

WCMS in interaction with alpha ventus

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des Deutschen Bundestages

Projektträger

Koordination

Content

- WCMS – description of the system
- General Topology of the Electrical Grid
- Grid Topology of alpha ventus
- Assumptions for the Grid Calculations
- Screenshots of the WCMS Program
- Outlook

WCMS - Wind Cluster Management System

The WCMS is a software system which combines geographically distributed wind farms as a single “Wind Power Plant” and manages these farms in order to provide grid and system services.

Overall Goals

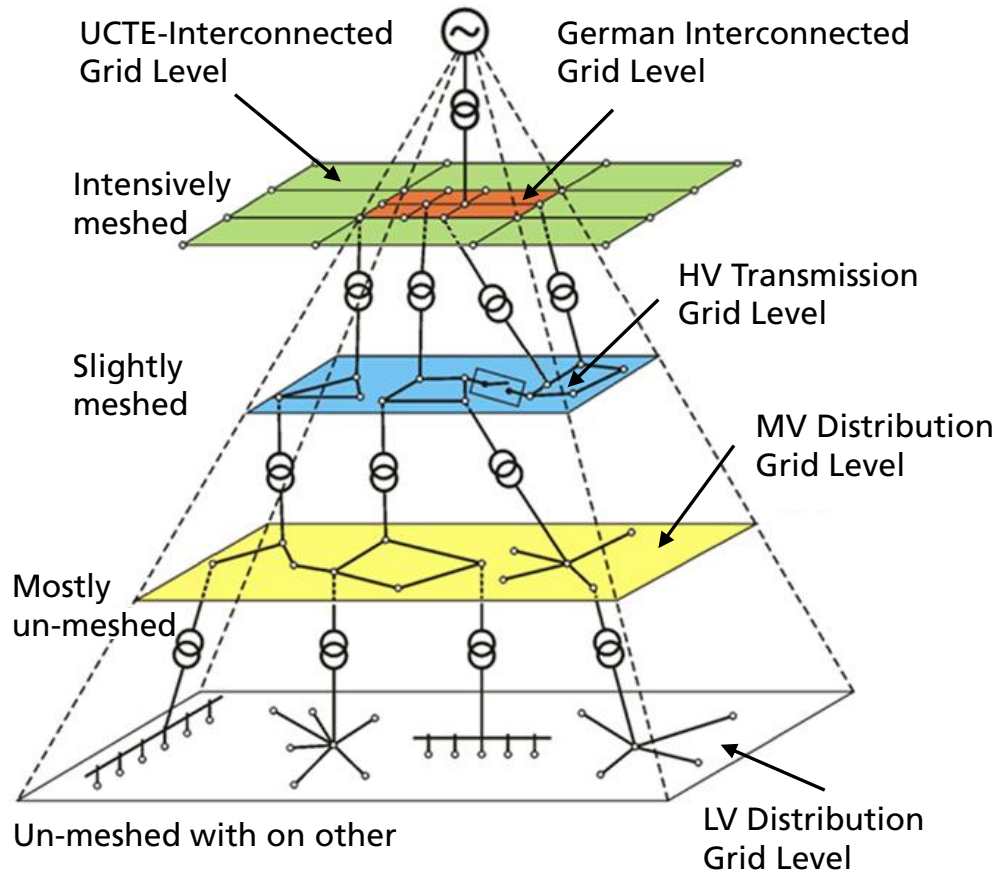
- Ensuring voltage and frequency stability
- Avoiding congestion
- Optimizing operation (minimization of losses and fluctuations)
- Supply wind power according an externally specified schedule

Necessary information

- Wind power forecast
- Reactive power capabilities (PQ-curves) of single turbines or wind farms
- Current grid topology



