Operational costs induced by fluctuating wind power production in Germany and Scandinavia

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Overview of the presentation

1. Calculation of wind integration costs
2. The Wilmar Planning Tool
3. Results
4. Conclusions

Calculation of wind integration costs

- The costs of integrating wind power are calculated by comparing variable system costs in two power system configurations:
  - with wind power production
  - with an alternative power production having “conventional” properties (predictable, less variable)

- The choice of alternative power production is not straight forward and will influence the resulting integration costs!

Calculation of wind integration costs

- Our choice: Three model runs:
  - with stochastic wind power production forecasts
  - with perfectly predictable but still fluctuating wind power production
  - with constant wind power production

- Approach divide operational integration costs into two components:
  - costs related to partial predictability
  - costs related to variability

Main idea behind the Planning Tool

- Improve decision making by using information contained in wind power production forecasts
- Stochastic information: Expected wind power production, but also precision of wind power forecast, i.e. the distribution of the wind power production forecast errors
- Decisions before wind power production is known: Trade on day-ahead market
- Decision after wind power is known (recourse actions): Activation of regulating power

Main idea behind the Planning Tool

- How:
  - Build system-wide stochastic optimisation model with the wind power production forecast as a stochastic input parameter
  - Covering both day-ahead and intraday (regulating power) market
- Consequence: Model makes optimal unit dispatch on these markets that are robust towards wind power production forecast errors.

Why is it relevant?

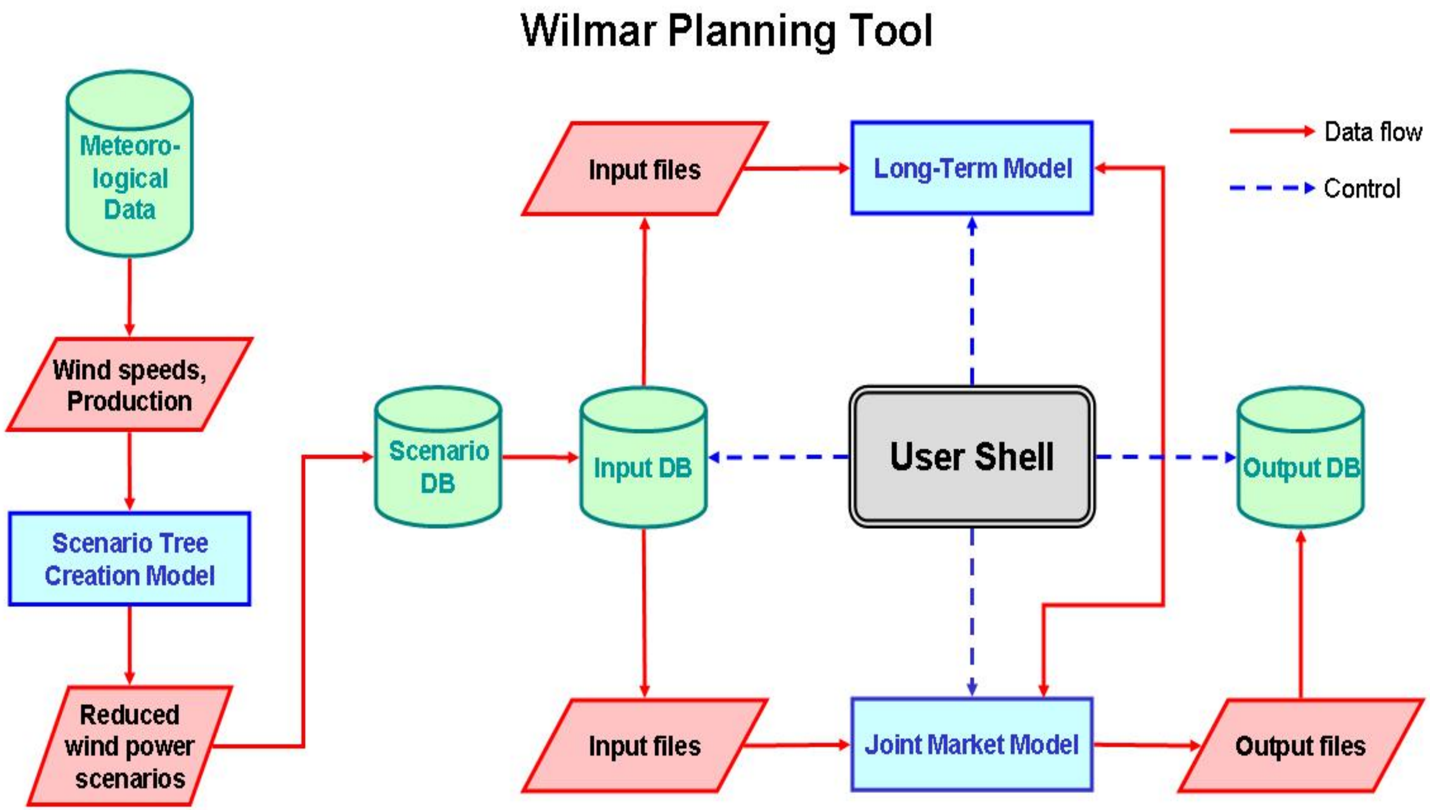
- Planning tool enables the analysis of:
  - Power prices (day-ahead and intraday)
  - Operation patterns
  - Reserve power need
  - Feasibility of integration measures
  - Value of wind power production

