGUSTENBORG	28.6	35.3	-
NORDBORG	24.1	33.3	-
BROAGER	24.9	28.3	4500
TOTAL	325.8	487.6	-



Case study (II) – system today



Case	Interconnected DH systems				
I	5 separated DHs				
II	Merged Sønderborg (town) and Augustenborg				
III	Merged Broager, Sønderborg and Augustenborg				
	Merged Gråsten, Broager, Sønderborg and				
IV	Augustenborg				
V	Merged all five DH				



Case study (III) – system in 2029

	Installed capacity 2013 (MW)	Installed capacity 2029 (MW)	
Anaerobic digestion	0	42	
Gas boilers	105 55		
Biomass boilers	19	28	
Large scale heat pumps	0 50 (electrical capacity		
Solar heating	24 179		
Heat storage	4,100 MWh	9,500 MWh	
Wind turbines	14.6		
Photovoltaics	14.8 60		

Case	Interconnected DH systems
VI	5 separated DHs
VII	Merged all five DH

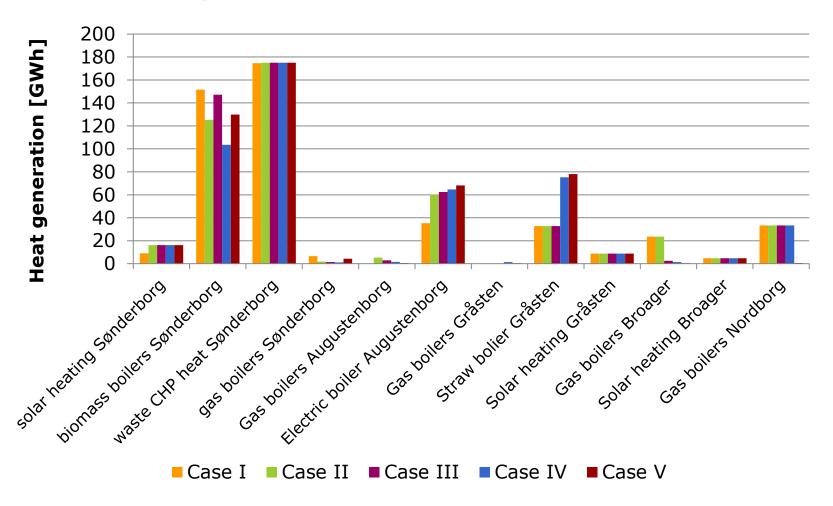


Results - model validation

Total energy consumption	Reference consumption (GWh/yr)	Reference scenario (case I) (GWh/yr)	Difference [%]	Referent CO ₂ emissions (including waste) (kton/yr)	Reference scenario (case I) (kton/yr)
Gas	571.87	554.82	-2.98%		
Coal	13.6	13.6	0.00%		
Heating oil	116	116	0.00%		
Wood and straw	188.09	201.27	7.01%		525.05
Individual heat pumps	21.238	21.24	0.01%		
Individual electric heating	53.534	53.54	0.01%	528.57	
Waste consumption	212.5	214.81	1.09%		
Classical electricity	451.5	466.89	3.41%		
Diesel and gasoline	506.8	506.6	-0.04%		
Other and unknown	12.87	0	-100.00%		
Total	2148	2149	0.05%	ECOS 2016	

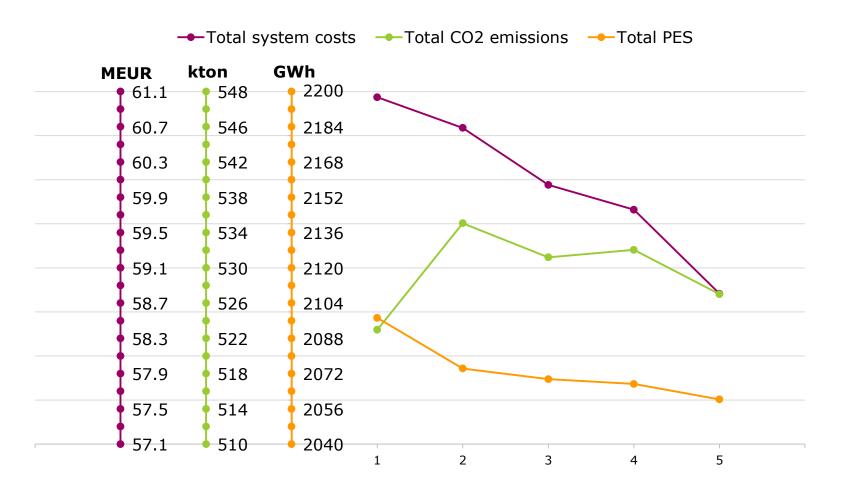


Sønderborg – today's system (I)





Sønderborg – today's system (II)





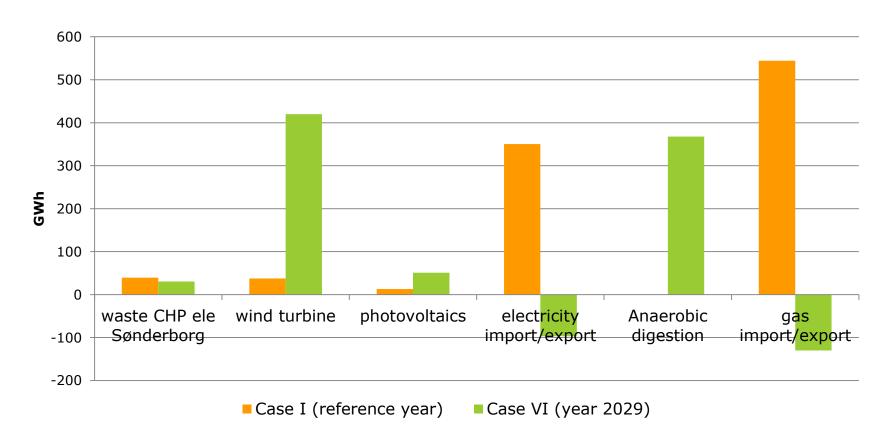
Sønderborg – today's system (III)

