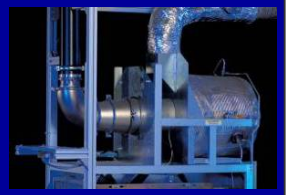
ISET

Electrical Engineering and Systems Technology

for the Use of Renewable Energies

and Decentral Energy Supply

Applications oriented Research and Development



Institut für Solare Energieversorgungstechnik Verein an der Universität Kassel e.V.

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Integration of Large Wind Farms into the Power Supply System

DEWEK 2008

Session No. 15: Grid Integration

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DWD

e·on Netz

VATTENFALL

UNIKASSEL VERSITÄT

ISET

Bremen, 27. November 2008

Agenda

- Introduction
- Analyses and strategies
- Concept elaboration
- Pilot plants
- Conclusion / Outlook

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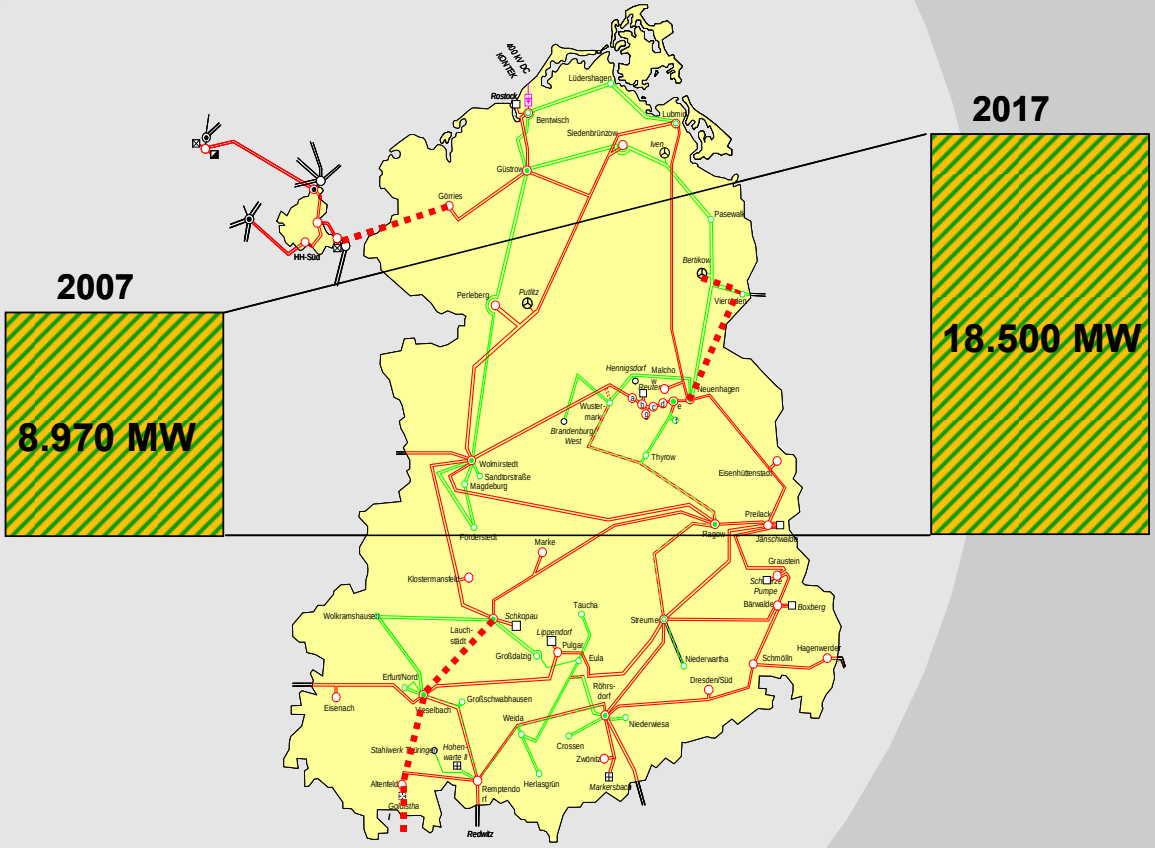
Introduction

Influence of intermittent wind power feed-in on the reliability of the grids?

→ Development of new concepts and strategies and implementation in hard- and software.

Installed Wind Capacity:



Source: Vattenfall Europe Transmission

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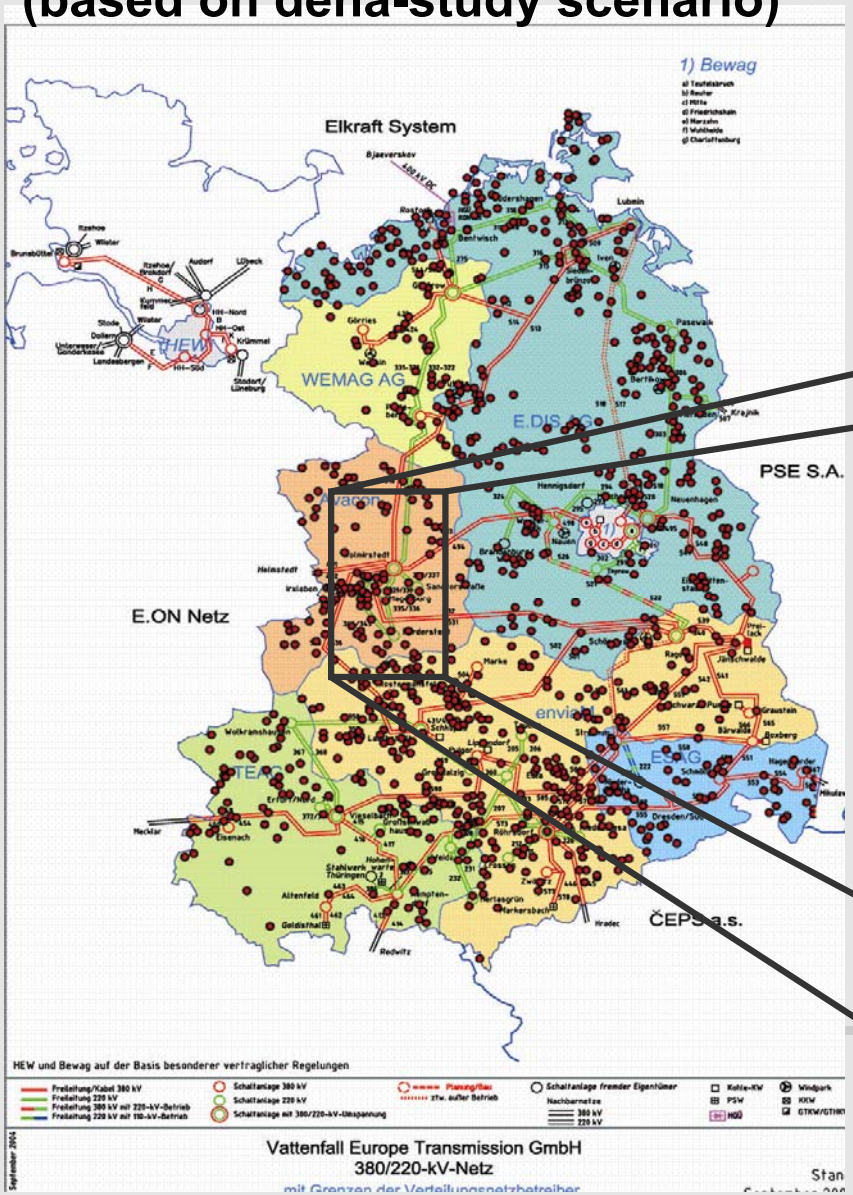
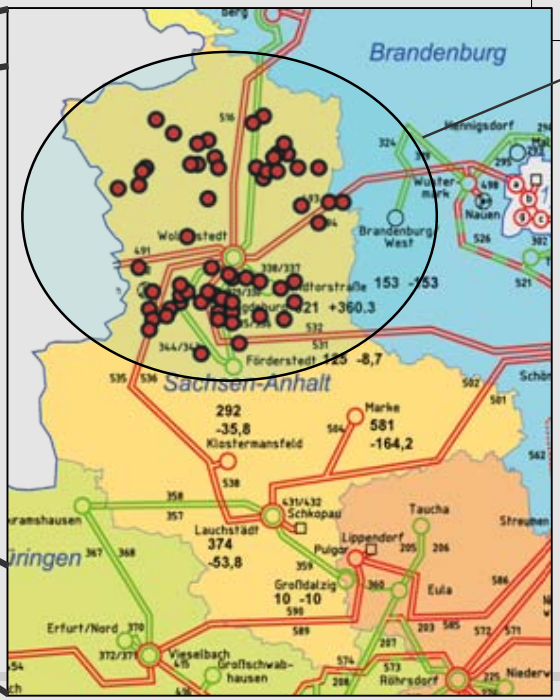
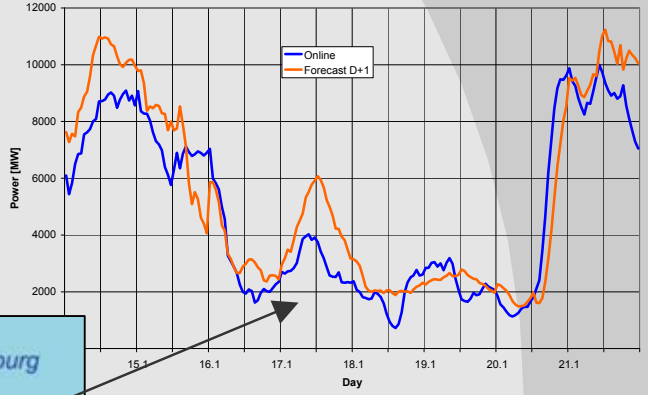
Analyses and strategies

