Power to Heat

Competition or Interaction between Electricity and District Heating?

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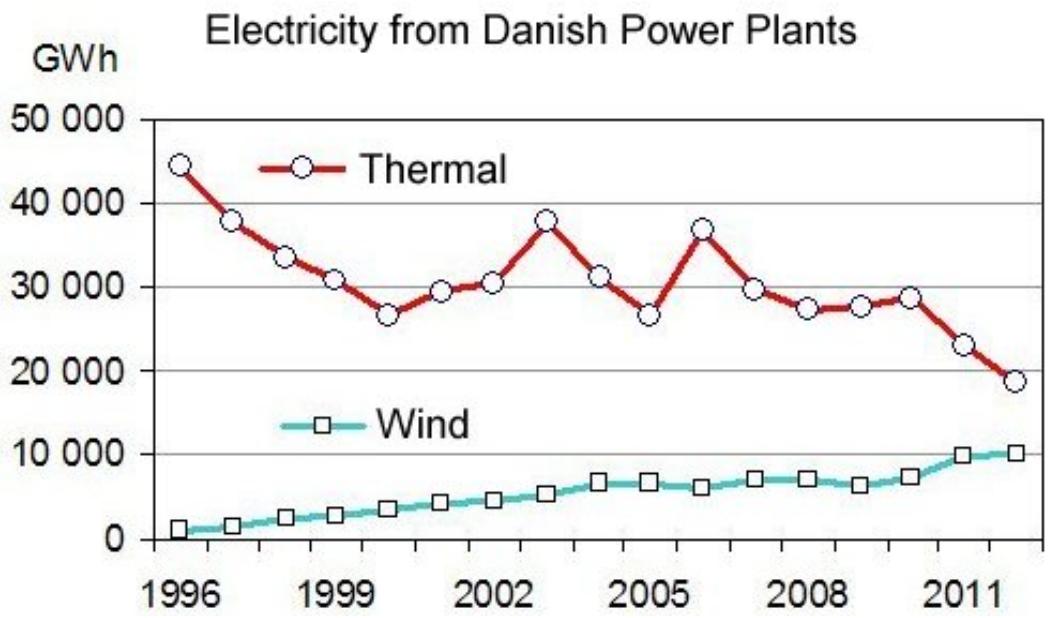
CHP[1] and Wind – Elements of Danish Energy Policy

- Thermal efficiency of CHP: about 90%
  - The CHP process serves 50% of all space heating in Denmark and 65% of the thermal electricity production
- Wind energy production was 28% of the electricity consumption in 2012
  - The national target for 2020 is 50% wind energy
- **CHP and wind are competing for a limited electricity demand**

The thermal power plants are losing market shares and money

Thermal power plants are being closed or mothballed

How are the prospects for 2020?



[1] CHP: Combined Heat and Power

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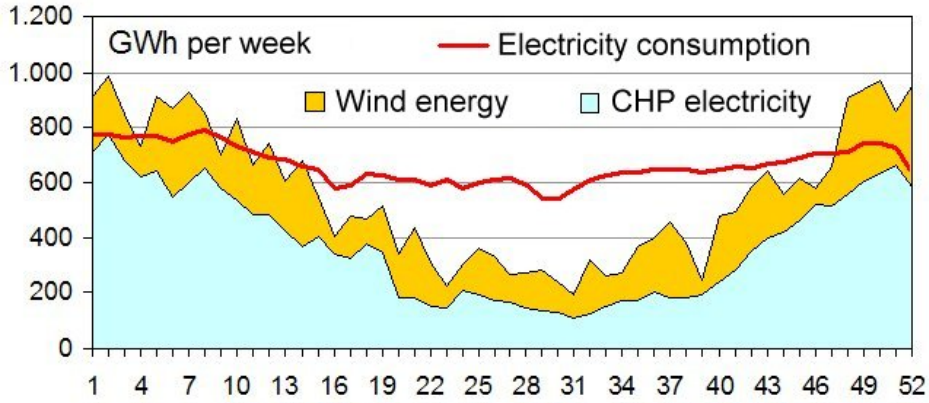
Electricity Surplus during Cold Seasons

