

A Booming Market for **Solar** District Heating Opportunities and Challenges



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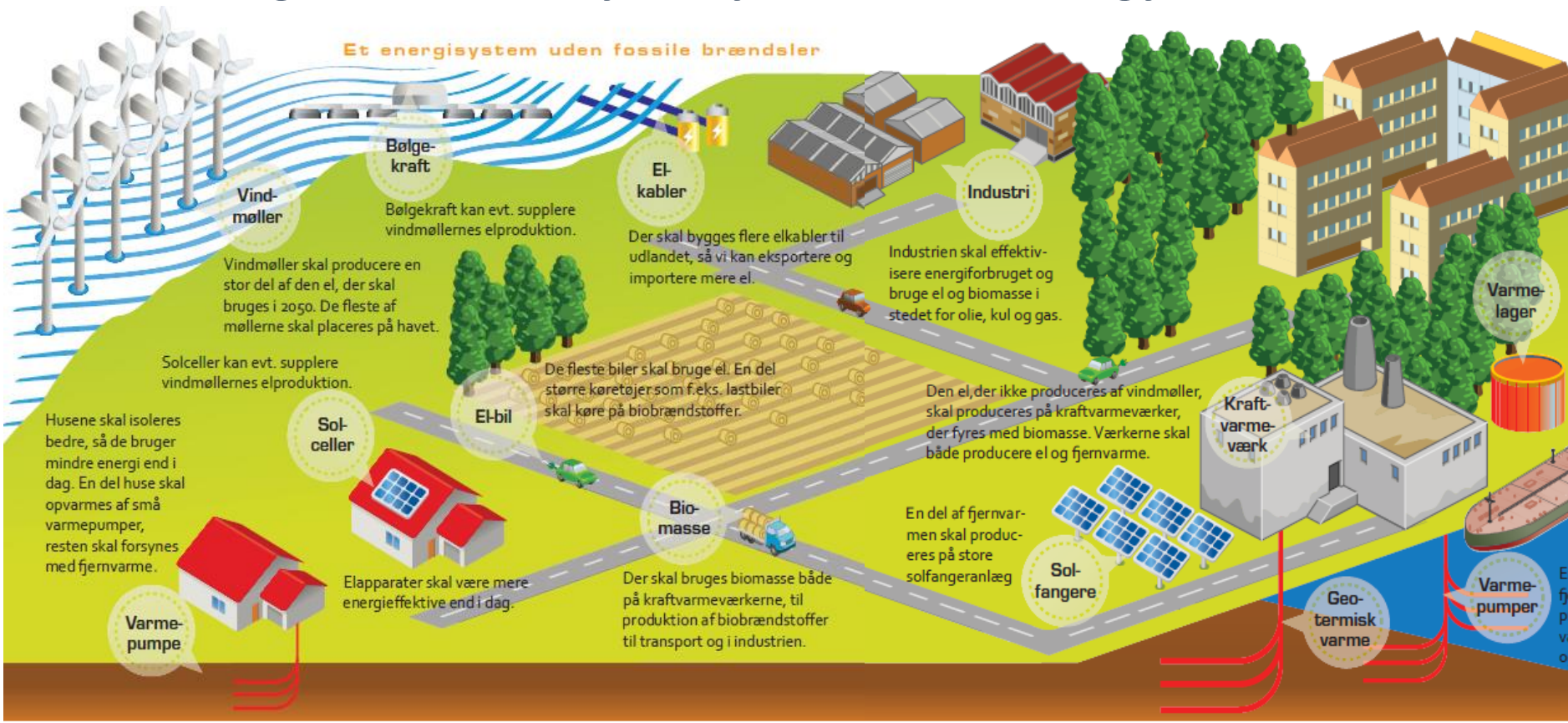
Operating Agent for IEA-SHC Task 45
“Large Solar Heating/Cooling
Systems ...”

A Booming Market for Solar District Heating

Opportunities and Challenges

Denmark plans to:

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

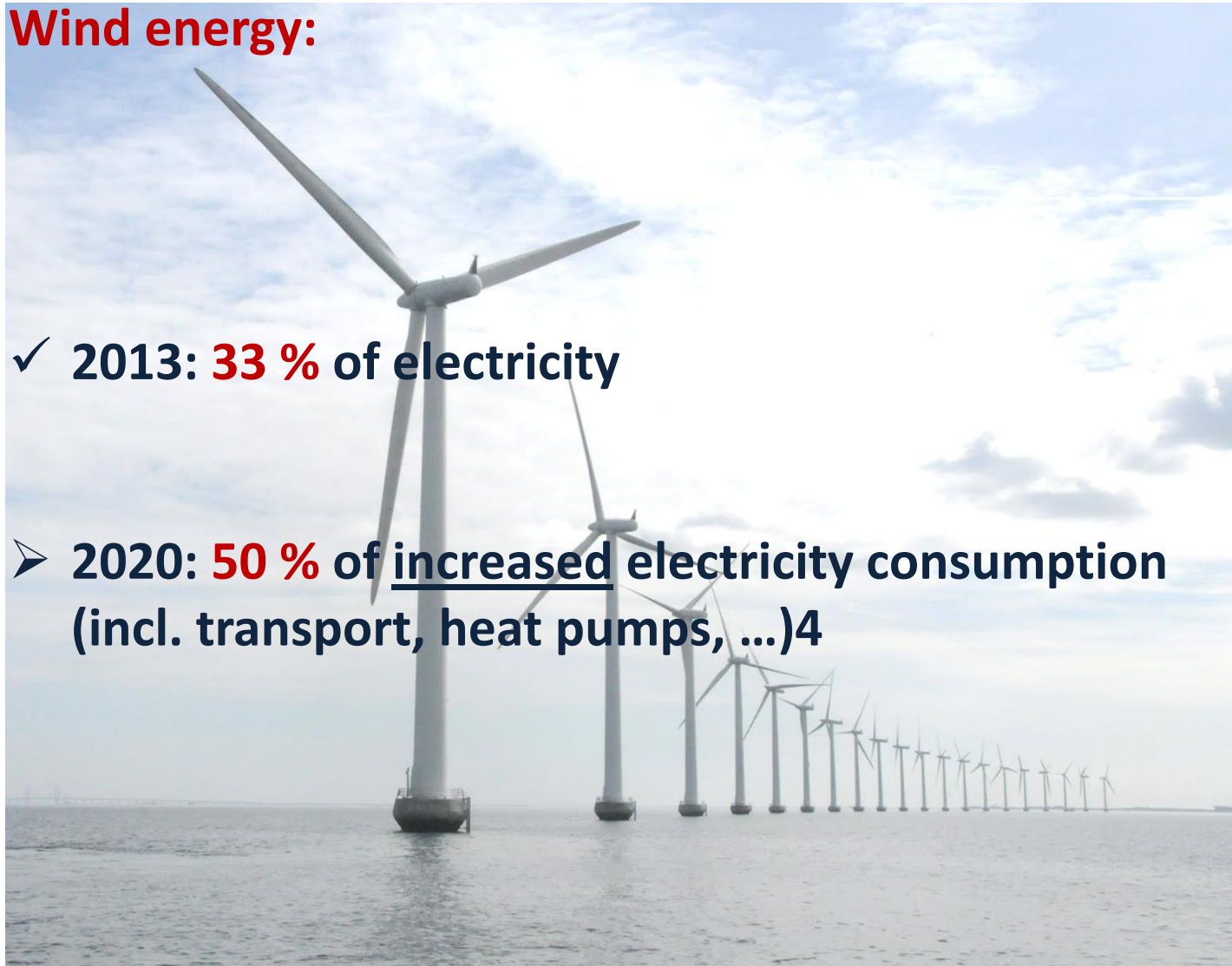


A Booming Market for **Solar** District Heating

Opportunities and Challenges

Wind energy:

- ✓ 2013: **33 %** of electricity
- 2020: **50 %** of increased electricity consumption (incl. transport, heat pumps, ...)4



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Opportunities and Challenges

Solar thermal:

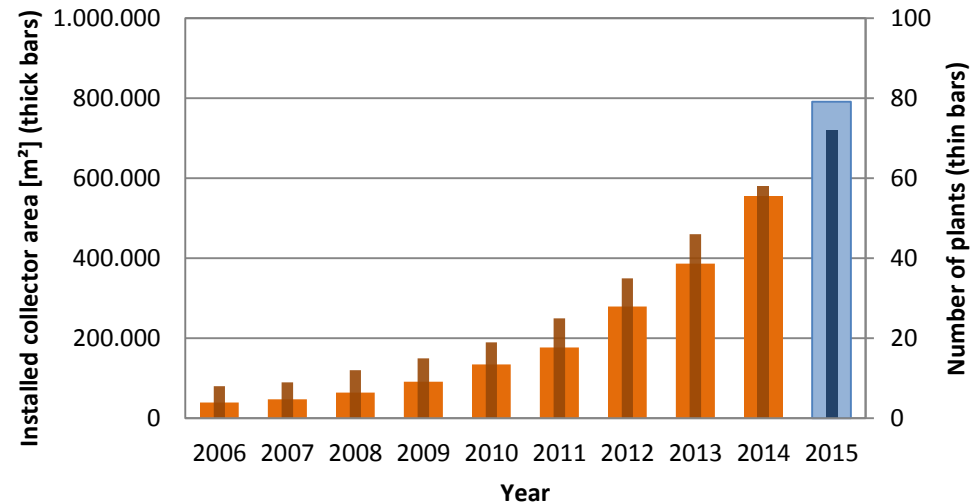
- 2030: 15 % of decreased heating demand
- 2050: → 40 % of decreased heating demand - **80 %** of the solar heat via district heating