Time series of wind power feed-in for grid nodes
(based on dena-study scenario)







Grid Calculation by TSOs

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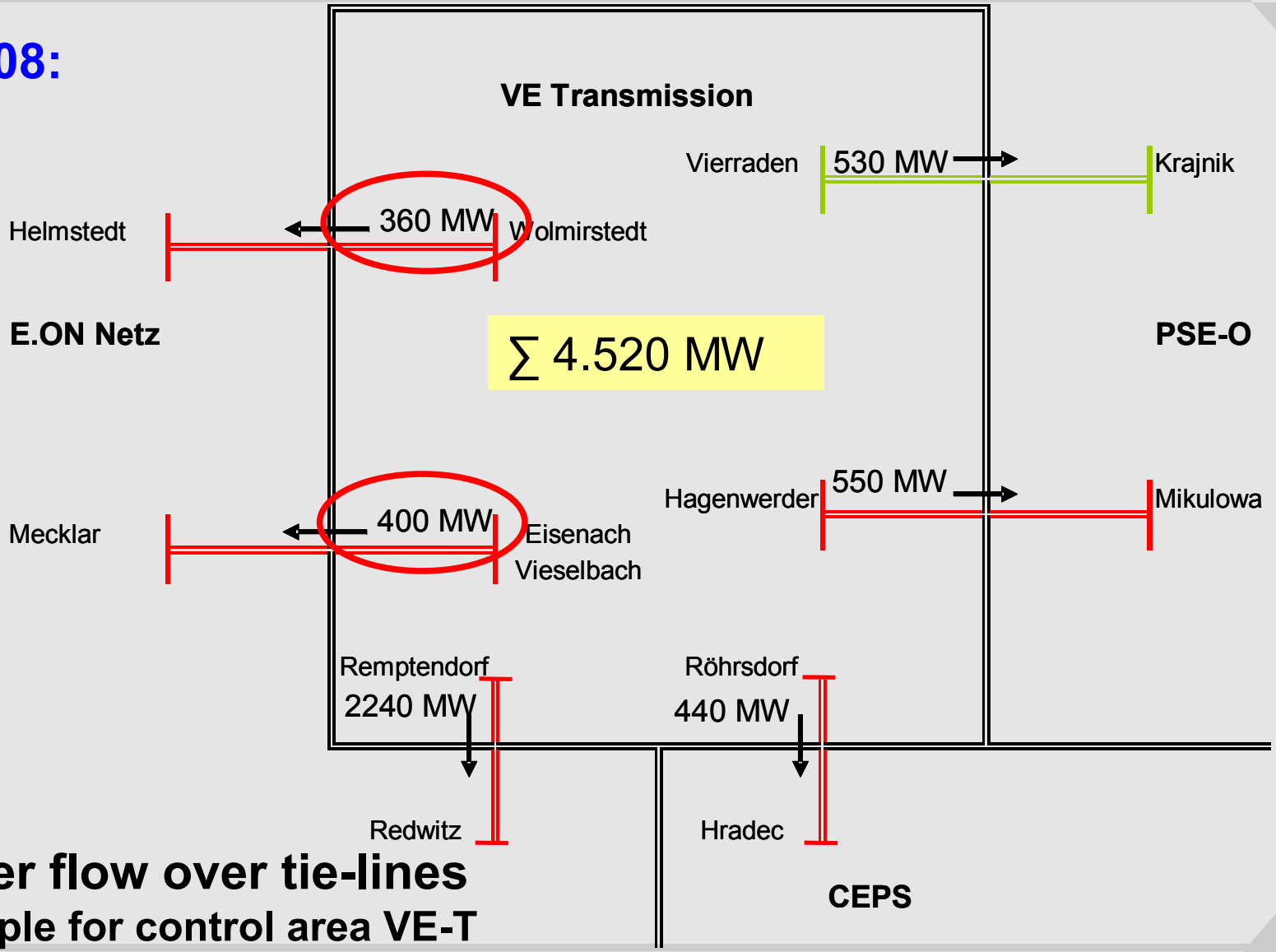
Analyses and strategies

2008:



Power flow over tie-lines

Example for control area VE-T

Source: Vattenfall Europe Transmission

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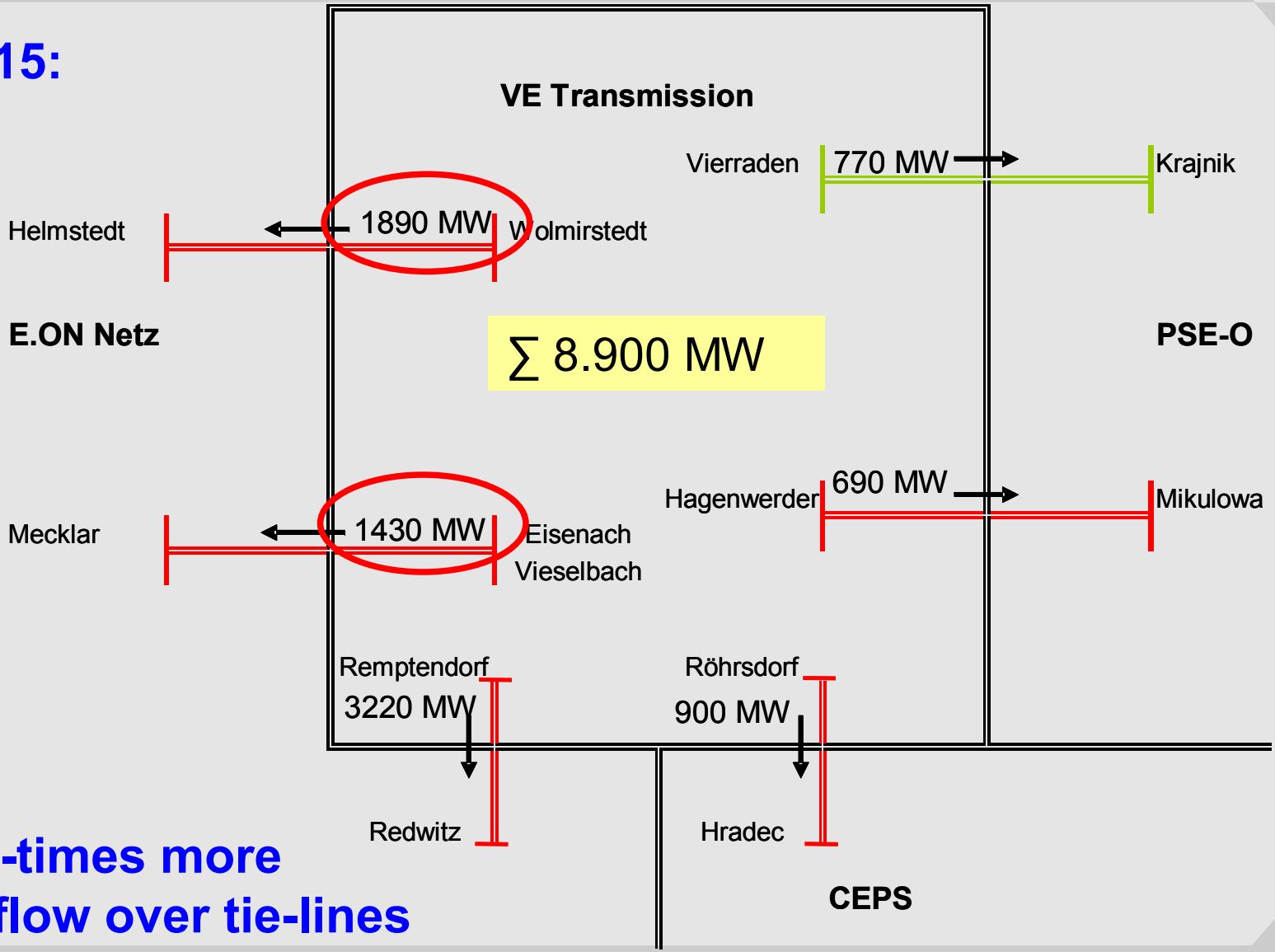
Analyses and strategies

2015:



Up to 4-times more power flow over tie-lines

Source: Vattenfall Europe Transmission

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Analyses and strategies

Requirements for high penetration of wind power in the electrical supply system:

- **Generation Management**
- **Supply of reactive power**
- **Supply of balancing power (technical ability)**
- **Improvement of wind power feed-in scheduling**

→ Control system is needed to utilize the wind 'power plant' capabilities

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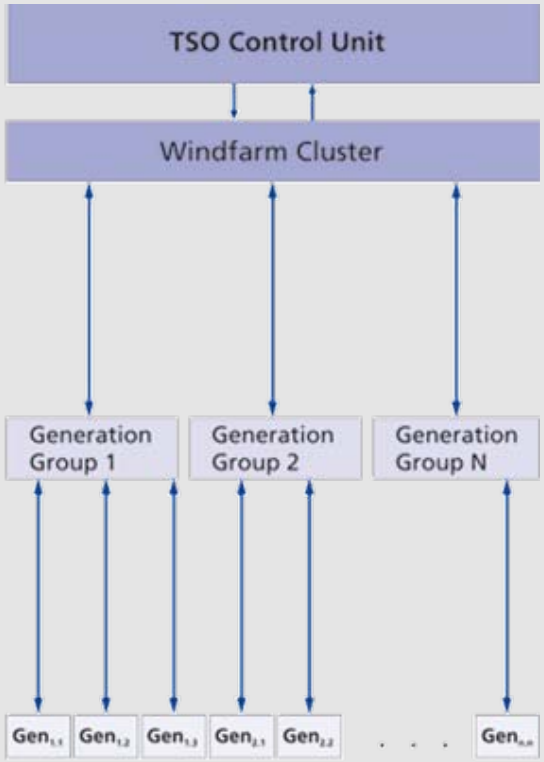
Concept elaboration

- **Distributed generation**

⇒ **Aggregation necessary**

Generation Group Cluster 	Requirements: Profile Based Operation Mode • active power limitation • supply of balancing power • supply of reactive power • scheduling • congestion management • generation management
Generation Group 	Requirements: • maximum power limitation (dynamic treshold values) • short circuit current • emergency cut-off (disconnection) by network outages • coordinated start-up and shut-down procedures (gradients limitation)
Single Generator	Requirements: • safe and reliable operation • maximum energy yield

- **Predictability**



All wind farms connected to one grid node are the smallest unit for the system operator = Cluster