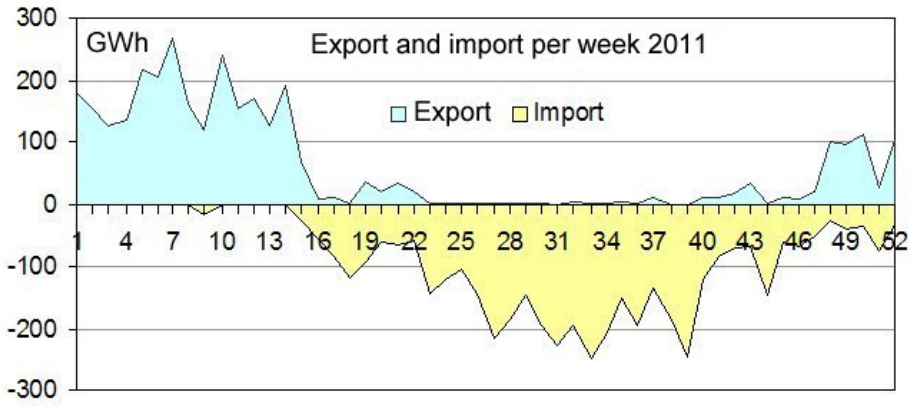
CHP covers a major part of the electricity consumption during the winter

Wind power causes electricity surplus in winter and less need for alternative supply during summer

So Denmark has a need of having electricity moved between winter and summer

For the time being an essential part is set off by export and import





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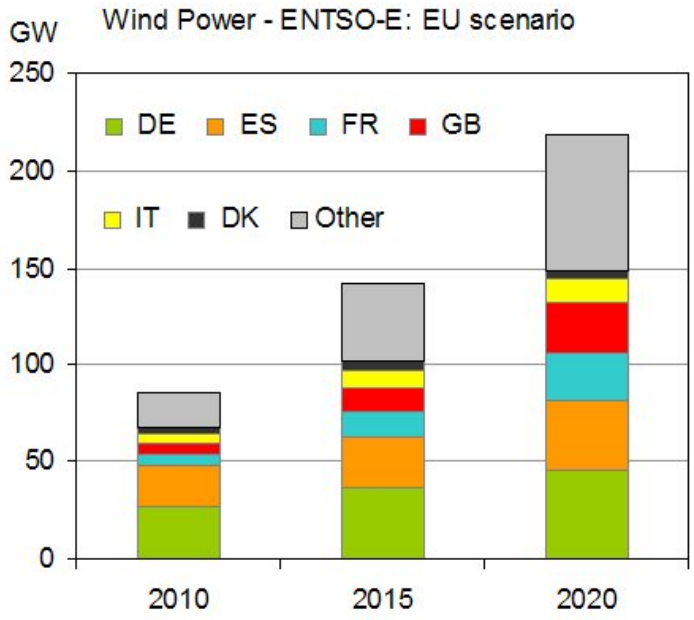
Future Balancing Services in Short Supply



- ENTSO-E expects 125 GW additional wind power capacity in Europe
- The plans for the necessary balancing capacity are vague in most countries
- The Danish strategy is based on both international and domestic initiatives

- Statnett prepares for another great Norwegian export business
  - The Norwegian investment is expected to be 12-20 billion NOK
  - The capacity of the new interconnectors (up to 7 GW) will be modest compared with the 125 GW
- Balancing services will be a seller's market

FIGUR 10.2: Potensielle nye utenlandsforbindelser.
Fra Statnetts Nettutviklingsplan 2010