WCMS - Description of a Grid Topology



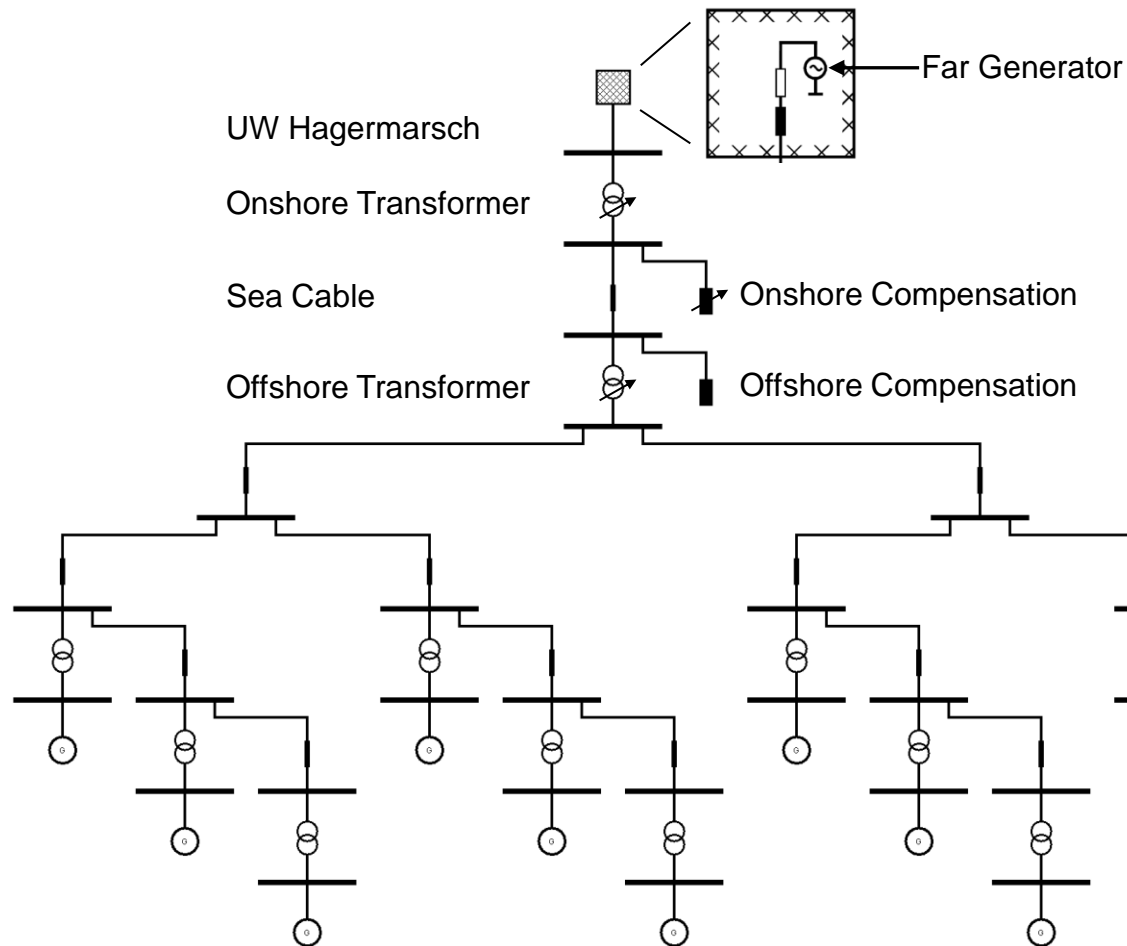
Meshed Grid:

Not designed for worst case power flow
→ mainly problems with congestion
in time periods of high feed-in

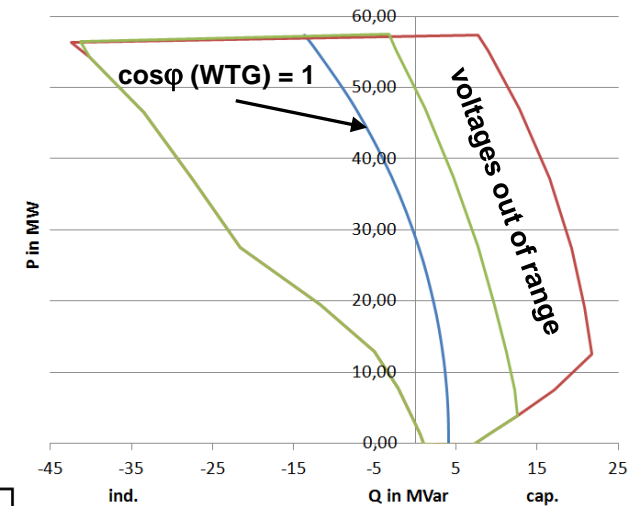
Un-Meshed / Radial Grid:

Designed for worst case power flow
→ basically no congestion problems
→ mainly voltage problems

