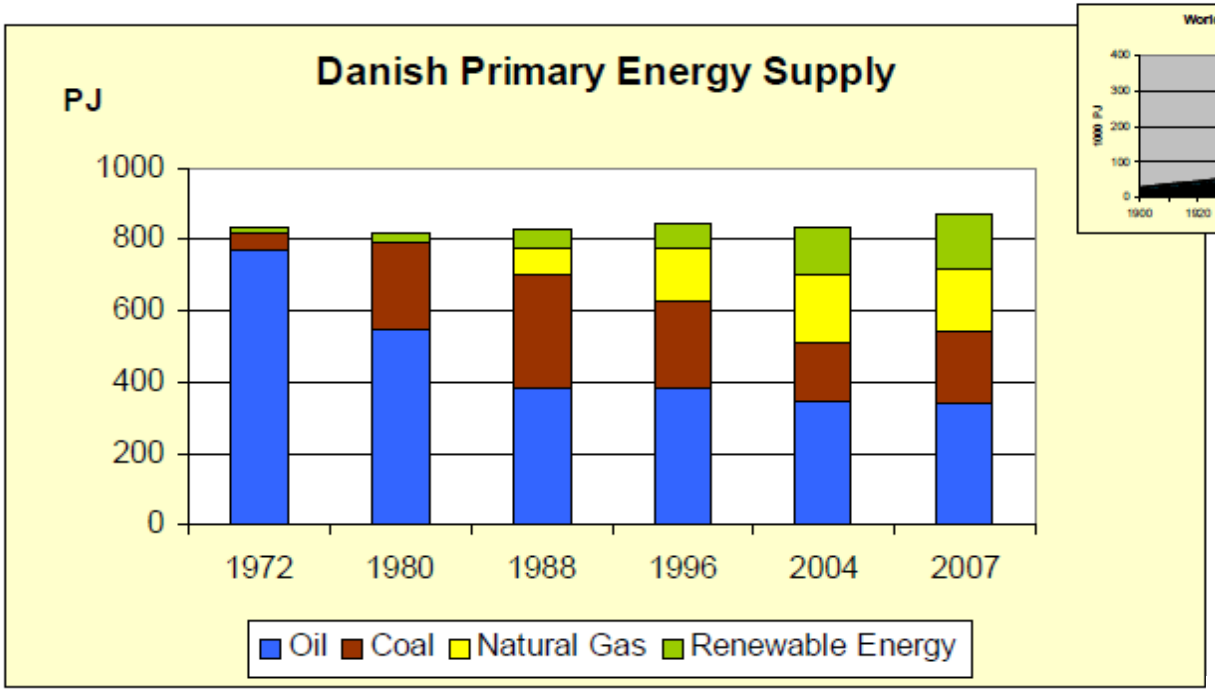
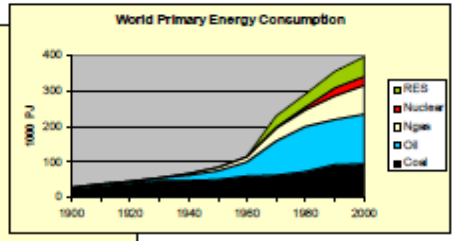
More than 750,000 m^2 solar district heating collectors installed in Denmark

The story!

Four decades of years of stable energy consumption with an active energy policy





SDH solar district heating

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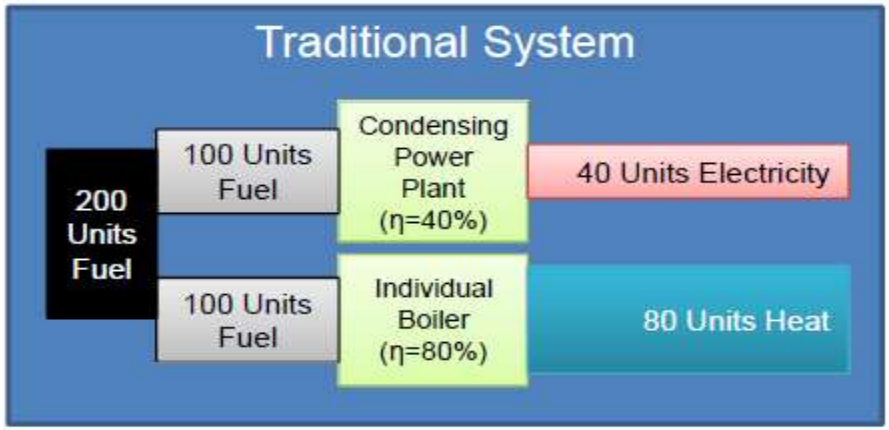
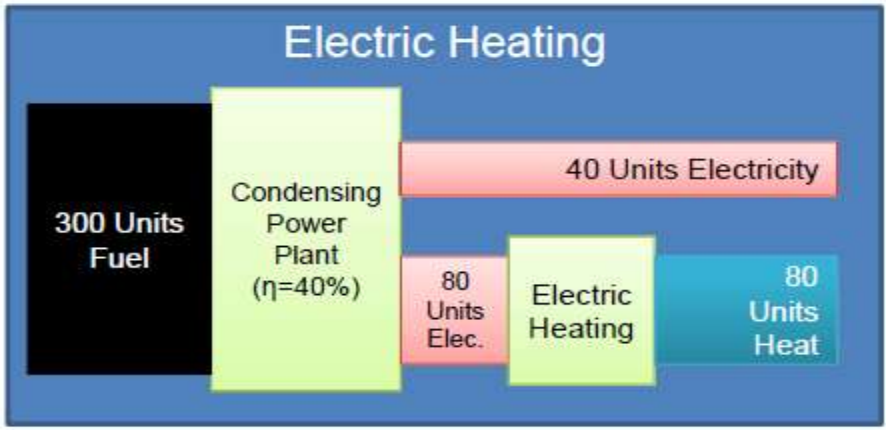
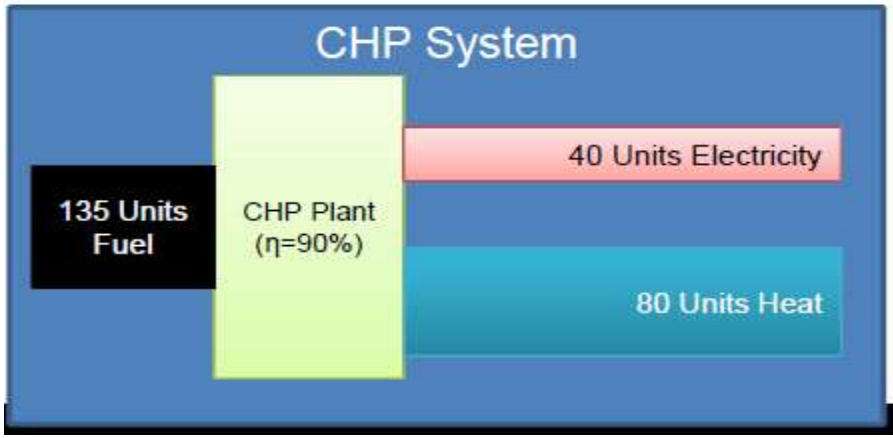
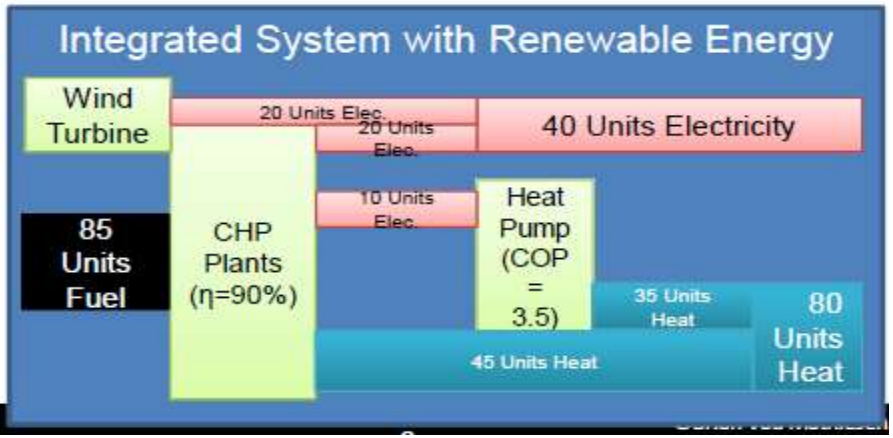
Types of energy systems