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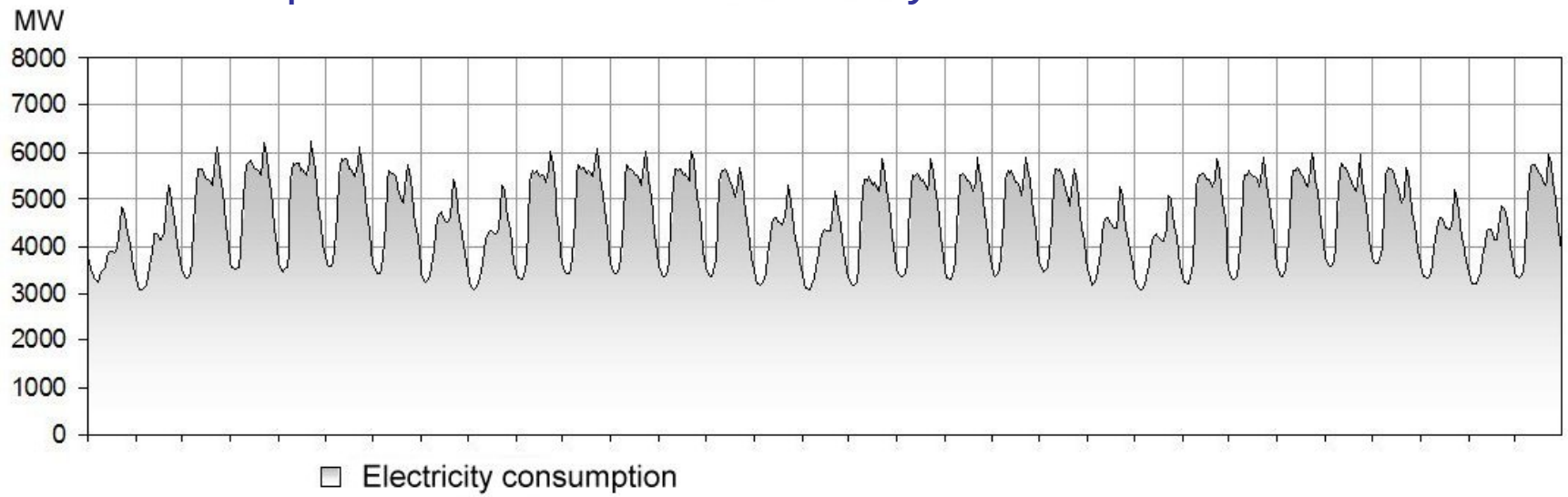
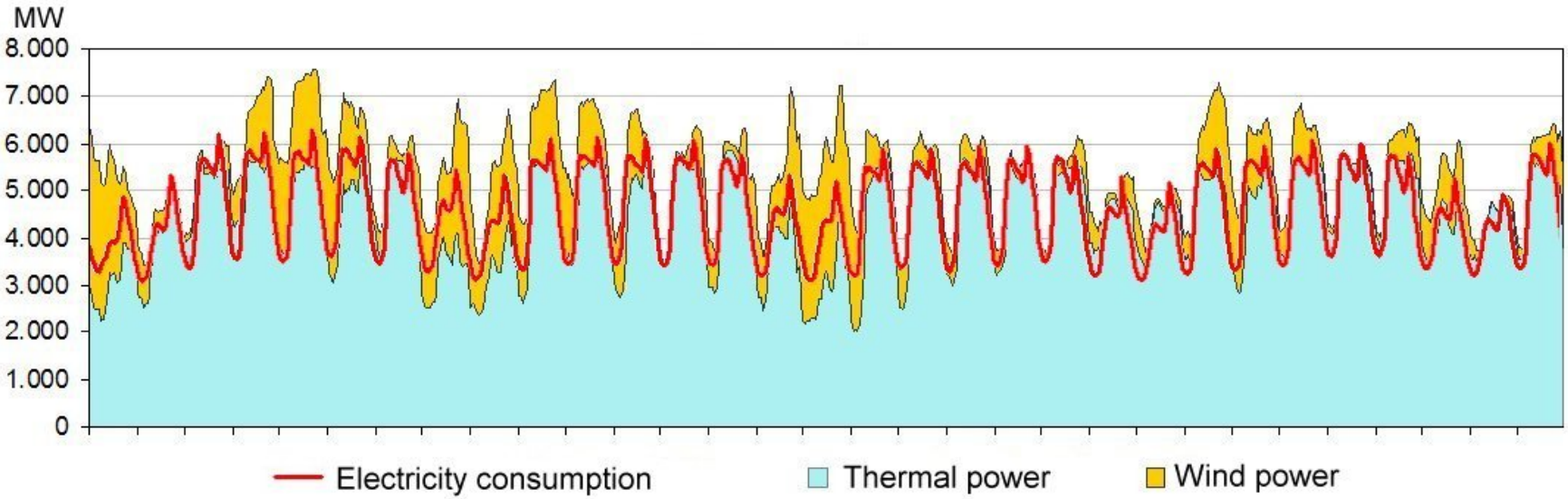
Hourly variations

