Paul-Frederik Bach

Towards 50% Wind Electricity in Denmark

Energy Group Meeting
Rome
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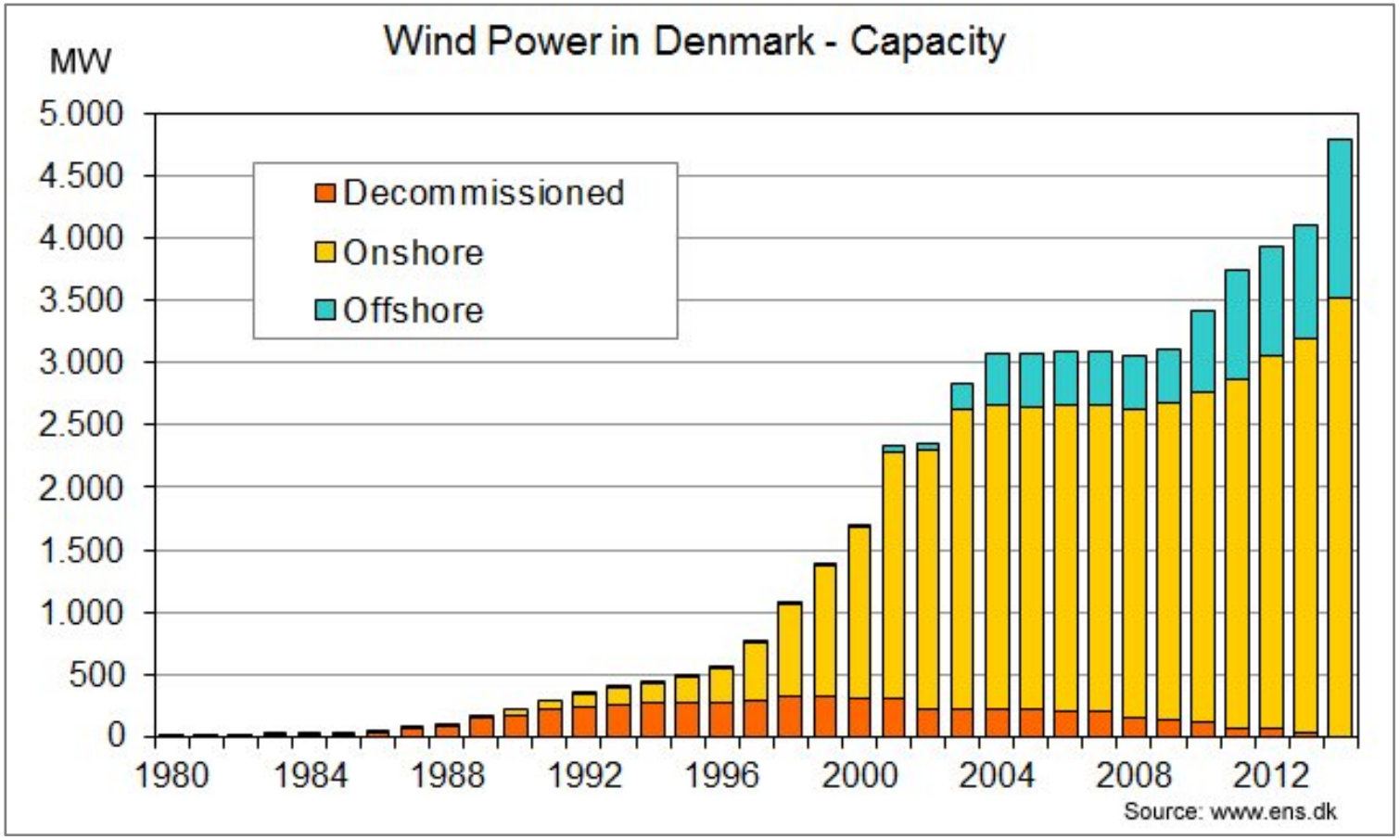
The Capacity Development



