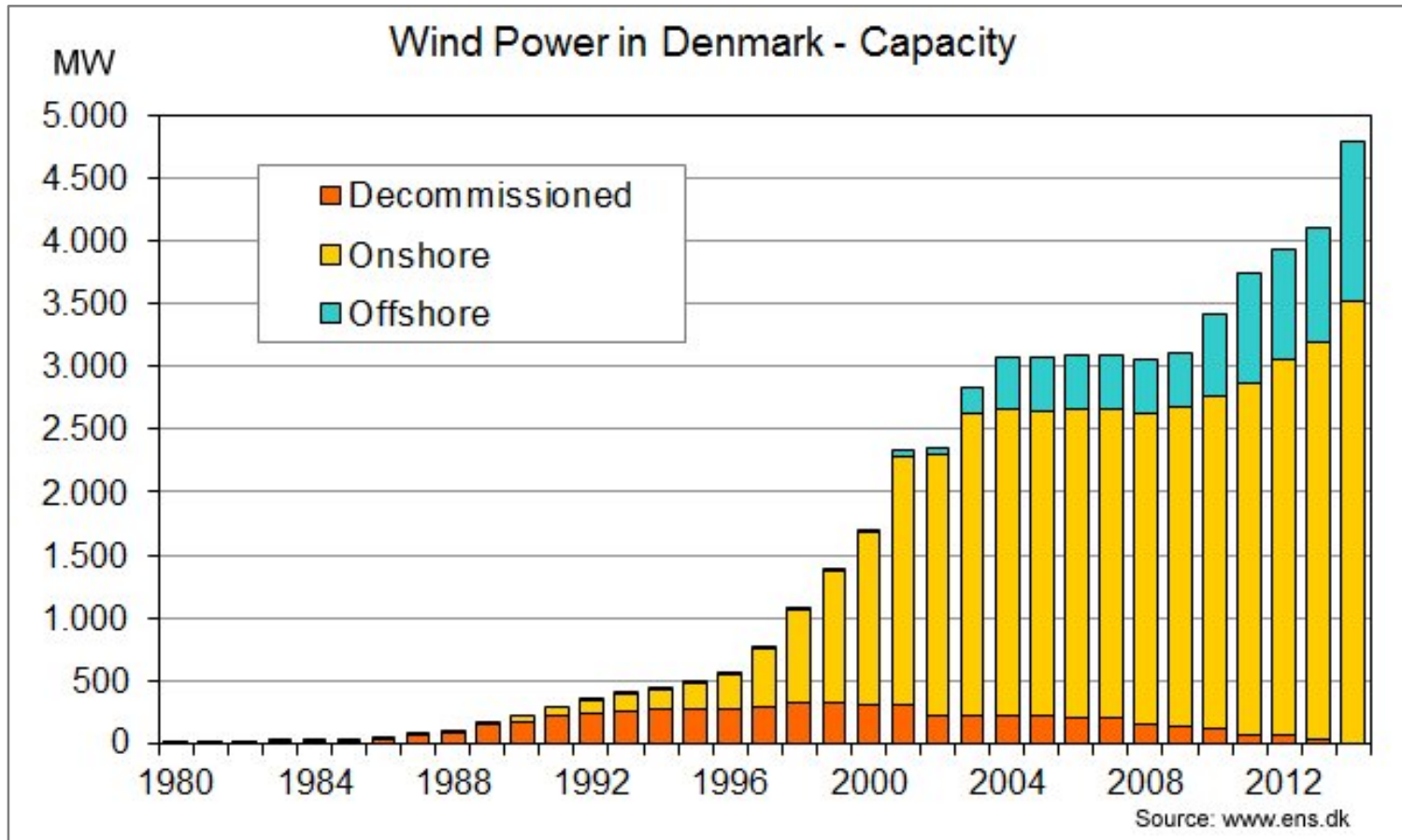


Paul-Frederik Bach

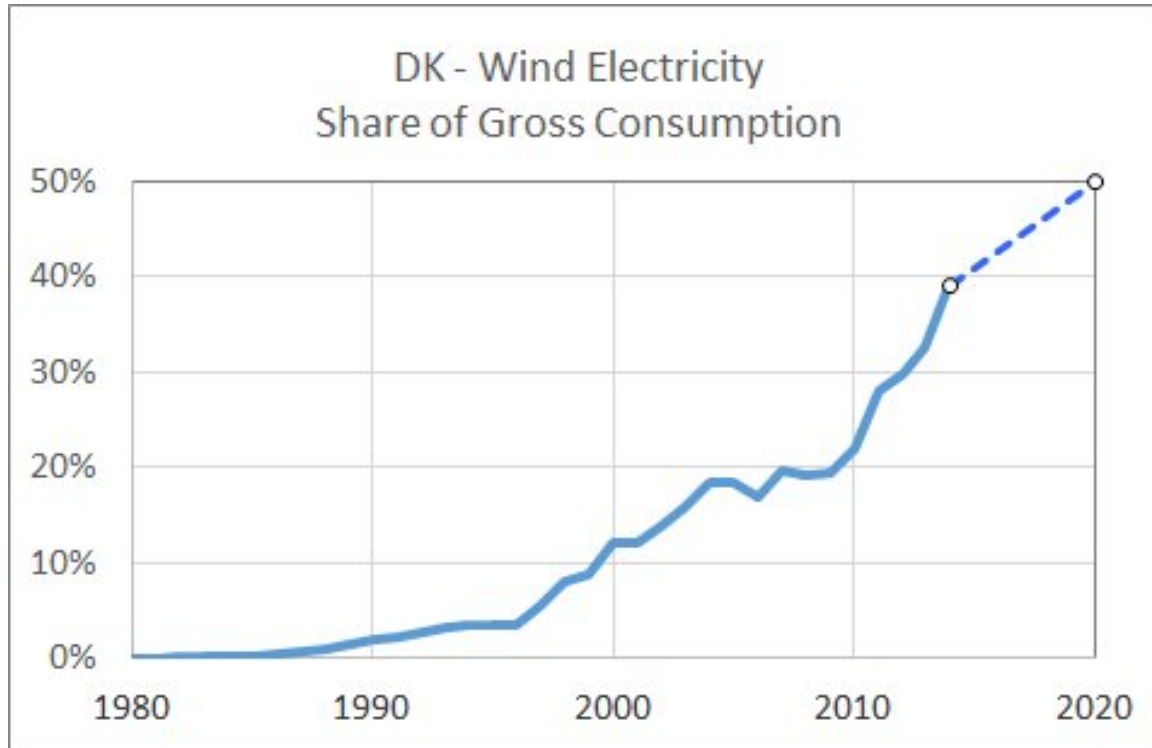
Towards 50% Wind Electricity in Denmark

Energy Group Meeting
Rome
23 September 2015

The Capacity Development