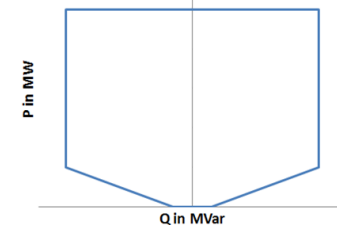
WCMS – Grid Topology of alpha ventus



PQ-Curve at UW Hagermarsch:



PQ-Curve of a wind turbine:



WCMS - Assumptions for Grid Calculation

Assumption for the calculations, presented within the following slides:

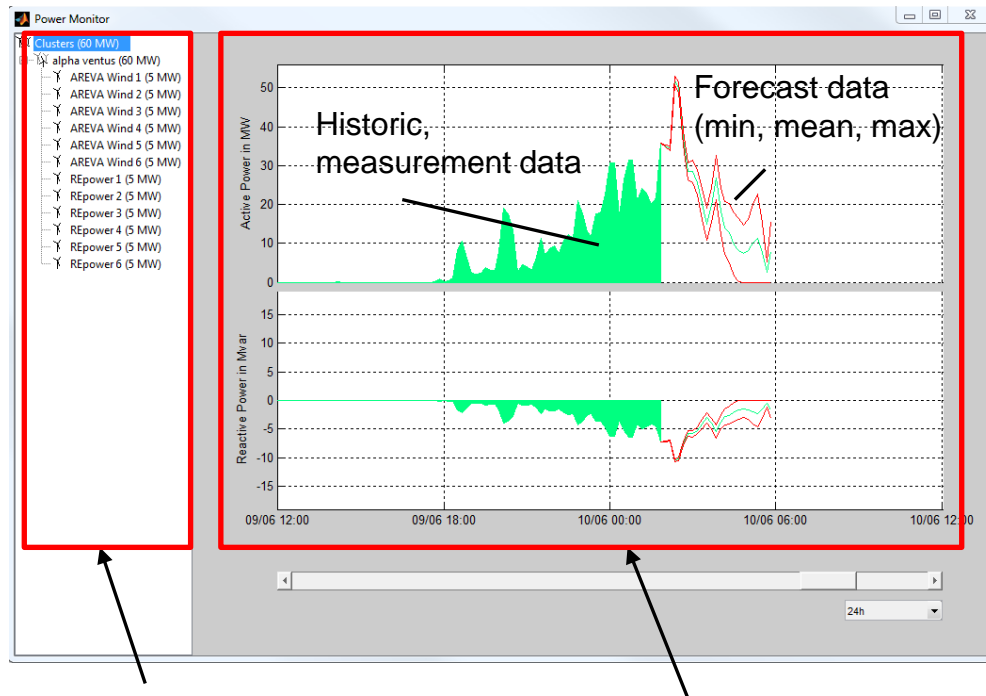
- No voltage controlled grid nodes – except Far Generator

Voltage value at the Far Generator: $105\% * U_n = 115.5 \text{ kV}$

- Compensation units in maximum position
- Transformer taps in neutral position (rated transmission ratio)
- Wind turbines feed-in maximum available power; $\cos \varphi = 0.98$ inductive

