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Measures to reduce the impact and cost of an increasing share of intermittent RES in the electricity generation

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RESPOND
Renewable Electricity Supply interactions with conventional POwer generation, Networks and Demand

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- Network options to mitigate impacts
- Market and cost impact options
- Generation and demand response options
- How much impact on spot price? Example from DK
- Which options could mitigate the price variations and the price reduction?
- Reduction of variation in intermittent generation and possible price impacts
- Are the illustrated impacts relevant in a broader EU perspective? – EU RES targets and the timing

Main features of negative impacts large scale intermittent RES-E

- A higher share of intermittent RES-E implies a more variable, and less predictable and controllable supply of electricity

→ e.g. more demand for **flexible** generators

- A higher share of RES-E leads to more expensive network operation (voltage rise effects, increased fault levels, energy losses)

→ e.g. more demand for technical and economic measures for network **controllability**

Options to reduce impacts on networks, DSO & TSO

- Technical options:
  - Active network management, micro-grid concept, dynamic islanding etc (DSO)
  - Storage (TSO, DSO)
  - Demand response (DSO)
  - More interconnections (TSO)
  - Improved wind power output forecasting (TSO)

- Economic/commercial options:
  - Virtual power plants (TSO)
  - Time of use network tariffs (TSO, DSO)
  - Locational network tariffs (TSO, DSO)
  - Interruptible contracts (TSO, DSO)

Problems and Impacts
Focus on markets and costs

- **Variability of intermittent sources - markets**
  - Price variation high
  - Low prices at times of high wind output
  - Low revenues for both intermittent generators and other base load generators
- **Unpredictability of intermittent sources**
  - High balancing costs
  - High and inflexible reserve requirements
  - Low capacity values for intermittent generation

Different categories of options to mitigate the problem of price variations

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Two major alternatives

- **Reduce the output variations**
  - Interconnection capacity
  - Flexible generation technologies in mix
  - Mix of intermittent generation technologies
  - Dispersed location of intermittent technologies

- **Demand options that adjust to output variations**
  - Increase price flexibility – demand response (regulation, technology)
  - Storage of electricity or heat
  - New demand technologies (heat pumps, hybrid electric cars)

Generation technologies and variability

- **Flexible generation technologies wanted**
  - **Low stop and start costs as well as fast regulation properties**
  - **Reasonable part load characteristics – efficiency, emissions**

- **PV and wind power combination reduce variation**
  - **Somewhat uncorrelated production but dominated by cost differential**

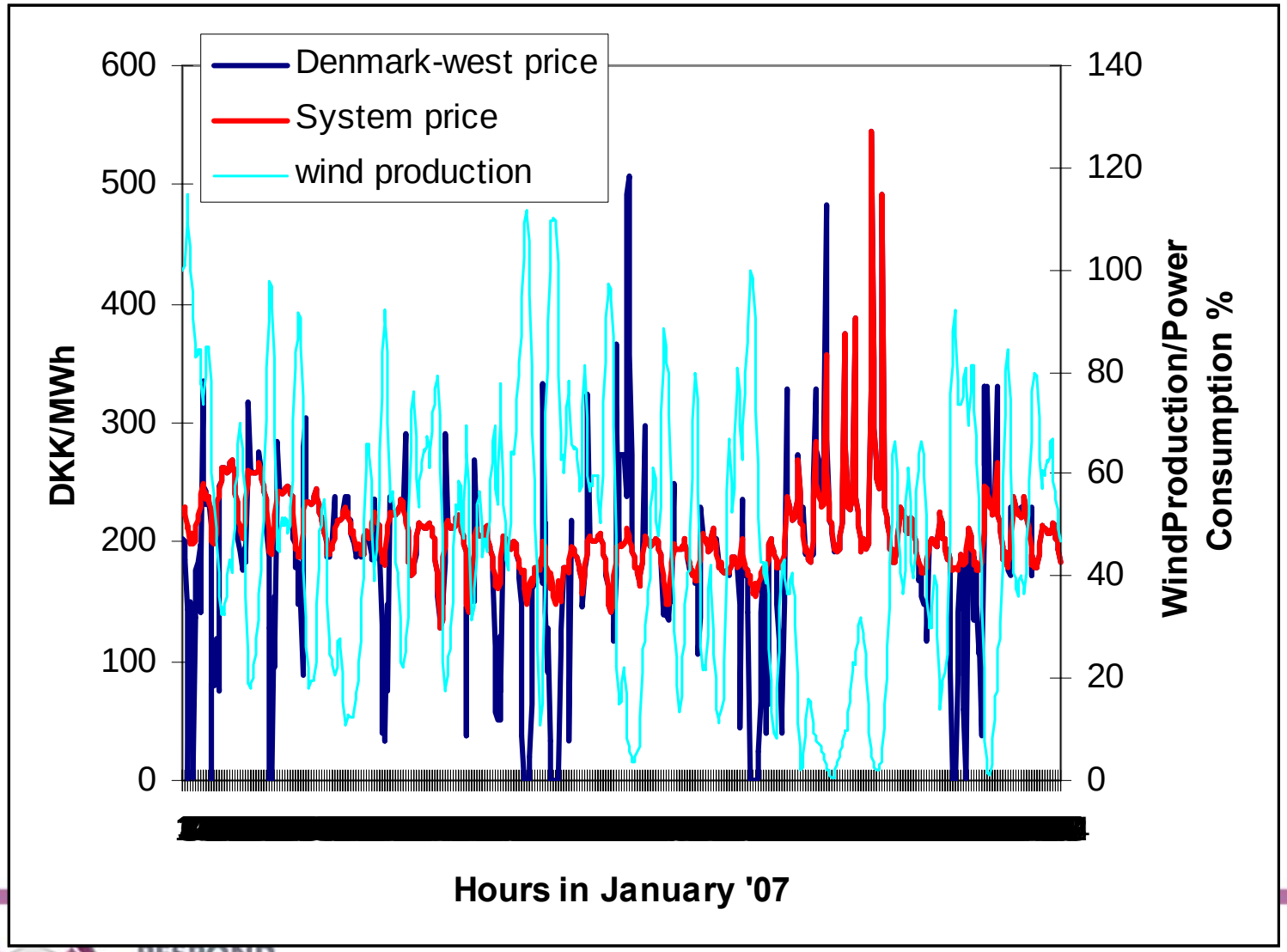
- **Wind power and CHP can work**
  - **CHP can only be flexible with heat storage and correct subsidy scheme for CHP**
- **PV or Wind and Hydro**
  - **Excellent combination with sufficient hydro storage**