Nearly 40% Wind Electricity in 2014



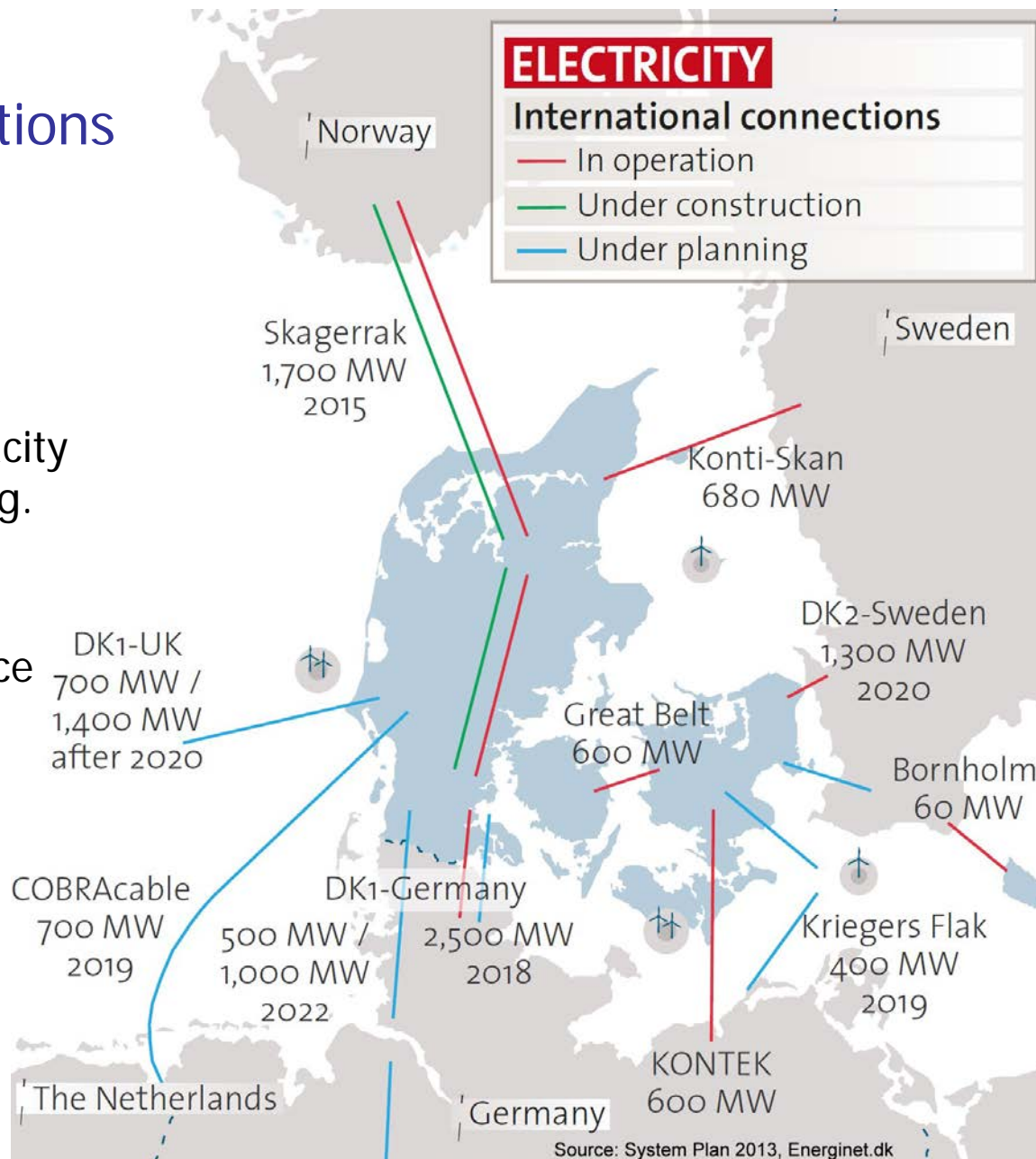
- Decisive conditions for a successful integration so far:
 - The strong interconnections
 - The development of international electricity markets
 - The IT revolution

