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 …"

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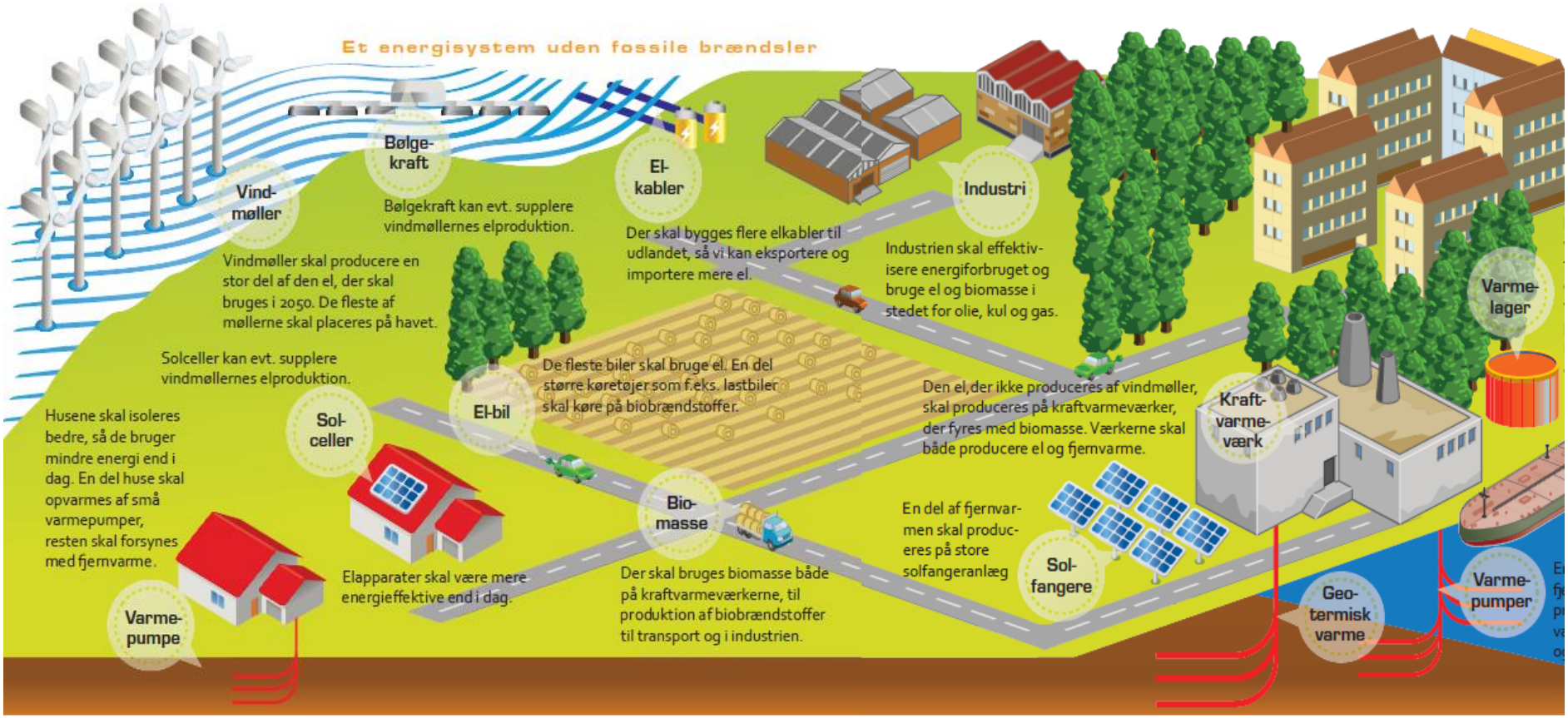
Opportunities and Challenges

Denmark plans to:

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



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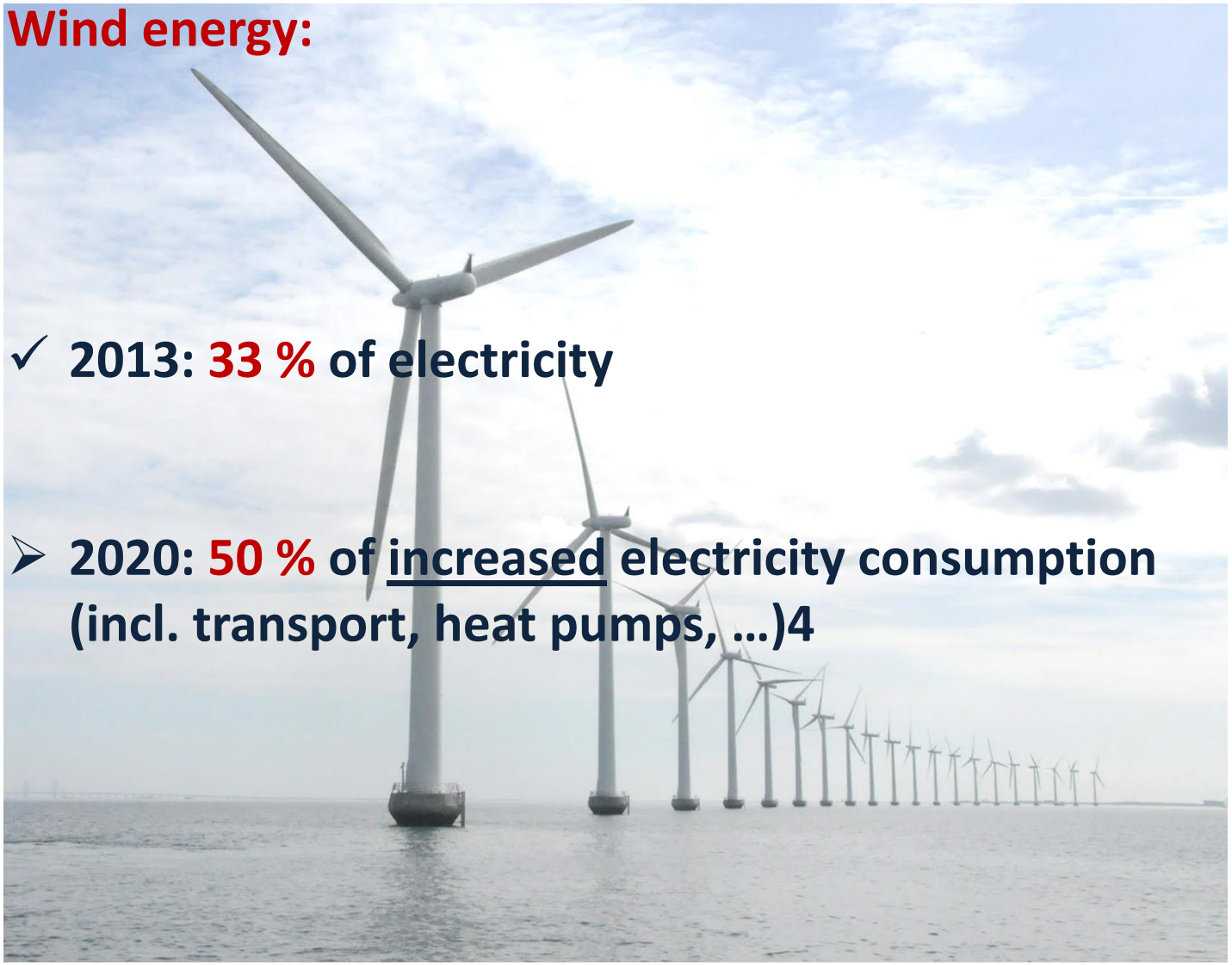
Opportunities and Challenges



