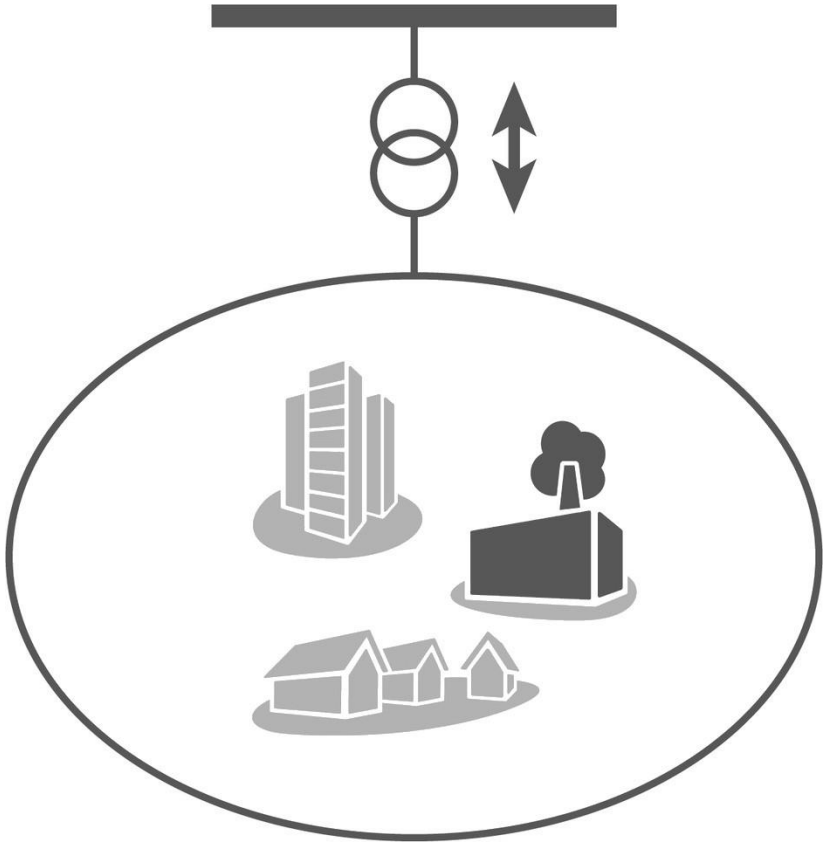
# Vertical Grid Load Forecast

**Dr. Ulrich Focken**

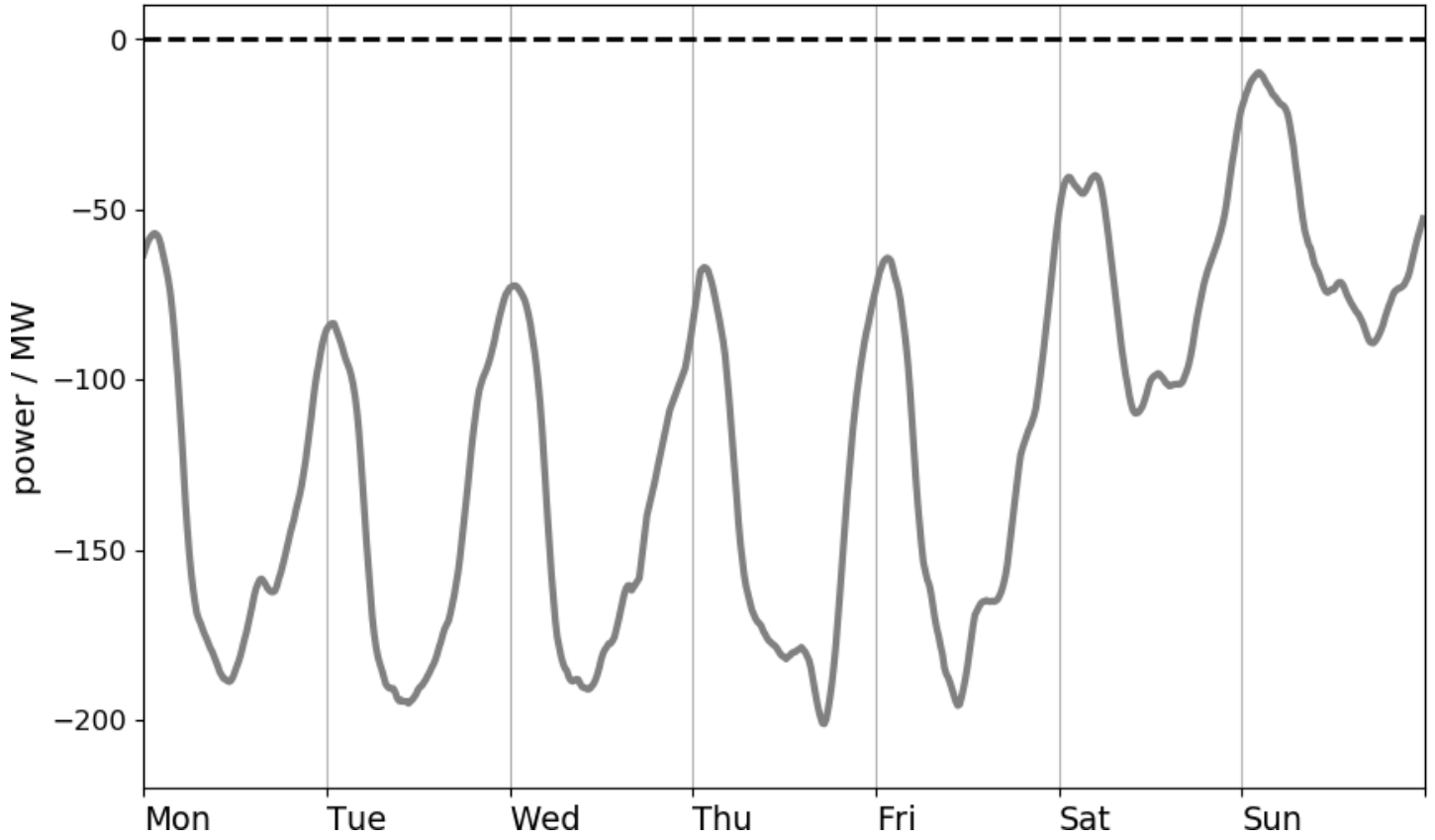
ESIG, 2019 Meteorology & Market Design for Grid Services Workshop

05. June 2019

# Vertical Grid Load old world



vertical grid load = consumption + production




grey line: vertical grid load

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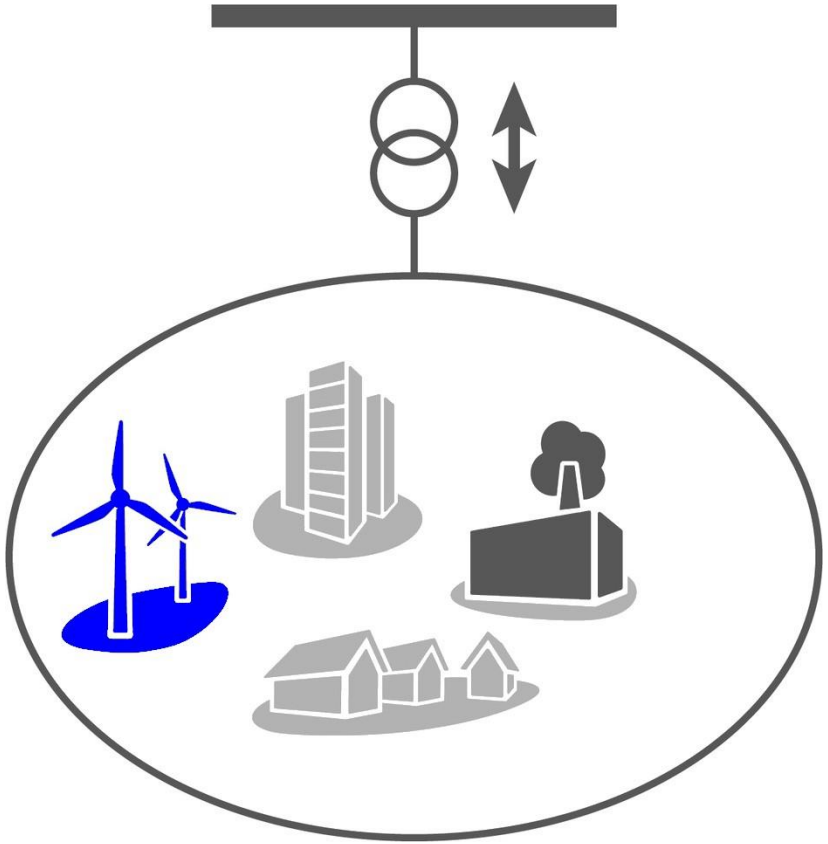
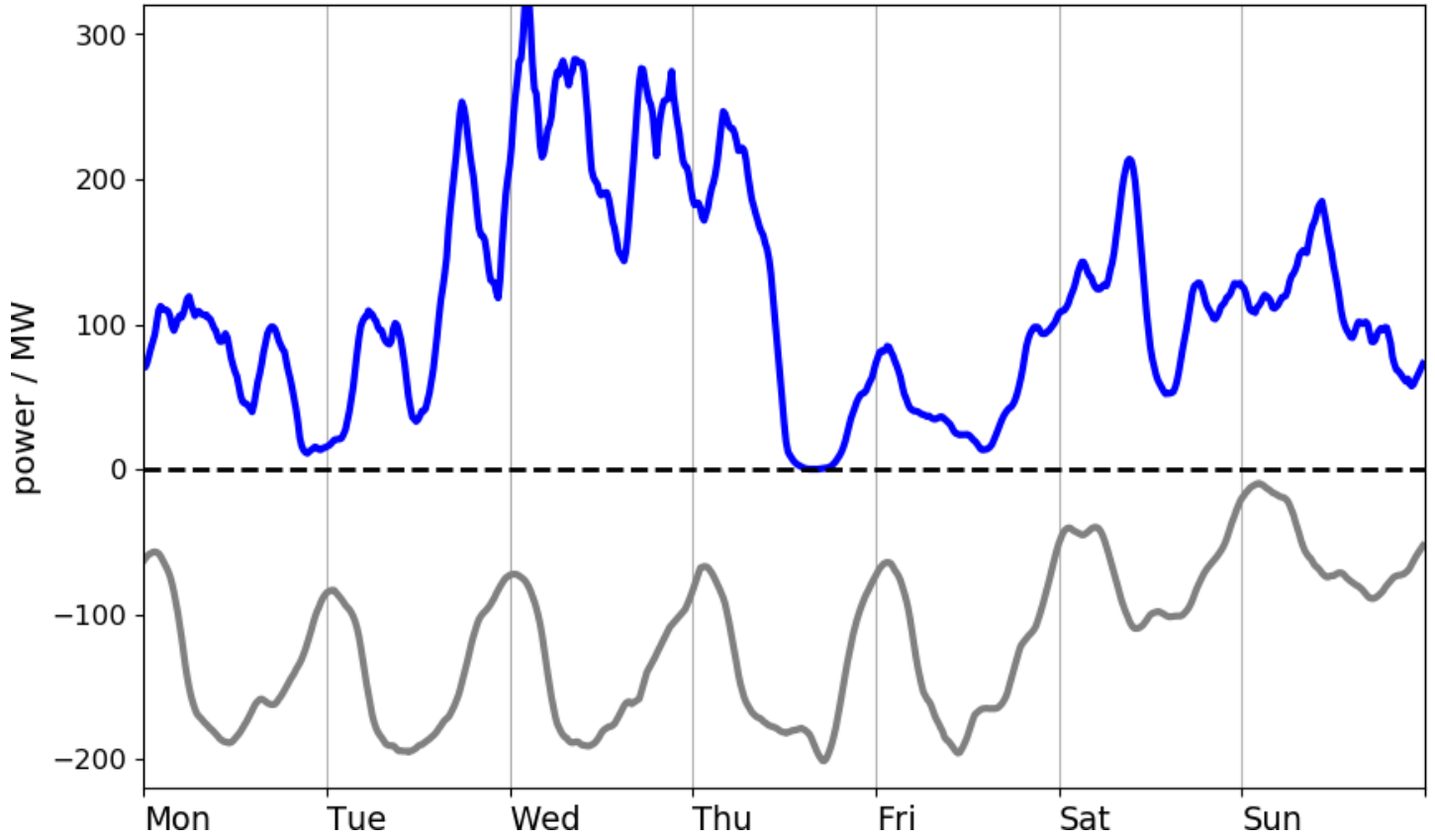
# Vertical Grid Load in change due to renewables