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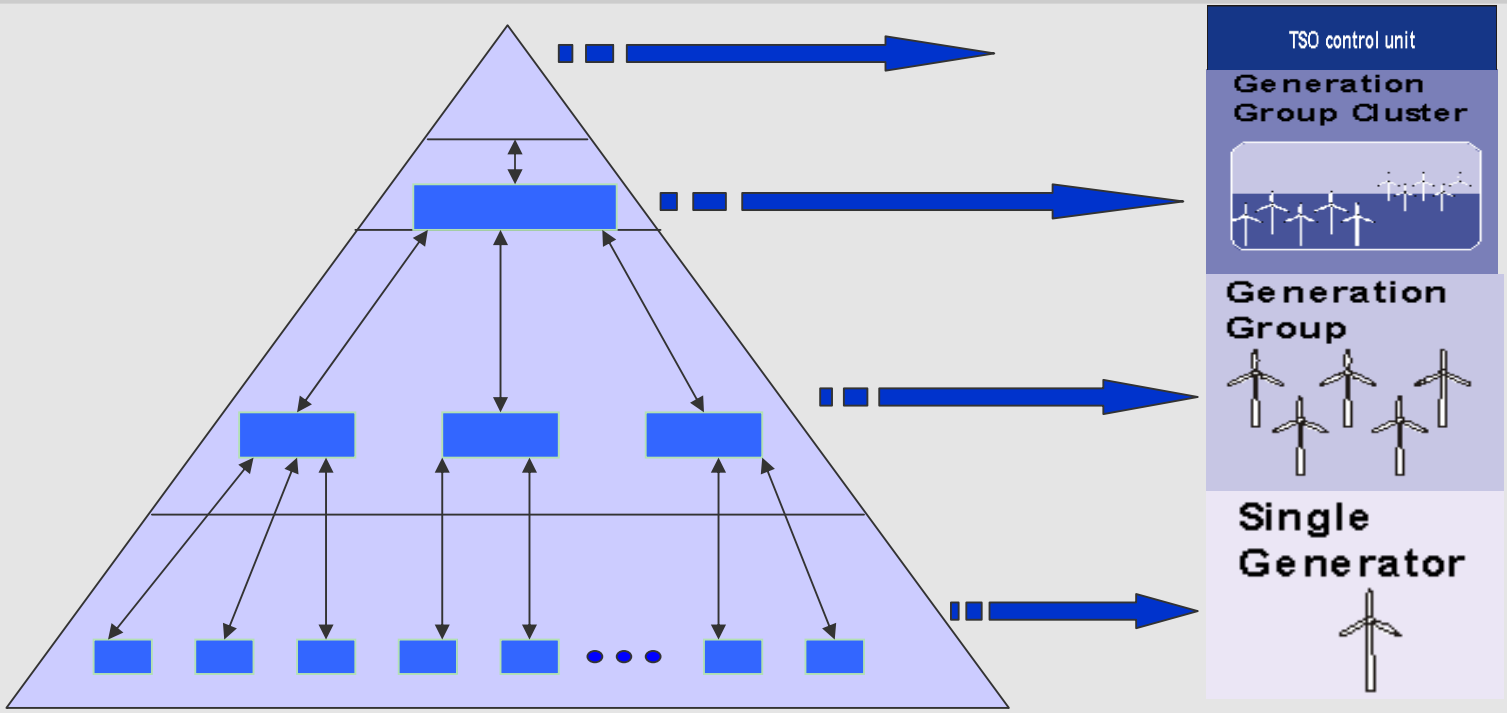
Concept elaboration



- Geographical distributed Wind Farms are aggregated to *Wind Farm Cluster* (one Cluster for every transmission system node)
- *Wind Farm Cluster Management System* supports the TSO by operating the cluster according to the requirements of the *power transmission system*

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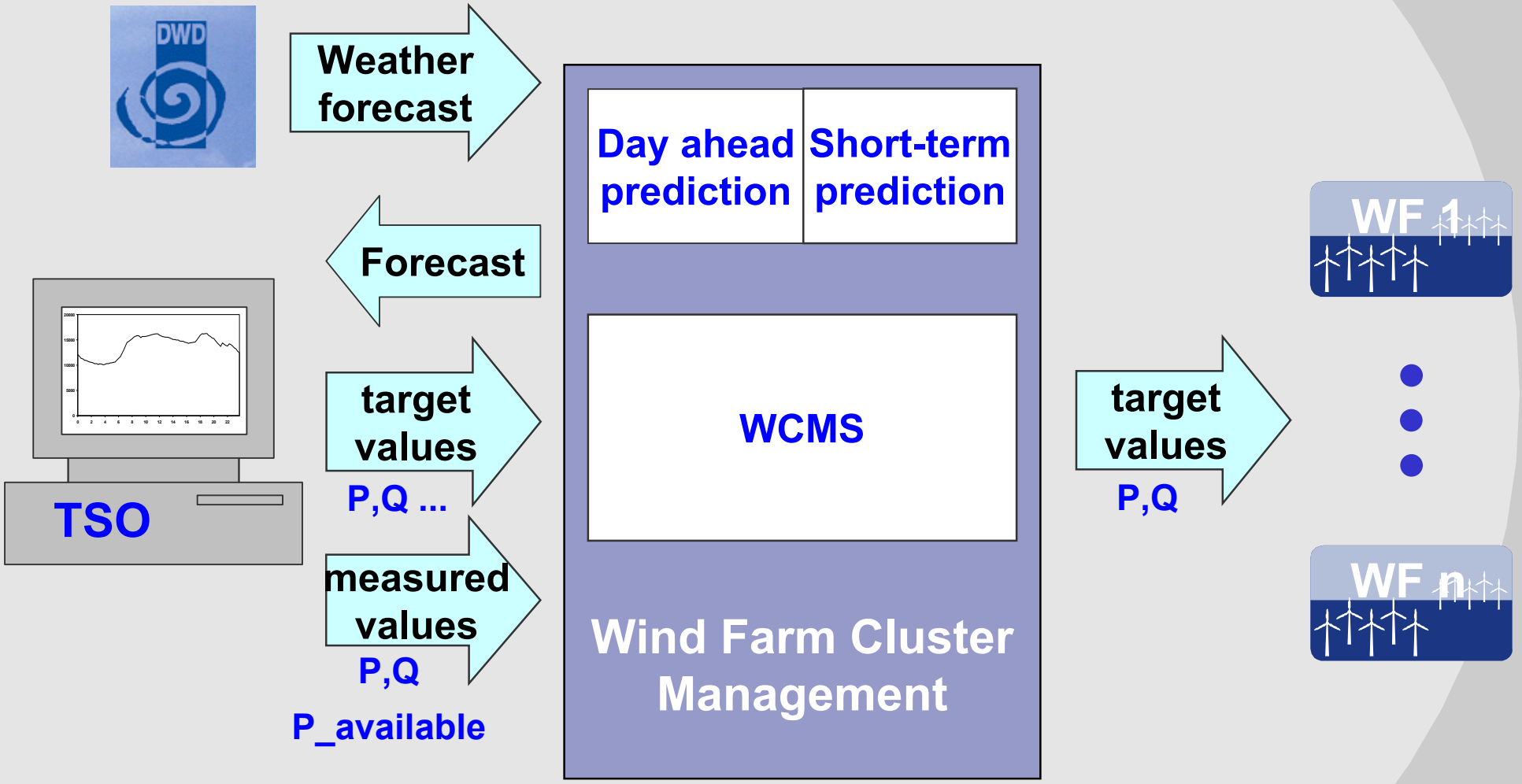
Concept elaboration