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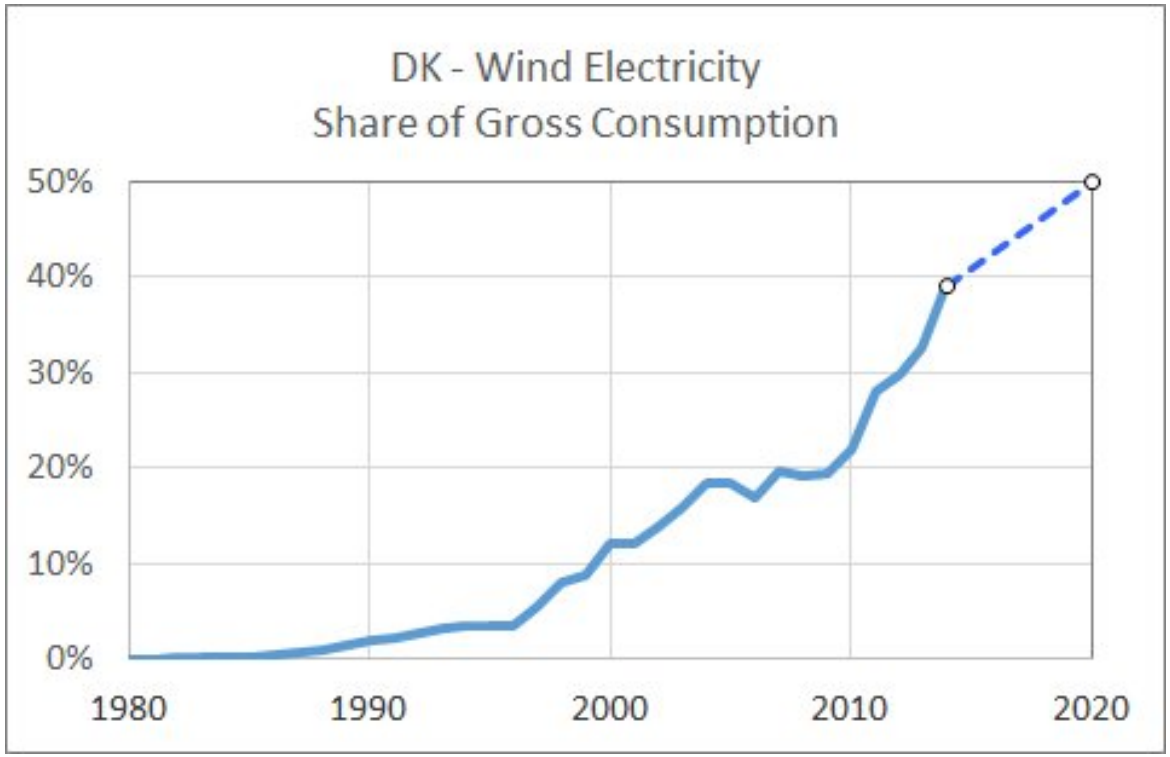
Nearly 40% Wind Electricity in 2014



- Decisive conditions for a successful integration so far:
  - The strong interconnections
  - The development of international electricity markets
  - The IT revolution

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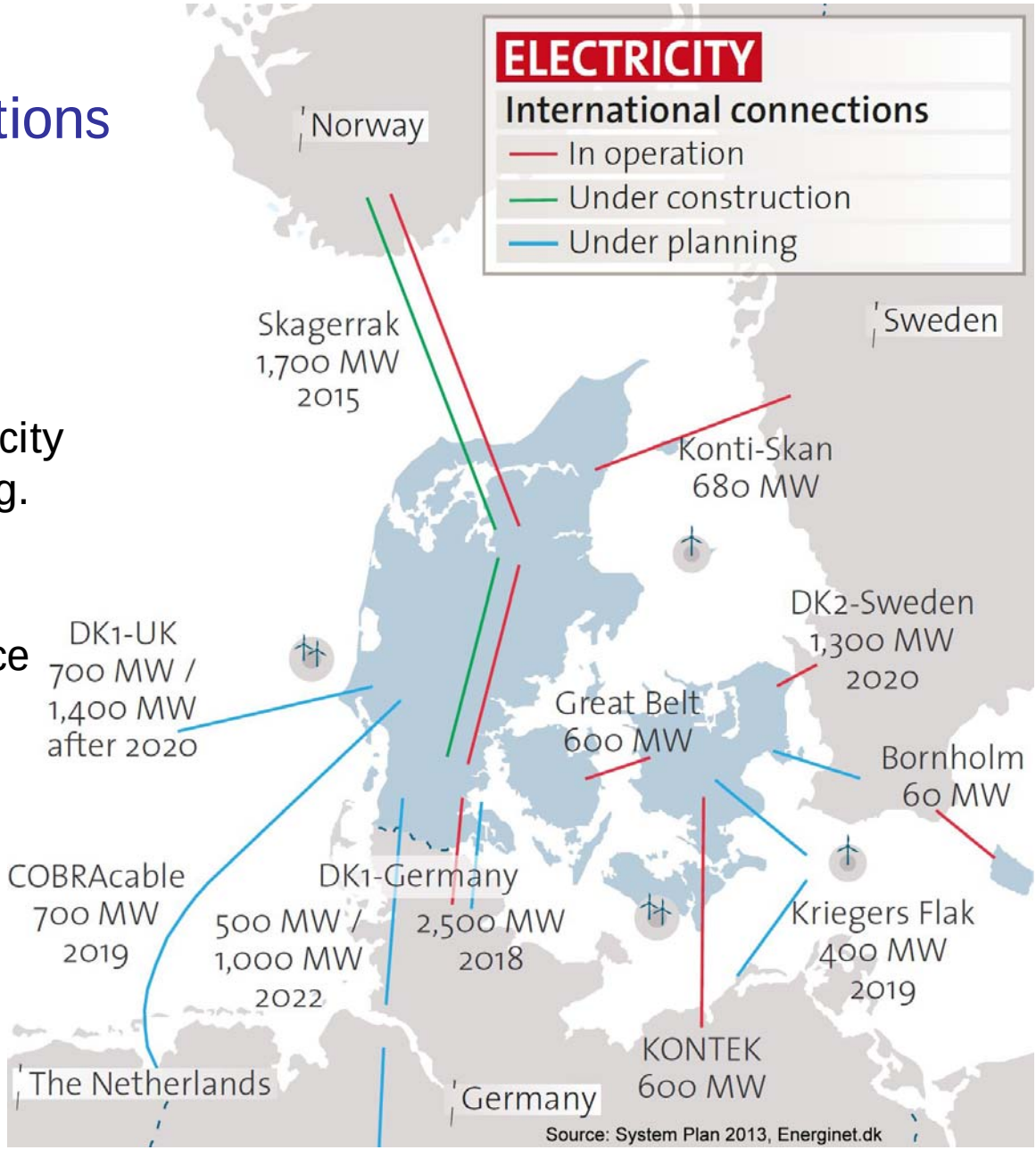
The Interconnections

