Variability and Unpredictability of Wind Energy as challenges for European system and market operation

Paris
6 June 2008

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Overview

1. Introduction

2. Market Design in selected European Countries

3. Key issue: Intraday Markets

4. Key challenge: Liquidity

5. Final Remarks

Motivation

- Increasing share of Renewable Energy Supply

- Notably strong increase in fluctuating, supply-dependent electricity production, i. e. Wind Energy

→ Challenges for operation of grids and power plants

Overview over major European systems and markets

Country	Grid operator(s)	Market Operator	National Consumption (2007)
France	RTE	Powernext	480 TWh
Germany	RWE Transportnetz Strom E.ON Netz Vattenfall Transmission EnBW Transportnetz	EEX	556 TWh
Nordic Countries	Statnett Svenska Kraftnaet Fingrid Energinet.dk	Nordpool	395 TWh
Spain	REE	OMEL	268 TWh
UK	National Grid	APX UK	373 TWh (2006)

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General alternatives for interaction between grids and markets

- ISO model
  - System operator is responsible for market and grid
  - Mandatory Power pool
  - System optimization by ISO covering both power plants and grid usage
  - Most prominent example: PJM

- Power exchange model
  - Separated responsibilities: grid operators and power exchanges
  - Trading both bilaterally and through Power Exchange
  - Decentralized optimization by market participants
  - Grid operation based on submitted schedules and management of deviations
  - Nowadays used in all liberalized European markets

Advantages and Disadvantages of the Power Exchange Model

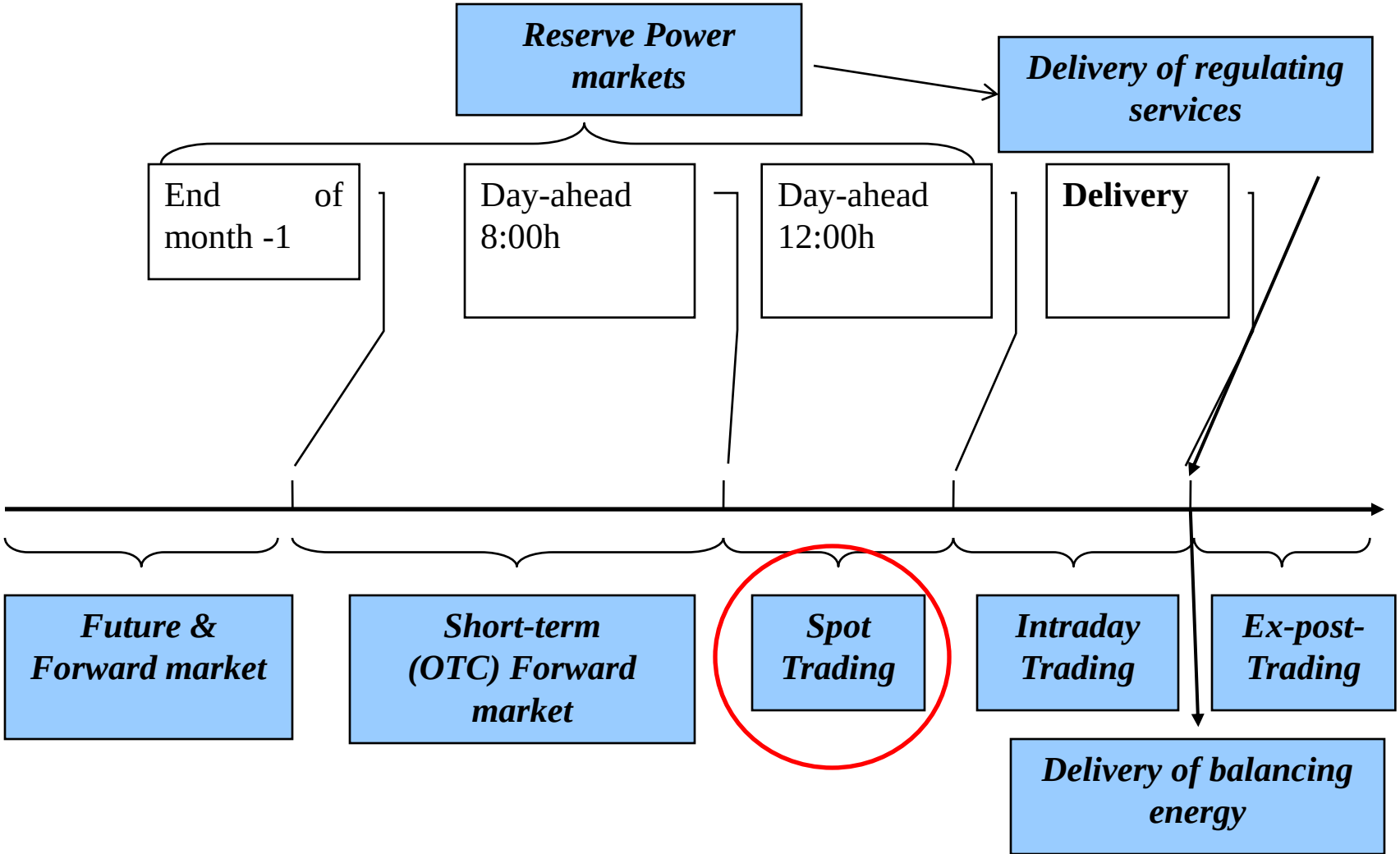
Cons

- Market operation does not fully reflect technical constraints
  - Nodal pricing hardly possible
- Coordination efforts between power exchanges and grid operators necessary
- Lower liquidity in the power market
- Decentralised optimization may result in inefficient resource use