Consumption and Production: January 2011





Production surplus is typical for January

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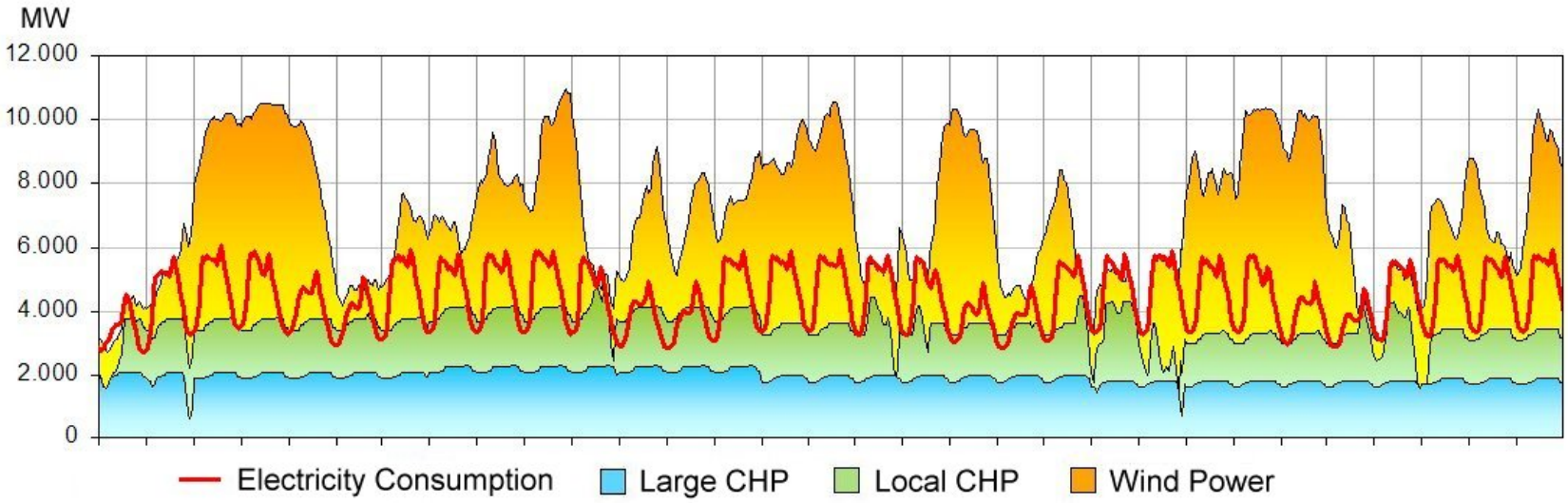
Wind Power scaled up to 50% of Annual Electricity Consumption

Electricity from the CHP process and from wind

- again with January as an example



- This picture does not look realistic
  - The production in January exceeds consumption by 62%
  - The electricity overflow is 6,8 TWh for a year - or 40% of the wind energy
  - Up to 7,000 MW export capacity will be needed
  - Germany and Denmark will have overflow simultaneously