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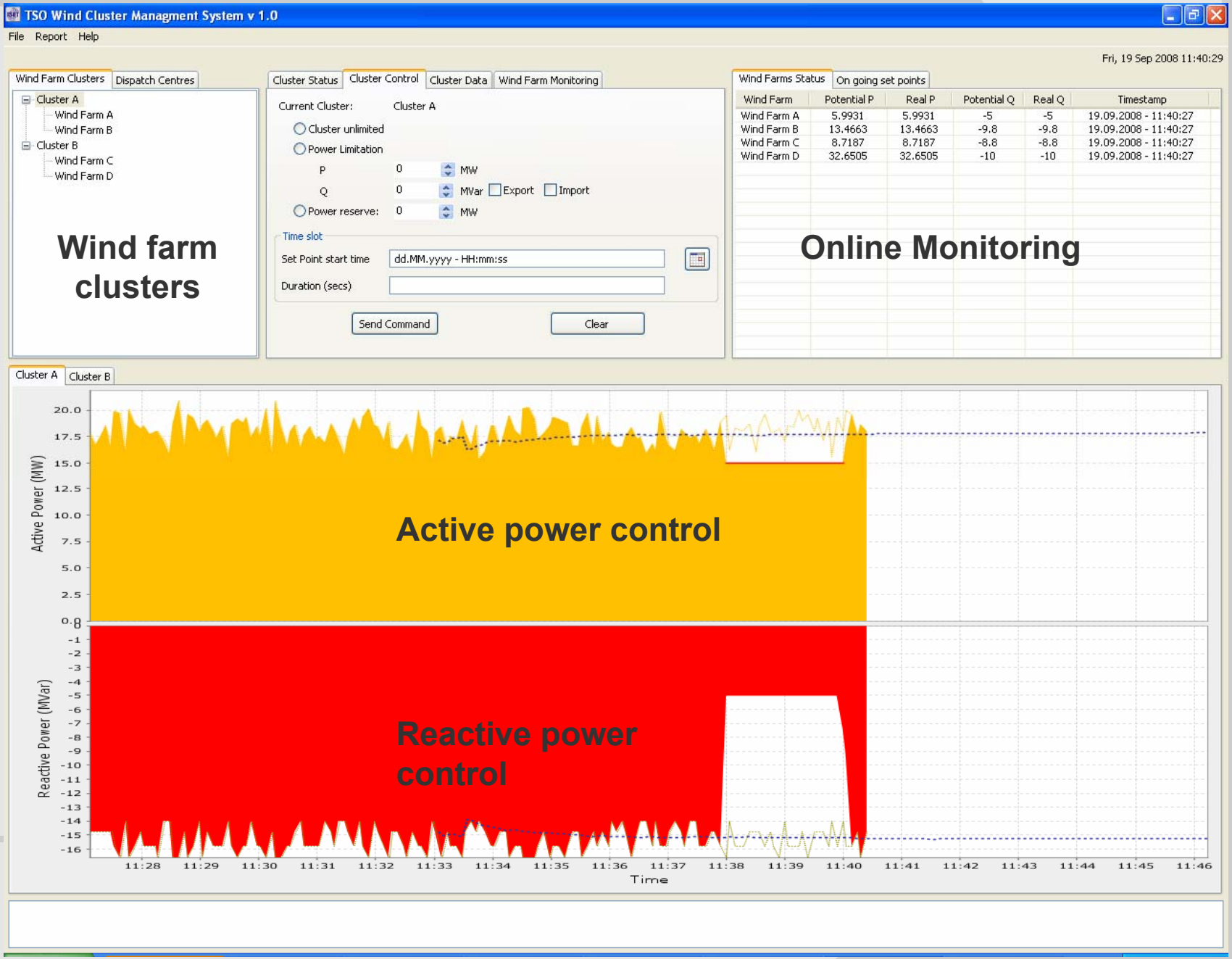
Concept elaboration

Graphical User Interface



Concept elaboration

Control strategies:

Active power control

- Congestion Management
- Reduction of gradients
- Supply of balancing power
- Scheduling of wind power feed-in

Reactive power control

- Supply of reactive power
- Voltage control

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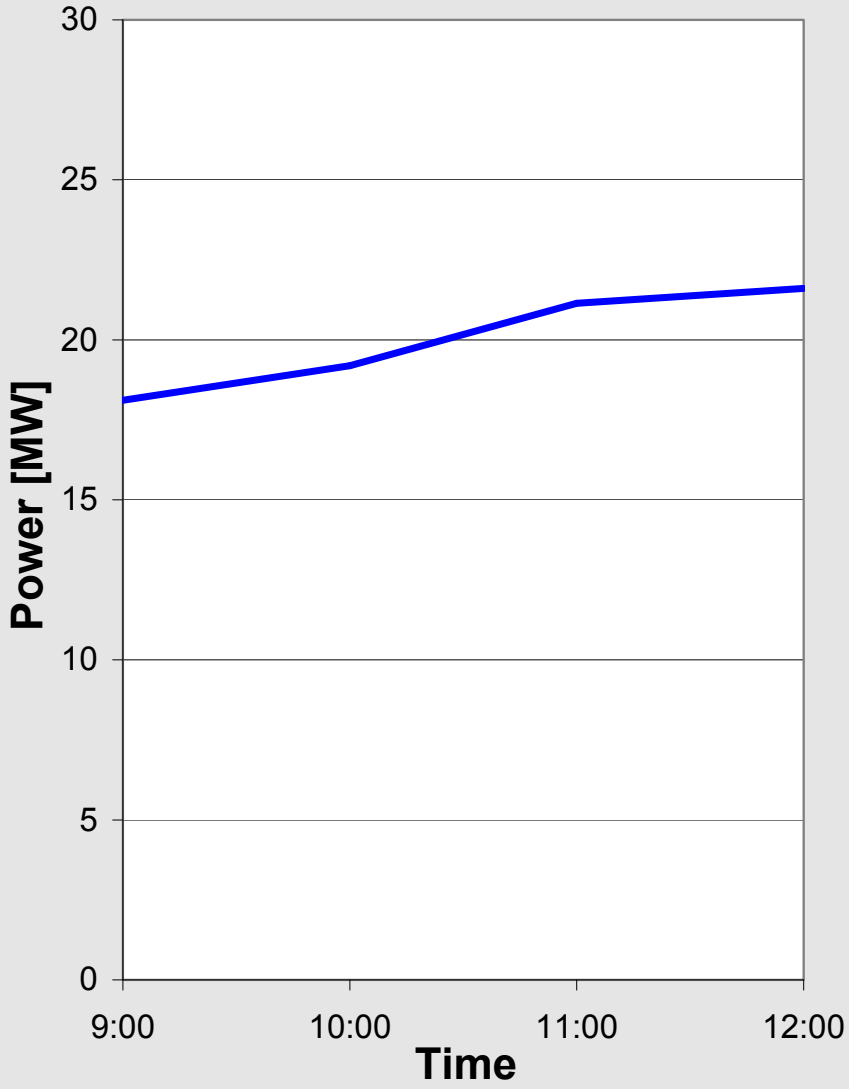
Concept elaboration