	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%

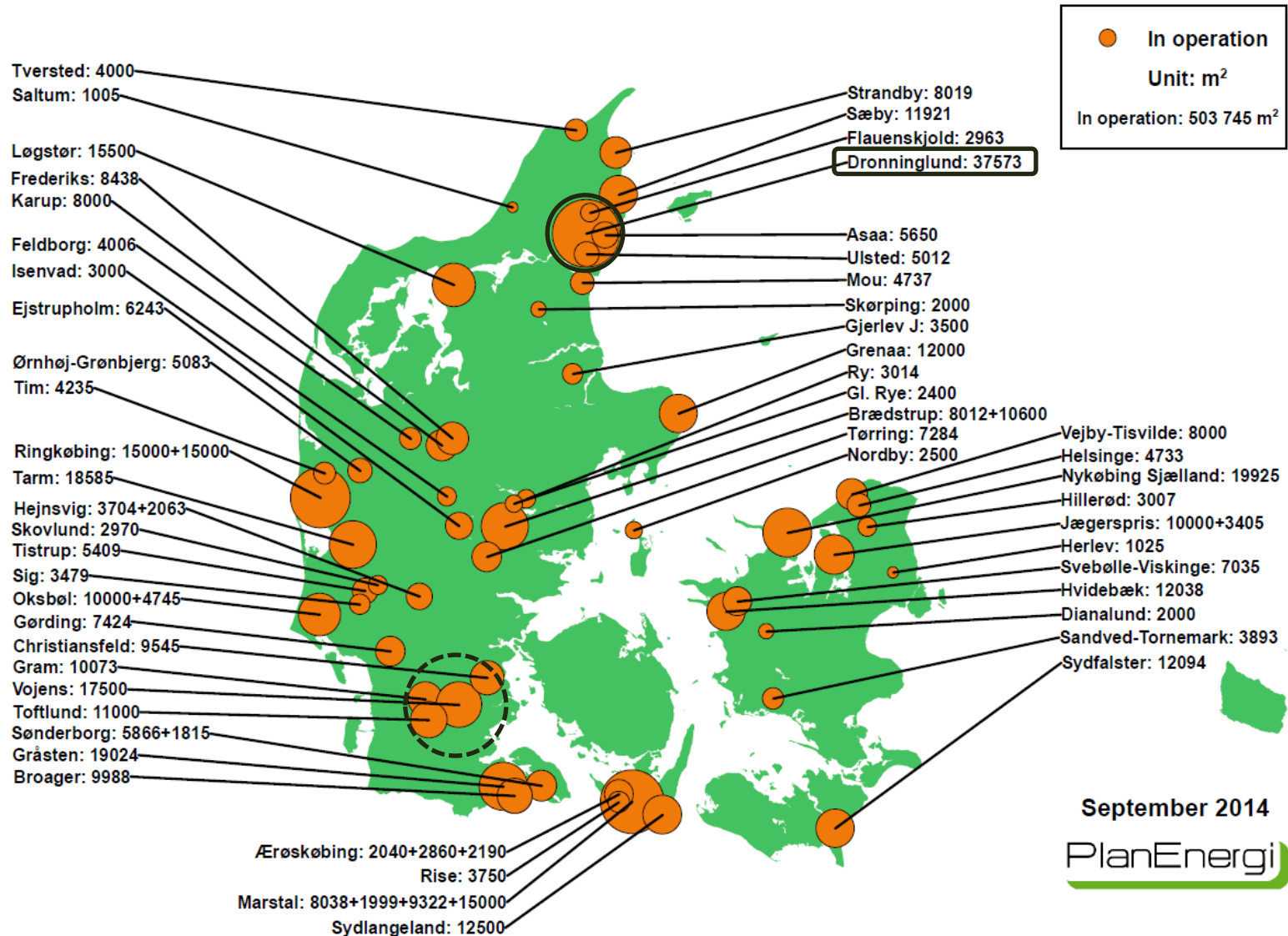


Solar District Heating in Denmark
Sum of collector area and the number of plants



A Booming Market for Solar District Heating

Opportunities and Challenges



September 2014

PlanEnergi

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

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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)

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Opportunities and Challenges

