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VŠE
P R A H A



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WHAT IMPACT DO THE NEXT-DAY RES PROJECTIONS HAVE ON THE ENERGY MIX?



- Last 20 years brought many changes
 - Shift from state-owned monopoly to deregulated structures
 - Market dynamics more complex
 - Characteristics of electricity as commodity
 - Nearly instantaneous
 - Restrictions on transmission
 - Demand is inelastic (short-term)
 - Interesting how these developments affect prices on the electricity market





INTRODUCTION – PROBLEM STATEMENT

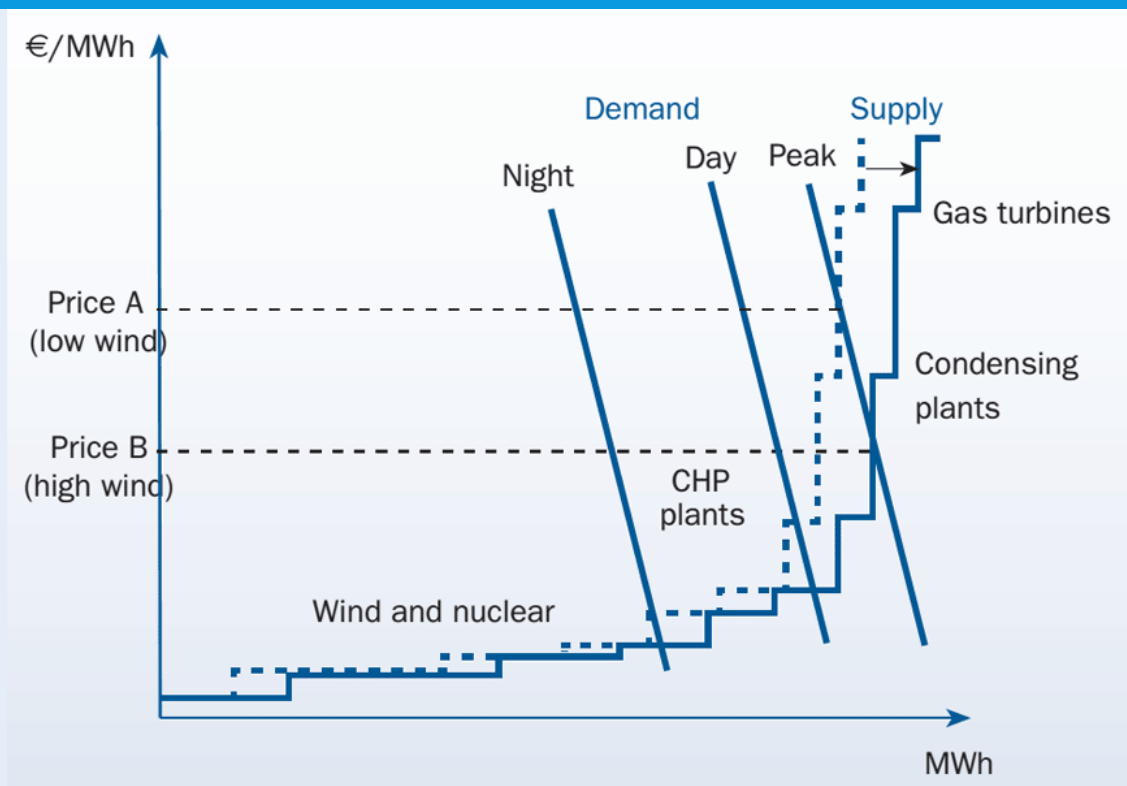
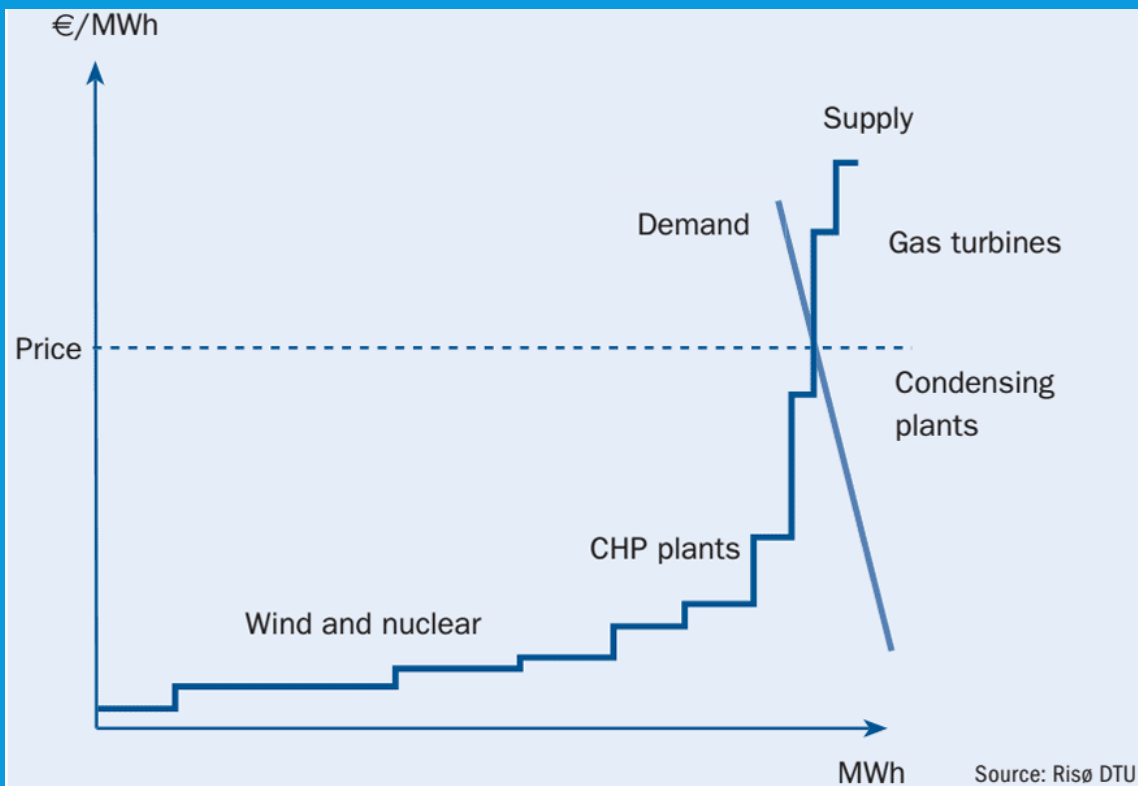