Demand options

Demand options and necessary regulatory measures that shift demand or exploit the low prices (increase demand)

- **Metering**
  - **and billing that transfer the price signals to final consumers**
- **Tariff restructuring**
  - **increase fluctuations that consider variations in environmental tax elements – including the PSO tariff that finance RES subsidies**
- **New demand technologies (heat pumps, hybrid electric cars)**

Impact on Spot Price: DK example



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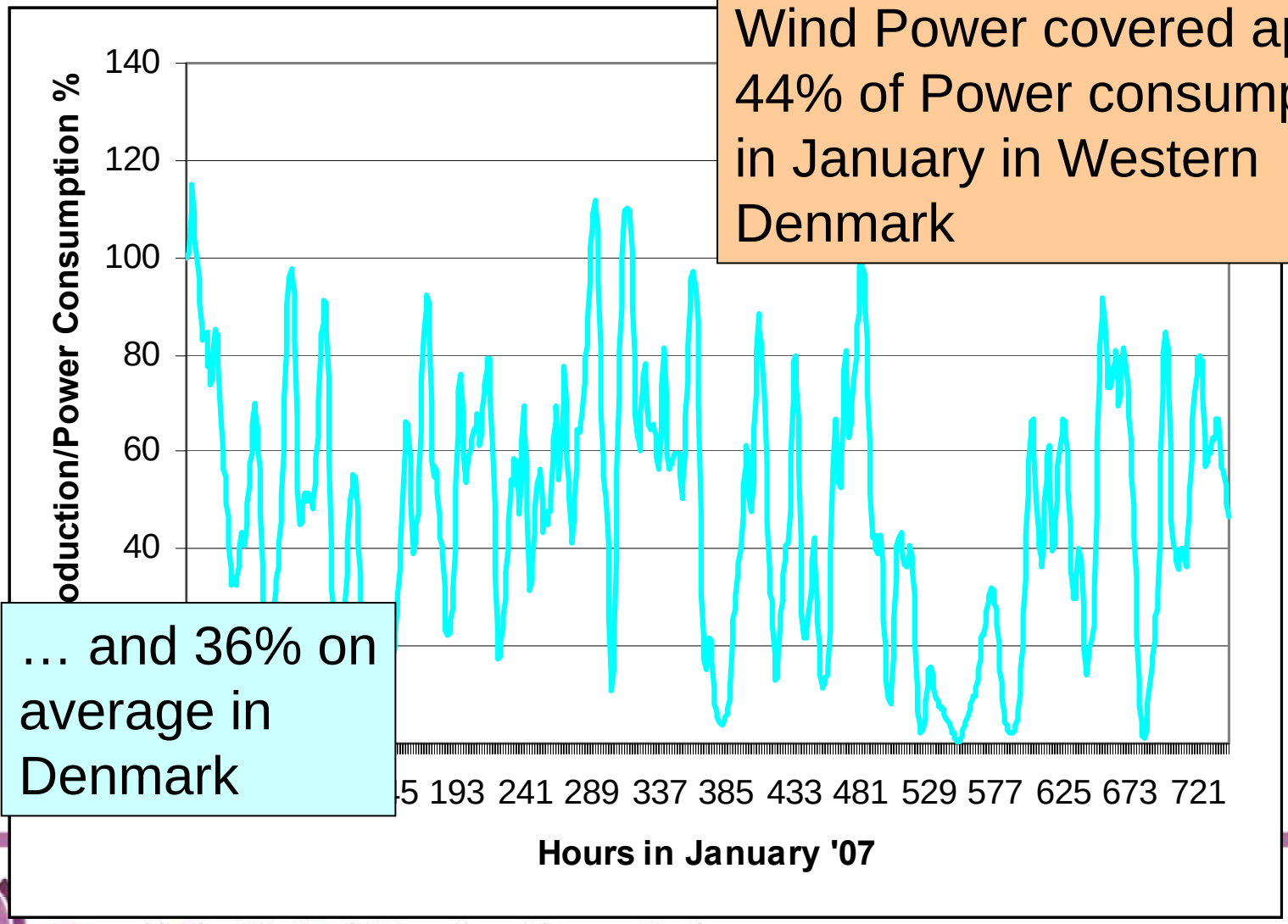
Source: Poul Erik Morthorst