grey line: former vertical grid load
blue line: real wind production

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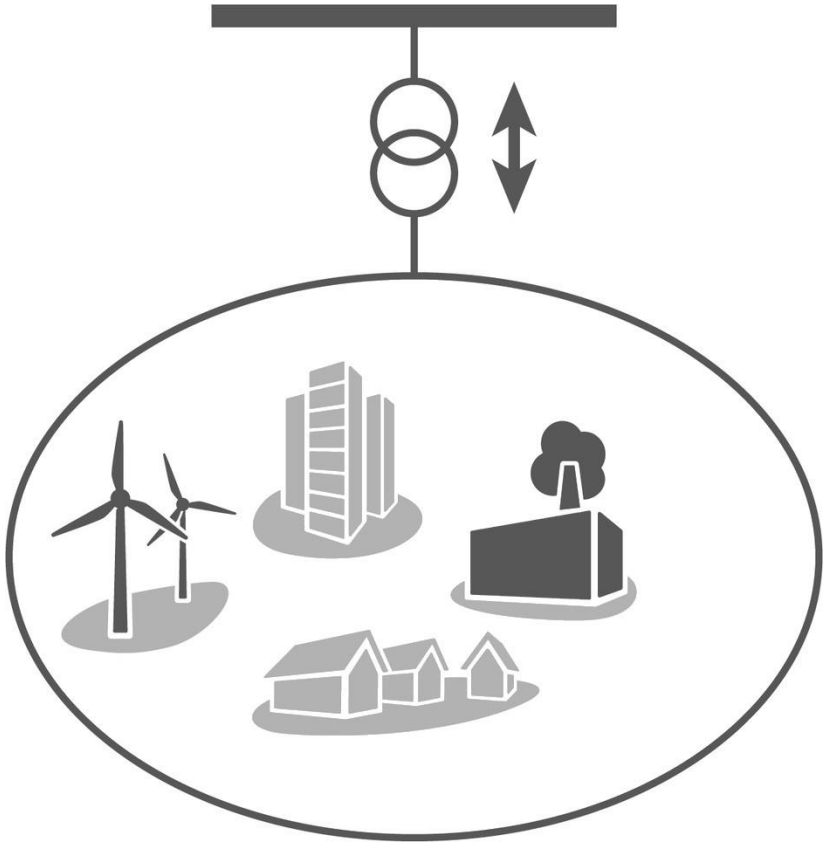
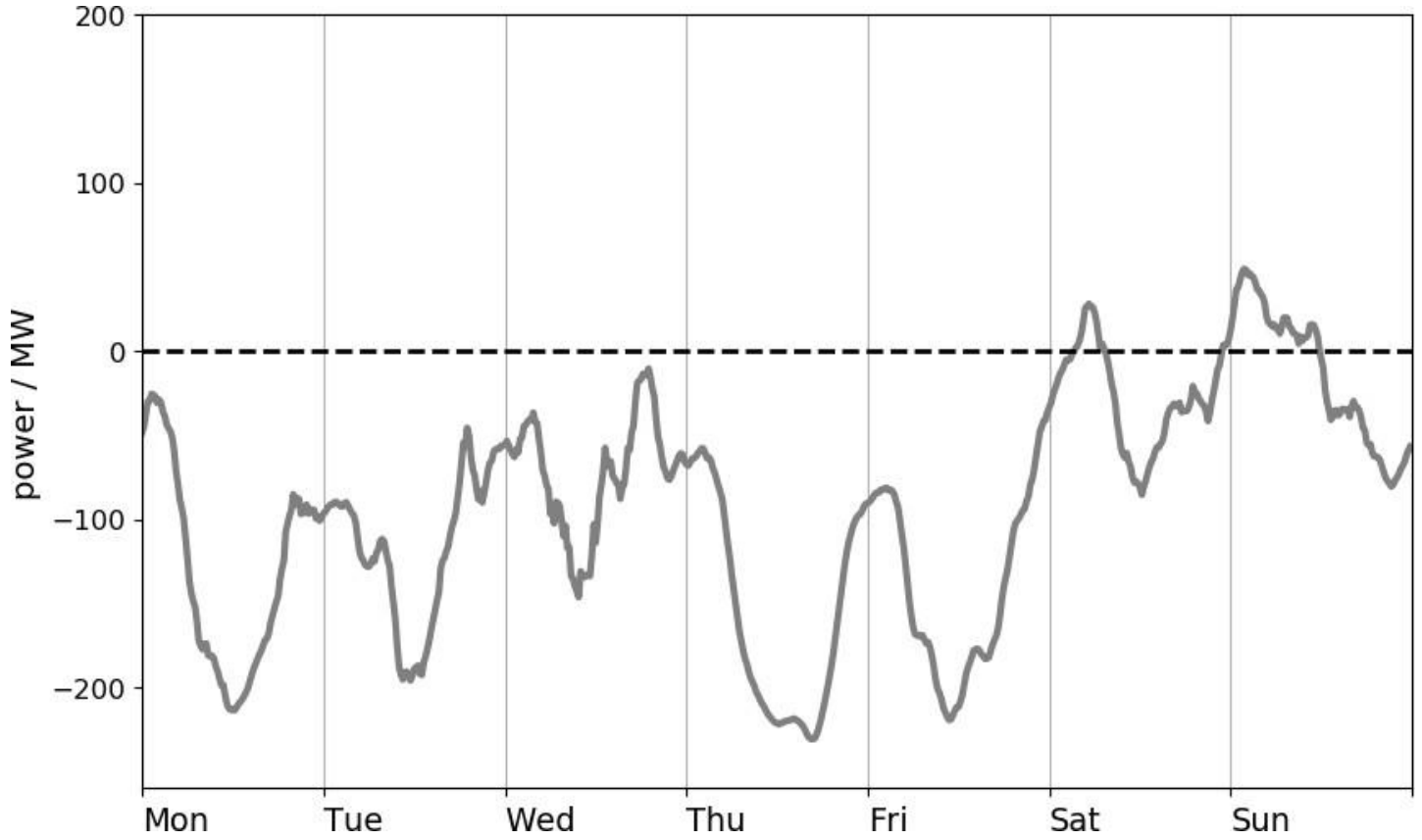
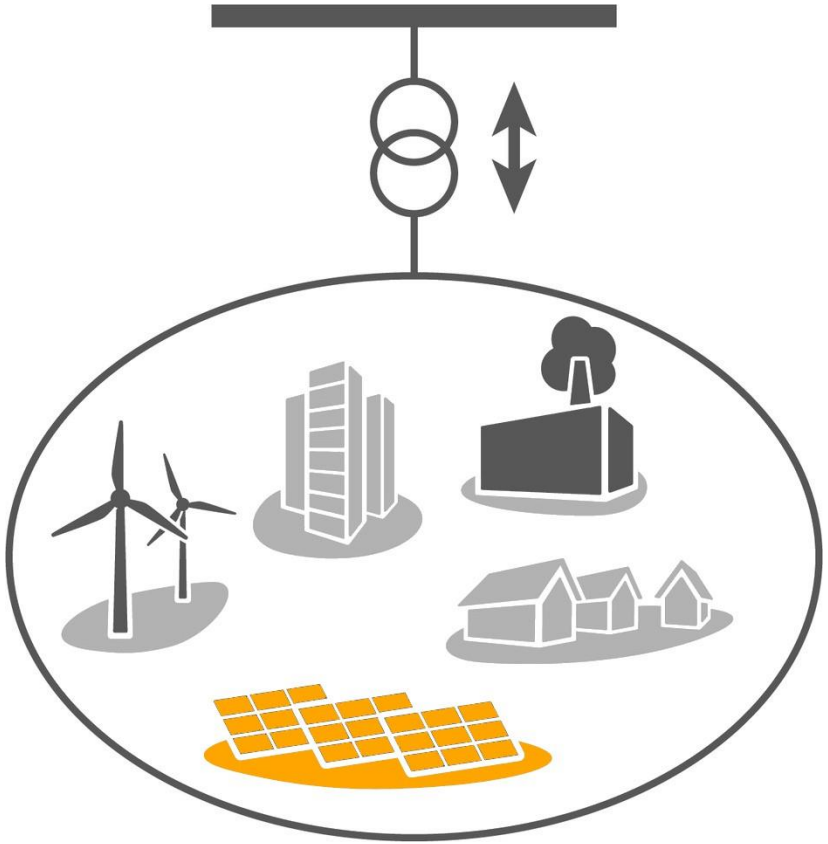
# Vertical Grid Load in change due to renewables

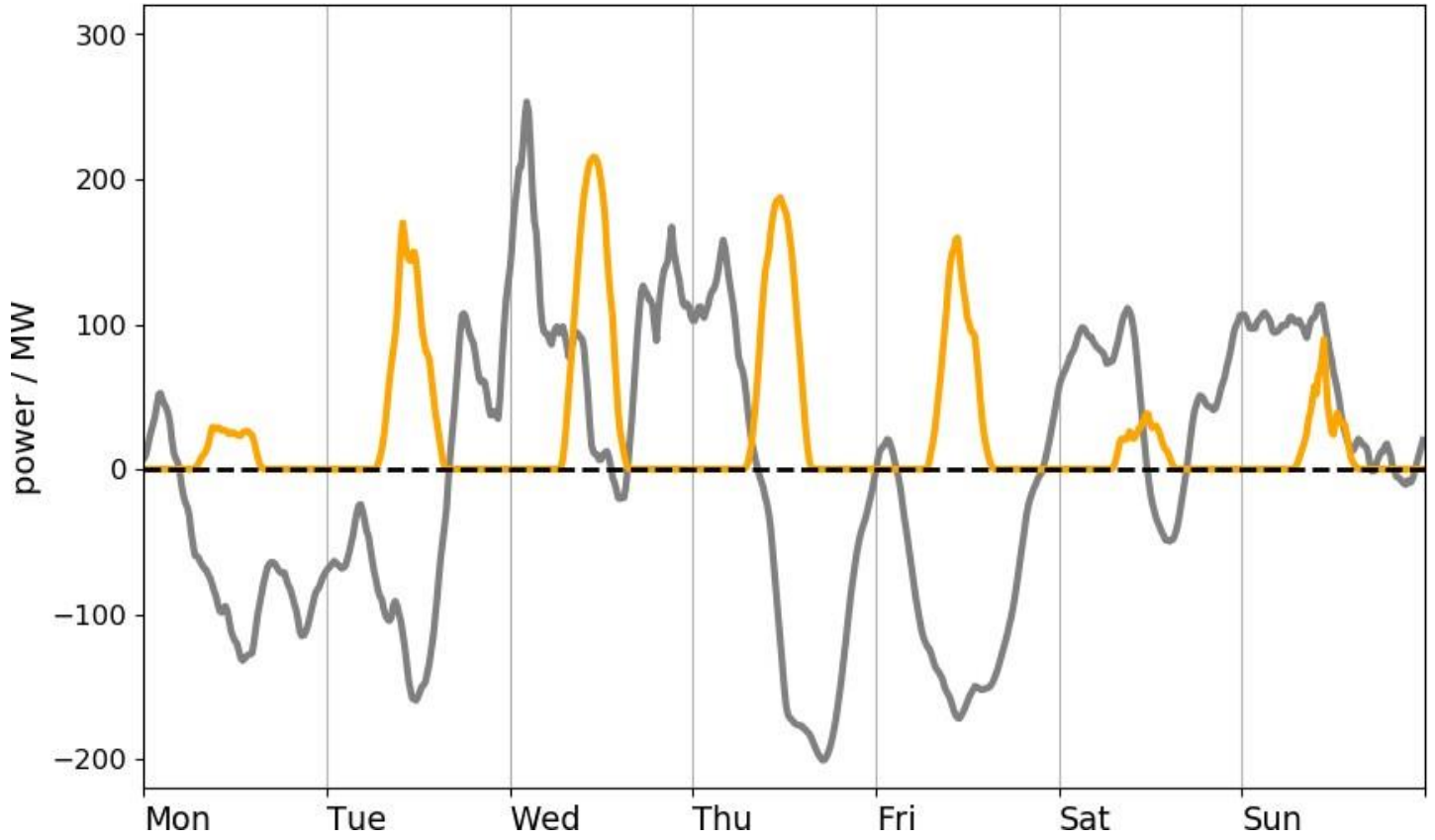





grey line: resulting vertical grid load (+wind)