- As a function of:
  - Installed wind power capacities
  - Precision of wind power forecasting tools
  - Power system configuration

Framework of the Planning Tool

- Large-scale integration of wind power in a large liberalised electricity system
- Marginal costs determine unit dispatch, i.e. the market power is not analysed → results provide lower bound on real world costs.
- Market structure:
  - Day-ahead market (Elspot at Nord Pool)
  - Intraday market (Elbas at Nord Pool + Regulating power market run by Nordic TSOs)
  - Market for primary (spinning) reserves
  - Market for secondary (minute) reserves
  - Heat markets

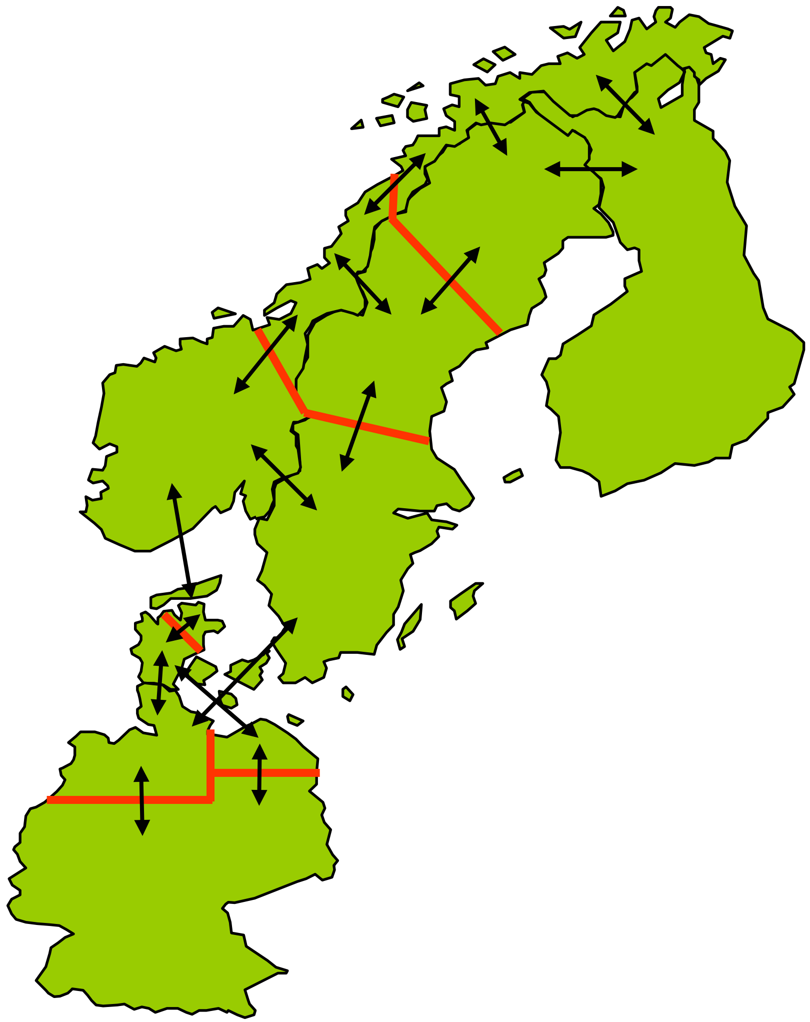
Overview of the Planning Tool



Overview of the Planning Tool

Subdivision of the considered countries into model regions to consider:

- Spatial concentration of the installed wind power
