

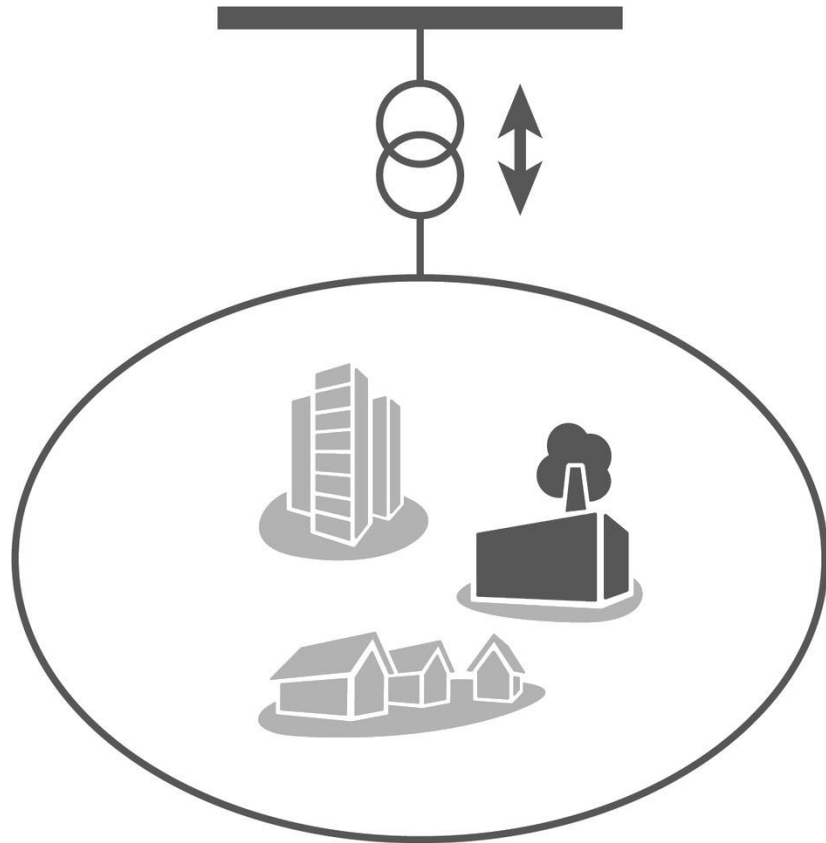
# Vertical Grid Load Forecast

**Dr. Ulrich Focken**

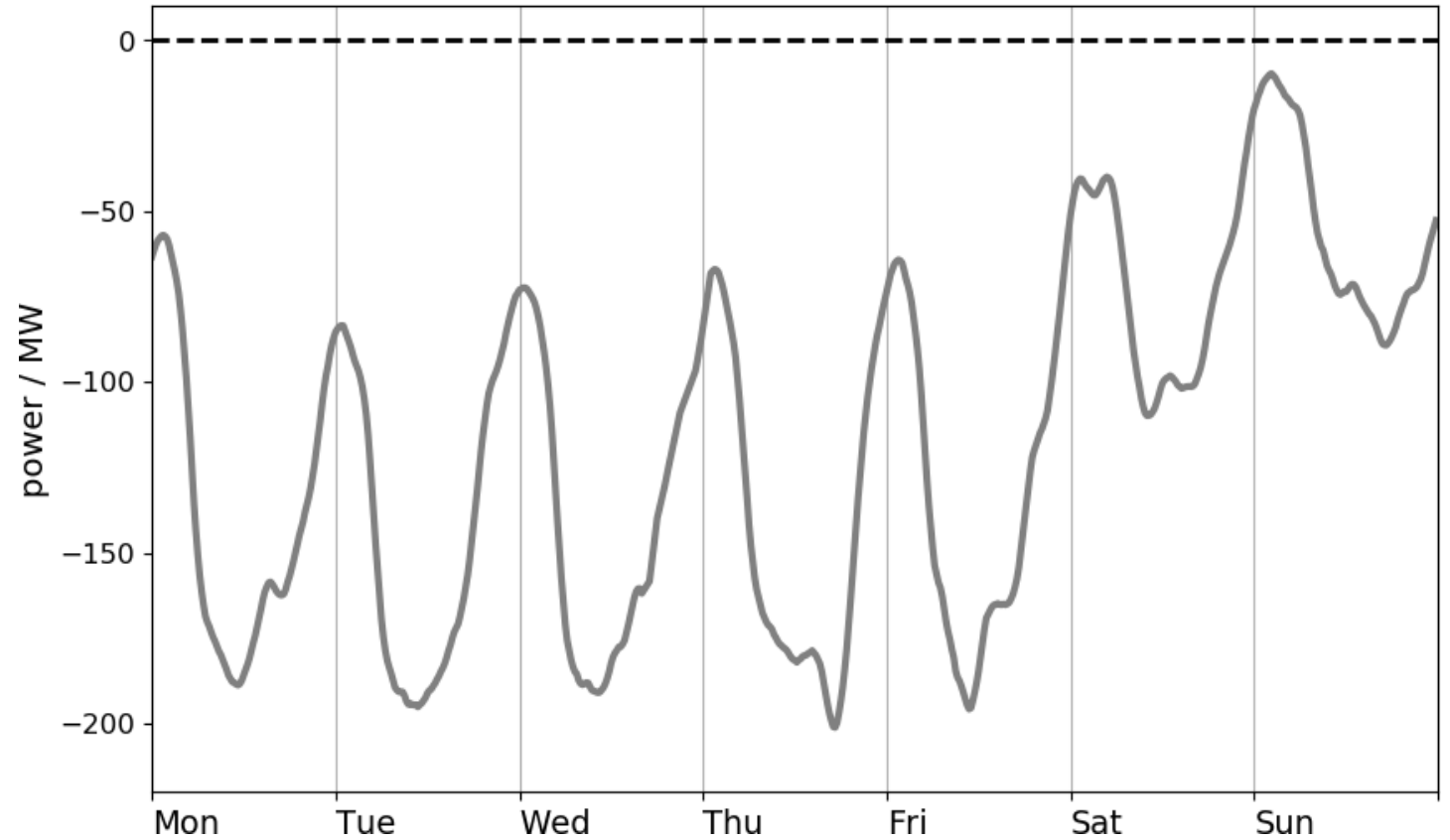
ESIG, 2019 Meteorology & Market Design for Grid Services Workshop