# Vertical Grid Load in change due to renewables






grey line: former vertical grid load (+wind)
orange line: real solar production

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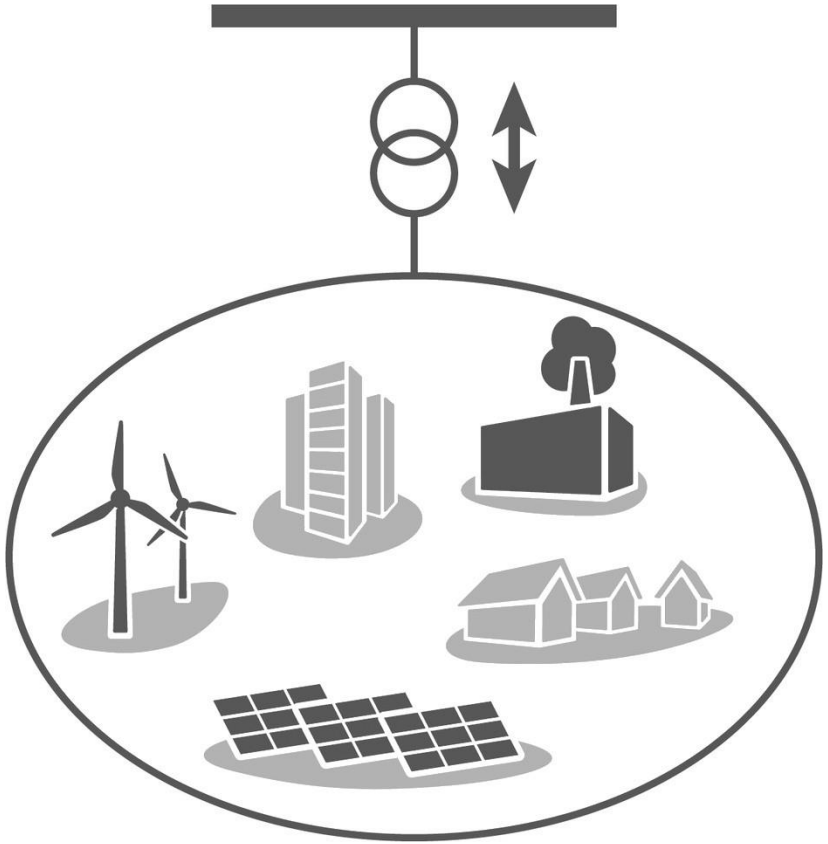
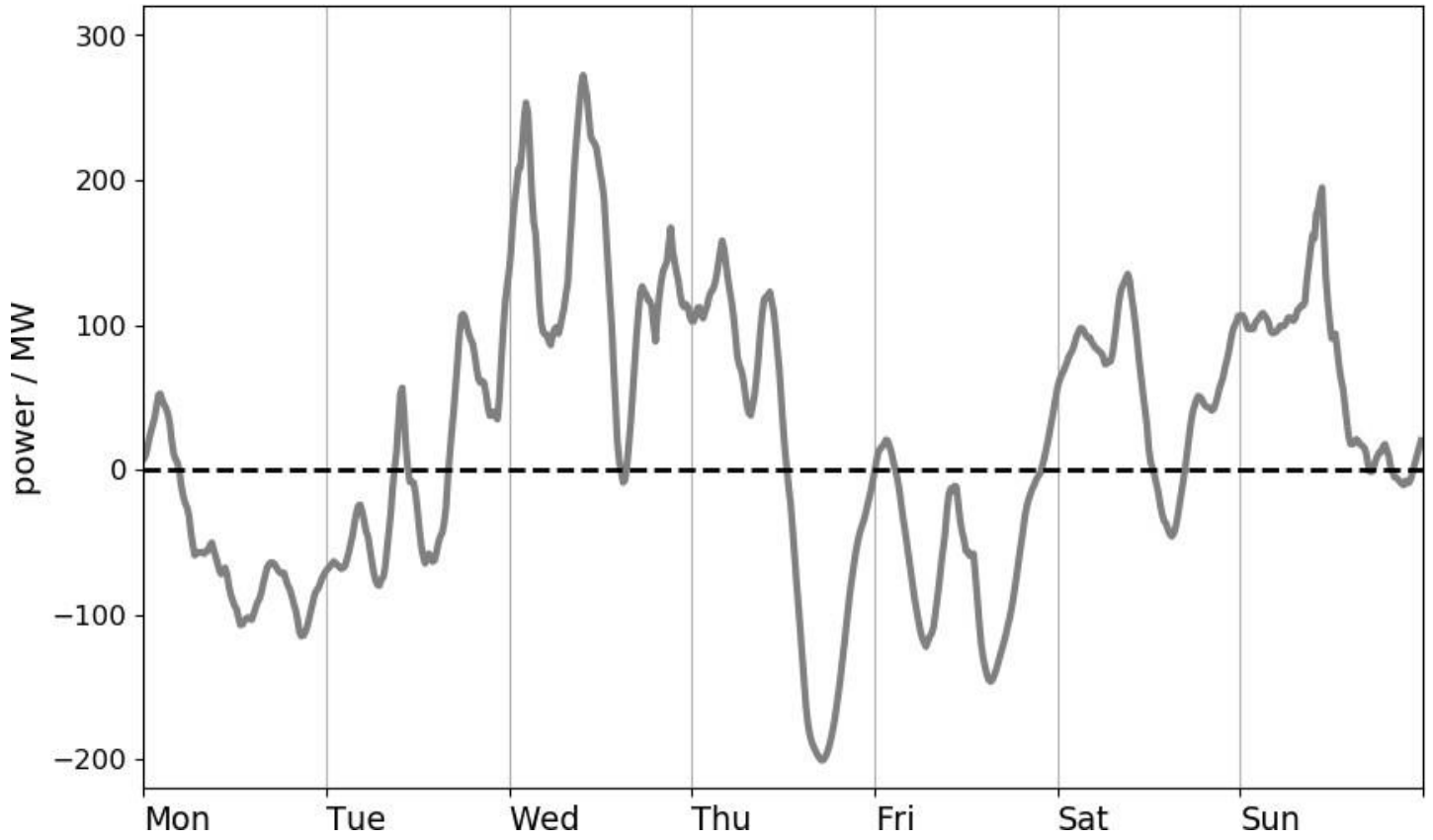
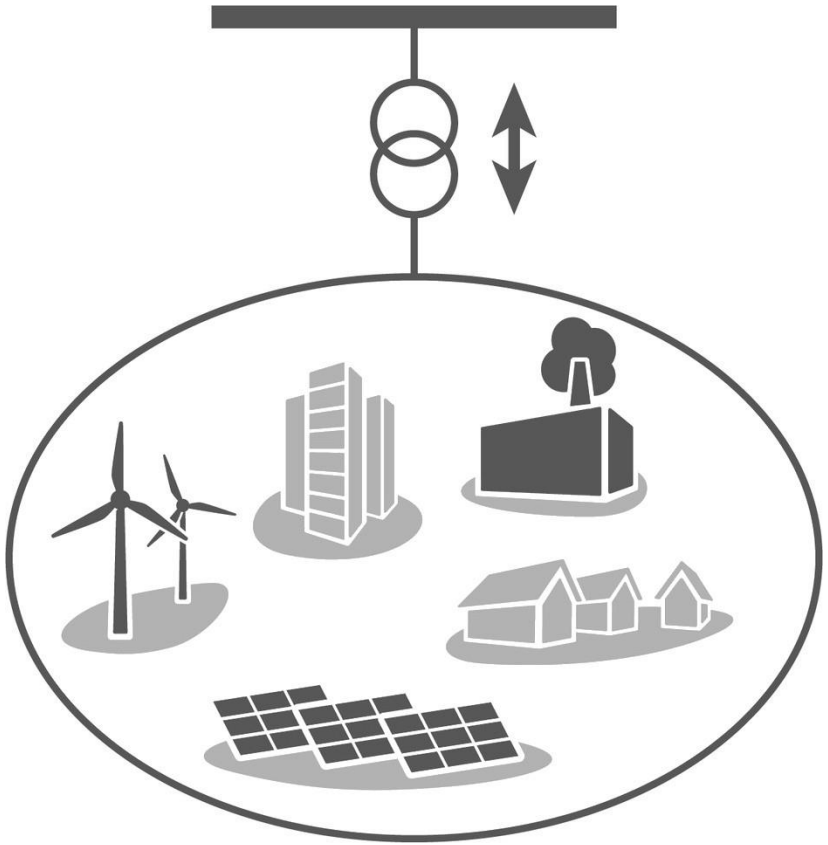
# Vertical Grid Load in change due to renewables

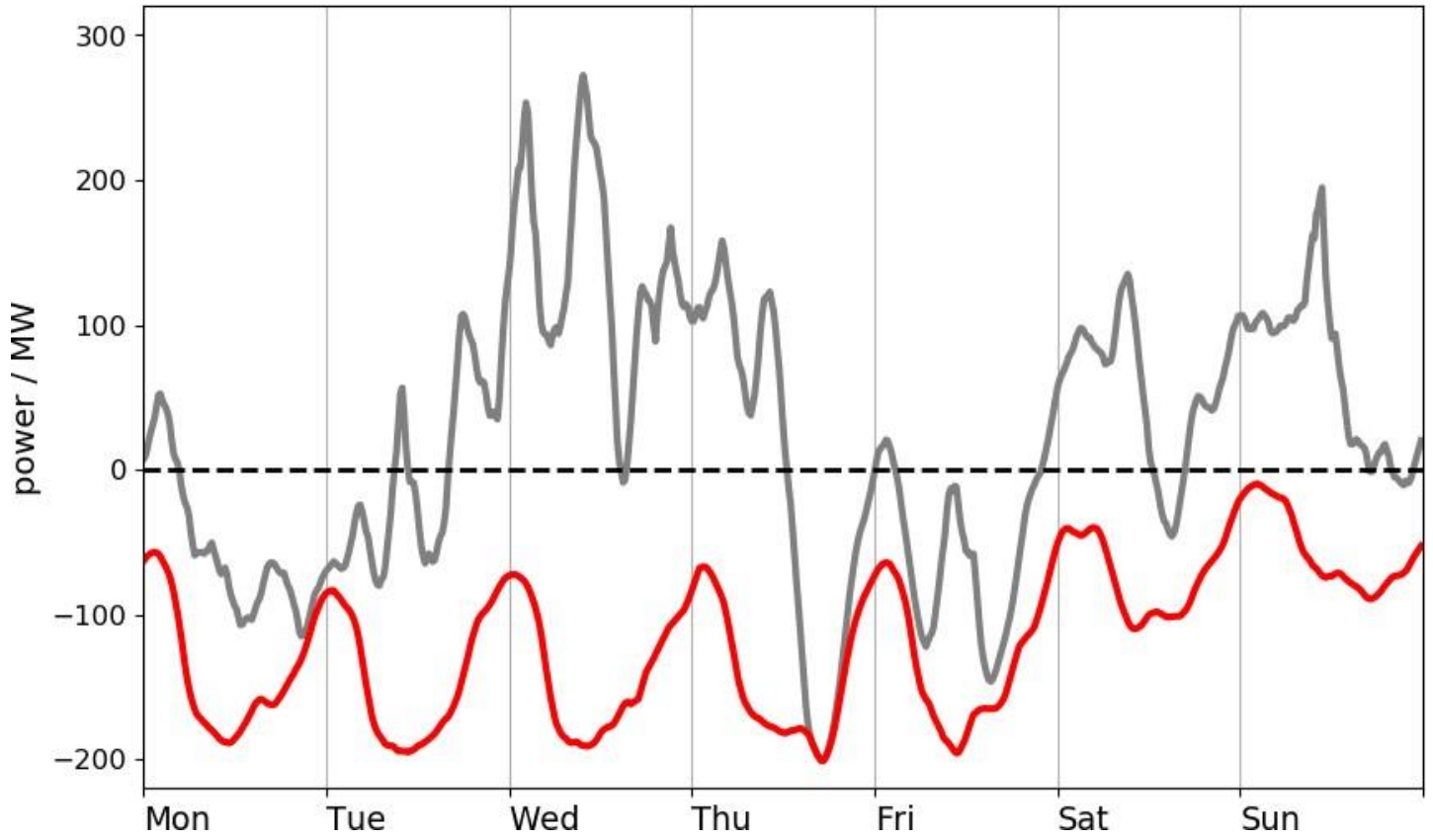





grey line: resulting vertical grid load (+wind +solar)

# Vertical Grid Load in change due to renewables






grey line: resulting vertical grid load (+wind)
red line: Old world vertical grid load without renewables

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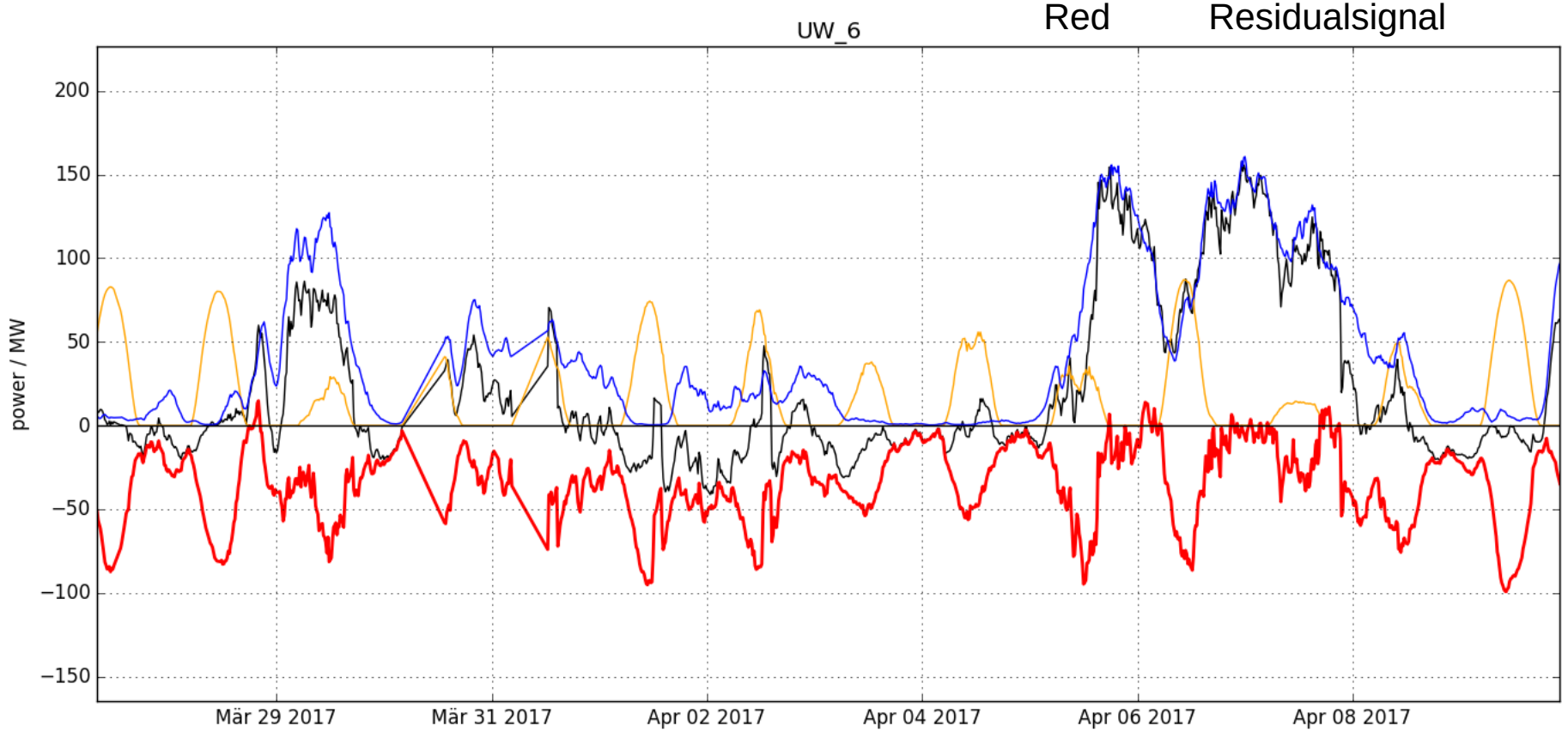
# Example of decomposition on a substation