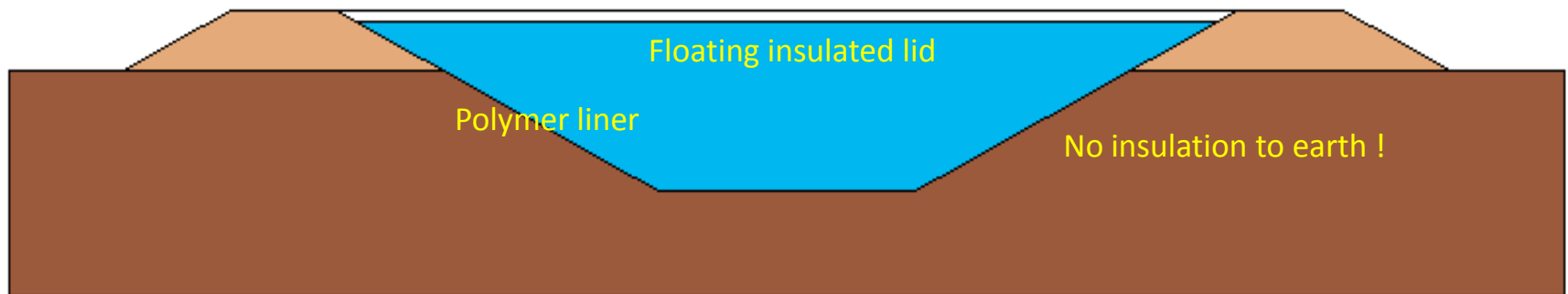
Interaction with dynamic electricity production

- ❑ 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**

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Opportunities and Challenges

Cheap storage technology, water pit (or borehole)



Price \approx 20 €/m³

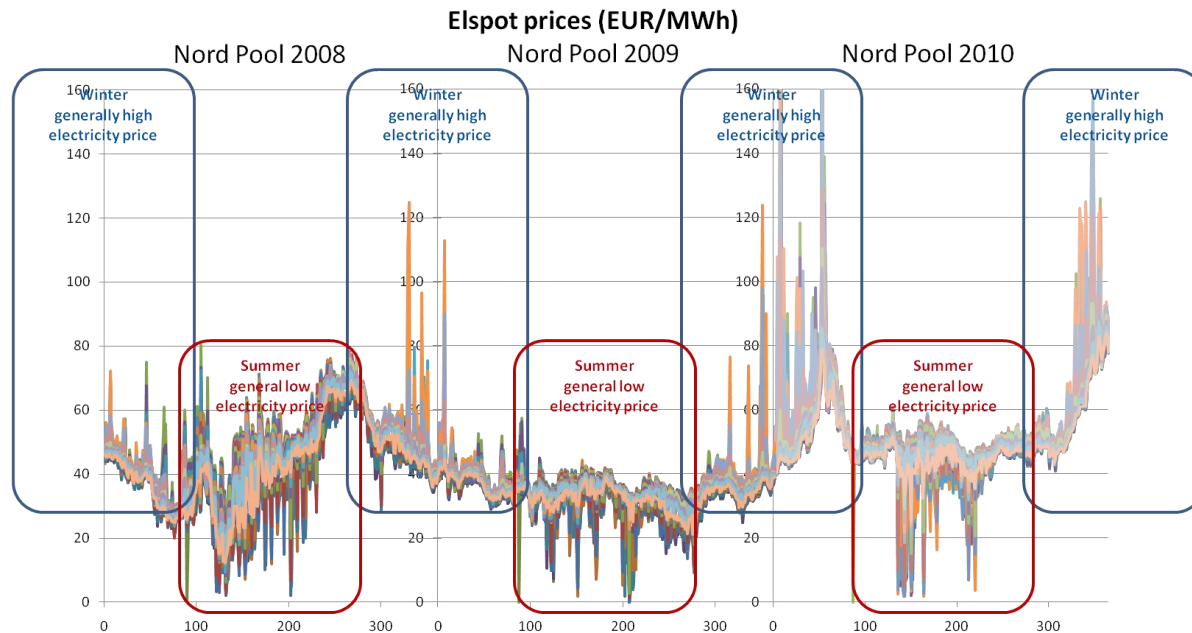
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Opportunities and Challenges

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:



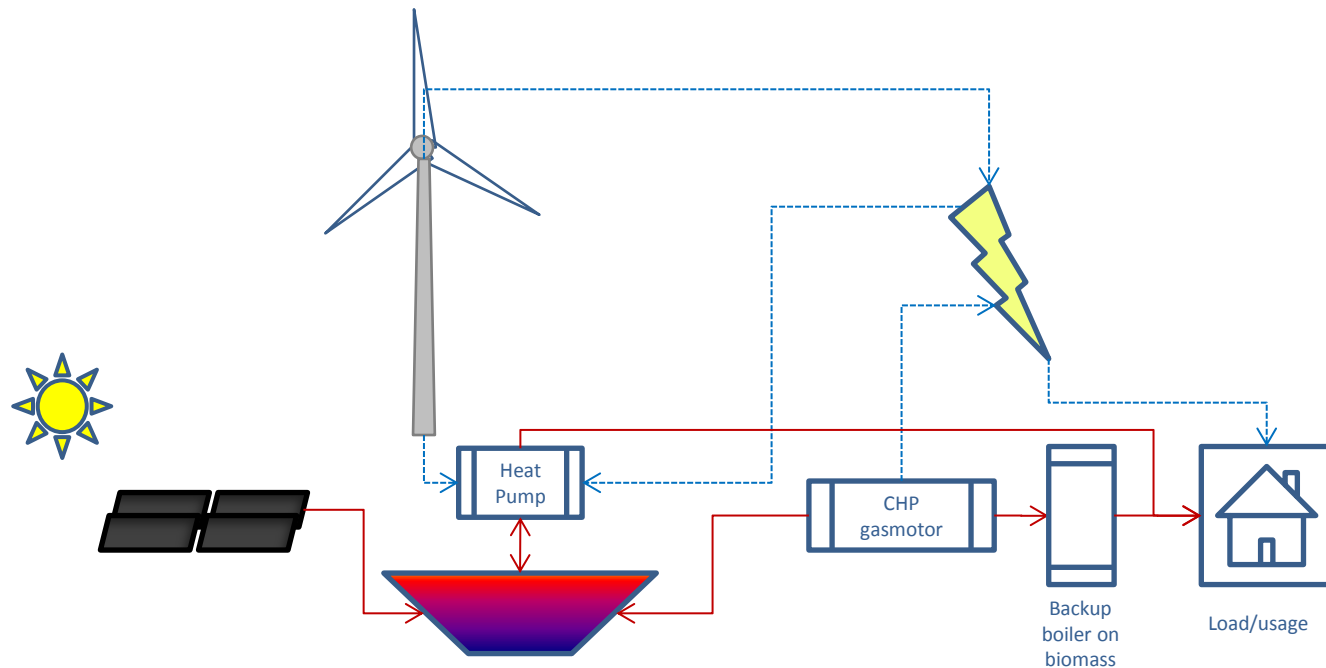
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Opportunities and Challenges

Interaction with liberal electricity market

Solution:

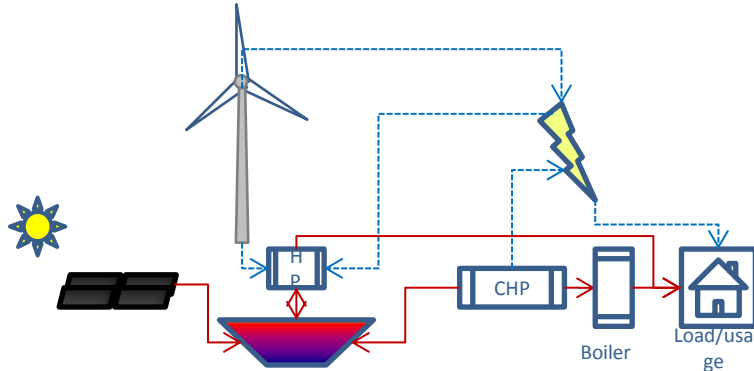
Combined technologies and **heat storage** interacting with the electricity grid ...



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Opportunities and Challenges

Benefits from combining technologies and using heat storage



Solar:

- ✓ Produce free heat

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:

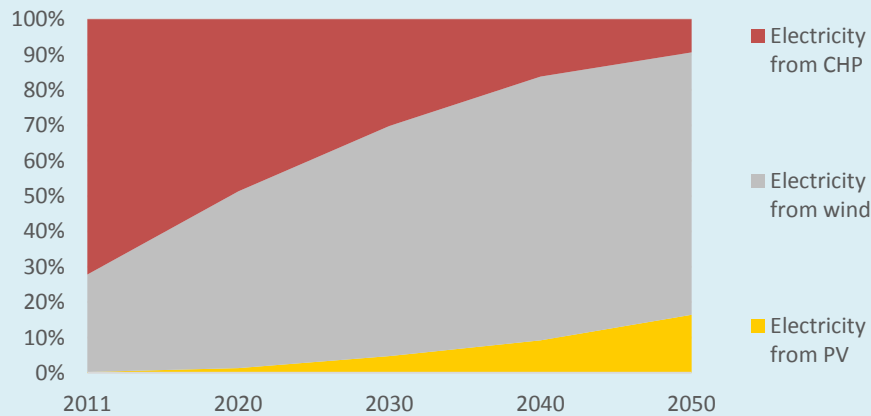
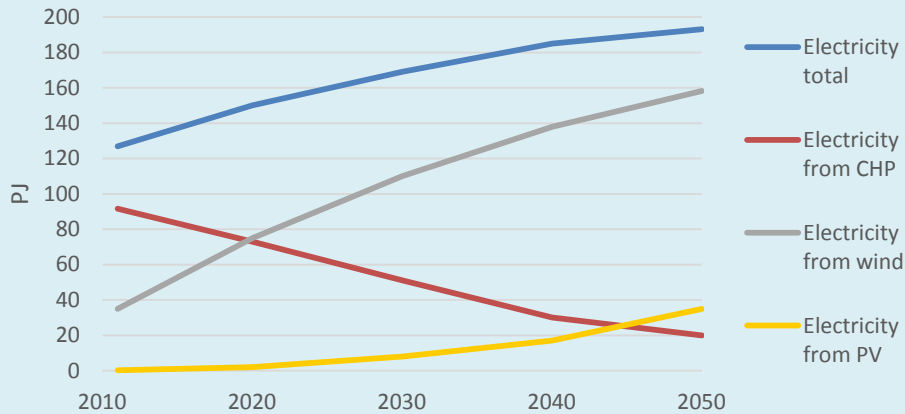
- ✓ Gives the flexibility
- ✓ Makes the combinations of technologies possible

