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On the market value of wind power

Model analysis of the Central European Power Market

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1. **Introduction**
   - *Motivation*
   - *Parameters influencing the market value of wind power*
2. **Methodology**
   - *Approach*
   - *Modelling wind power price interactions*
3. **Model results**
   - *Sensitivities of market value on analysed parameters*
   - *Wind deployment scenarios*
4. **Future Trends in the CEPM**
5. **Conclusions, Outlook**

Motivation

– **Wind power affects power markets (prices) already today**

– **Literature:** *De Miera et al. (2008), Sensfuß et al. (2008), Munksgaard and Morthorst (2008)*

Findings

(1) Wind power replaces more expensive generation → lowers power price

(2) High wind generation coincides with low power prices and vice versa

Question:

– **What are the implications of (2) on the market value of wind power?**

Literature

Lamont (2008) 'Assessing the long-term system value of intermittent electric generation technologies'

– **Key analytical finding: market value of wind power can be split up in two components**

$$mv = \frac{\sum_{h=1}^{H} (p_{PX,h} \cdot P_{Wind,h})}{\sum_{h=1}^{H} (P_{Wind,h})} \Longrightarrow mv = \boxed{\overline{p_{PX}}} + \boxed{\frac{\mathrm{cov}(p_{PX}, P_{Wind})}{\overline{P_{Wind}}}}$$

with

mv	*market value of wind power*
$p_{PX,h}$	*hourly power price at power exchange*
$P_{Wind,h}$	*hourly wind power generation*
p_{PX}	*power price vector*
P_{Wind}	*wind power generation vector*
$\overline{p_{PX}}$	*base load price*
$\overline{P_{Wind}}$	*mean wind power*

Literature

Lamont A. D. (2008) 'Assessing the long-term system value of intermittent electric generation technologies'

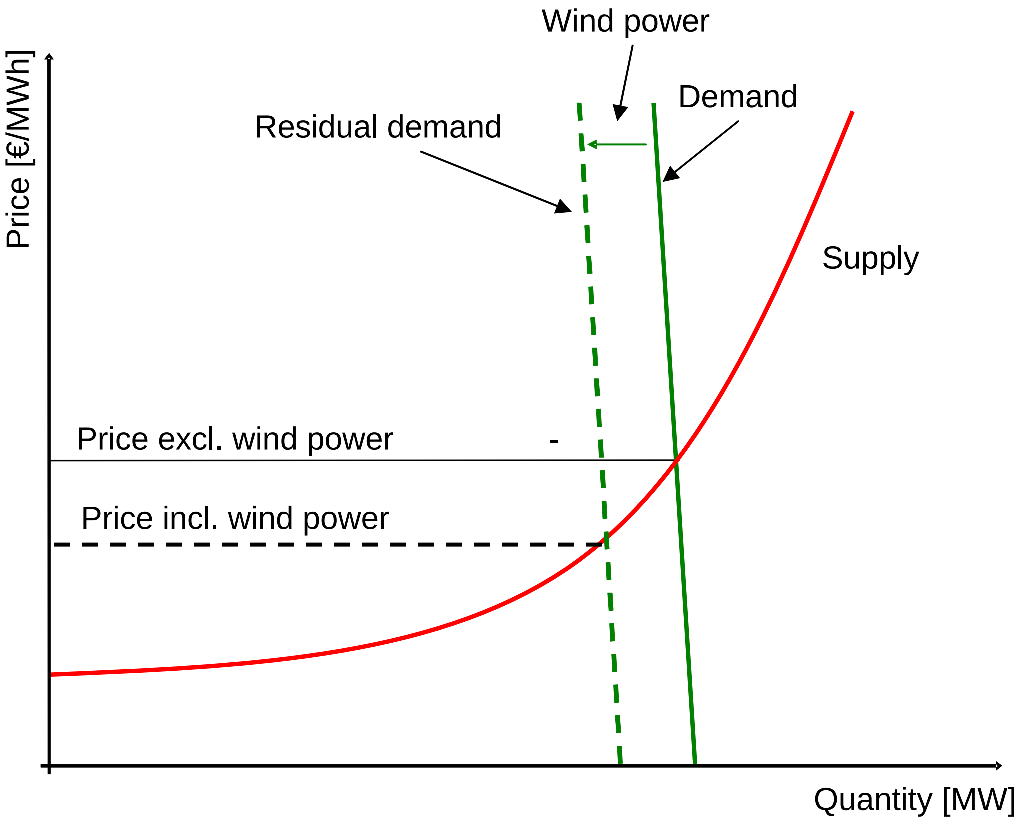
Further findings related to market value:

- **Market value decreases with increasing wind share relative to base load price**
- **Explanation: Decreasing wind power - price covariance**

Questions:

1. **Which parameters are affecting the covariance between wind power and power price?**
2. **Relevance of effect for Central European Power Market (CEPM)?**

Key parameters influencing wind-price correlation



- Wind power share
- Wind power-demand, -supply correlation
- Variability of wind power and demand
- Supply characteristics (supply mix, fuel and CO2-certificate price level and variations)

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Approach

- **Model based analysis**
- **Focus on difference between market value and baseload price**

i. Sensitivity on parameter changes for CEPM

- wind share
- wind demand correlation
- wind variability
- supply characteristics

ii. Country analysis for future wind deployment scenarios

iii. Qualitative assessment of impact of future trends

Modelling wind power - price interactions

Representation of the power market

$$\pi_h = s(Q_{D,res,h})$$

with

π_h	*hourly power price*
$Q_{D,res,h}$	*Hourly residual demand (= demand – wind power)*
s	*Supply function*

Assumptions

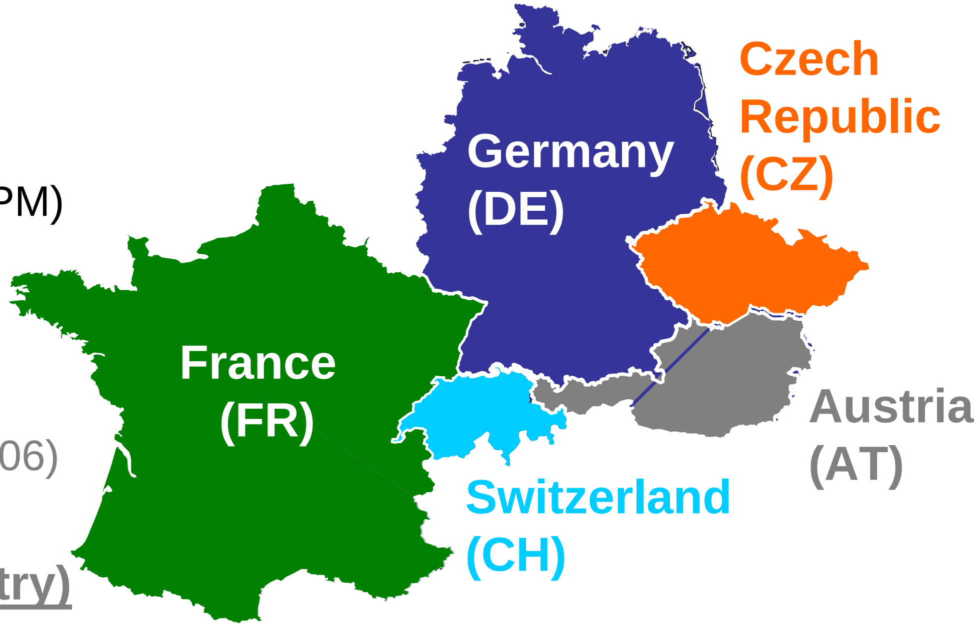
- Static consideration
- Isolated power market
- Perfect competition
- No power plant operation constraints
- No internal congestions

Market value

Baseload technology: $mv_{base} = \overline{\pi_h}$

Wind power: $mv_{Wind} = \overline{\pi_h} + \frac{\mathrm{cov}(\pi_, P_{Wind})}{\overline{P_{Wind}}}$

Framework, Data



System boarders

– Central European Power Market (CEPM)

Reference year

– 2006 (measured data)
– (Simulated wind power data: 2000-2006)

Wind power generation (per country)

– Measured/simulated hourly time series for 2006

Demand (per country)