The Interconnections

More wind power will take more dispatchable capacity.

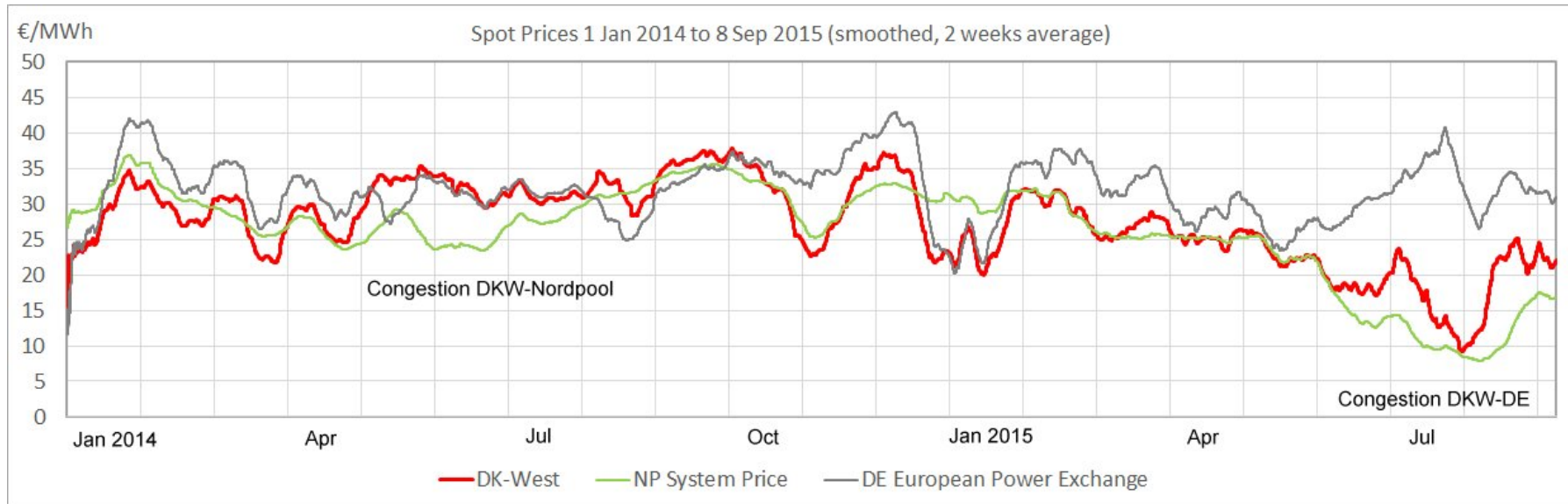
The dispatchable capacity in Denmark is declining.