Pros

- Decentralised optimisation provides opportunities for innovations
- Market incentives to avoid inefficient market designs
- Larger market zones less prone to excercise of market power
- Derivative markets easier to establish
- Market prices more easily provide right incentives for investment in generation

Trading possibilities in power markets (Example: German Market)



Spot market characteristics

Country	Market Operator	Spotmarket gate closure	Exchange traded Spot volume (2007)	Share of national consumption
France	Powernext	11:00 day-ahead (7 days per week)	44 TWh	9 %
Germany	EEX	12:00 day-ahead (Mo-Fr)	123 TWh	22 %
Nordic Countries	Nordpool	12:00 day-ahead (7/7)	291 TWh	74 %
Spain	OMEL	10:00 day-ahead (7/7)	195 TWh	73 %
UK	APX UK	60 min before delivery (7/7)	10.6 TWh	3 %

General observations

- Liquidity is in general limited – less than 25 % of the consumption
  - But last years have seen an increase in liquidity in many markets

- Exceptions to the rule:
  - Nordpool: Long Trading History and Obligation to use the Pool for Cross-Zonal Trades
  - OMEL: Capacity payments in the past only for Trades over the Pool

Market Design Spot markets

Two basic alternatives

- Continuous Trading
  - APX UK
- One-time Auctioning
  - Nordpool
  - Powernext
  - EEX
  - OMEL
- In fact EEX and others also offer opportunities for continuous trading, yet hardly used

Alternative Spot Market Designs

Pro Continuous Trading

- Gate closure much closer
- New Information can be used continuously

→ In principle better suited for wind integration

Pro Single Auction

- Concentration of Liquidity
- Also Complex Bids may be supported by market design
- Observed higher Liquidity in Auction markets
- Coherence with traditional planning mechanisms (day-ahead planning) in utilities)
- Preference of market participants for auction in those markets with choice

Wind Power Integration – Depending on Support Scheme

- Feed in tariffs:
  - Wind farm operators deliver wind energy to the grid operators
  - Grid operators deliver energy to the market
  - Grid operators are in charge of wind variability and impredictability
    - Not only at the technical level
    - But also at the commercial level
- Renewable quota, bonus and investment subsidy systems:
  - Wind farm operators deliver wind energy to the market
  - Wind farm operators are in charge of wind variability and impredictability
    - at the commercial level
  - Grid operators are only in charge of (short-term) deviations between wind schedules and actual wind intake
    - only at the technical level

Wind Power Integration – Current Status

- Majority of EU member states has implemented a feed-in tariff system

- Notable exceptions:
  - UK: Renewable obligation certificate system
  - Sweden and Norway: Green certificate system
  - Denmark: Investment subsidies for off-shore wind, premium for on-shore wind
  - Spain: Feed-in tariff with possibility to opt for market participation + premium

- EU-commission:
  - Pushes towards Europe-wide certificate system for renewables
  - Yet national exceptions are allowed