05. June 2019

## Vertical Grid Load old world

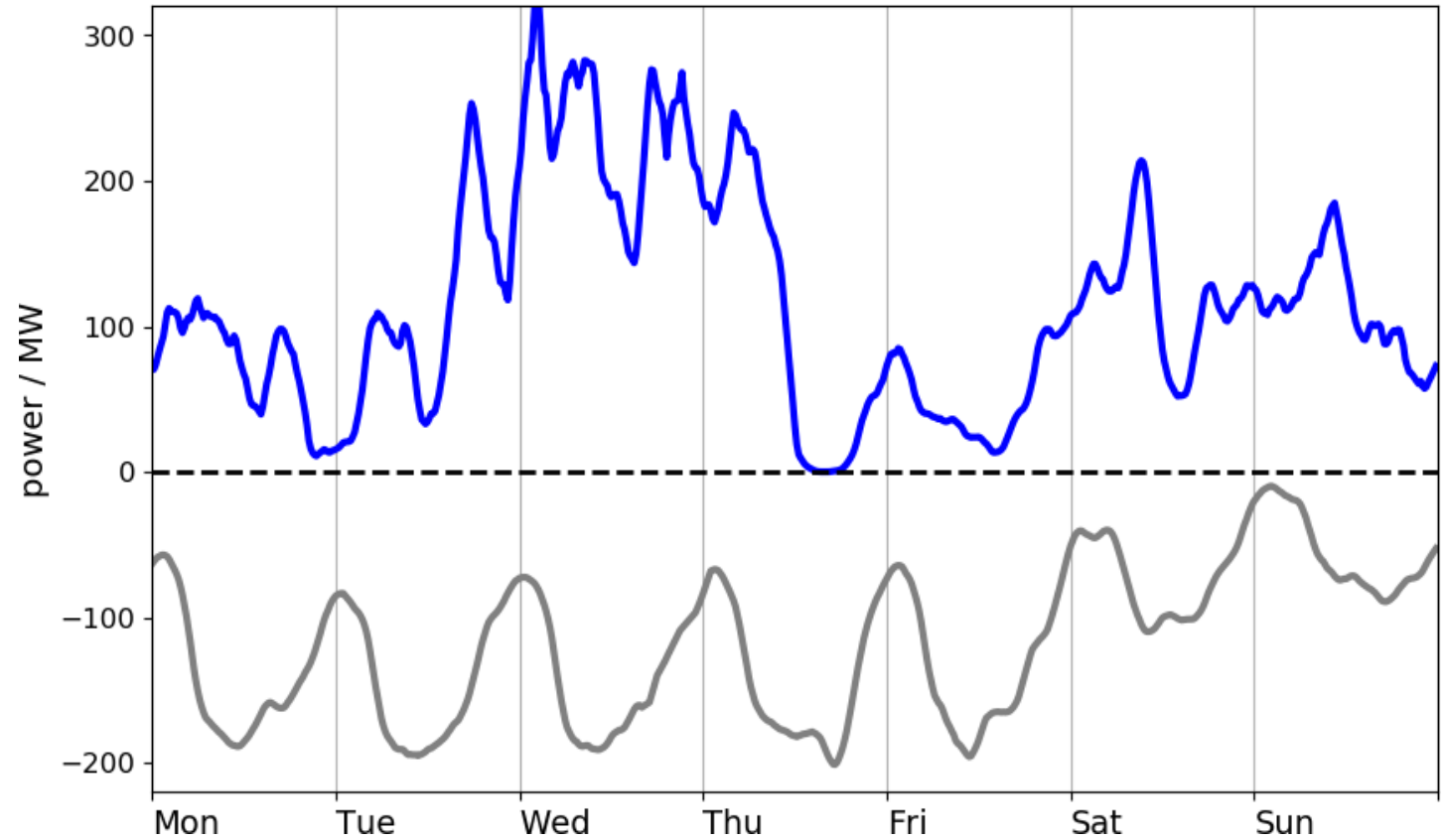
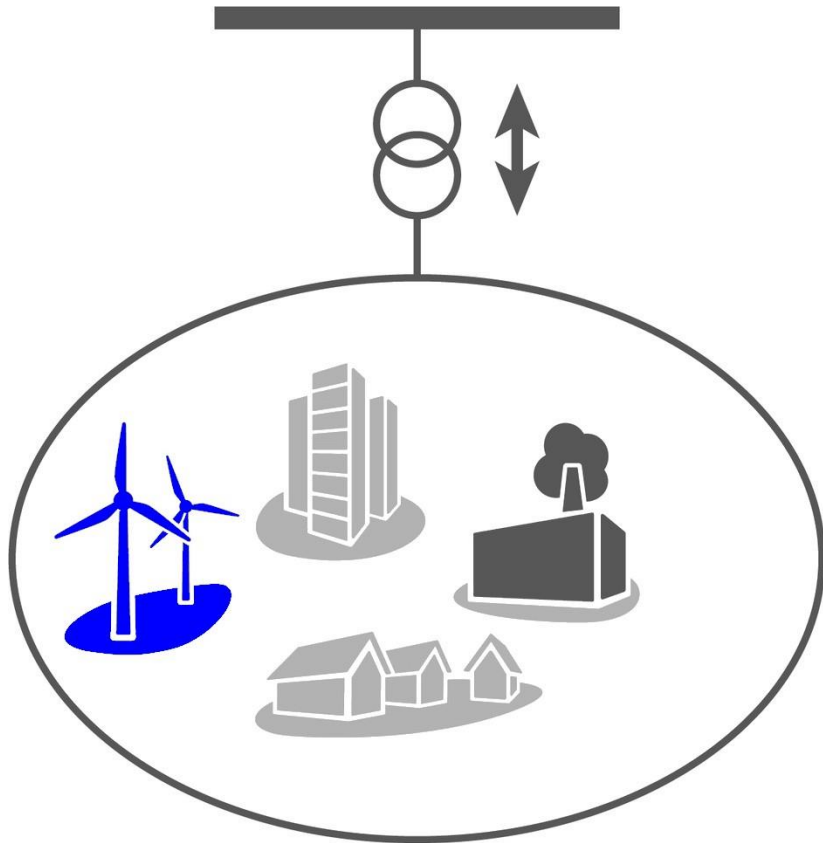


vertical grid load = consumption + production



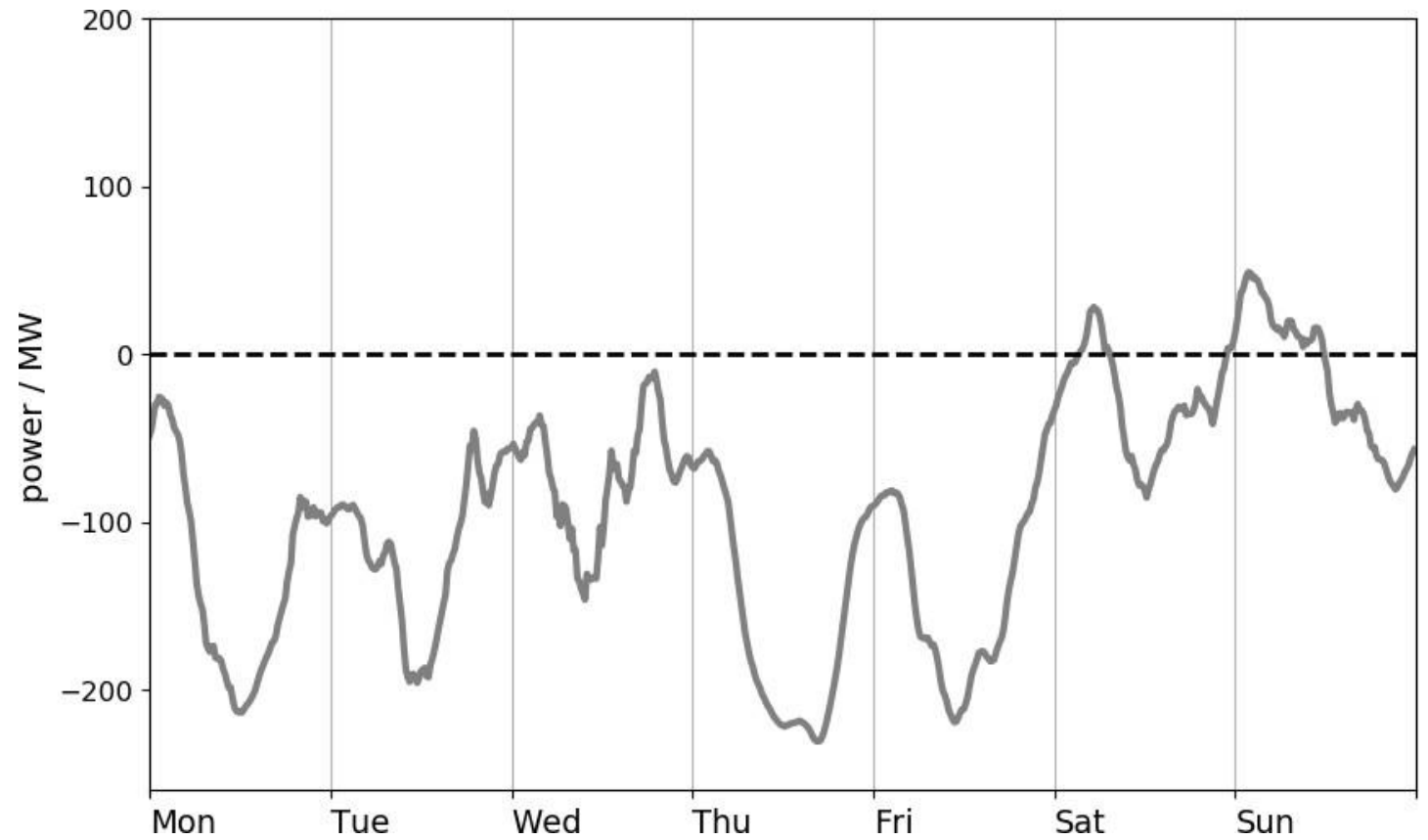
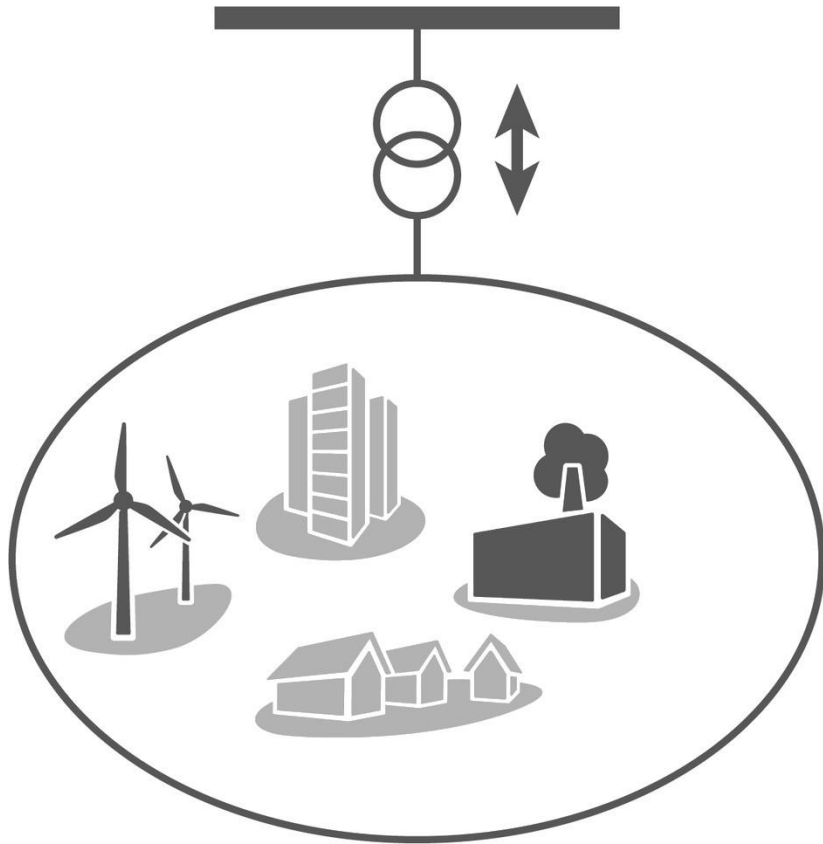
grey line: vertical grid load

