



AALBORG UNIVERSITY
DENMARK

RENEWABLE ENERGY ALTERNATIVES FOR SMALL DISTRICT HEATING PLANTS

Nikola Botzov

M.Sc. Sustainable Energy Planning and Management



4DH

4th Generation District Heating
Technologies and Systems

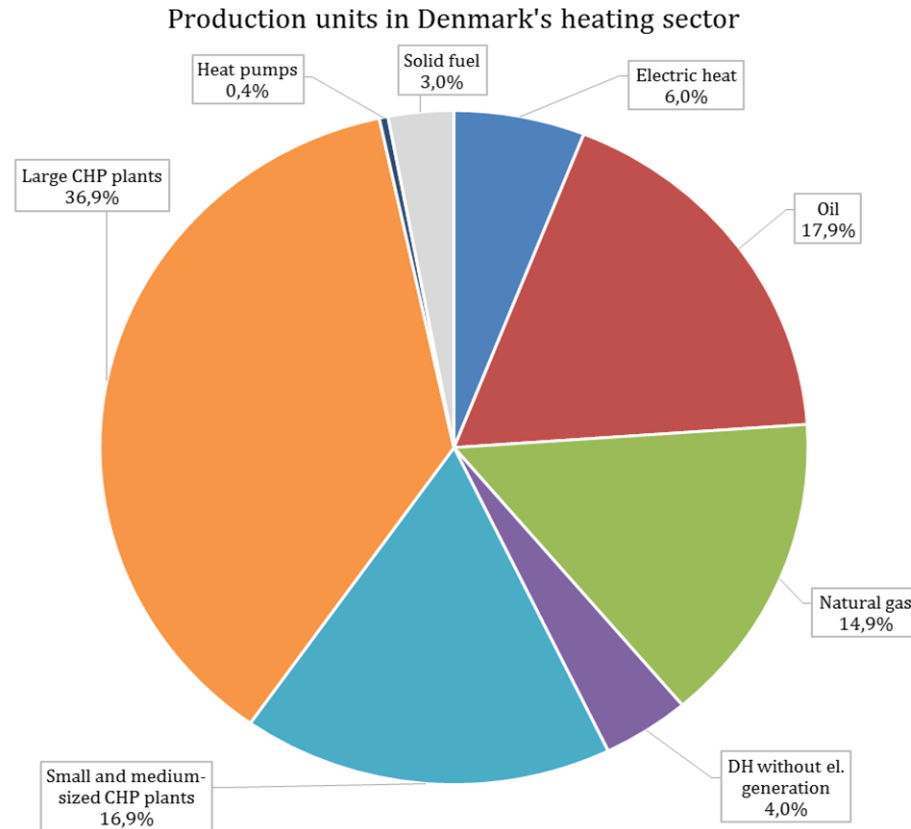
2nd International Conference on Smart Energy Systems and 4th Generation District Heating
Aalborg, 27-28 September 2016

AGENDA

- Introduction
- Methodology
- Scenarios and Results
- Business-economic assessment
- Sensitivity analyses
- Optimization
- Conclusion