New interconnections are supposed to replace dispatchable capacity in Denmark



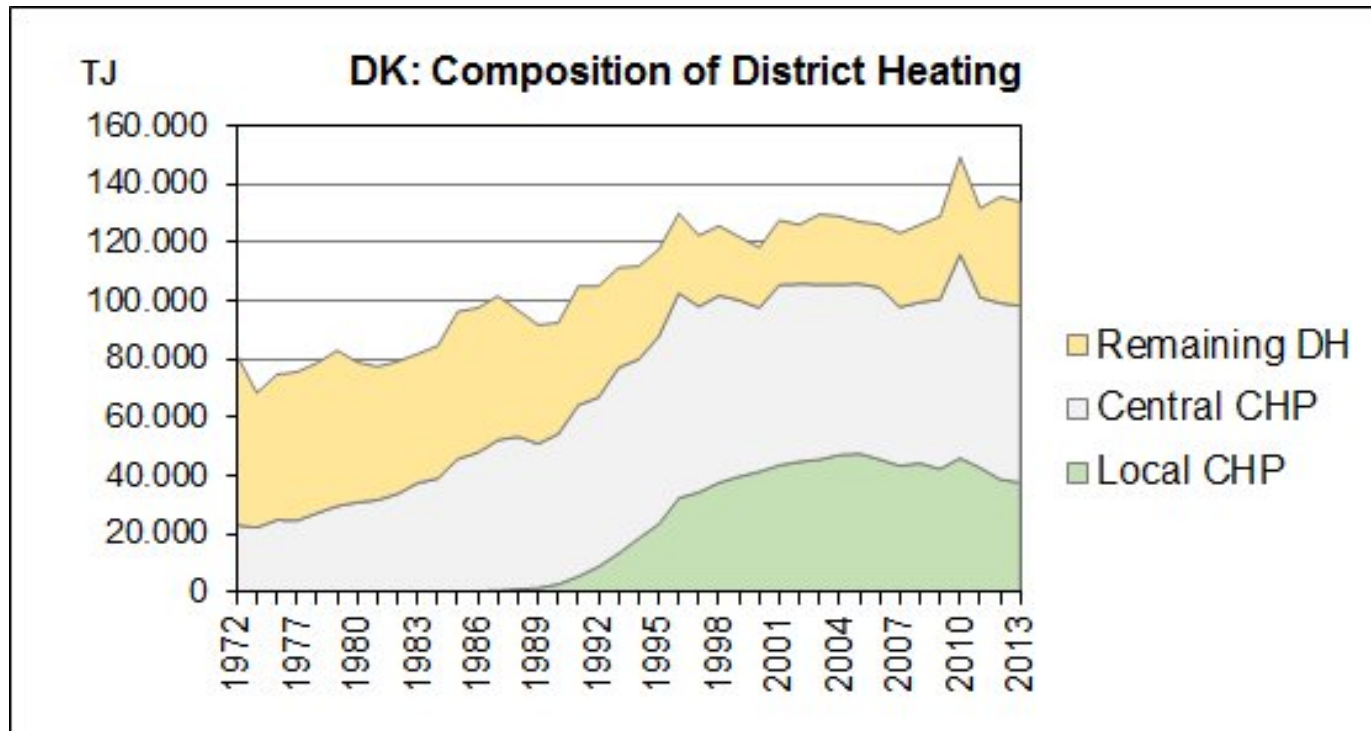
Spot Prices Reveal Bottlenecks in the Grids