## Vertical Grid Load in change due to renewables



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

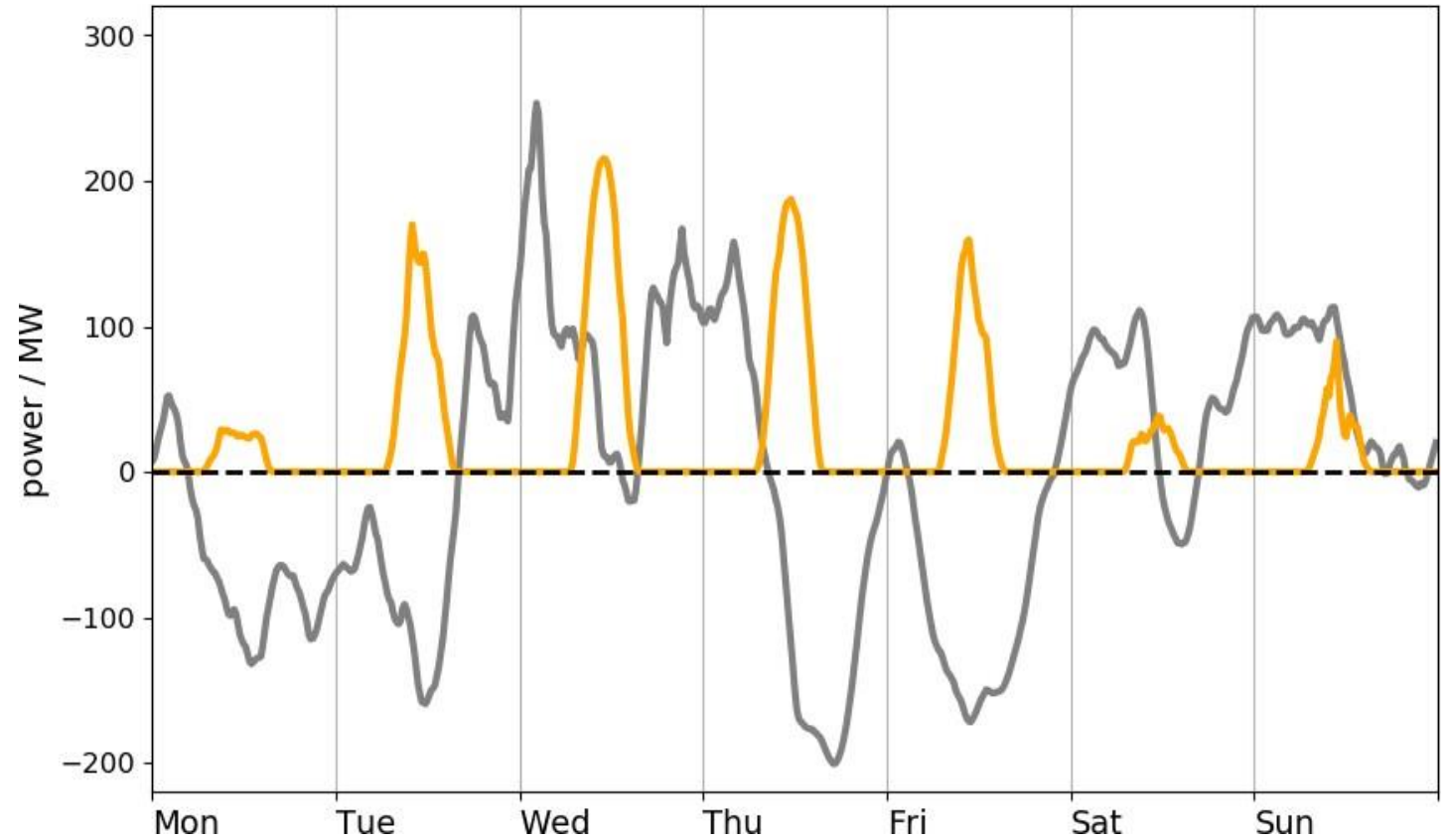
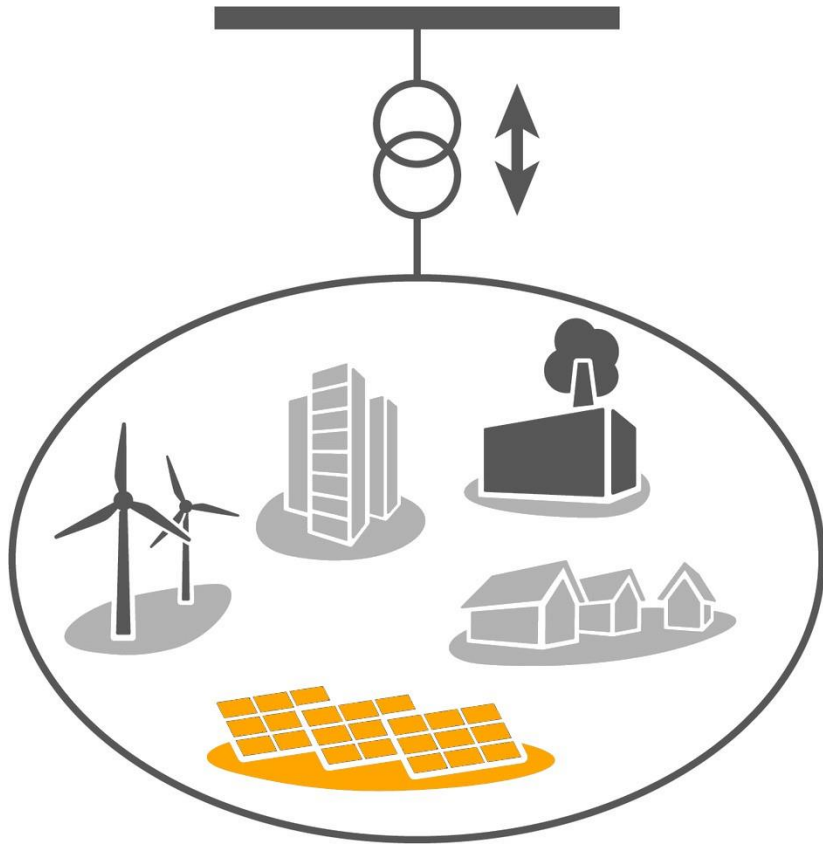
## Vertical Grid Load in change due to renewables



grey line: resulting vertical grid load (+wind)

