Solar District Heating

Experiences from Denmark

Jan Erik Nielsen

PlanEnergi

- Consultant Engineers
- 30 employees
- Renewable energy & energy planning

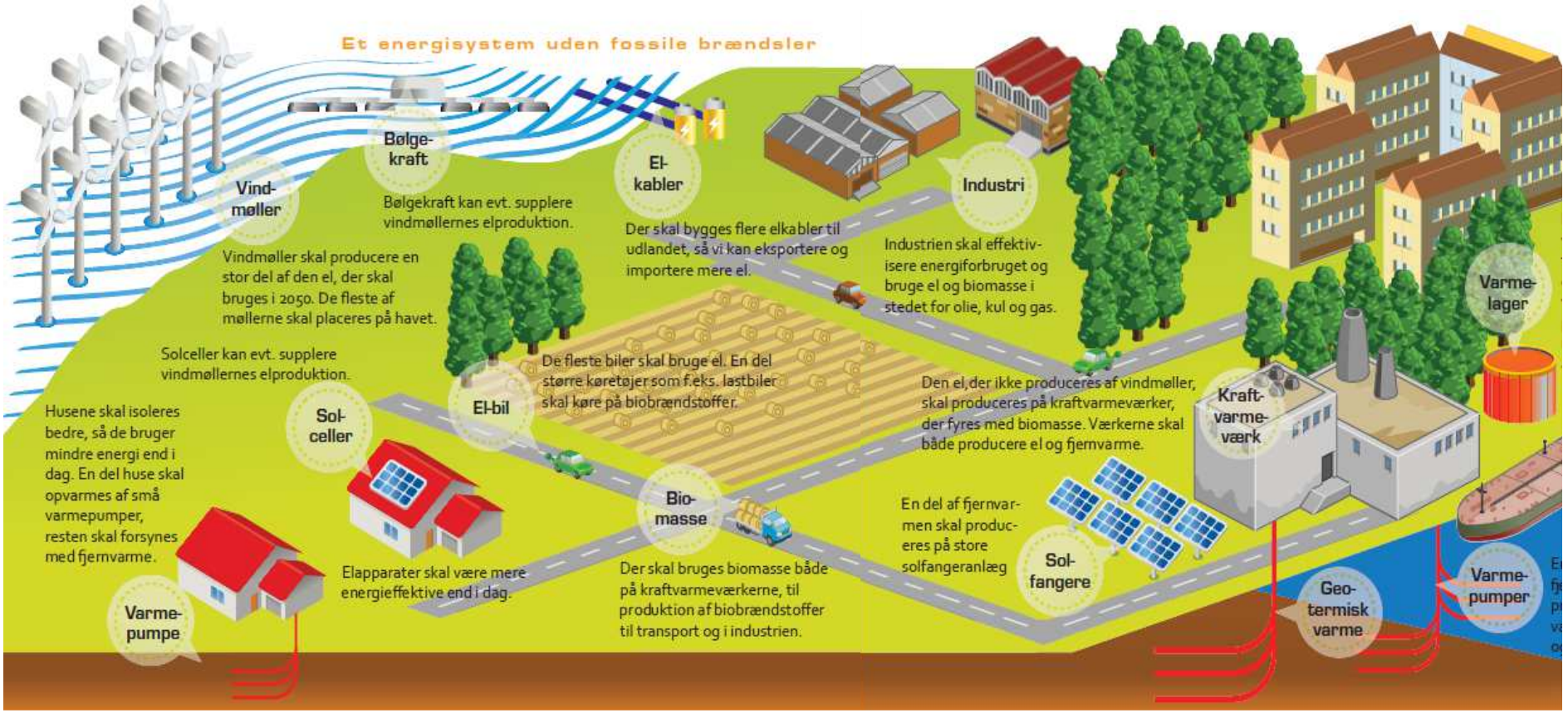
Operating Agent for IEA-SHC Task 45 "Large Solar Heating/Cooling Systems ..."

Solar District Heating

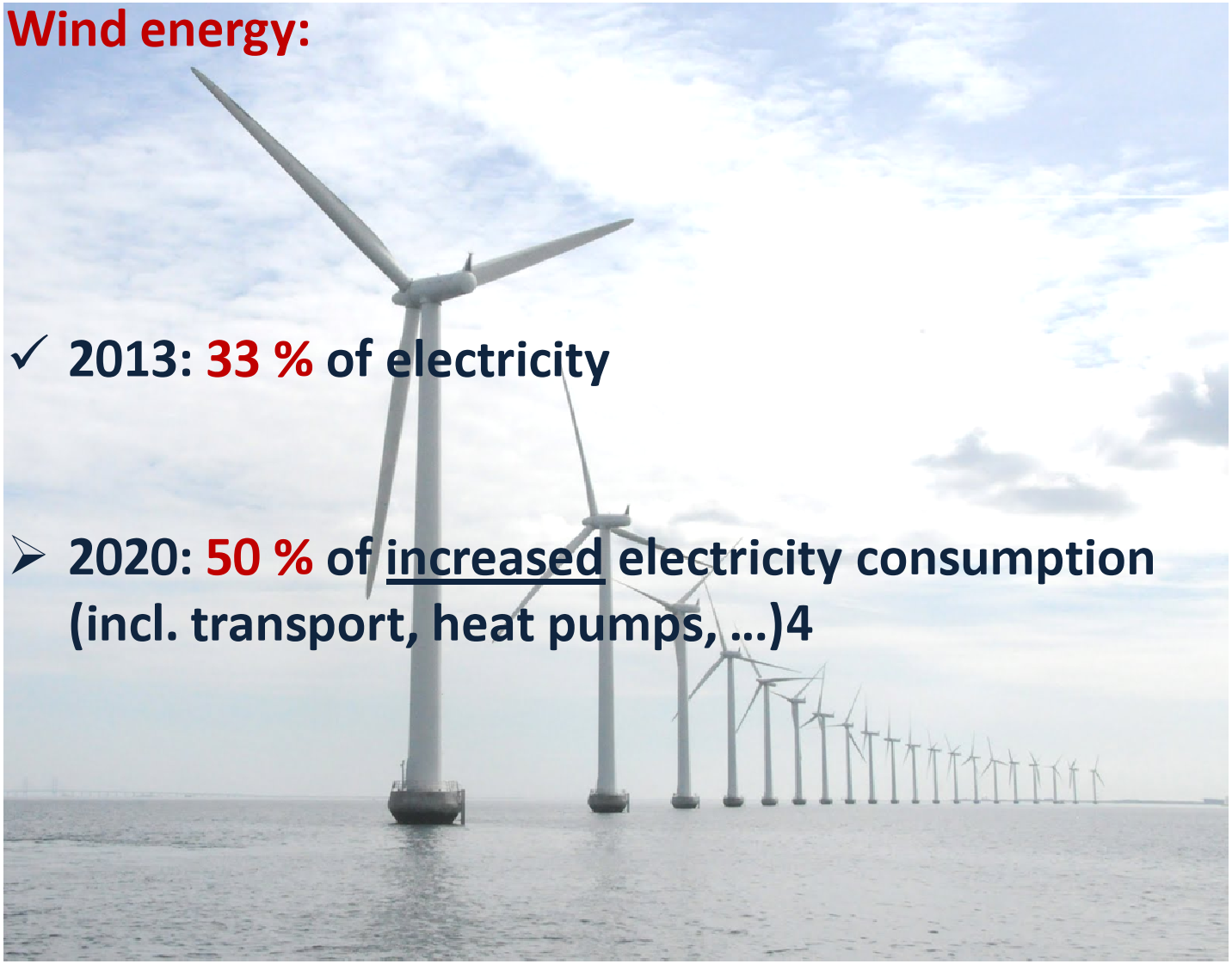
Experiences from Denmark

Denmark plans to:

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



Solar District Heating
Experiences from Denmark



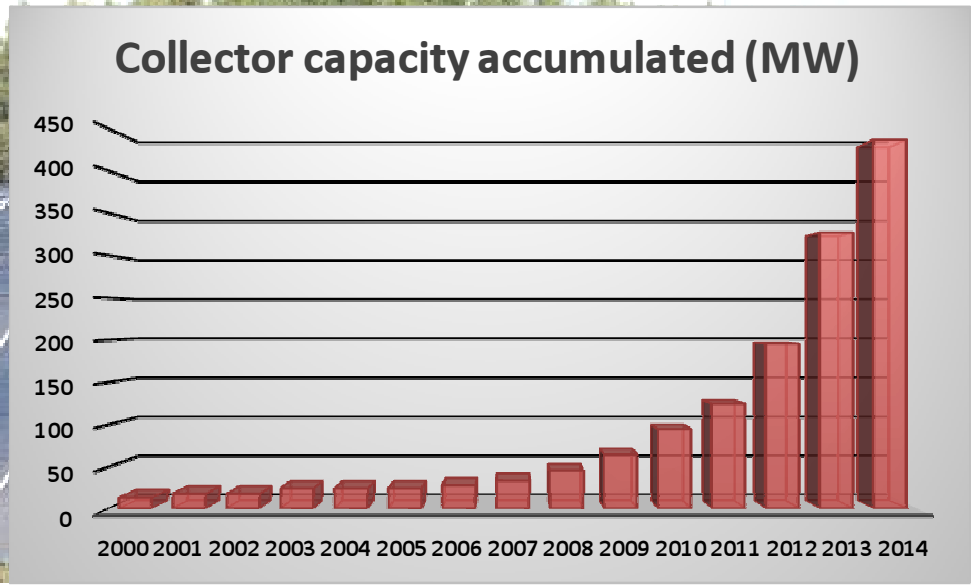
Solar District Heating

Experiences from Denmark

Solar thermal:

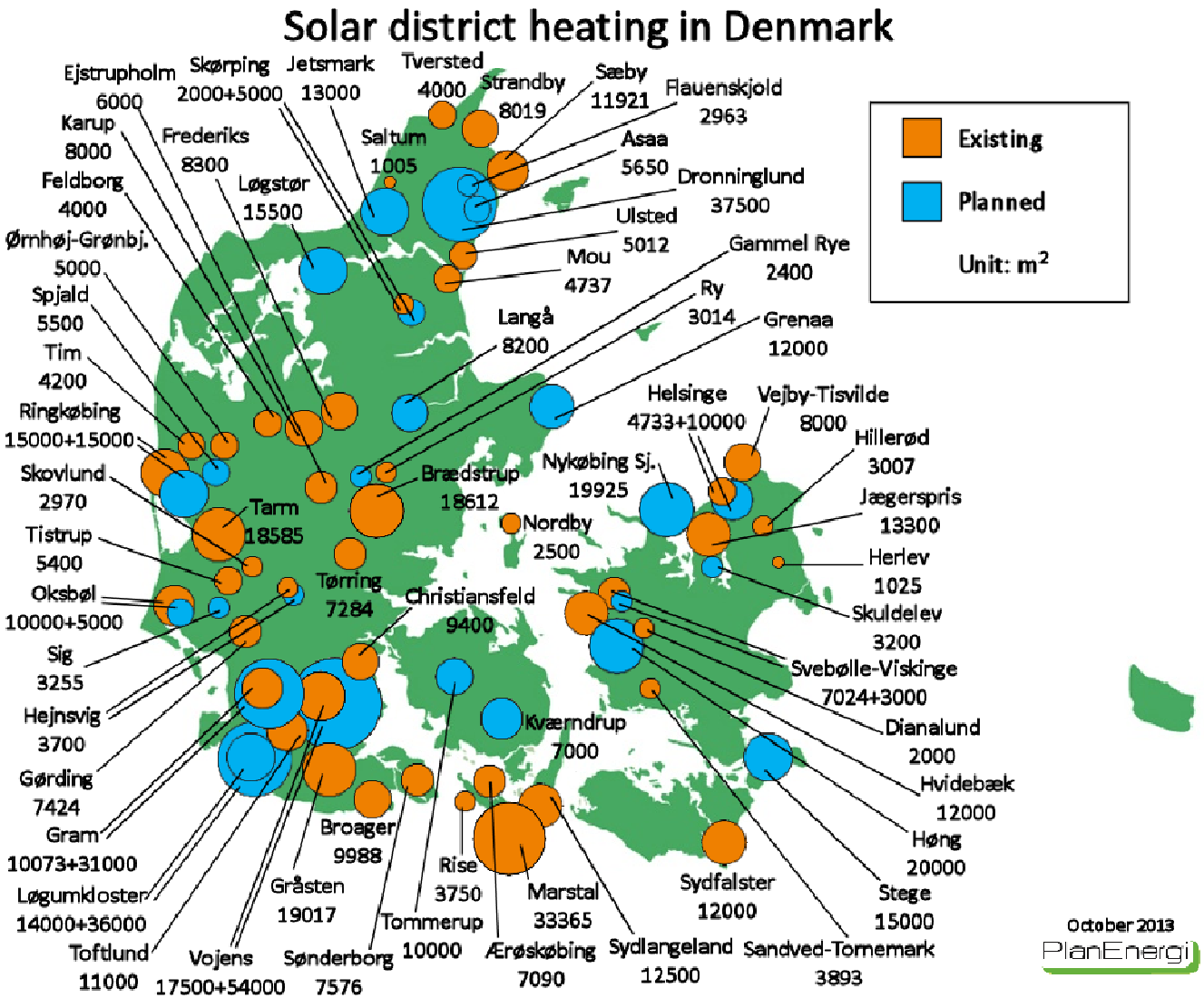
- **2030: 15 % of decreased heating demand**
- **2050: → 40 % of decreased heating demand - 80 % of the solar heat via district heating**

	District heating total	Solar District Heating	
	PJ	PJ	%
2011	133	0.30	0.2%
2012	150	0.50	0.3%
2013	140	1.00	0.7%
2014	135	1.33	**1.0 %**



Solar District Heating

Experiences from Denmark



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

Solar District Heating
Experiences from Denmark

Long time tradition for district heating in Denmark

- 60 % of all heating demand* is now supplied by district heating
  - Large central CHP: 35 plants; 45 % of district heating supply
  - Small de-central CHP: 540 plants; 20 % of district heating supply
  - Small heating centrals: 1 213 plants; 20 % of district heating supply
- Low temperatures
  - 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

Solar District Heating
Experiences from Denmark

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
- 2 companies competing rather hard:

ARCON SOLAR

SUNMARK SUSTAINABLE SOLAR SOLUTIONS

Good performance

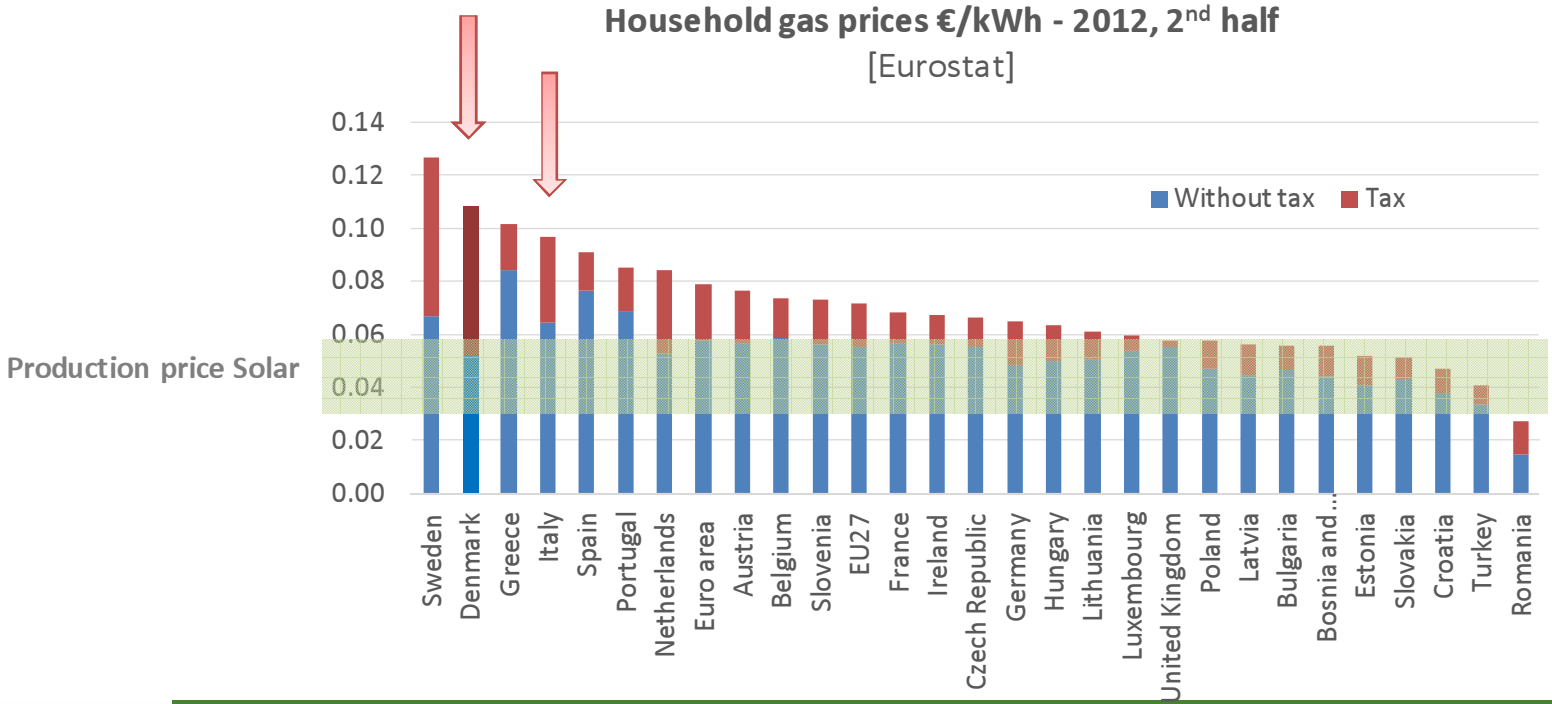
- Max. collector field output > 530 kWh/m²; max. efficiency > 50 %
- Average output: 440 kWh/m²; average efficiency: 40 %

Solar District Heating
Experiences from Denmark

Good heat production price

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

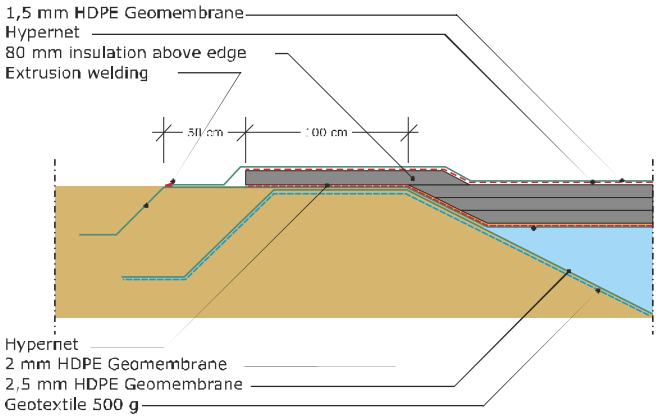
Gas price (with/without tax)

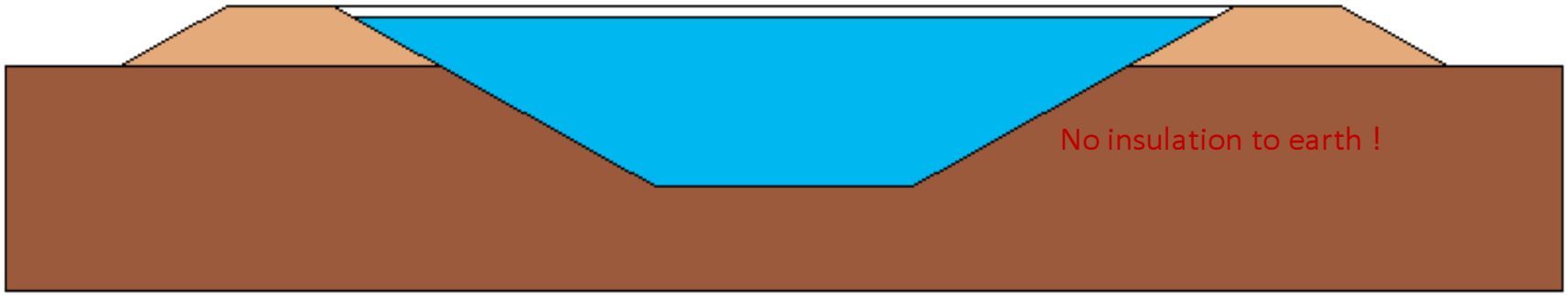


Interaction with dynamic electricity production

- 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)