forecast

Supply of balancing power by means of short term prediction and tolerance band

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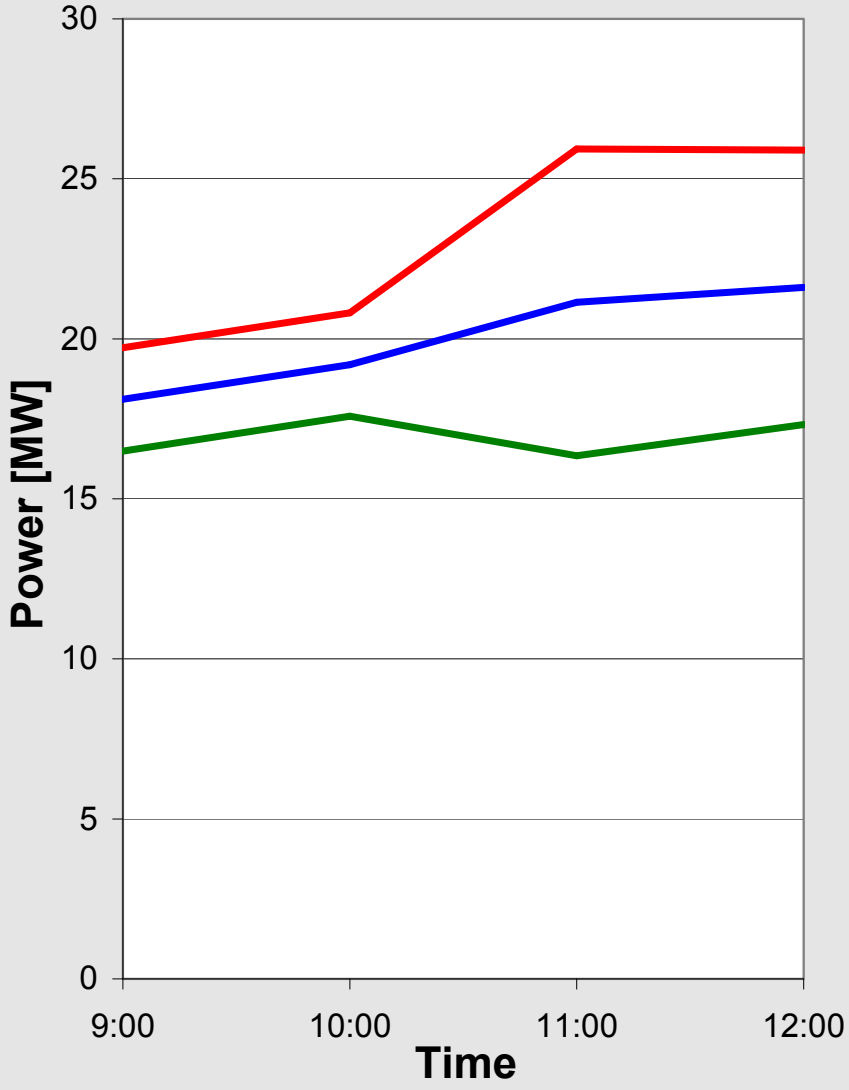
Concept elaboration



upper level of prediction interval

forecast

lower level of prediction interval

Supply of balancing power by means of short term prediction and tolerance band

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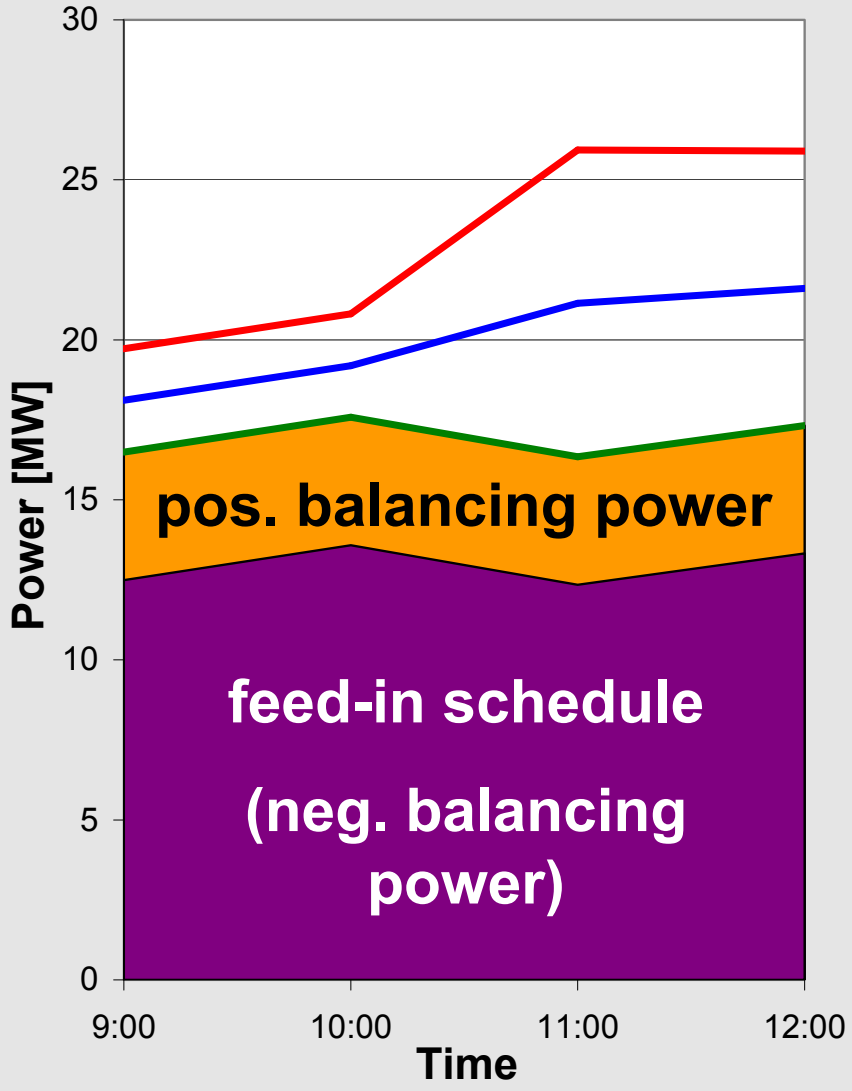
Concept elaboration



upper level of prediction interval

forecast

lower level of prediction interval

Supply of balancing power by means of short term prediction and tolerance band

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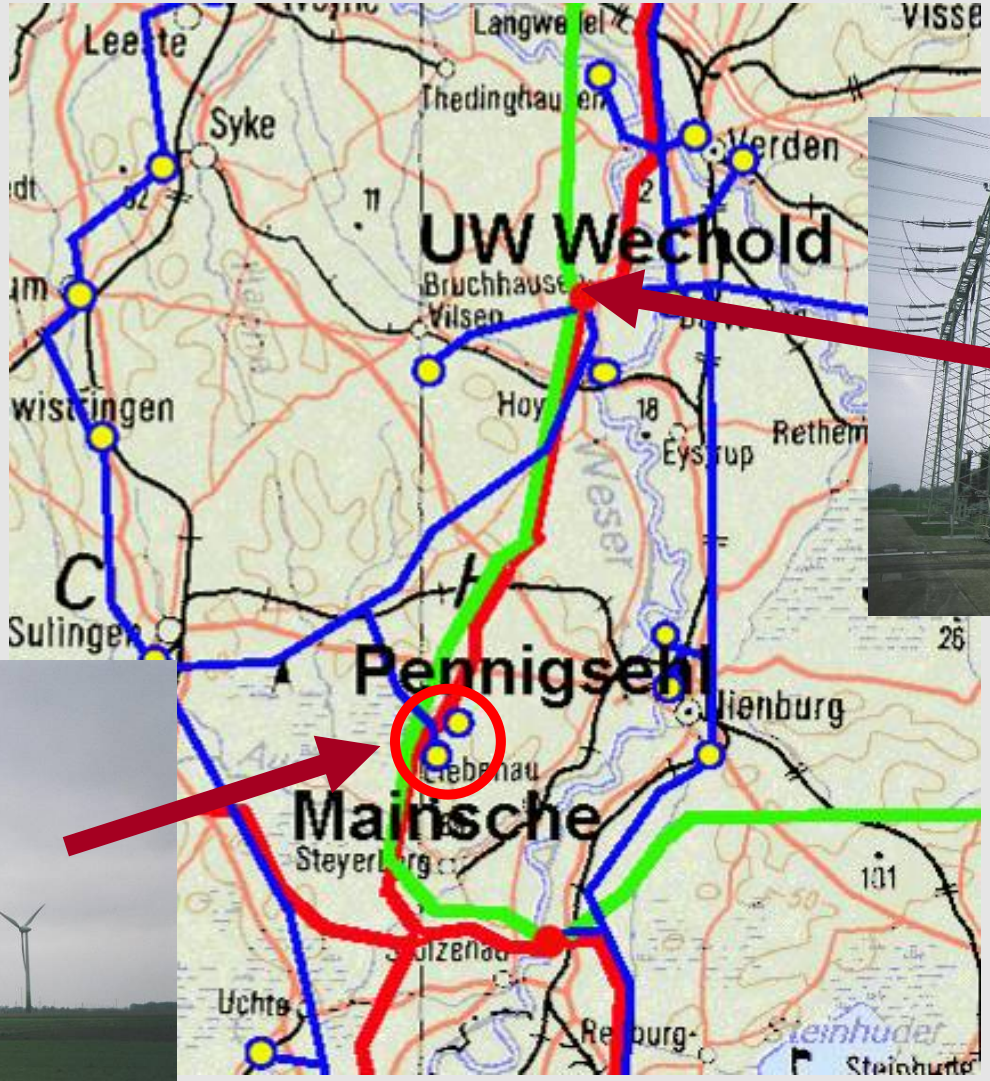
Pilot plants

