A Booming Market for Solar District Heating
Opportunities and Challenges

Jan Erik Nielsen
PlanEnergi
- Consultant Engineers
- 30 employees
- Renewable energy & energy planning

Operating Agent for IEA-SHC Task 45
“Large Solar Heating/Cooling Systems ...”
Denmark plans to:

- Phase out all fossil fuels before 2050
- Heating and electricity all by renewable energy before 2035
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Wind energy:

- **2013:** 33% of electricity
- **2020:** 50% of increased electricity consumption (incl. transport, heat pumps, ...)
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Solar thermal:

- 2030: 15% of decreased heating demand
- 2050: 40% of decreased heating demand - 80% of the solar heat via district heating

### Solar District Heating in Denmark

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of plants (thin bars)</th>
<th>Installed collector area [m²] (thick bars)</th>
<th>Sum of collector area and the number of plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>2007</td>
<td>0</td>
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<td>2008</td>
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<td>2013</td>
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<tr>
<td>2014</td>
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<td>0</td>
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</tr>
<tr>
<td>2015</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tbody>
</table>

### Table: Solar District Heating

<table>
<thead>
<tr>
<th>Year</th>
<th>District heating total</th>
<th>Solar District Heating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PJ</td>
<td>PJ</td>
</tr>
<tr>
<td>2011</td>
<td>133</td>
<td>0.30</td>
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<tr>
<td>2012</td>
<td>150</td>
<td>0.50</td>
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<td>2013</td>
<td>140</td>
<td>0.66</td>
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<tr>
<td>2014</td>
<td>135</td>
<td>1.09</td>
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<tr>
<td>2015</td>
<td>130</td>
<td>1.25</td>
</tr>
</tbody>
</table>
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**PlanEnergi**

**September 2014**

**Task 45**

**SHC Conference 2014**

**OCTOBER 13-15**

**BEIJING, CHINA**
WHY so successful in DK?

- Long time tradition for district heating
- Good price / performance of ground mounted collectors
- High tax on natural gas
- Competitive heat production price
- Interaction with liberal electricity market

Prices ex. VAT
Long time tradition for district heating in Denmark

- 60% of all heating demand* is now supplied by district heating
- Low temperatures in the network
  - Forward 70 - 80°C; Return 35 - 45°C ... still going down
- Available district heating networks in the country side with cheap ground
- Special structure of de-central district heating companies:
  Small, user owned -> local back-up -> positive attitude from local authorities

*) Low application temperature: < 80°C
Good price of installations

- Prices down to 190 €/m² collector ≈ 270 €/kW (system in operation)
- Average around 250 €/m² ≈ 360 €/kW
- Large modules - fast installation

Good performance

- Max. collector field output > 530 kWh/m²; max. efficiency > 50 %
- Average output: 440 kWh/m²; average efficiency: 40 %

Solar Thermal x PV

- Costs per m²: Solar Thermal ≈ PV
- Energy production per m²: Solar Thermal 2-3 higher than PV
Good heat production price

- Prices down to 30 €/MWh (0.03 €/kWh)
- Average around 45 €/MWh (0.045 €/kWh)
Simple solar district heating systems with solar fractions of 5-25% are most popular so far - around 10,000 m² (7 MW) - but it seems to be cost effective too, to go for higher solar fractions / long term storage due to:

- Improved storage technology (simple/cheap)
- LARGE SYSTEMS → small storage losses & lower specific costs
- Interaction with liberal electricity market
- Benefits from combining technologies
Cheap storage technology, water pit (or borehole)

Price ≈ 20 €/m³
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LARGE SYSTEMS $\rightarrow$ small storage losses & lower specific costs

**Surface area per volume**
(Cylinder, Radius = Height)

1.2 $\rightarrow$ 0.1 $\Rightarrow$ Factor 12 on surface area/volume (heat loss/storage capacity)

**Cost per equivalent m³**

500 $\rightarrow$ 20 $\Rightarrow$ Factor 25 on costs/volume (cost/storage capacity)
Problem:
As renewable electricity production increases - the mismatch of production versus load increases and so do the dynamics of the electricity price:
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Interaction with liberal electricity market

**Solution:**

Combined technologies and **heat storage** interacting with the electricity grid ...
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Benefits from combining technologies and using heat storage

Solar:
- Produce free heat

Heat pump:
- Produce cheap heat
- Fast capacity regulation (load) → earn money
- Reduce storage volume

CHP:
- Produce valuable electricity → earn money
- Fast capacity regulation (prod.) → earn money

Storage:
- Gives the flexibility
- Makes the combinations of technologies possible
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Trend: More and more electricity production from wind & PV ... →
Less and less need for electricity production from CHP ...
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Examples

>30 systems on-line at www.solvarmedata.dk

System info:
- Size
- Price
- Measured output
- ...
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Example: Jægerspris (2010)

- Users: 1,300
- Sold heat 2013: 28,000 MWh
- Collector area: 13,400 m²
- Collector output 2013: 6,600 MWh
- Specific output 2013: 490 kWh/m²
- Solar fraction ≈ 20%
- System price: 221 €/m²
- Solar heat price*: 35 €/MWh
- Other heat resource: Natural gas

*) 20 years, 3% net interest rate, operation & maintenance 1% of investment per year
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Example: Marstal (2012) “SUNSTORE 4” (EU 7th FP)

- Collector area: 18 000 + 15 000 m²
- Store volume: 75 000 m³
- Heat pump: 1 MW
- Boiler: 4 MW (wood chip)
- CHP: 0.75 MWe (ORC)
- Renewable fraction: 100 %
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Marstal:
Now in total 33 000 m² (23 MW) solar panels & 75 000 m³ pit heat storage
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Dronninglund - so far the biggest solar district heating system in the world

37,300 m² (26 MW) collectors

60,000 m³ storage
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New large systems coming up:

✓ Gram: + 31 000 m² (in total: 41 000 m²); 110 000 m³ water pit storage
✓ Vojens: + 53 500 m² (in total: 71 000 m²); 200 000 m³ water pit storage

http://www.vojensfjernvarme.dk/
Lars Damkjaer, Gram District Heating Company:

“Expanding (in 2014) from 15 % to >50 % solar fraction increasing the collector area from 10 000 m² to 41 000 m² (29 MW) - is the basic element in our plan to become the cheapest district heat provider in Denmark”.
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Jan Erik Nielsen, PlanEnergi:

- District heating is a good argument for solar heating
- Solar heating is a good argument for district heating

- Renewable electricity production
  - Solar (PV, CSP)
  - Wind
  - CHP (biomass)

  FITS VERY WELL WITH:

- Renewable heat production
  - Solar (thermal)
  - Heat pump (wind)
  - CHP (waste heat)
  - HEAT STORAGE

Thank you for your attention
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