SDH
solar district heating

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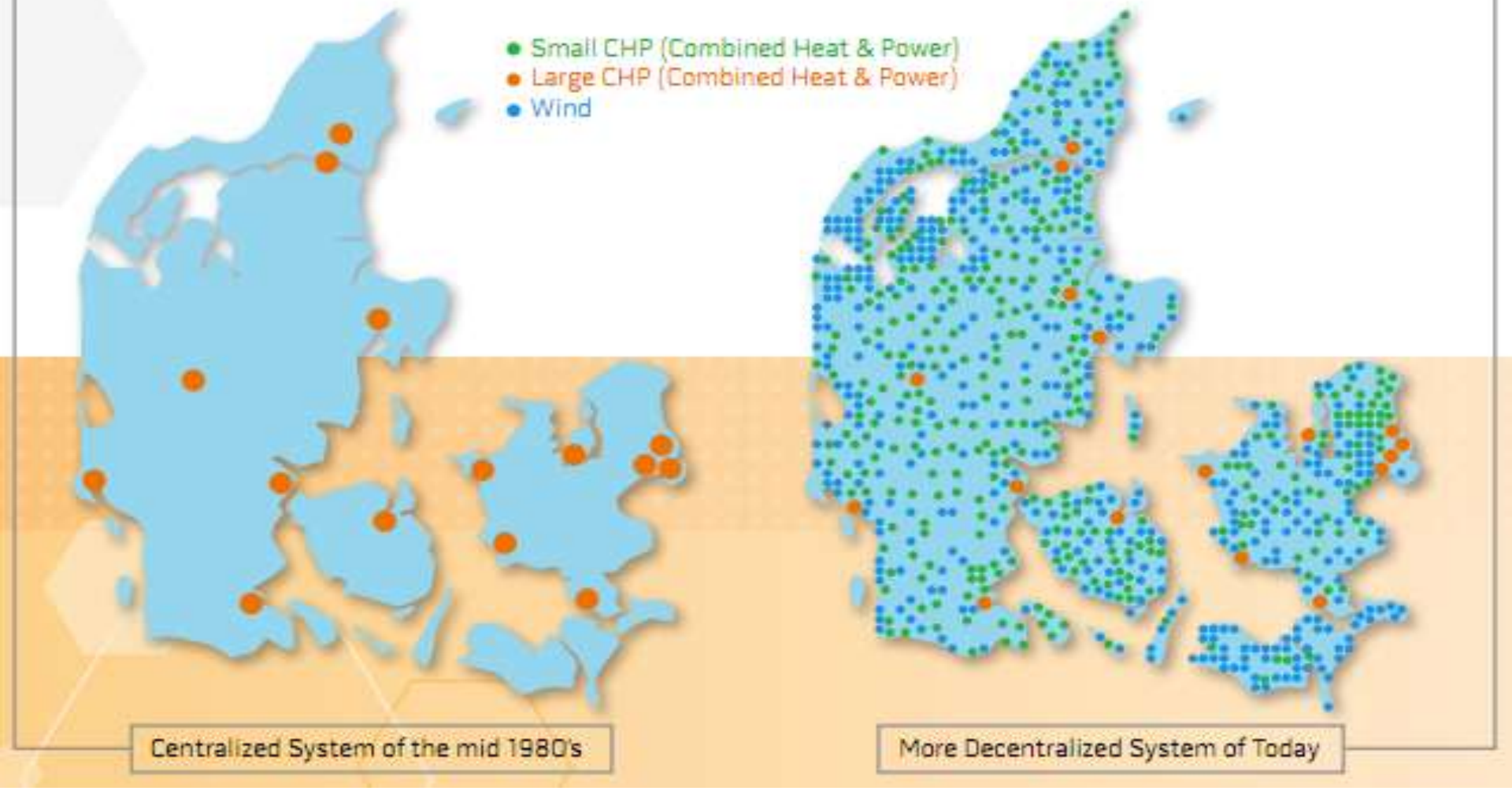
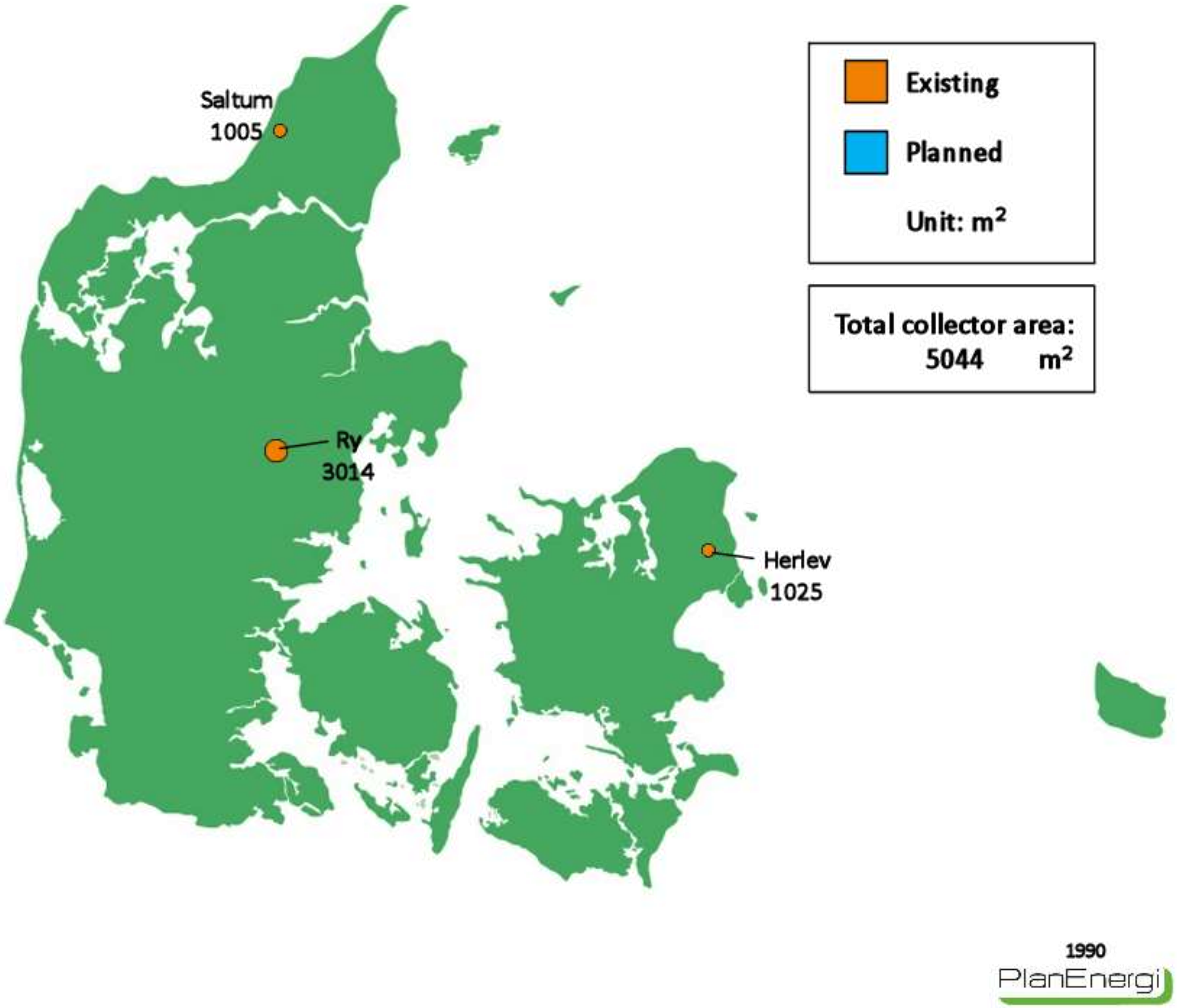
DENMARK's PROGRESS OVER THE PAST TWO DECADES



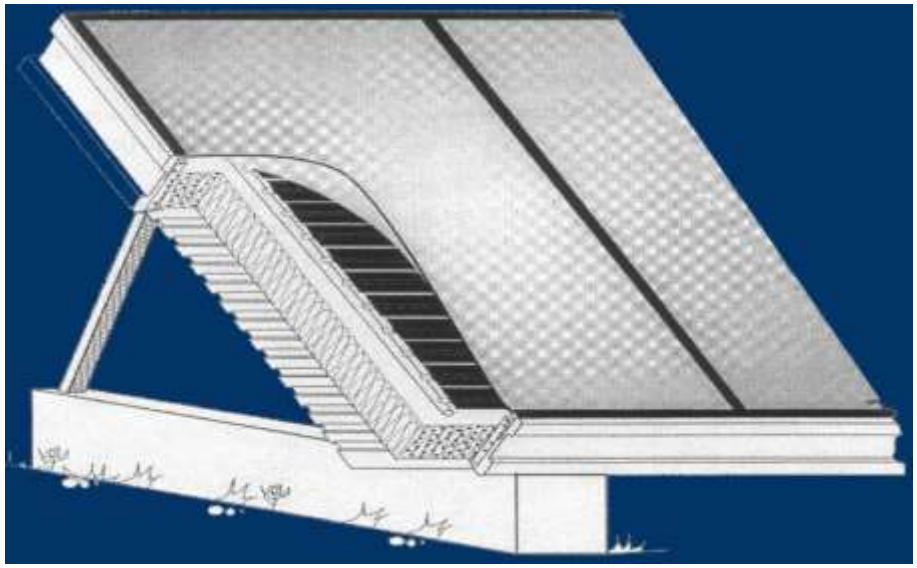
The beginning of SDH (1988)

- Solar district heating came from Sweden. First Swedish plants are from 1984
- Large flat plate collectors (12.5 m^2) in series (up to 11 collectors)
- License production startet in Denmark by Arcon Solar

