DISTRICT HEATING in The Danish Energy System

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GRØN ENERGI

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Danish District Heating Association is:

- The Association for more than 400 companies who has a 99% supply of district heating – heat comfort for 1,7 million Danish homes (64%)
- 50 municipality owned utilities and companies who has a supply of 70% of all district heating
- Around 340 cooperatives owned by the consumers. Many are in the process of merging to fewer and larger cooperatives
- Other members
  - 3 transmission companies
  - 11 associated members

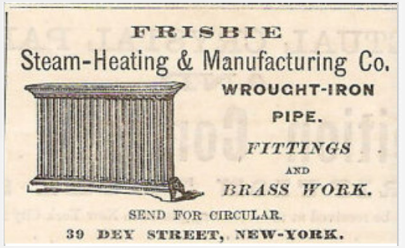
District Heating is an old invention

Roman legionnaires in Britannia

- Hot geothermal water in Chaudes-Aigues Cantal in France around 500 B.C.

1877 commercial district heating in USA

- First plant in New York – based on steam

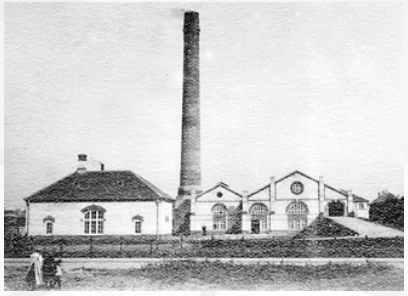


1893 first plant in Europe

- Plant in Hamburg with a real utility and distribution grid based on hot cooling water from a power plant.

1903 first plant in Denmark

- Utilization of heat from waste incineration in Frederiksberg, part of Copenhagen

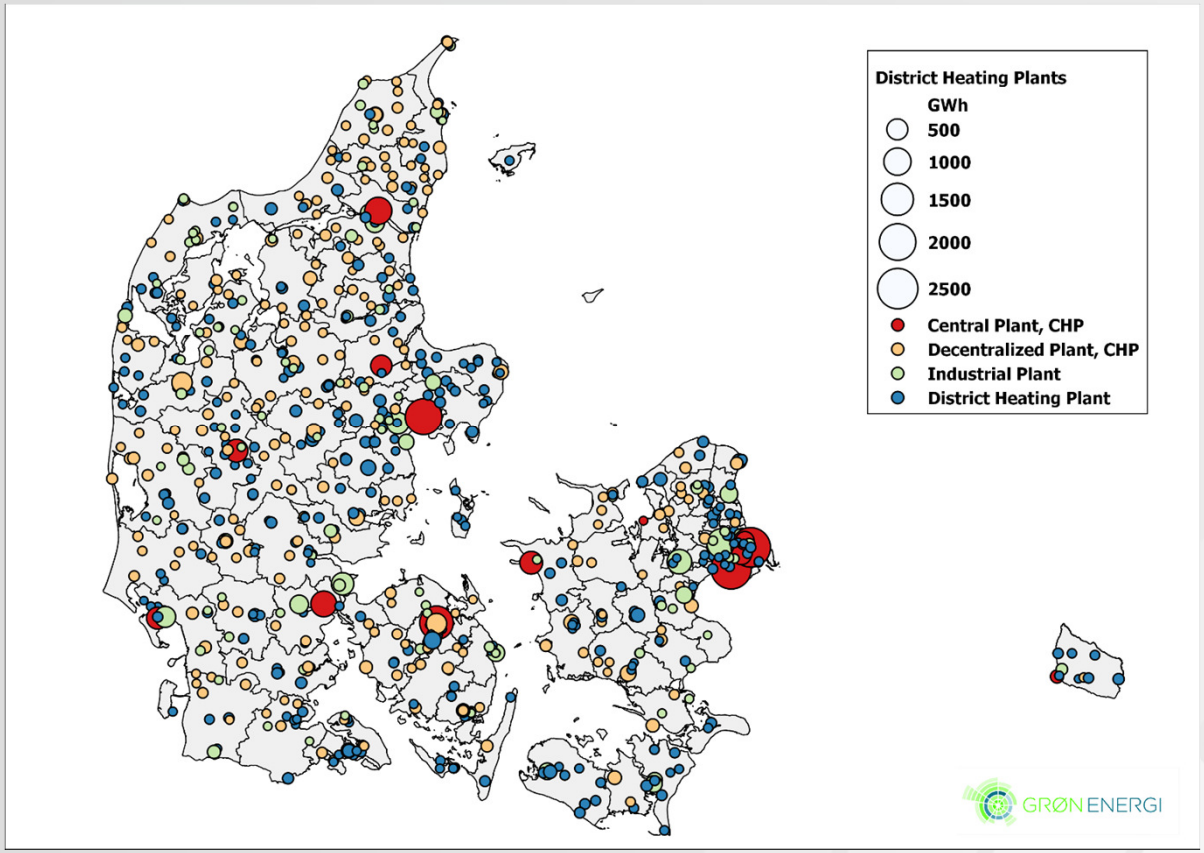


History: District Heating for 1.7 million homes

From oil and coal to solar and wind via natural gas

- 1920 first plant that utilized surplus heat from power plants.
- 1973 the first oil crises – many heating stations used oil as fuel. The first oil units converted to coal in 1974.
- 1979 the second oil crises – and a new Heating Supply Act.
- 1983 to 1995, deployment of district heat from local CHP units based on natural gas.
- Cogeneration of electricity and heat with a high total efficiency and time of use tariff in many years.
- 2003 - 04, liberalization of the power market. Local CHP was granted 15 years of base-subsidy – until end of 2018.
- Biomass integration and conversion from CHP to boilers consequential declining electricity generation.
- 2006 the first thermal solar plant in Brædstrup for heat cogeneration with a natural gas fired CHP plant – now there are more than 70 thermal solar plants.

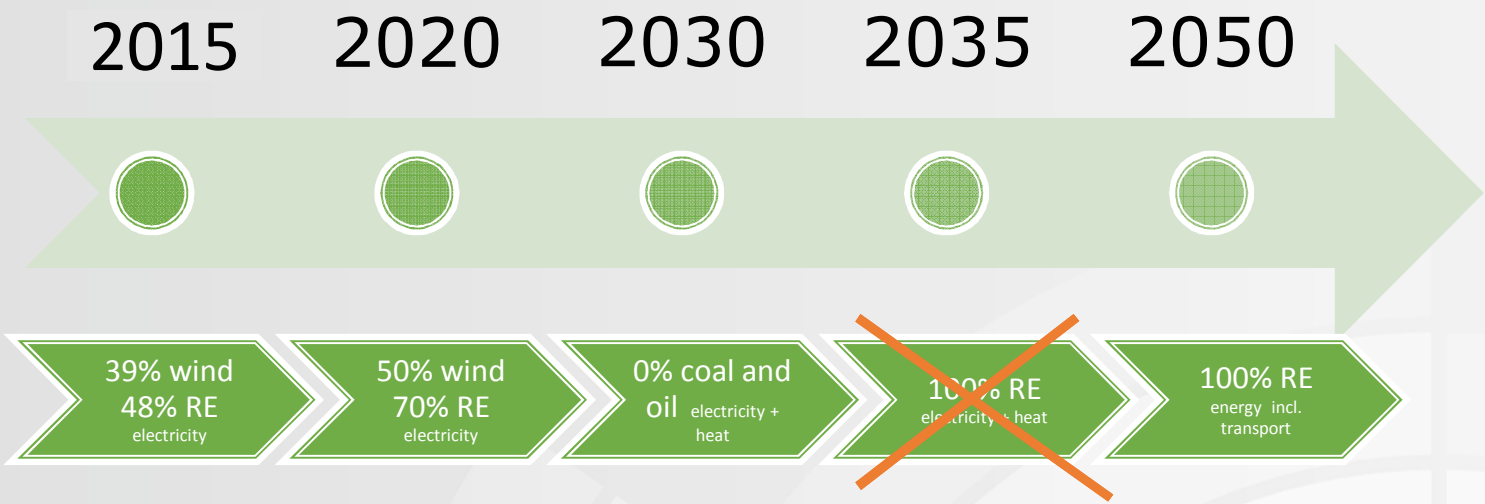
District Heating in Denmark



- More than 460 plants and units generate district heating
- Coal, biomass (straw, woodchips and pellets), natural gas, municipality waste, thermal solar and biogas.
- 60.000 km district heating transmission and distribution grid
- 64% of all homes uses district heating.