WCMS – Active and Reactive Power Forecast

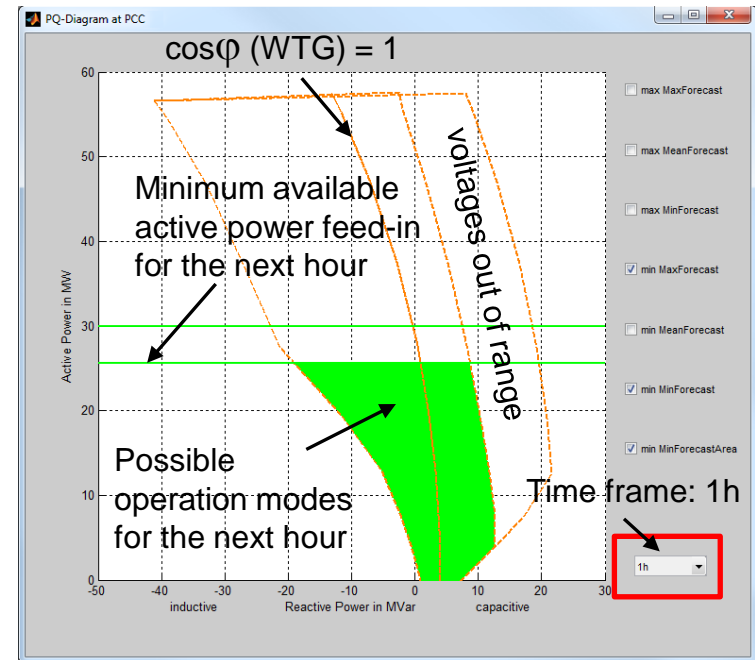
Power Monitor



Get information of a single turbine or the whole cluster

Active and reactive power data (gross values – without grid losses)

PQ-Curve at UW Hagermarsch



Active and reactive power data relating PCC node (net values – including grid losses)

WCMS – Voltage and Utilization Factor Monitor



Voltage Monitor

Utilization Factor Monitor

WCMS – Main Monitor - Creating a Setpoint

The screenshot displays the 'Main Monitor' application window. It features a 'Messages' table with columns for Time of info, Type, Level, Time, Message, forecast, voltage/load, and node/component. Below this is an 'Inbox' section with a table for Time, Status, and Message. A context menu is open over the 'Inbox' table, listing options: 'create setpoint', 'send selected setpoint(s)', 'delete selected setpoint(s)', and 'calculate grid interactions'. An arrow points from the text 'Can define setpoint via context menu' to the 'create setpoint' option. To the right, a 'Create setpoint' dialog box is open, showing fields for Cluster, Node, Start time, Start date, End time, End date, and Control. The 'Control' field is set to 'P, Q', with 'P in MW' set to 20 and 'Q in MVar' set to 5. The dialog has 'Cancel' and 'OK' buttons.

Time of info	Type	Level	Time	Message	forecast	voltage/load	node/component
24-Apr-2012 10:49:27	warning	2	01:00 10-Jun-2010 02:50:00	voltage > 105% Un	min.	voltage	Sea Cable - Offshore Transformer
24-Apr-2012 10:49:27	warning	2	01:00 10-Jun-2010 02:50:00	voltage > 105% Un	mean	voltage	Sea Cable - Offshore Transformer
24-Apr-2012 10:49:27	warning	2	01:20 10-Jun-2010 03:10:00	voltage > 105% Un	max.	voltage	Sea Cable - Offshore Transformer
24-Apr-2012 10:49:27	warning	3	02:20 10-Jun-2010 04:10:00	voltage > 105% Un	min.	voltage	Sea Cable - Offshore Transformer
24-Apr-2012 10:49:27	information	4	02:50 10-Jun-2010 04:40:00	voltage > 105% Un	mean	voltage	Sea Cable - Offshore Transformer
24-Apr-2012 10:49:27	information	5	03:50 10-Jun-2010 05:40:00	voltage > 105% Un	max.	voltage	Sea Cable - Offshore Transformer

Can define setpoint via context menu

Cluster: Clusters
Node: Default Cluster Node
Start time (HH:MM:SS): 2 : 20 : 0
Start date (dd/mm/yy): 10 June 2012
End time (HH:MM:SS): 5 : 20 : 0
End date (dd/mm/yy): 10 June 2012
Control: P, Q
P in MW: 20
Q in MVar: 5
Buttons: Cancel, OK

WCMS – Main Monitor – Finding Setpoints

The screenshot shows the 'Main Monitor' window with a 'Messages' table. The table has columns: Time of info, Type, Level, Time, Message, forecast, voltage/load, and node/component. A row is highlighted with a context menu open, showing options: 'find solution', 'clear selection', and 'Assisted Dispatch'. The 'Find solution' dialog box is open, showing settings for 'Voltage at node' (Sea Cable - Offshore Transformer), 'shall be' (lower than 103 % Un), 'using' (max. forecast), 'controlling' (PQ nodes - generators), 'Time (HH:MM:SS)' (3:10:0), and 'Date (dd/mm/yy)' (10 June 2010). The dialog has 'Cancel' and 'OK' buttons.