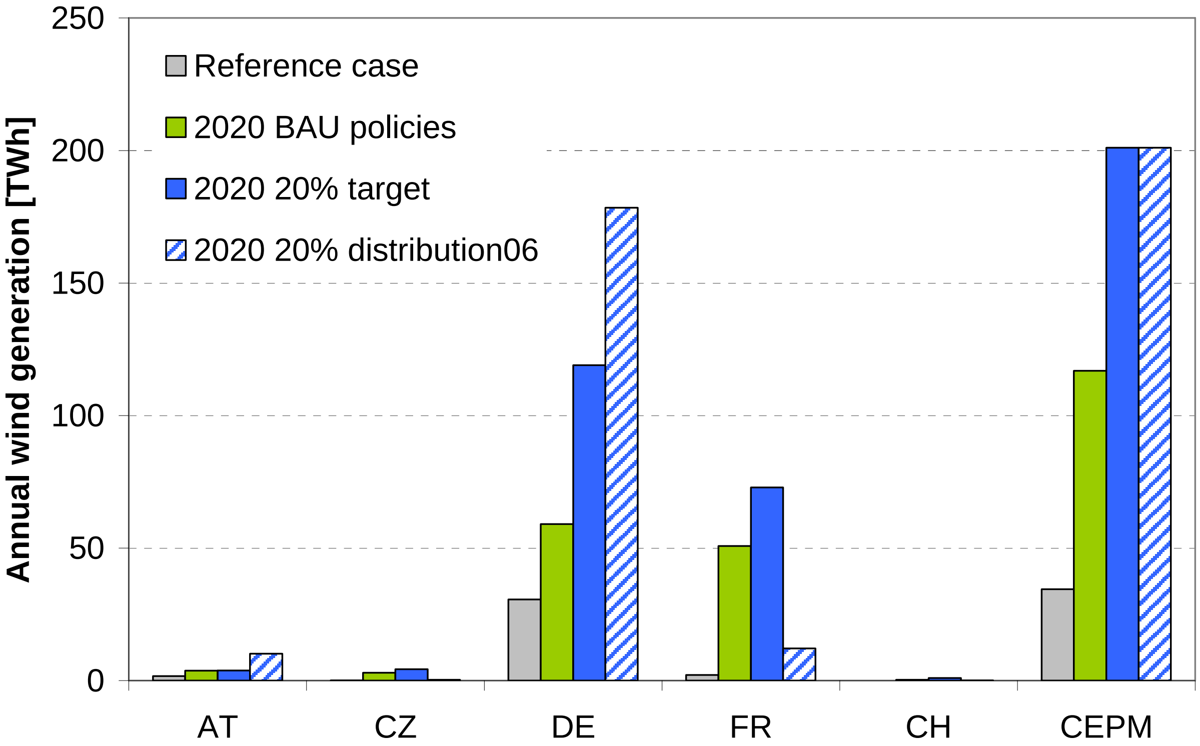
– Hourly time series from UCTE

Supply (for CEPM)

– Average available capacity
– SRMC

Investigated wind scenarios

i. Reference case: 2006 data
ii. 2020 BAU: Current support policies retained until 2020
iii. 2020 20% target: Support policies in line with 20% RE target
iv. 2020 20% distribution06: deployment as for iii) but distribution according to i)



Source:
own scenarios
based on Green-X model
(cf. Resch et al., 2008)