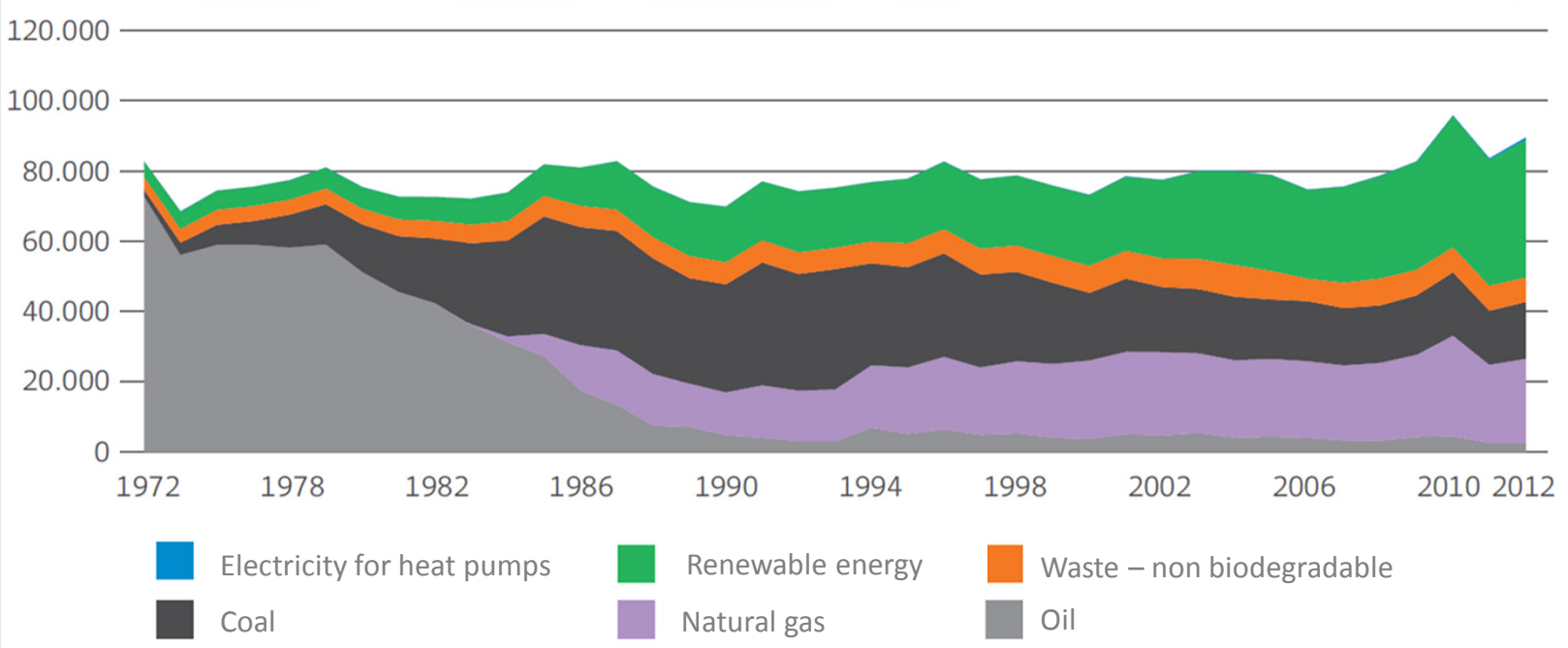
Ambitious Danish Energy policy

Denmark is going for a 100% renewable (RE) energy system by 2050



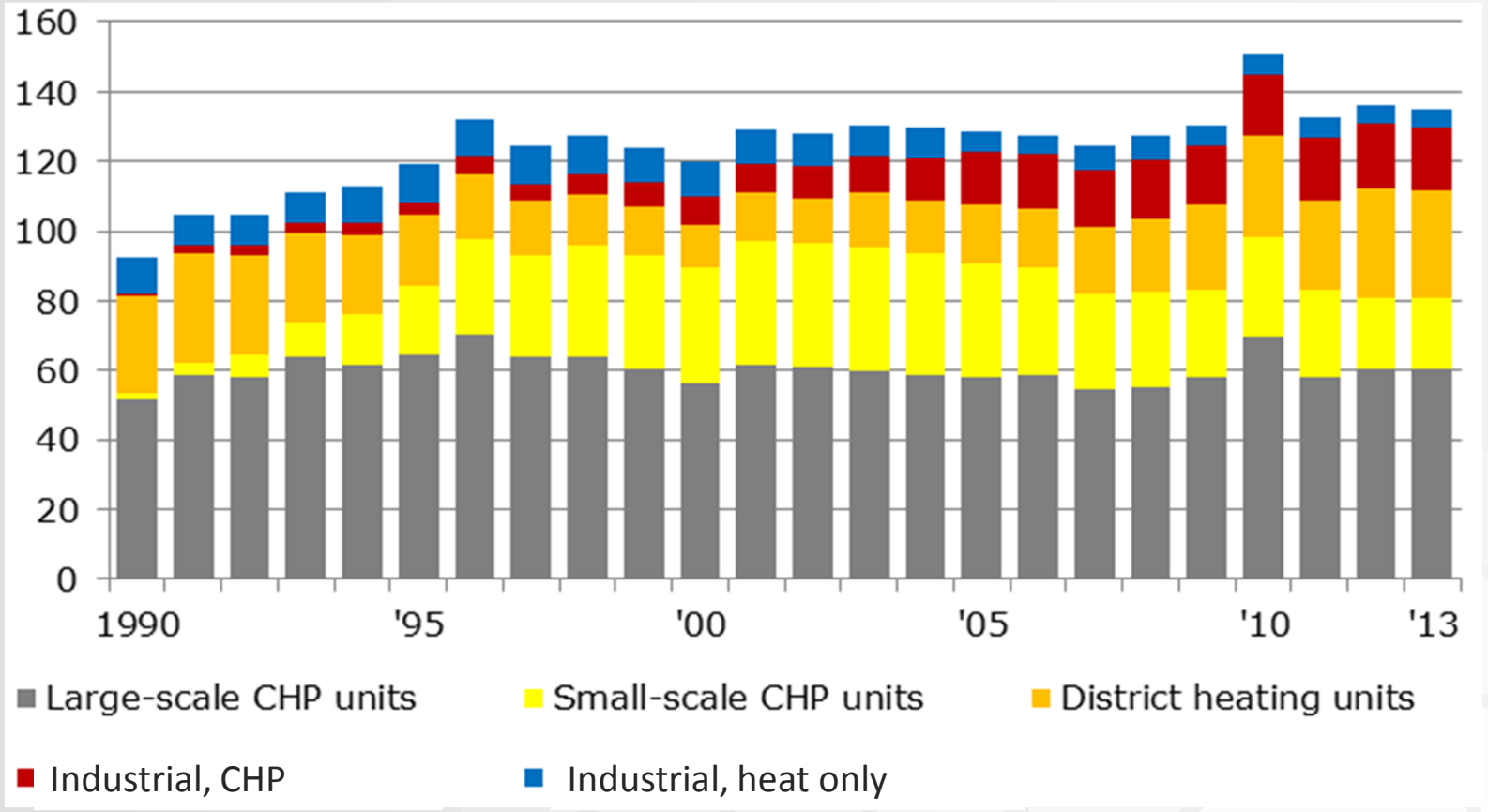
Political plans and agreements

District Heating – From oil to multiple fuels

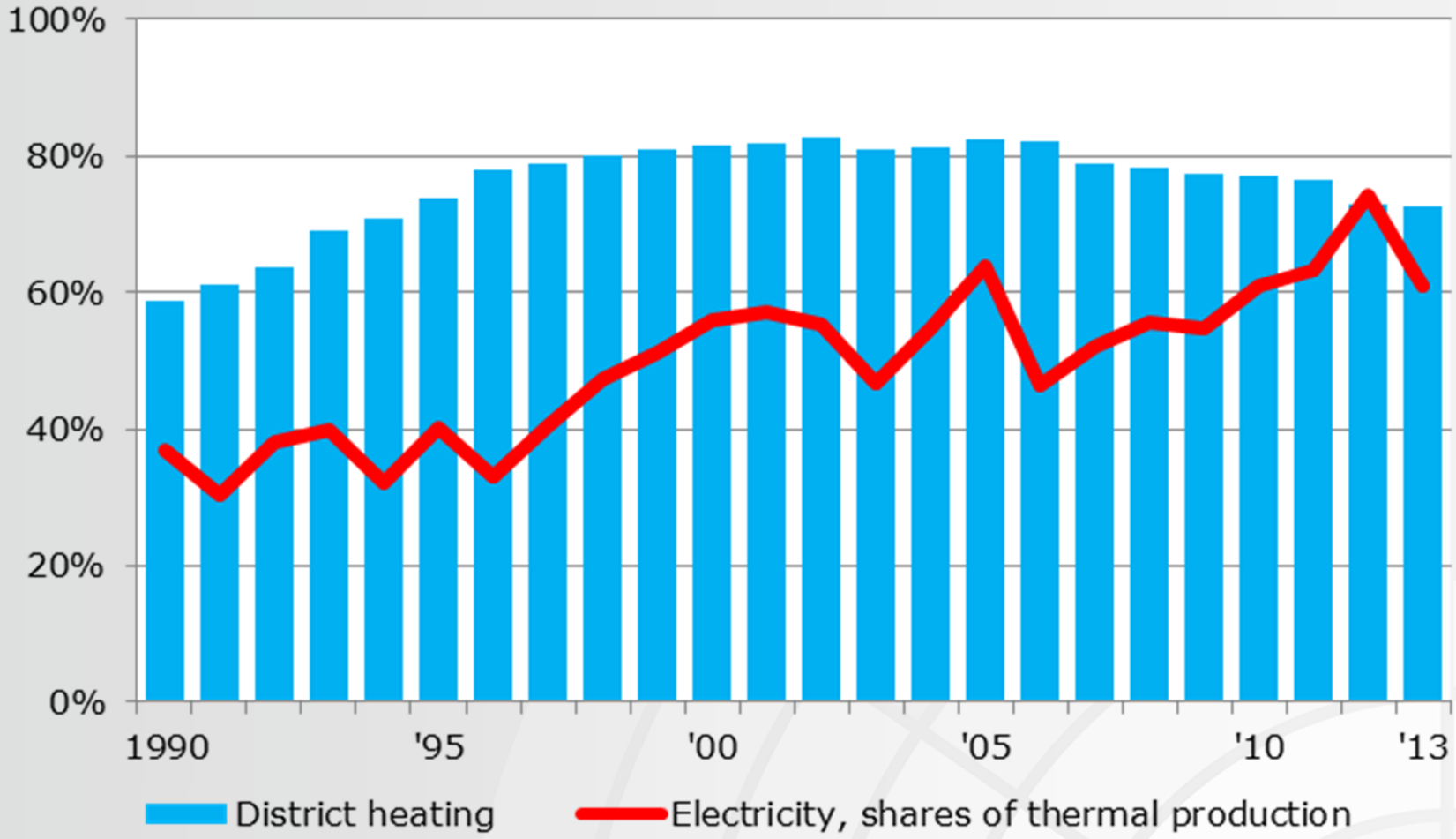


- Change in fuel used for district heating generation 1972 – 2012 (PJ)