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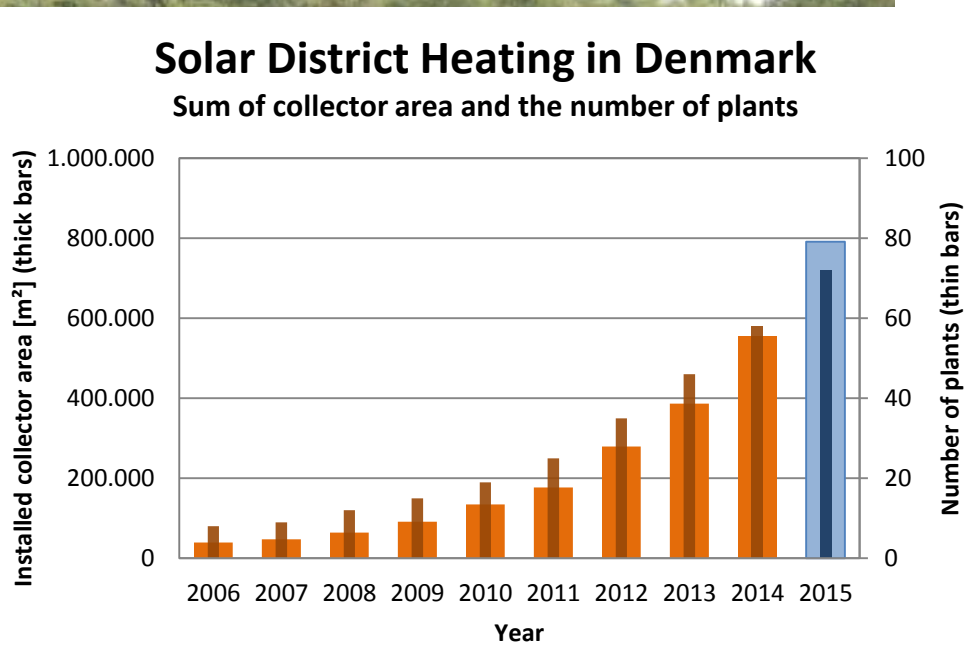
Opportunities and Challenges

Solar thermal:

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

	District heating total	Solar District Heating	
	PJ	PJ	%
2011	133	0.30	0.2%
2012	150	0.50	0.3%
2013	140	0.66	0.5%
2014	135	1.09	0.7%
2015	130	1.25	1.0%



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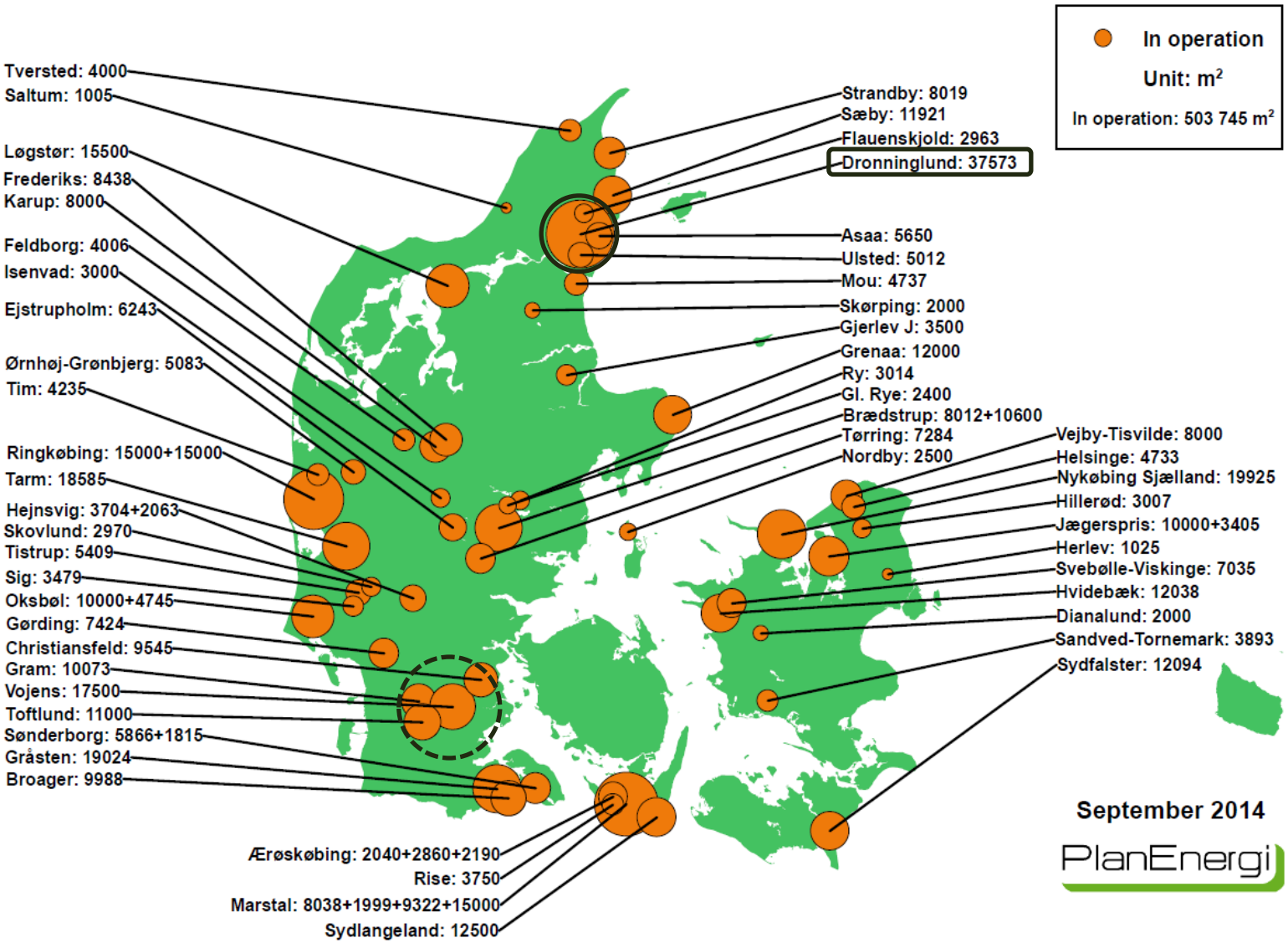
Opportunities and Challenges