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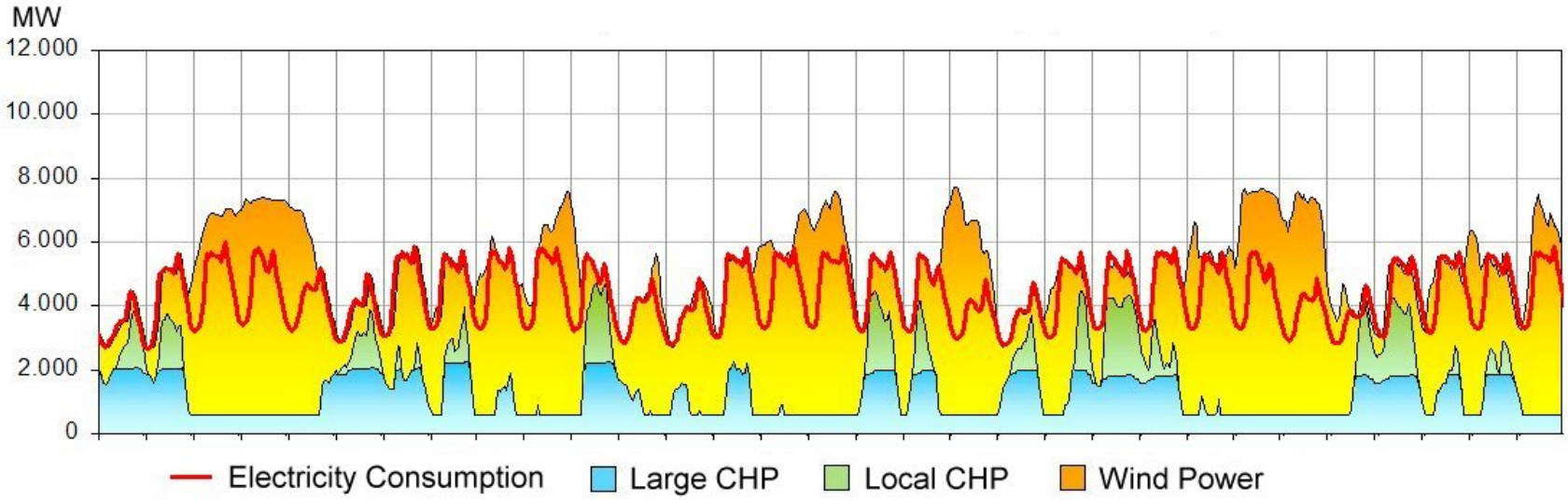
Low Market Prices force CHP Production down

In this case 55% of heat demand in January is covered by backup boilers

A certain minimum thermal production is maintained for security reasons



- For a full year:
  - Backup boilers have taken over 24% of the heat production
  - Electricity overflow reduced from 40% of the wind energy to 17%
  - The need for export capacity reduced by 2,600 MW
- This picture is more realistic – but bad news for the CHP business

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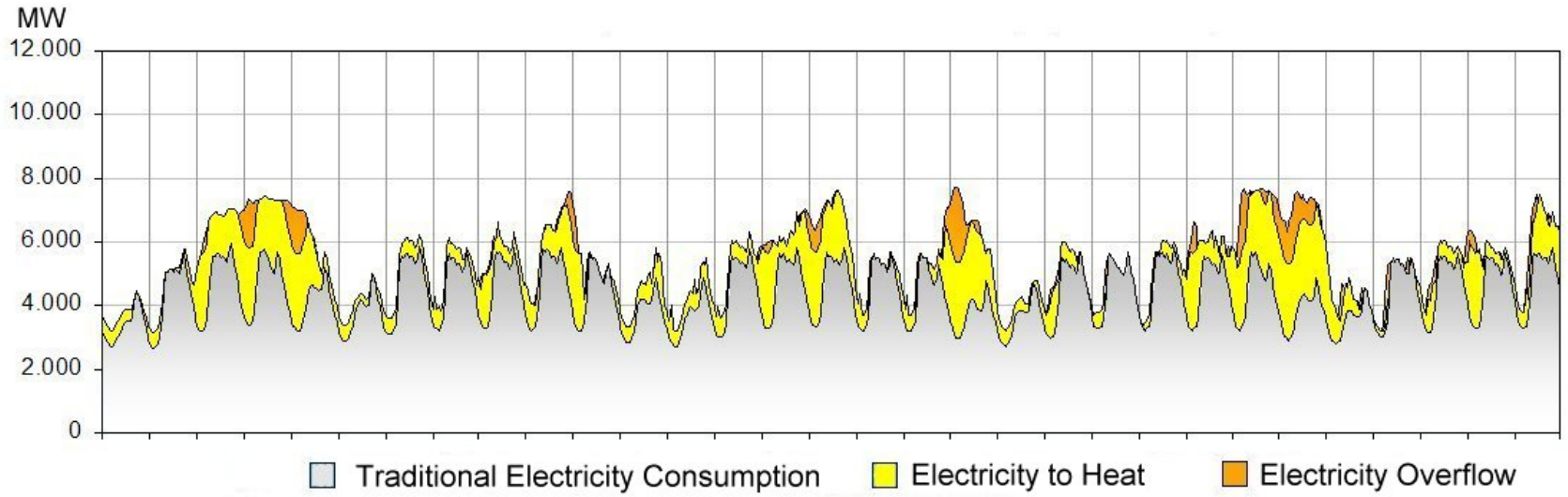
Electricity converted to Heat