More wind power
will take more
dispatchable capacity.

The dispatchable capacity
in Denmark is declining.

New interconnections
are supposed to replace
dispatchable capacity
in Denmark



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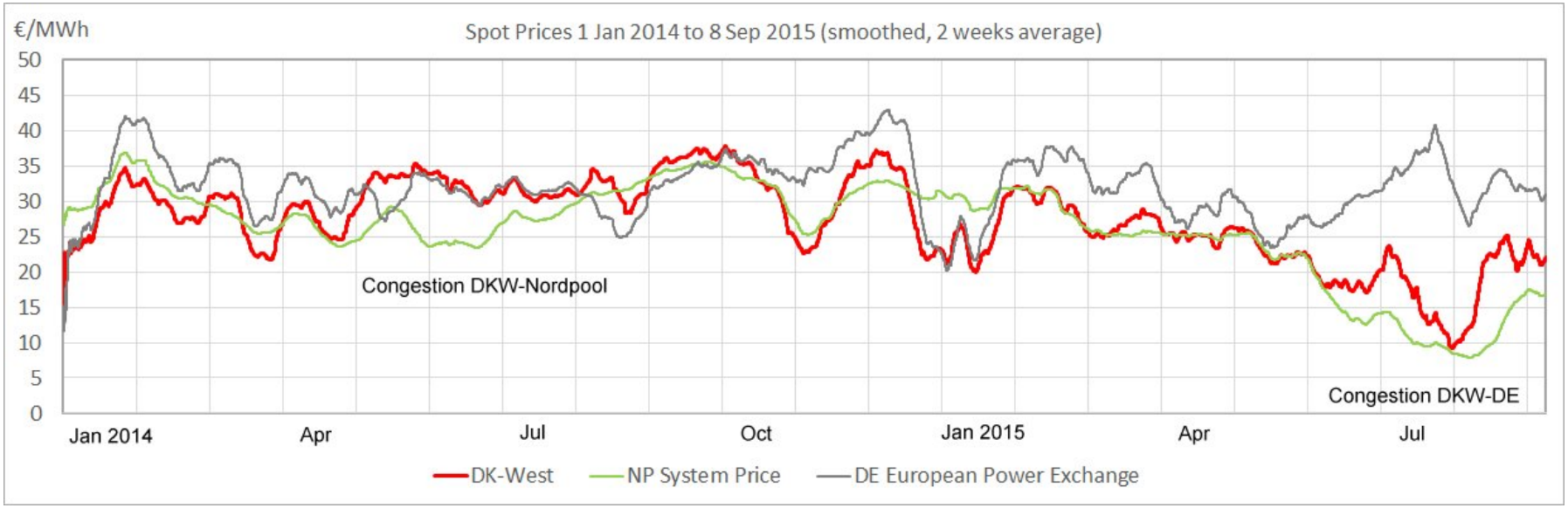
Spot Prices Reveal Bottlenecks in the Grids

- Optimal grid planning is a delicate balance
  - Grid reinforcements usually create new bottlenecks somewhere else



- Congestion creates price differences
- During the summer 2014 Denmark had the same spot price as Germany
  - There were bottlenecks between Denmark and the other Nordic countries
- Danish spot prices switched toward Nordic prices in 2015
  - After commissioning of Skagerrak 4 (700 MW) the bottleneck has move to the German border
  - Now owners of wind turbines complain that spot prices do not even cover maintenance cost