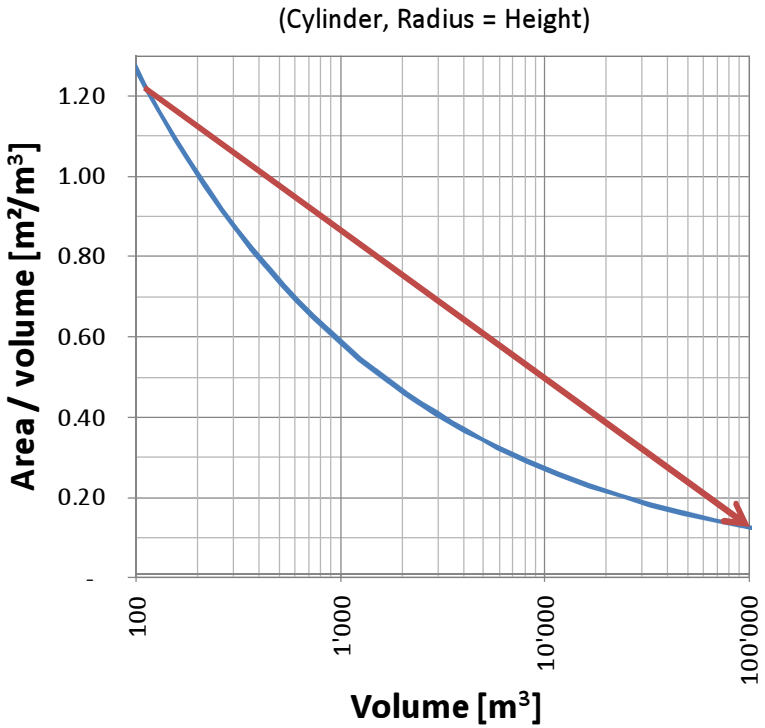


Price: 20 €/m^3

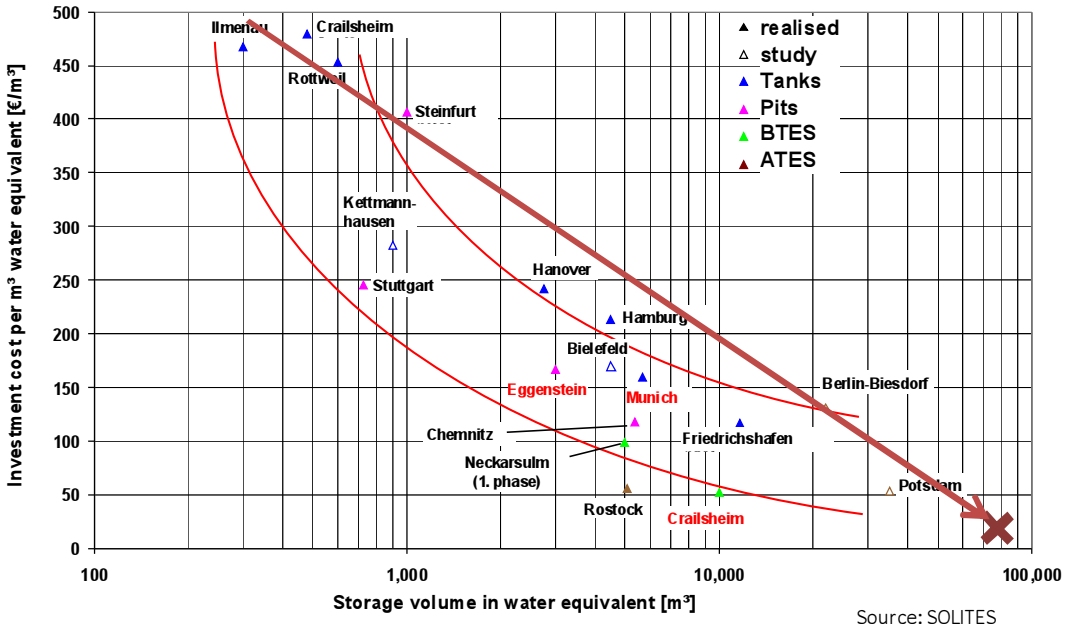
Solar District Heating
Experiences from Denmark

LARGE SYSTEMS → small storage losses & lower specific costs

Surface area per volume



Cost per equivalent m³



Source: SOLITES

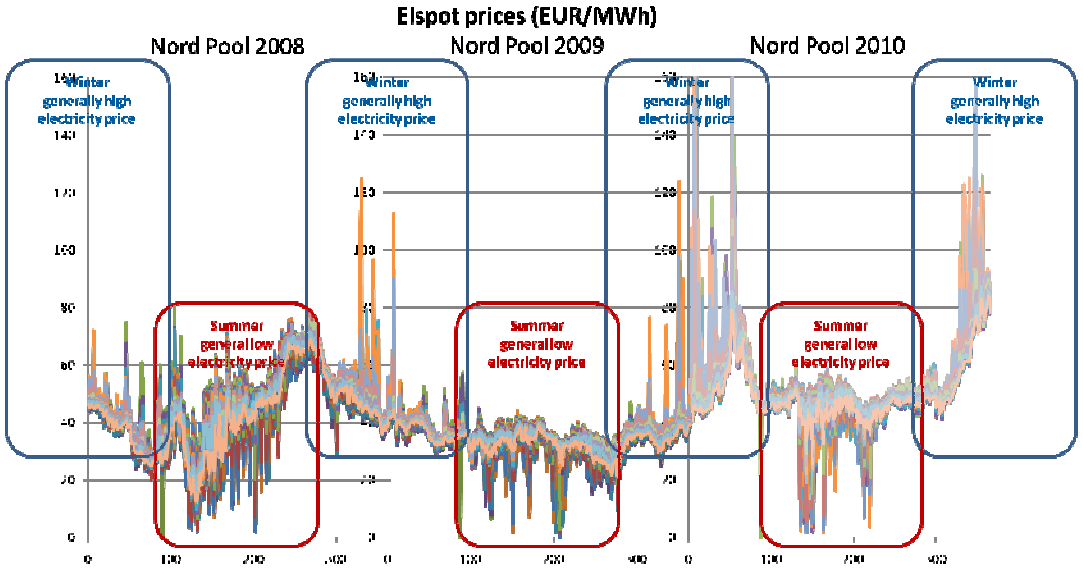
1.2 → 0.1 → Factor 12 on surface area/volume (heat loss/storage capacity(

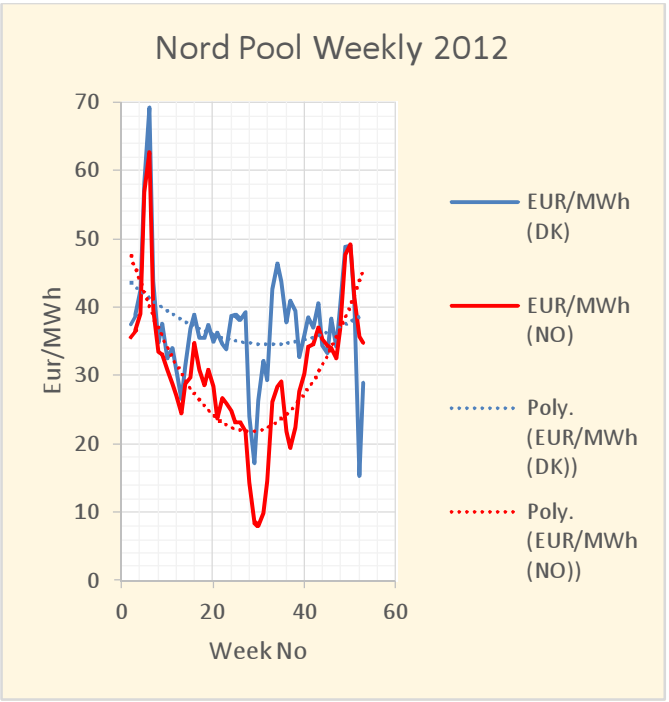
500 → 20 → Factor 25 on costs/volume (cost/storage capacity)

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:

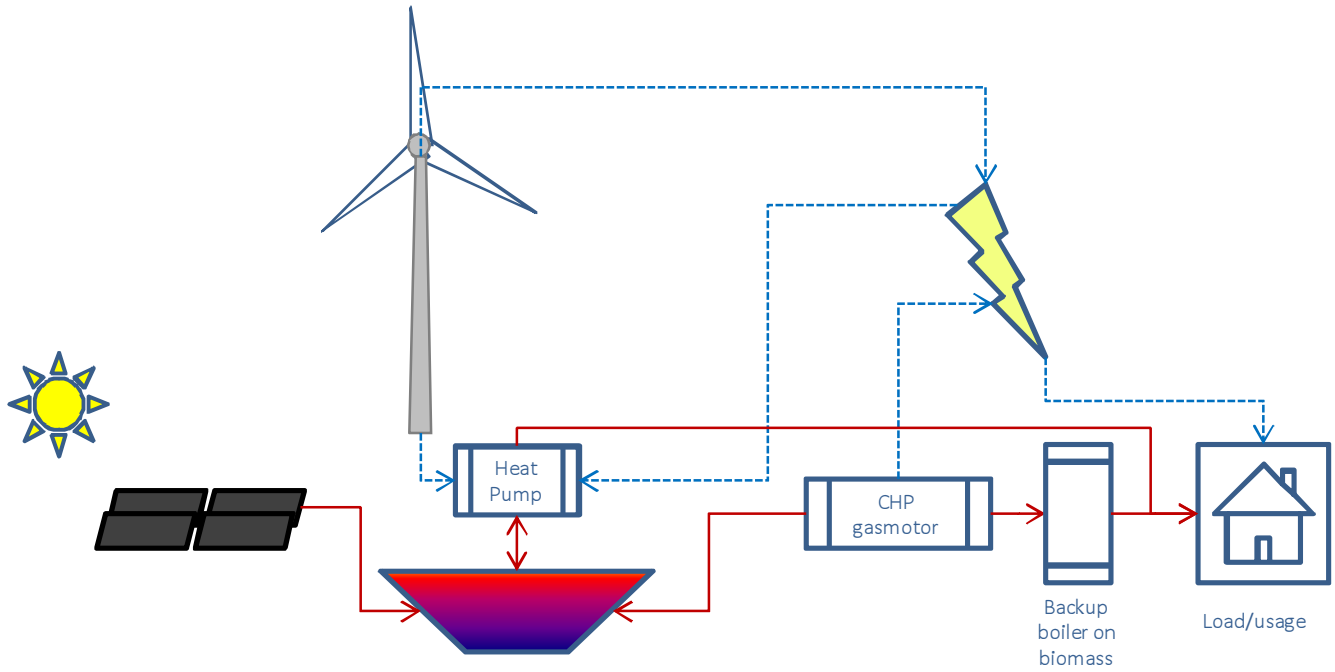




Interaction with liberal electricity market

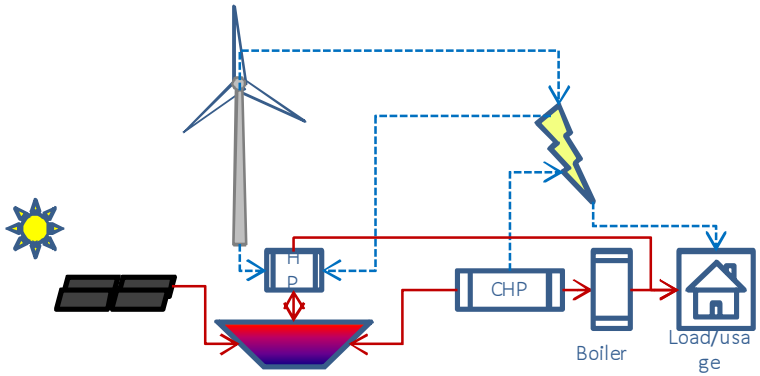
Solution:

Combined technologies and heat storage interacting with the electricity grid …



Solar District Heating
Experiences from Denmark

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

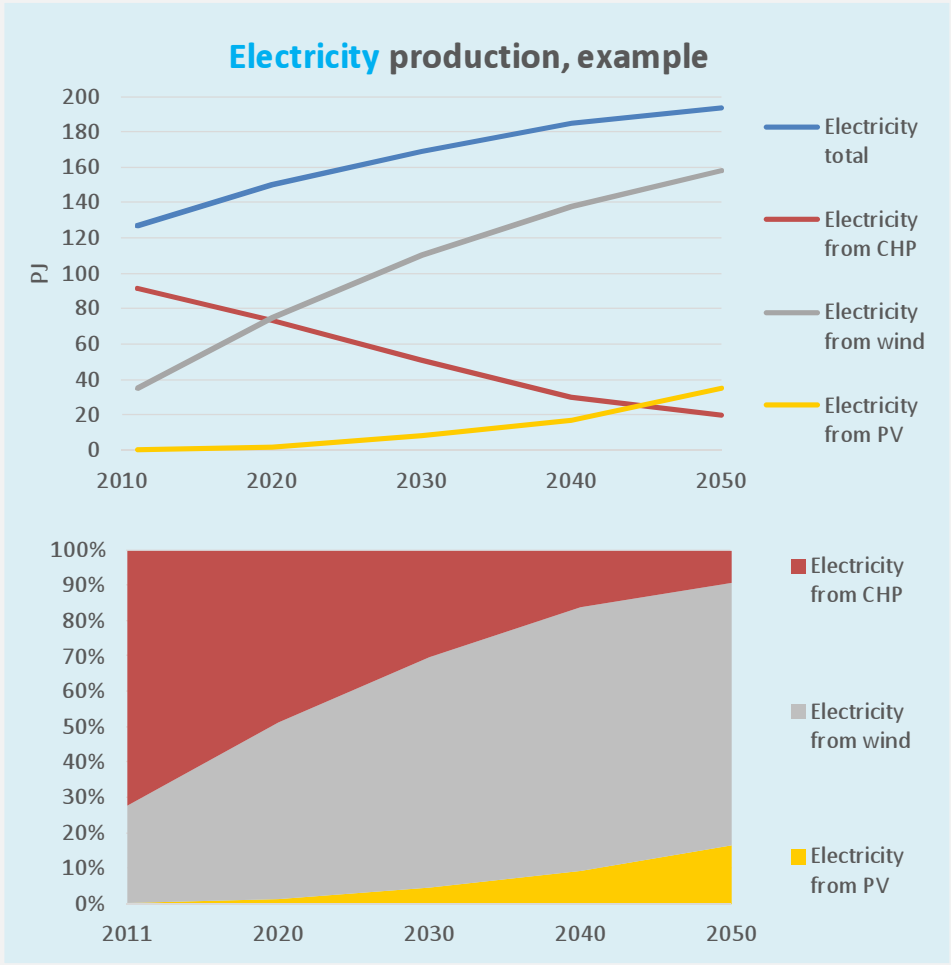
Storage:
- ✓ Gives the flexibility
- ✓ Makes the combinations of technologies possible