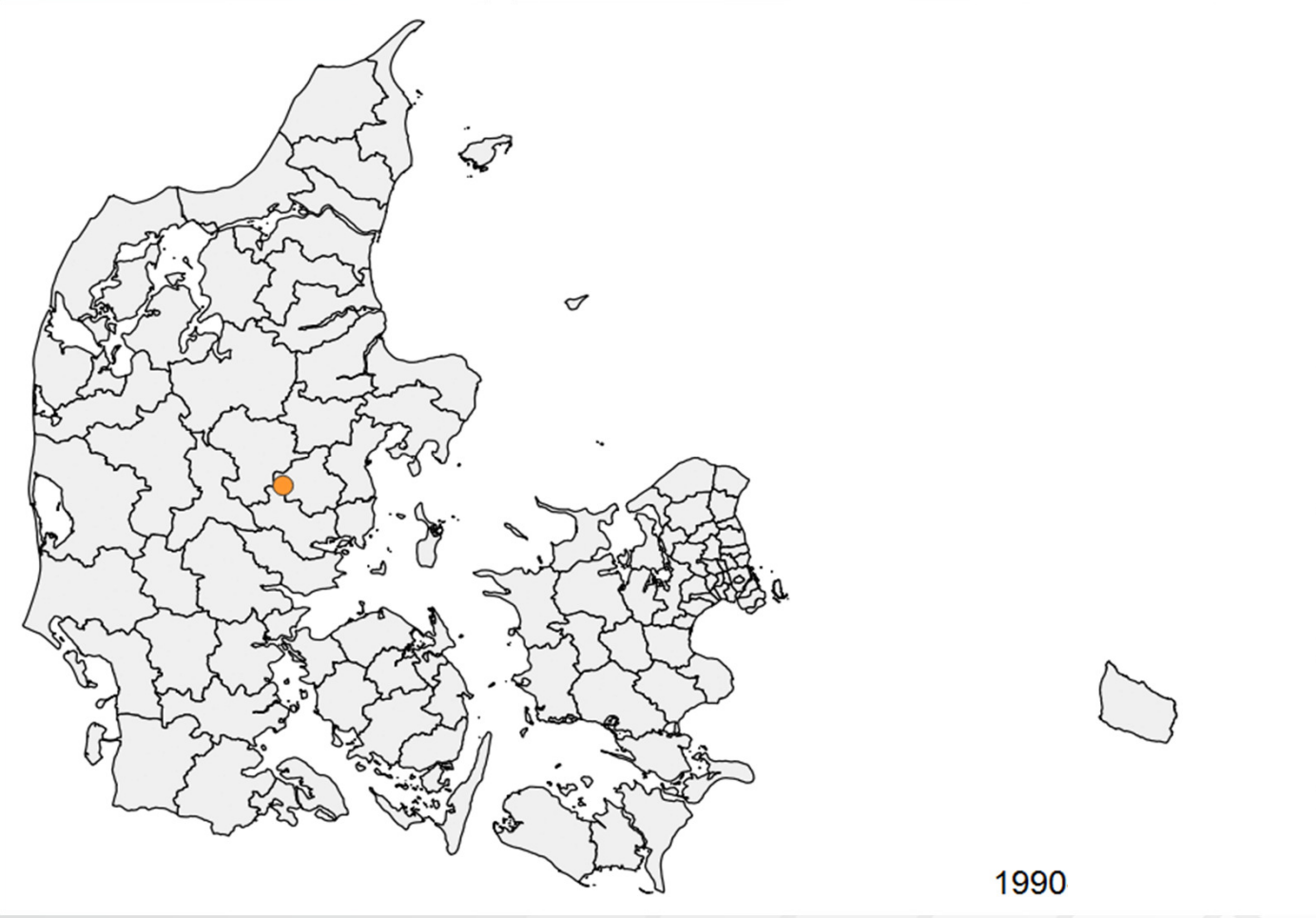
District Heating from CHP – Large and small



CHP – cogeneration of heat and electricity

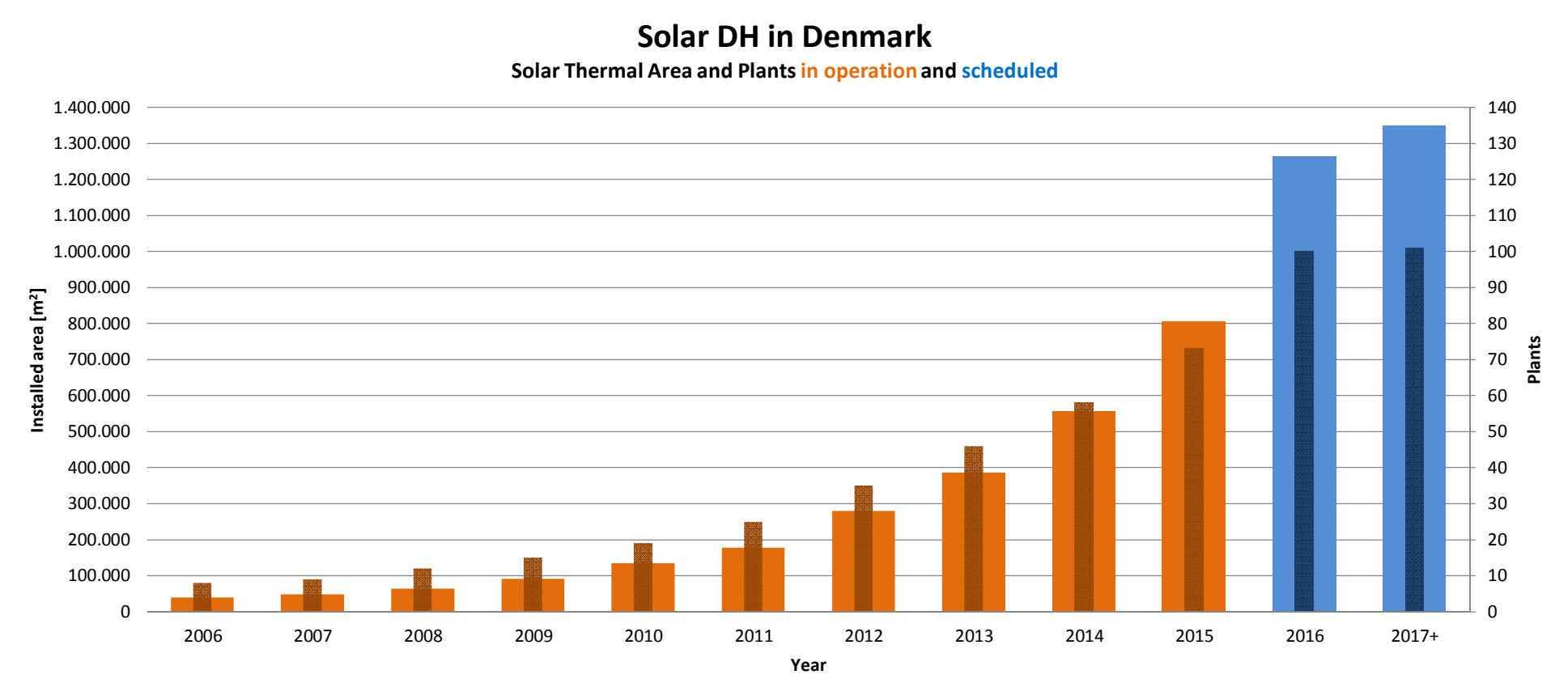


Thermal Solar energy for district heating – the new area for growth

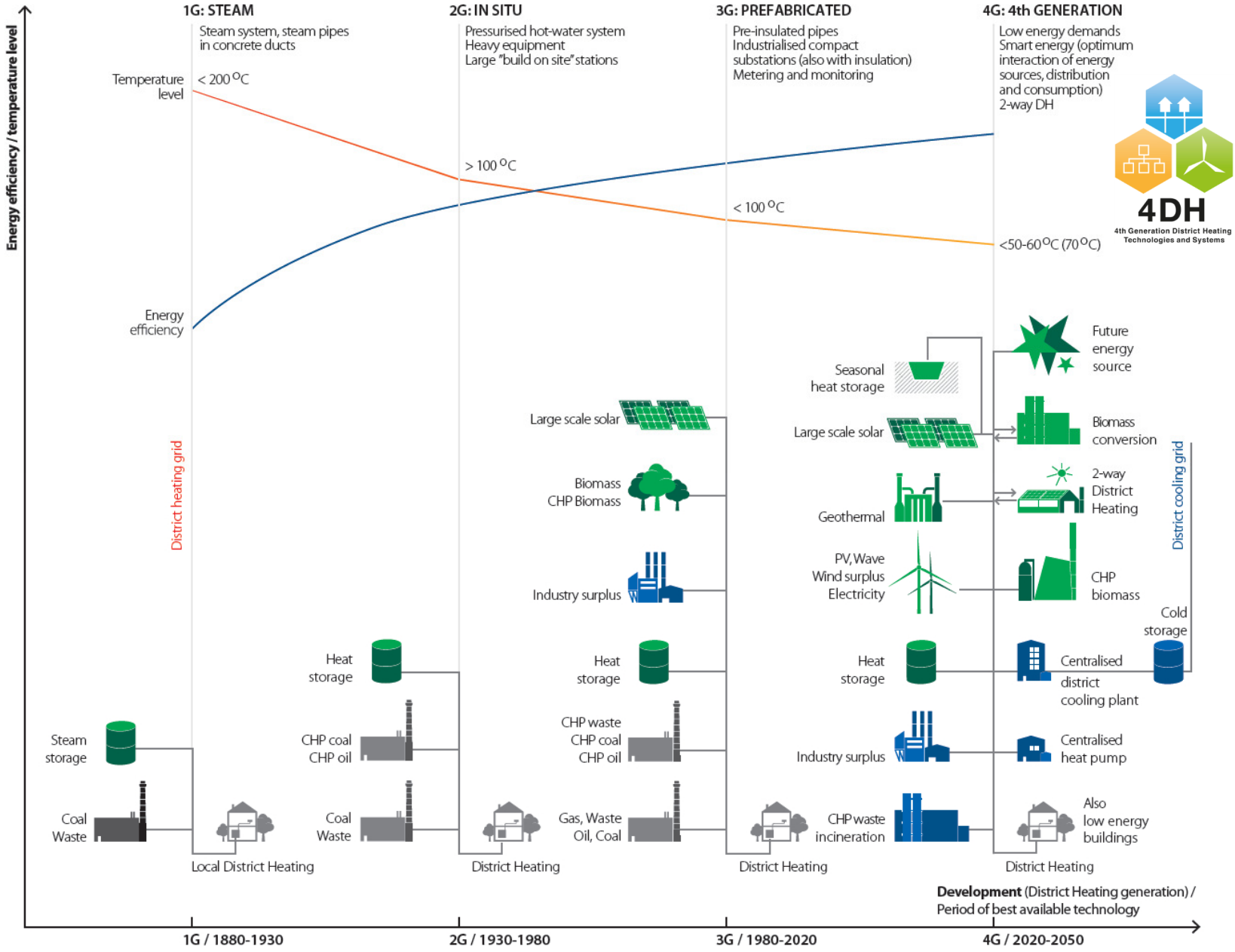


- Existing (m^2)
- Largest 70.000 m^2
- Total > 800.000 m2
- Scheduled (m^2)
- Largest >150.000 m^2
- Total > 500.000 m2