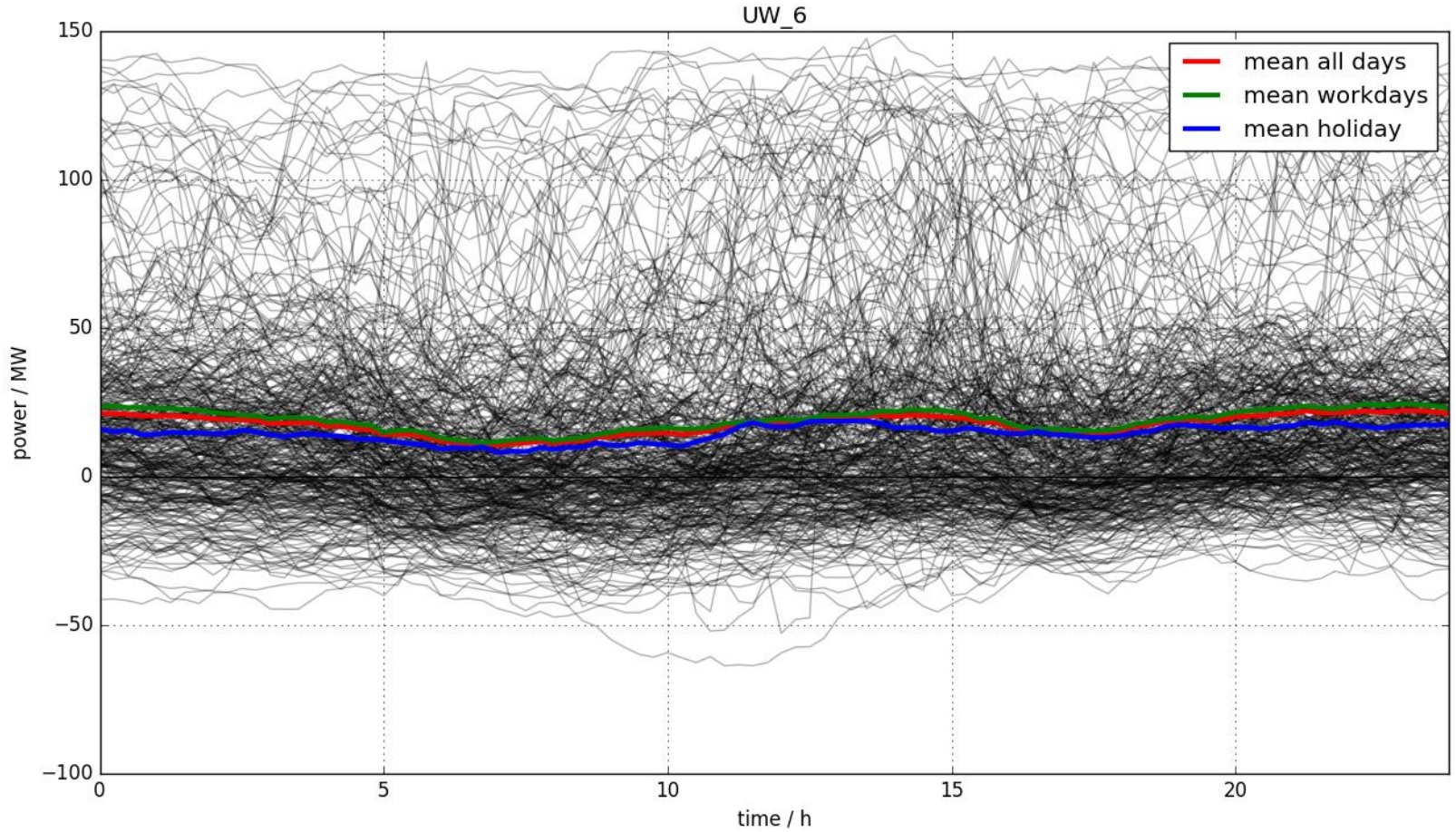
| | |
|---|---|
| Black | Measurement of vertical net load |
| Blue | Upscaling wind |
| Yellow | Upscaling solar |
| Red | Residualsignal |




**→ Do we really know the wind and solar components?**

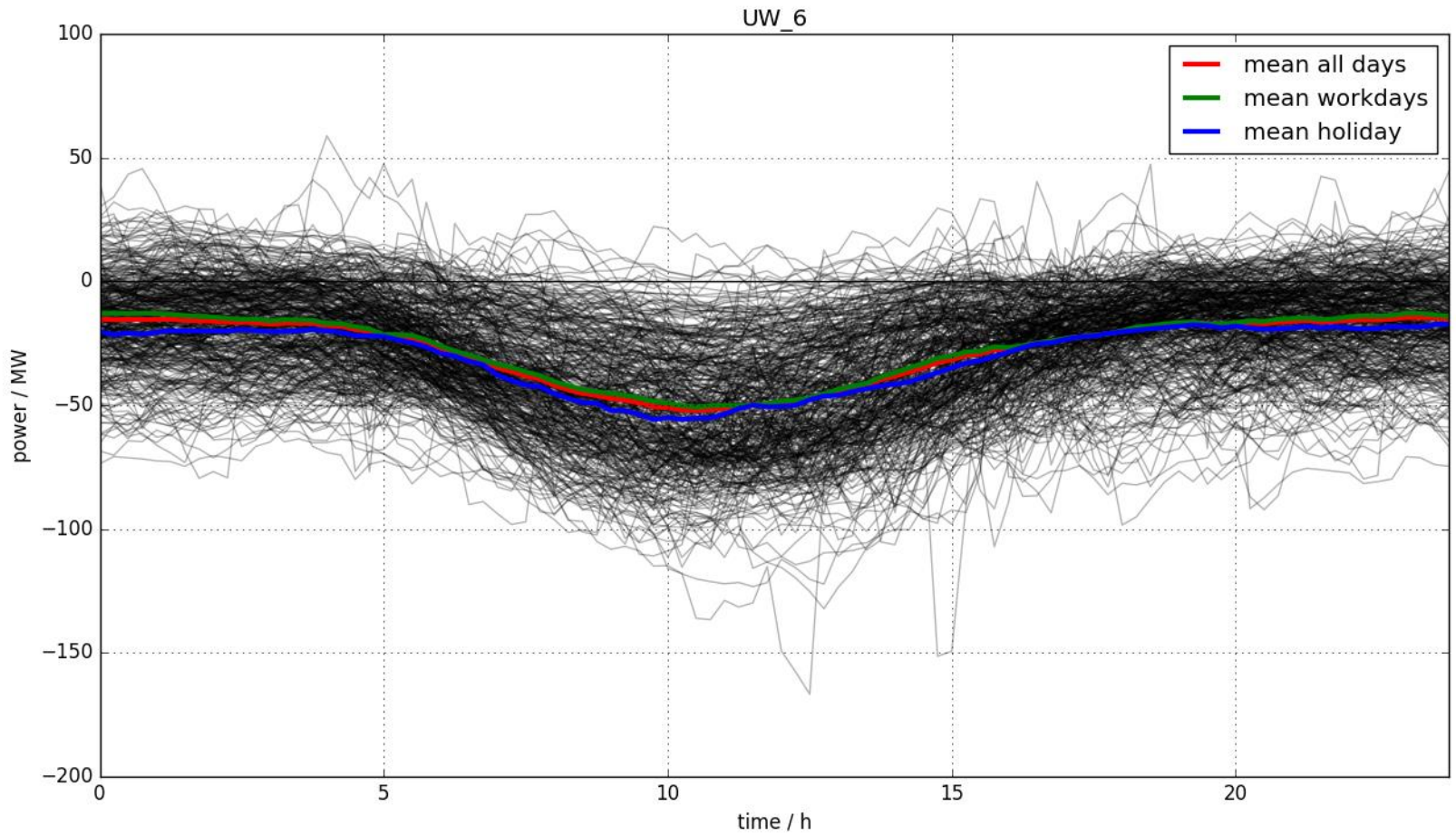
# Residual load

**Without** an optimized distribution of PV and wind proportions



# Residual load

**With** an optimized distribution of PV and wind proportions

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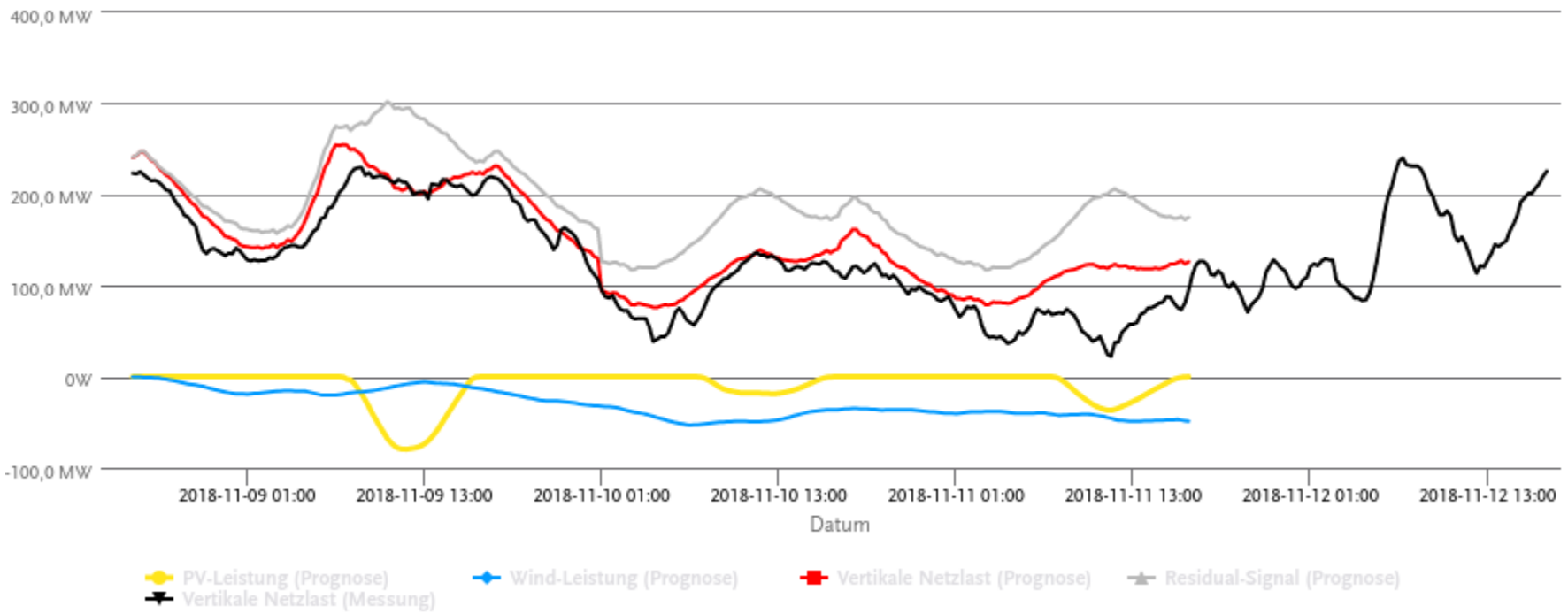
# Example forecast Vertical Grid Load

vertical grid load = consumption + production
= consumption + wind + solar + other production