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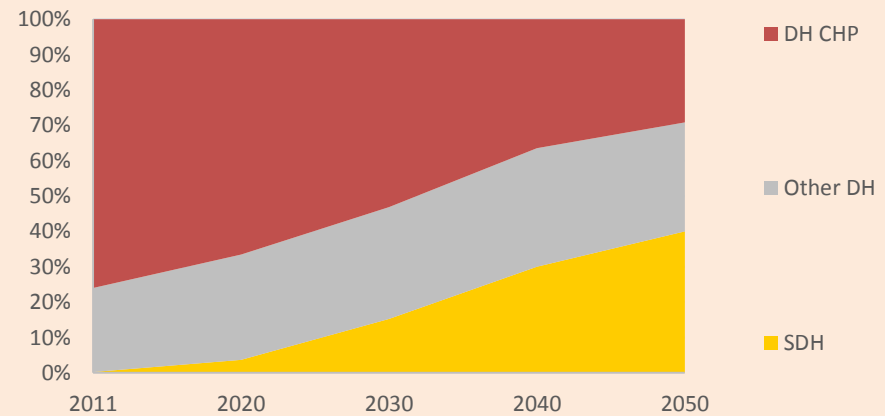
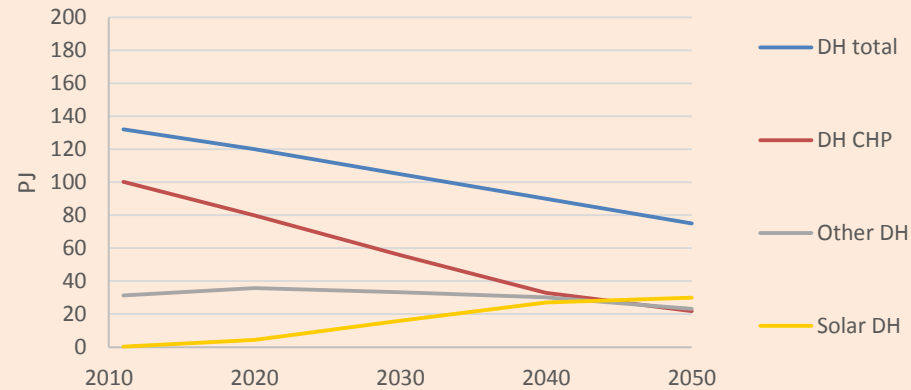
Opportunities and Challenges

**Trend: More and more electricity production from wind & PV ... →
Less and less need for electricity production from CHP ...**