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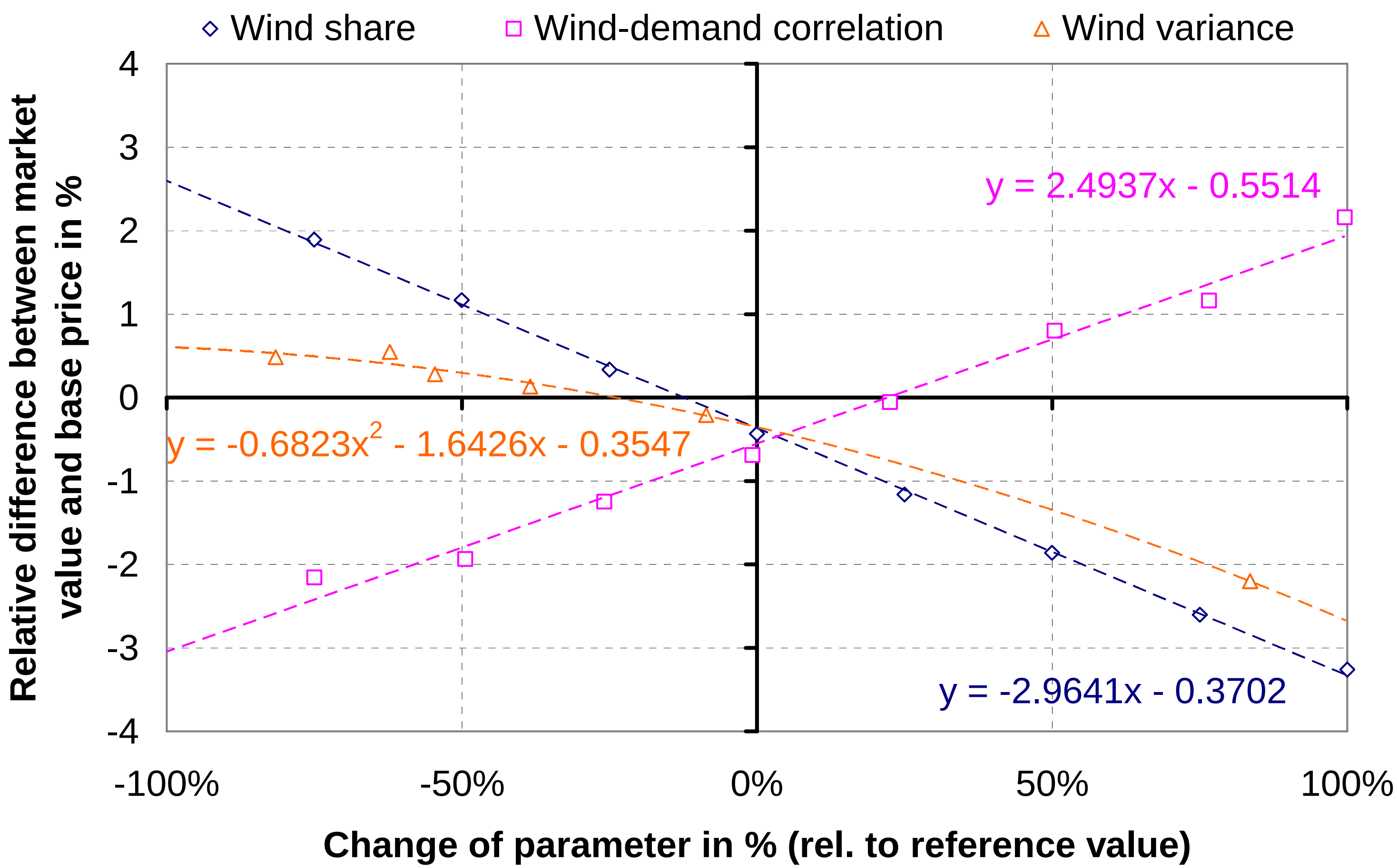
Sensitivity analysis for CEPM (1)

Reference case (2006)