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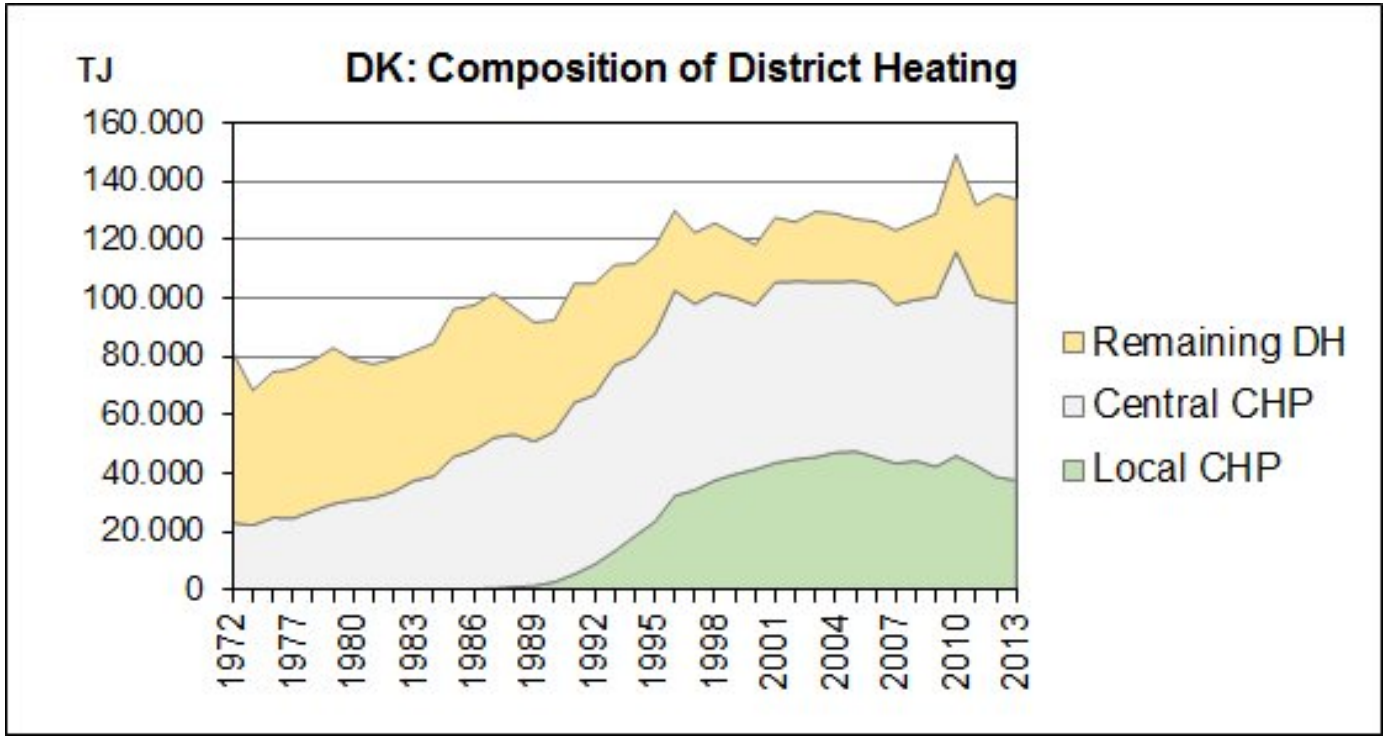
Heat and Electricity in Denmark



- District heating supplies nearly 60% of all space heating in Denmark
- 73% of district heating was from Combined Heat and Power (CHP) in 2013
  - Two categories: Central CHP and Local CHP
  - Local CHP was encouraged by subsidies to end by 2018
- Electricity production from CHP is flexible due to the heat storages
  - This flexibility is available now in contrast to Smart Grid flexibility