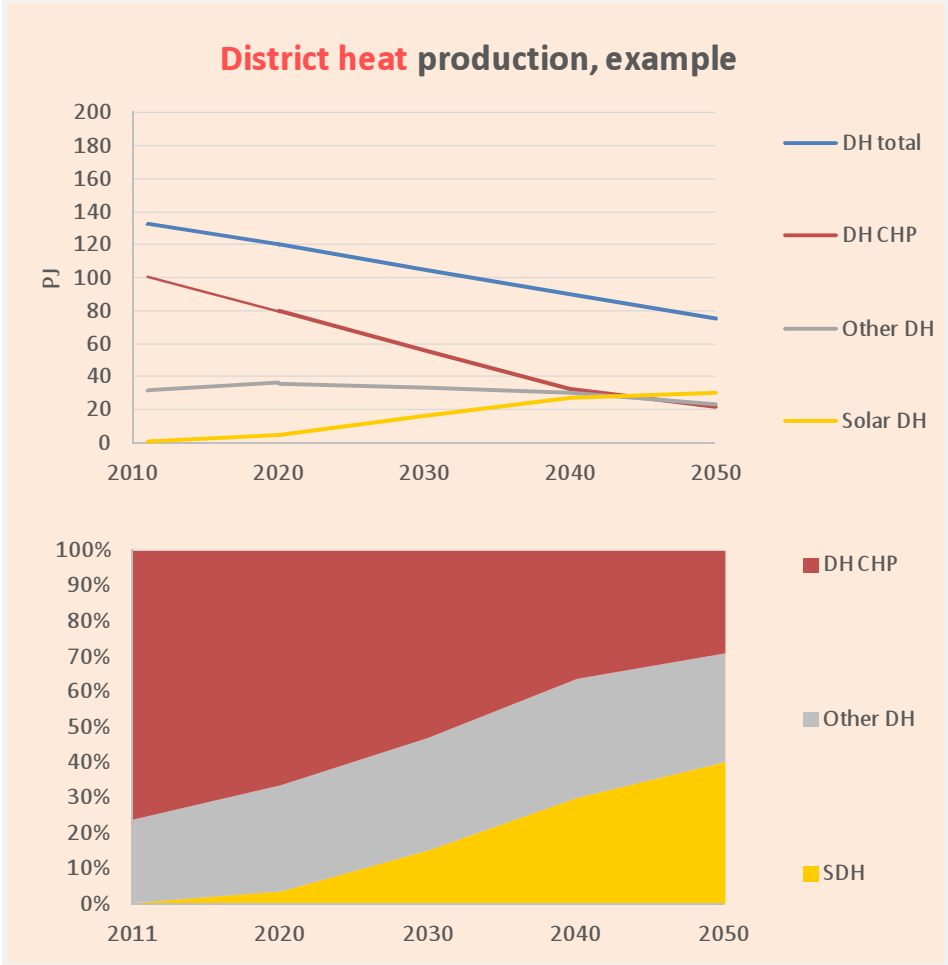
Solar District Heating

Experiences from Denmark

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

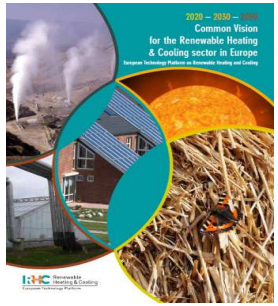
Less and less need for electricity production from CHP …



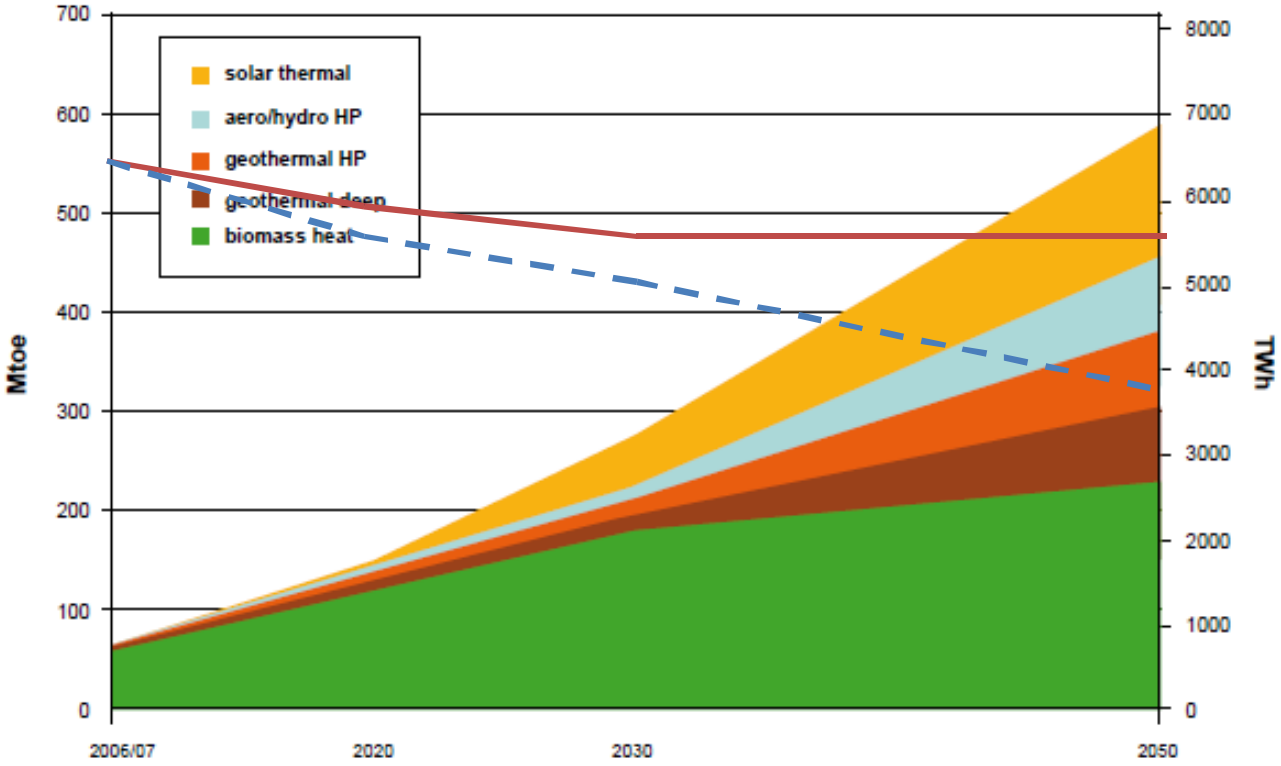


Potential for "Renewable Heating" (2011)

RHC Renewable Heating & Cooling
European Technology Platform



http://www.rhc-platform.org/publications/

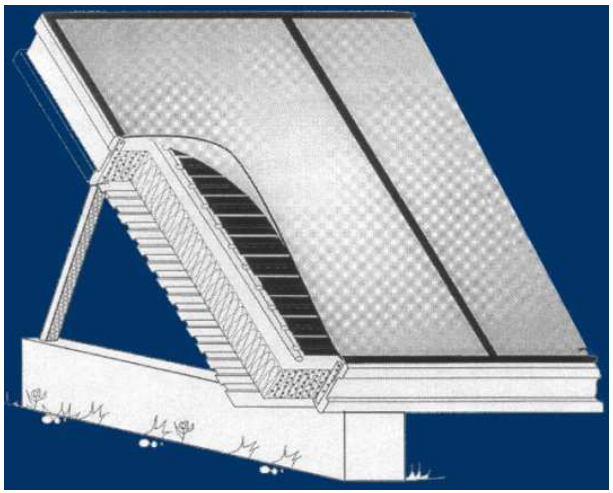


Heat load scenarios:

- ❑ Business as usual
- ❑ Reduced demand

Technologies for Solar District Heating

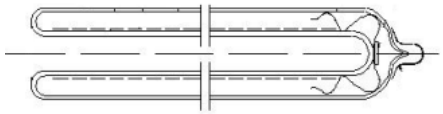
Flat plate collectors (FP)



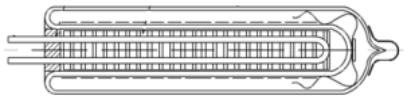
Technologies for Solar District Heating

Evacuated tubes (ETC)