Wind power in Western Denmark

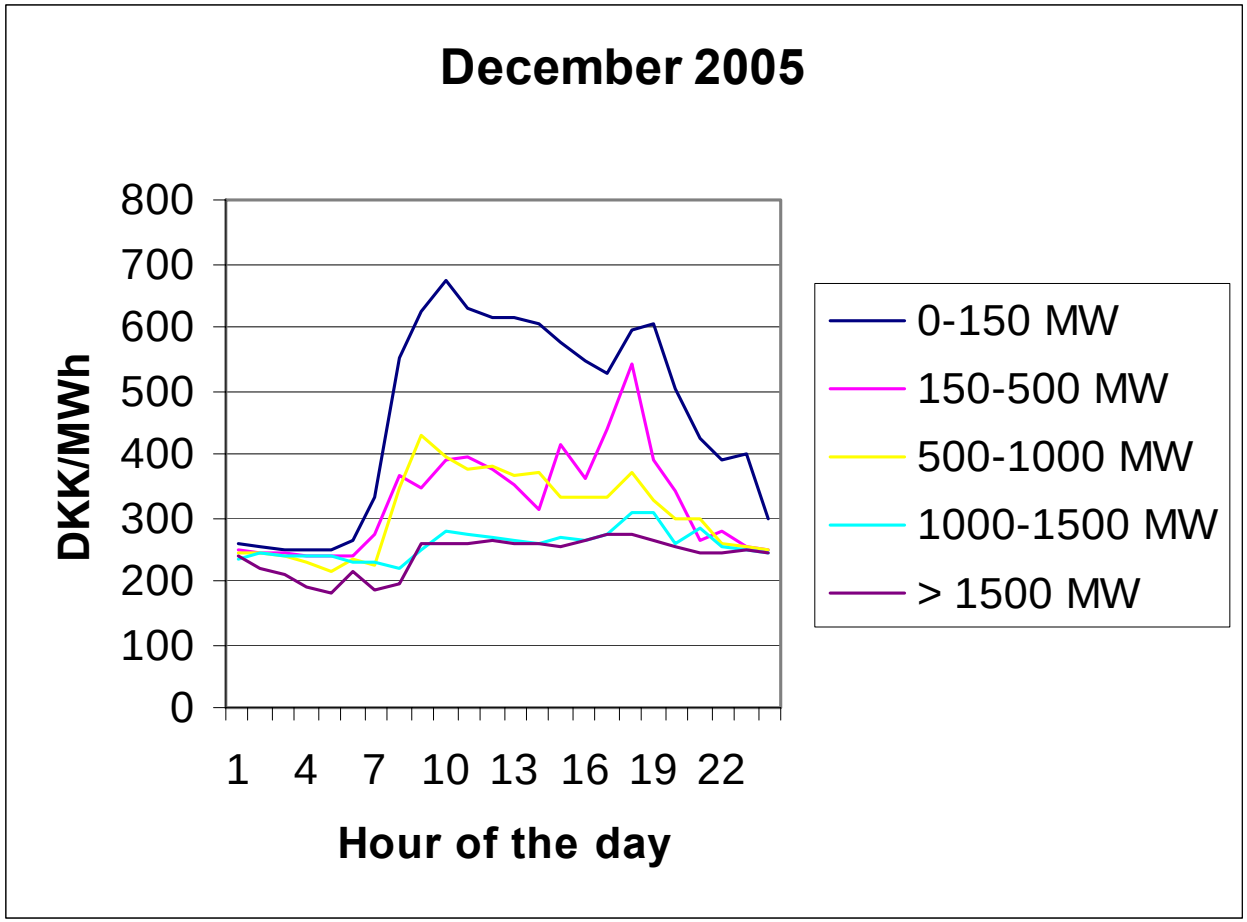


Wind Power covered approx. 44% of Power consumption in January in Western Denmark

… and 36% on average in Denmark

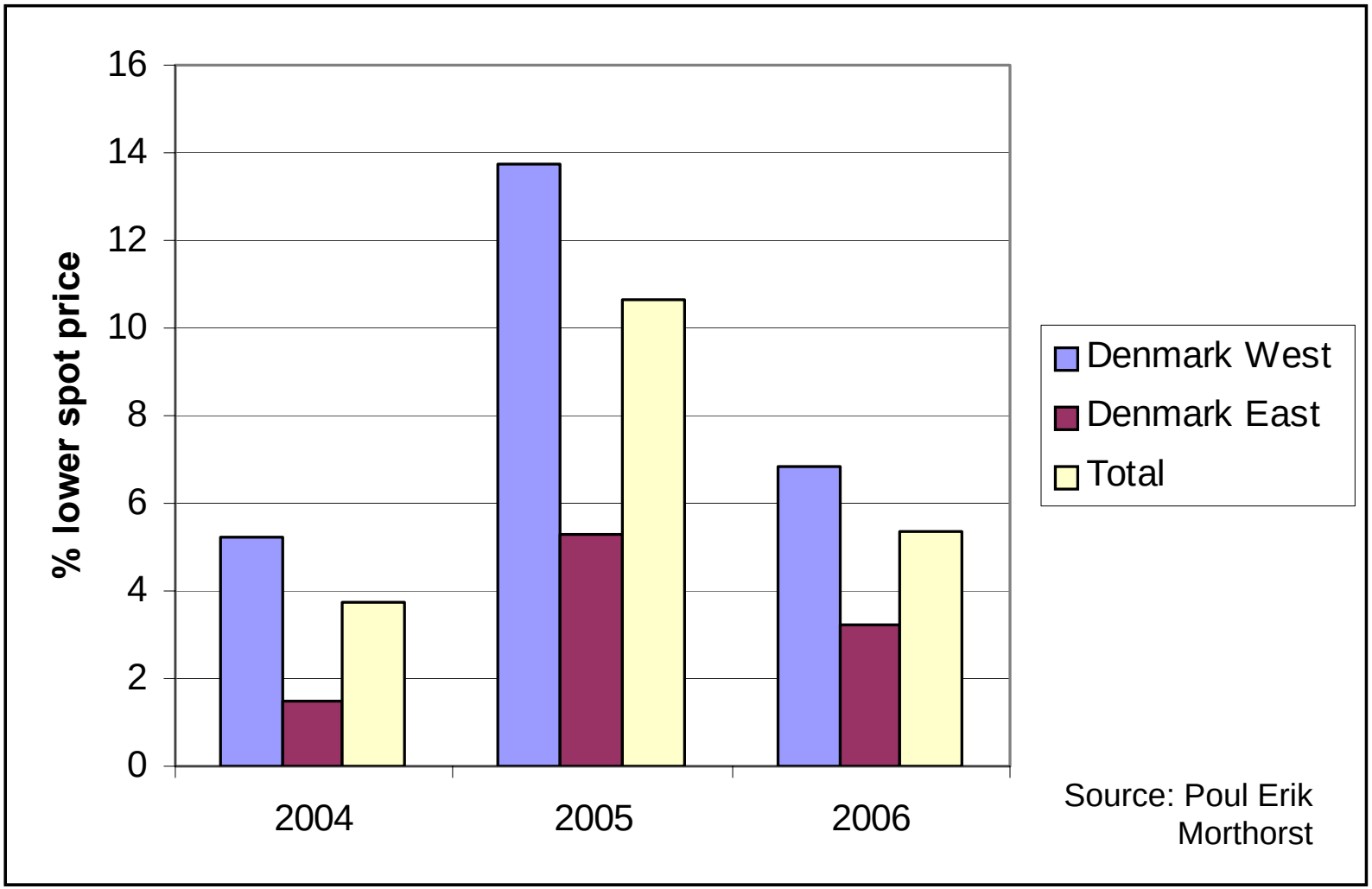
Source: Poul Erik Morthorst

Impact at the Western-Denmark power market



Source: Poul Erik Morthorst

Lower spot market prices: results for 3 years



Source: Poul Erik Morthorst

Interconnections, storage and demand response

- Interconnection capacity
  - Reduce the impact of variability on prices
  - Reduce the reserve requirement