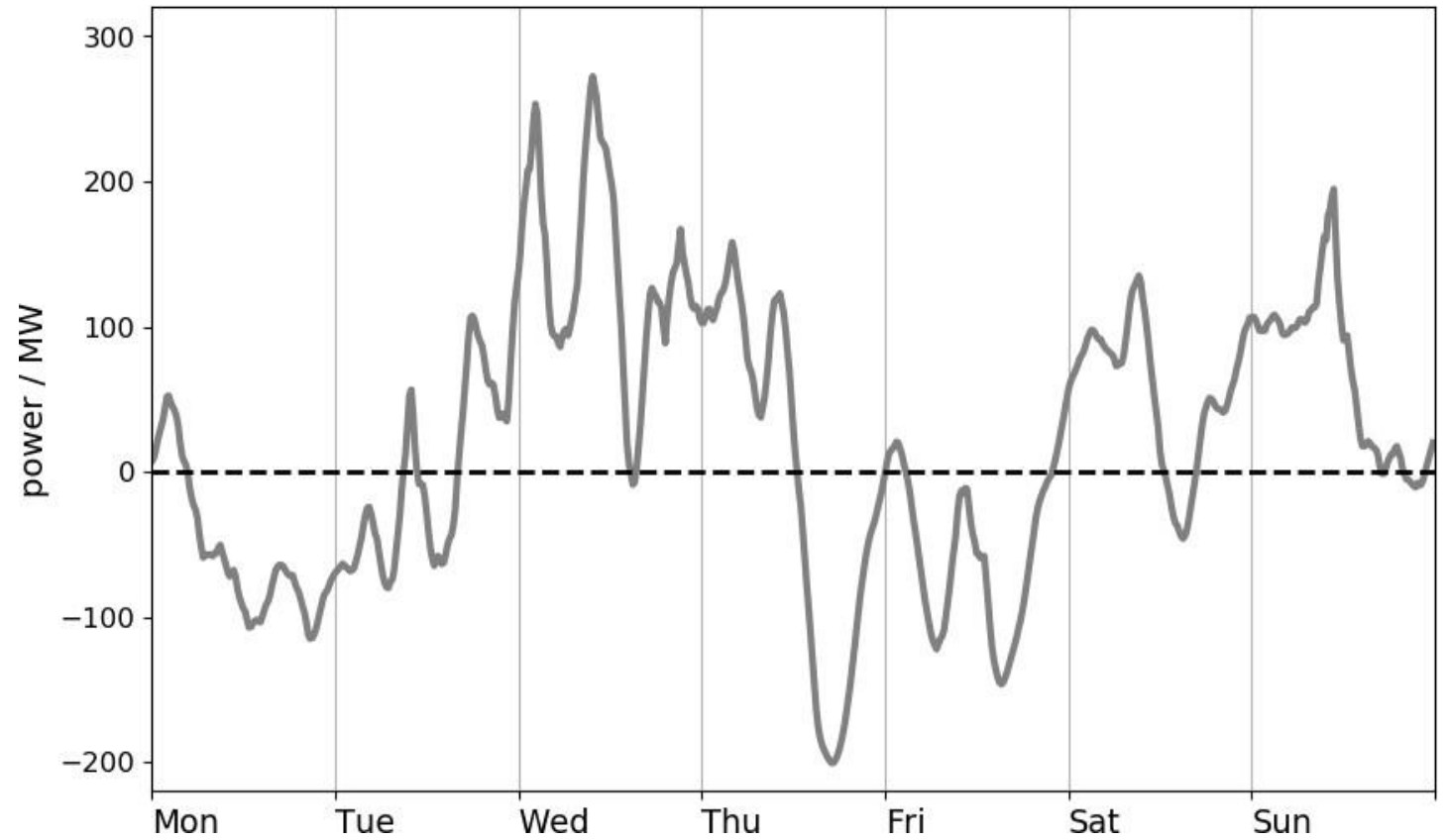
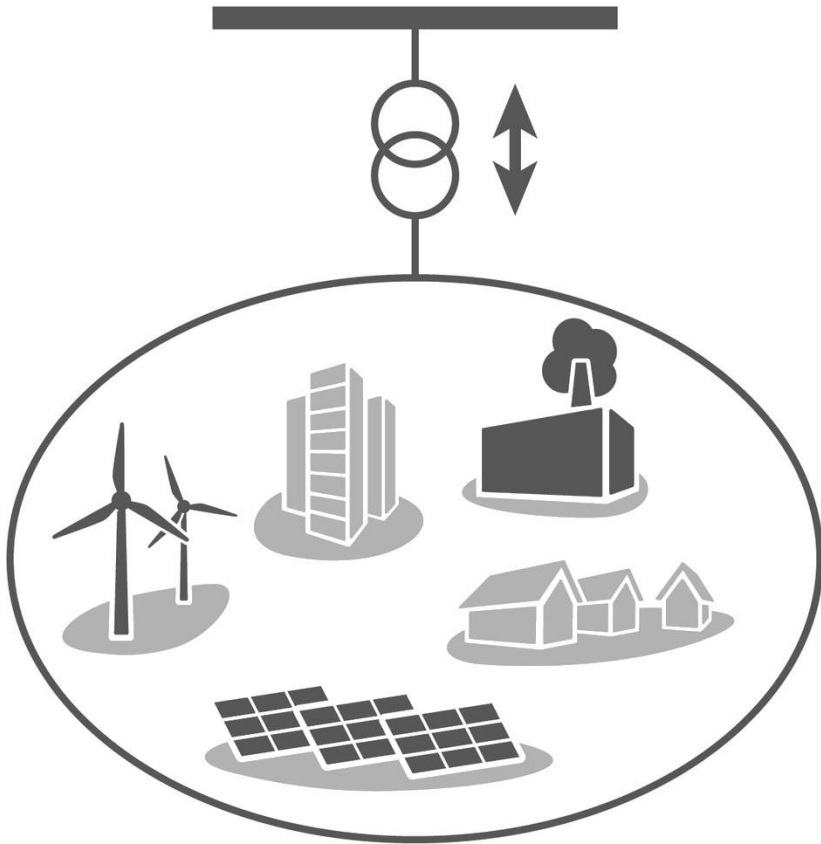


## Vertical Grid Load in change due to renewables



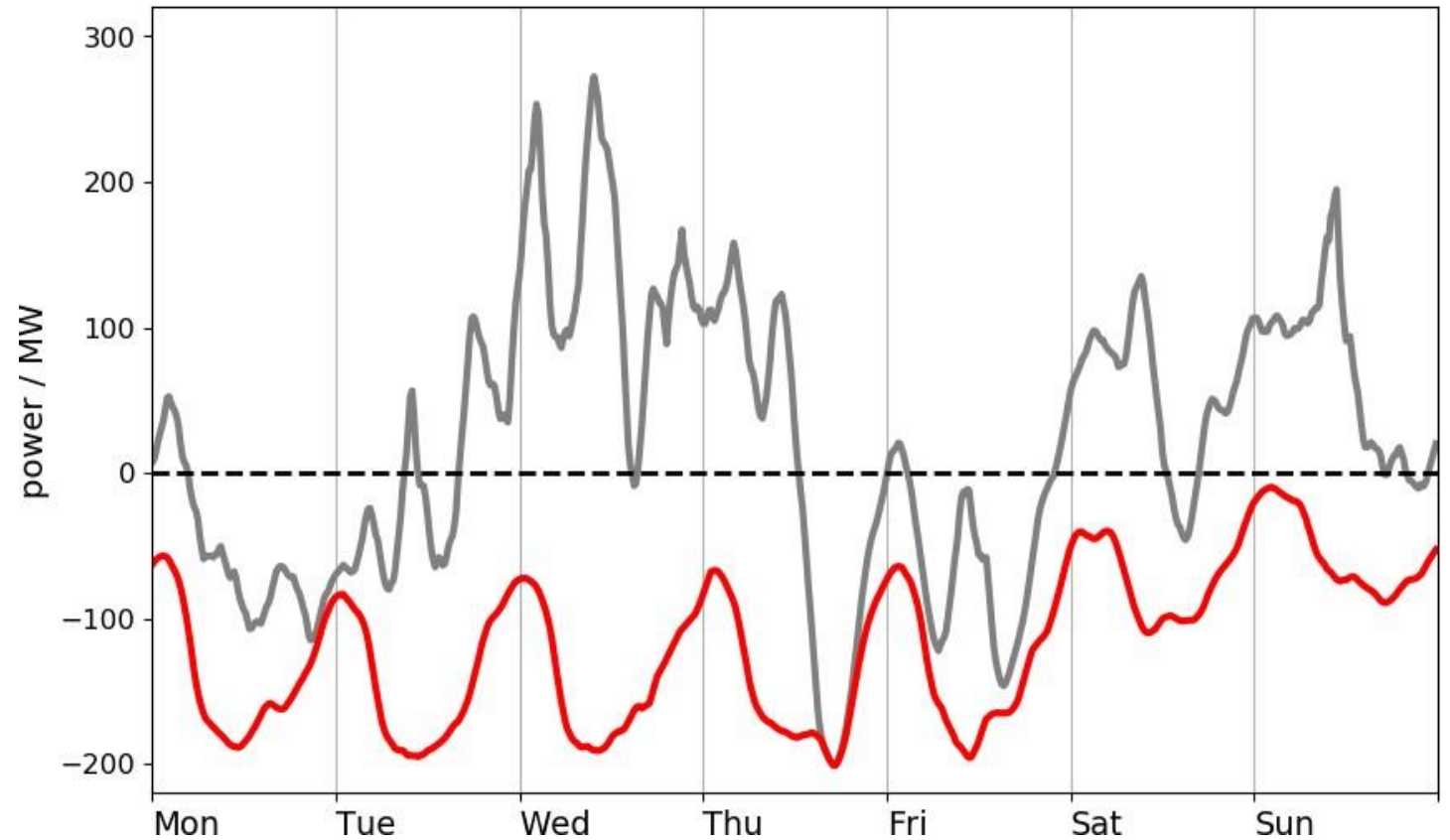
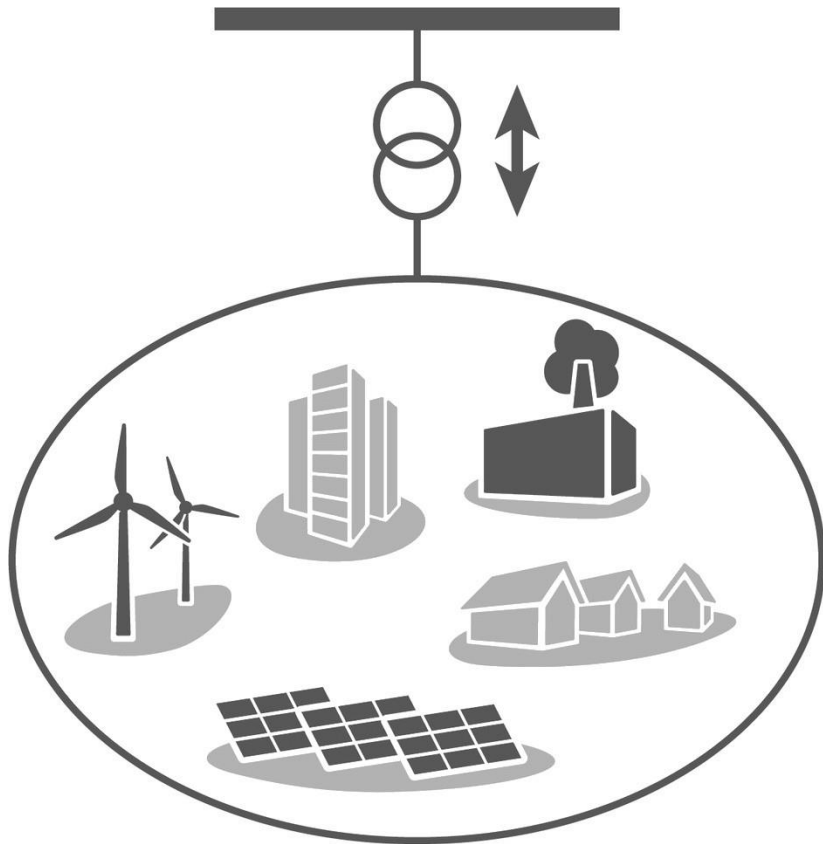
grey line: former vertical grid load (+wind)  
orange line: real solar production