Time of info	Type	Level	Time	Message	forecast	voltage/load	node/component
24-Apr-2012 10:49:27	warning	2	01:00 10-Jun-2010 02:50:00	voltage > 105% Un	min.	voltage	Sea Cable - Offshore Transformer
24-Apr-2012 10:49:27	warning	2	01:00 10-Jun-2010 02:50:00	voltage > 105% Un	mean	voltage	Sea Cable - Offshore Transformer
24-Apr-2012 10:49:27	warning	2	01:20 10-Jun-2010 03:10:00	voltage > 105% Un	max.	voltage	Sea Cable - Offshore Transformer
24-Apr-2012 10:49:27	warning	3	02:20 10-Jun-2010 04:10:00	voltage > 105% Un	min.	voltage	Sea Cable - Offshore Transformer
24-Apr-2012 10:49:27	information	4	02:50 10-Jun-2010 04:40:00	voltage > 105% Un	mean	voltage	Sea Cable - Offshore Transformer
24-Apr-2012 10:49:27	information	5	03:50 10-Jun-2010 05:40:00	voltage > 105% Un	max.	voltage	Unshore Transformer - Sea Cable

Find solution dialog box settings:

- Voltage at node: Sea Cable - Offshore Transformer
- shall be: lower than 103 % Un
- using: max. forecast
- controlling: PQ nodes - generators
- Time (HH:MM:SS): 3:10:0
- Date (dd/mm/yy): 10 June 2010

Can define
setpoint using
'problem
solver'
via context
menu

Perform
necessary
specifications

WCMS – Breaking Down a Setpoint

Single turbine consequences of a PCC setpoint are calculated, with relationships such as:

$$\Delta U_{node} = f(\Delta P_{nodes}, \Delta Q_{nodes})$$

$$\Delta \Phi_{u,node} = f(\Delta P_{nodes}, \Delta Q_{nodes})$$

Voltage problems

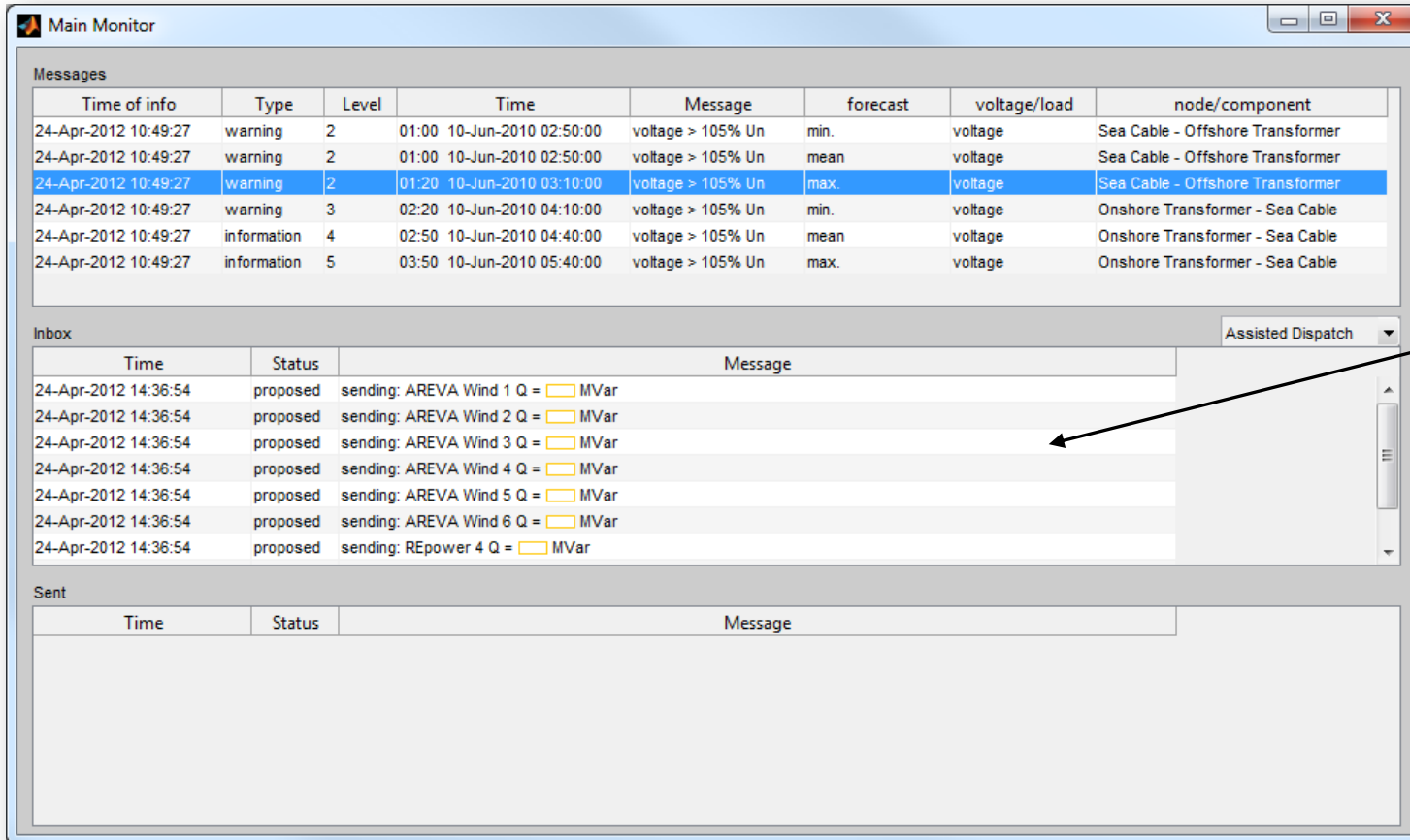
$$\Delta P_{component} = f(\Delta P_{nodes}, \Delta Q_{nodes})$$