WHY so successful in DK?

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

Prices ex. VAT

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Opportunities and Challenges

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

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Opportunities and Challenges

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

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Opportunities and Challenges

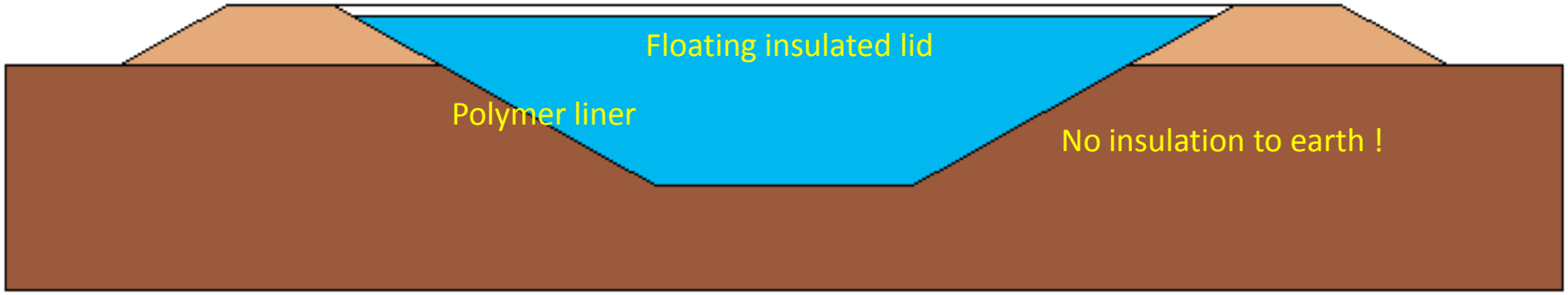
Good heat production price

- Prices down to 30 €/MWh (0.03 €/kWh)
- Average around 45 €/MWh (0.045 €/kWh)

Interaction with dynamic electricity production

- 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 €/m^3

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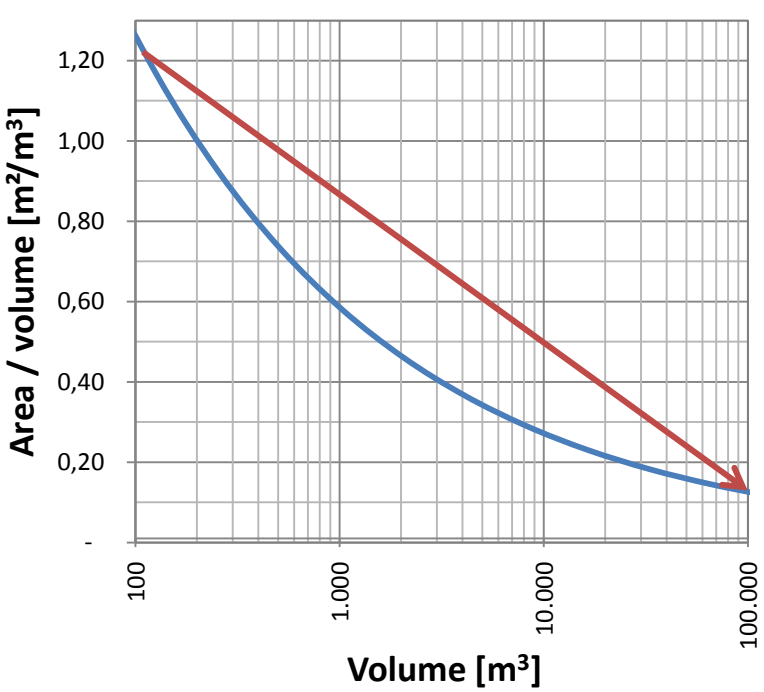
Opportunities and Challenges