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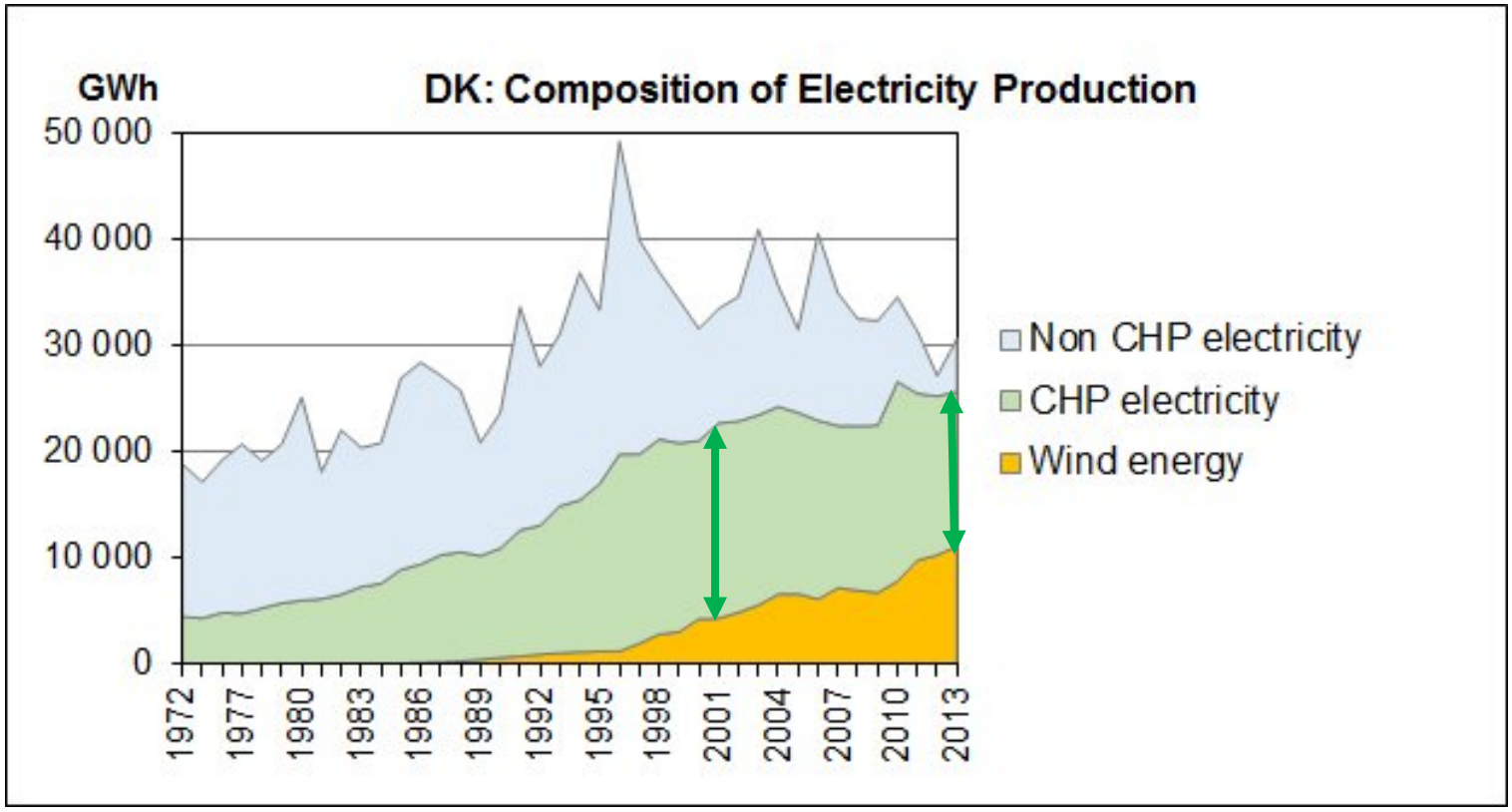
Trends in Thermal Electricity Production



- The thermal electricity production has been falling since 1996
  - Non-CHP production is rapidly decreasing
- Wind and CHP are now the dominating electricity sources
- The CHP production is slightly declining from 18.4 TWh in 2001 to 14.6 TWh
  - Declining CHP production causes reduced operational flexibility