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



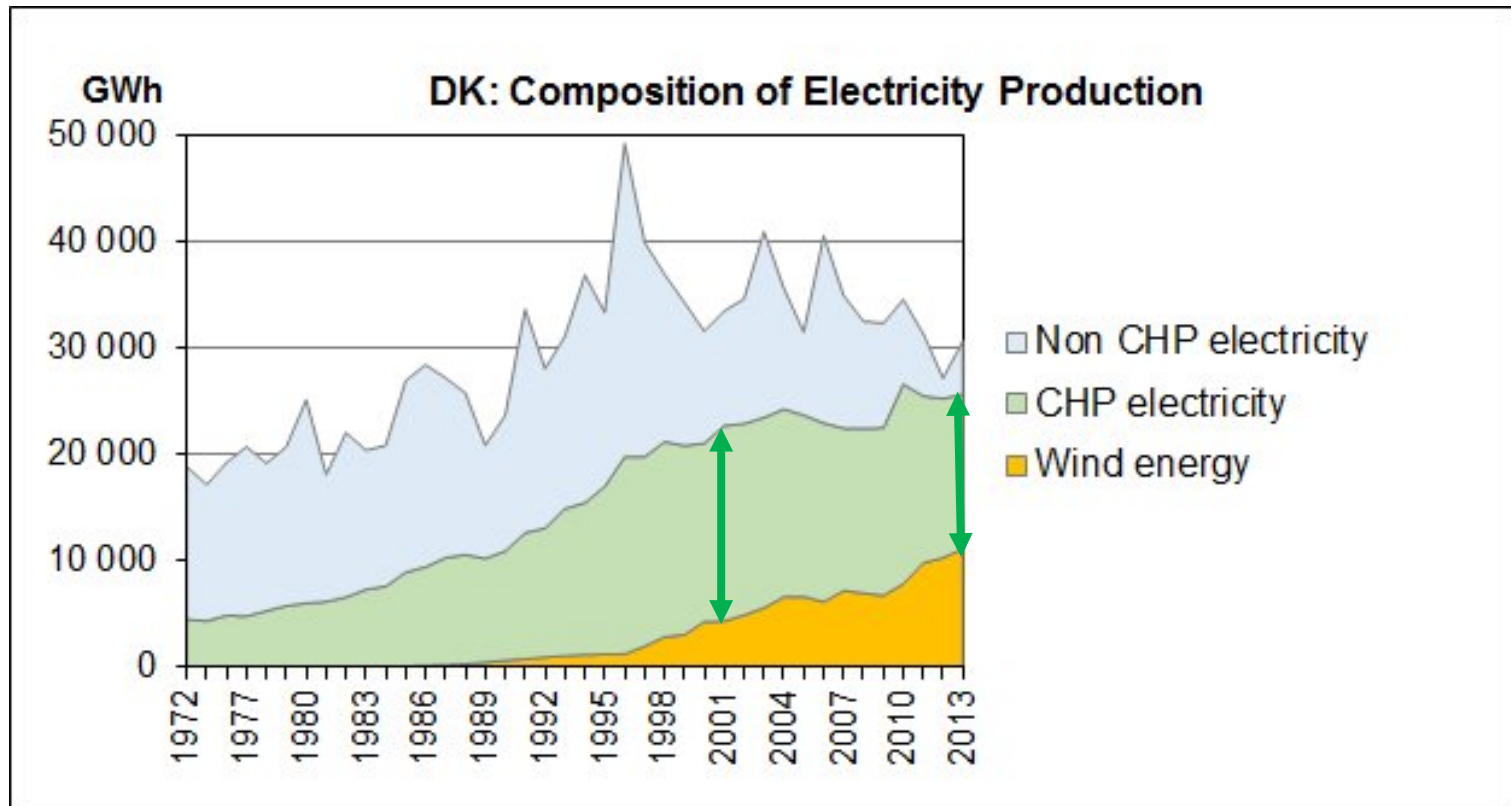
- Congestion creates price differences
- During the summer 2014 Denmark had the same spot price as Germany
 - There were bottlenecks between Denmark and the other Nordic countries
- Danish spot prices switched toward Nordic prices in 2015
 - After commissioning of Skagerrak 4 (700 MW) the bottleneck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

Heat and Electricity in Denmark



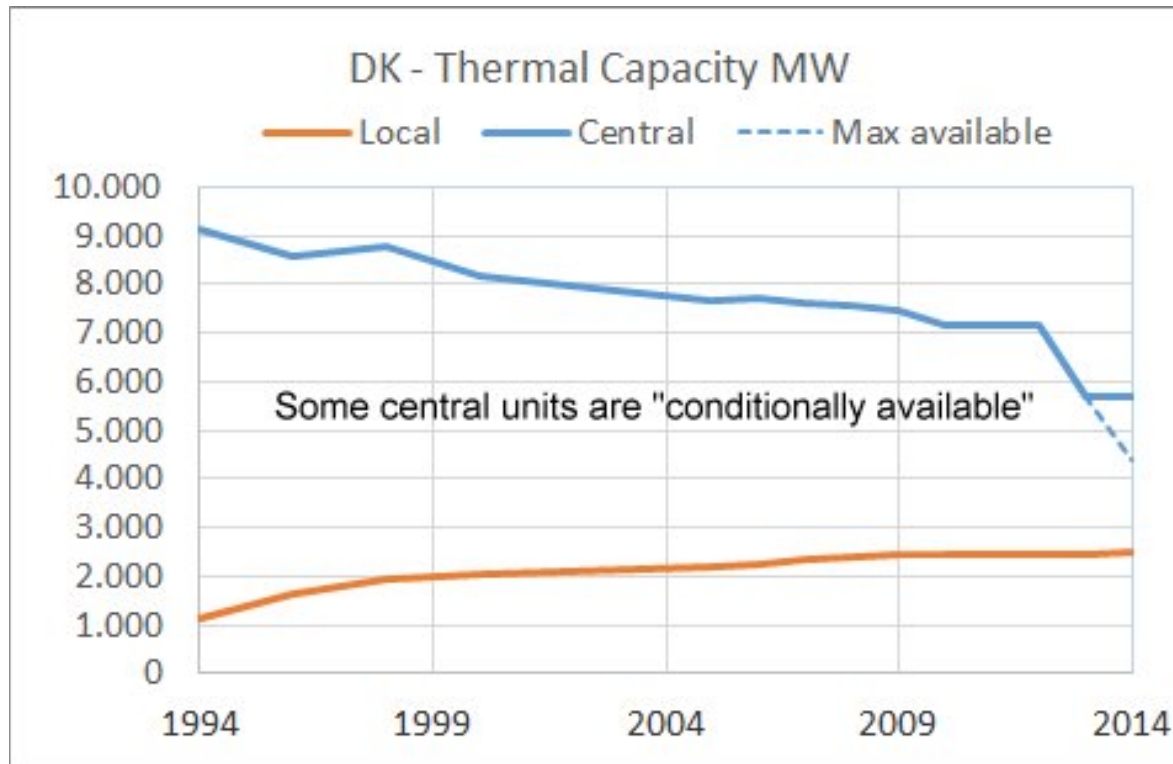
- District heating supplies nearly 60% of all space heating in Denmark
- 73% of district heating was from Combined Heat and Power (CHP) in 2013
 - Two categories: Central CHP and Local CHP
 - Local CHP was encouraged by subsidies to end by 2018
- Electricity production from CHP is flexible due to the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