- Examining the day-ahead forecast for RES in DE
- Effect on the spot-market price
- RES are a price maker
- Wind and solar energy production is highly variable

- What impact do the next-day projections on RES availability have on the energy mix?
- What differences have to be considered in the structure of the markets in CZ and AT (With respect to trade from DE)?



INTRODUCTION – RES EFFECT ON MERIT-ORDER



- Hourly spot market data for 2013
 - Wholesale electricity markets from DE, AT, CZ
 - Data from EPEX, EXAA, and OTE/PXE
 - Next-day and day-ahead prices
- Historical hourly data for wind and solar
 - Next-day projections
 - Actual production
 - Expected grid load
 - Actual grid load



- Using two illustrative case studies
 - How does the market behave with respect to RES production
- Time series analysis
 - Austria – R
 - Czech Republic – Stata

RESULTS – CZECH REPUBLIC

- Spot price is highly correlated to RES production (~ 93%)
- Wind and solar have an effect on lowering the price of electricity
 - High production of variable res means lower market price
- Multiple regression equation was formulated

$$\begin{aligned} & \textit{Spotprice}_{GER} \\ &= \beta_0 + \beta_1 \textit{Spotprice}_{GERT_1} + \beta_2 \textit{Spotprice}_{GERT_2} + \beta_3 \textit{Windproduction}_{GER} \\ &+ \beta_4 \textit{Photovoltaicproduction}_{GER} + \beta_5 \textit{Allowences} + \beta_6 \textit{Coal} + \beta_7 \textit{Gas} \\ &+ \beta_8 \textit{Consumption}_{GER} + \varepsilon \end{aligned}$$