$$\Delta Q_{component} = f(\Delta P_{nodes}, \Delta Q_{nodes})$$

Congestion

$$\Delta S_{component} = f(\Delta P_{nodes}, \Delta Q_{nodes}) \equiv \Delta Utilization_{component}$$

WCMS – Main Monitor - Proposed Setpoints



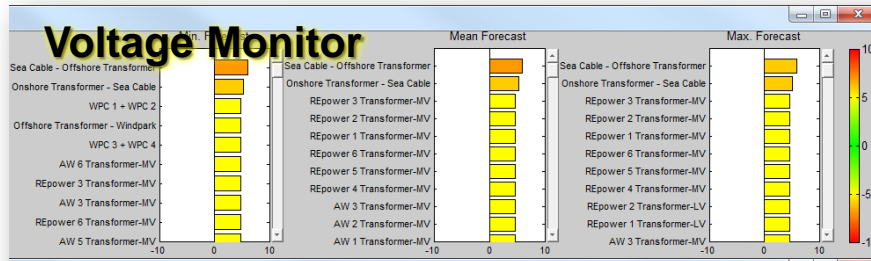
The screenshot displays the 'Main Monitor' window with three main sections:

- Messages:** A table with 9 columns: Time of info, Type, Level, Time, Message, forecast, voltage/load, and node/component. It lists several warning and information messages related to voltage levels and transformer components.
- Inbox:** A table with 3 columns: Time, Status, and Message. It shows a series of 'proposed' messages for sending AREVA Wind Q and REpower 4 Q values.
- Sent:** A table with 3 columns: Time, Status, and Message. It is currently empty.

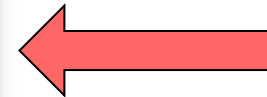
An arrow points from the text 'Setpoints needed to reach the specified solution (values hidden to preserve confidentiality)' to the 'Message' column of the 'Inbox' table, specifically to the 'sending: AREVA Wind 4 Q = [redacted] MVar' entry.

Setpoints
needed
to reach the
specified
solution
(values hidden
to preserve
confidentiality)