Electricity production, example

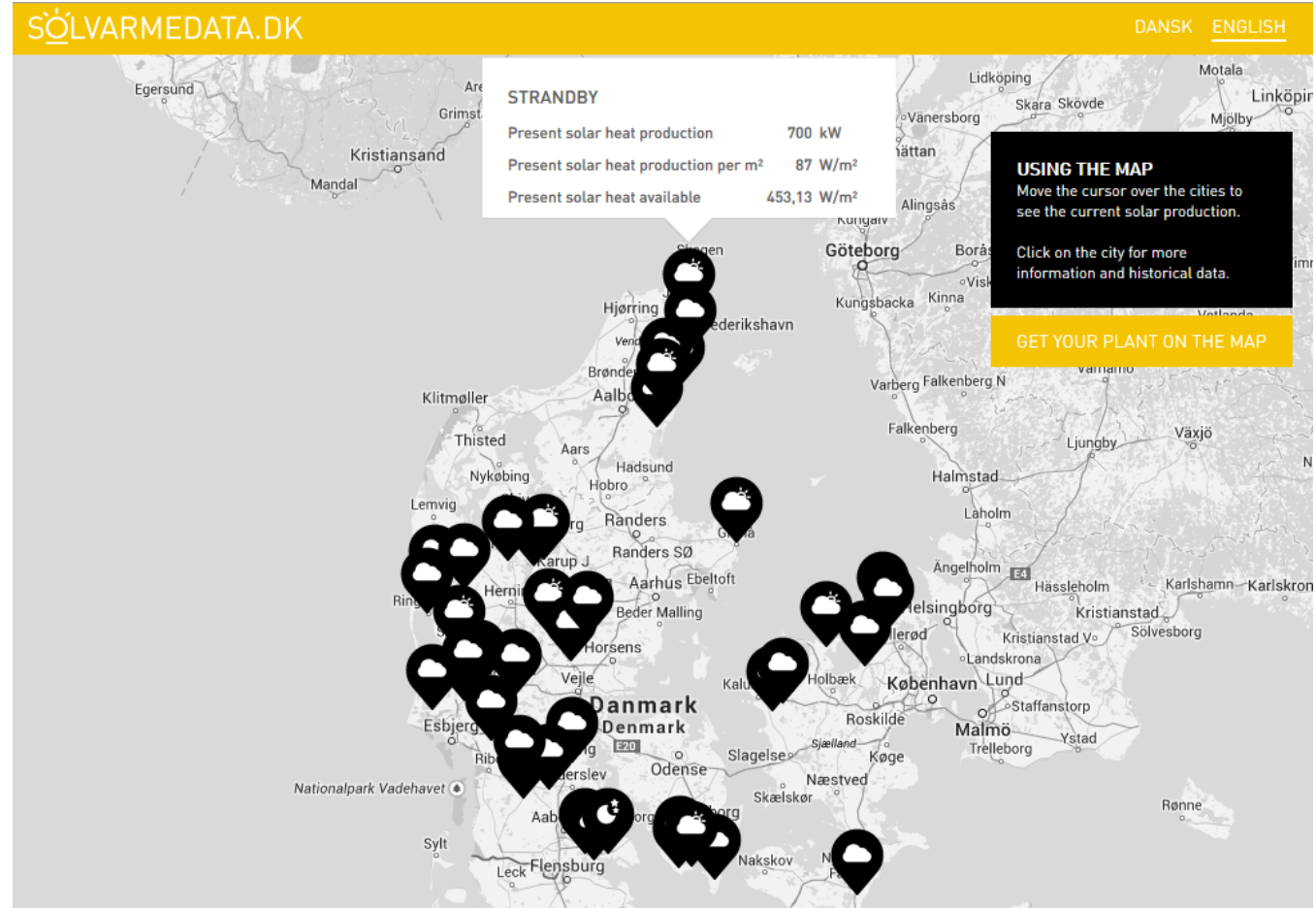


District heat production, example



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Examples



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

System info:

- Size
- Price
- Measured output
- ...

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Examples

SÖLVARMEDATA.DK DANSK [ENGLISH](#)

[CURRENT PRODUCTION](#) [ABOUT THE PLANT](#)

STRANDBY DISTRICT HEATING

Year of construction	2008	Construction surface area (m2)	25000
Solar Heating System	ArCon	Number of solar modules (pcs.)	641
Subsidized by	Energinet.dk	Angle of solar panels (degrees)	35
Efficient surface of solar panels (m2)	8019	Estimated maximum heat efficiency (MW)	6

Estimated annual heat production (MWh)	0
Expected share of solar heat in total annual plant production (%)	18
Expected reduction of CO2 per year caused by solar heating (tons/yr)	1570
Alternative fuel at heating plant (natural gas, wood flakes, straw etc.)	Natural gas
Investment - subsidies not included 2010 (million DKK)	14
Subsidies (million DKK)	3,4
Expected net economic result over 25 years (million DKK)	14
Return of investment period (years)	8,1

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Examples


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[CURRENT PRODUCTION](#) [ABOUT THE PLANT](#)

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STRANDBY DISTRICT HEATING

CURRENT PRODUCTION Measurement: 06.10.2014, at: 15:06:25



Present solar heat production: **700 kW**

Present solar heat production per m²: **87 W/m²**

Present solar heat available: **453 W/m²**

SEARCH IN DATA

From date:

To date:

Display:

QUICK LINKS

[Actual 24 hours](#)

[Latest 7 days](#)

[Latest 30 days](#)

[Latest quarter](#)

[Latest year](#)

HISTORICAL DATA

Total solar heat production for the period: **3.672,79 MWh**

Total solar heat available for the period: **1.082.203,31 Wh/m²**

Logs	Heat production (MWh)	Heat production / m ² (Wh/m ²)	Solar heat available (Wh/m ²)
januar 2013	24,80	3.093	18.573
februar 2013	105,60	13.169	44.426
marts 2013	186,54	23.262	55.020
april 2013	310,50	38.720	81.944
maj 2013	532,10	66.355	145.143
juni 2013	619,05	77.198	170.051
juli 2013	691,14	86.188	187.026
august 2013	511,31	63.762	146.758
september 2013	434,30	54.159	122.083
oktober 2013	170,88	21.310	58.600
november 2013	65,82	8.208	36.247
december 2013	20,74	2.587	16.332

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

System info:

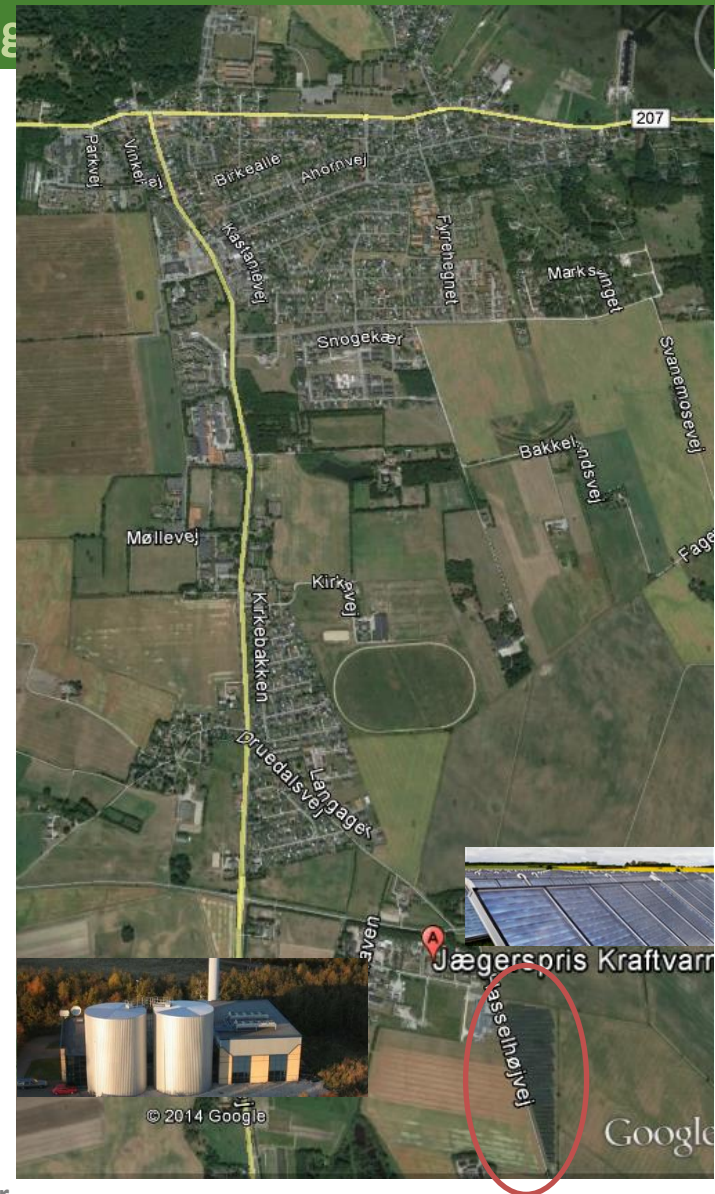
- Size
- Price
- Measured output
- ...

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Opportunities and Challenges

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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Opportunities and Challenges

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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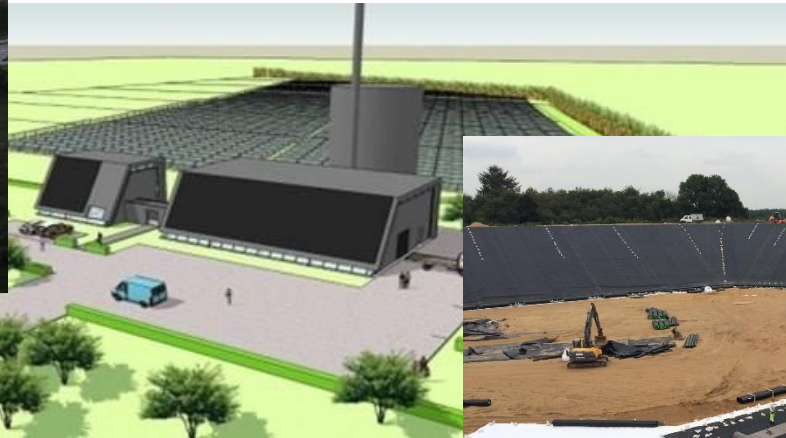
Opportunities and Challenges

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

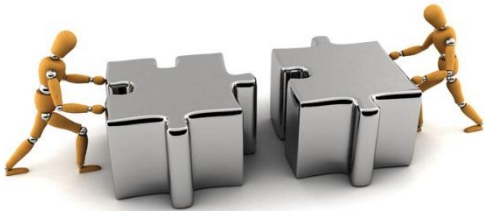
Lars Damkjaer, Gram District Heating Company:

“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:



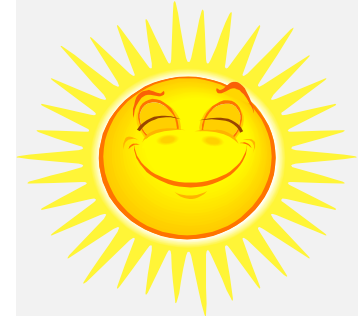
- ✓ District heating is a good argument for solar heating
- ✓ Solar heating is a good argument for district heating



- ✓ 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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