Add 900 MW large heat pumps and 1,500 MW electric boilers

- introducing additional controllable electricity consumption



- For the full year:
  - The backup boilers' share of the heat supply reduced from 24% to 5%
  - Electricity overflow reduced from 17% to 4% of the wind energy
    - Thus CHP has absorbed 90% of the electricity overflow from case 1

Coordination of electricity and heat is an efficient domestic measure for balancing variations from renewable energy

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Lessons Learned from the Cases

- Increasing surplus of electricity to be expected during the cold season
  - Stronger competition for sale of electricity
  - Decreasing electricity production from power plants
  - Further decrease of CHP production
- Thermal plants are mainly serving as wind power backup
  - Decreasing power plant utilization
  - Poor economy
  - Uncertainty about the future and reluctance in investment decisions
  - Probably further closure of large and local power plants
- The CHP systems can offer flexibility to the power system
  - Surplus of electricity can be used for heating
  - The CHP plants can increase the electricity production when needed and store the heat for later use
  - The range of facilities in the electricity market have made it possible
- Phasing out CHP means lost flexibility and lost efficiency

Flexibility, a new business opportunity for CHP systems?

- depending on the regulatory framework and the electricity market

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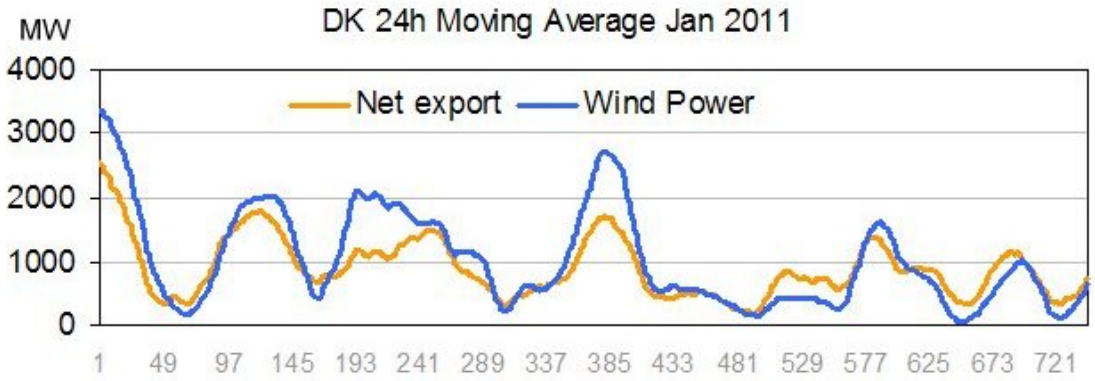
The Present Situation in Denmark

- During a long period the use of electricity for heating was unacceptable
  - Electric heating was prevented by high duties
- This policy was not sustainable
  - Negative spot prices indicated inefficient electricity markets
  - A considerable share of the wind energy was exported



- More flexibility by integrating electricity with heat and gas
  - Since 2008 a special legislation allowed large electric heaters
  - 325 MW large electric heaters installed so far
  - Another legislation is expected to pave the way for large heat pumps