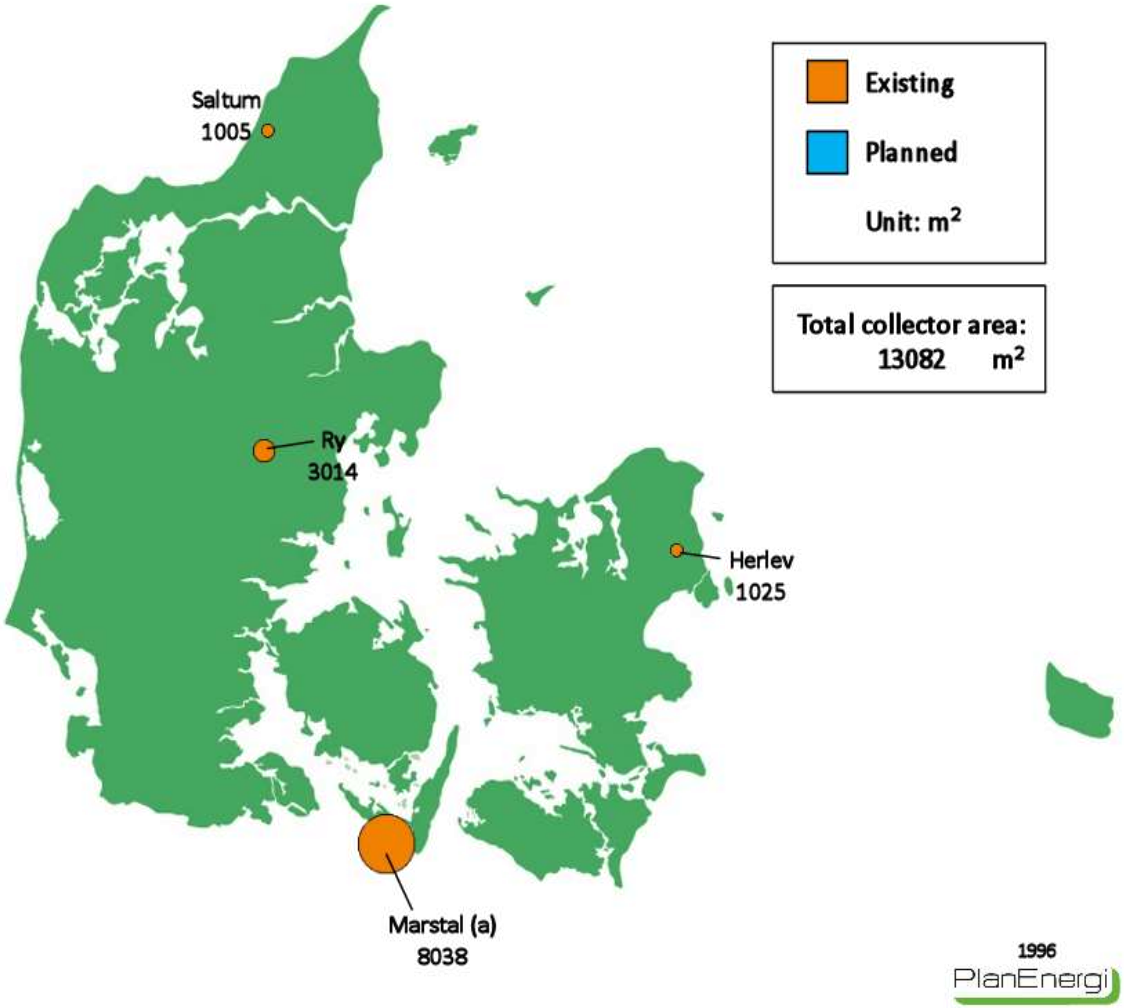
Solar district heating in Denmark



The flat plate solar collector



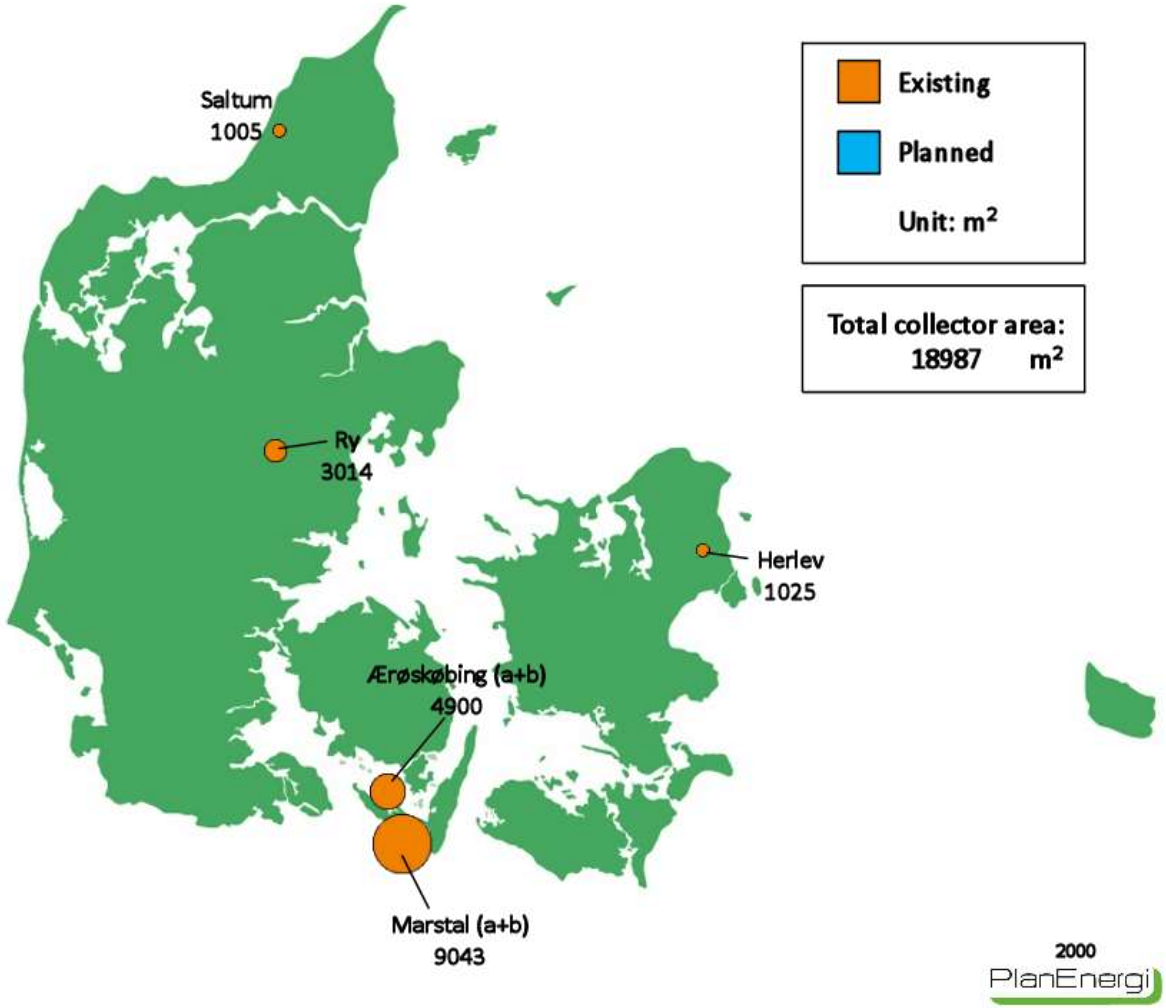
Solar district heating in Denmark



Marstal (1) 1996

Variable flow intro-duced

Solar district heating in Denmark

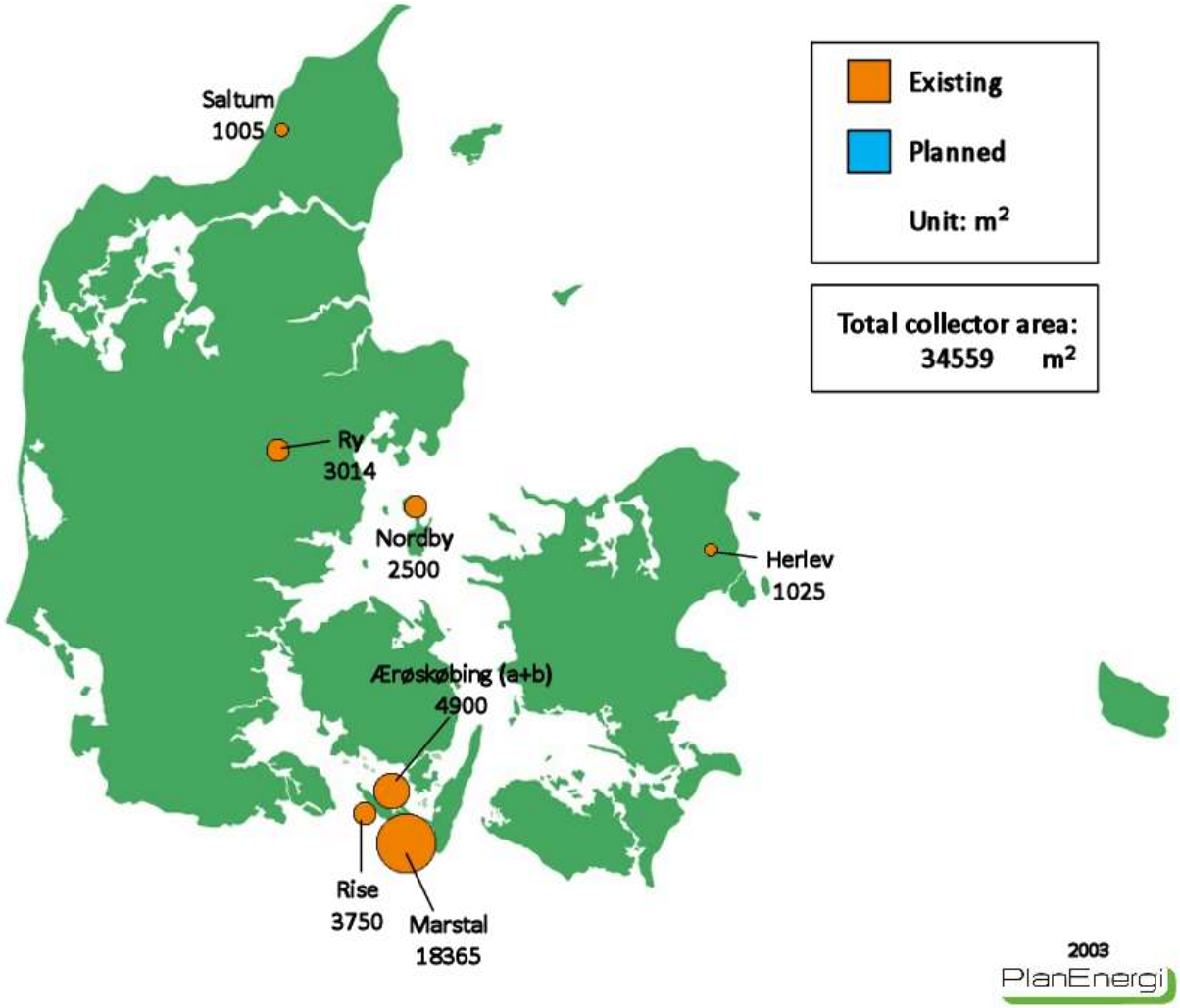


Rise 4 000 m² / 2,8 MW
Solar fraction 45% with steel tank.
Combined with wood pellet boiler

Ærøskøbing 4 900 m² / 3,4 MW
Combined with a straw fired boiler

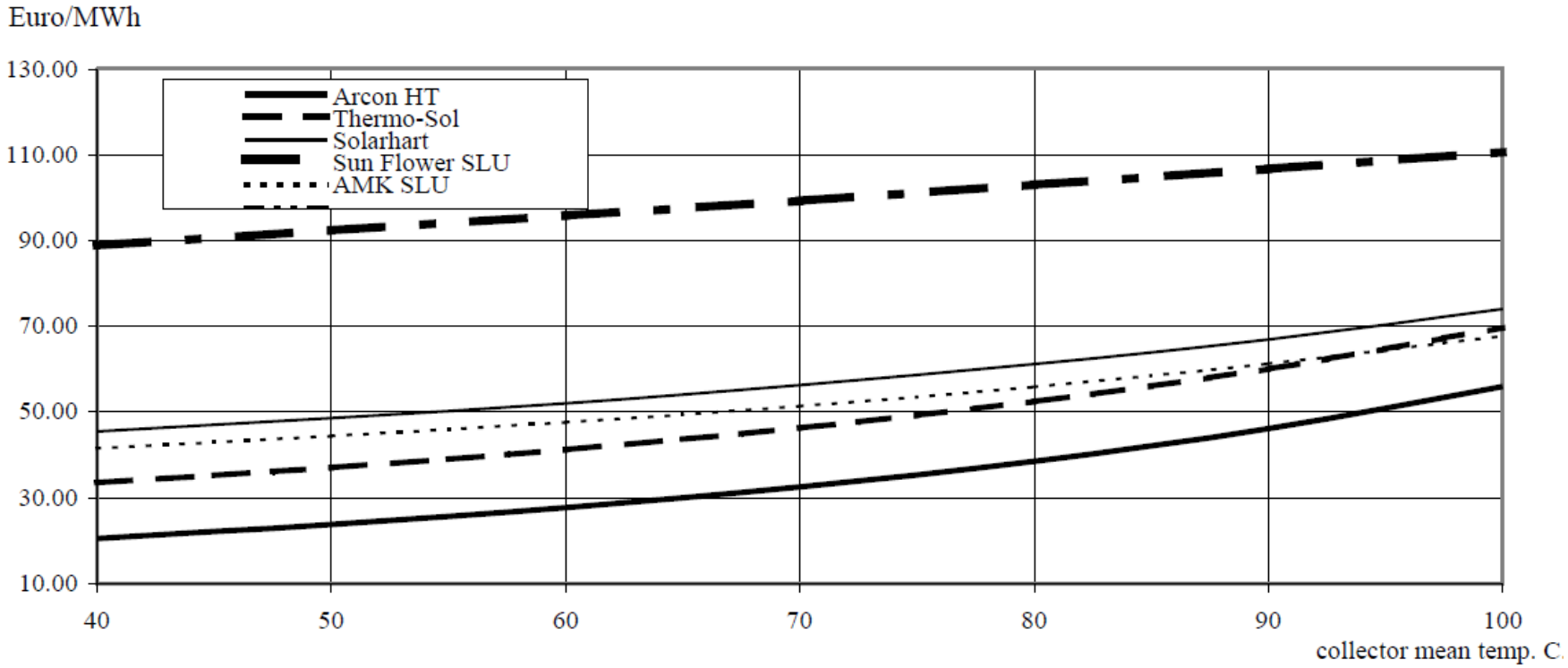
Nordby 2 500 m² / 1,8 MW
Combined with wood chip boiler

Solar district heating in Denmark




www.solarmarstal.dk

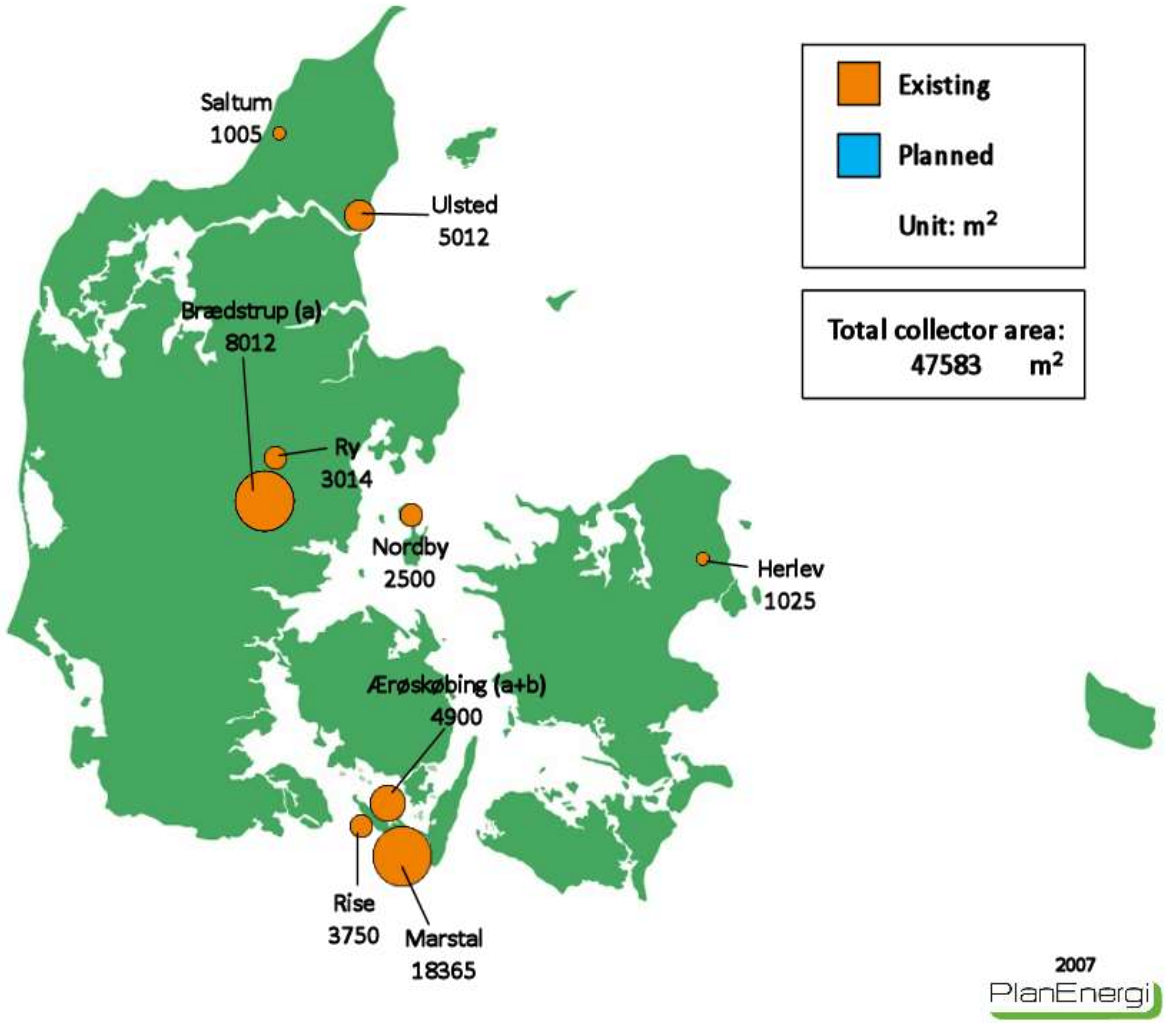
Comparison of solar collectors 2003
SUNSTORE 2 - Marstal