INTRODUCTION

HEATING SECTOR



- Issues in the heating sector

- Merit order effect
- Returning to old technologies

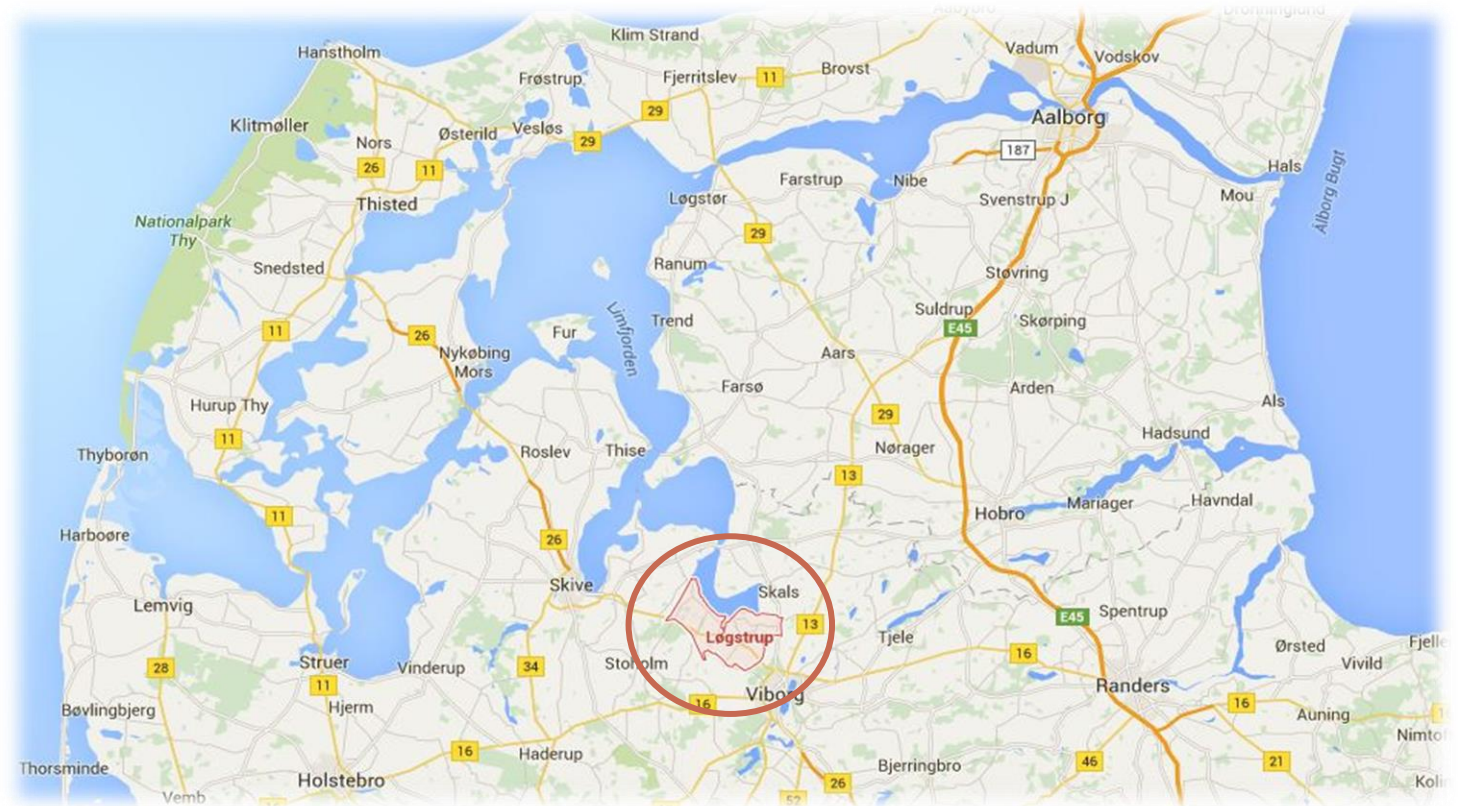
- Possibilities for the future

- Heat pumps
- Solar thermal panels
- Other possibilities

INTRODUCTION

CASE

- **Løgstrup Varmeværk**
 - 750 connections
 - Natural gas-fired plant
 - 2 CHP units and 1 boilers
 - 17.100 MWh/year heat demand
 - 550 DKK/MWh heat price
 - Integrating solar thermal energy



METHODOLOGY

- Focus
- Data collection
- Simulation software
- Scenarios
- Economic assessment