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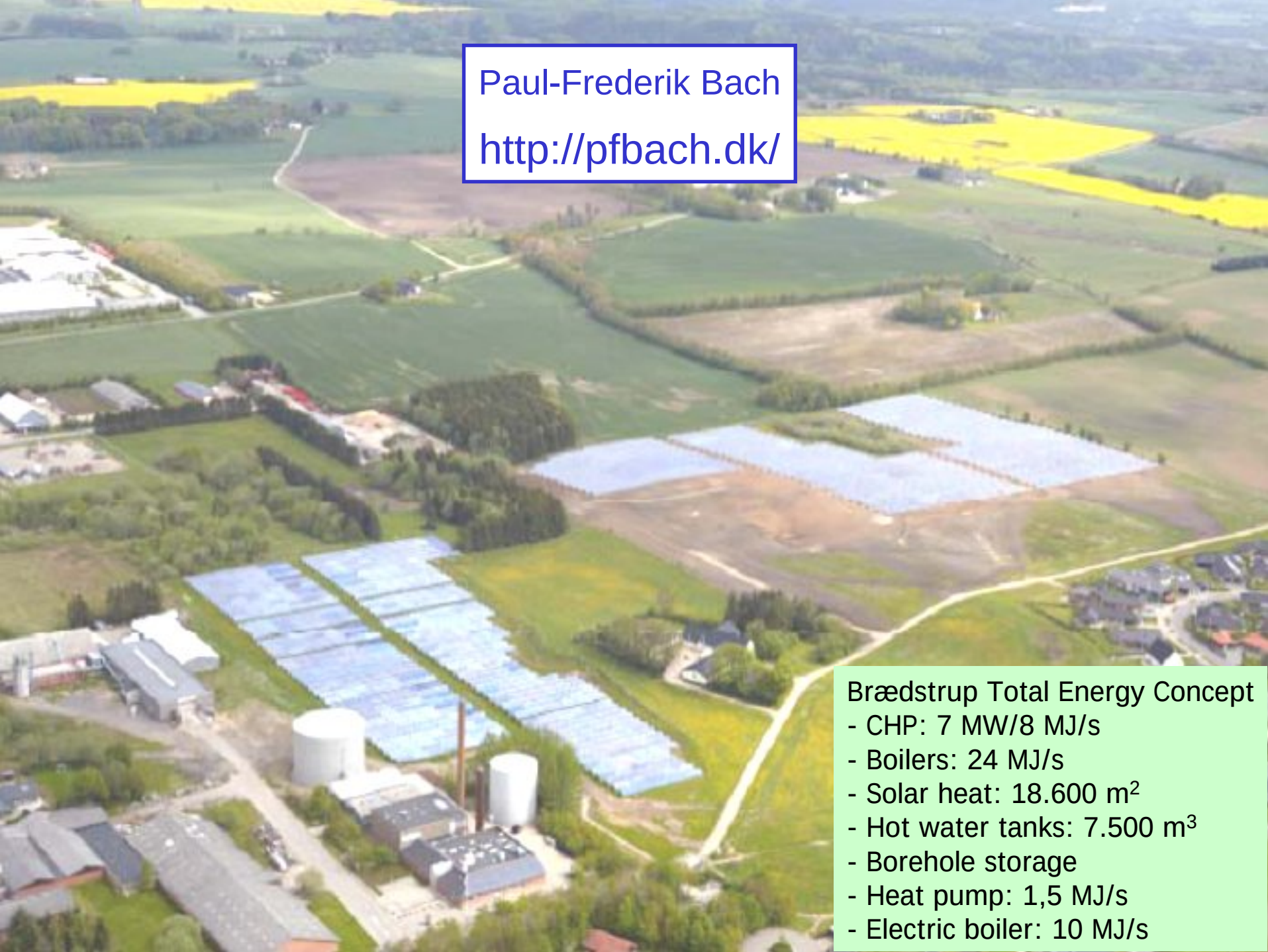
The Need for Further Research

- Analyse and understand results from existing total energy concepts
- Estimate technical potential for installation of large heat pumps
  - Large heat pumps seem to require complex concepts
- Develop operational control of complex energy systems
  - Communication systems (the Danish CHPCOM project)
- Development and maintenance of models for analysis and simulation
  - Should reflect all relevant concepts and their operational constraints
  - Should demonstrate operational conditions, flexibility, security of supply etc.
- Analyse economy of complex energy systems
  - Avoid investments in CHP systems with poor chances of survival
  - Estimate an optimal combination of large heat pumps, electric heaters and heat accumulators
  - Estimate the need for supporting mechanisms in order to maintain CHP production at a desired level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Brædstrup Total Energy Concept
- CHP: 7 MW/8 MJ/s
- Boilers: 24 MJ/s
- Solar heat: 18.600 m2
- Hot water tanks: 7.500 m3
- Borehole storage
- Heat pump: 1,5 MJ/s
- Electric boiler: 10 MJ/s