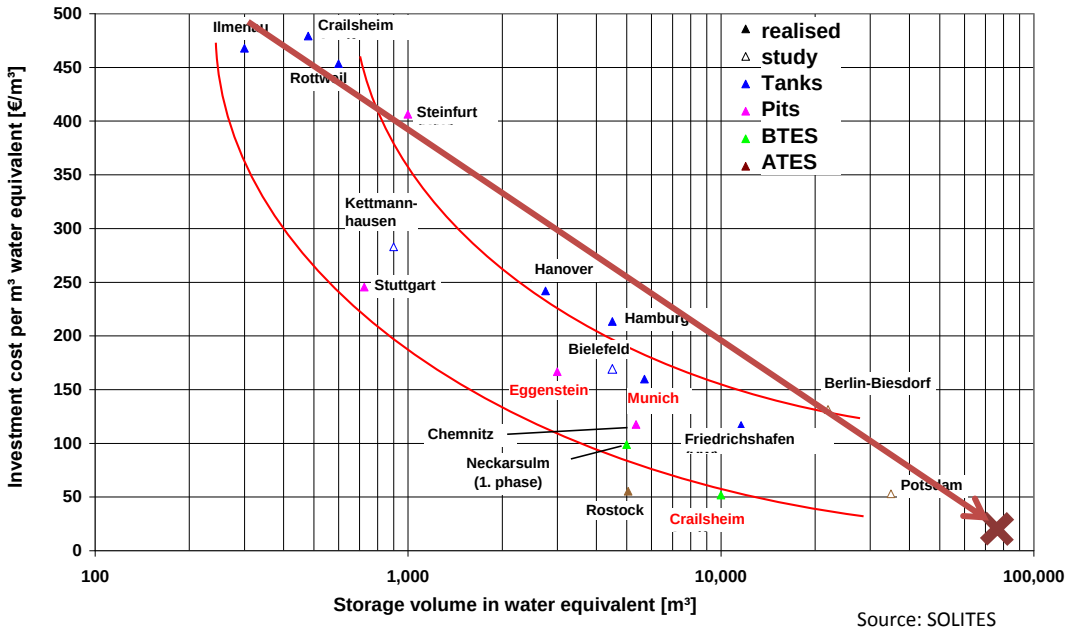
LARGE SYSTEMS → small storage losses & lower specific costs

Surface area per volume

(Cylinder, Radius = Height)



Cost per equivalent m³



Source: SOLITES

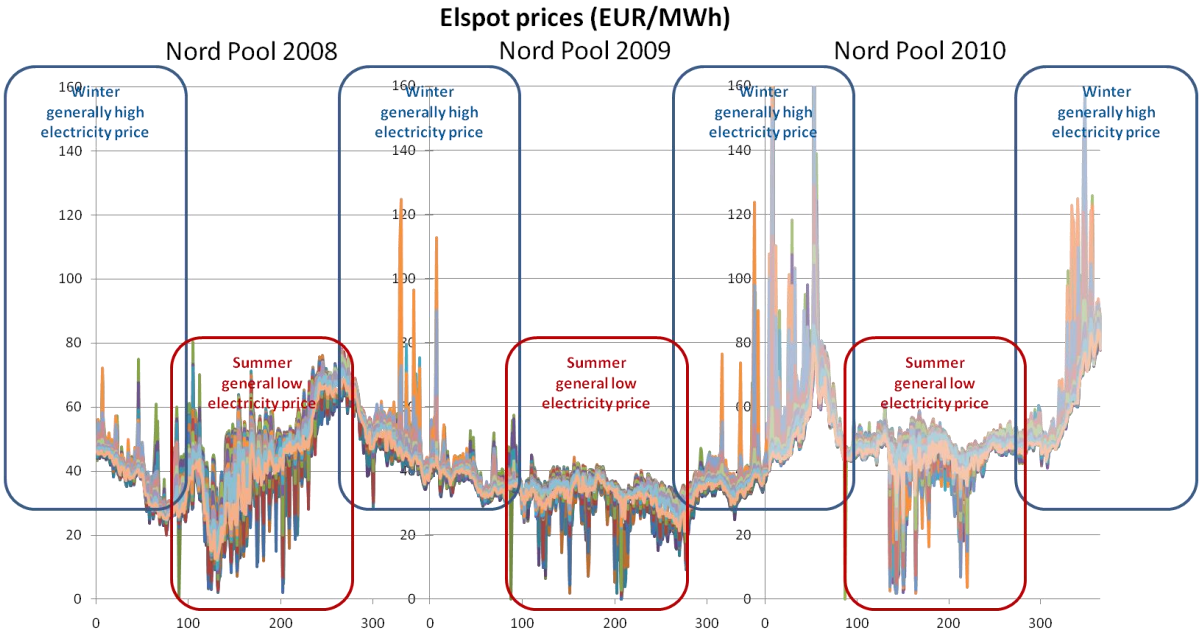
1.2 → 0.1 ➔ Factor 12 on surface area/volume (heat loss/storage capacity)

500 → 20 ➔ Factor 25 on costs/volume (cost/storage capacity)

Interaction with liberal electricity market

Problem:

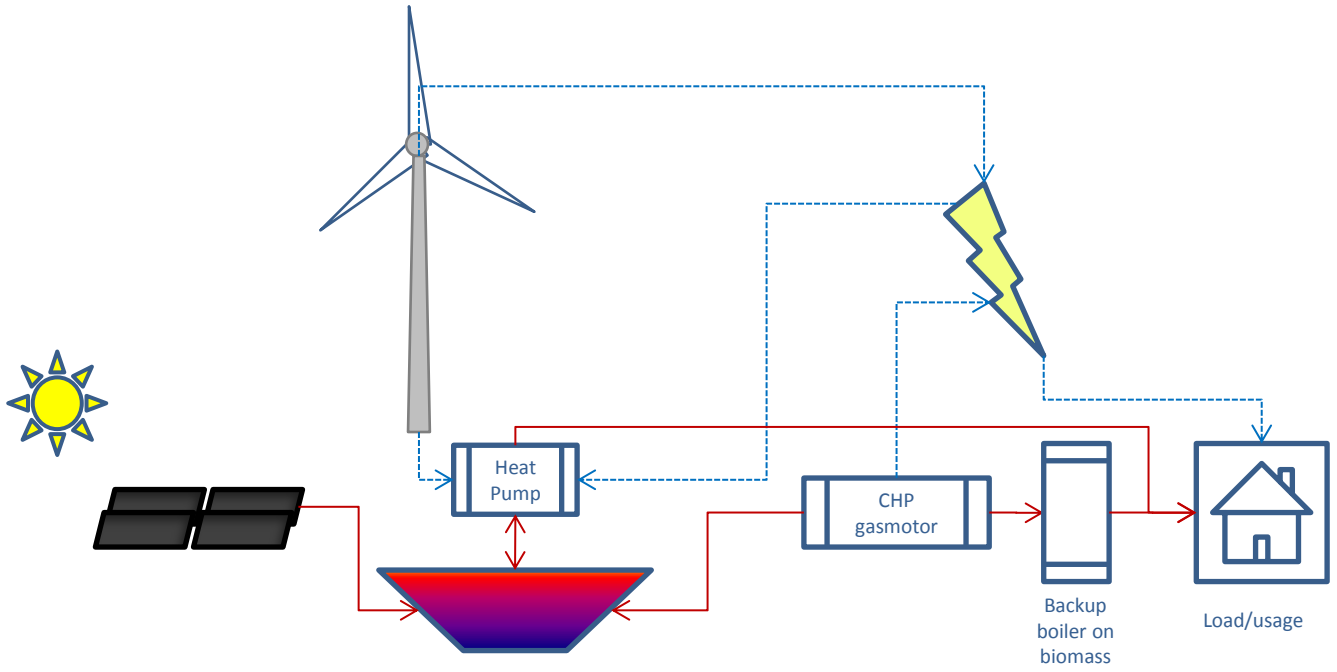
As renewable electricity production increases - the mismatch of production versus load increases and so do the dynamics of the electricity price:



Interaction with liberal electricity market

Solution:

Combined technologies and heat storage interacting with the electricity grid …



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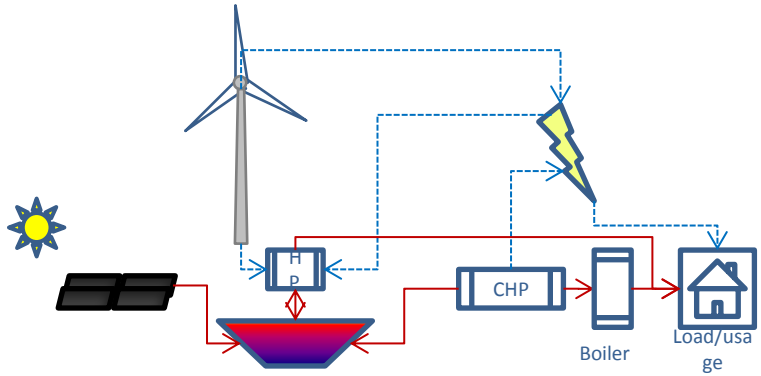
Opportunities and Challenges

Benefits from combining technologies and using heat storage



Solar:

- ✓ Produce free heat

CHP:

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

Heat pump:

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

Storage:

- ✓ Gives the flexibility
- ✓ Makes the combinations of technologies possible

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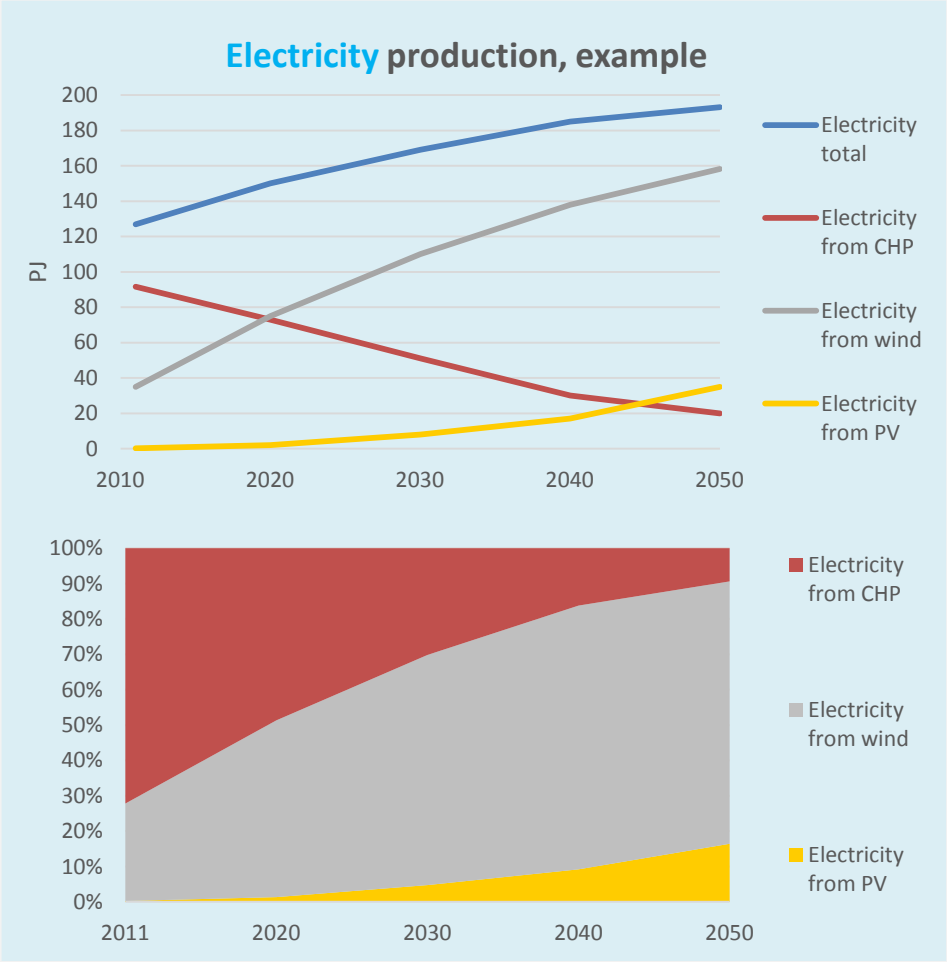
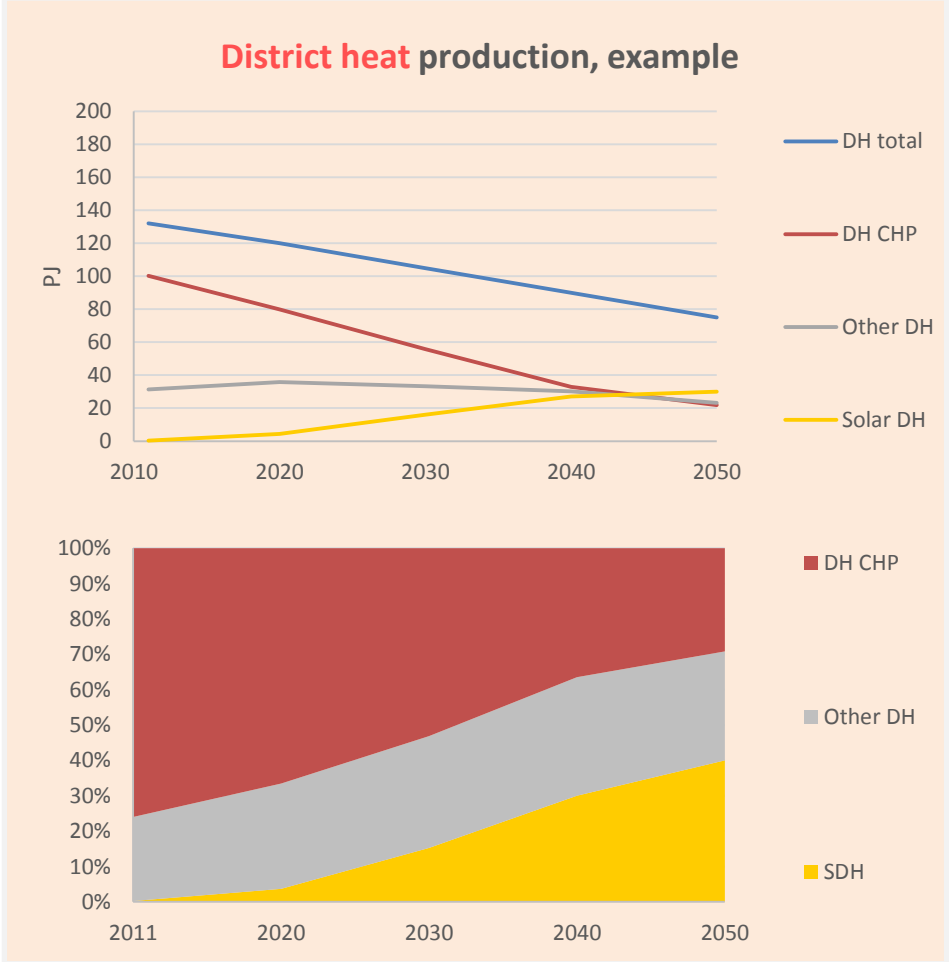
Opportunities and Challenges