*black*: measurement of vertical grid load

*red*: prediction (3 days ahead) of vertical grid load

*yellow*: prediction of solar feed-in

*blue*: prediction of wind feed-in

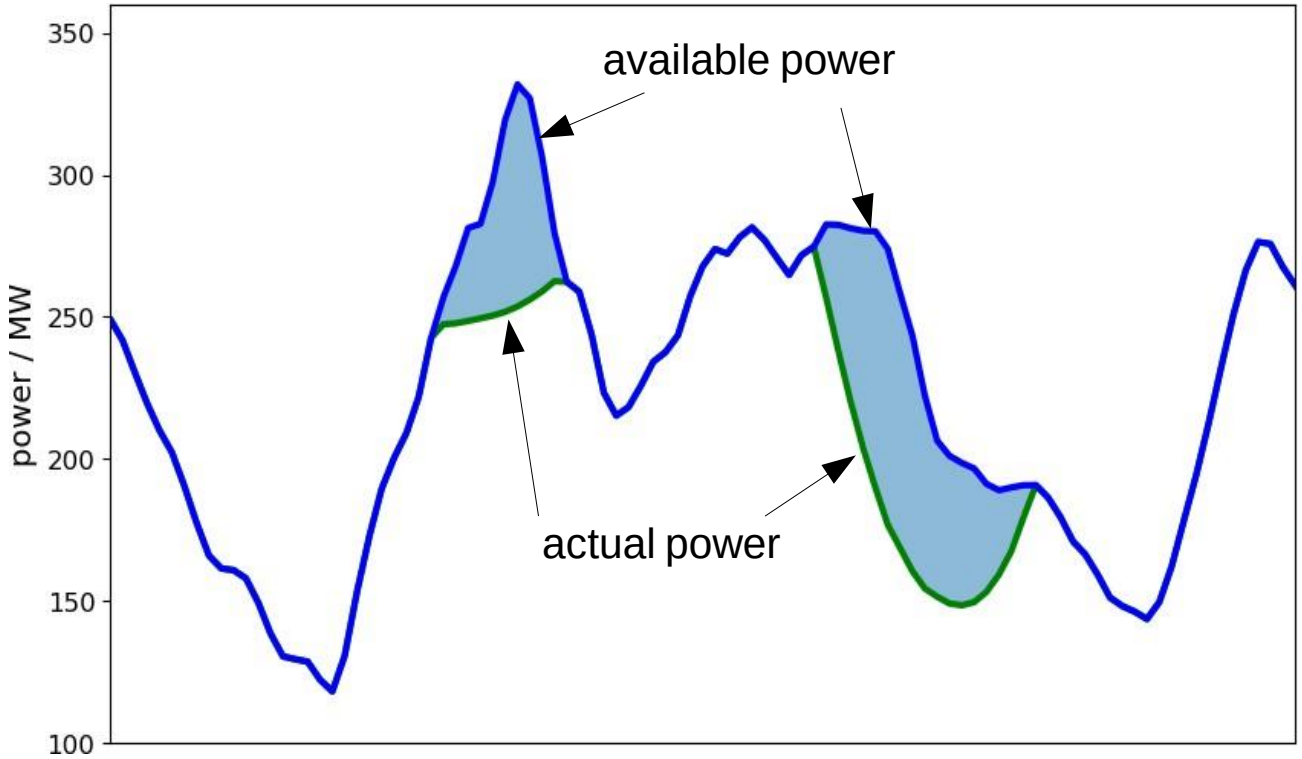
wind and solar as negative values

# … which one is the correct target?

- power forecaster usually predict the **actual power**, this target is measureable!

- to predict grid congestions, grid operators need the **available power**
(no measurement!)

What would happen if grid operators use the actual power forecast to predict congestions?



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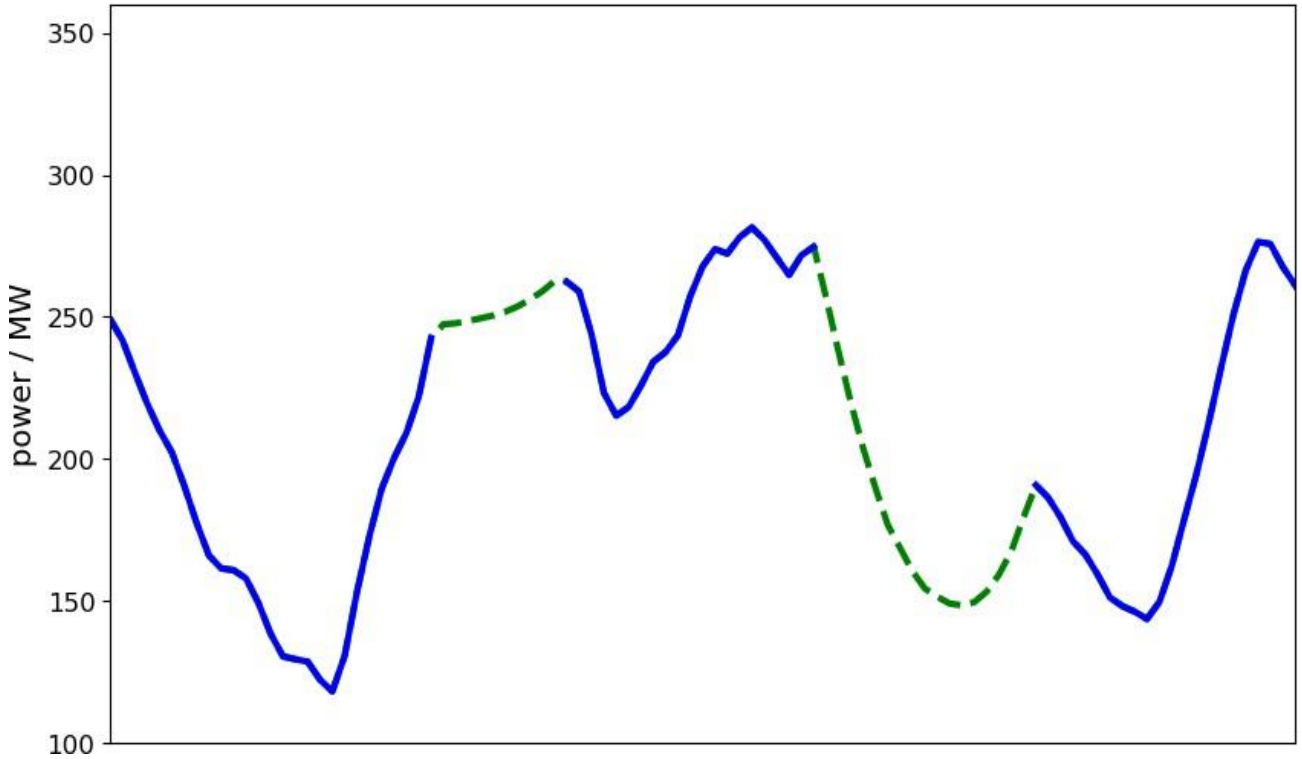
What would happen if grid operators use the actual power forecast to predict congestions?

➔ **No future grid congestion visible...**



# Thank you for your attention

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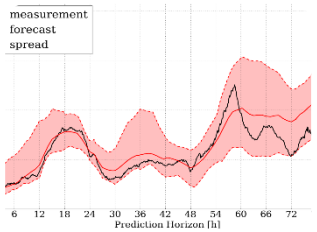
# About energy & meteo systems

## Company

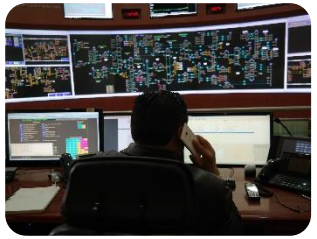
- Owner-managed since its founding in 2004
- Located in Oldenburg, Germany
- 90 employees (software developers, physicists, meteorologists and industrial engineers)

## Services




- Accurate power forecasts for solar, wind and demand
- Market-leading Virtual Power Plant (SaaS)
- Consultancy and R&D

## Users



- Transmission, Distribution and Independent System Operators
- Energy trading companies
- Plant operators (IPPs, utilities etc.)

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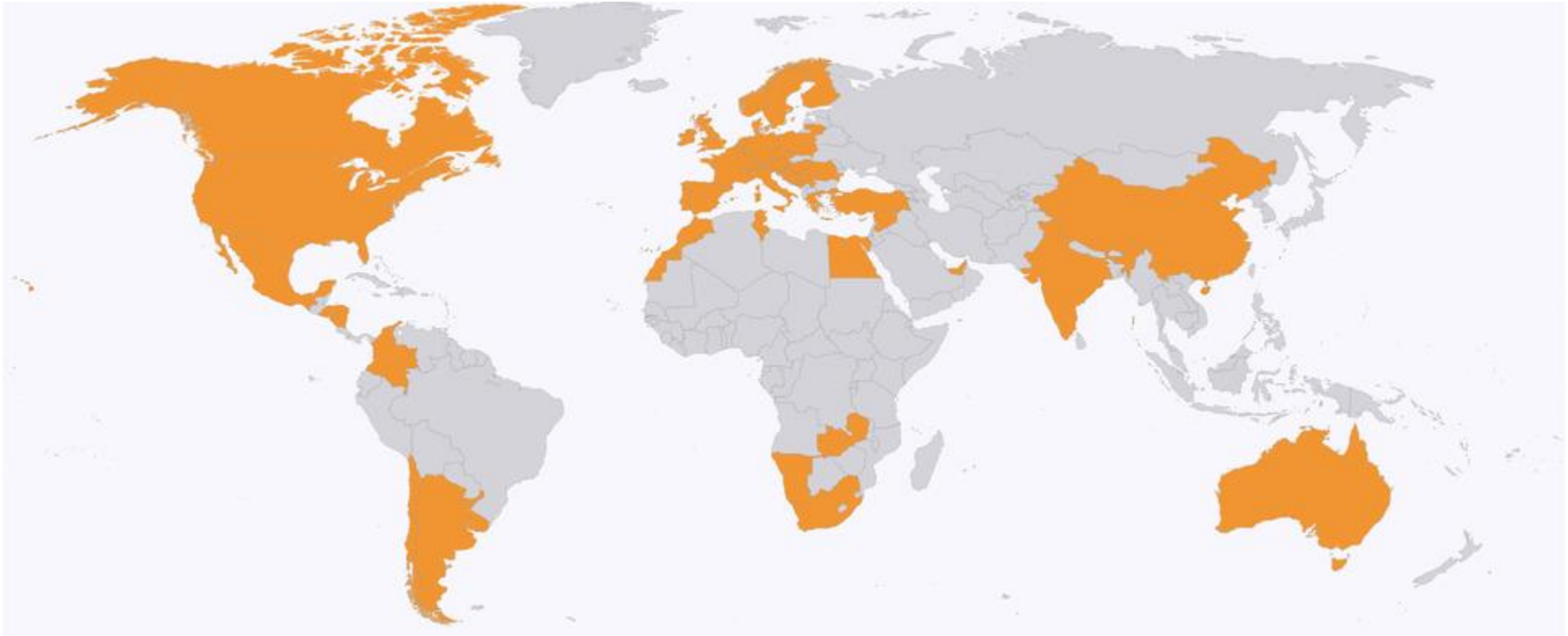
# About energy & meteo systems

International business activities



Currently, we are forecasting about 280 GW of wind power and nearly 150 GW of solar power

# Choice of our customers







Tennessee Valley Authority







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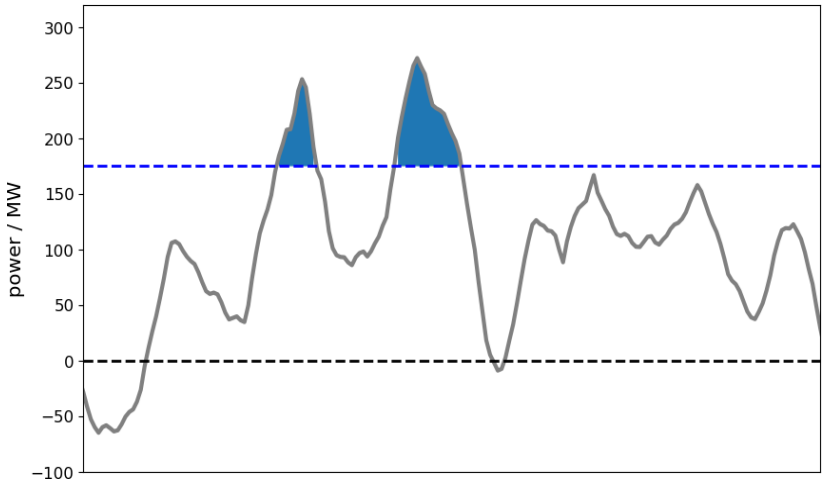
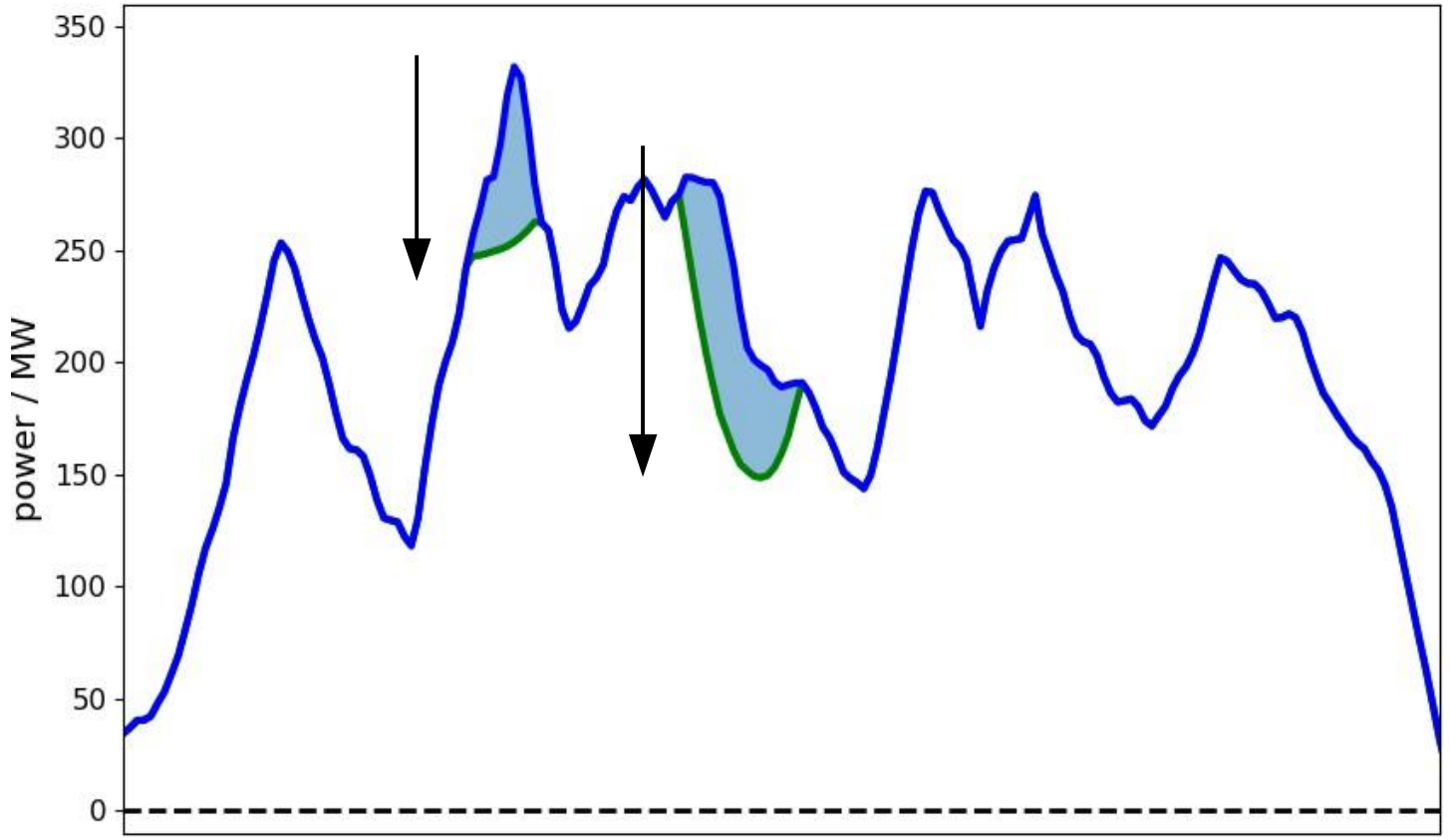
# Question: how to manage grid congestions in nodal market