TECHNICAL ANALYSIS SCENARIOS

- Solar thermal heating

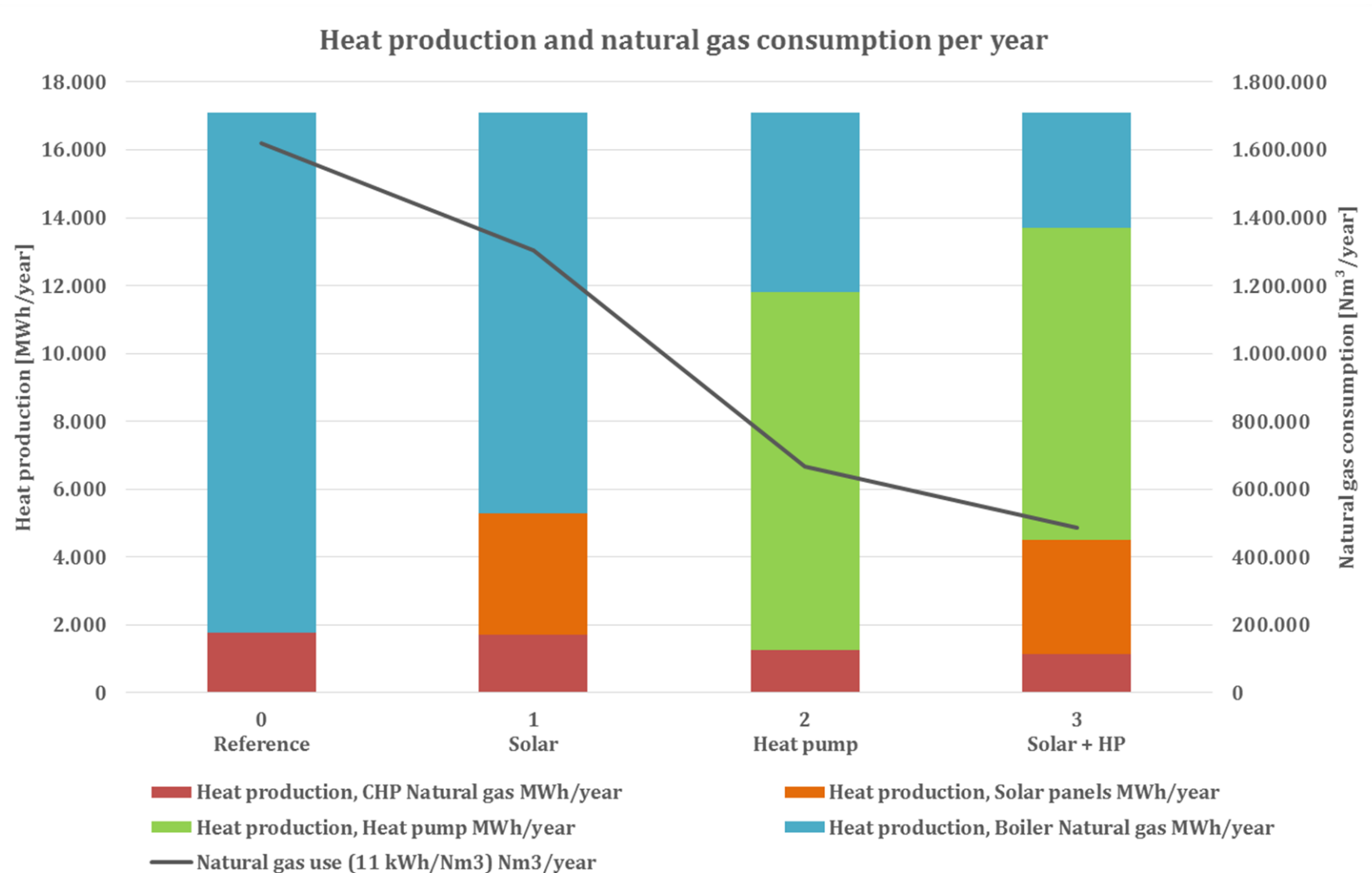
- Ground water heat pump

- Combined

	<i>Reference scenario</i>	<i>Scenario 1 – Solar</i>	<i>Scenario 2 – HP</i>	<i>Scenario 3 – Solar + HP</i>
	2,3 MW and 5,8 MW NG CHP units	7031 m ² solar thermal panels	1,5 MW ground water HP	7031 m ² solar thermal panels
	5,8 MW NG boiler	2000 m ³ heat store		1,5 MW ground water HP
	390 m ³ heat store			2000 m ³ heat store