Sensitivity of relative price difference on parameter variations

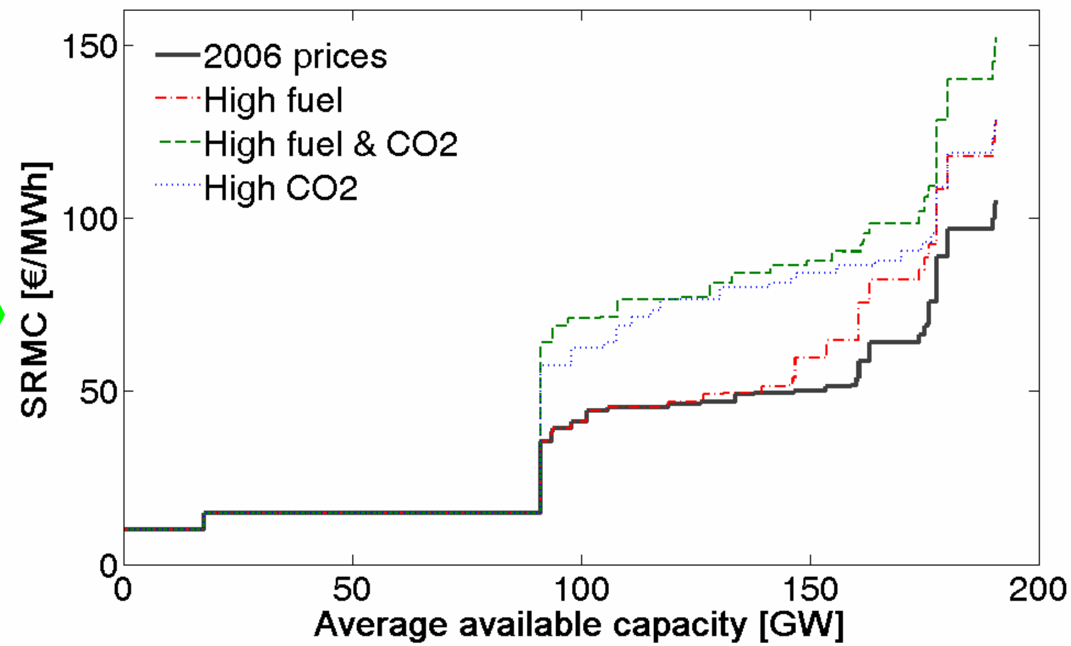


Sensitivity analysis for CEPM (3)

Fuel and CO2-certificate price

Investigated scenarios	**Gas [€/MWh]**	**Oil [€/MWh]**	**CO2 [€/tCO2]**
2006 prices	21.4	32.5	17
High fuel	27.9	41.3	17
High CO2	21.4	32.5	50
High fuel&CO2	27.9	41.3	50