grey line: vertical grid load

- Possible production is needed to get the possible vertical net load !




blue line: wind power

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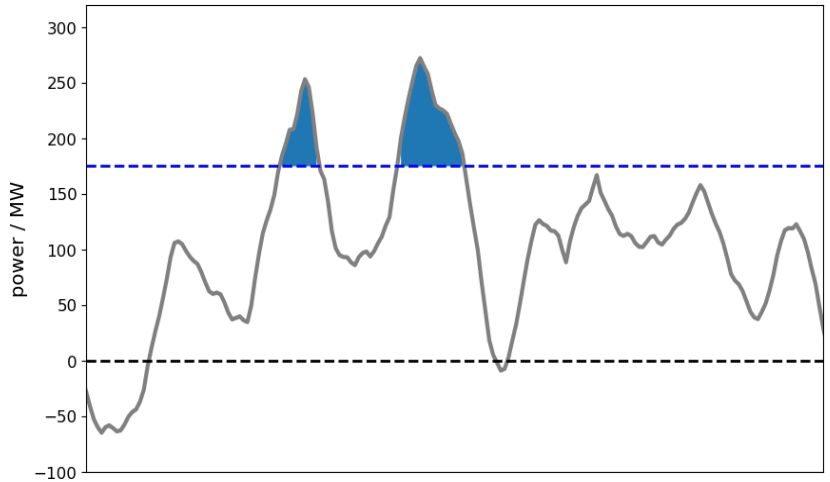
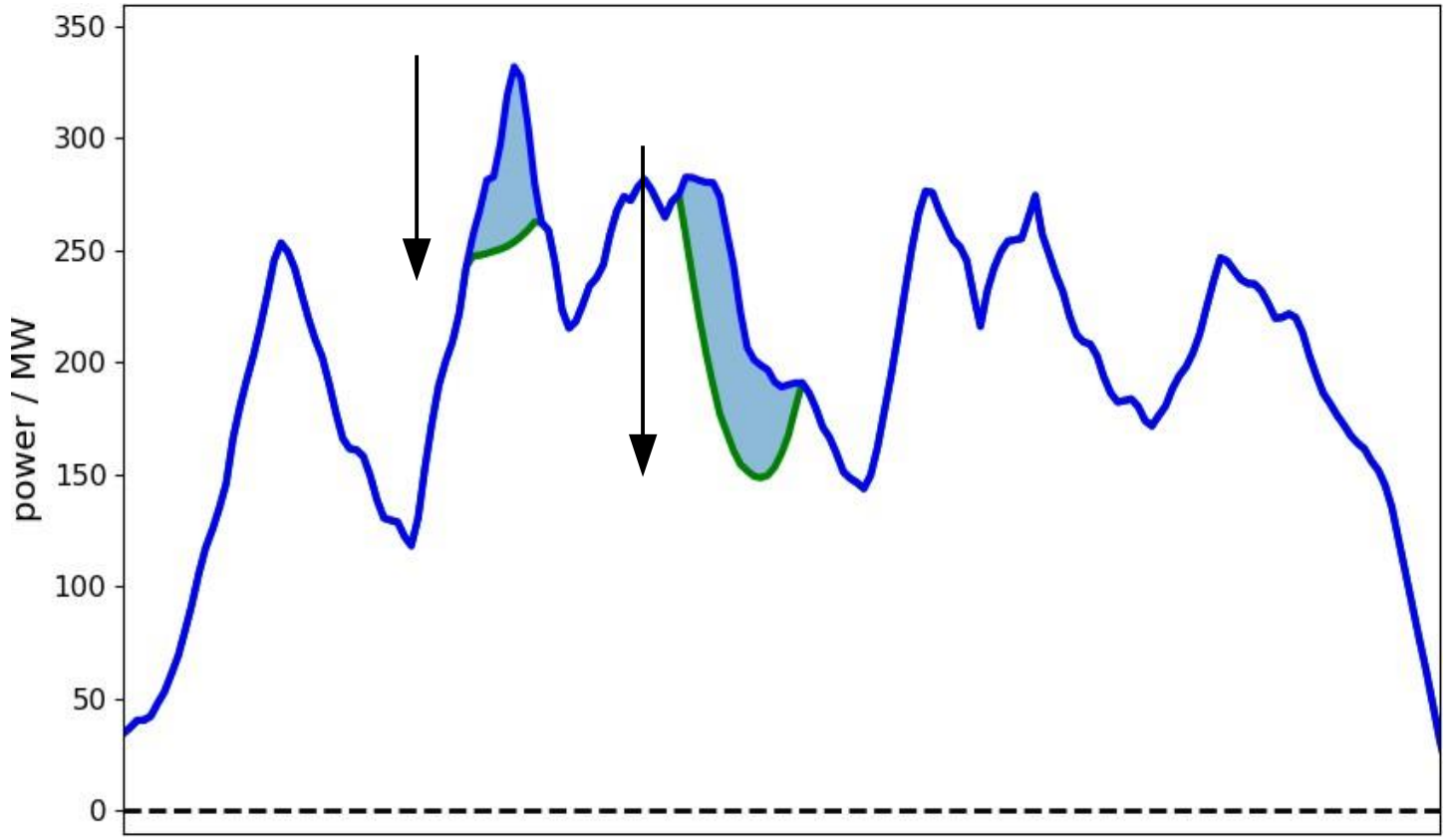
# example: grid congestions mangement in Germany




grey line: vertical grid load

- grid congestion leads to online **curtailment of renewable energies**
- day-to-day business in Germany „**EinsMan**“




blue line: wind power

- Process will change to planed process (dayahead and intraday) „Redispatch“, forecast of vertical net load is essential.for congestion forecast

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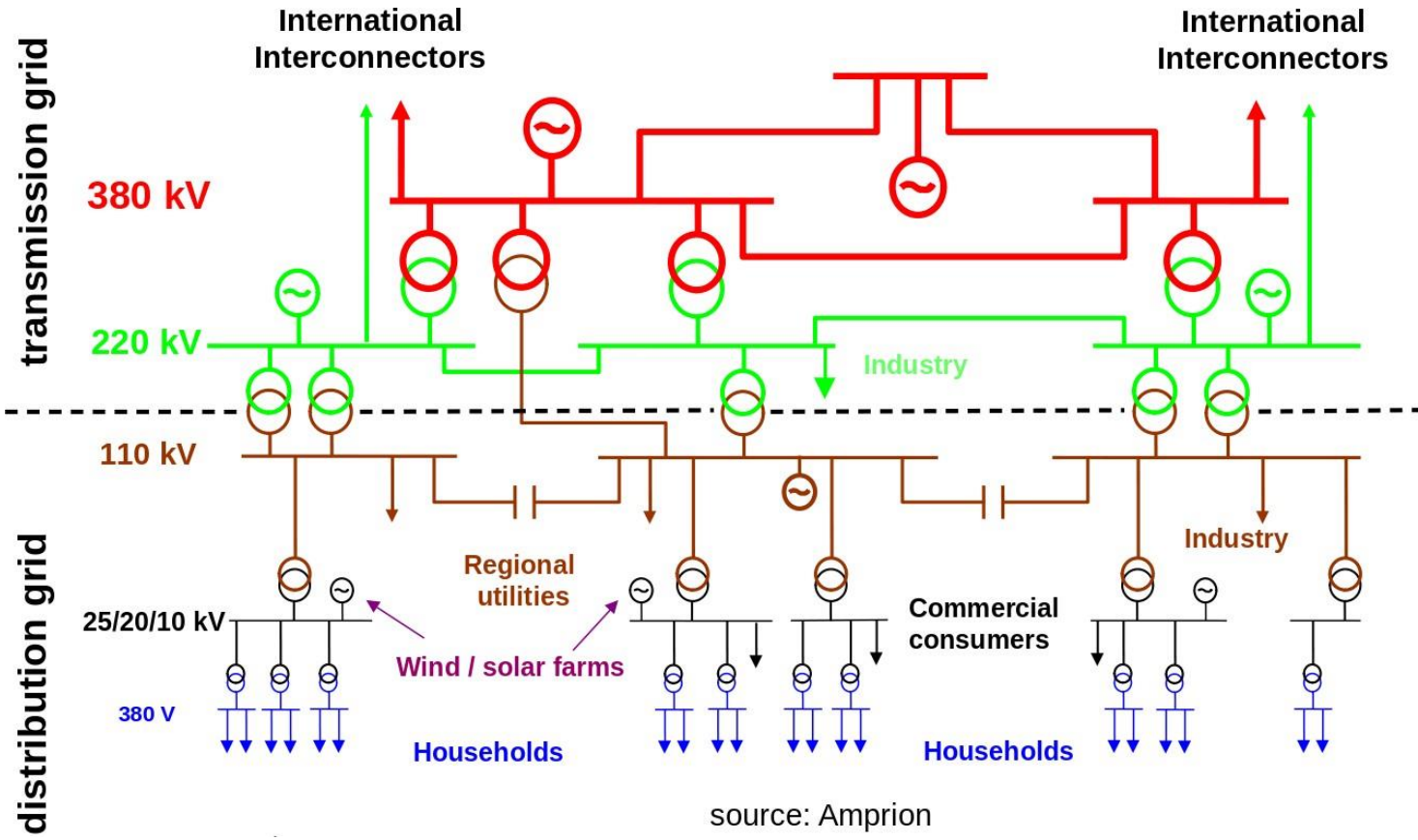
# Reactive vs. Proactive grid congestion management

- a **power-flow calculation** for **future** grid states (day ahead) is necessary to identify upcoming grid congestions and be prepared

**reactive → proactive**

- elementary input for a predictive power-flow study is the **prediction** of **wind**, **solar** and the **vertical grid load** of all grid connection points




source: Amprion

# Backup: downregulation of wind power


green line:
**requested target**
blue area:
**resulting active power**
yellow line:
**available power**

# State of the Art: Integration of renewable energies

Most important challenges:

- **predictability** of renewable power feed-in
- **remote control** of renewables („downregulation“, like **Redispatch** or **EinsMan**)
- detection of **grid congestions** in all grid levels
- European grid operator processes: **DACF** (Day-Ahead Congestion Forecast)