- Spatial distribution of the electrical demand
- Bottlenecks in the transmission grid



Overview of analysed case scenarios (1)

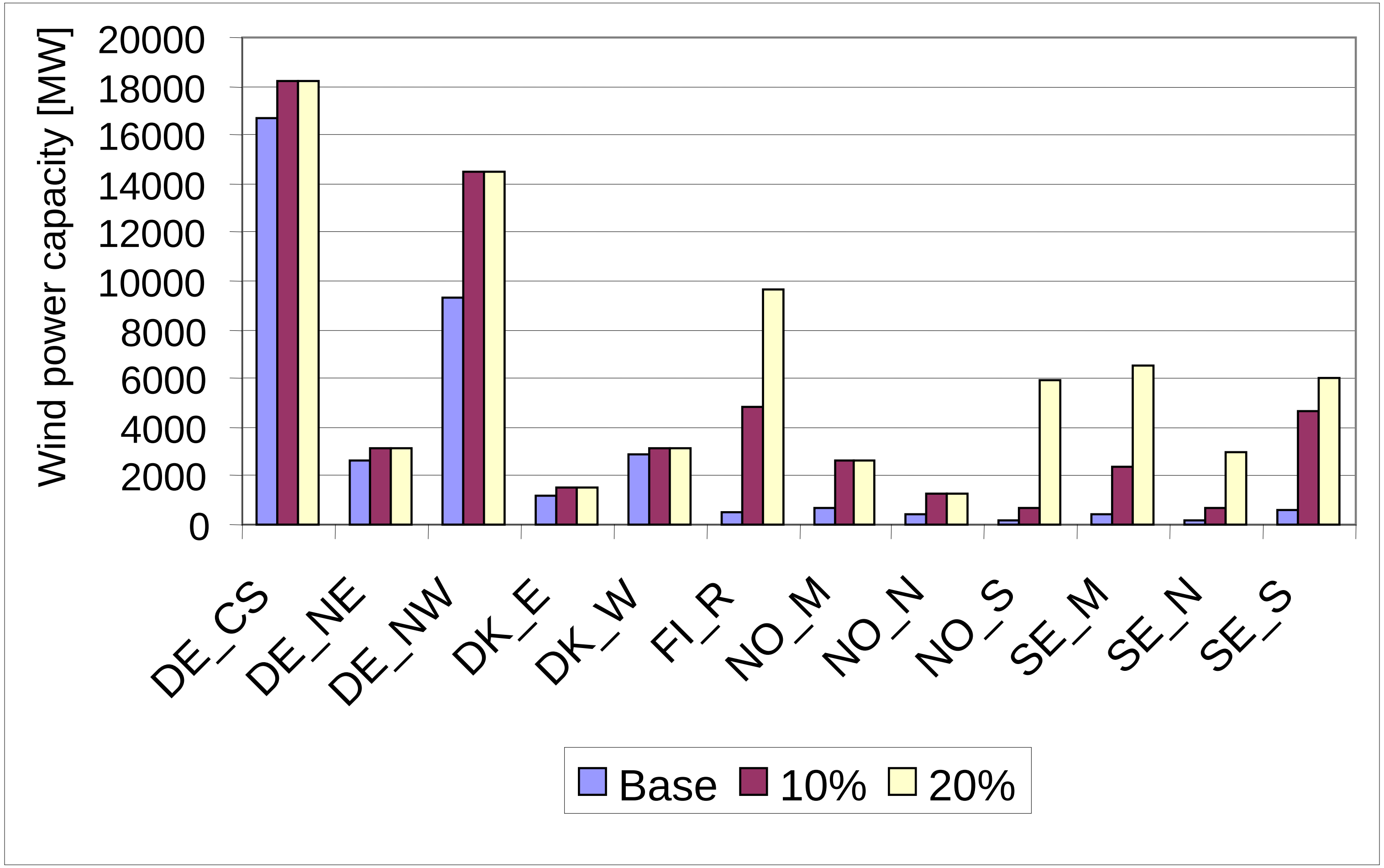
- Consideration of Germany and Scandinavian countries.
- Considered time period: Five selected weeks representing the variation between weeks in wind power production, electricity demand and heat demand determined by using a scenario reduction algorithm
- Time-series are based on the year 2001.
- Base power system configuration for 2010:
  - Already decided power plant investments are included in 2010 (e.g. Finnish nuclear power)
  - Already announced decommissioning of power plants are included
  - New transmission lines: Storebælt 600 MW (DK_W – DK_E), Fennoskan 2 (SE_M – FI), New line between North-western and North-eastern Germany (DE-NW - DE_NE)