Sources: EEX, BAFA, DG TREN



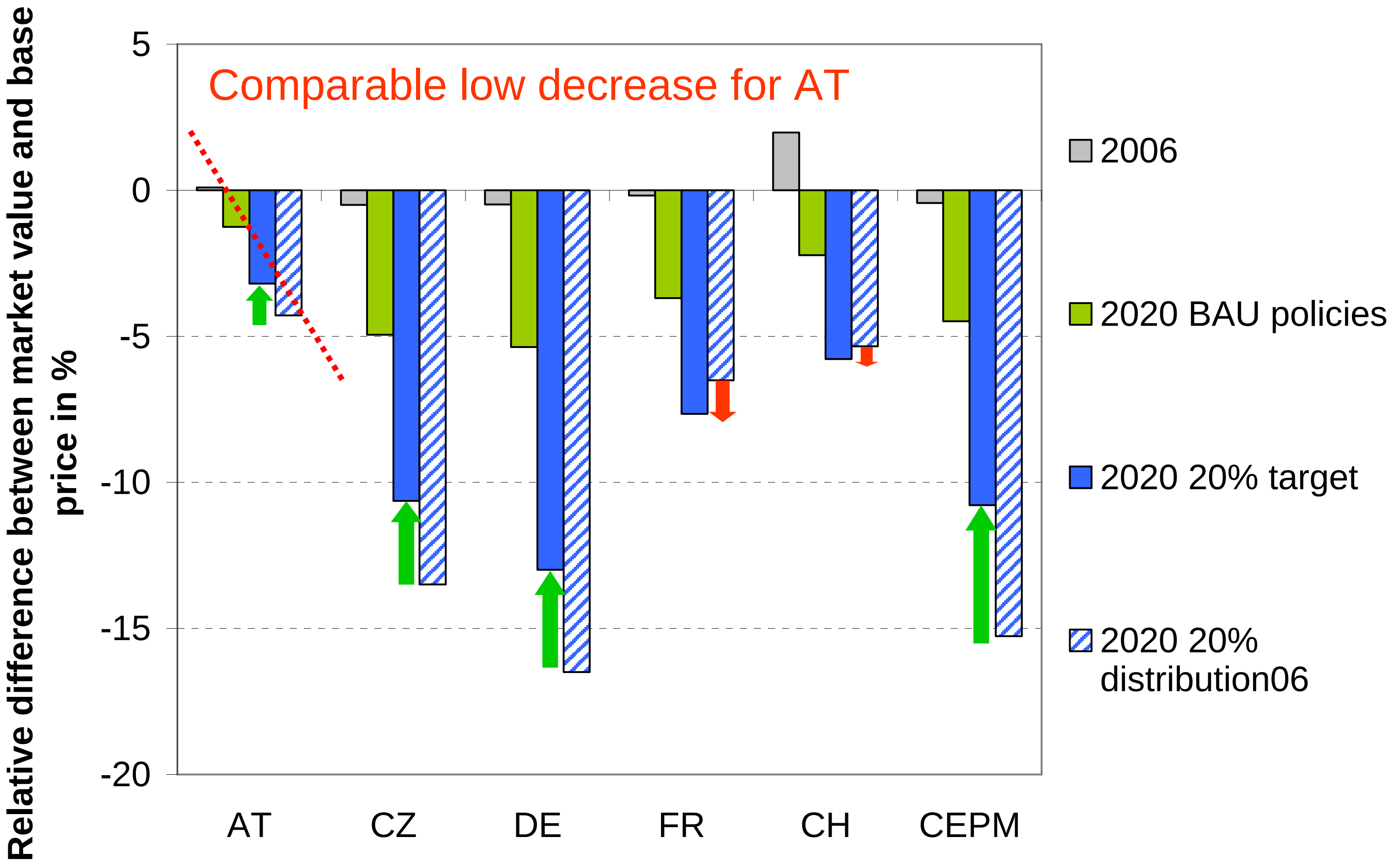
Results

- **2006:** no significant sensitivity
- **2020 20% target:** relative price difference increases from 10.6 to 12.3% for all high price scenarios

Country analysis (1) based on real wind data

Wind scenarios on country level

Relative price difference for different wind scenarios



Country analysis (2) based on real wind data

1. **Low decrease for Austria**

2. **Impact of increased dominance of French wind power (and lower dominance of German wind power)**

Wind scenario 2020 20% target

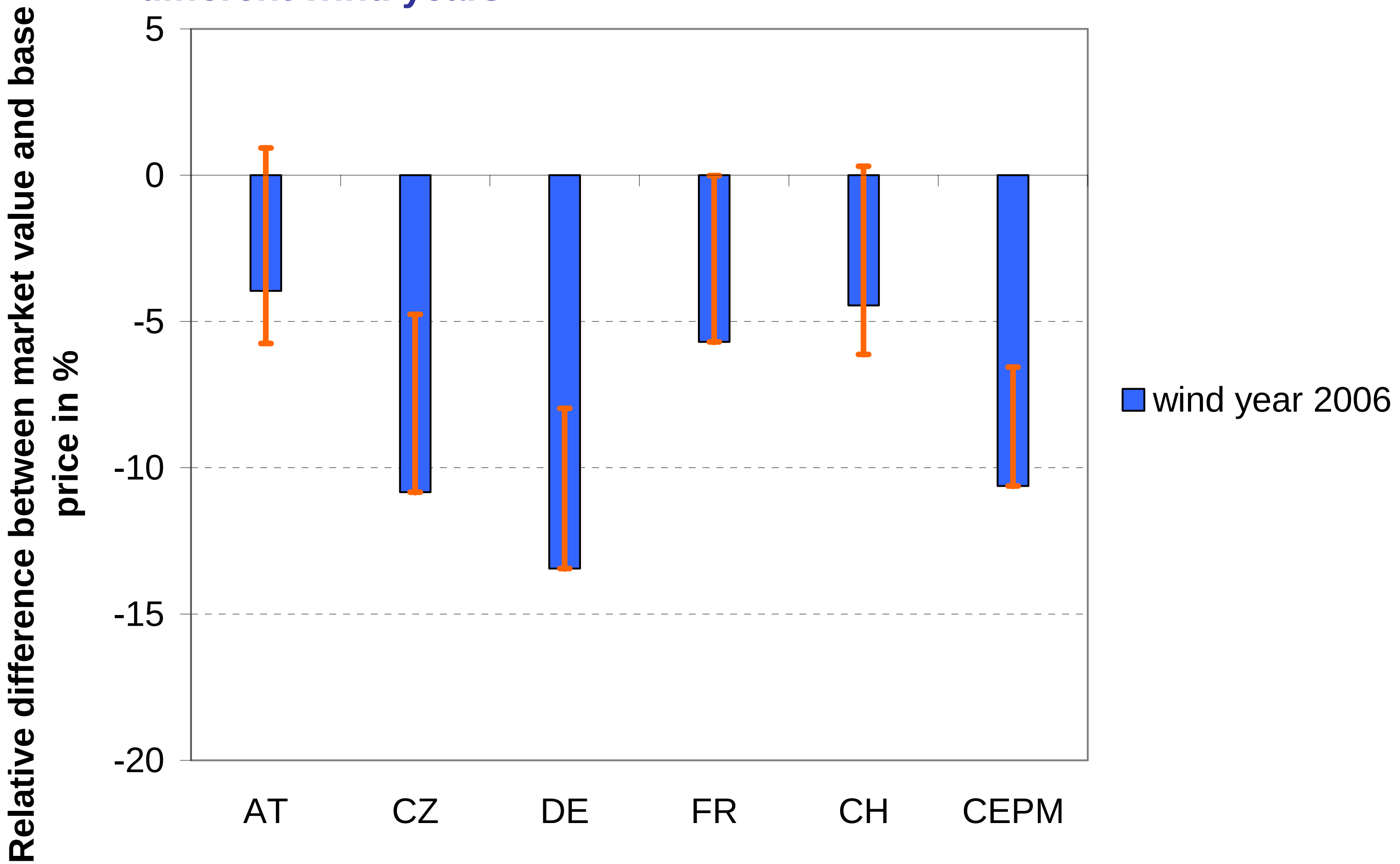
Linear correlation between wind generation