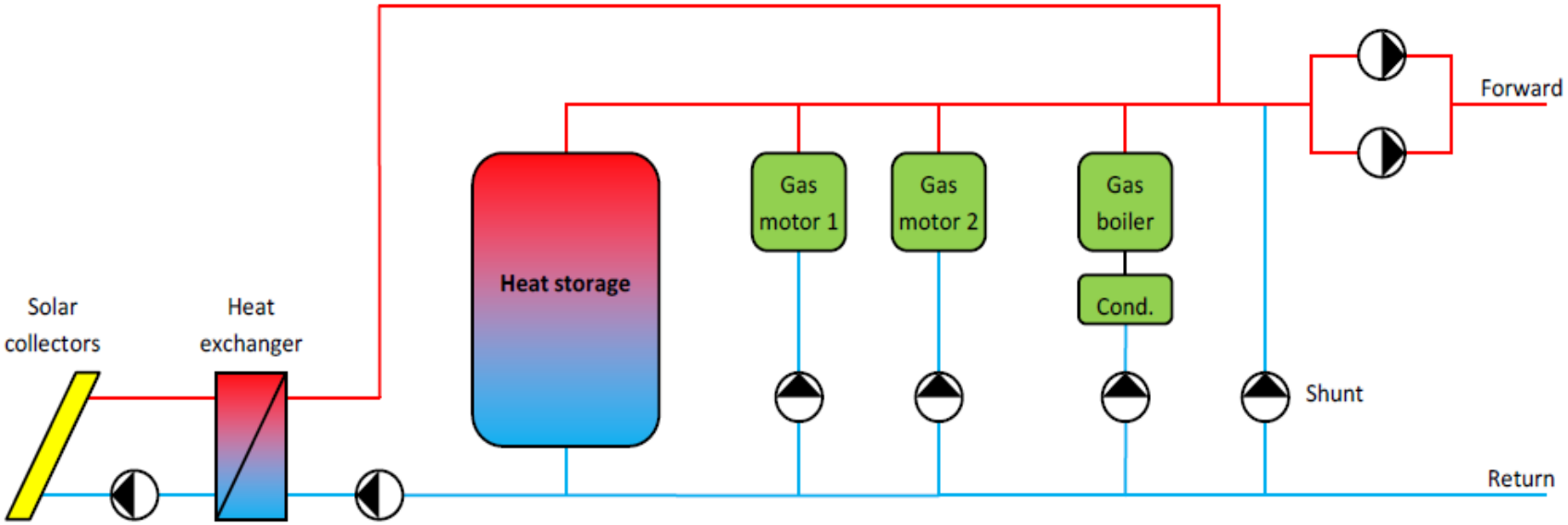
Solar heat combined with natural gas fired CHP

- 2005-2006 a commission leaded by the Danish grid operator Energinet.dk concluded that solar district heating might be socio economic feasible, and opened for support
- Variable electricity prices for CHP plants were introduced in the Nordic countries. That ment periods with only gas boiler production

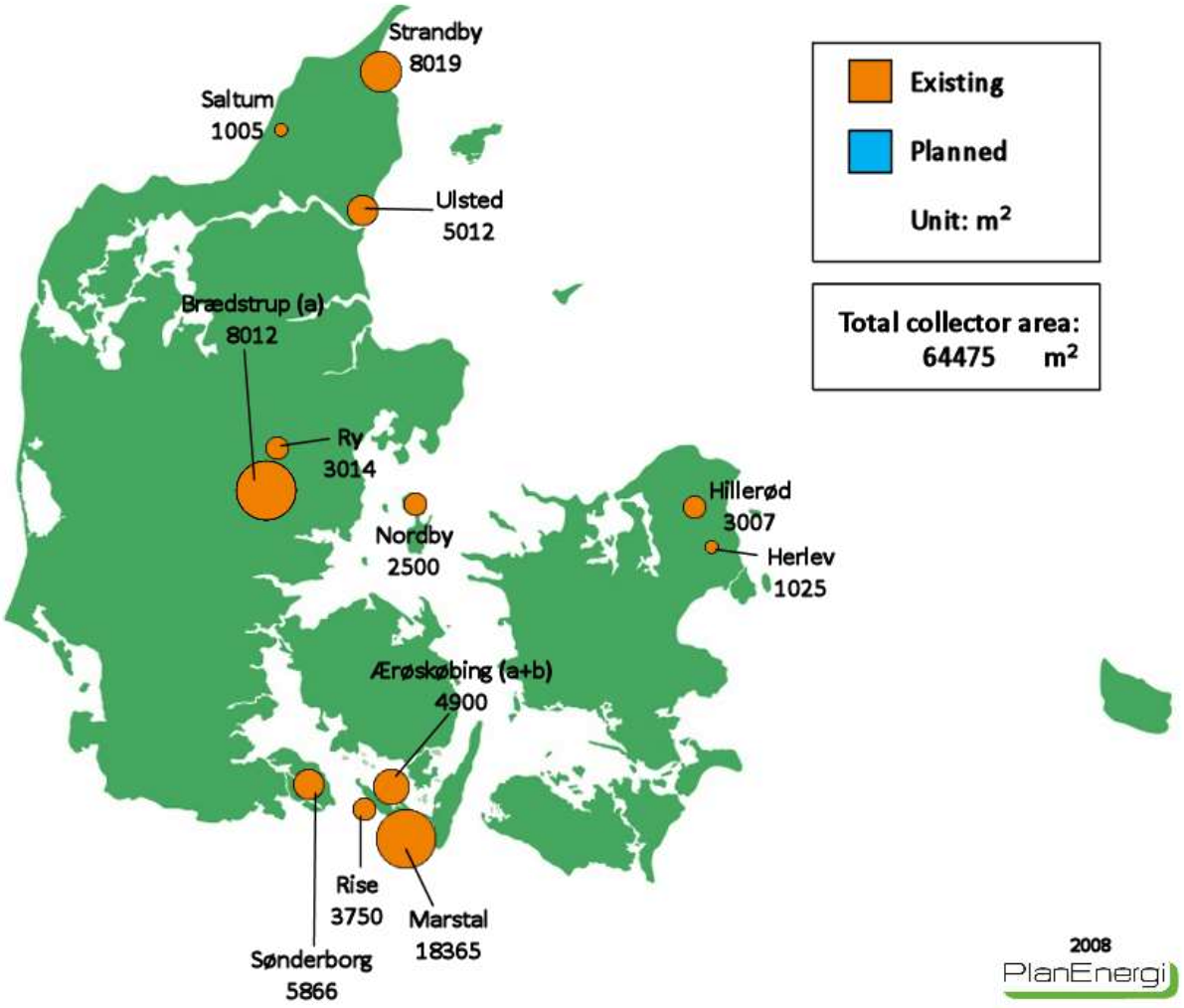
Solar district heating in Denmark



Principle diagram for solar and natural gas fired CHP



Solar district heating in Denmark



Incentives 2008

- High taxes on natural gas. App. same level as the gas price. No tax on solar.
- Not allowed to use biomass at natural gas fired plants
- Saved CO_2 quotes could be sold
- Municipal guarantee for loans
- The solar group under Danish District Heating Association was started and arranged workshops and capacity building courses

Example from Tørring, Denmark

Keep it large and simple.

Example with 10.000 m^2 collectors in Tørring	
Cost of land (30.000 m^2)	80.000€
Collectors (10.000 m^2), pipes, pumps, antifreeze and heat exchangers	2.000.000€
Fence, ground shaping etc.	80.000€
Transmission pipe (1.000 m)	300.000€
Control system	80.000€
Consultancy	40.000€
Total	2.580.000€

Calculated production 4.500 MWh/year

Yearly capital costs:	
2.580.000 € x 6,7%/year =	173.000 €/year
Maintenance 1 €/MWh	4.500 €/year
Total production costs: 177.500 €/year / 4.500 MWh/year =	~ 40 € /MWh