## Vertical Grid Load in change due to renewables



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

## Vertical Grid Load in change due to renewables

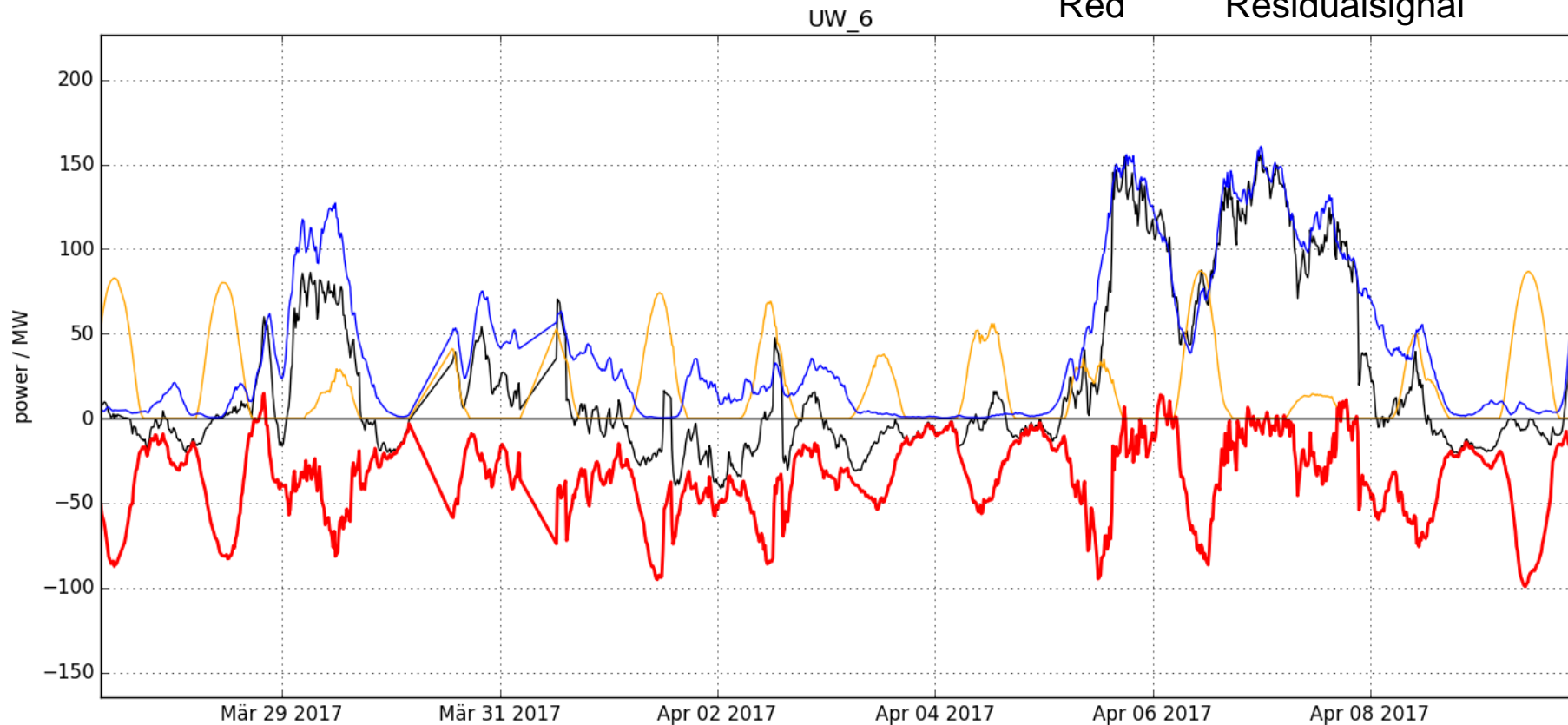


grey line: resulting vertical grid load (+wind)