110 kV grid

220 kV grid

380 kV grid



Substation Wechold

Wind Farm Mainsche/Pennigsehl: 33 WT / 60,4 MW

Cluster Wechold

16 wind farms about 250 MW

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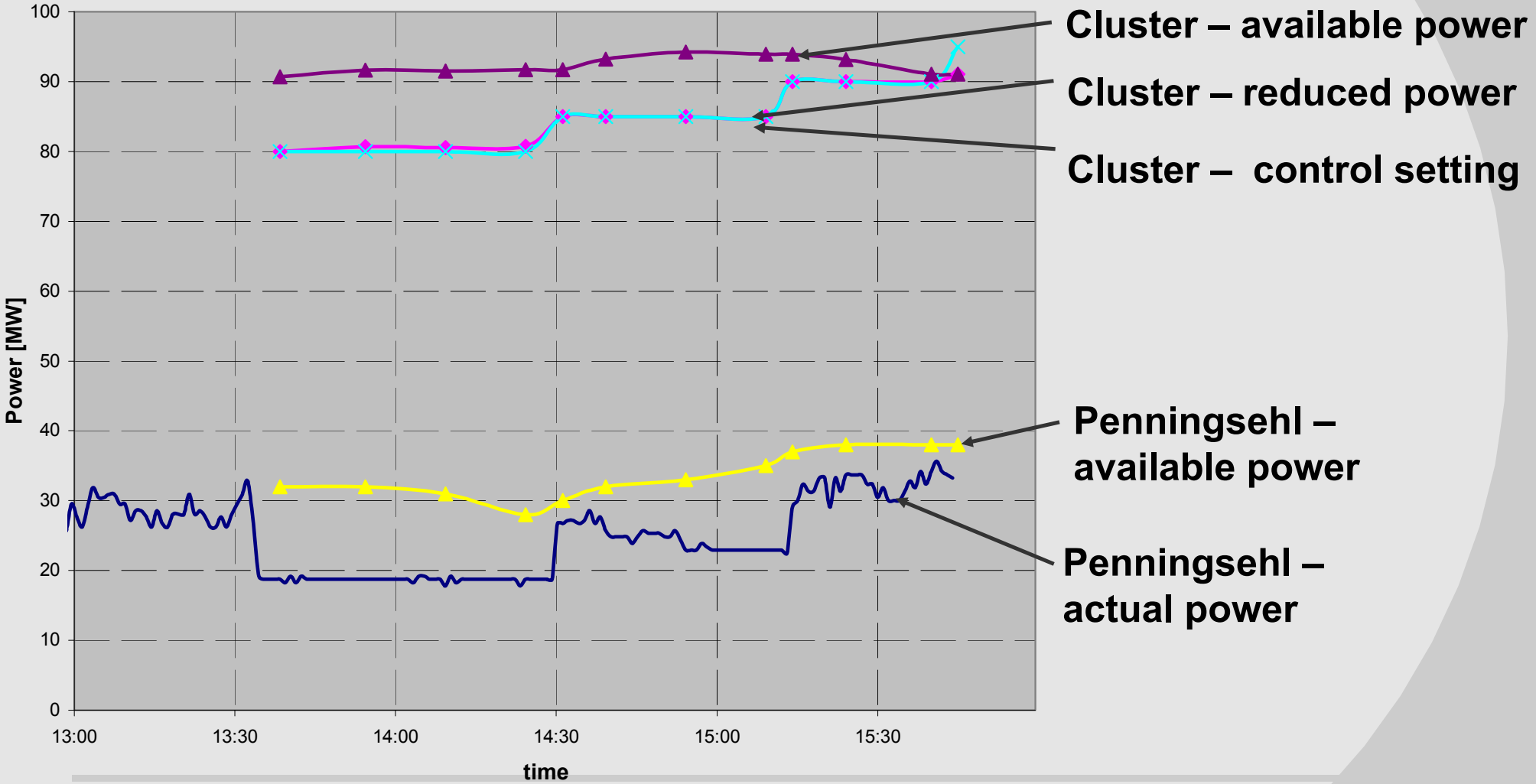
Pilot plants

Power Limitation for the Cluster



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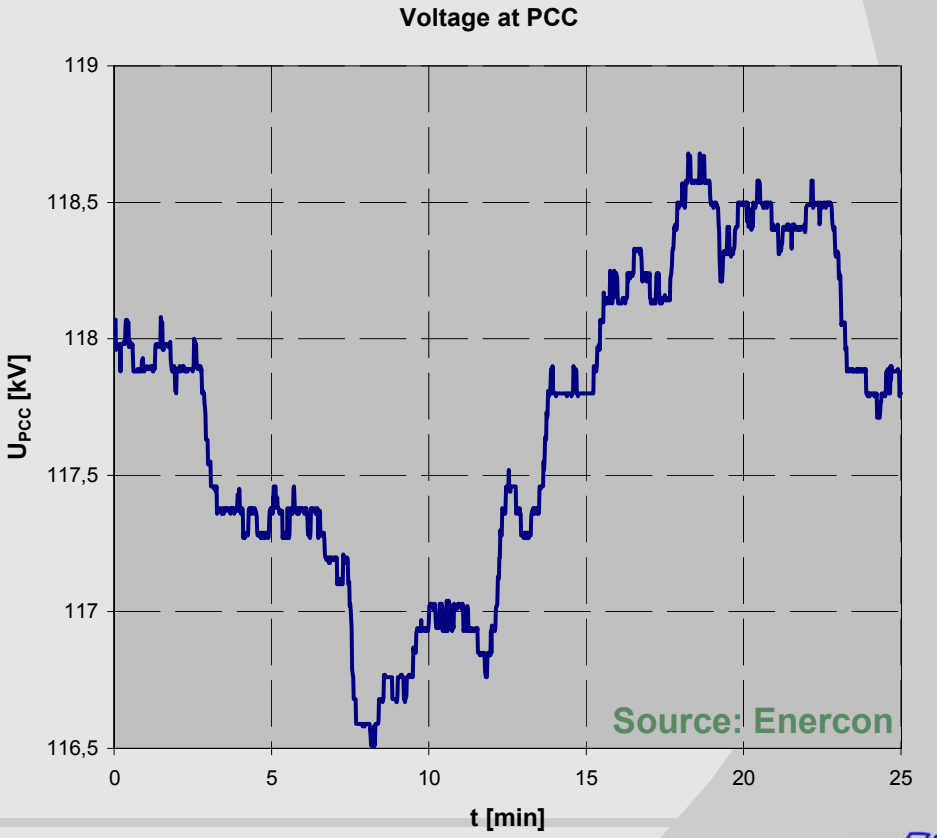
Pilot plants