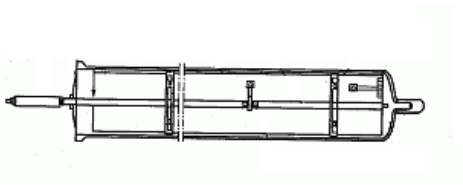
All-glass vacuum tube collectors

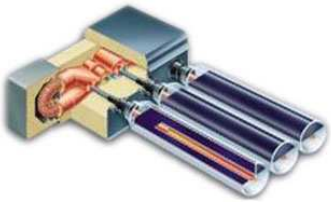


Glass-metal vacuum tube collectors



Heat pipe vacuum tube collectors

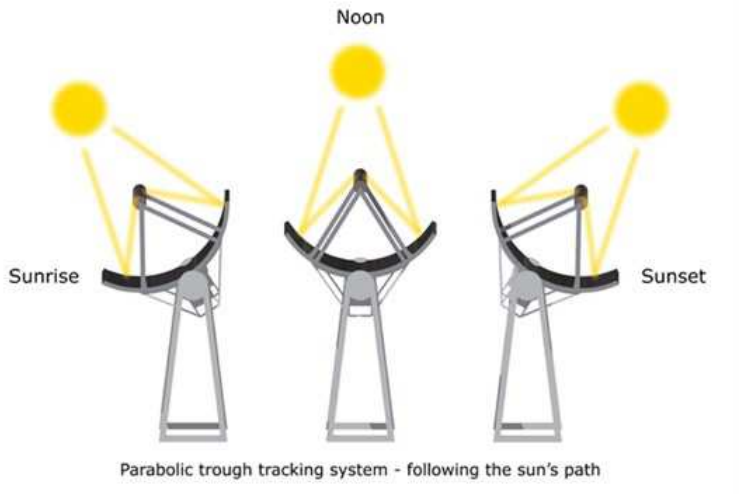




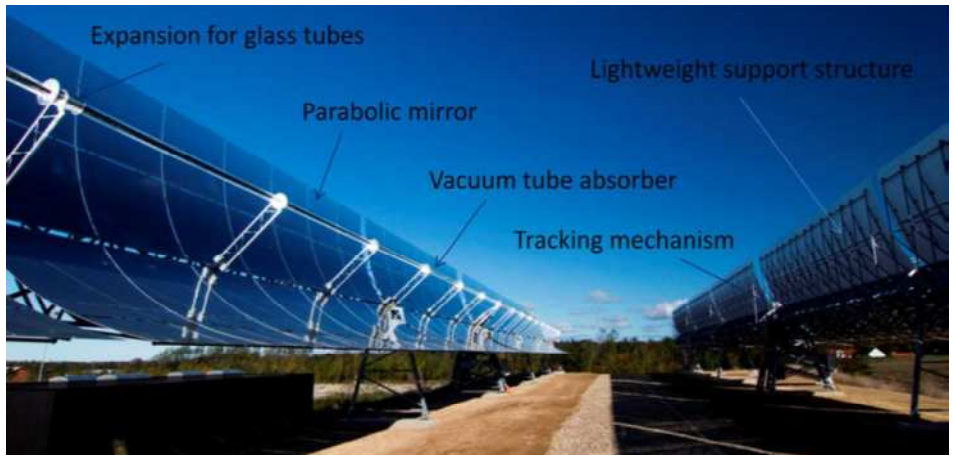
Evacuated Tube with Absorber

Technologies for Solar District Heating

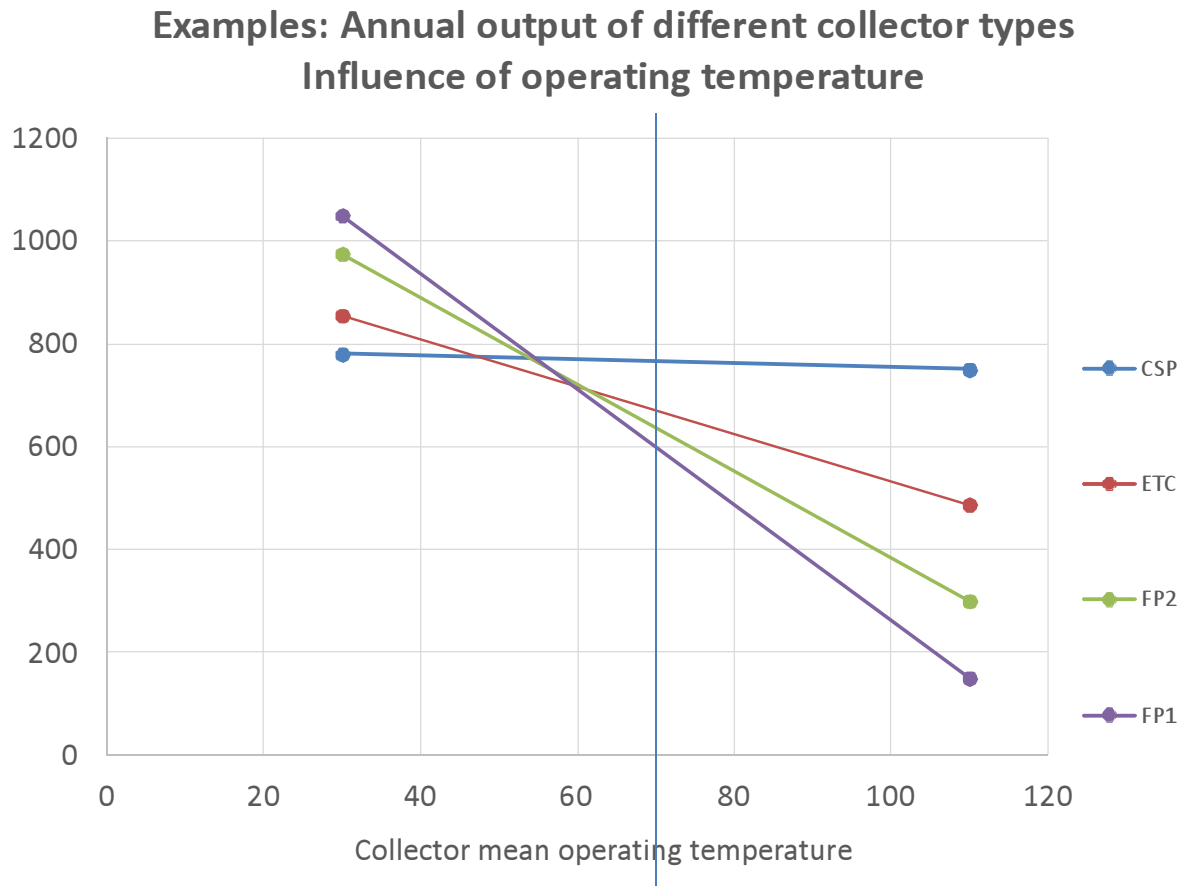
Concentrating collectors (CSP)

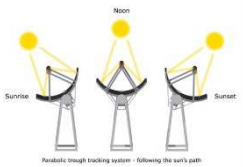


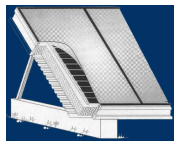
Parabolic trough tracking system - following the sun's path