Financing 1 mio €

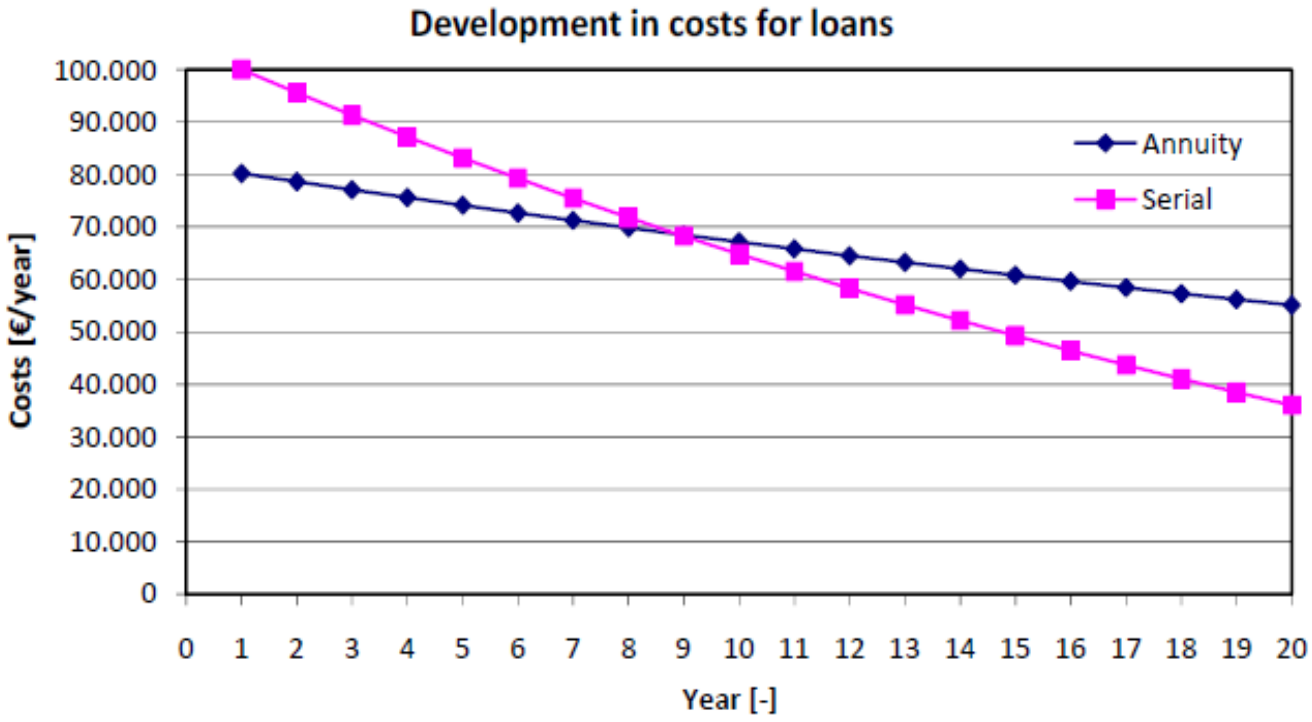
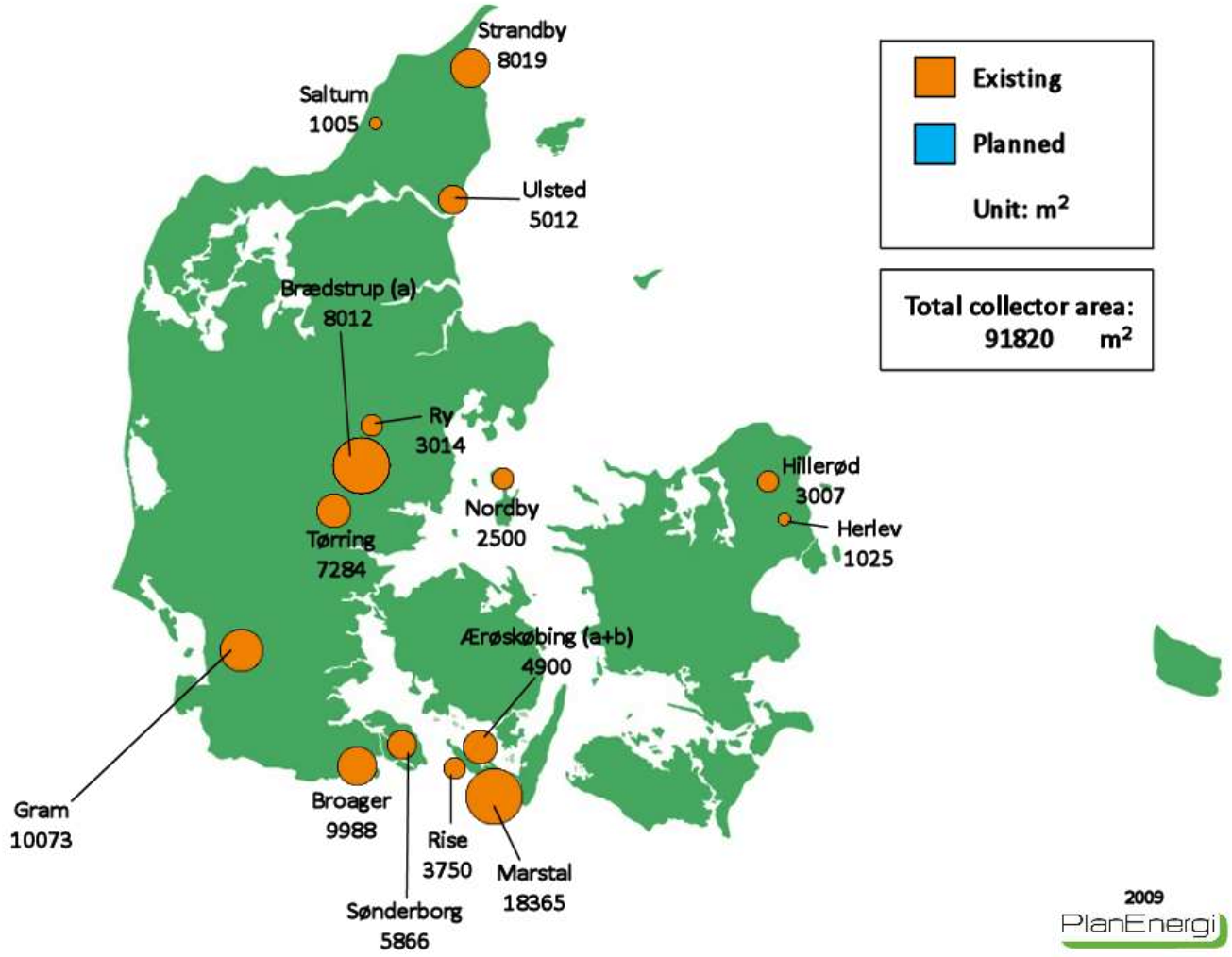


Fig. 2.4.1. Development in costs for annuity loans and serial loans, interest rate 5%, inflation 2%.

- Loan 20 years, inflation 2%

- Serial loan, 5%, 1.st year 10%
- Serial loan, 3%, 1,st year 8%
- Annuity loan, 5%, 1.st year 8%
- Annuity loan, 4%, 1.st year 7.4%
- Annuity loan, 5%, average 6.7%
- Annuity loan, 4%, average 6.1%
- Annuity loan, 3%, average 5.5%

Solar district heating in Denmark



SDH solar district heating

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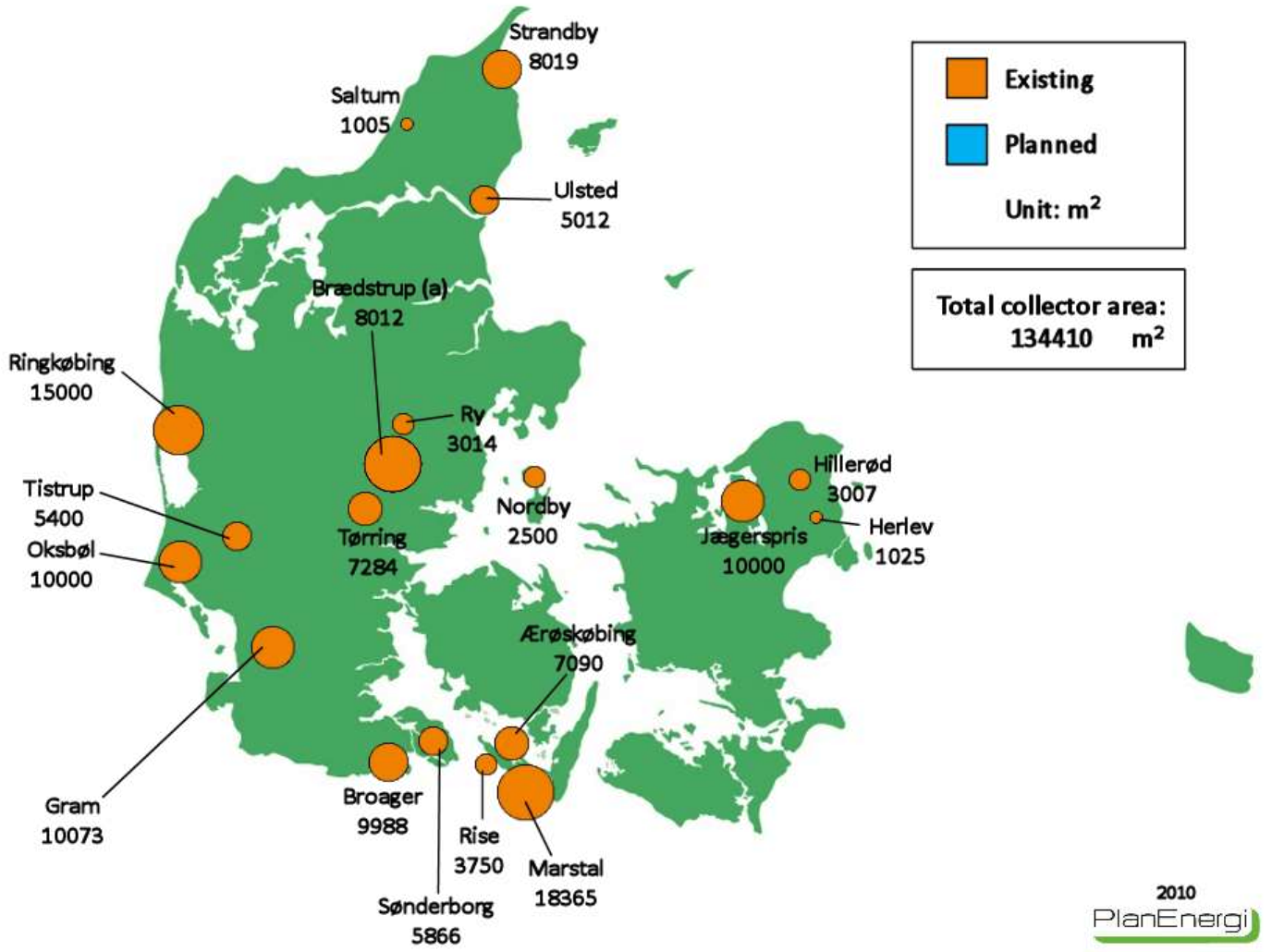
Solar district heating in Denmark



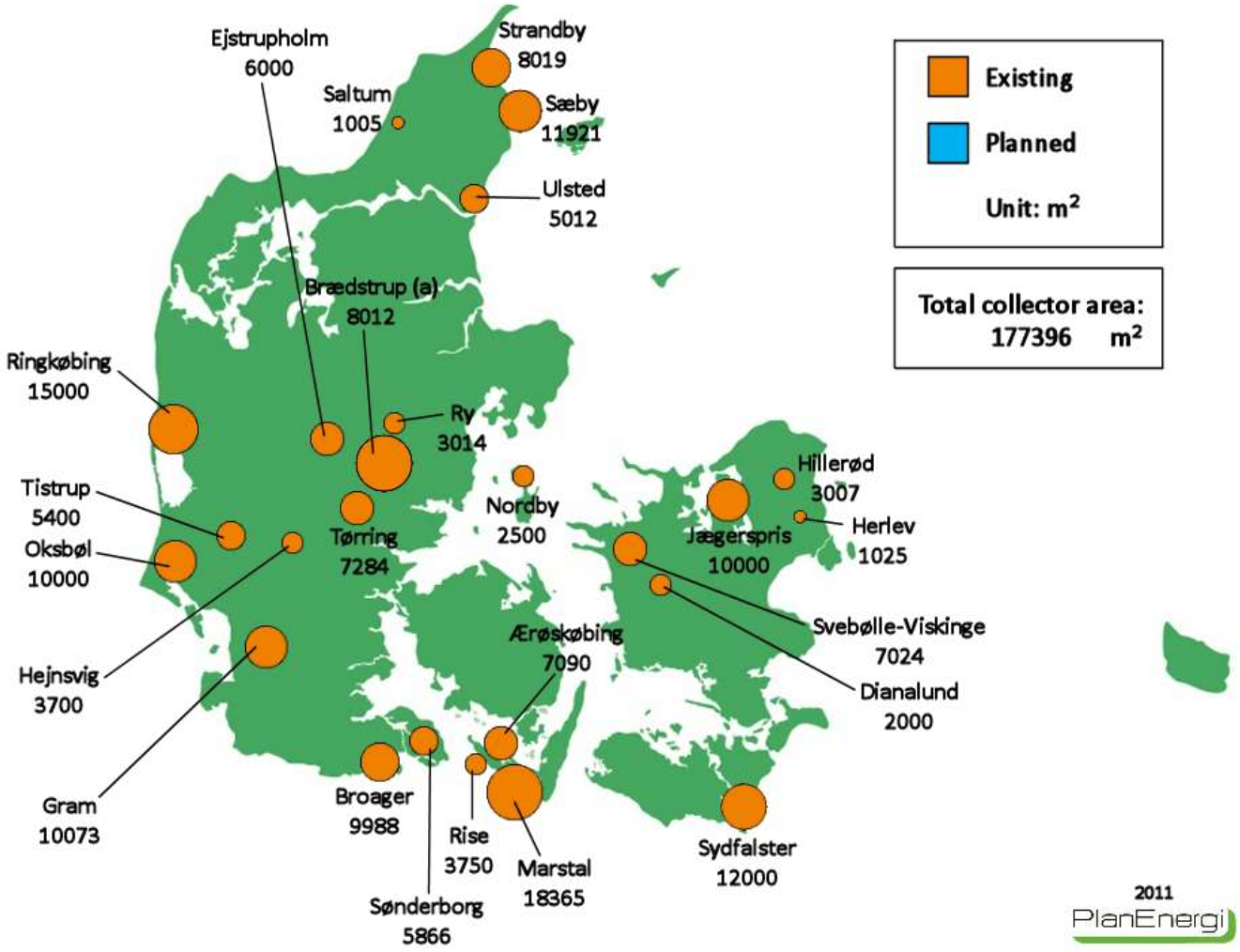
100 % of the heat demand covered with renewable energies in Crailsheim, Germany