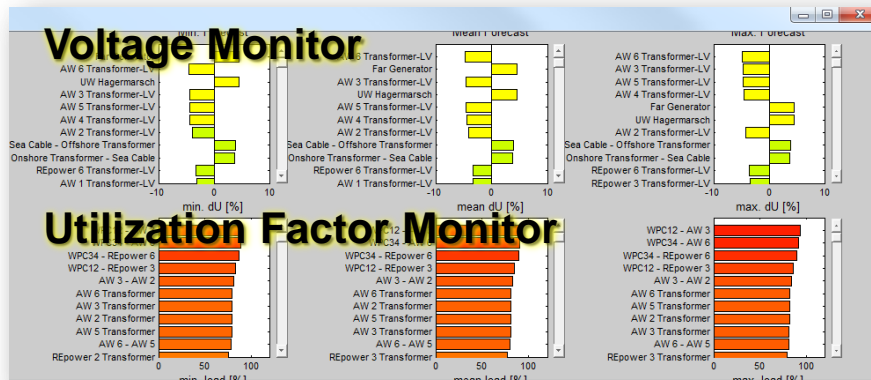
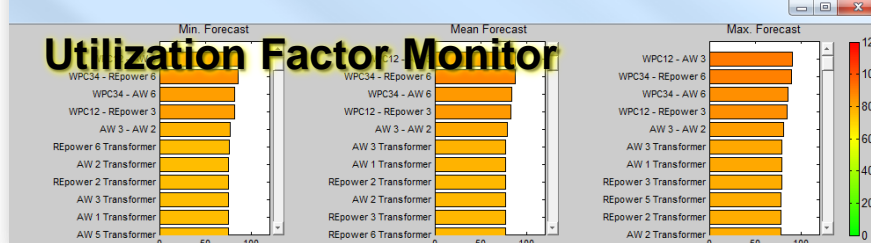
WCMS – Effects of the Proposed Setpoints



Current condition



Predicted future system state taking the current operation into account (refer to slides before)

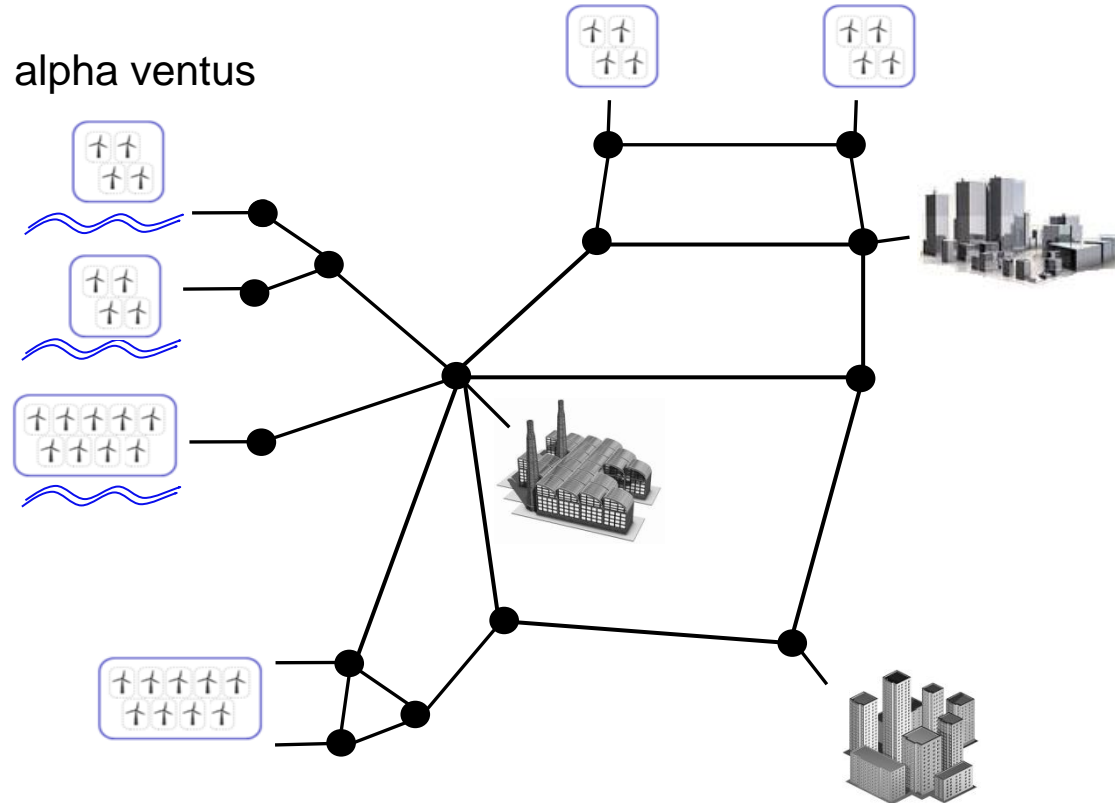


Condition after setpoints



Predicted future system state taking the proposed setpoints into account

WCMS - Outlook



WCMS is mainly being created for the technical operation of wind farms within extensive, also meshed grid structures

Interaction with a CVPP is required

CVPP = Commercial Virtual Power Plant

Thank you very much for your attention!