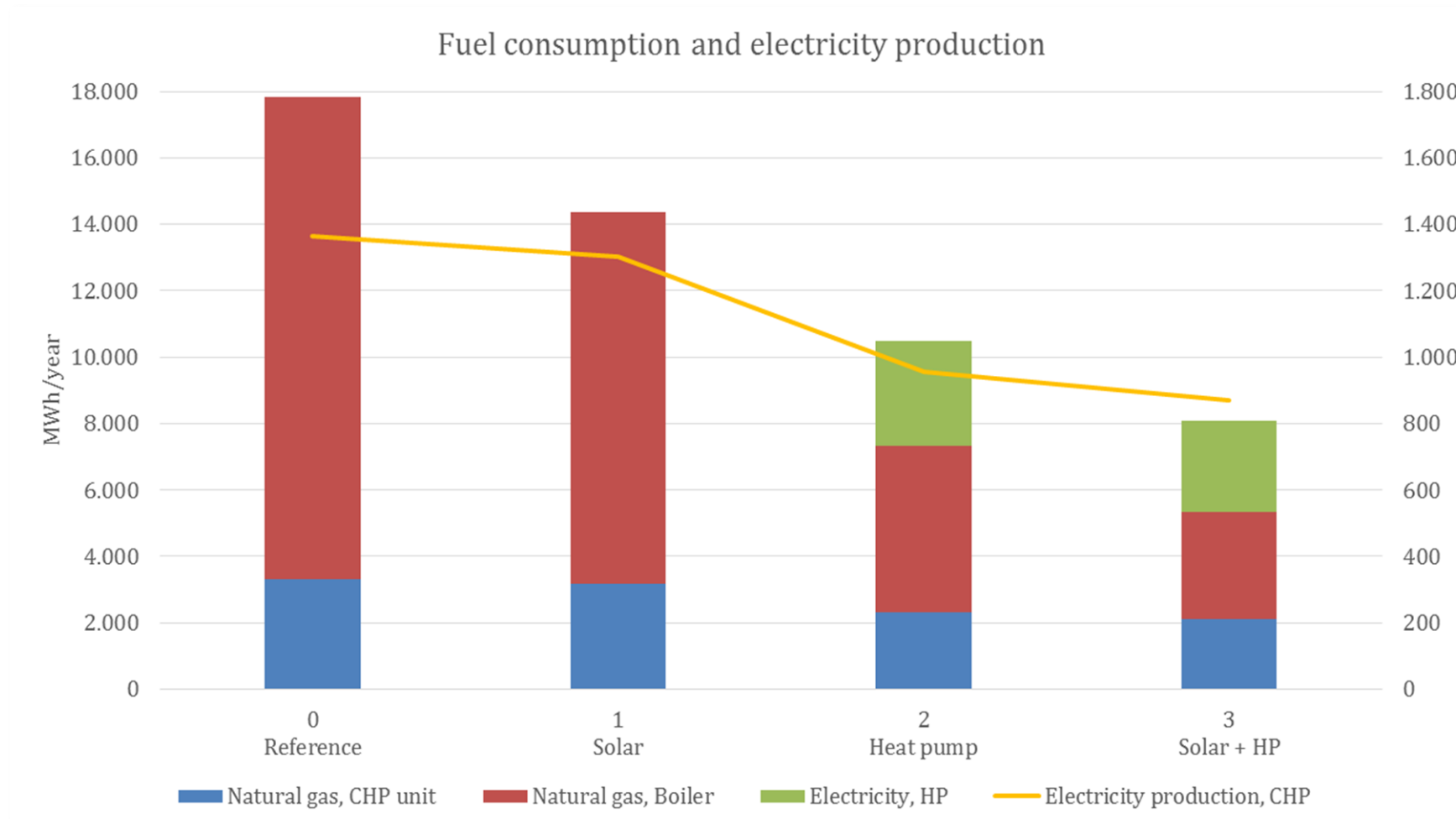
TECHNICAL ANALYSIS

HEAT PRODUCTION ON AN ANNUAL BASIS



TECHNICAL ANALYSIS

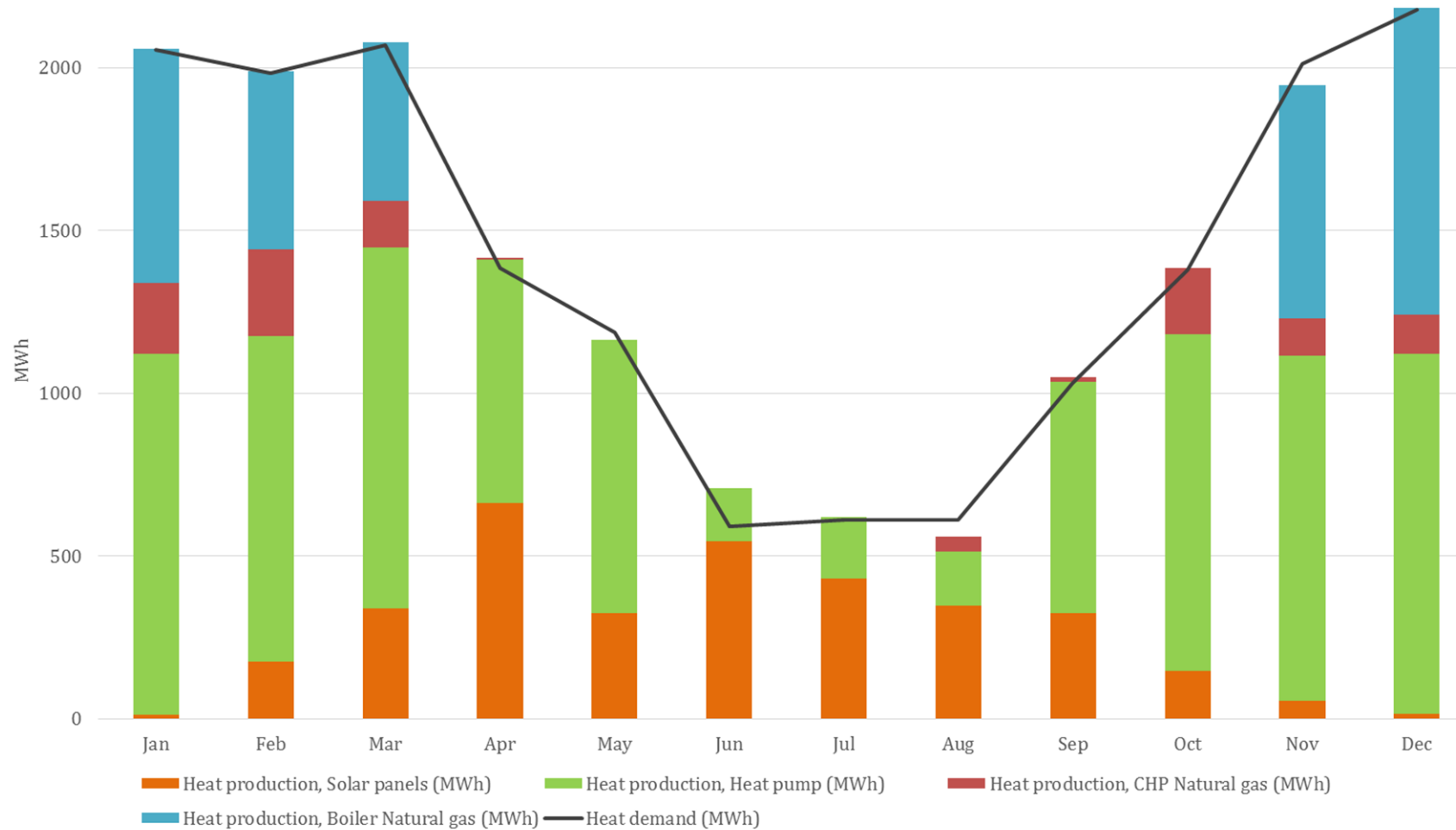
FUEL CONSUMPTION ON AN ANNUAL BASIS



TECHNICAL ANALYSIS

HEAT PRODUCTION ON A MONTHLY BASIS

Heat production from CHP, NG Boiler, Solar heating system and ground water HP



ECONOMIC ANALYSIS

BUSINESS ECONOMIC ASSESSMENT

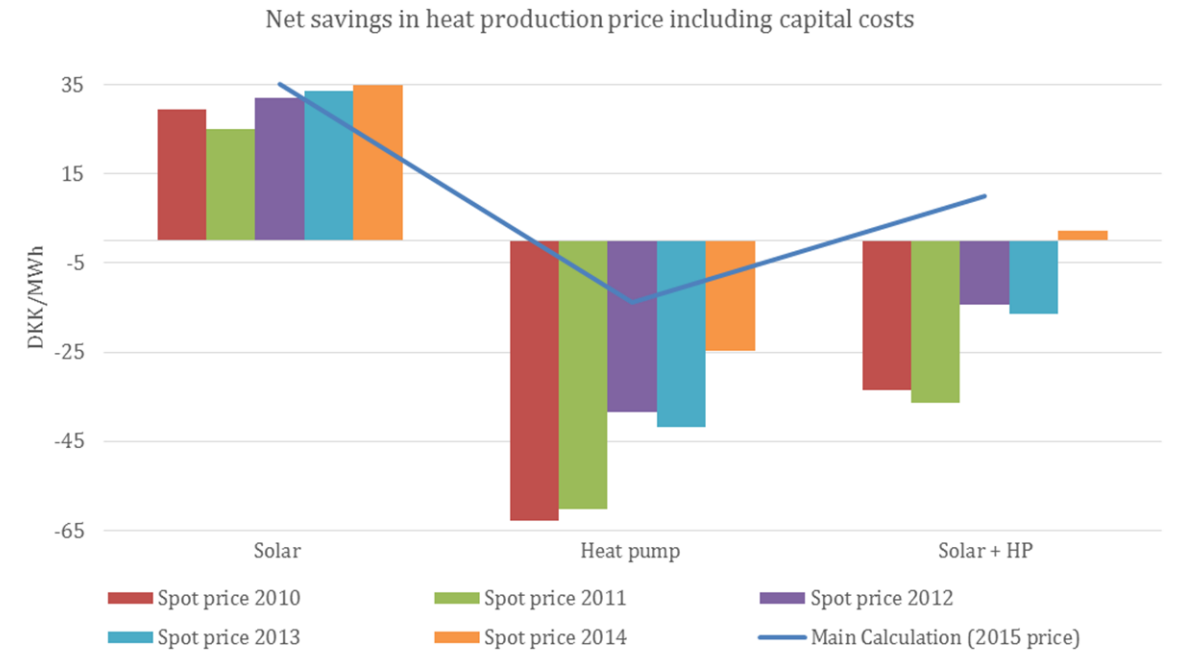