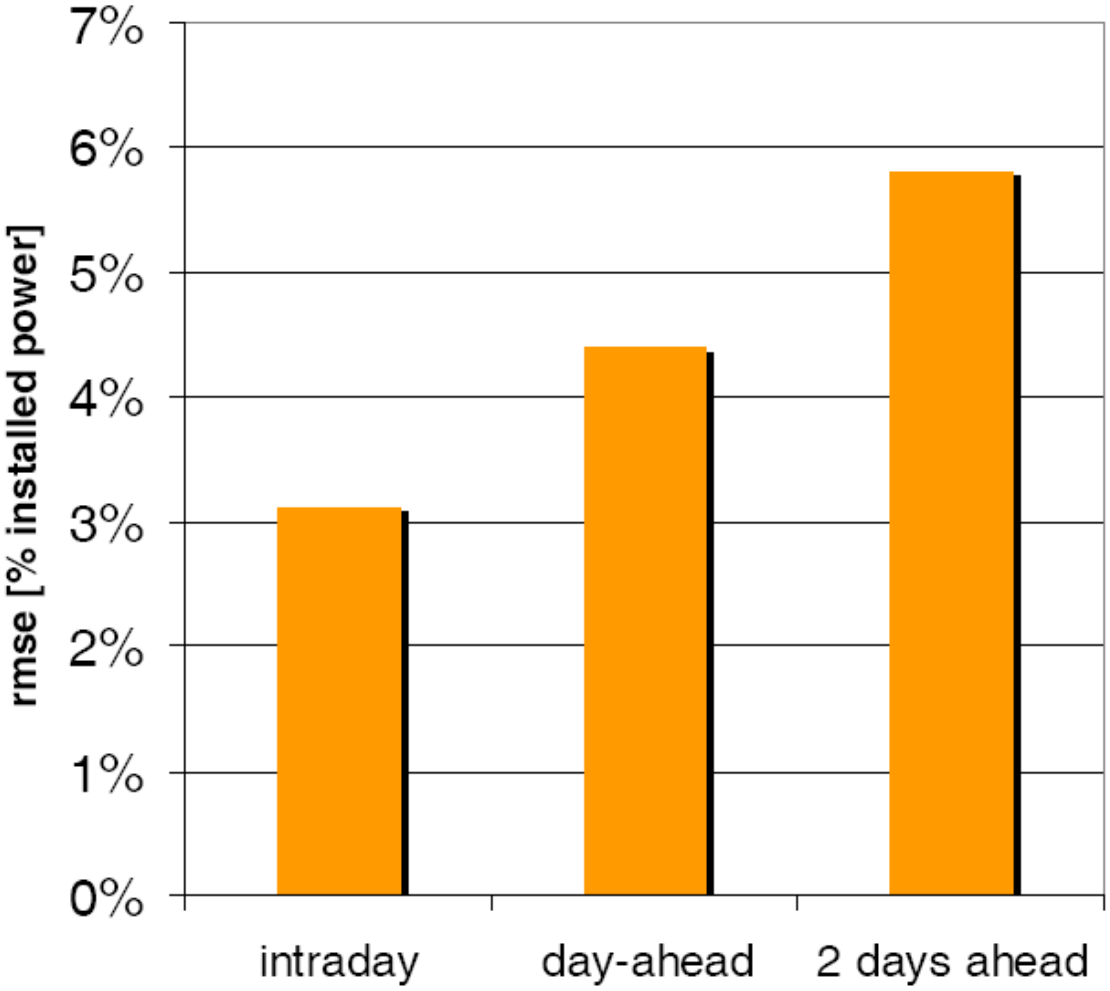
Wind Integration - Perspectives

- In the longer run increased market integration necessary
- In the medium term no market entry without subsidies

→ With all support schemes, somebody has to take the responsibility of and pay for wind variability and impredictability

→ Focus here not on who but on how

Limited wind predictability



Source:
Lange, Focken (2008)

Limited wind predictability - implications

- Variability known up to gate closure can be taken into account by spot markets

- Prediction error at time of spot market closure
  - 4 % - 5 % of installed capacity
  - i. e. 20 % of average wind production

- Intraday market helps reducing prediction error
  - 3 % of installed capacity
- Remainder has to be dealt with by regulating power
  → Charged as imbalance cost

→ What can be done through intraday markets?

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Intraday market characteristics

Country	Market Operator	Gate closure	Exchange traded Spot volume (2007)	Share of national consumption
Germany	EEX	75’ before delivery	1.6 TWh	0.3 %
	IntradayS	Even ex-post trades	?	
Sweden, Finland, Denmark East	Nordpool	60‘ before delivery	1.1 TWh	0.3 %
Spain	OMEL	6 auctions per day	25 TWh	8 %

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Needs for Intraday markets

New Information on / Changes in

- Load
- Wind
- Conventional Generator Outages

Assessment of Errors

- Day-ahead load forecast
  - About 2 % forecast error
  - i.e. for Germany about 1200 MW MAE (Mean absolute error)
- Plant outages
  - About 25 per plant and year, 10 h per outage on average
  - i.e. for Germany about 1700 MW MAE (Mean absolute error)
  - Yet first hour can not be provided by intraday market
  - → About 1400 MW MAE reasonable
- Wind forecast
  - 4 % RMSE of 20.000 MW
  - Own analysis 600 MW MAE for total German generation

→ Arithmetic sum yields 3200 MW corresponding to about 25 TWh

Why is liquidity much lower than expected?

- Large player are doing internal netting
- Downwards spiral of limited liquidity
- Market design – continuous trading
- Competition with regulation power market in the case of Nordpool

Possibilities for improved intraday trading possibilities

- Change from day-ahead spot auction to continuous spot trading until close to physical gate closure
- Move gate closure time for the spot auction e.g. to 6 p.m. on the day before
- Bundling of liquidity by introducing auctions in the intraday market
- Increase of liquidity by obliging market partners to bid into the intraday market

Assessment of possibilities for improved intraday trading possibilities

- Change from day-ahead spot auction to continuous spot trading until close to physical gate closure
  → Adverse impacts on trading liquidity to be expected
- Move gate closure time for the spot auction e.g. to 6 p.m. on the day before
  → Rather limited improvement
- Bundling of liquidity by introducing auctions in the intraday market
  → Interesting opportunity
  → OMEL gets much more liquidity with this model
- Increase of liquidity by obliging market partners to bid into the intraday market
  → Strong intervention with questionable effects

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Key points

- Wind energy will particularly benefit from increased liquidity in the intraday markets
- Assuming that wind power operators are obliged to cover balancing deviations
- organization of intraday auctions as done in Spain seems to be the most attractive way for increasing liquidity.
- Provision of inconsistent incentives and gambling opportunities has to be avoided