- One more MW from PV power plant → spot price -0.0007 €
- 6217 MW (real PV production in Jan 2013) → spot price -4.9€
- One more MW from wind power plant → spot price -0.0015 €
- 15,175 MW → spot price – 23 €

Source	SS	df	MS				
Model	2145334.15	8	268166.769	Number of obs = 8758			
Residual	227136.18	8749	25.9613876	F(8, 8749) =10329.45			
Total	2372470.33	8757	270.922728	Prob > F = 0.0000			
				R-squared = 0.9043			
				Adj R-squared = 0.9042			
				Root MSE = 5.0952			

Spotprice_GER	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
Spotprice_GER_T1	.9270143	.0102447	90.49	0.000	.9069323	.9470963
Spotprice_GER_T2	-.3449067	.008422	-40.95	0.000	-.3614159	-.3283975
Consumption_GER	.0005772	.0000103	55.98	0.000	.000557	.0005974
Windproduction_GER	-.0006112	.0000143	-42.66	0.000	-.0006392	-.0005831
Photovoltaicproduction_GER	-.0004521	.0000126	-35.74	0.000	-.0004769	-.0004273
Allowences	.8866638	.0851966	10.41	0.000	.7196585	1.053669
Coal	.001726	.0087655	0.20	0.844	-.0154564	.0189084
GAS	.1394607	.0307462	4.54	0.000	.0791908	.1997305
_cons	-17.83666	1.140829	-15.63	0.000	-20.07295	-15.60036