Technologies for Solar District Heating







Forward = 90° & Return = 50° → Tm = 70°C

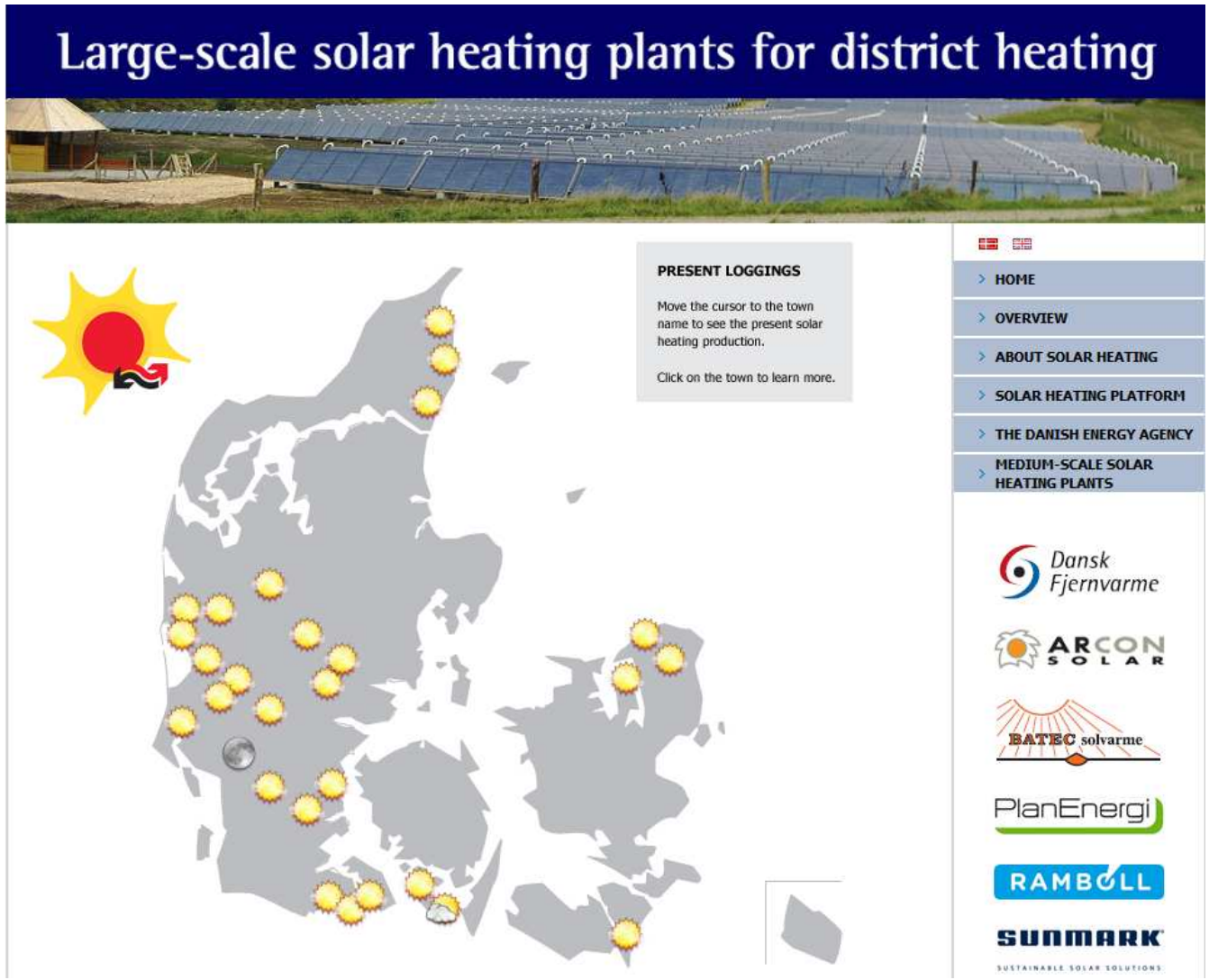
Solar District Heating
Experiences from Denmark

Examples

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

System info:

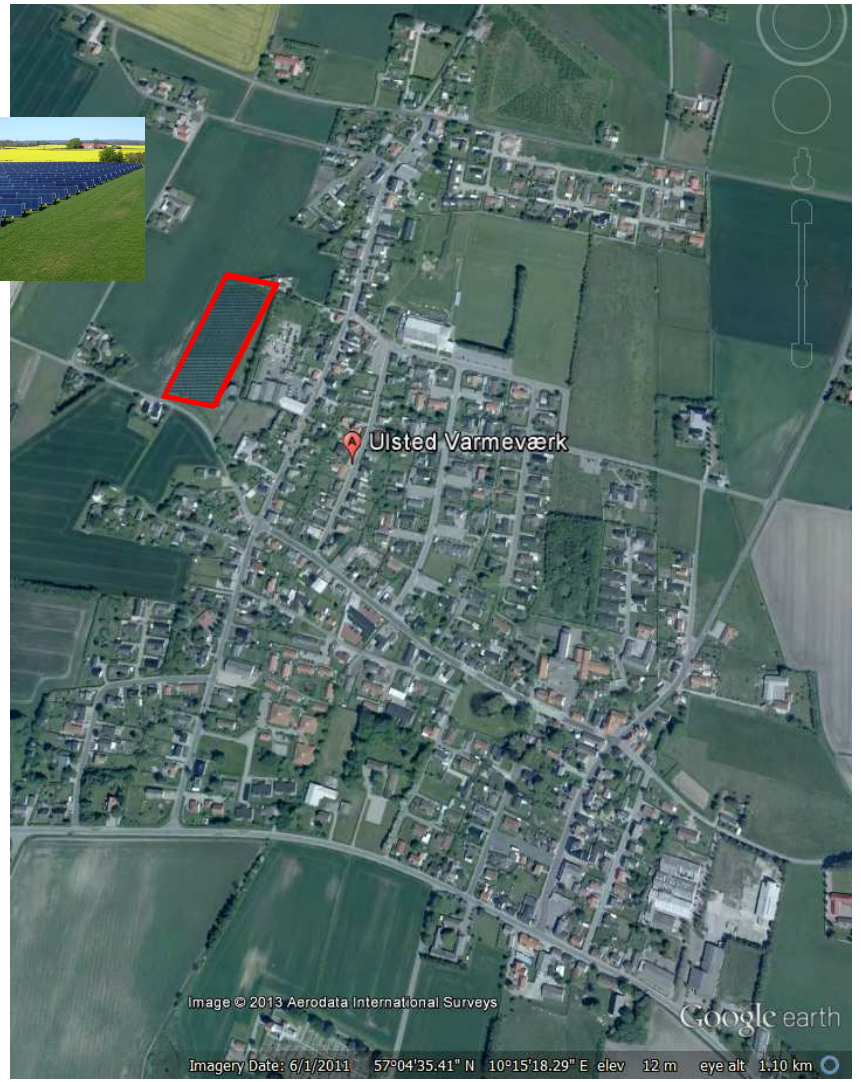
- Size
- Price
- Measured output
- …



Solar District Heating
Experiences from Denmark

Example: Ulsted (2006)

- Inhabitants: 1 100
- Collector area: 5 000 m²
- Solar fraction: 23 %
- System price: 270 €/m²
- Solar heat price*: 48 €/MWh
- Other heat resource: Pellets



*) 20 years, 3% net interest rate, operation & maintenance 1% of investment per year

Solar District Heating
Experiences from Denmark

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 %

Solar District Heating

Experiences from Denmark

Solar District Heating

Experiences from Denmark

Solar District Heating

Experiences from Denmark

Solar District Heating

Experiences from Denmark

Solar District Heating

Experiences from Denmark

Marstal:

Now in total 33 000 m^2 (23 MW) solar panels & 75 000 m^3 pit heat storage

Solar District Heating
Experiences from Denmark

Dronninglund now operating:

37 300 m² (26 MW) collectors

60 000 m3 storage

Solar District Heating
Experiences from Denmark

Lars Damkjaer, Gram District Heating Company:

"Extending (in 2014) from 15 % to 56 % solar fraction
11 000 m² to 45 000 m² (32 MW)
is the basic element in our plan to become the
cheapest district heat provider in Denmark".

Solar District Heating
Experiences from Denmark

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)
  - ❑ STORAGE

Thank you for your attention

jen@planenergi.dk

www.planenergi.dk