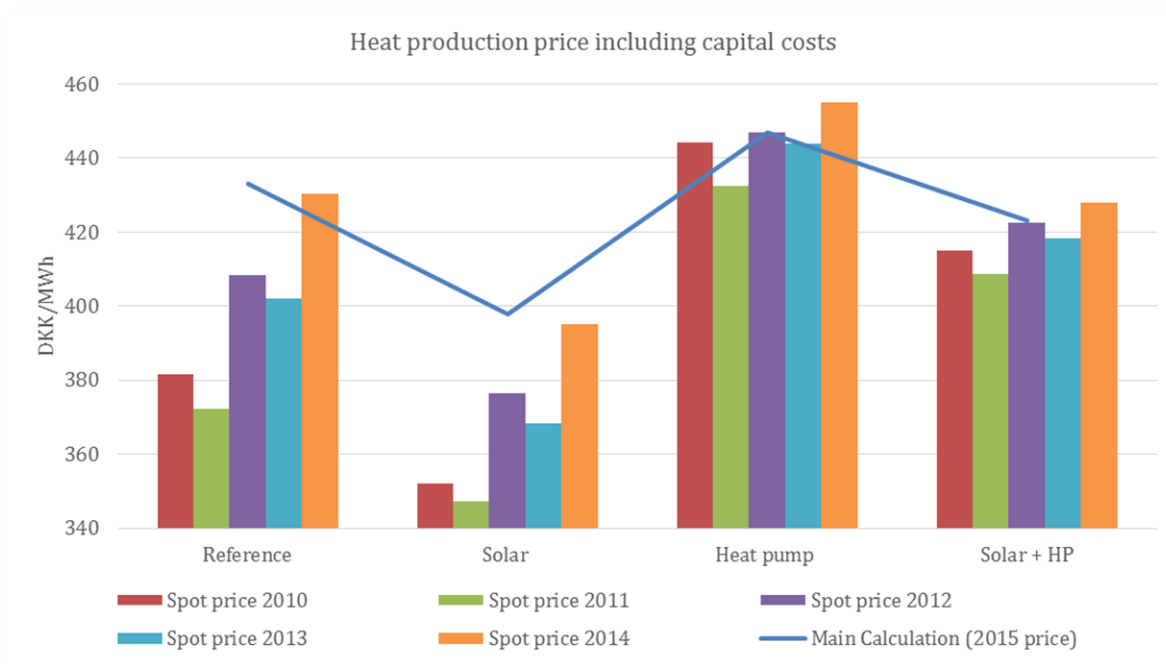
Input parameters:

- Natural gas price: 2,52 DKK/Nm³
- Electricity price: 2015 spot prices
- Taxes: 2016 levels

<i>Main calculation</i>		<i>S 0</i>	<i>S 1</i>	<i>S 2</i>	<i>S 3</i>
		<i>Reference</i>	<i>Solar</i>	<i>Heat pump</i>	<i>Solar + HP</i>
<i>Investments, total</i>	DKK	0	17.243.900	14.650.000	31.098.900
<i>Operation expenditures</i>	DKK/year	7.405.000	5.866.000	6.461.000	5.183.000
<i>Operation savings</i>	DKK/year	-	1.539.000	944.000	2.222.000
<i>Capital costs, total</i>	DKK/year	0	935.929	1.183.229	2.050.748
<i>Net savings</i>	DKK/year	-	603.071	-239.229	171.252
<i>Heat production price including capital costs</i>	DKK/MWh	433	398	447	423
<i>Savings, heat production price incl. capital costs</i>	DKK/MWh	-	35	-14	10
<i>Savings in the annual heating bill</i>	DKK/year		1.129	-439	320