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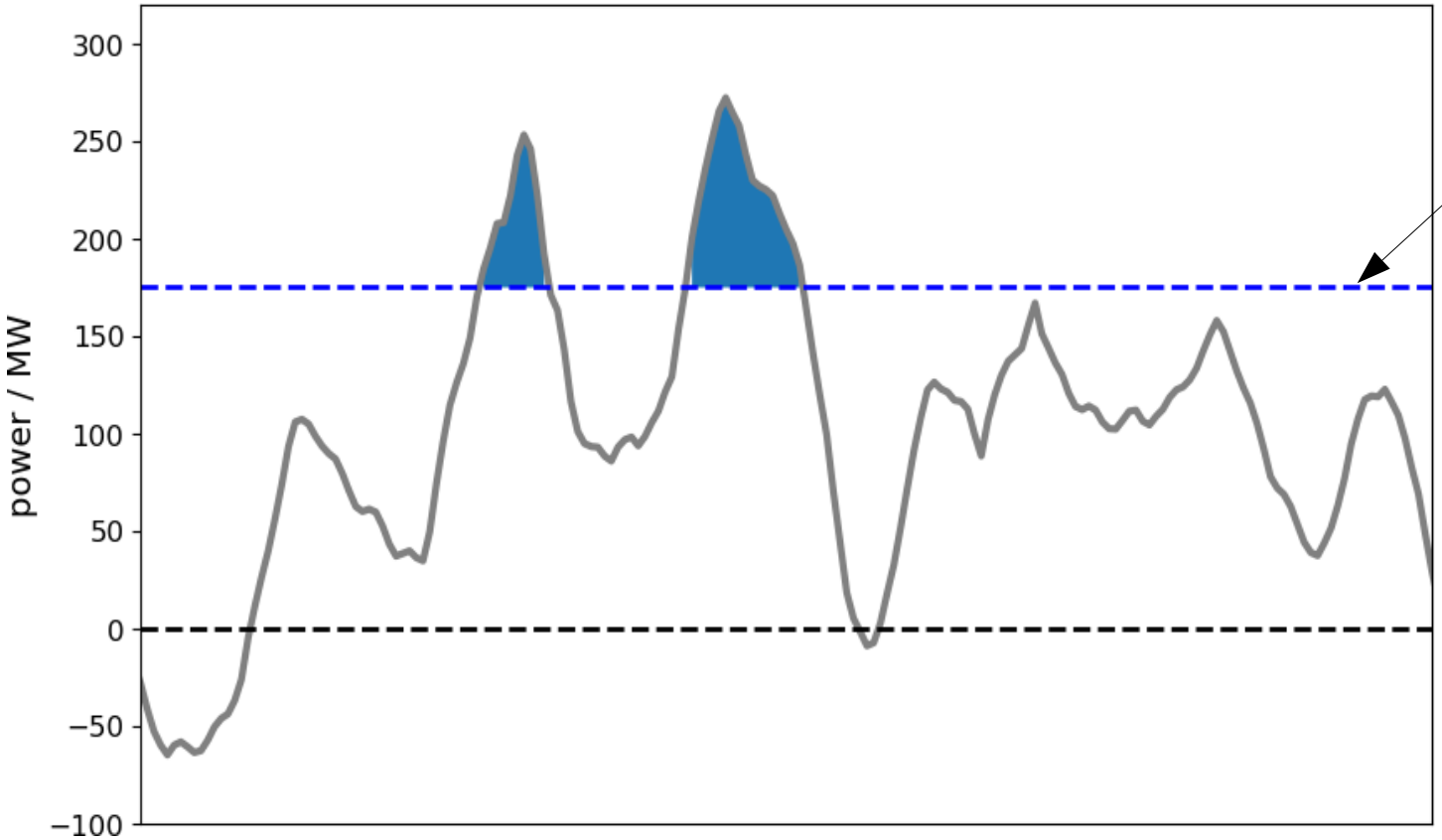
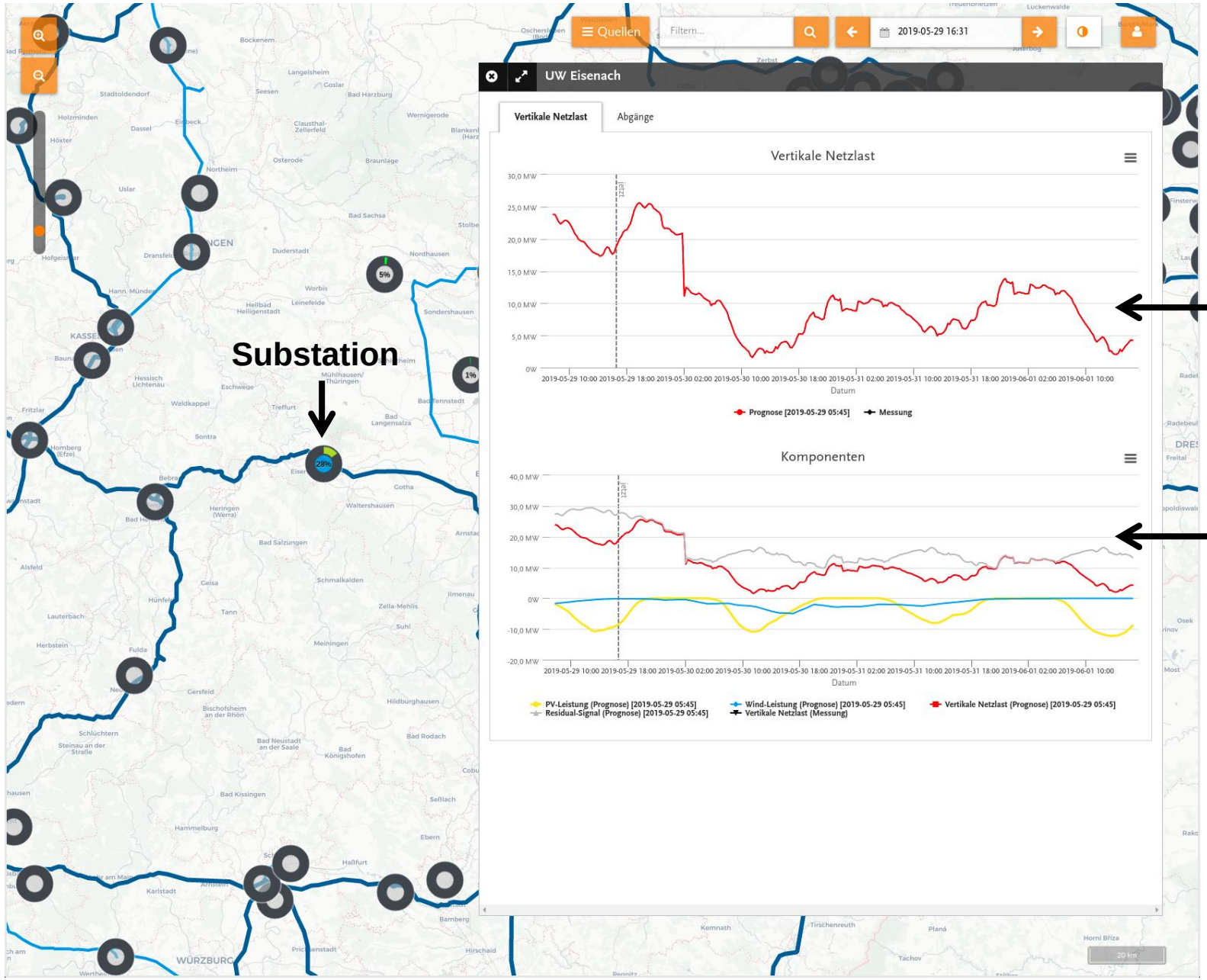
# example: grid congestions




grey line: vertical grid load

- exemplary **limit** of transformer station or grid line → 175MW
- two time intervals with **grid congestions**
- **congestion management** required!




# Vertical Grid Load portal by emsys

Measurement and forecast of Vertical Grid Load

Components of vertical grid load

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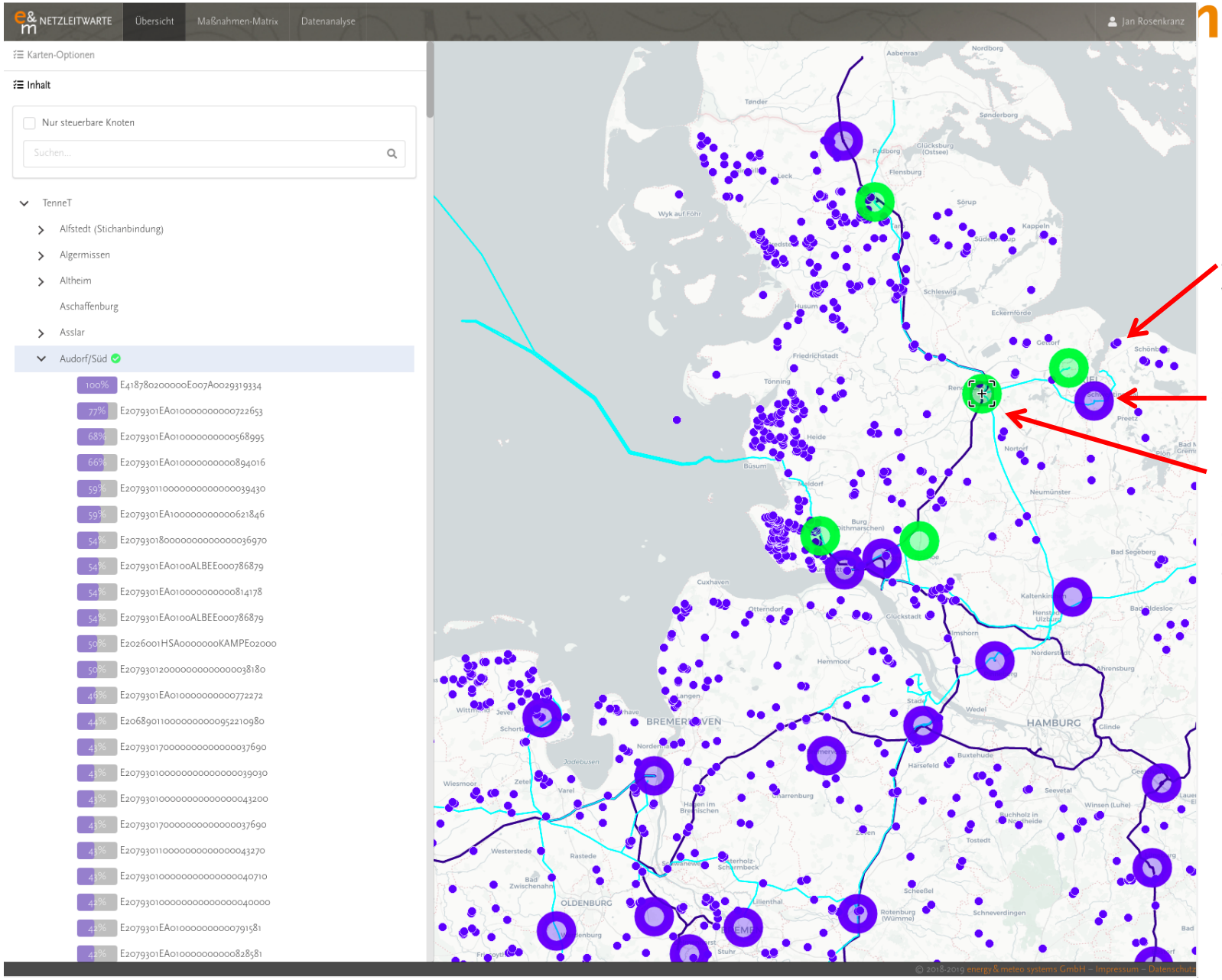


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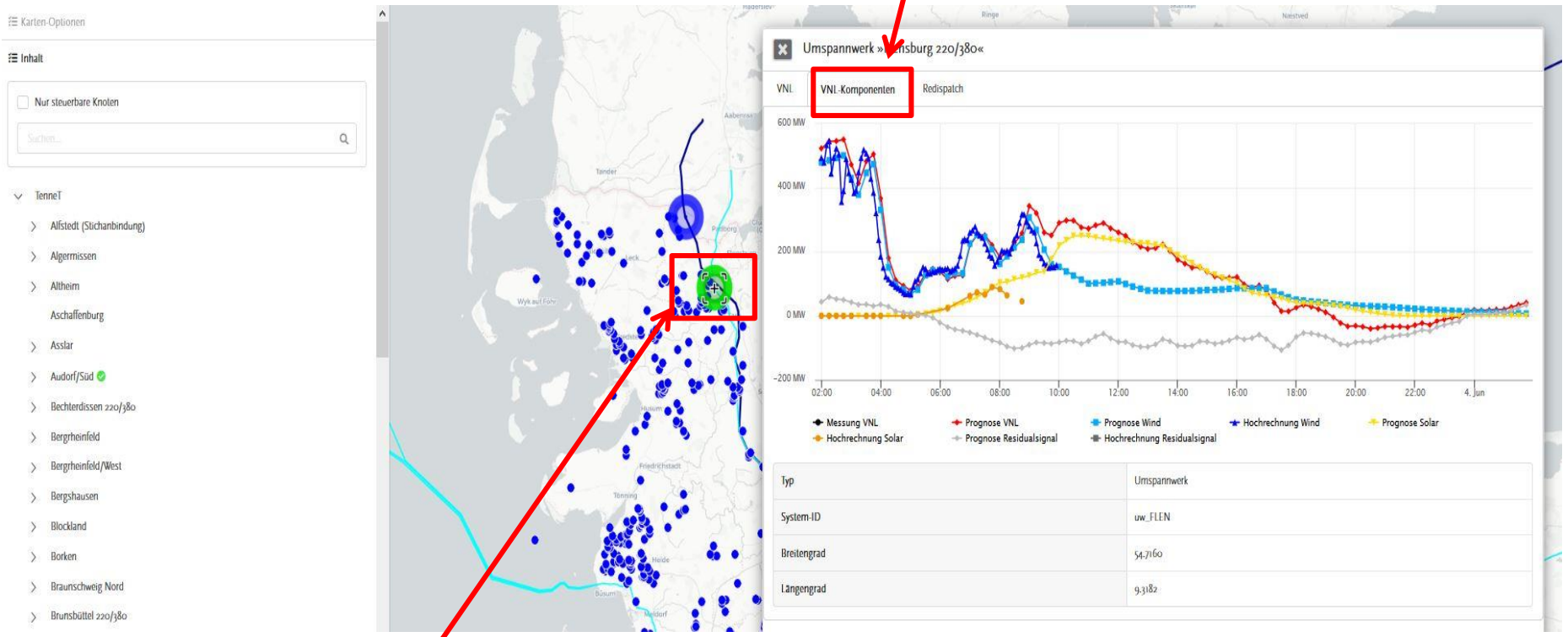
# Grid Operator Control Room