Trend: More and more electricity production from wind & PV … →

Less and less need for electricity production from CHP …





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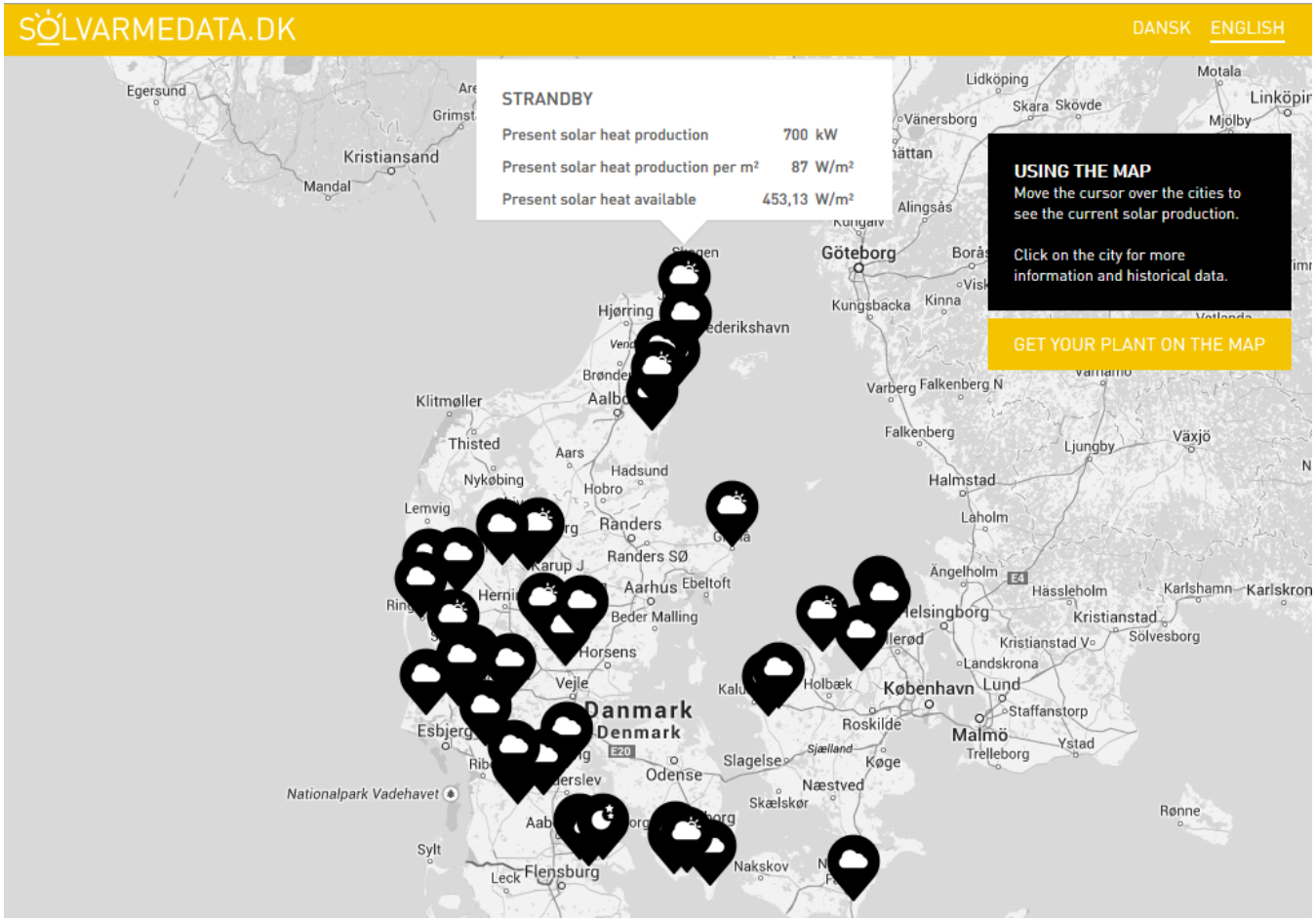
Opportunities and Challenges