	I	II	III	IV	V	
TOTAL SYSTEM	61.039	60.653	59.934	59.621	58.563	MEUR
COSTS						
DIFFERENCE	Referen	0.386	0.719	0.313	1.058	MEUR
(SAVINGS)	ce					
PIPE LENGTH	-	3,000	11,000	6,000	13,000	m
PIPE COST	-	2.25	8.25	4.5	9.75	MEUR
NPV		3.00	1.52	-0.25	4.63	MEUR
IRR		16.32%	5.99%	3.36%	8.86%	
PAYBACK TIME		6.77	15.66	21.82	11.72	
PAYBACK TIME		7	16	22	12	years



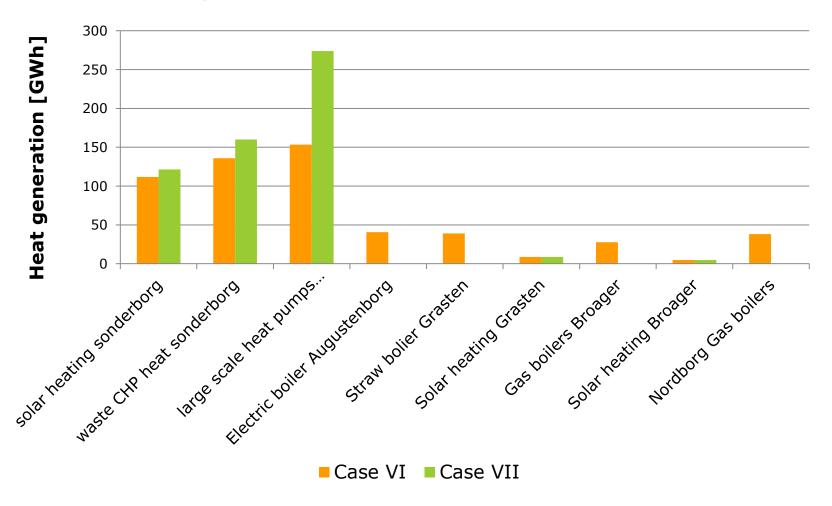
Sønderborg – 2029 (I)

Generation and power sectors:



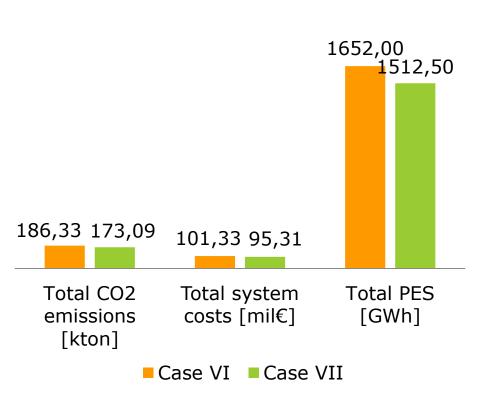


Sønderborg – 2029 (II)





Sønderborg – 2029 (III)



	CASE VI	CASE VII	
TOTAL SYSTEM COSTS	101.3 3	95.311	MEUR
DIFFERENCE (SAVINGS)	0	6.019	MEUR
PIPE LENGTH	0	33,000	m
PIPE COST	0	24.75	MEUR
NPV		57.05	MEUR
IRR		23.98 %	
PAYBACK TIME		4.58	
PAYBACK TIME		5	years



Conclusions (I)

- ✓ For the current energy systems, three out of four DH interconnections are economic feasible with the dynamic payback times of 7, 12 and 16 years, while one of the interconnections has a dynamic payback time of 22 years which is more than considered project lifetime of 20 years. After the last interconnection is being set in place, the total socio-economic costs are 4.1 % lower than in the reference case.
- ✓ For the anticipated energy system of the year 2029, connecting all five DH systems has a payback time of only 5 years. Moreover, the investment proposed leads to the savings in PES of 8.4 %, lower CO₂ emissions for 7.1 % and reduced total system costs for 5.9 %.
- ✓ There is no correlation between the lengths of the interconnections and the economic indicators of the investments. Thus, the investment in interconnection is dependable upon the structure of the DH supply plants being interconnected.



Conclusions (II)

- ✓ In the system of today, with the current electricity and fuel prices, between the three boiler technologies, electric boiler has the lowest running costs, followed by biomass and gas boilers. Gas driven CHPs do not have economic benefits of running in the DH systems with the current electricity prices on day-ahead markets. The model shows that they do not operate a single hour either in the reference year or the year 2029.
- ✓ Large-scale heat pumps, with the average electricity price levels similar to current ones, completely replace the production of all the boilers, including the electricity, biomass and gas ones.
- ✓ Finally, interconnecting the DH systems is beneficial in both the current energy system and the anticipated system in the year 2029; however, greater benefits are achieved in the system of the future.
- ✓ Connecting DH grids brings more flexibility to the system, making it cheaper, less environmentally harmful and more energy efficient to integrate intermittent energy sources in the power sector.



Thank you for your attention!