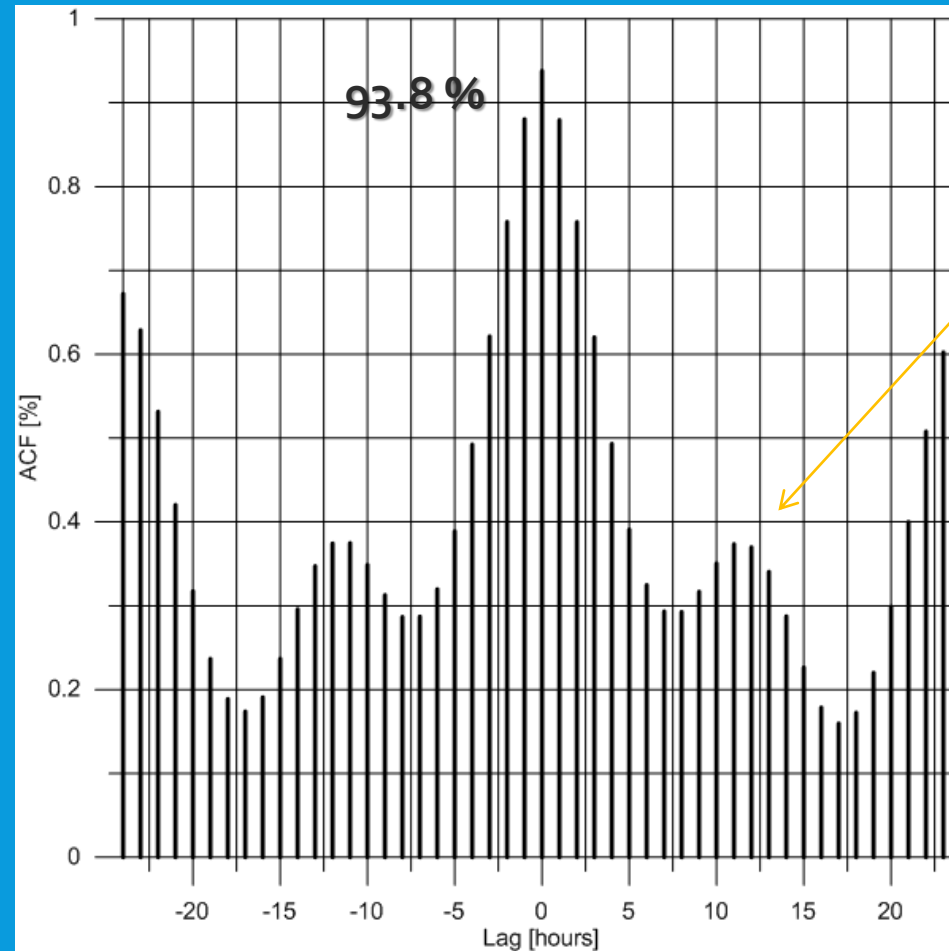
RESULTS – CZECH REPUBLIC

- In CZ RES decrease rentability of conventional energy producers
 - Mainly coal power will be affected (long-term)
 - Gas can be used to fill „gaps“ and is not that critical (high MC)
- Base load electricity production will be affected
 - Nuclear is cheap, because of low MC
 - Hard to adapt to grid load fluctuations (has to be levelled out by other producers)

- Germany is the biggest supplier of RES in Europe
- Austria mainly imports energy from DE and CZ
 - Quite saturated with respect to hydropower
 - Wind production was strongly developed, potential for solar (costly)
- Important role of transnational market dynamics
 - Interconnectivity (EU₄: DE, AT, CH, FR)
 - With respect to DE: grid congestion problem (last 10 years)
 - Stronger interconnectivity alone is not the solution

Austria market is very small (EXAA trade volume is about 3.2% from EPEX)

Strong influence of German market



We see already some stationarity (here: per day basis)

Fluctuation through RES production

Solar next day
correlates with diurnal
price development

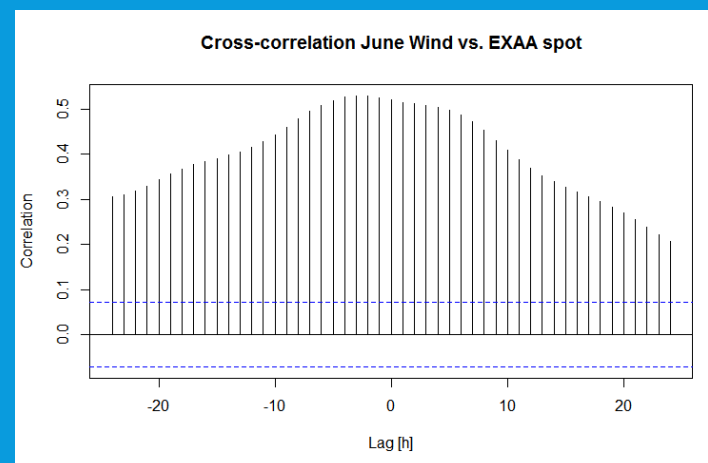
```
Call:
lm(formula = diff(solDec1std) ~ diff(-tsEXAADec1std))

Residuals:
    Min       1Q   Median       3Q      Max
-1.55993 -0.09173 -0.01490  0.06936  1.94781

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)   -5.266e-05  1.569e-02  -0.003    0.997
diff(-tsEXAADec1std)  2.338e-01  4.360e-02   5.363  1.1e-07 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4276 on 741 degrees of freedom
Multiple R-squared:  0.03736, Adjusted R-squared:  0.03606
F-statistic: 28.76 on 1 and 741 DF, p-value: 1.097e-07
```

CCF for wind shows
correlation of 52%
(Time series and wind
next-day).



RESULTS – COMPARISON

- Our research indicates that
 - AT has more possibilities to cope with RES fluctuations
 - AT is a rather small market which is highly shaped by Germany
 - CZ there are two pathways
 - Either further integrate market to increase interconnectedness
 - No mid-term integration to avoid negative effects on the national grid
- DE will affect electricity markets in whole Europe (comparison with other studies)
 - If a highly interconnected European grid is desirable a decentralised, resilient and manageable grid is crucial
 - Otherwise there will be negative effects due to congestion and variability

- Spot-market price is highly influenced by RES availability
 - Next-day projection errors can lead to large price deviations
 - Deviations especially large if cumulated error of RES projection and grid load
 - Market can level out such fluctuations (up to a certain point)
- Grid resilience is crucial, because future RES development is projected to increase
 - EU2020 goals and farther
 - Decentralisation where possible
 - Development of bulk electricity storage possibilities
- Generally our results are in line with other recent publications (other countries)