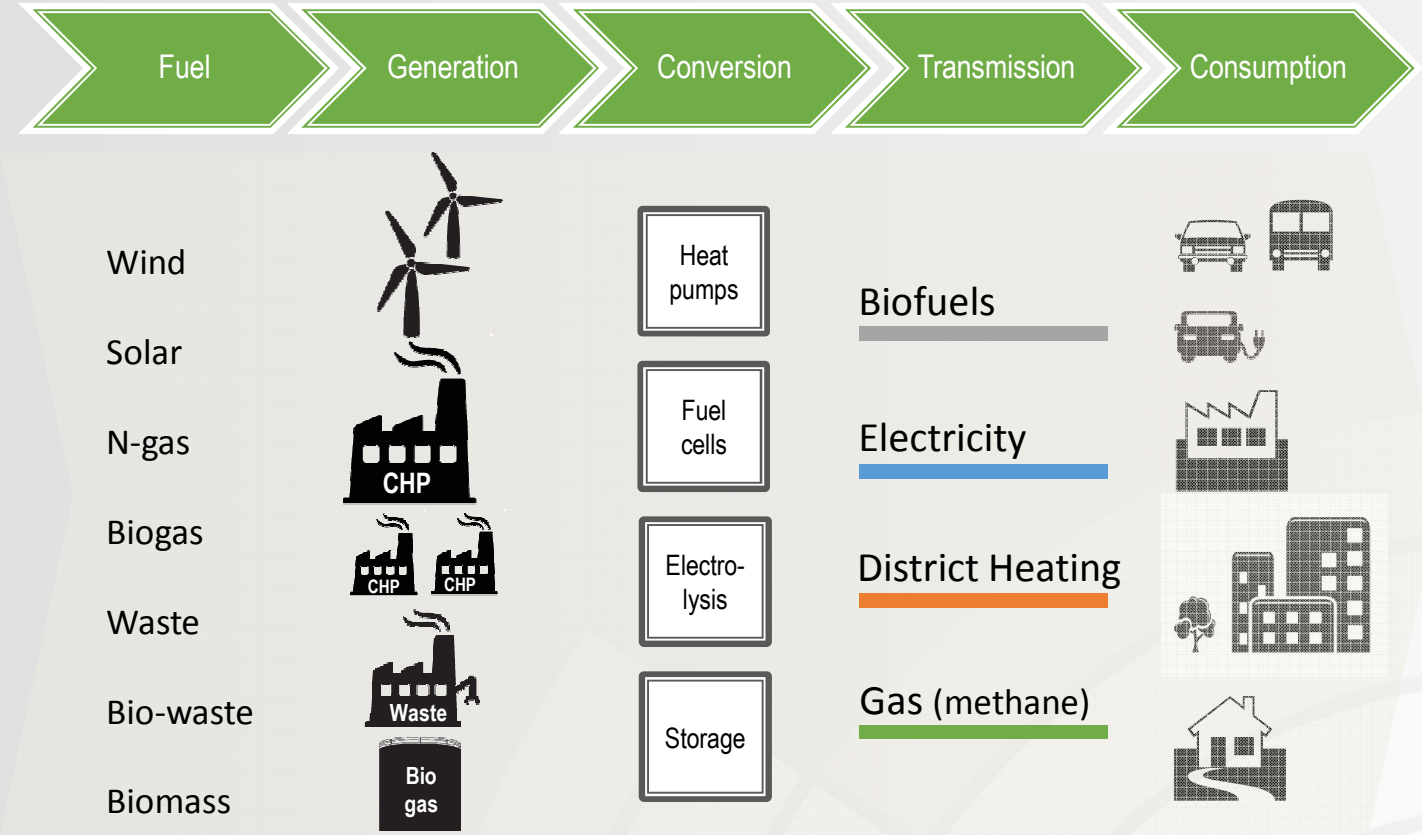
Solar DH in is in growth



Moving towards low temperature DH and 100% RE



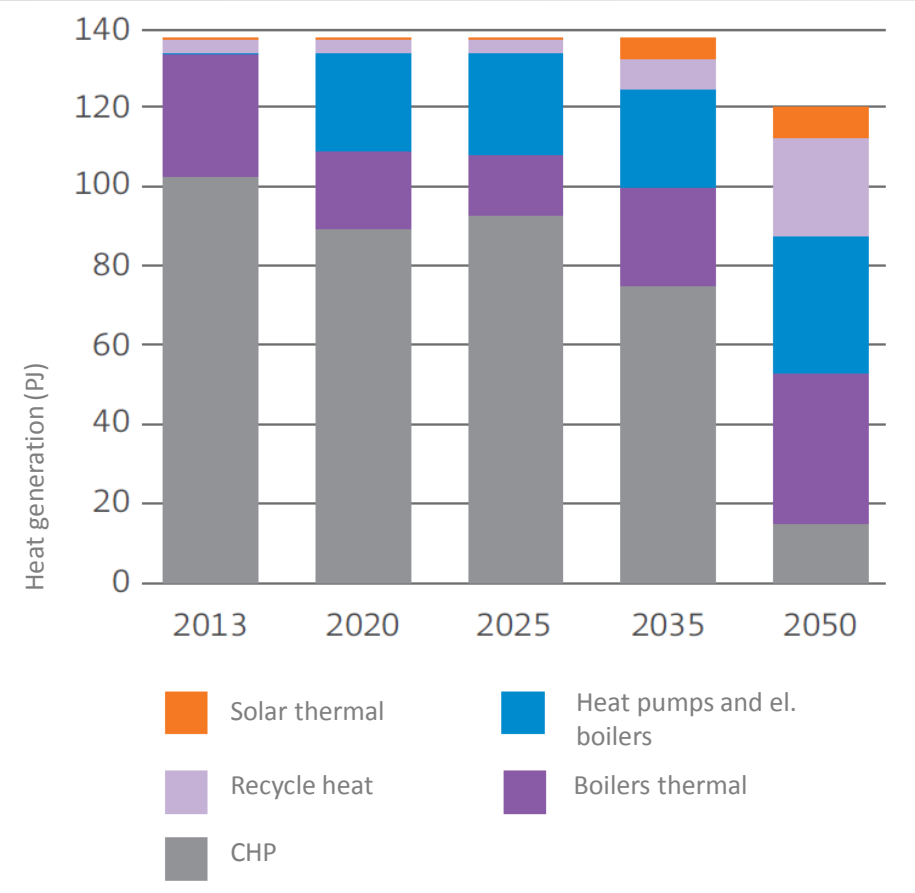
The energy system of tomorrow



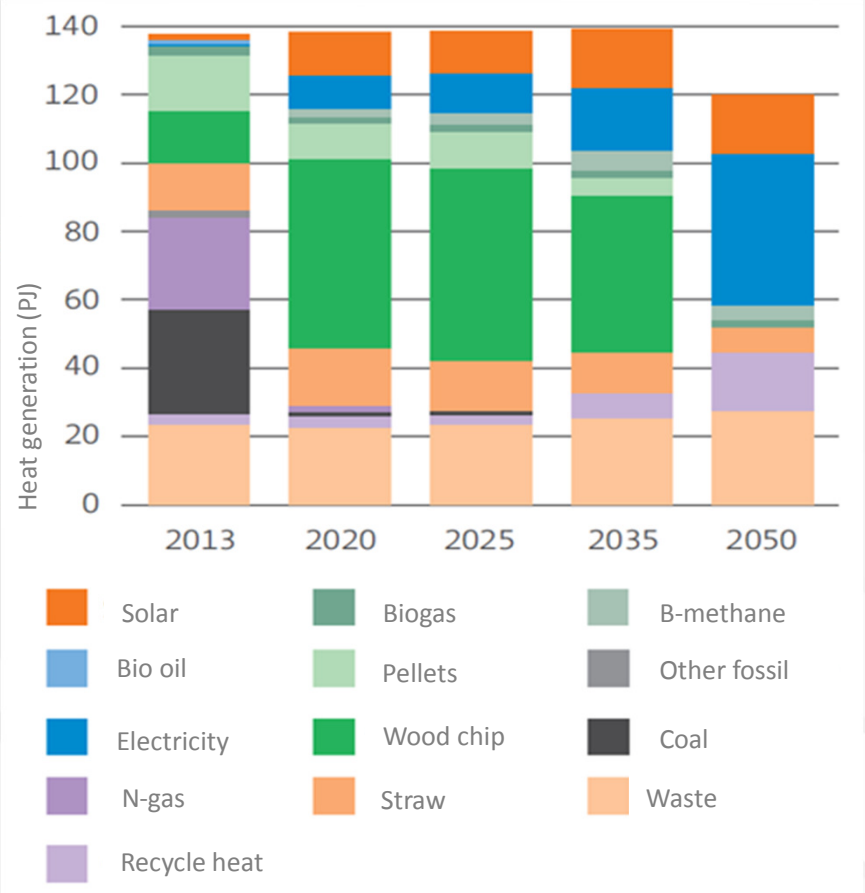
Fuel diversification and coherent energy systems calls for Smart Energy