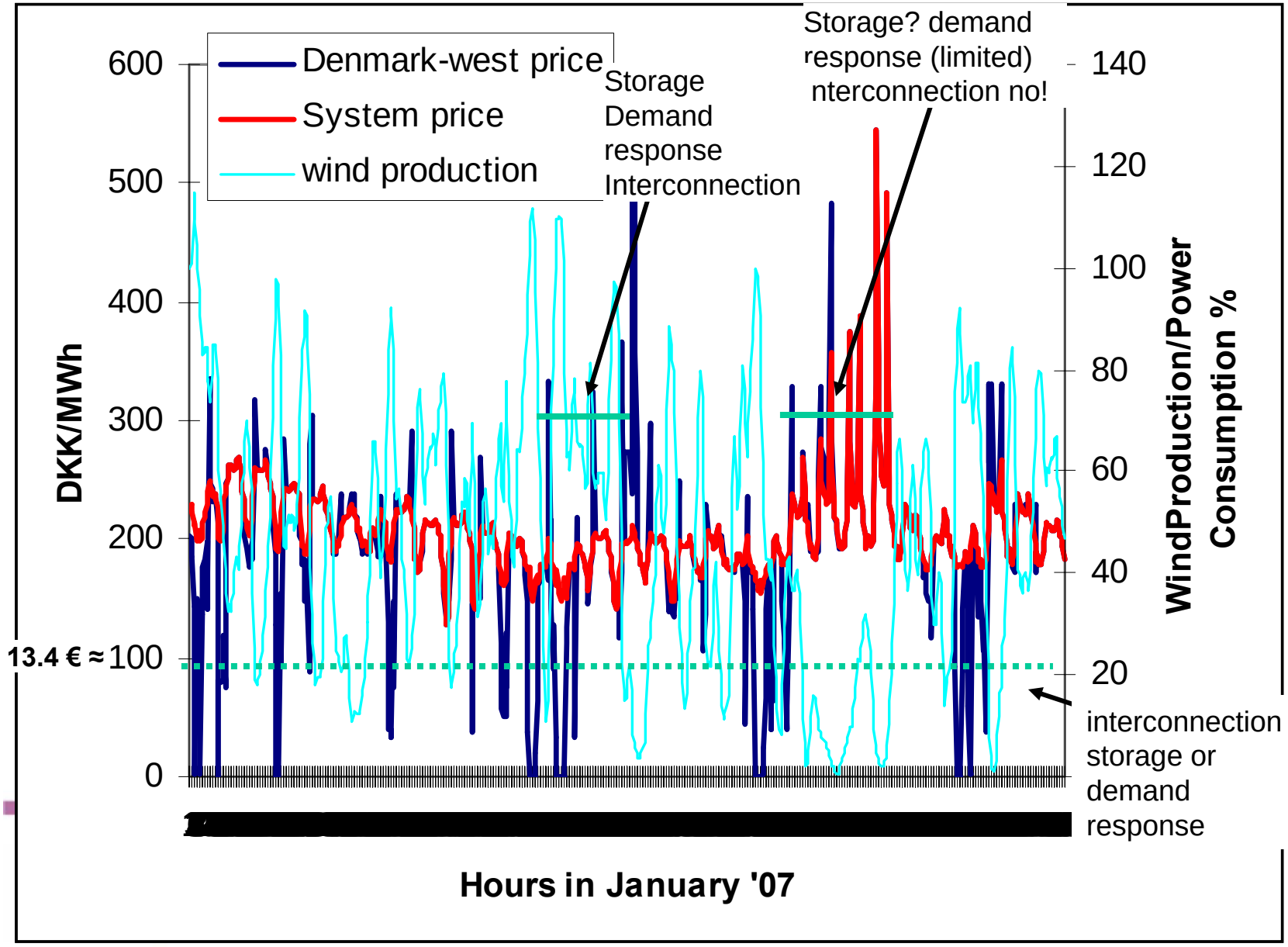
- Storage technologies
  - Use the variability of prices to store electricity or heat related to CHP – mainly short term (hours)
  - Hydro storage – both in short term and for longer term storage

- Demand response
  - Reduce variation of prices – flattened duration curve
  - Regulatory part – requires price pass through
  - Technological part - investments

Example of price impact reduction in a system with high intermittent shares and interconnection constraints