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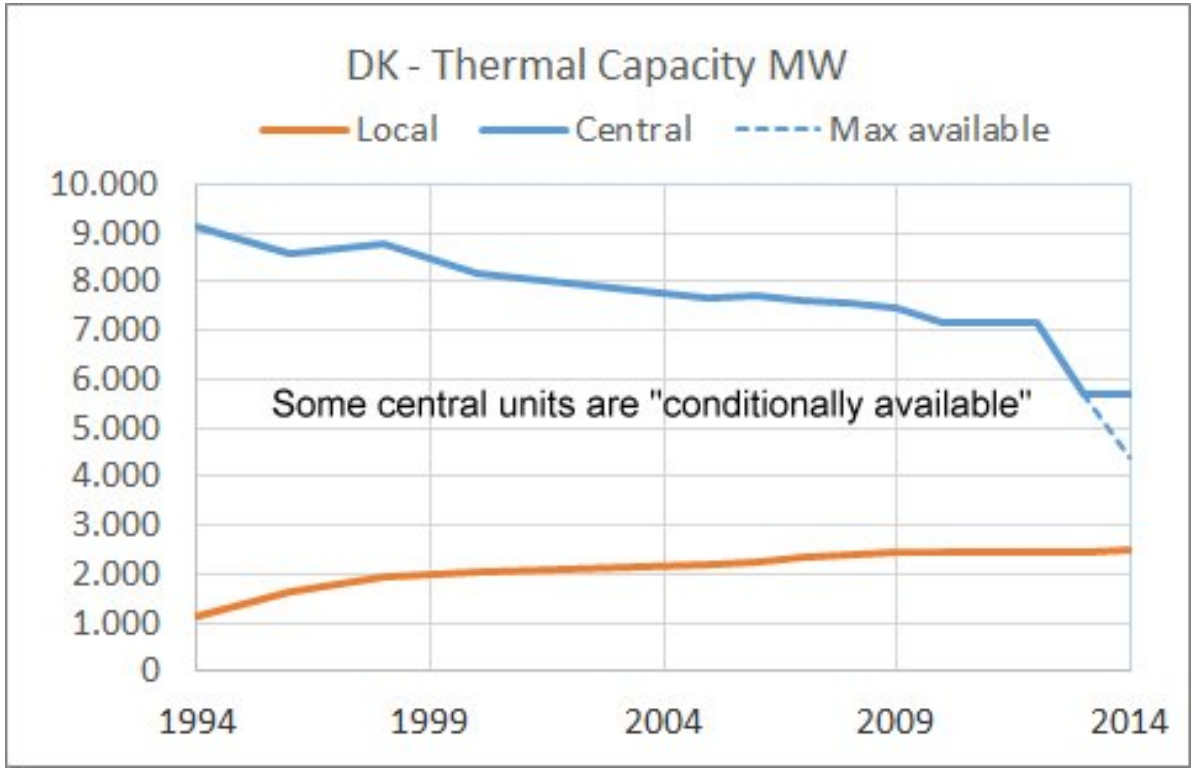
Thermal Capacity Adjusted to Business Volume



- Denmark is no longer self-sufficient in all situations
- CHP will be an increasing dilemma
  - Most of the small local CHP units will probably close down after 2018
  - Large municipalities acquire large CHP units

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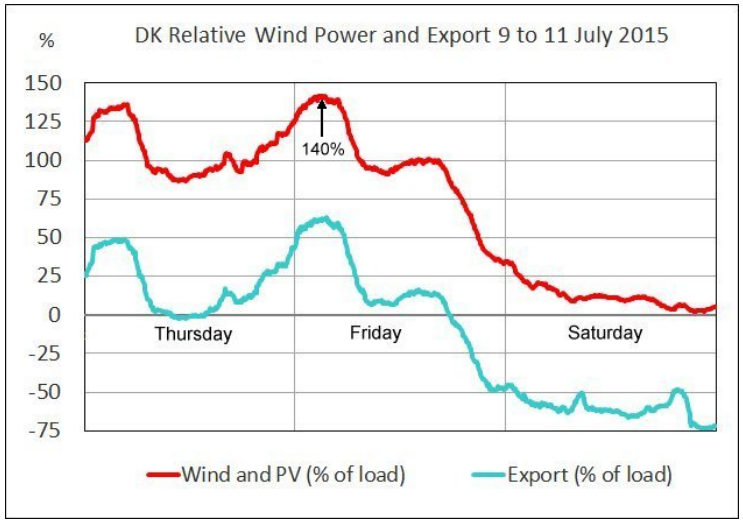
Case:

140% Wind Power in Denmark in 2015

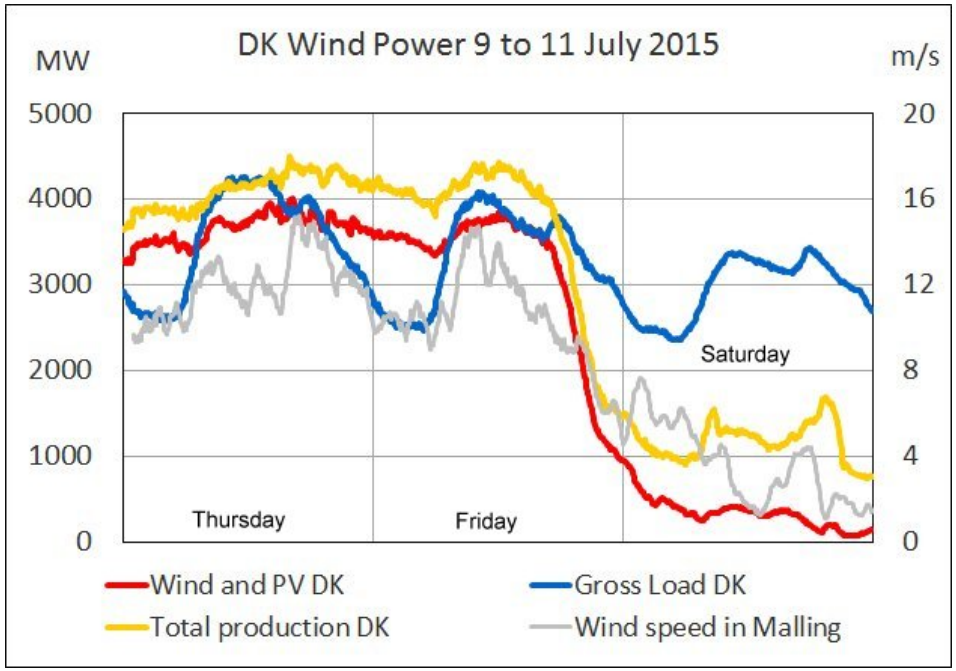
theguardian

Wind power generates 140% of Denmark's electricity demand



From Friday morning to Saturday night:

- Wind power from 140% to 2%
- Exchange from 60% export to 75% import



- A certain thermal capacity was kept running for security reasons
- Wind power changes faster than wind speed
- Most balancing services were purchased abroad
- It is widely assumed that export prices are practically 0 while import prices are very high.

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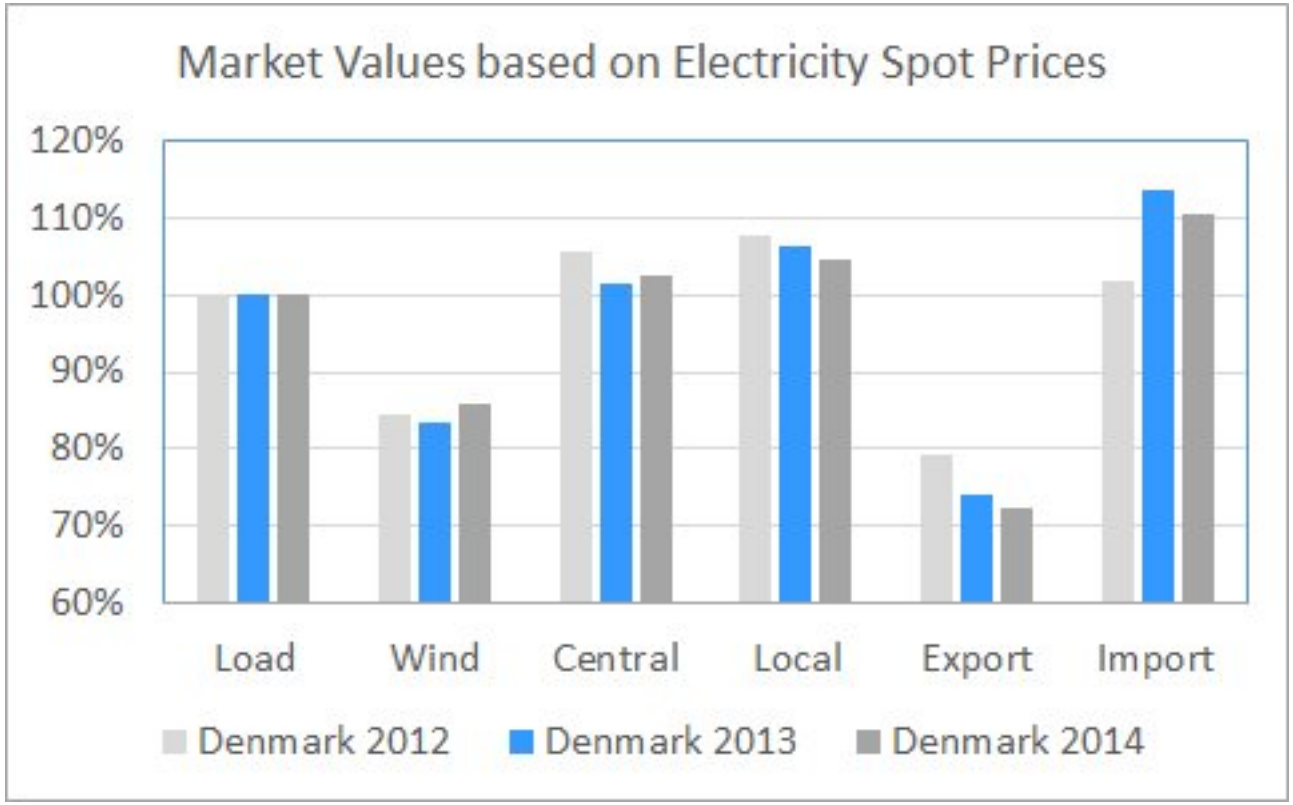
Facts about the Cost of Balancing Services



- Average market values 2012-2014:
  - Value of wind energy: About 85% of demand value
  - Value of export: decreasing from 80% to 65% of import value
- Domestic balancing services should be developed

