DISTRICT HEATING in
The Danish Energy System

Kasper Jessen, Project Analyst
Green Energy
Green Energy is an analysis department at Danish District Heating Association

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 legions 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.
- 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
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 $m^2$
- Scheduled ($m^2$)
- Largest >150,000 $m^2$
- Total > 500,000 $m^2$
Solar DH in Denmark

Solar Thermal Area and Plants in operation and scheduled

Year

Installed area [m²]

Plants

0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400


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
40% of electricity consumption from wind power

2020
~ 70% of households receives district heating
~ 50% of electricity consumption from wind power
District heating from wind power – excellent match

- Annual wind power generation and need for heating is an obvious match
- Heating generated from electric heat pumps and electric boilers
Domination of Windpower

- **Norge**: 128 TWh, 13 TWh, 4 TWh, 5 GW
- **Sverige**: 397 TWh, 137 TWh, 21 TWh, 8 GW
- **Nordtyskland**: 99 TWh, 57 TWh, 26 TWh, 26 GW
- **Danmark**: 33 TWh, 13 TWh, 19 TWh, 6 GW

Total for the Nordic Pricing Area: 99 TWh, 29 TWh, 76 TWh, 29 GW

prisområde
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

What are we going to do with CHP?

What are we going to do with the electrification?
Reduction in Power Plant Capacity towards 2020

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

Reduction in thermal power plant capacity and growth in wind power capacity together with extra interconnectors capacity to Norway, Sweden, Germany and Netherlands 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!
Competition

Heating Prices incl. VAT for 2015
Acontoprices 367 CHP (18,1 MWh 130 m² standard house)
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
  - ~ 13 hours of full load operation to fill storage

- Electric boilers/heat pumps

- Thermal storages
  - Total storage capacity: 65 GWh
  - ~ storage capacity of 1.000.000 electric vehicles
Only few large scale elec. Heat Pumps in DH today!

- Total + expansion: 107.4 MW-heat
- DEA 2020: 555.6 MW-heat

Electric HP in DH-systems:
- Quantity chart showing growth from 2003 to 2015
- Total heat output chart
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

Danish District Heating Association
Fjernvarmens Hus
Merkurvej 7
6000 Kolding
Phone +45 76 30 80 00

mail@danskfjernvarme.dk