Examples

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

System info:

- Size
- Price
- Measured output
- …



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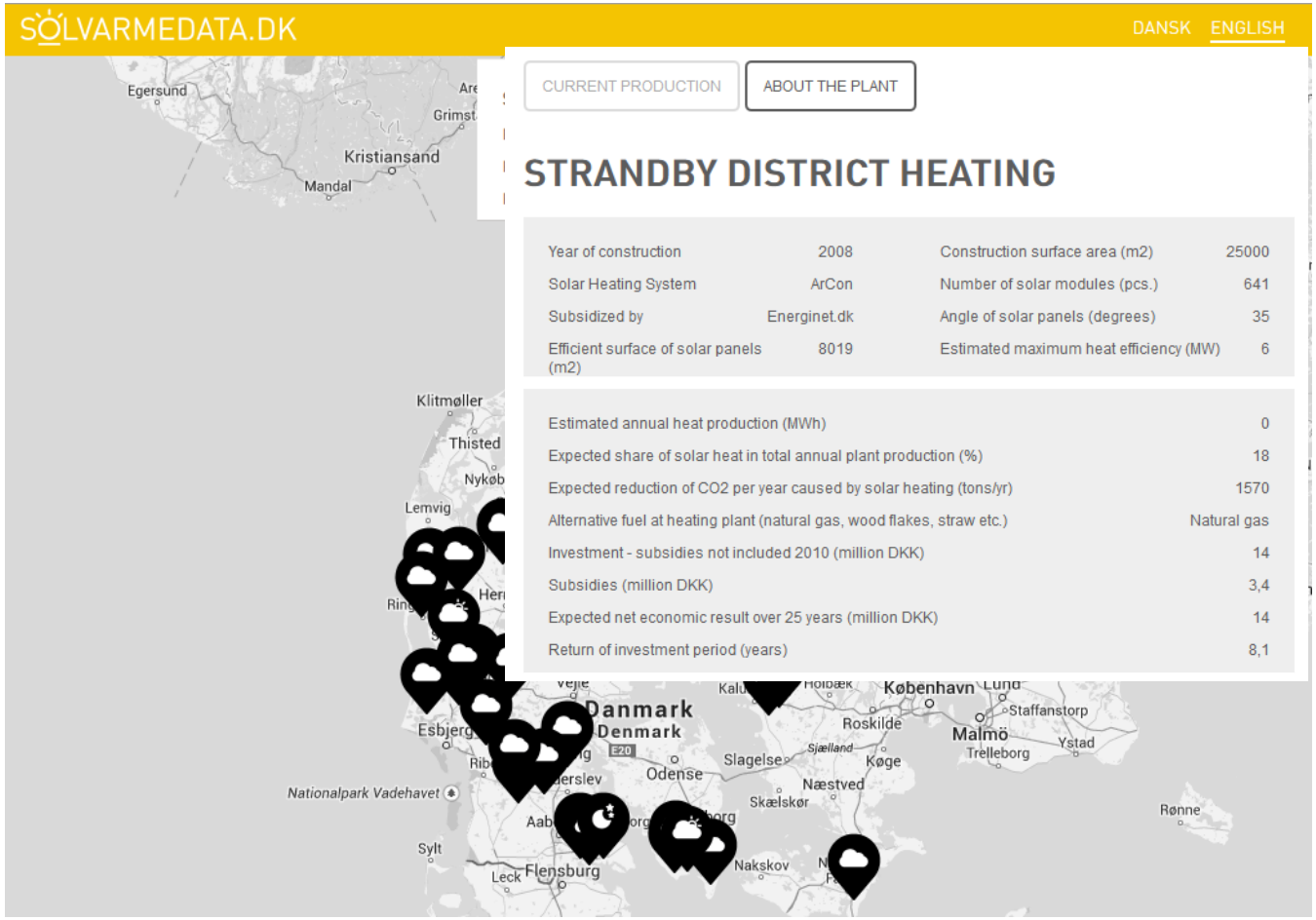