SENSITIVITY ANALYSES

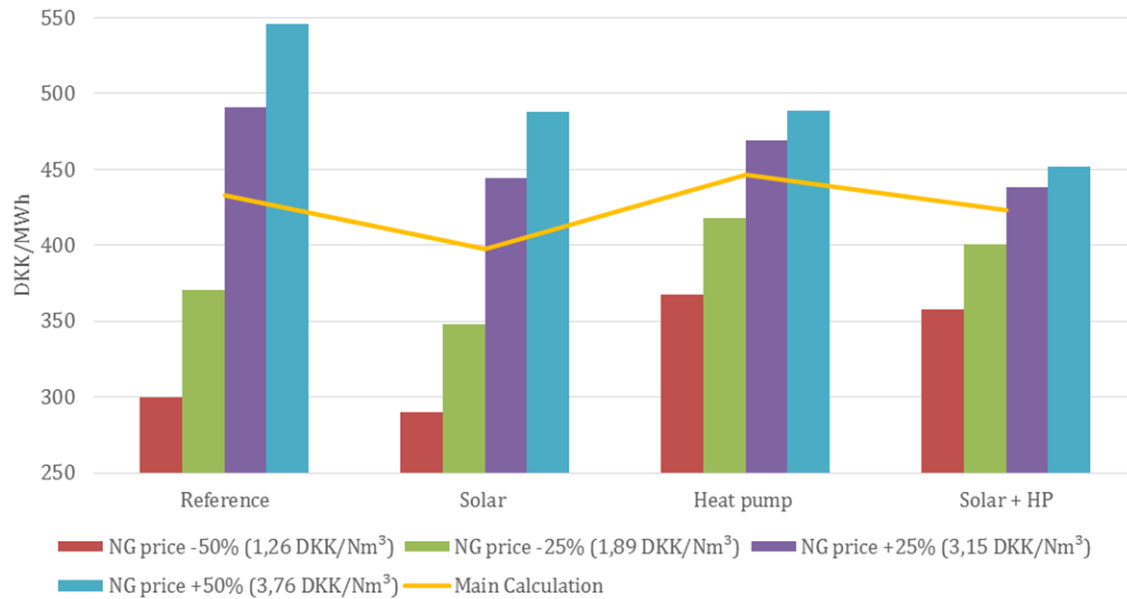
ELECTRICITY PRICE



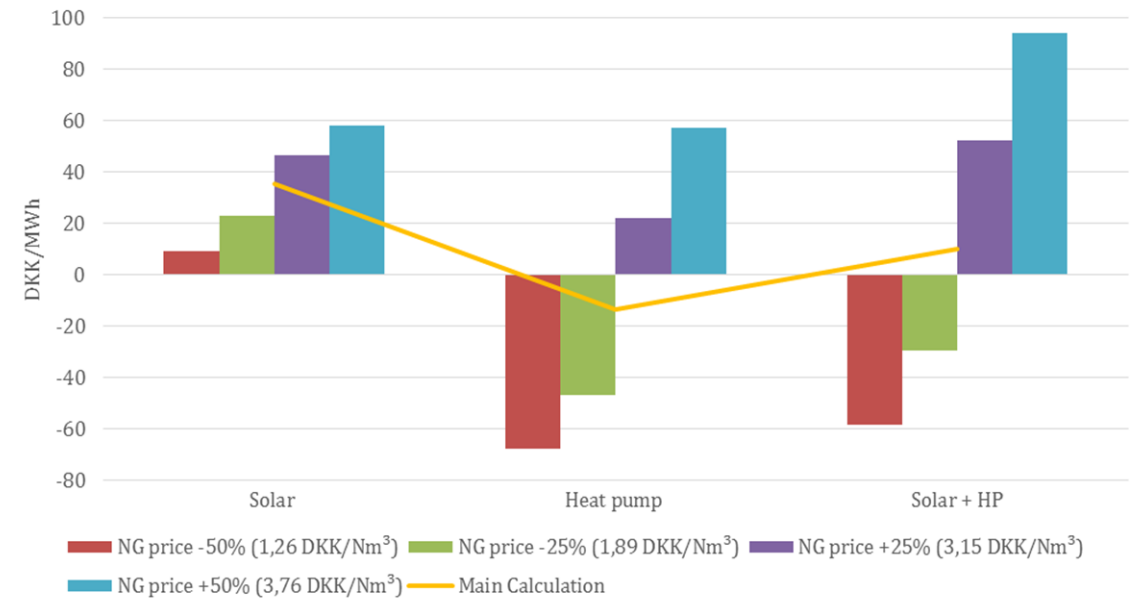
SENSITIVITY ANALYSES

NATURAL GAS PRICE

Heat production price including capital costs

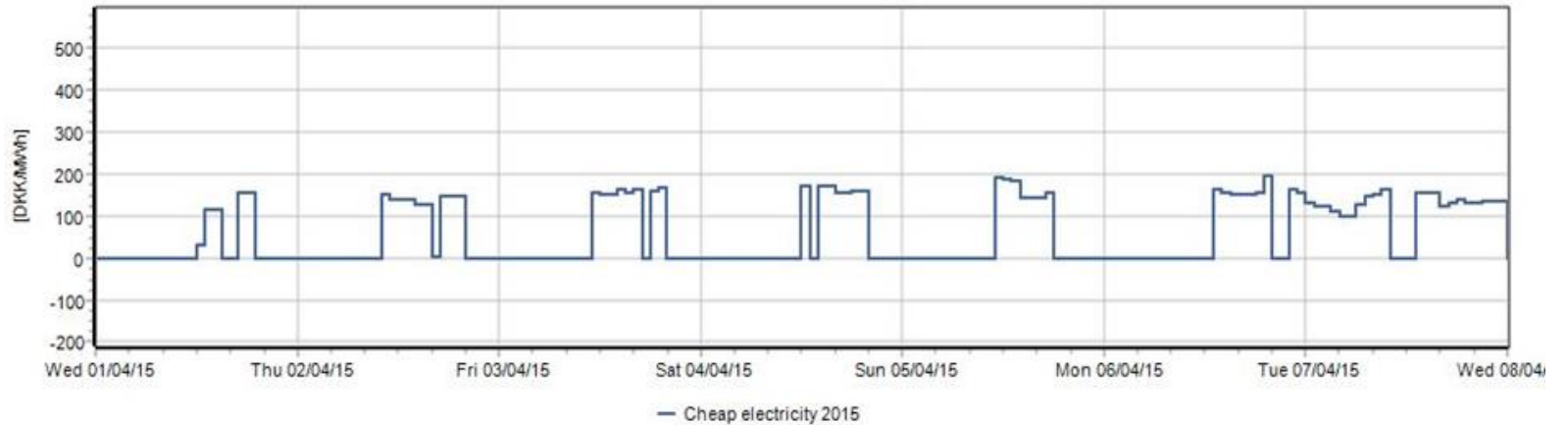


Net savings in heat production price including capital costs

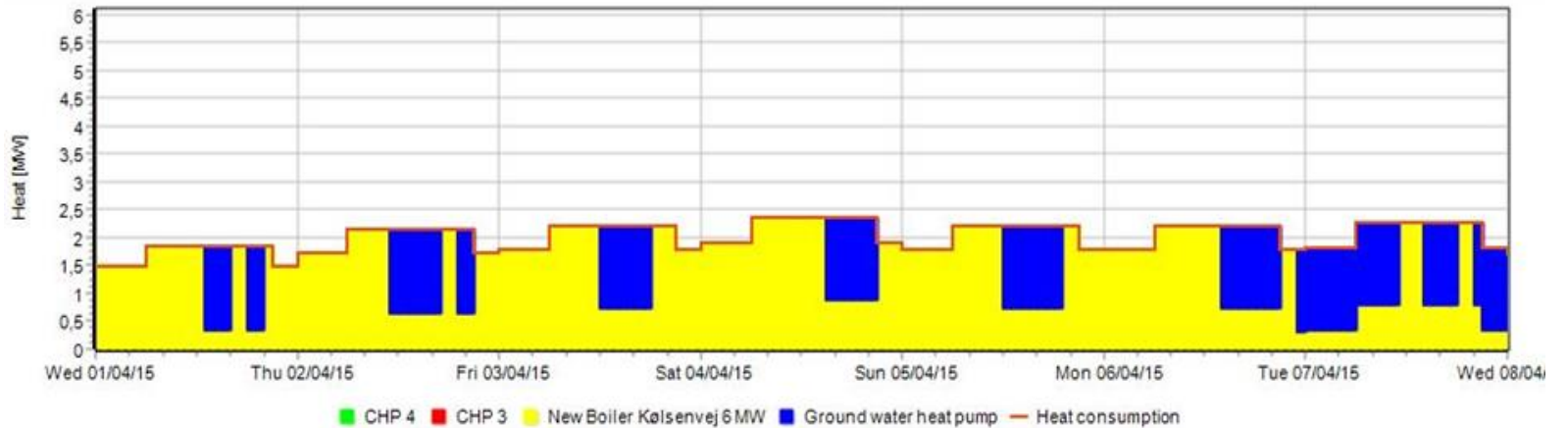


OPTIMIZATION HEAT PUMP ECONOMY

- Utilization of cheap electricity from wind turbines



- Tax reduction



CONCLUSION

Best alternative



FINAL CONCLUSION

All-in-all, under the current conditions in the DH sector in Denmark, the integration of solar thermal panels is more feasible in small DH plants, due to their favourable business-economic performance and robustness to variation of key economic parameters.

Nonetheless, with the aim of reaching future energy-related national goals, heat pumps have more potential from an energy production perspective. Hence, if the necessary measures for improving their economic performance are taken, heat pumps can be widely implemented in small DH plants in Denmark and can accelerate the transition of the national energy system away from fossil fuels.

Thank you for your attention!