Key role for district heating in the future

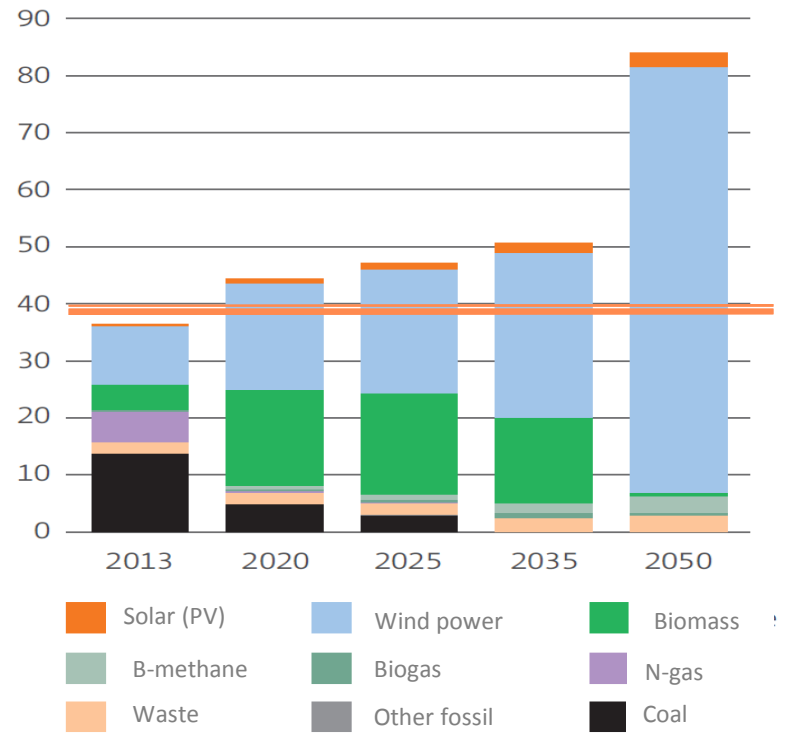
- Type of Generation

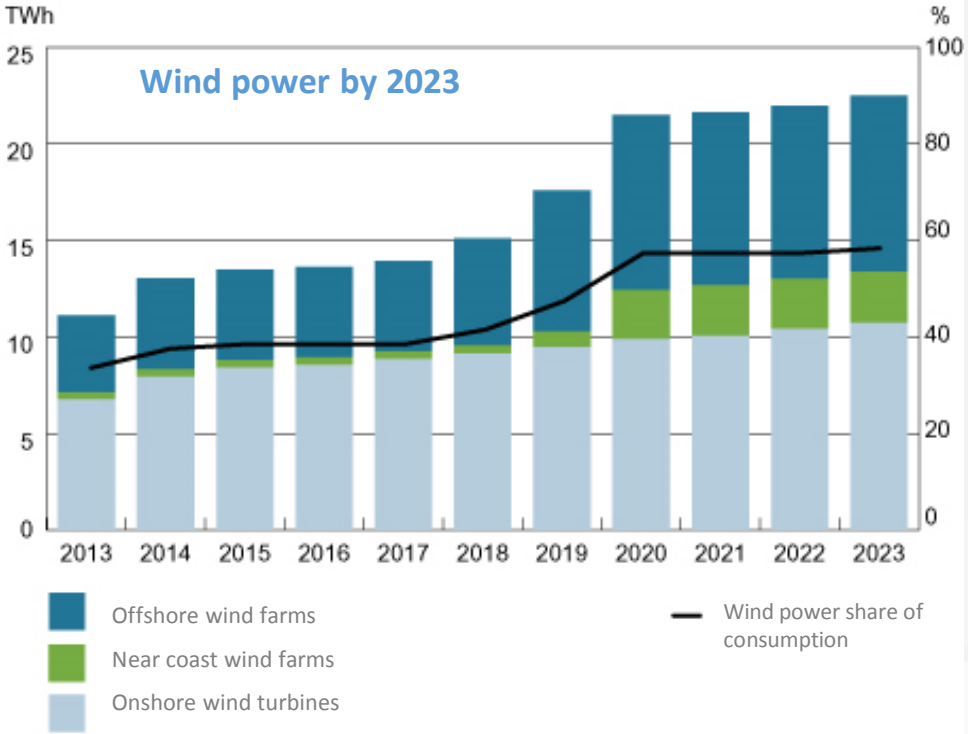


- Origin of Fuel



Massive growth in electricity generation





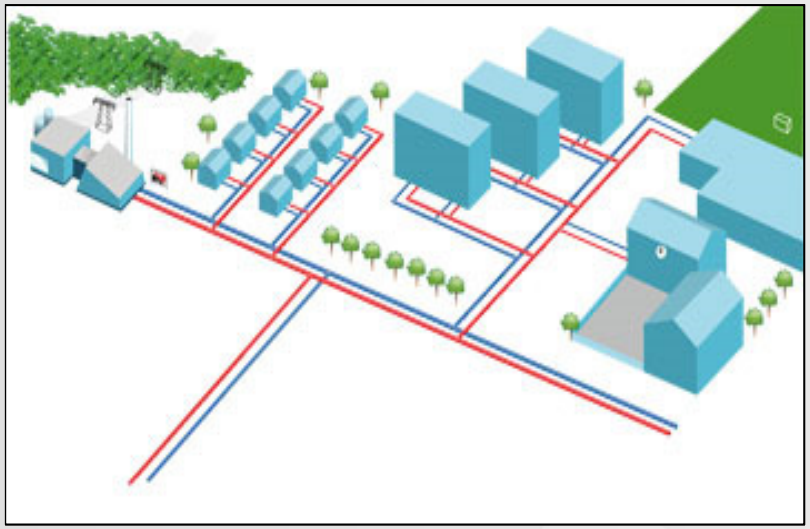
Wind power - more than enough to cover the Danish consumption

Calls for electrification and new consumption – option for wind to heat

DISTRICT HEATING IN DENMARK – A BIG SUCCESS LIKE WIND POWER

2015

64 % of households receives district heating



2020

~ 70 % of households receives district heating

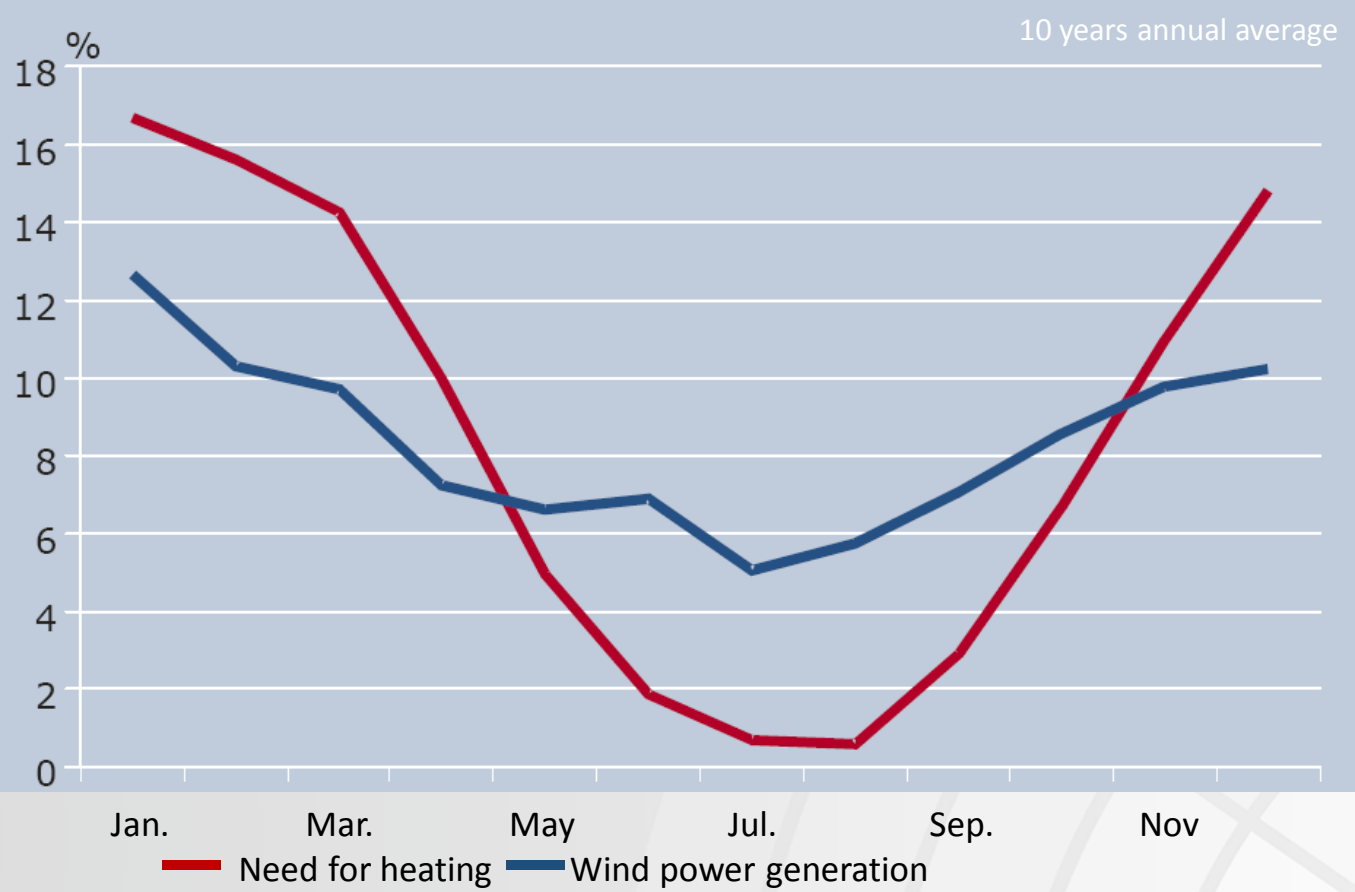
2015

40 % of electricity consumption from wind power

2020

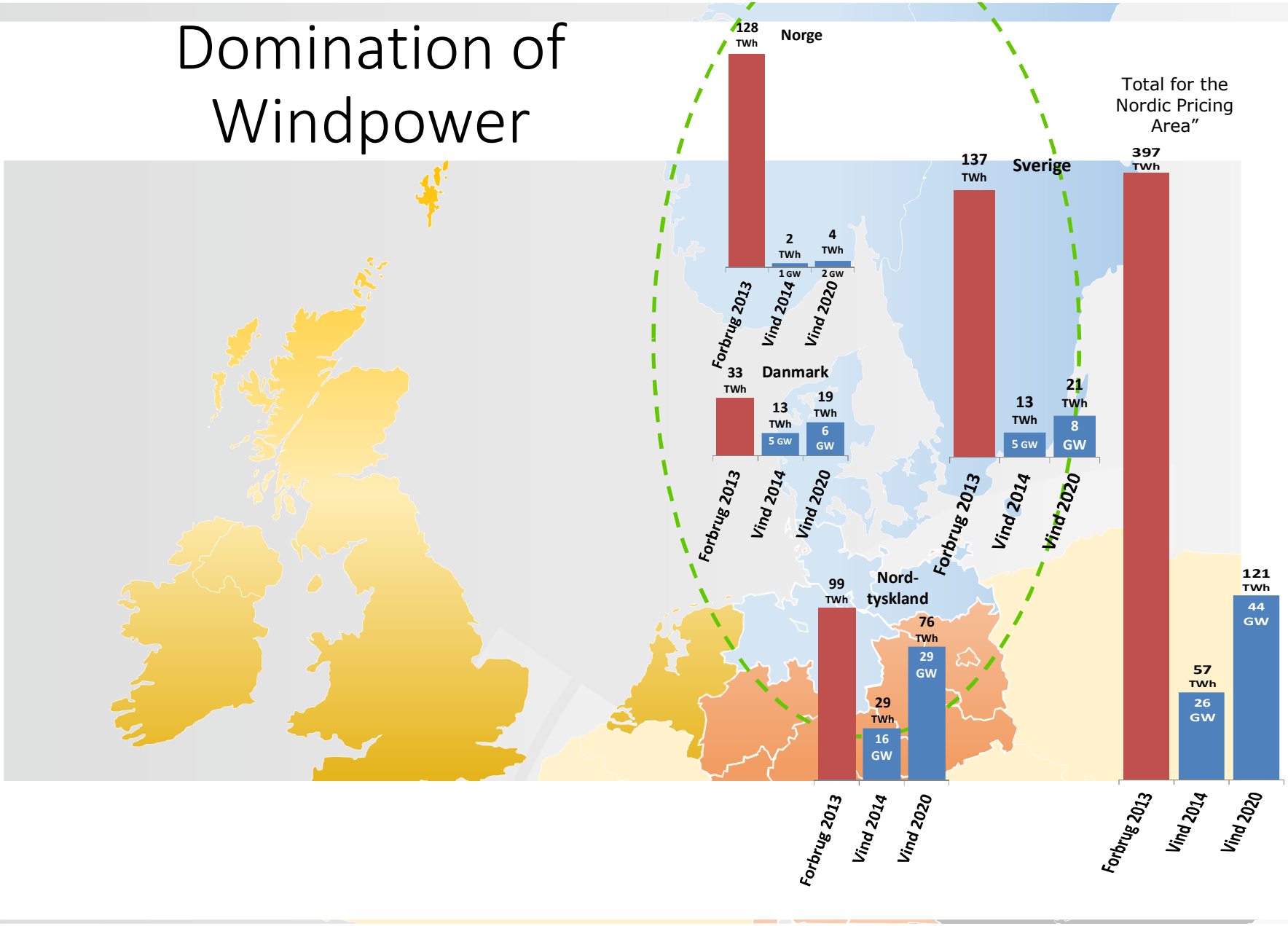
~ 50 % of electricity consumption from wind power