- app. 400 ha area needed for biomass to reach 100 % coverage of the heat demand

- app. 21 ha area needed for solar thermal to reach 100 % coverage of the heat demand

Source: Solites, City of Crailsheim

Solar district heating in Denmark



SDH solar district heating

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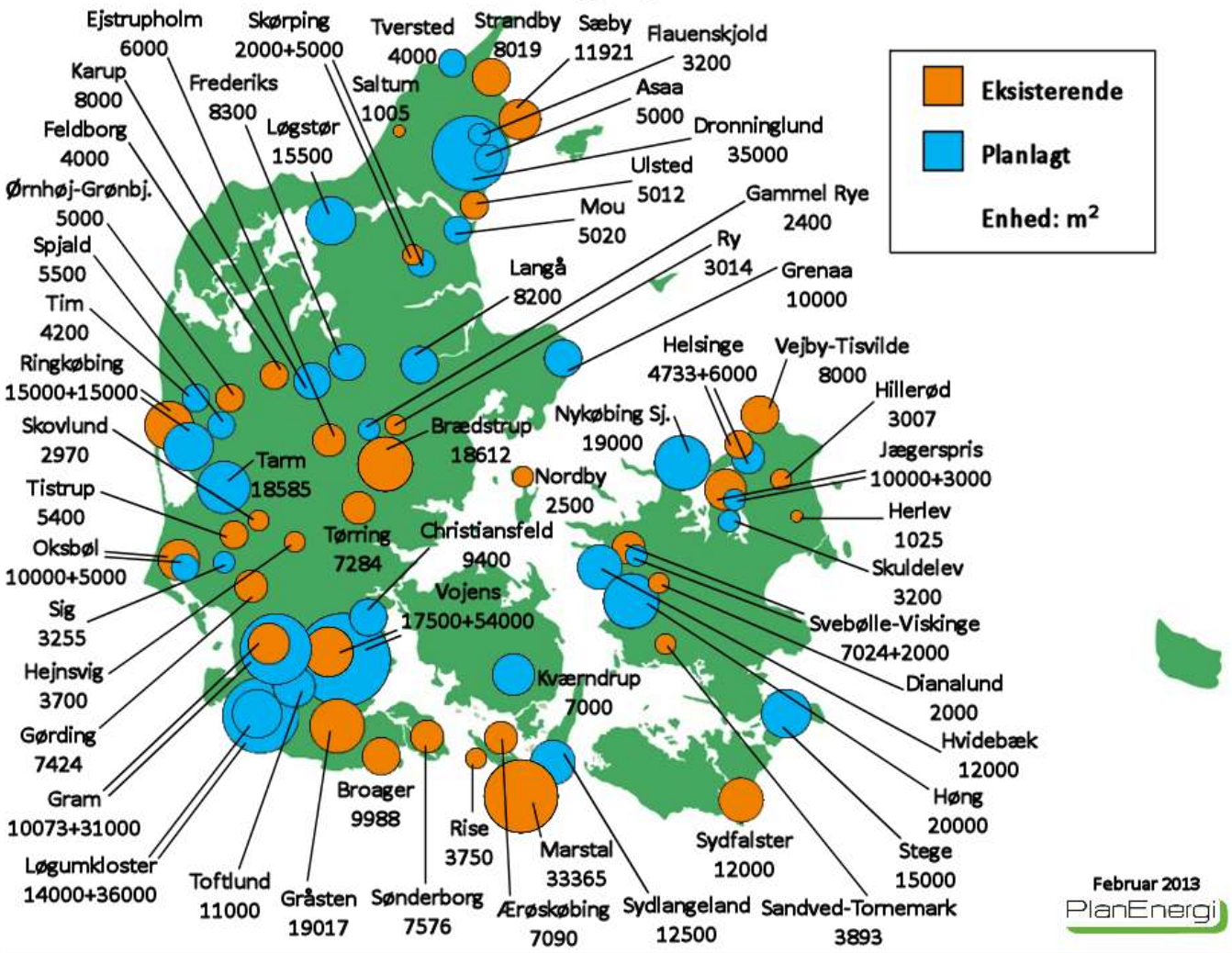
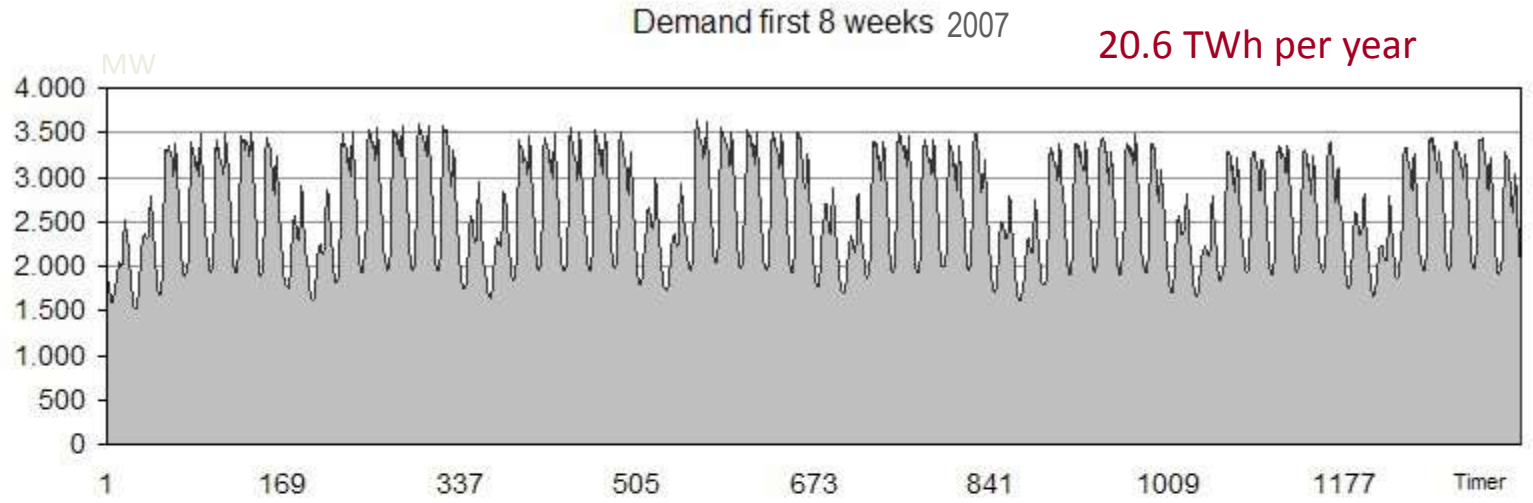
Solvarmeanlæg i fjernvarmenet



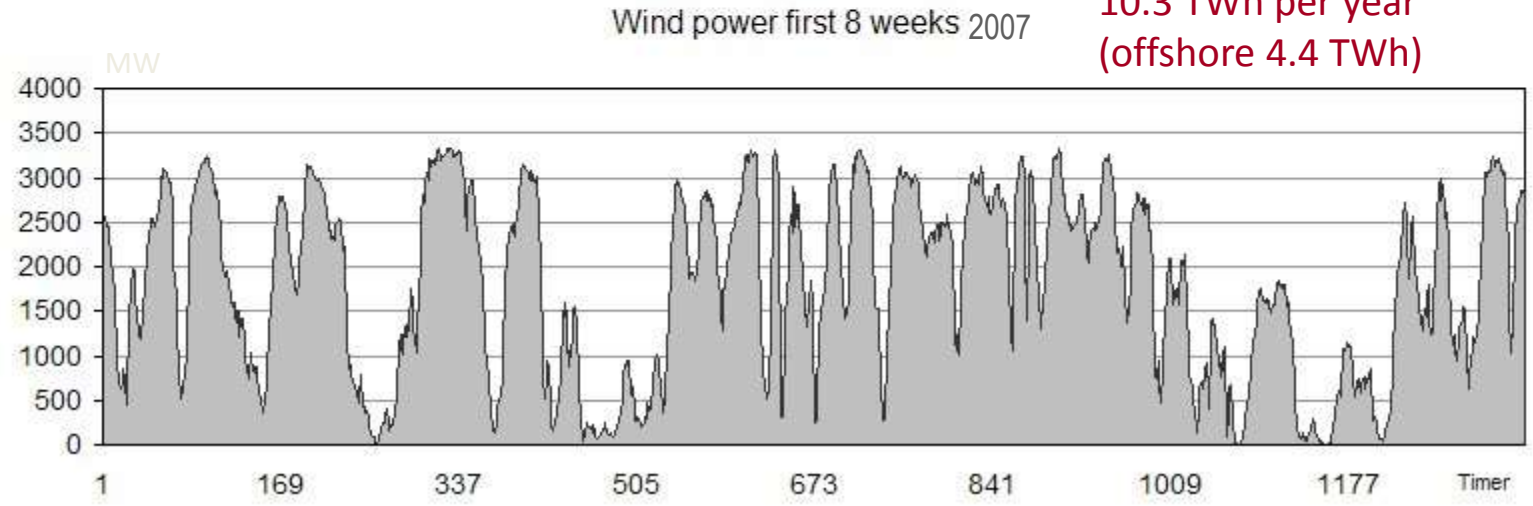
Status 2013

- 279,348 m^2 implemented end of 2012
- More than 400,000 m^2 in the pipeline. Most of it to be implemented in 2013
- The interest rate is app. 3% for a 20 year annuity loan. Inflation is 2%
- Solar counts as energy savings
- Supply security tax was announced to be introduced for all fuels – but solar is not a fuel
- All heat and power production shall be without fossil fuels in 2035
- Larger plants and plants with high solar fraction are coming
- Reliable and durable technology with guaranty for efficiency

Balancing the powersystem DK1 ~ 50 % wind?