red line: Old world vertical grid load without renewables

## Example of decomposition on a substation

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

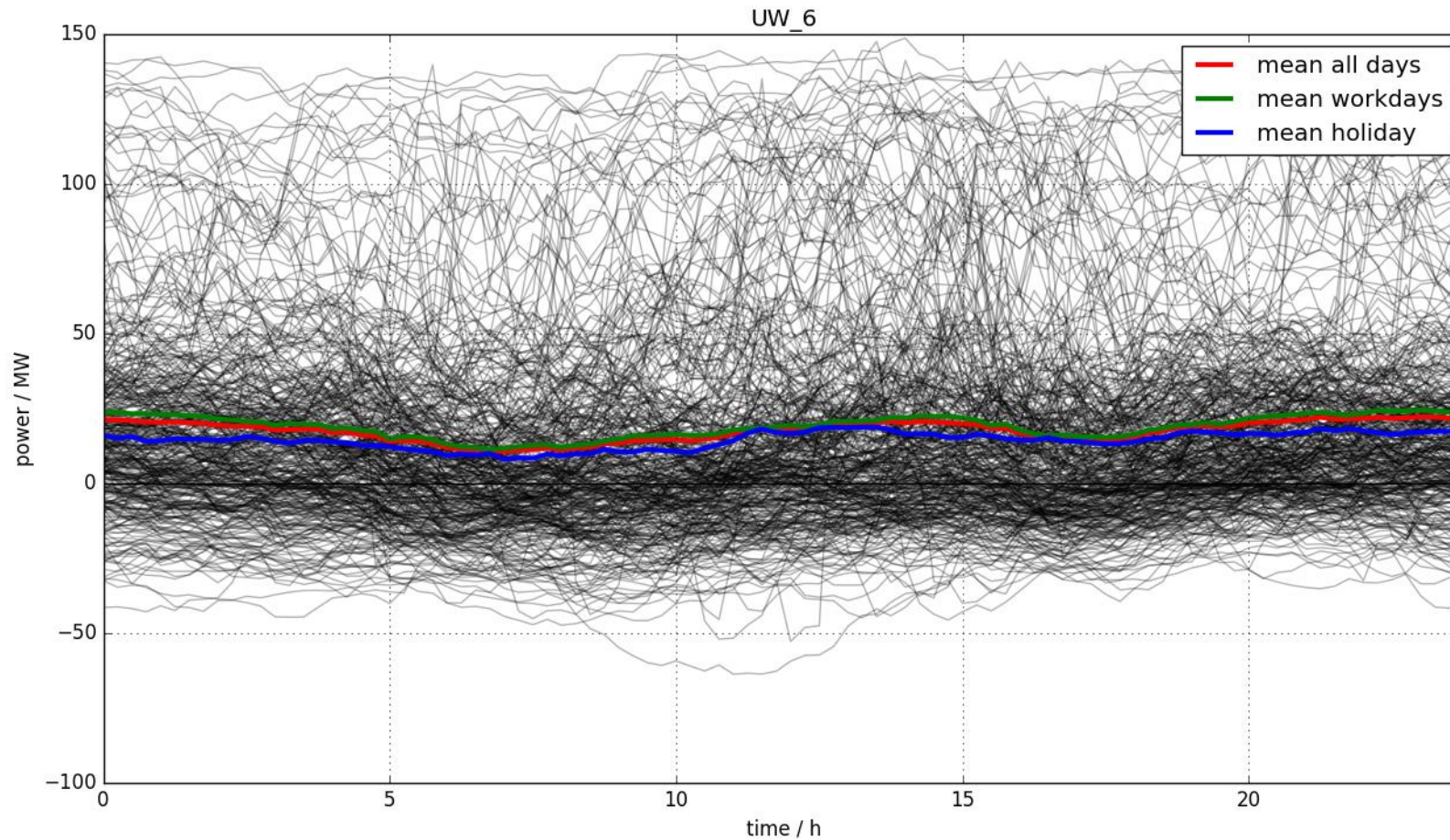


→ **Do we really know the wind and solar components?**



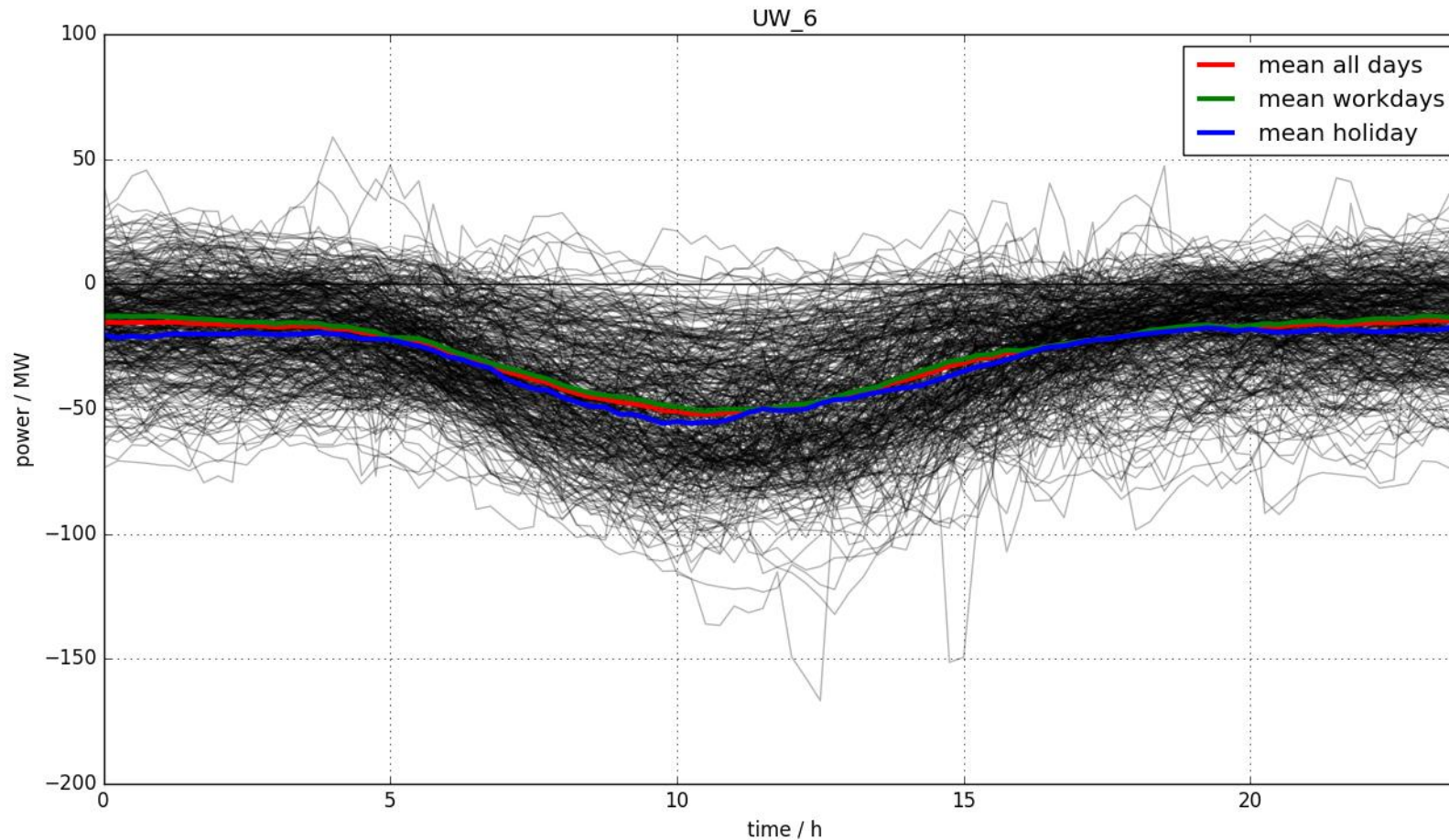
## Residual load

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



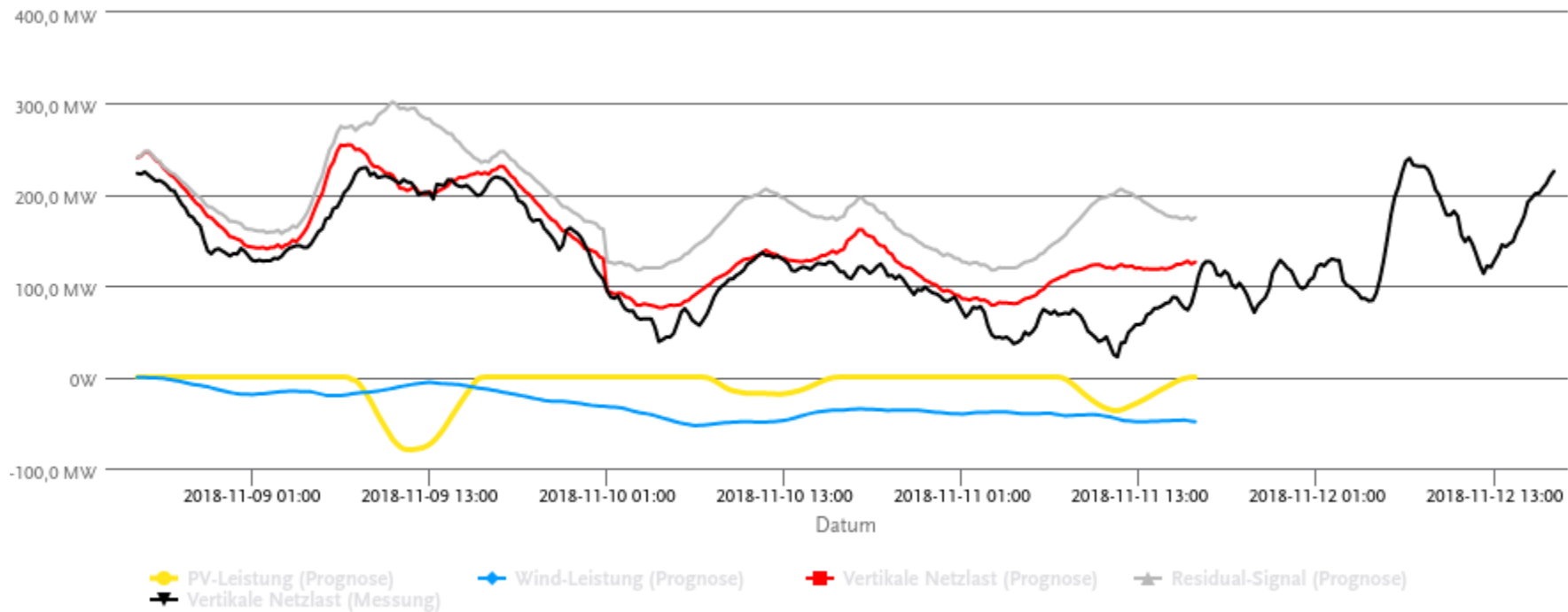
## Residual load

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



