RENEWABLE ENERGY ALTERNATIVES FOR SMALL DISTRICT HEATING PLANTS

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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
**Case Study**

- **Løgstrup Varmeværk**
  - 750 connections
  - Natural gas-fired plant
  - 2 CHP units and 1 boiler
  - 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**

<table>
<thead>
<tr>
<th></th>
<th>Reference scenario</th>
<th>Scenario 1 – Solar</th>
<th>Scenario 2 – HP</th>
<th>Scenario 3 – Solar + HP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NG CHP units</strong></td>
<td>2,3 MW and 5,8 MW</td>
<td>7031 m² solar</td>
<td>1,5 MW ground</td>
<td>7031 m² solar</td>
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<tr>
<td></td>
<td>NG CHP units</td>
<td>thermal panels</td>
<td>water HP</td>
<td>thermal panels</td>
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<tr>
<td><strong>Solar thermal panels</strong></td>
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<tr>
<td><strong>Ground water HP</strong></td>
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<td><strong>Ground water HP</strong></td>
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<tr>
<td><strong>Boiler</strong></td>
<td>5,8 MW NG boiler</td>
<td>2000 m³ heat store</td>
<td></td>
<td>1,5 MW ground</td>
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<td></td>
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<td></td>
<td>water HP</td>
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<tr>
<td><strong>Heat store</strong></td>
<td>390 m³ heat store</td>
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<td>2000 m³ heat store</td>
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</table>
TECHNICAL ANALYSIS
HEAT PRODUCTION ON AN ANNUAL BASIS

Heat production and natural gas consumption per year

- Heat production, CHP Natural gas MWh/year
- Heat production, Heat pump MWh/year
- Natural gas use (11 kWh/Nm3) Nm3/year
- Heat production, Solar panels MWh/year
- Heat production, Boiler Natural gas MWh/year
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

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

Heat production price including capital costs

Net savings in heat production price including capital costs
SENSITIVITY ANALYSES
NATURAL GAS PRICE

Heat production price including capital costs

Net savings in heat production price including capital costs

- NG price -50% (1.26 DKK/Nm³)
- NG price -25% (1.89 DKK/Nm³)
- NG price +25% (3.15 DKK/Nm³)
- NG price +50% (3.76 DKK/Nm³)
- Main Calculation
OPTIMIZATION
HEAT PUMP ECONOMY

- Utilization of cheap electricity from wind turbines
- Tax reduction
CONCLUSION

Best alternative
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!