- Why is the low prices a problem?
- In a system with high intermittent shares there are unattractive low prices – from the generators view
- There is a lot of short term price variation
- There might be longer periods of high prices
- And the average spot market price is lower
- Especially wind generators will experience low prices

Demand response, storage or interconnection

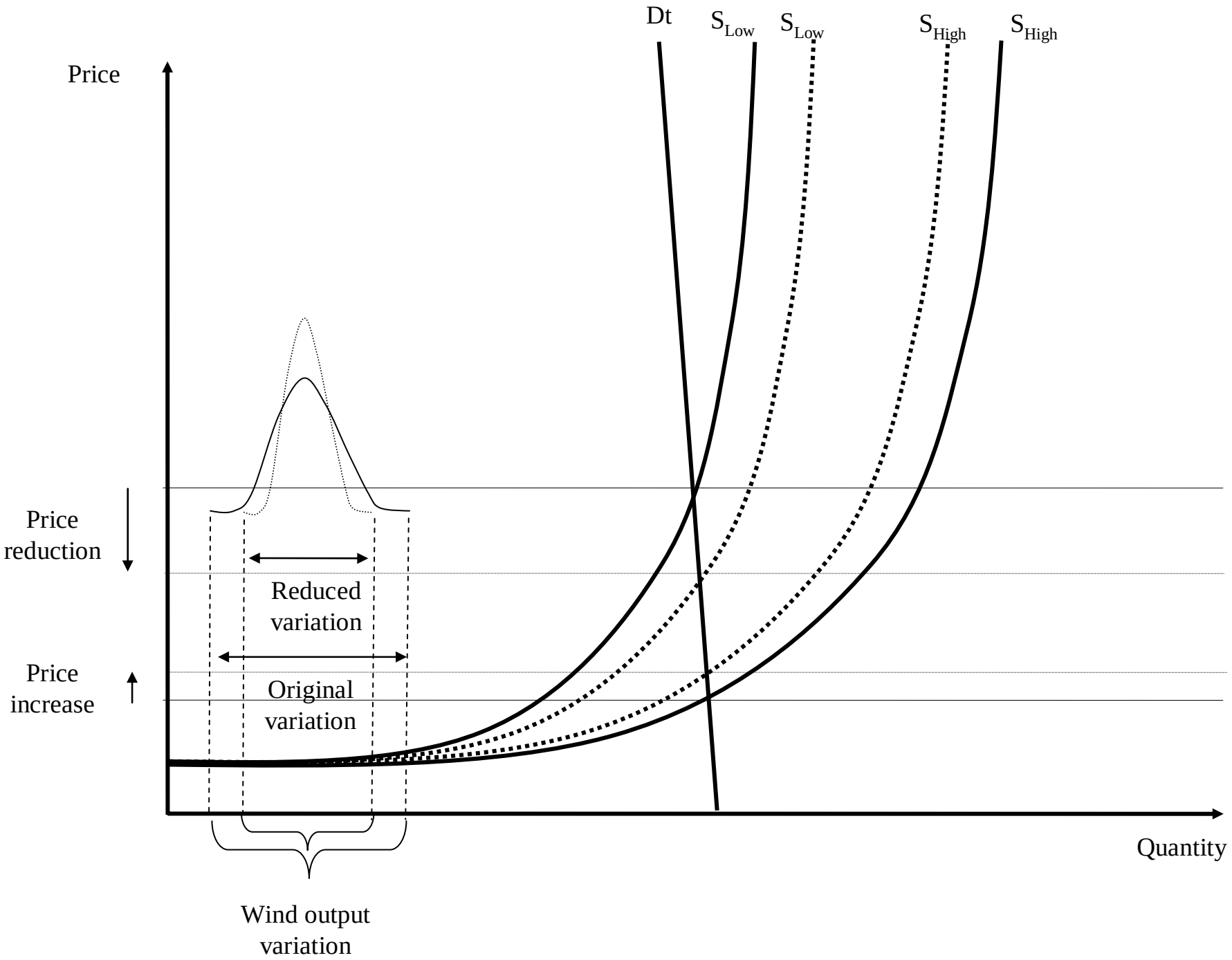


What will the impact of reduced variation in electricity generation be?

- For the options targeting a reduction of variability the main efficiency argument will be related to less capacity requirements and better average fuel efficiency in the long term

- But what about the short term effect for the market?

- Assume that less variability will reduce the max intermittent output and increase the minimum output identically
  - Lower maximum generation will increase prices
  - Higher minimum generation will reduce prices
  - What is the net effect and the distribution?