## 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

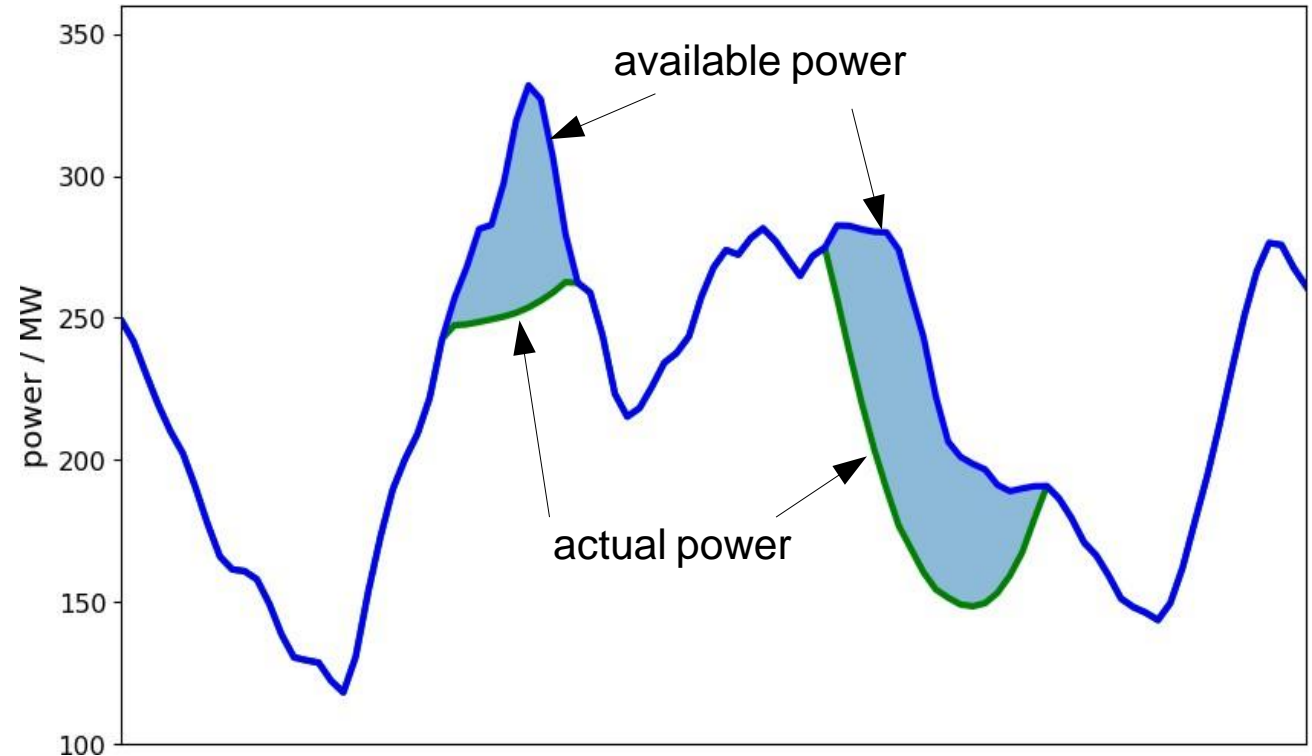
*blue*: prediction of wind feed-in

wind and solar as negative values

## ... which one is the correct target?

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

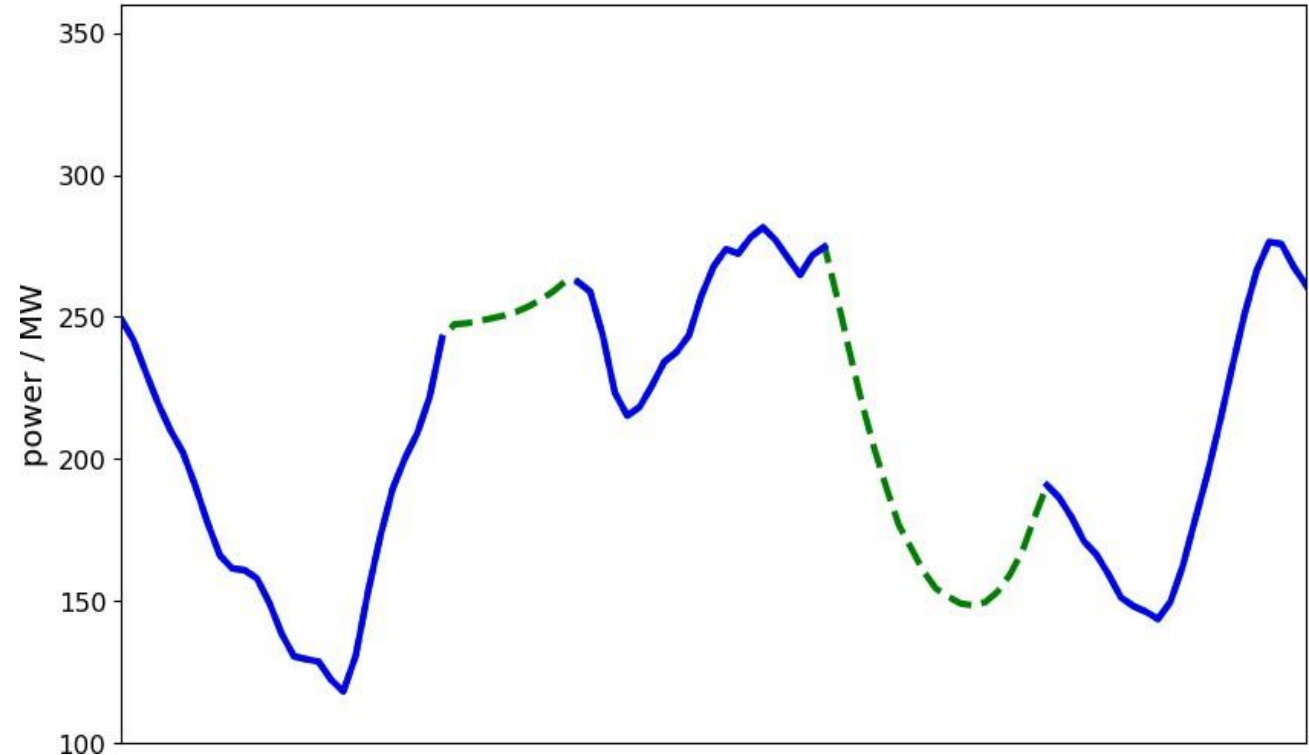


## ... which one is the correct target?

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

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





# Thank you for your attention

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ulrich.focken@energymeteo.de