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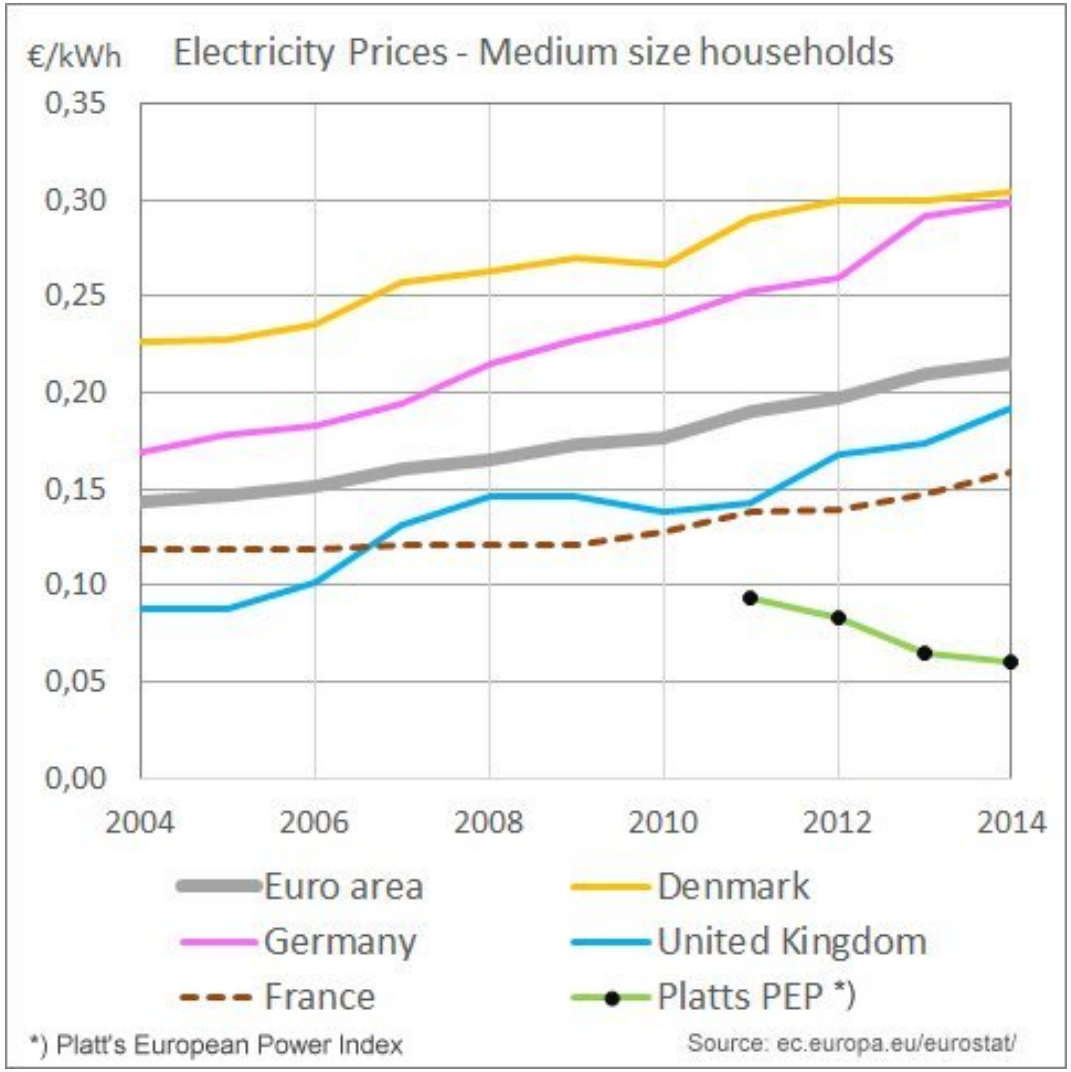
Increasing Electricity Prices at Consumer Level



- The Euro area had 4% average annual rise from 2004 to 2014.
- The influence of wind power is uncertain
- There seems to be an increasing gap between consumer prices and wholesale prices.
- The decline of wholesale prices is a problem to owners of thermal power plants
- The gap may moderate consumers' interest in active demand response.

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Smart Grid Research in Denmark

- A recent report describes what needs to be developed and demonstrated in order to facilitate the use of 50% wind power in the power system by 2020.
- Some main observations:
  - The research in **market design** and **communi-cation** was insufficient so far.
  - Technical sciences have dominated the research so far. **Social sciences** are necessary for efficient market design.
  - Flexible demand response has **two purposes**: Improving total system balance and preventing overload in local grids. It will take complex measures to unite the two considerations in one fair market model.
  - The cost-benefit report from 2010 should be updated. Essential assumptions, such as PV capacity and penetration of electric cars, are continuously changing.
  - Several proposed measures are based on fluctuating market prices. Potential measures should be analysed together because they will have an impact on market prices.
  - The implementation of demand response in Denmark will take years.
  - The dissemination of research results is insufficient. How can the practical use of research results be improved?


Thank you!
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