Control of the cos φ at the wind farm…

…leads to a voltage variation at the wind farm connection of 2 kV…



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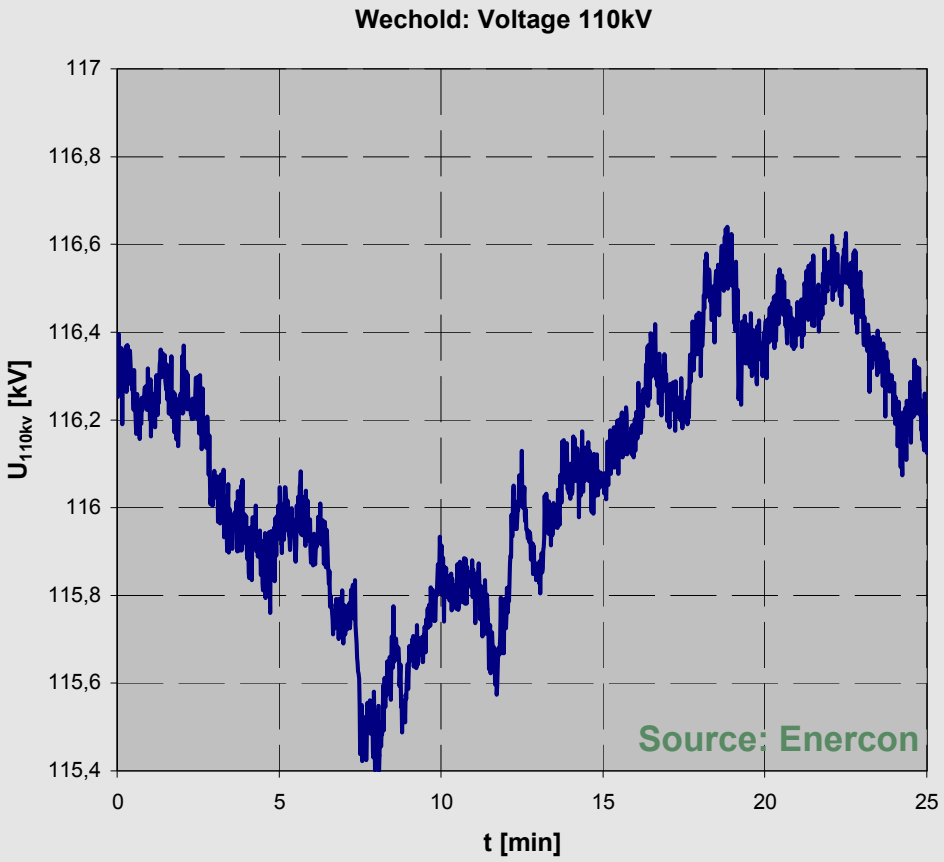
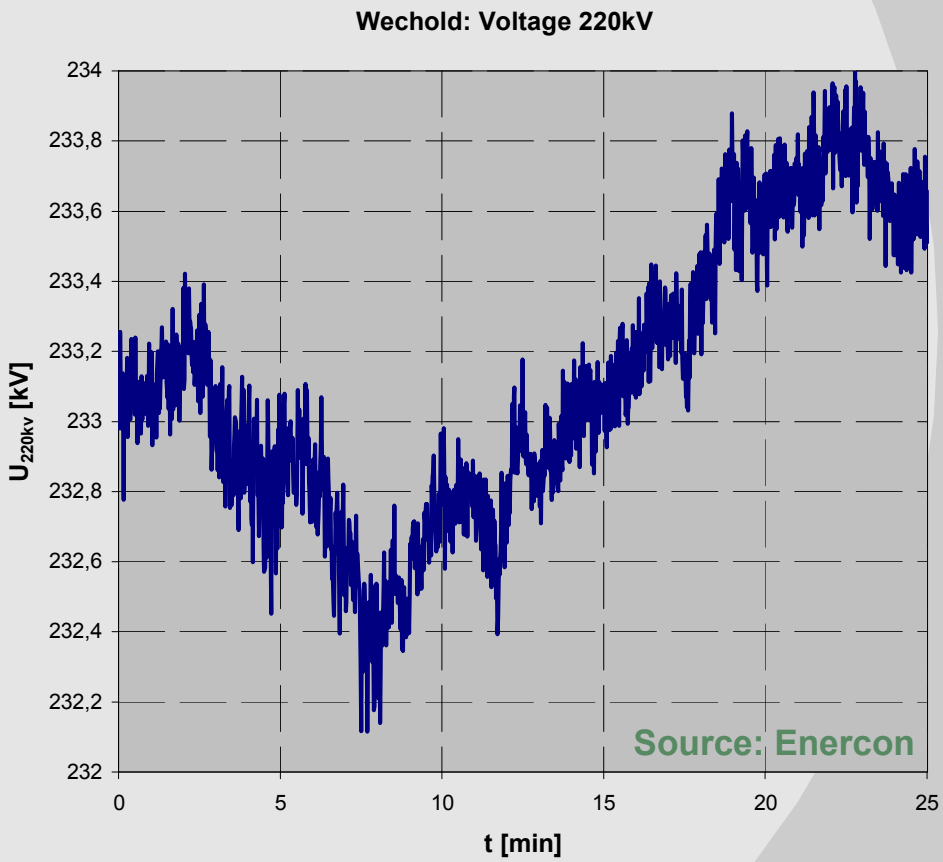
Pilot plants

… and of 1,2 kV at the 110 kV and 220 kV level at the substation Wechold





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Conclusion

- Integration of large amounts of wind power make new tools for grid operation necessary
- For integration of wind power, the Wind Farm Cluster Management System (WCMS) has been developed at ISET
- Provides forecast and allows control for each grid node
- Gives the TSO an extended control of the ‘Wind Power Plant’
- Its capabilities have been demonstrated in a field test in Germany

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Outlook

- Second field test in control area of Vattenfall Europe transmission
- European Project „Wind on the Grid“ Demonstration in Spain and Portugal
- Demonstration with the first german Offshore Windfarm “alpha ventus”

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Thanks for your attention!

Visit ISET at Stand B 03

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