Dt
S_{Low}
S_{Low}
S_{High}
S_{High}
Price
Price reduction
Price increase
Reduced variation
Original variation
Quantity
Wind output variation

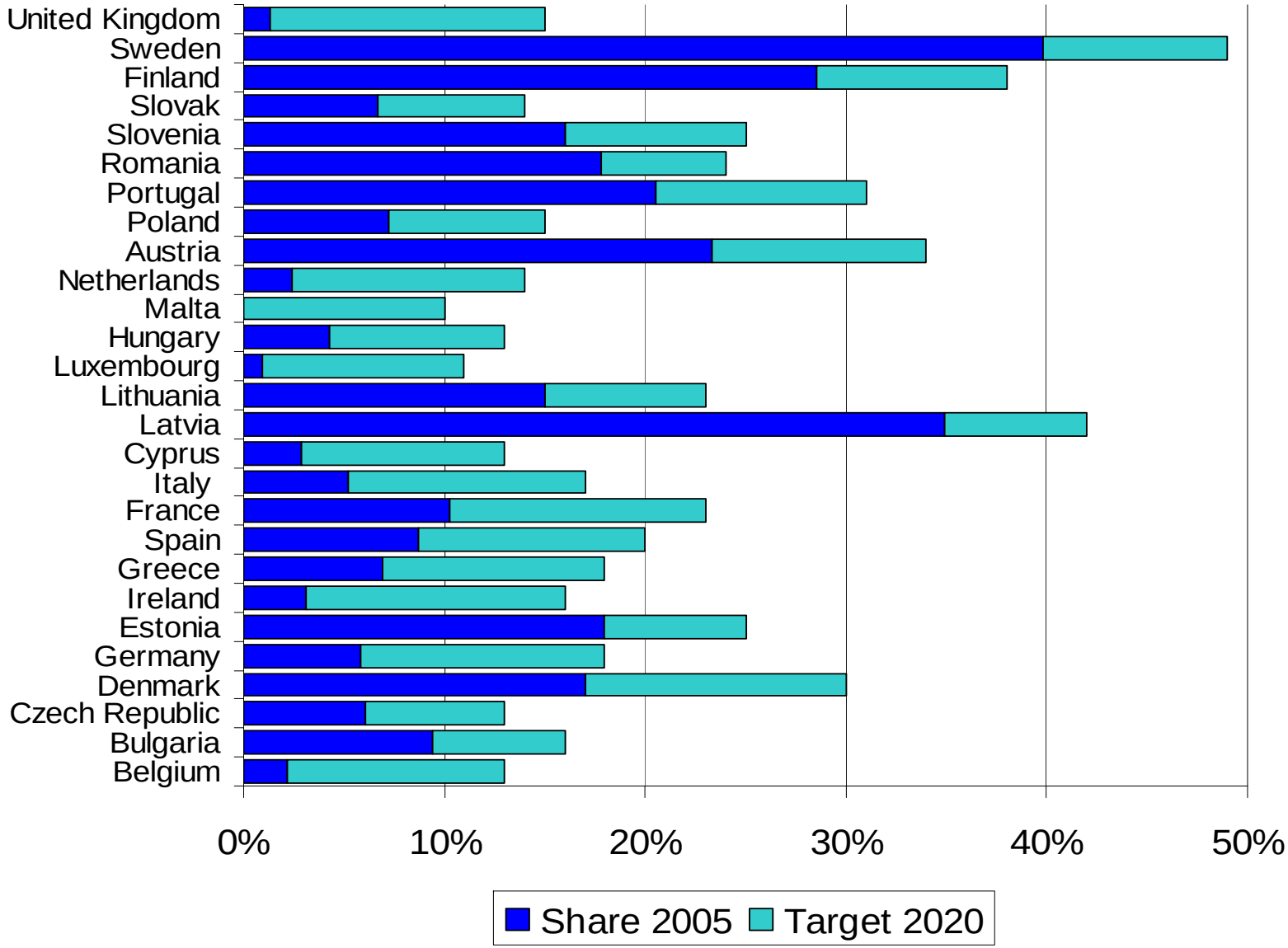
Prices will tend to be reduced more than they are increased

- For the average generator this is not attractive
- For the peak plants this is even less attractive
- But for wind generators this might even be a positive impact as they have high output at times of low prices and low output at times of high prices
- Therefore less variation might even increase the market part of their revenue in combination with better capacity value characteristics

Are the impacts and the options illustrated relevant?