District heating from wind power – excellent match



- Annual wind power generation and need for heating is a obvious match
- Heating generated from electric heat pumps and electric boilers

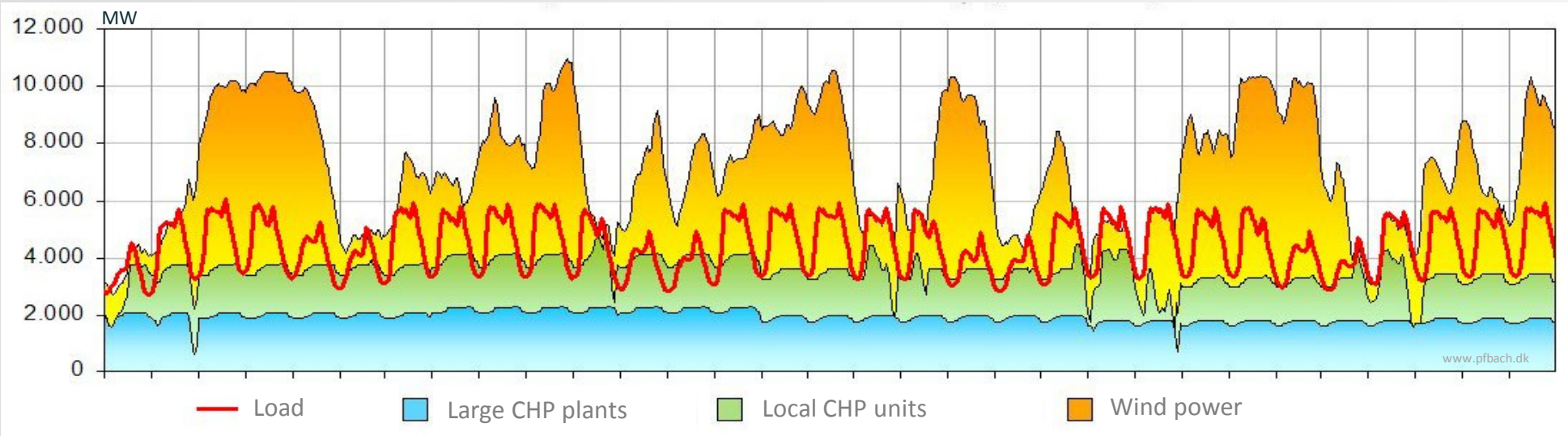
Domination of Windpower



2020 power generation with 50% wind power

Denmark January 2020 forecast - with 50% wind power (p.a.) and CHP

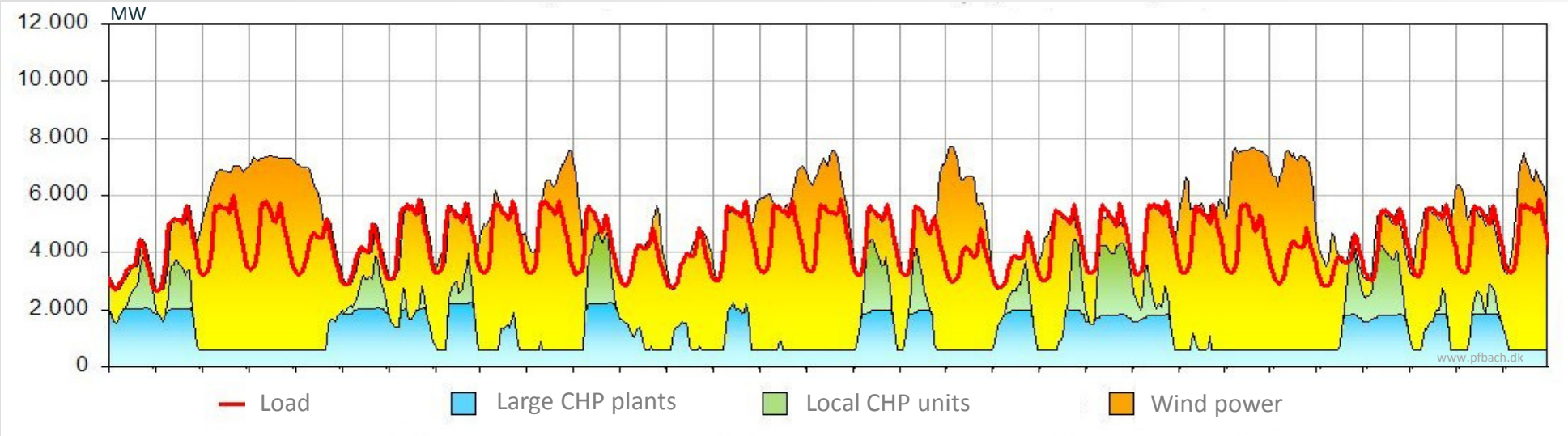
- Power generation will exceed load with 62%
- Power overload (not domestic usage) with 40% of the wind energy
- Need for export of 7,000 MW in dedicated hours



- Export calls for acceptance from neighboring power systems
  - Electricity is often exported at a very low market price due to overload

2020 power generation with thermal boilers

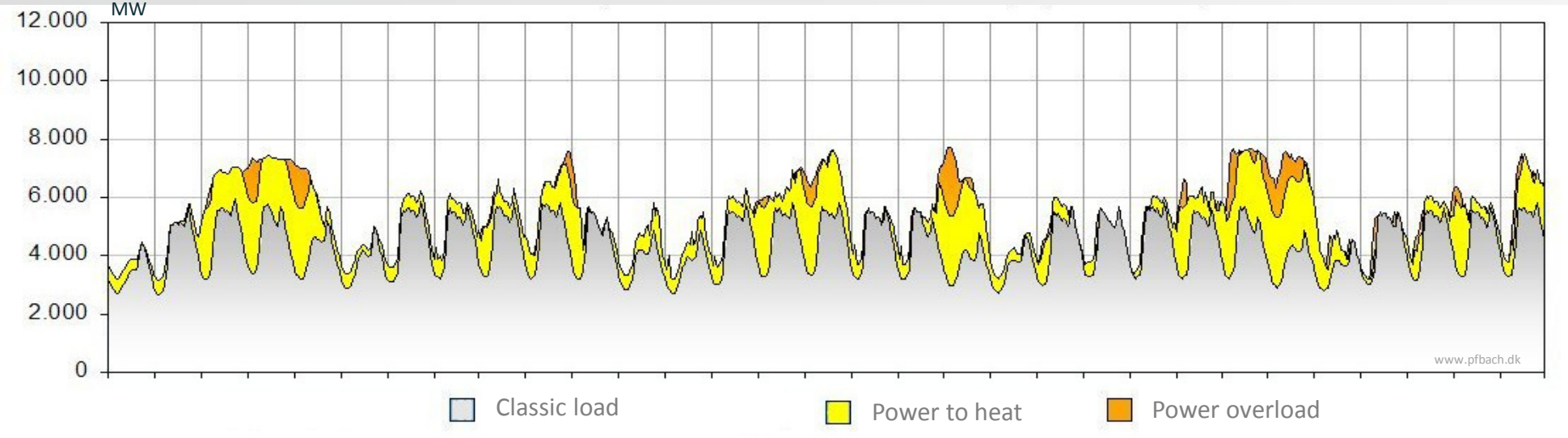
- Denmark January 2020 forecast - with 50% wind power (p.a.) little CHP
  - Thermal boilers will cover 24% of the heat demand – CHP phase out
  - Power overload (not domestic usage) reduction from 40% to 17% of the wind energy
  - Need for export of 2,600 MW in dedicated hours



- Investments in new heat only based on biomass will phase out CHP
  - Many CHP units will be stranded investments!

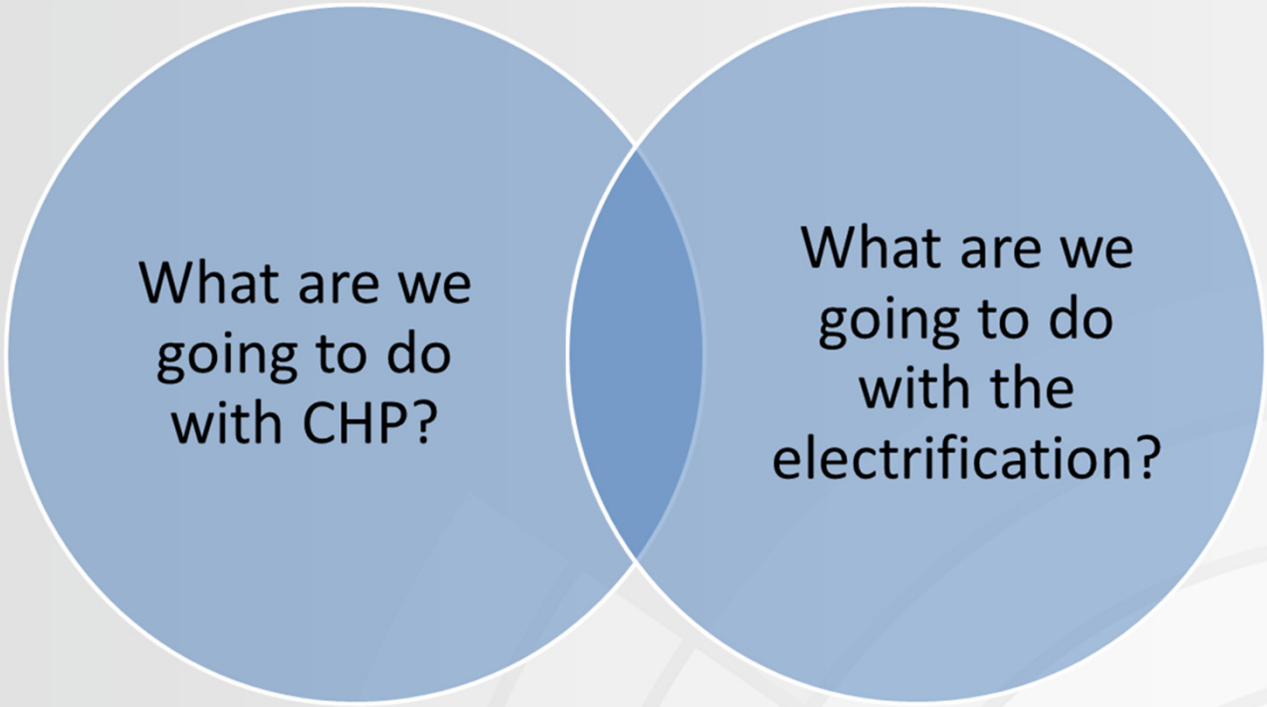
2020 power generation with power to heat