Overview of analysed case scenarios (2)

- Base:
  - For all countries, forecasted wind power capacities for 2010 are considered.
- 10 % wind:
  - For Denmark and Germany: Forecasted wind power capacities for 2015 (equal to cover ca. 29 % and ca. 11 % of the annual electricity demand, respectively).
  - For Finland, Norway and Sweden: Wind power capacities equal to cover 10 % of the annual electricity demand.
- 20 % wind:
  - For Denmark and Germany: Forecasted wind power capacities for 2015 (equal to cover ca. 29 % and ca. 11 % of the annual electricity demand, respectively).
  - For Finland, Norway and Sweden: Wind power capacities equal to cover 20 % of the annual electricity demand.

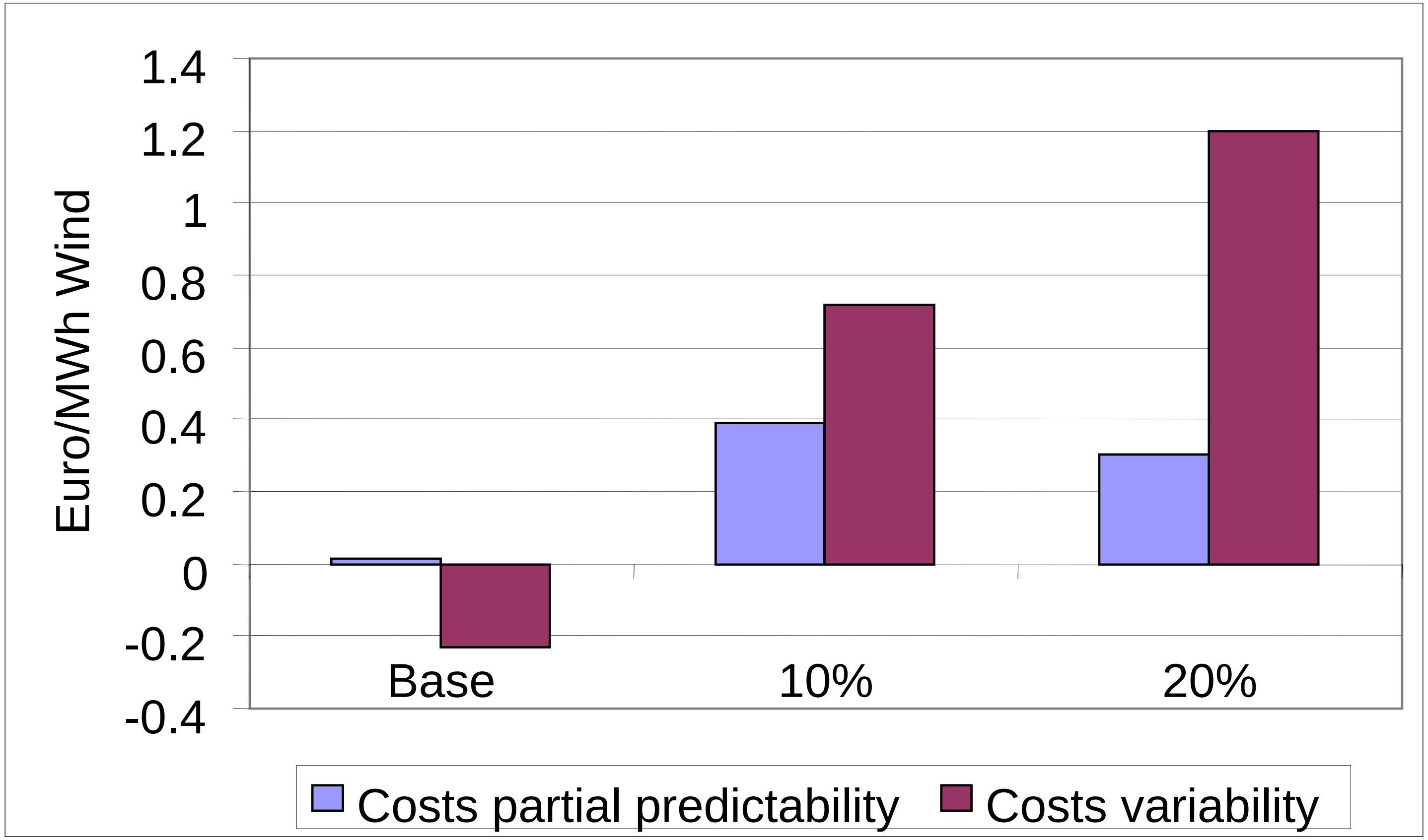
Overview of analysed case scenarios (3)

Resulting wind power capacities for the different case scenarios:



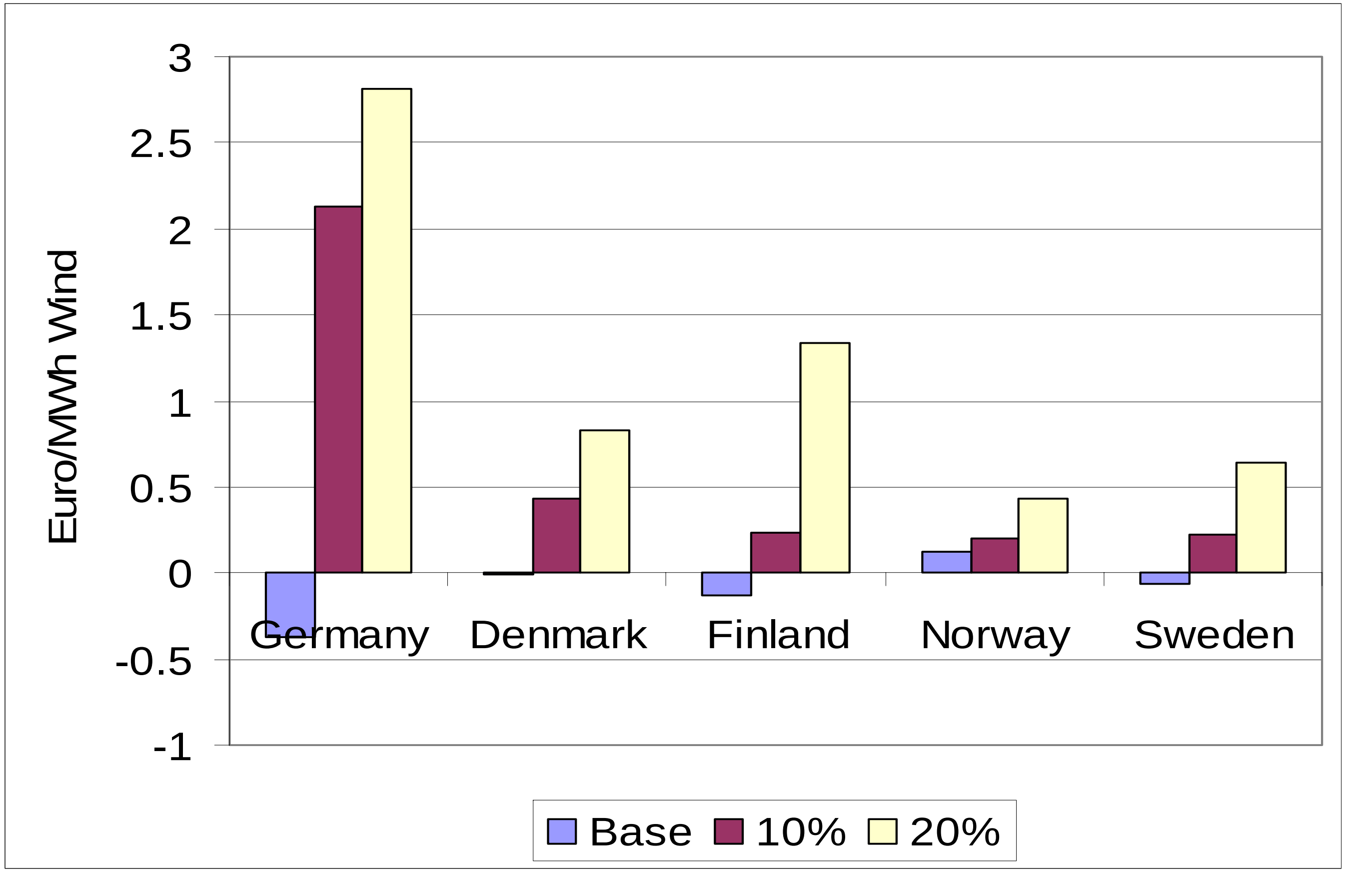
Results (1)

Increase in system operation costs per MWh wind power production:



Results (2)

Increase in system operation costs per MWh wind power production per country:



Results (3)

Ratio between the average wind power production in each wind case and the sum of the transmission capacity to other countries included in the model and the average power demand:

Country	Transmission capacity to other model regions [MW]	Base	10%	20%
Denmark	5050	0.12	0.11	0.09
Finland	2300	0.01	0.11	0.21
Germany	1720	0.08	0.09	0.09
Norway	4220	0.02	0.09	0.15
Sweden	8110	0.01	0.06	0.11

Conclusions

- The wind power integration costs are lower in hydro dominated countries (especially Norway) compared to thermal production dominated countries (Germany, Denmark).
- The wind power integration costs increases when a neighboring country gets more wind power.
- Germany has the highest integration costs although their ratio in Table 1 is among the lowest. The reason is that the wind power capacity in Germany is very unevenly distributed with the model region North-western Germany (DE_NW) having a wind impact ration of 0.31 in wind case 10% and 20%.
- Denmark has the highest share of wind power among the countries, but also excellent transmission possibilities to neighboring countries compared with e.g. Finland. Therefore the wind power integration costs of Denmark are lower than those of Finland in wind case 20%.