20.6 TWh per year

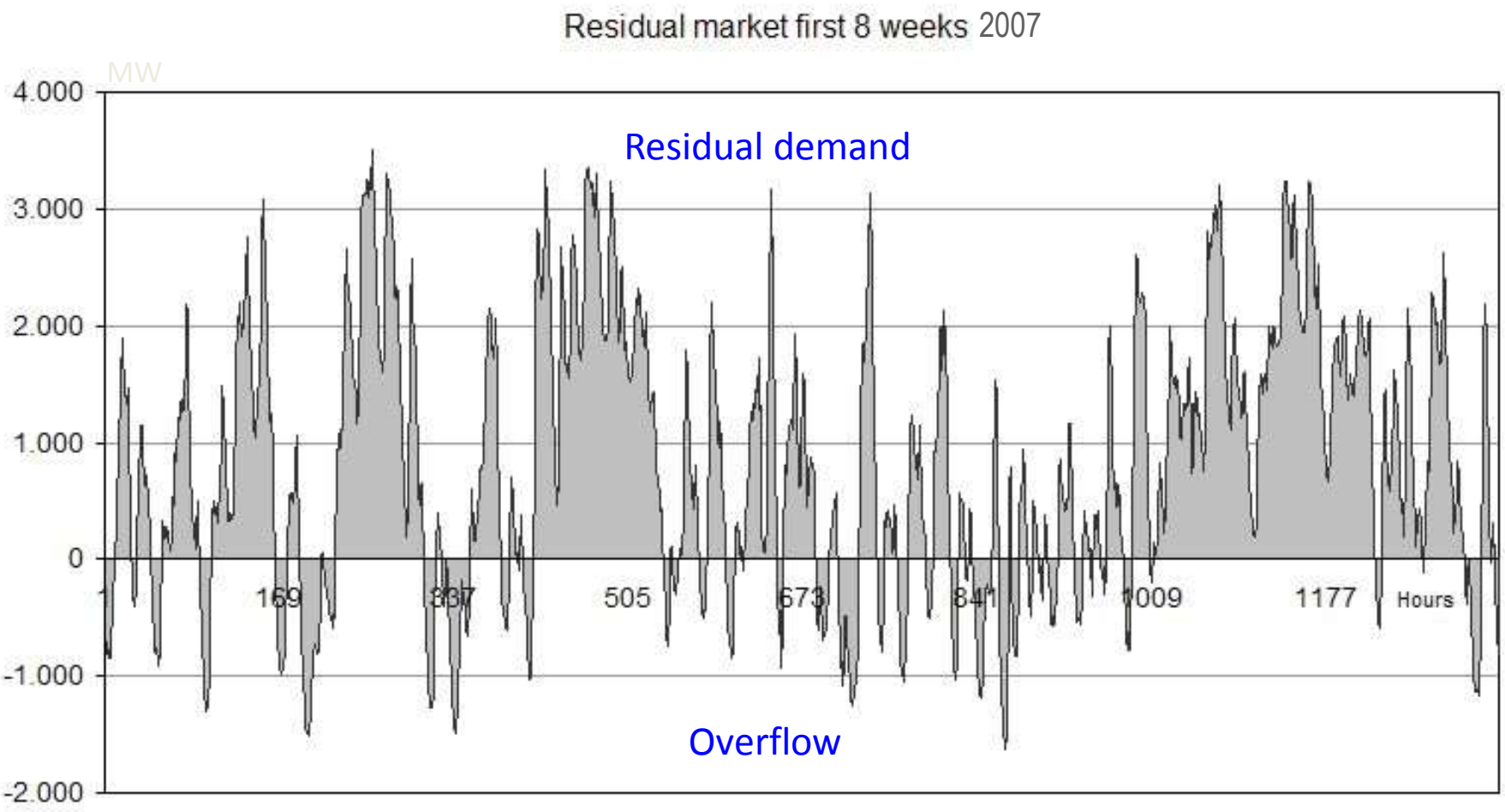


10.3 TWh per year
(offshore 4.4 TWh)

Vision of 50 % windpower !

Subtracting wind power from demand leaves a residual demand and an overflow

Who is going to pay for the residual?



This profile demands a lot of expensive regulating power

The SUNSTORE concept can integrate renewable electricity in heat production. Examples Braedstrup and Marstal

35 – 40 000 m²

HP

CHP

Boiler

End use

50 – 100 000 m³ Very cost effective heat storage (demonstration)

Benefits from combining technologies

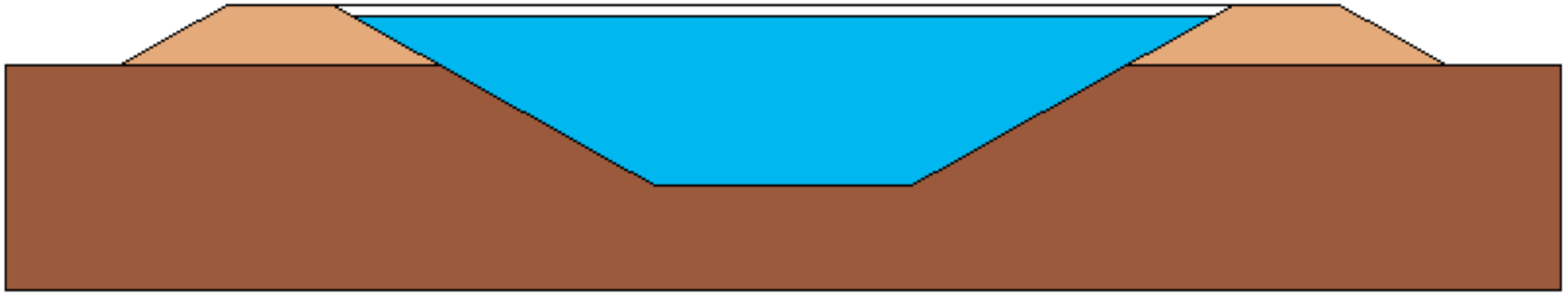
Solar:
- ✓ Produce free heat

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

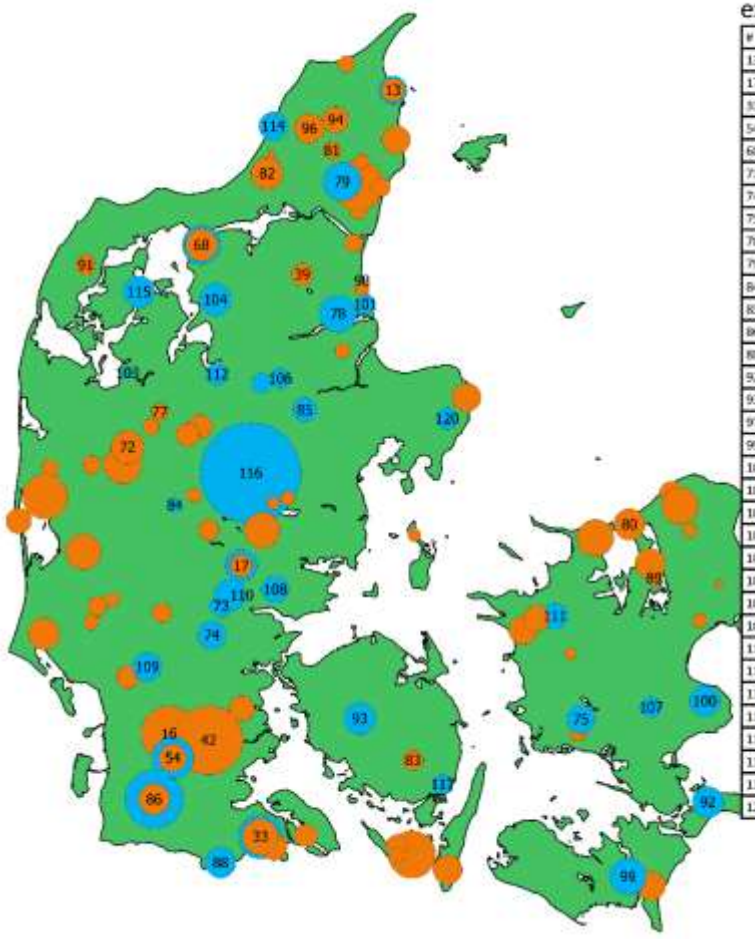
Heat pump:
- ✓ Produce cheap heat
- ✓ Fast capacity regulation (load) → earn money
- ✓ Reduce storage volume

Storage:
- ✓ Gives flexibility
- ✓ Makes combinations possible

Design of pit heat storage



Solar District Heating in Denmark



Planned new & expansions

#	Plant	Collector area (m2)
13	Strandby	(8019)+4000
17	Tørring	(7284)+8000
33	Gråsten	(19024)+10000
54	Toftlund	(11000)+15000
68	Løgstør	(15208)+7000
73	Bredsten - Balle	7800
74	Egtved	12000
75	Fuglebjerg	12000
78	Hadsund	20513
79	Hjallerup	21546
84	Kølkær	2800
85	Langå	8505
86	Løgumkloster	(14000)+36000
88	Padborg	13961
92	Stege	14505
93	Tommerup	15000
97	Ørum	6000
99	Øster Tørreby	20000
100	Østervang (Hårlev)	14000
101	Als (Mariagerfjord)	5947
103	Ejning	1800
104	Farsø	15400
106	Hammershøj	6000
107	Haslev	6400
108	Hedensted	11000
109	Holsted	12500
110	Jelling	15000
111	Jyderup	10000
112	Løgstrup	7000
114	Løkken	12000
115	Nykøbing Mors	15000
116	Silkeborg	150000
117	Skårup (Sydfyn)	5418
120	Trustrup-Lyngby	7000

New plants & expansions in operation

#	Plant	Collector area (m2)
16	Gram	(10073)+34851
39	Skærping	(2000)+5292
42	Vojens	(17500)+52492
72	Aulum	16000
77	Haderup	4234
80	Hundested	14465
81	Jerslev J	4612
82	Jetsmark	15183
83	Kværndrup	6200
86	Løgumkloster	14000
89	Skuldelev	3742
91	Snedsted (Thy)	6000
94	Taars	10011
96	Vrå	13200
98	Øster Hurup	3225