- RES intermittent generation shares are only high in a few countries?
- But already at low shares networks will experience the impacts
- If EU targets are becoming reality the illustrated example might become the average rather than just a Danish extreme
- Therefore identifying a mix of options to mitigate the intermittent effects is vital to have a smooth implementation of the RES targets

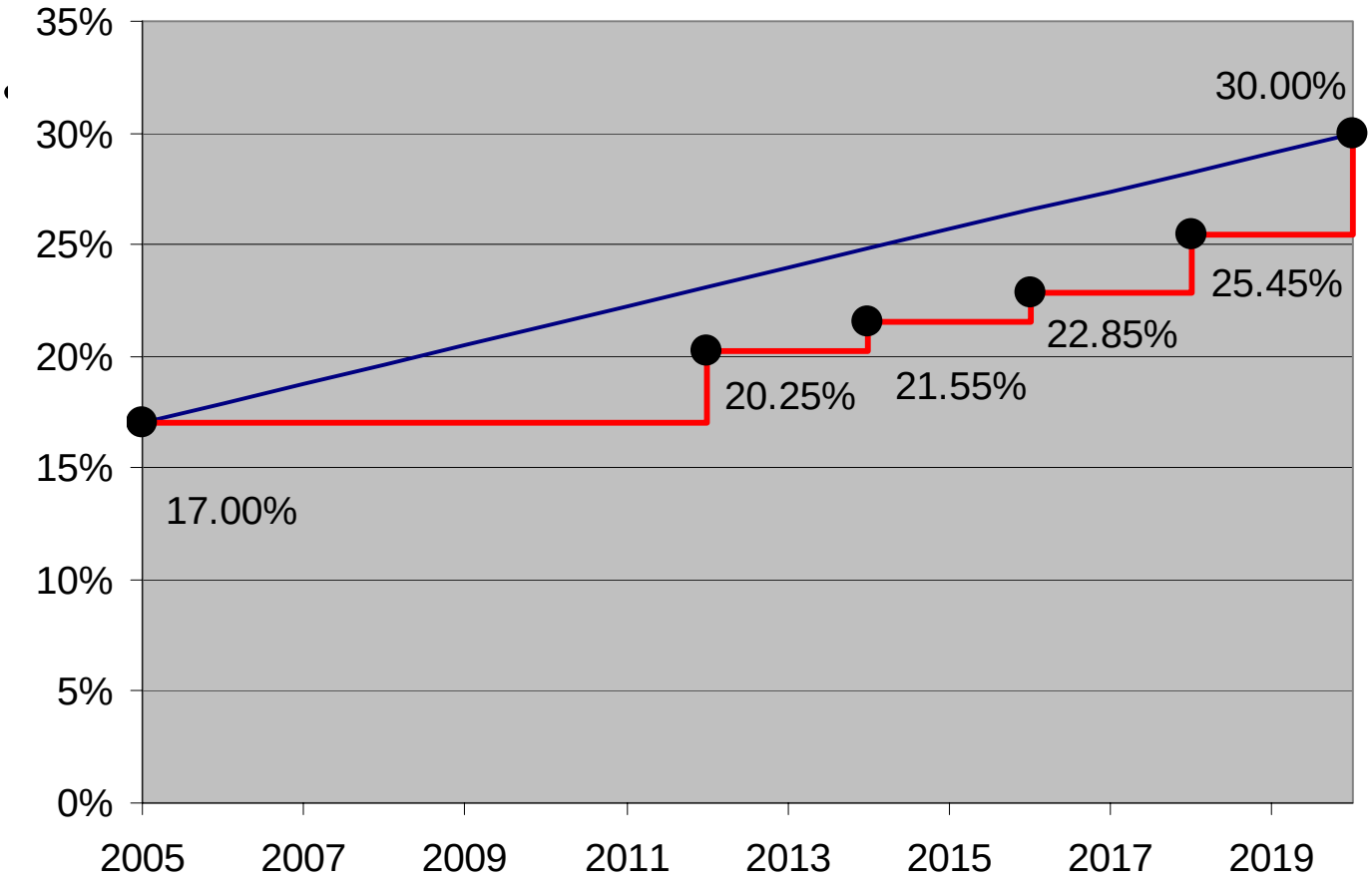
National RE Targets



Timing and options

- First we cannot wait to implement options to 2020 as interim targets are binding
- Different response options are relevant at different time horizons
- Targets are gradually increased up to 2020 – so we must make sure that options implemented in 2015 don't interferes with options planned to be in effect later on.
  - if we build interconnection
  - low prices during night-time to be exploited by hybrid (electric) vehicles will not be available (DK case)

Interim Target for DK



Concluding remarks

- **New EU RES targets will increase the impacts that must be addressed due to high targets**
- **Market price effects of intermittent energy will become larger**
- **A larger share of RES generation will be market based**
- **Variability in intermittent generation could be matched by flexible units in generation mix and cheap storage technologies where available**

  and/or

- **Interconnection and demand response are important options – but they must be evaluated taking account of each other**