	AT	CZ	DE	FR	CH	CEPM
AT	1.00	0.44	0.20	0.12	0.18	*0.23*
CZ	0.44	1.00	0.73	0.32	0.39	*0.69*
DE	*0.20*	*0.73*	*1.00*	*0.51*	*0.38*	*0.95*
FR	*0.12*	*0.32*	*0.51*	*1.00*	*0.57*	*0.75*
CH	0.18	0.39	0.38	0.57	1.00	*0.51*
CEPM	0.23	0.69	0.95	0.75	0.51	*1.00*

Country analysis (3) based on simulated Tradewind data

Wind scenarios on country level

Relative price difference for the 20% target scenario for different wind years



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Qualitative assessment of future trends

Effect of parameter increase on	base load price	price difference base - MV	MV of wind power
Demand	+	↓	++
Storage capacity	– 1)	↓	o2)
Wind capacity	–	↑	- -
Wind offshore share	o	↓	+
Geographic wind power distribution in CEPM	o	↓	+
Fuel price	++	↑	+
CO2 certificate price	++	↑	+

1) under assumption of a convex supply curve
2) simulation results indicate a slight decrease for both base price and price difference

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Conclusions

- Base load price no proper indicator for significant wind shares
- Market value will vary considerably between countries
- Modify Feed-In Tariff schemes in order to reflect the market value of wind power
- Increasing incentive to utilise second best potentials having low correlation with overall wind power generation

Outlook

Future work necessary to increase reliability of quantitative results:

- **Improvement of data base**
- **Improvement of model representation of CEPM**

Thank you for your attention

Further information / questions:

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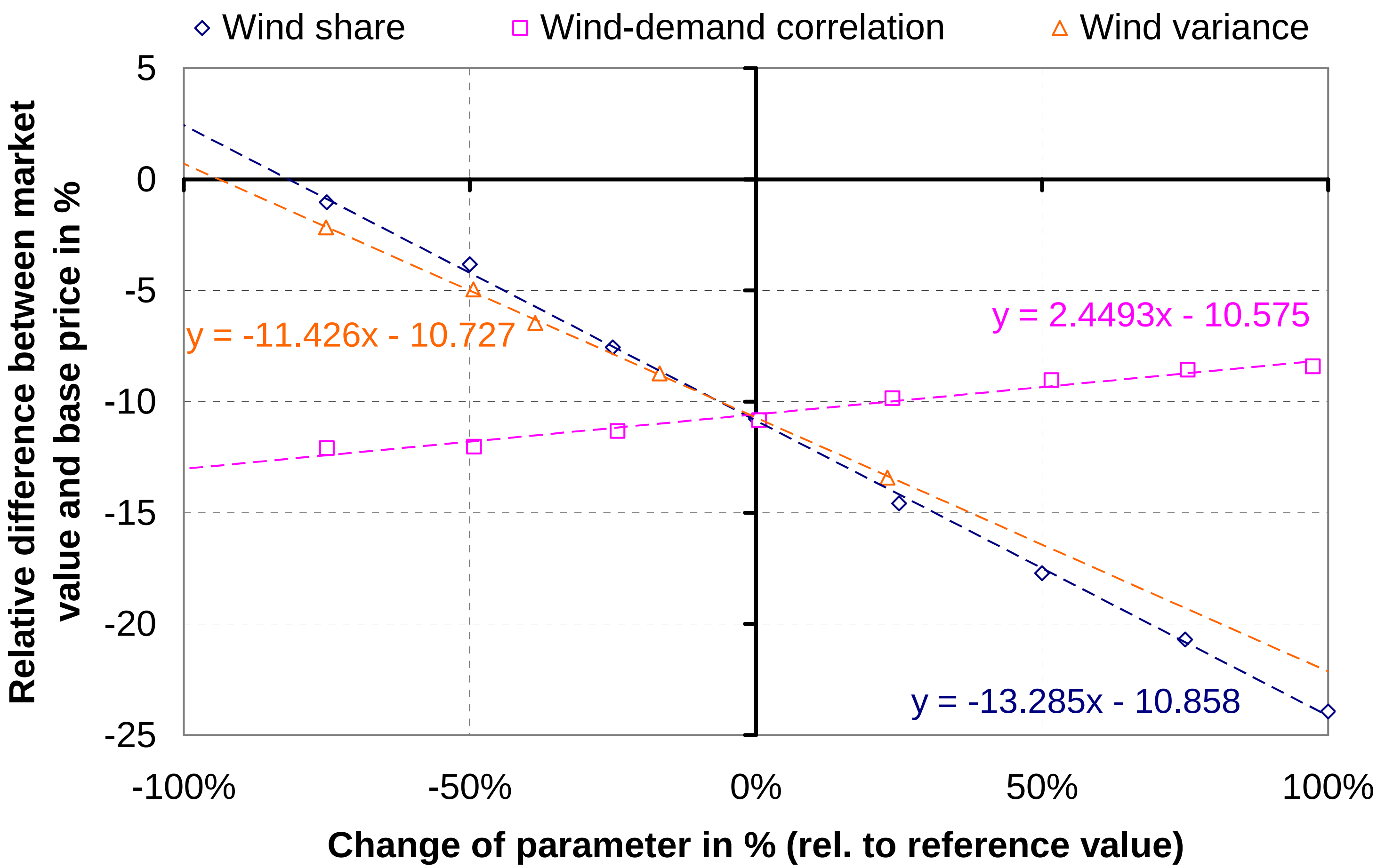
Sensitivity analysis for CEPM (2)

Wind scenario 2020 20% target

Sensitivity of relative price difference on parameter variations



Future trends of analysed parameters (1)

1. **Wind share**
   - Significant increase of wind generation:
     20% RE scenario in 2020 (Resch et al., 2008): appr. 200 TWh
   - Increase of electricity demand:
     Up to 30% for 2020 depending on efficiency improvement

   Expected trend: increasing wind share

2. **Wind power variability**
   - Better geographic distribution of onshore wind sites within CEPM
   - Increased offshore share (Bremen et al., 2006)

   Expected trend: decreasing variability

Future trends of analysed parameters (2)

3. **Wind power - demand correlation**
    - 2006: low and positive (0.05-0.14)
    - 2020: no significant change for CEPM
    - Increased storage capacity?

Expected trend: depends on storage capacity and operation

4. **Supply characteristics**
    - Short term: price developments (fuel, CO_2)
    - Medium to long term: Change of supply mix

Expected trend: broad bandwidth of future scenarios