- Denmark January 2020 forecast - with 50% wind power (p.a.) no CHP
  - Thermal boilers will cover 5% of the heat demand – CHP phased out
  - Integration of 900 MW electric heat pumps and 1,500 MW electric boilers
  - Power overload (not domestic usage) reduction from 40% to 4% of the wind energy
  - Minor export of maximum 2,100 MW in few hours



- CHP units will be used for backup in the power system
  - Calls for new funding scheme, new types of tariffs and lower taxation

Two major challenges



Reduction in Power Plant Capacity towards 2020

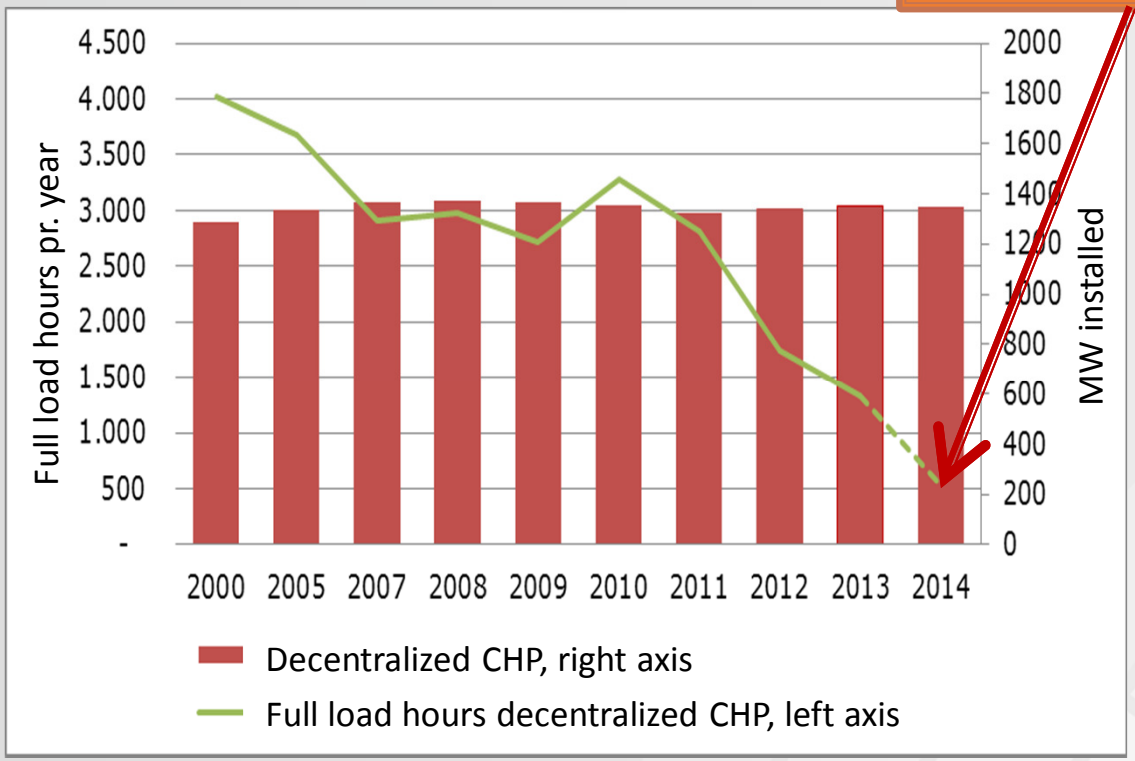
Capacity (MW)	2013	2020
Large plants CHP - Not in operation	4,600 (2,400)	4,100
Small plants (CHP) - Not in operation	1,800 (100)	1,100
Industrial CHP	600	600
Thermal capacity in operation	7,000	5,800
Interconnectors - Import/export	5,100	7,900
Offshore wind farms	1,300	2,700
Onshore wind turbines	3,300	3,000
Total capacity	19,200	19,400

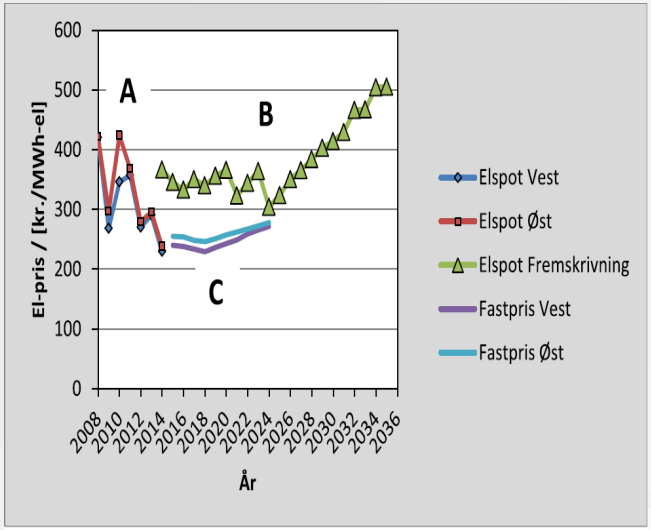
Reduction in thermal power plant capacity and growth in wind power capacity together with extra interconnectors capacity to Norway, Sweden, Germany and Netherland is a substantial change of the power system.
Some of the power plants will be converted from CHP to biomass boilers

Status

- More windpower – less CHP
- Low electricity prices

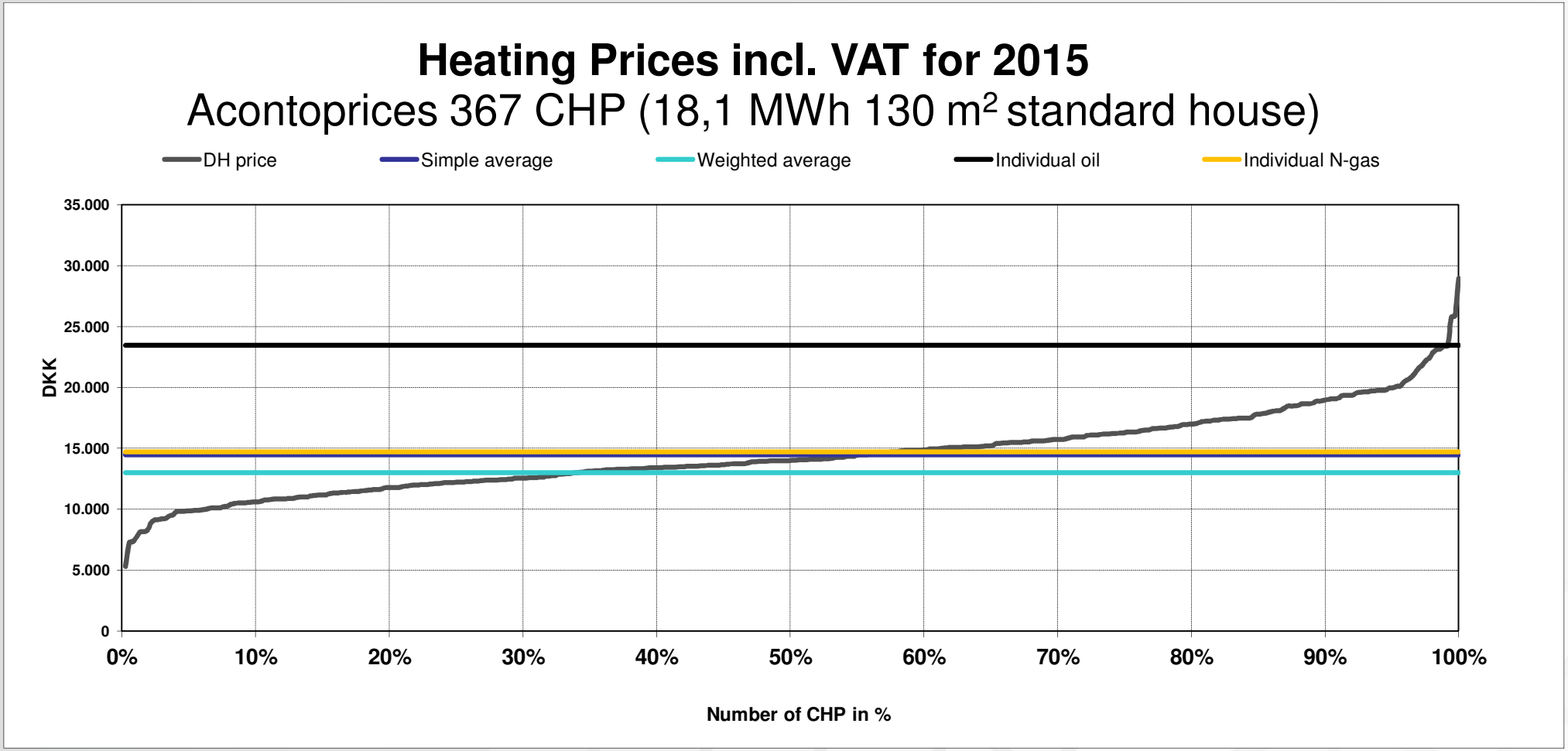
600 full load hours in 2014!