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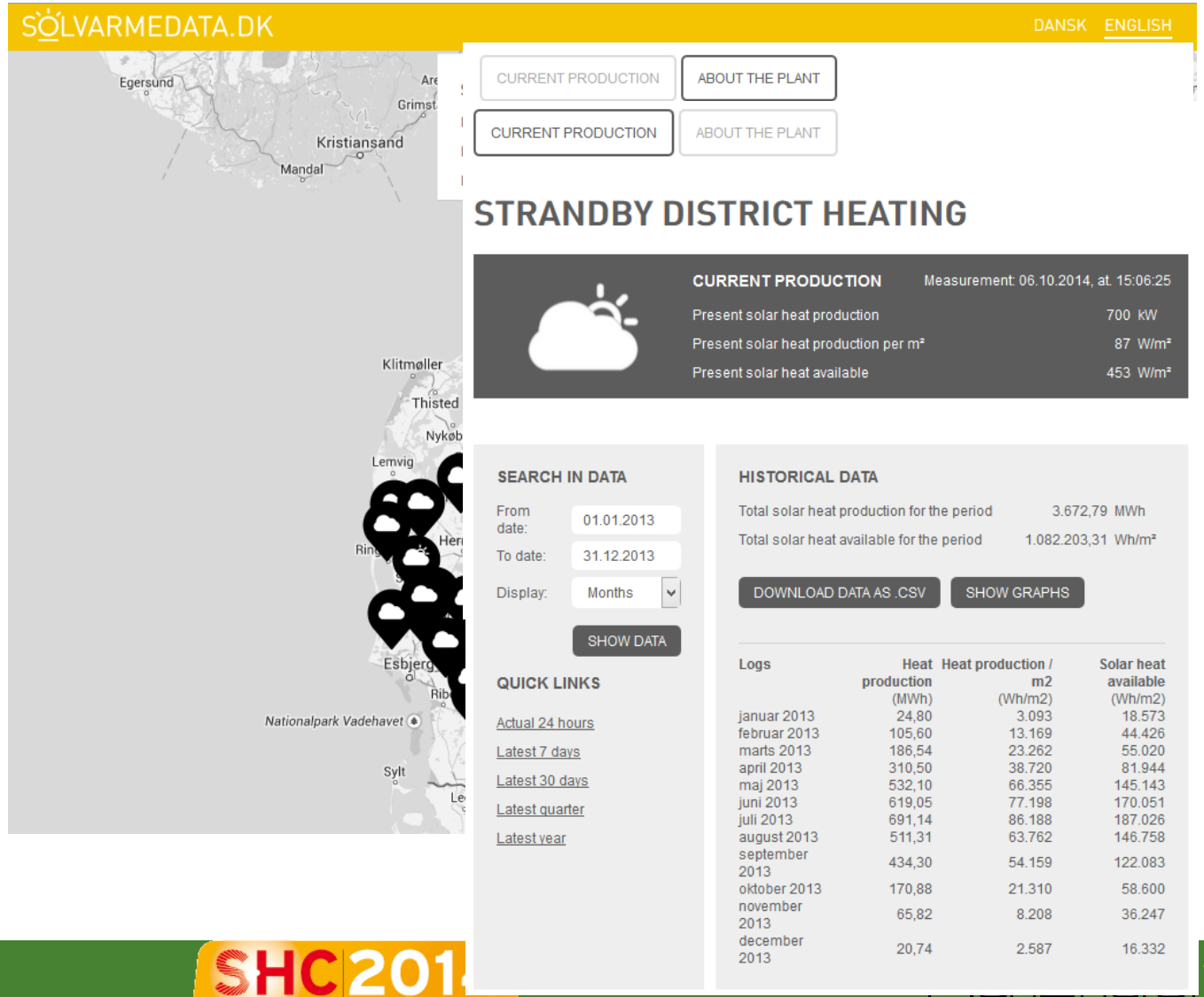

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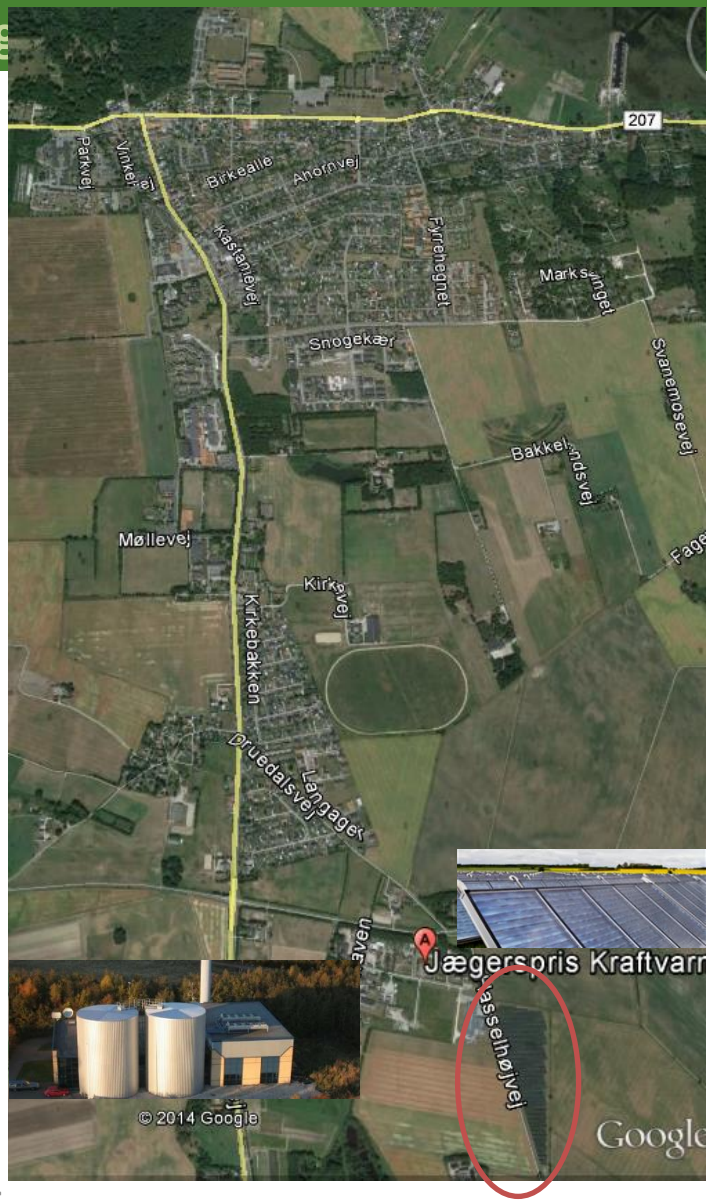
Opportunities and Challeng

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

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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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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Opportunities and Challenges

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/

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Opportunities and Challenges

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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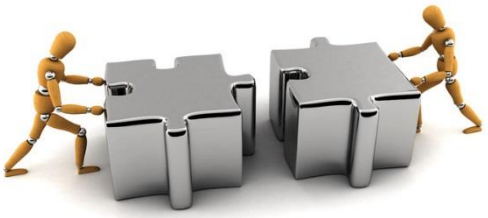
Opportunities and Challenges

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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