In operation

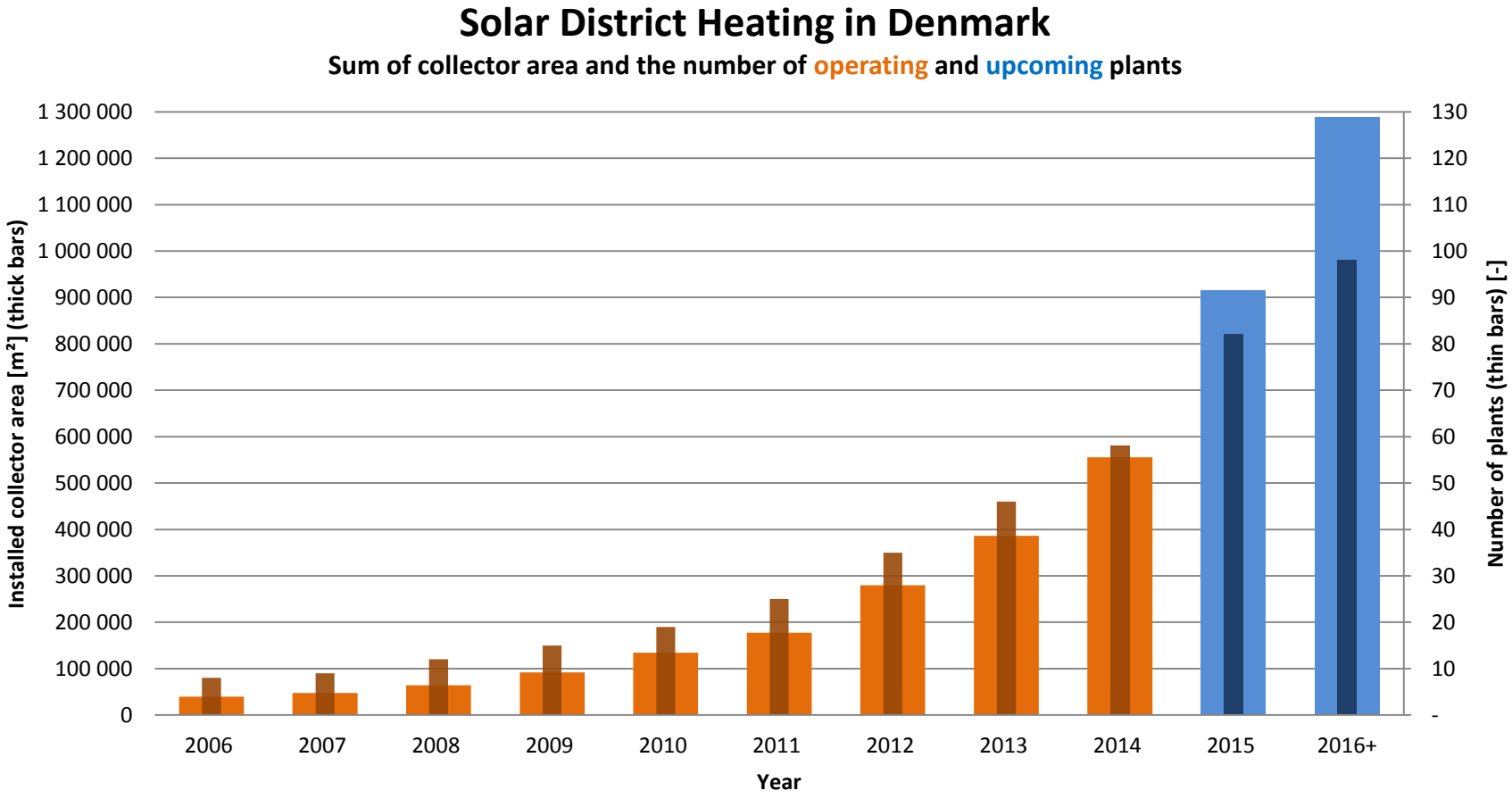
Planned / planned expansion

Total collector area (in operation):759 005m^2

Total collector area (planned):529 095m^2

October 2015

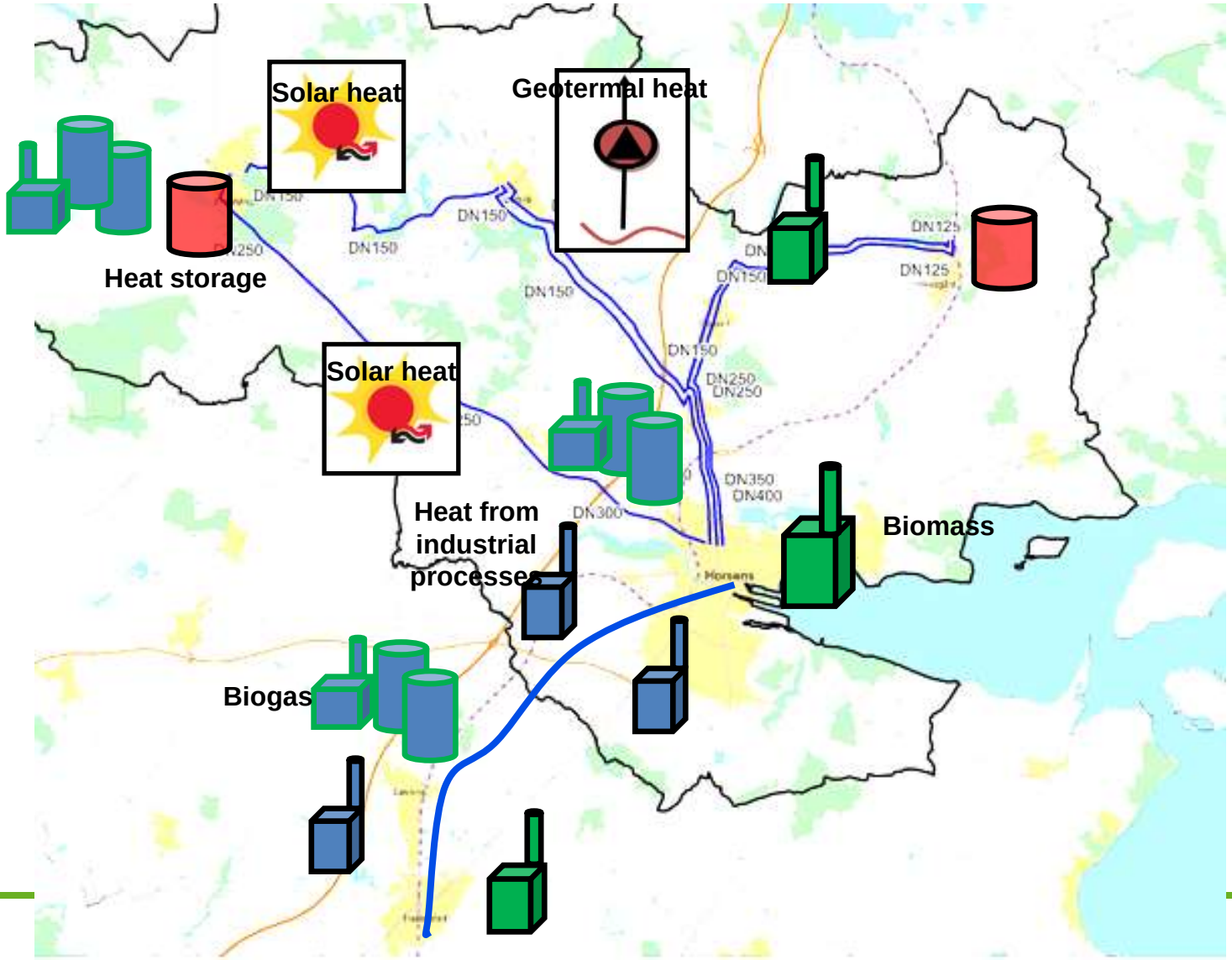
PlanEnergi


Solar District Heating in Denmark
Sum of collector area and the number of operating and upcoming plants
Installed collector area [m²] (thick bars)
Number of plants (thin bars) [-]
1 300 000
1 200 000
1 100 000
1 000 000
900 000
800 000
700 000
600 000
500 000
400 000
300 000
200 000
100 000
0
130
120
110
100
90
80
70
60
50
40
30
20
10
-
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016+
Year

Status 2015

- 900,000 m^2 implemented end of 2015
- More than 400,000 m^2 in the pipeline. Most of it to be implemented in 2016
- The interest rate is app. 3.5% for a 20 year annuity loan. Inflation is 1%
- Solar counts as energy savings for projects approved before 31th December 2015 and opened before 31th December 2016
- Supply security tax was cancelled
- All heat and power production shall be without fossil fuels in 2035 is questioned by the new Danish government, but Denmark shall still be supplied with 100% renewable energy in 2050
- Larger solar fraction and larger solar thermal plants
- Reliable and durable technology with guaranty for efficiency

Transmission lines in Brædstrup, Horsens and Hedensted?



The future ?! Renewable district heating and cooling!?

- ✓ Flexible
- ✓ Renewable
- ✓ CO_2-neutral
- ✓ Cost effective

Thank you for your attention

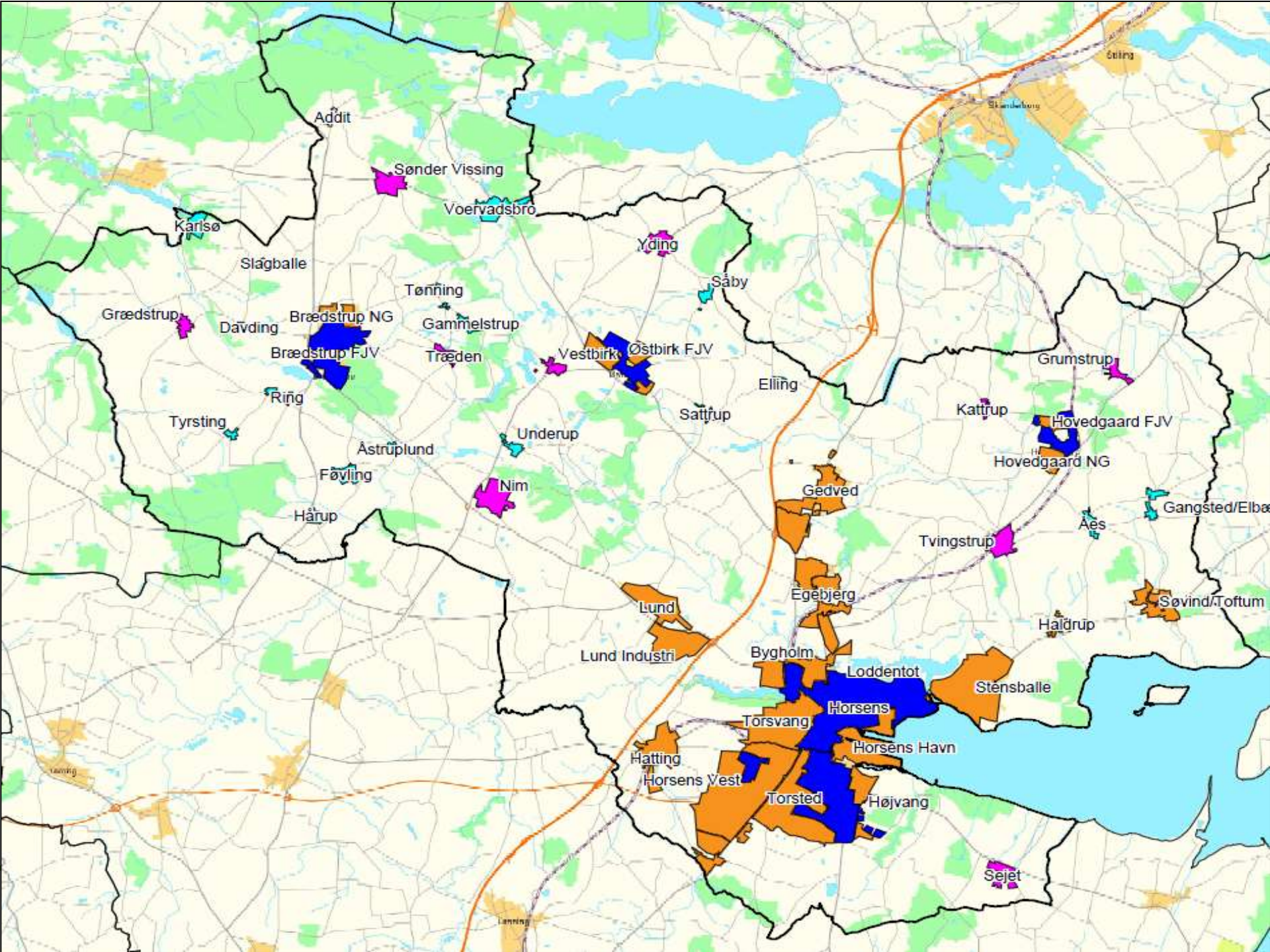
Per Alex Sørensen

pas@planenergi.dk

SW&W-Cartoon: Michael Hüter

More information

www.planenergi.dk
www.dronninglundfjernvarme.dk
www.solarmarstal.dk
www.sunstore4.eu
www.solar-district-heating.eu
www.iea-shc.org/task45


Addit
Sønder Vissing
Voervadsbro
Karlsø
Slågballe
Yding
Såby
Tønning
Grædstrup
Brædstrup NG
Gammelstrup
Davding
Brædstrup FJV
Træden
Vestbirk
Østbirk FJV
Grumstrup
Elling
Ring
Sattrup
Kattrup
Hovedgaard FJV
Tyrsting
Underup
Hovedgaard NG
Åstrup
Lund
Føvling
Nim
Gedved
Gangsted/Elbæ
Hårup
Åes
Tvingstrup
Egebjerg
Søvind/Toftum
Haldrup
Lund Industri
Bygholm
Loddentot
Stensballe
Horsens
Torsvang
Horsens Havn
Hatting
Horsens Vest
Torsted
Højvang
Sejet

Conversion of individual heat to district heat