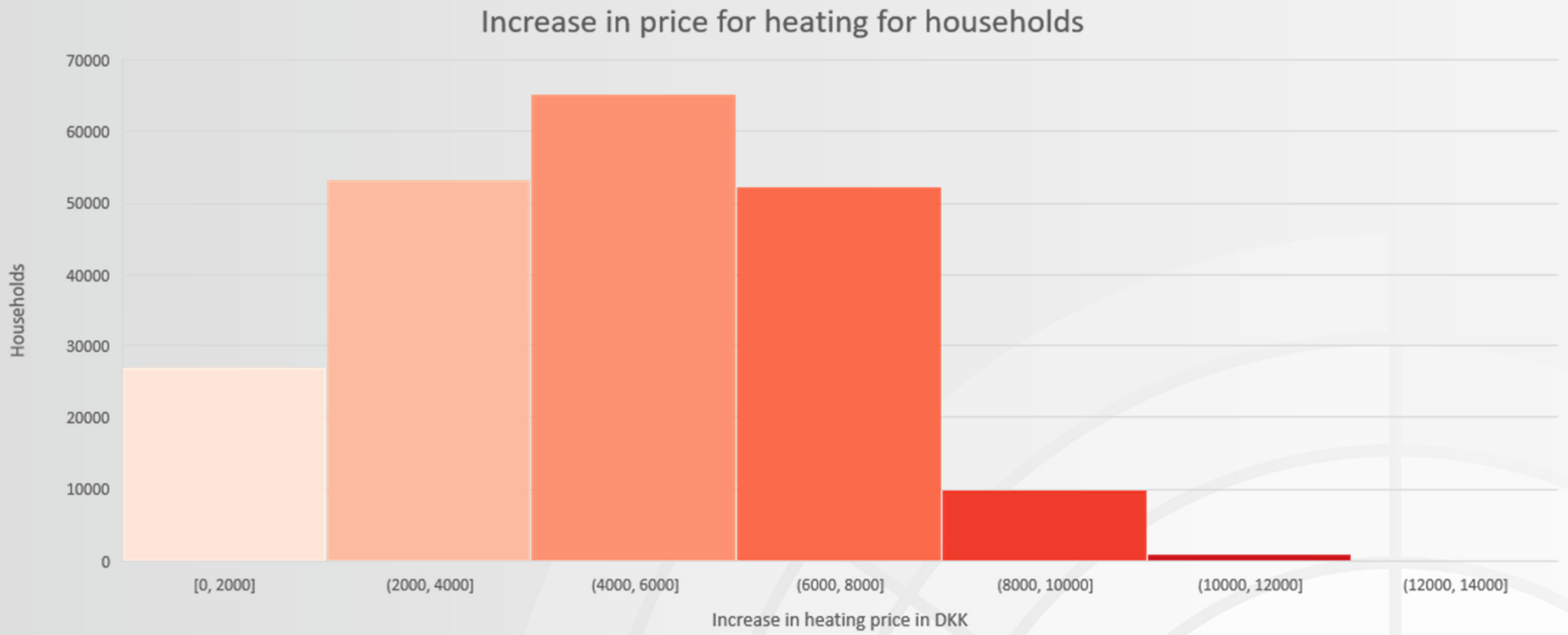


Figur 5.1 *– Elspot-prisens udvikling i Vest- og Østdanmark 2008-2014 (frem til 26-09-2014) samt Energistyrelsens fremskrivning af el-prisen pr. oktober 2012. Energi Danmark's fastpriskurser er oplyst pr. 06-10-2014 og det understreges, at prisen varierer fra dag til dag.*

Competition



Increase in heating prices from 2019: 2 billion



District heating can provide the solutions

Accumulation

1 mio. m3

CHP
”5000 MW +
”2000 MW”

Elec. boilers
400 MW

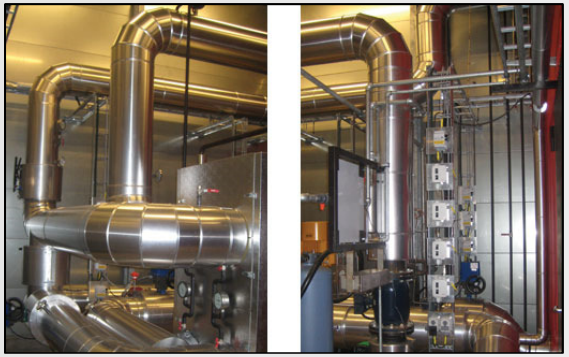
Heat Pumps
20 MW

STORAGE CAPACITY IN DANISH DISTRICT HEATING - 65 GWH

Wind power

Installed capacity: 4.800 MW

Electric boilers/heat pumps



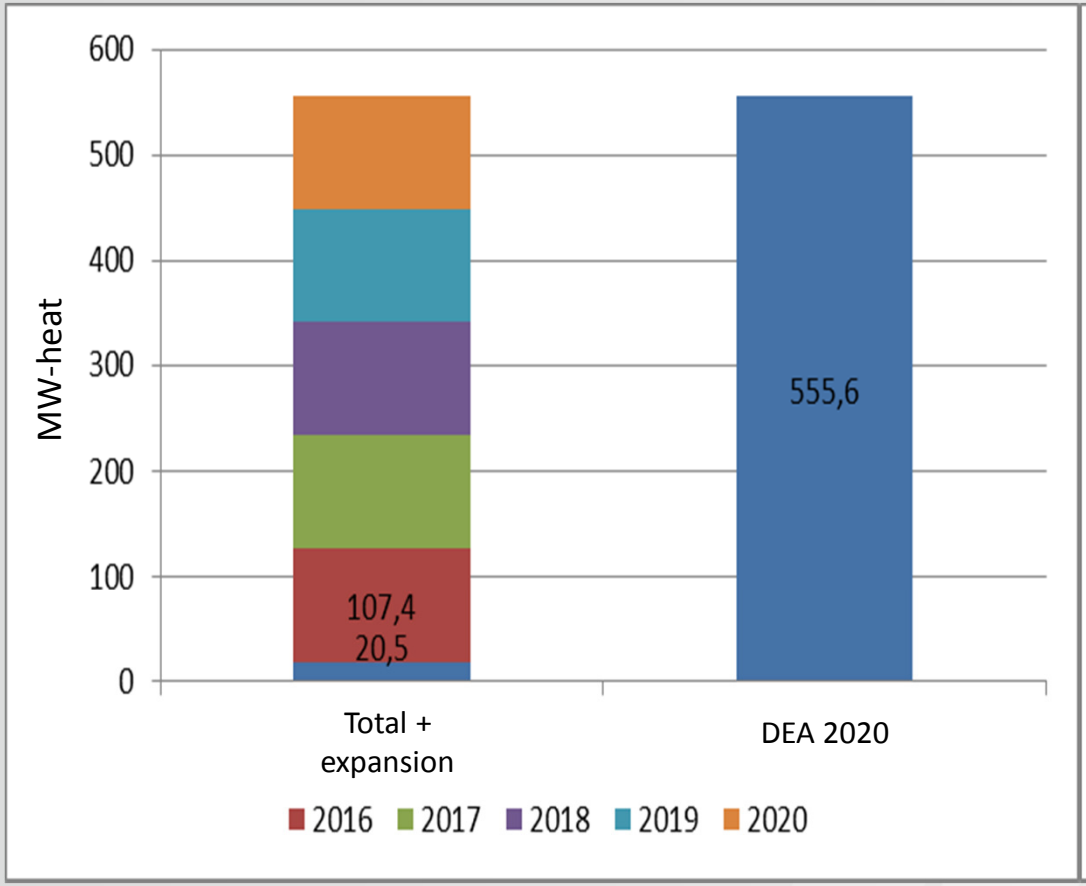
Thermal storages

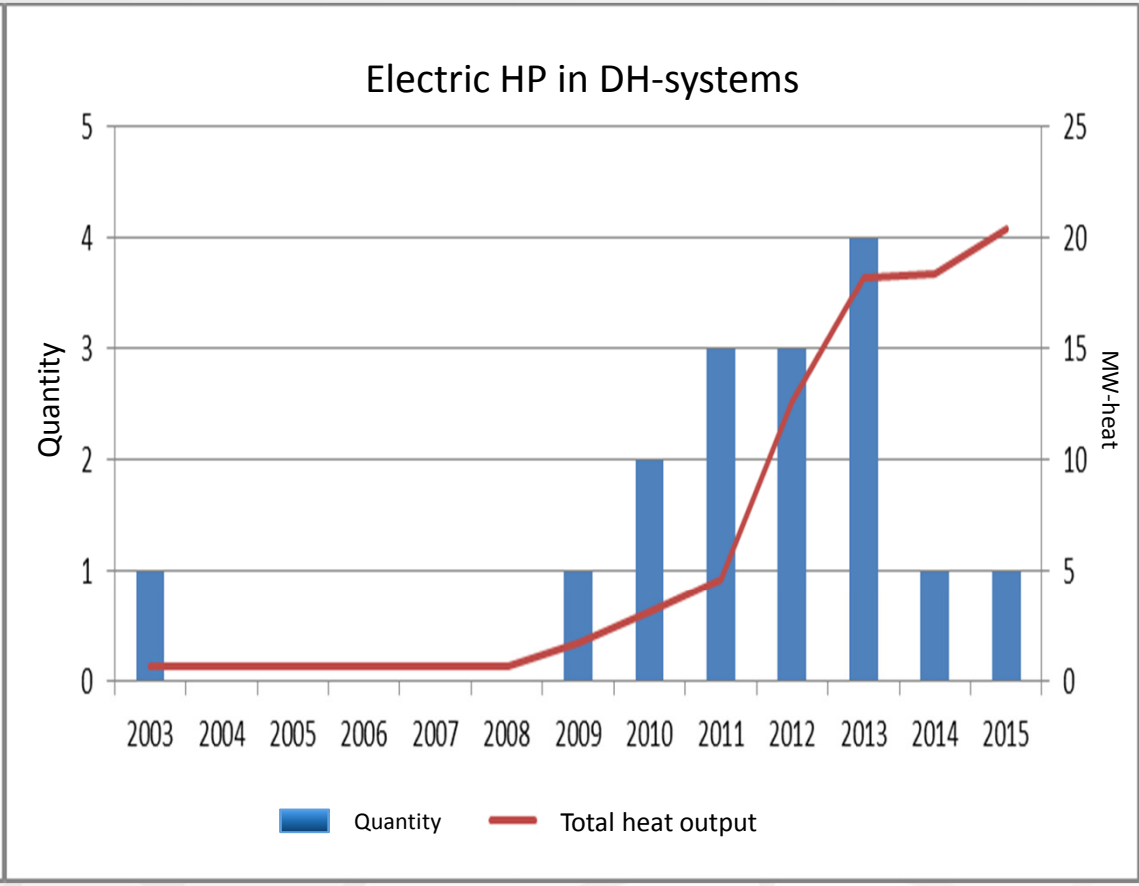
Total storage capacity: 65 GWh

~ 13 hours of full load operation to fill storage

~ storage capacity of 1.000.000 electric vehicles

Only few large scale elec. Heat Pumps in DH today!





Key points to be addressed

District Heating in the core of Smart Energy

- Denmark has shown that it is possible to balance a power system with more than 50% wind power.
- Electricity generation from wind turbines is not fully integrated in the energy systems.
- Storing and balancing wind power using the district heating systems is a profound solution.
- Denmark refrain from harvesting the full environmental benefit of wind power when exported.
- Export of wind power is a socioeconomic loss.

What to do?

- Taxes and regulation must be updated to enhance power to heat solutions with heat pumps in 100 MW_e class.
- CHP plants need a new business case as back up for wind power and technical balancing of the power system (ancillary services).

Thank you for your attention

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