View of Vertical Grid Load components




Selected controllable substation

# Planning of Redispatch Actions

***Redispatch*** *refers to interventions in the generation capacity of power plants in order to protect grid line sections from overload.*


Redispatch actions

**Potential** of Redispatch

Redispatch **Schedule** example

**Planning** of a Redispatch action to curtail down a wind power plant, e.g. 5 MW down from 09:15 to 09:30, on substation level

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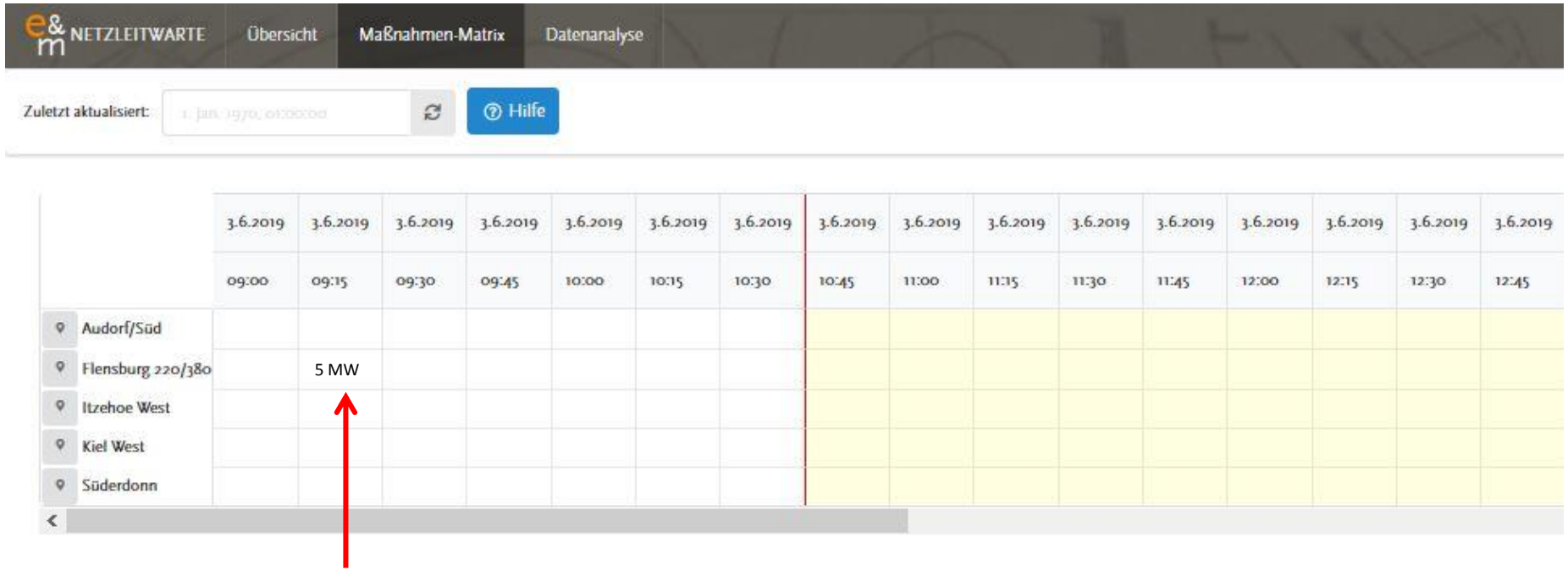
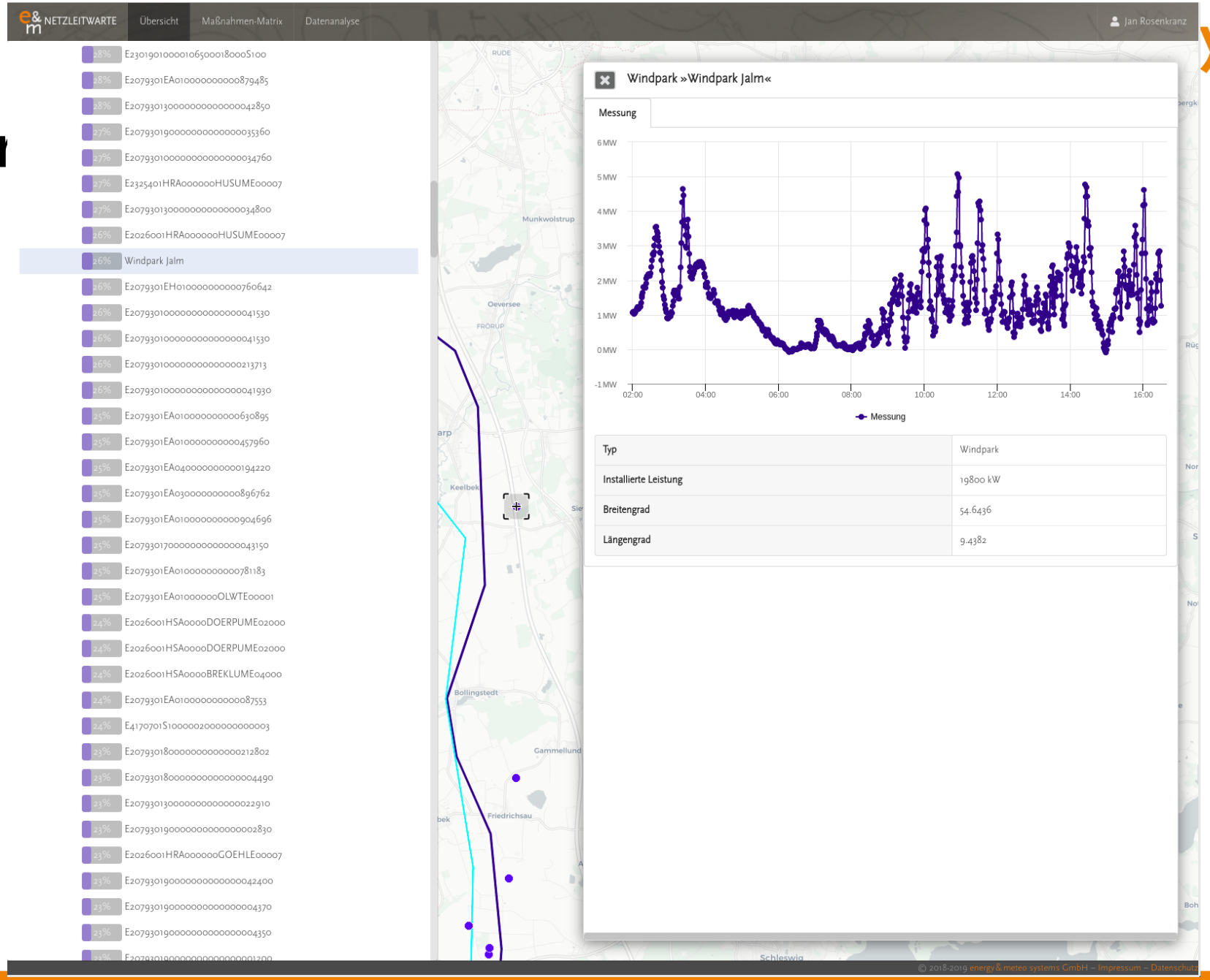
# Grid Operator Control Room

## Action matrix

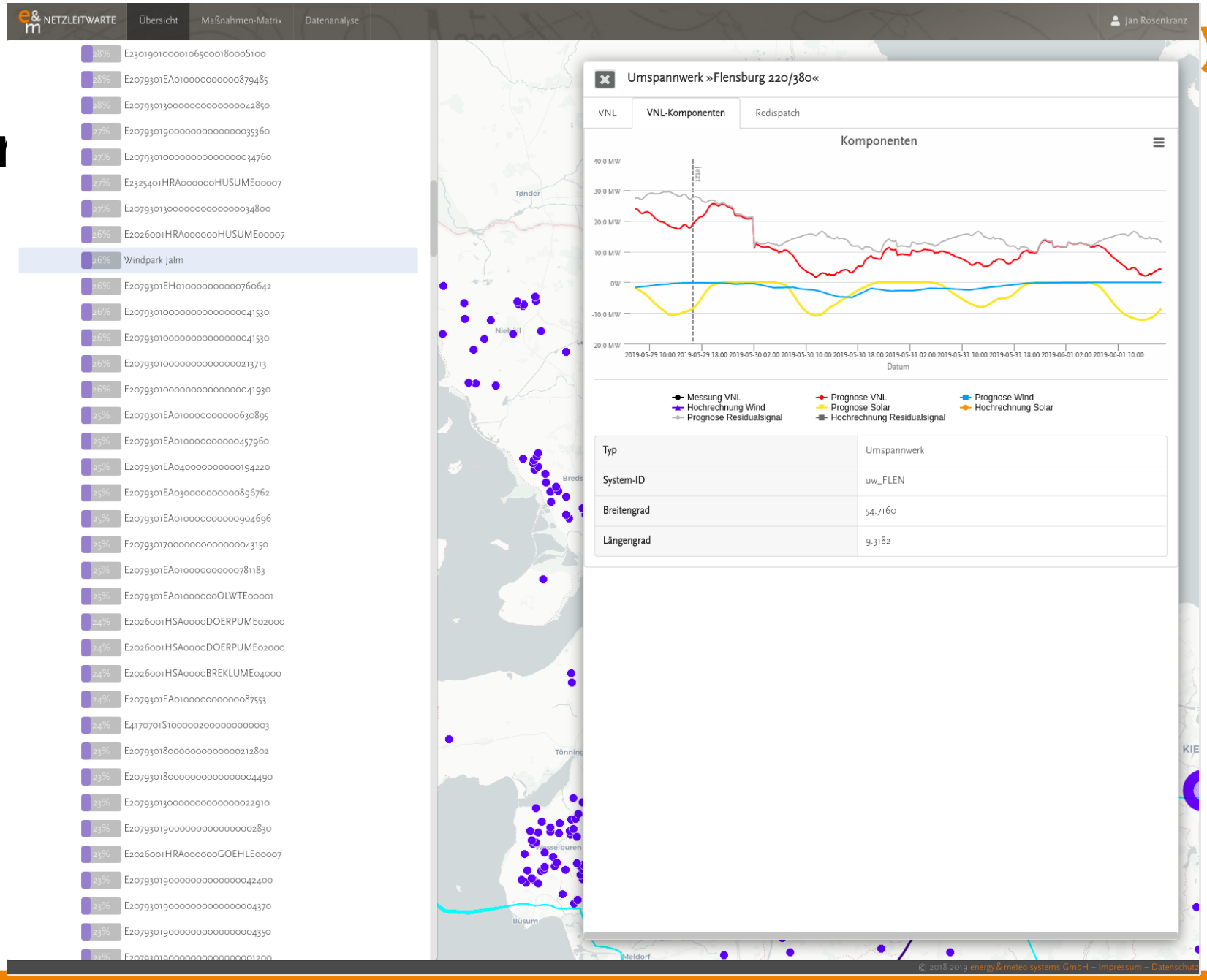



Example: Redispatch action of 5 MW down for 09:15 to 09:30

# Gr



# Gr

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# Comparison Germany - US

| | Germany | USA |
|---|---|---|
| Wind measurements of real power | No | Yes |
| Estimate of real wind power | Yes | Not needed |
| Estimate of possible power | Yes / No | ?? |
| PV measurements all assets | No | No |
| Standing data PV assets | Yes | No |
| Estimate of real PV power | Yes | Yes / No |
| Residual load calculation | Yes | ?? |
| Forecast of residual load | Yes | ?? |

What could be improved in many cases in the US (ISO, TSO and DSO):

➔ **Consider PV estimates in calculating clean residual load signal to get an idea of how much PV is connected to the node and to improve the vertical net load forecast!**

# And the actual status in the US ?

- How to get a **clean consumption „measurement“**?
  ➔ **Possible power** is needed from **wind**, in the **prediction** and **real production** as measurement !

- How to consider **PV** in the **vertical net load** ?
  ➔ Either with **PV estimates** or **correlation analysis**

**Looking forward to the discussion !!**

# Needs of grid operators to handle fluctuating energies

- **regional forecasts** of renewable energies wind and solar at transformer stations
- **measurement projection of the available power** of renewable energies as a target measure
- **vertical grid load forecasts** at (e.g.) transformer stations
- **detailed state of the grid** and future grid maintenance plannings

- **power-flow calculation for future timestamps** of the complete grid area based on predictions of the available power
- ability to **downregulate** the power feed-in of fluctuating energies
- **Re-dispatch** with renewable energies („Energiesammelgesetz“) and operating reserve („**MRL**“) with renewable energies are necessary to operate with a large amount of installed renewables