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

Thermal Capacity Adjusted to Business Volume



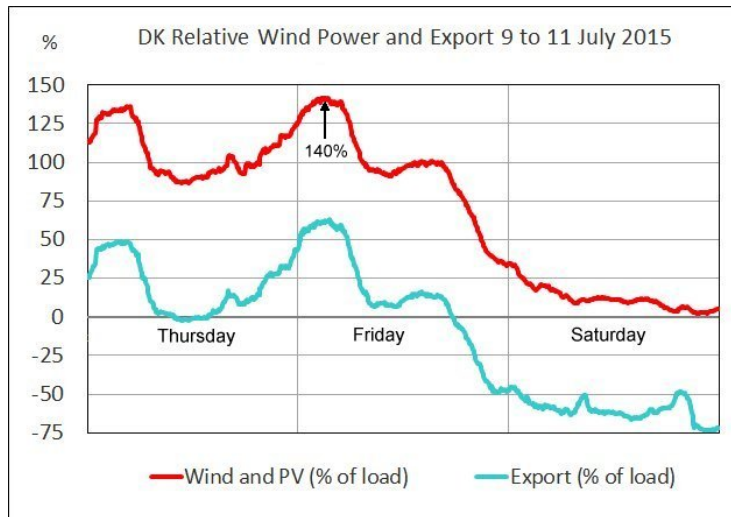
- Denmark is no longer self-sufficient in all situations
- CHP will be an increasing dilemma
 - Most of the small local CHP units will probably close down after 2018
 - Large municipalities acquire large CHP units

Case:

140% Wind Power in Denmark in 2015

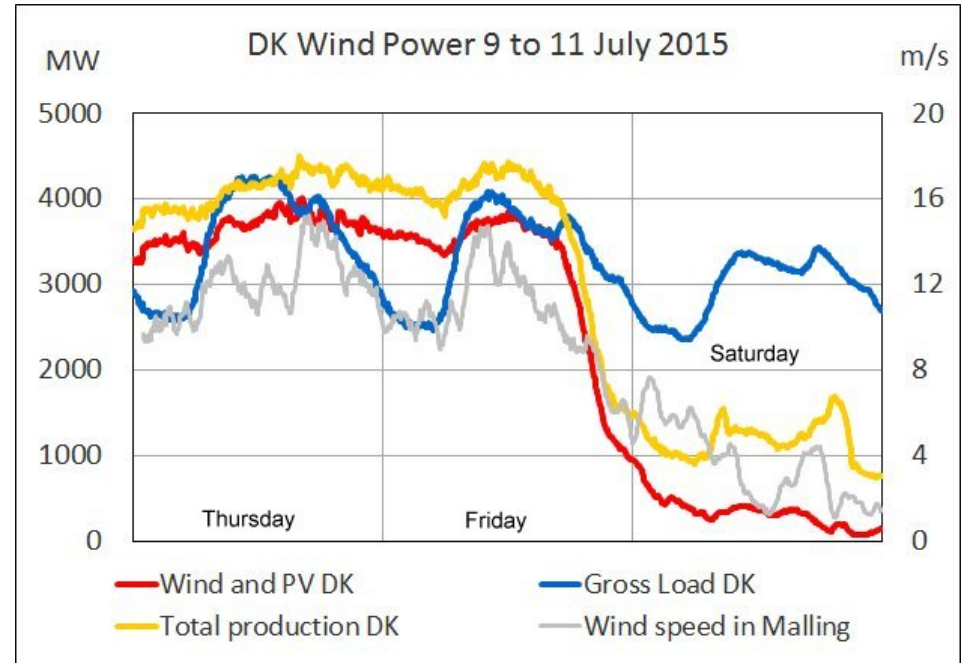
theguardian

Wind power generates 140% of Denmark's electricity demand



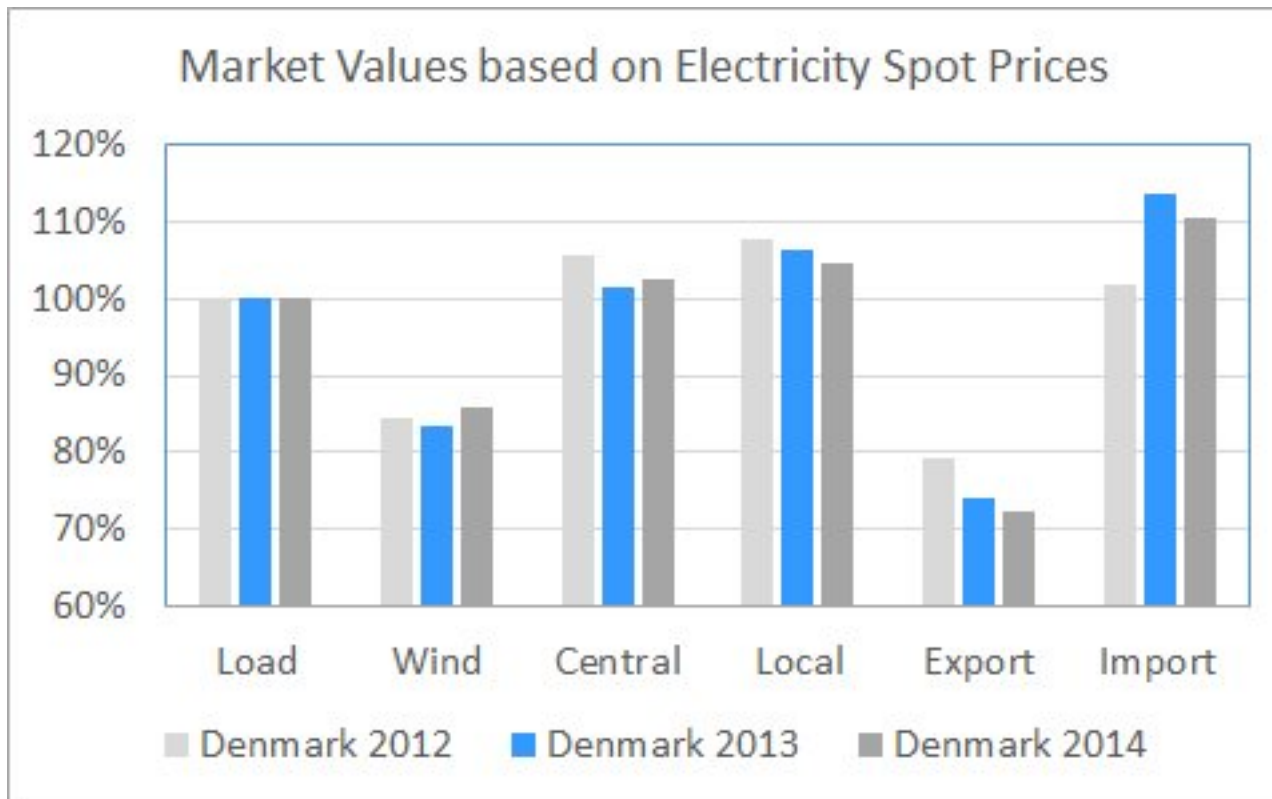
From Friday morning to Saturday night:

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



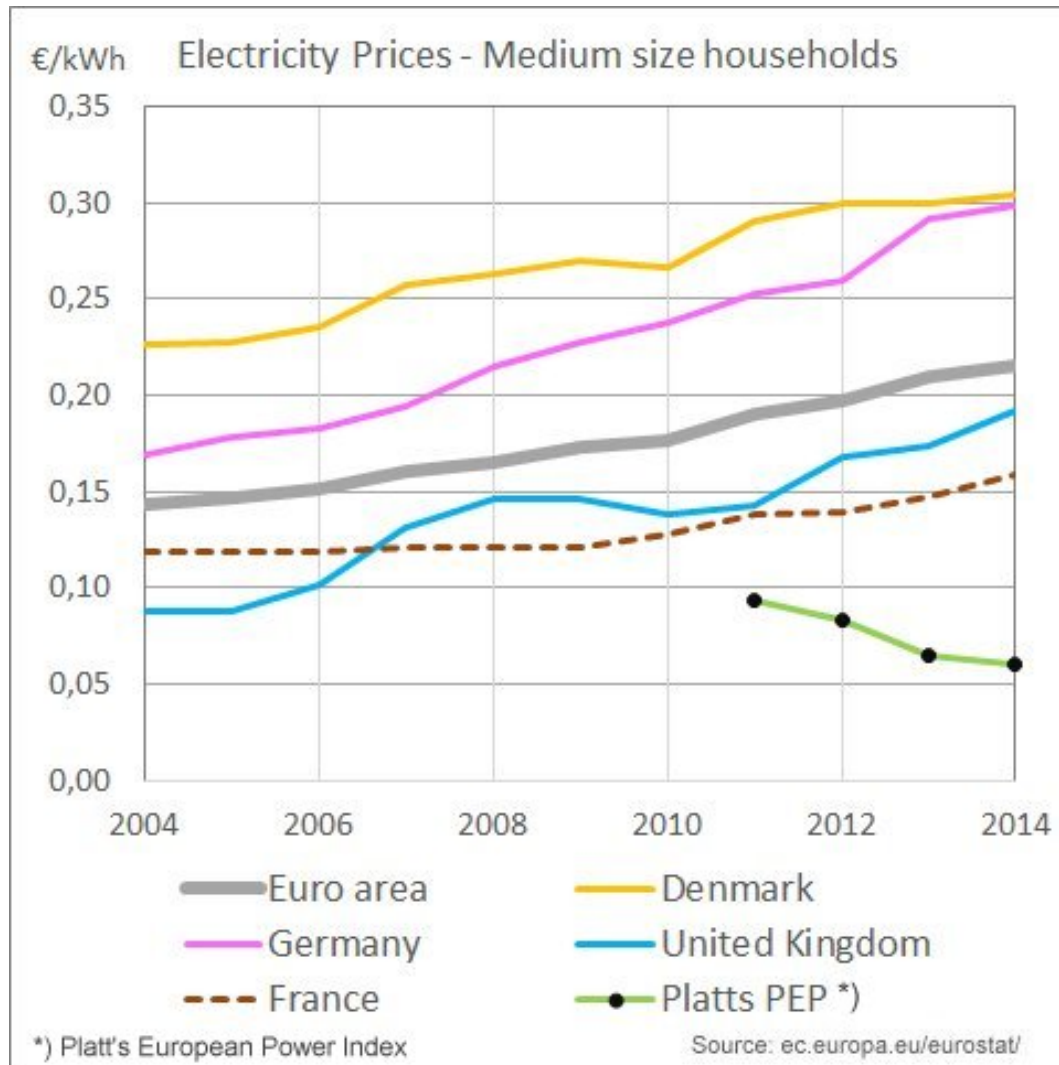
- A certain thermal capacity was kept running for security reasons
- Wind power changes faster than wind speed
- Most balancing services were purchased abroad
- It is widely assumed that export prices are practically 0 while import prices are very high.

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

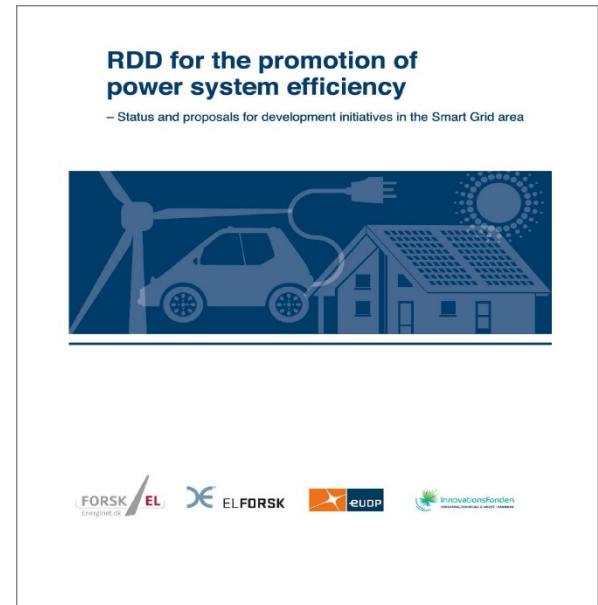
Increasing Electricity Prices at Consumer Level



- 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.

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 **communication** 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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