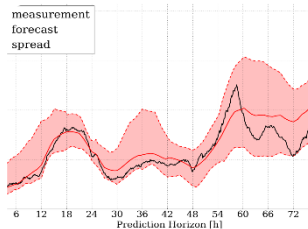
# About energy & meteo systems

## 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

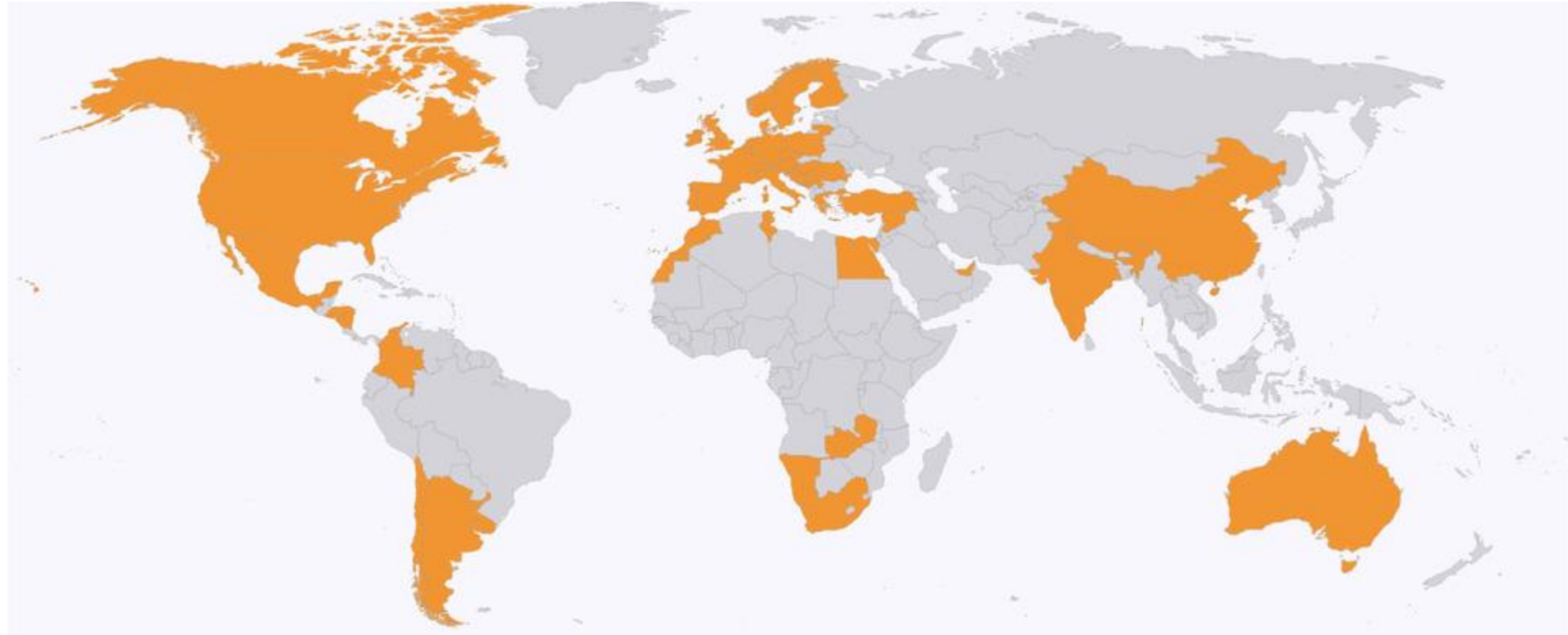
## Users



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

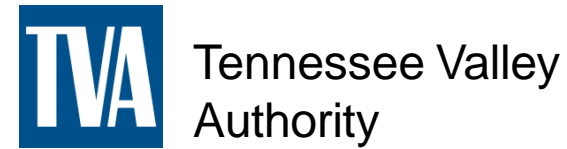
# About energy & meteo systems

International business activities

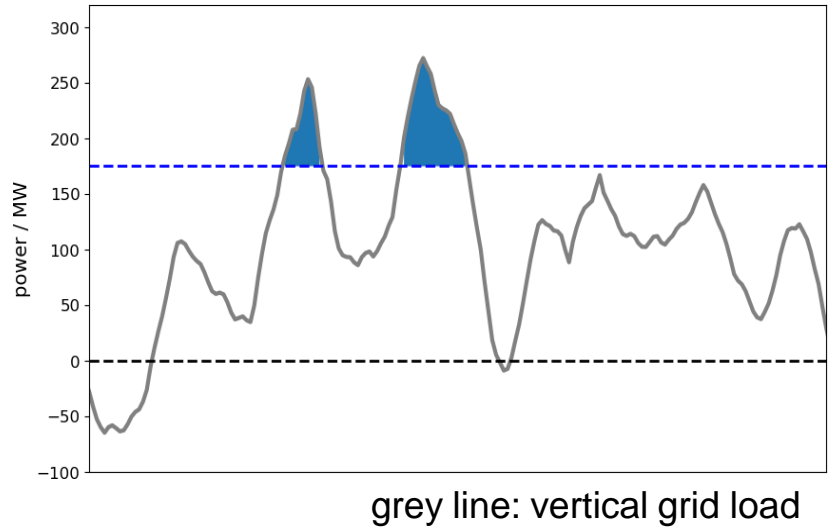


Currently, we are forecasting about 280 GW of wind power and nearly 150 GW of solar power

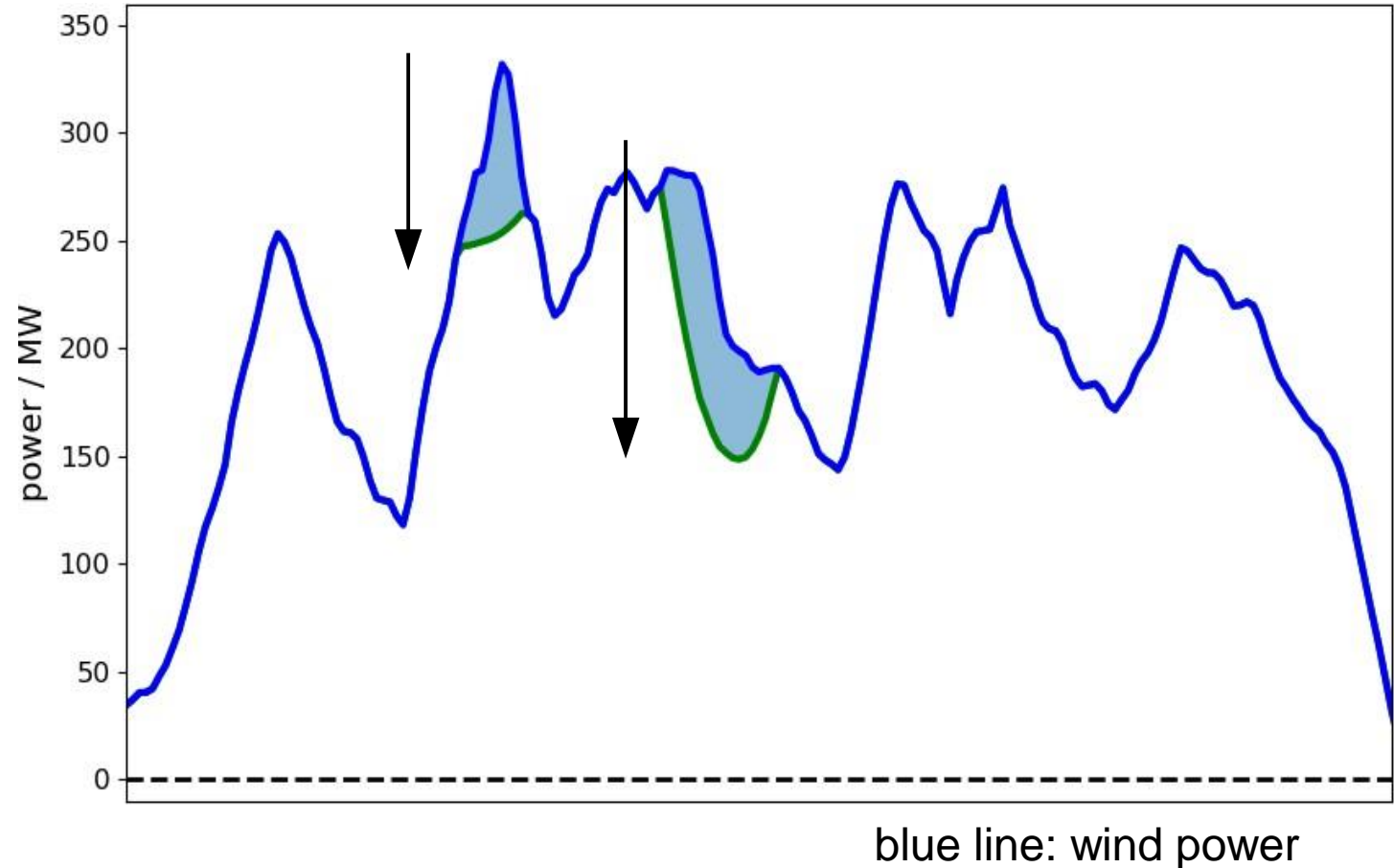
## Choice of our customers



## Question: how to manage grid congestions in nodal market

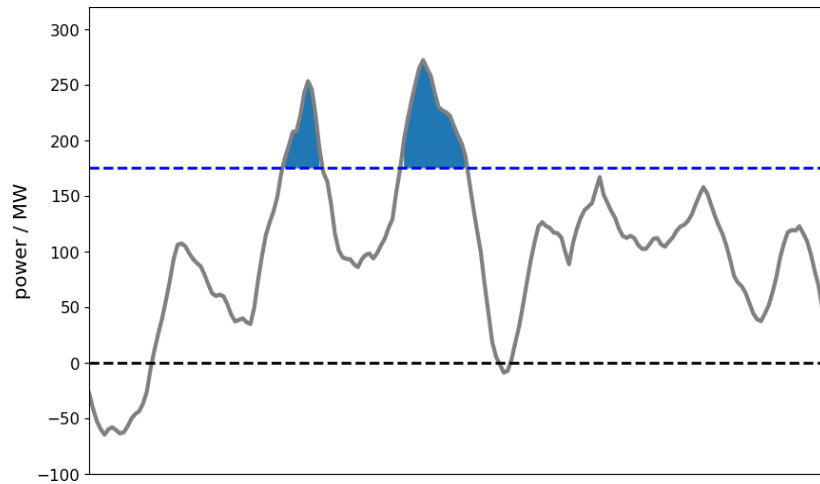


- Possible production is needed to get the possible vertical net load !





## example: grid congestions management in Germany

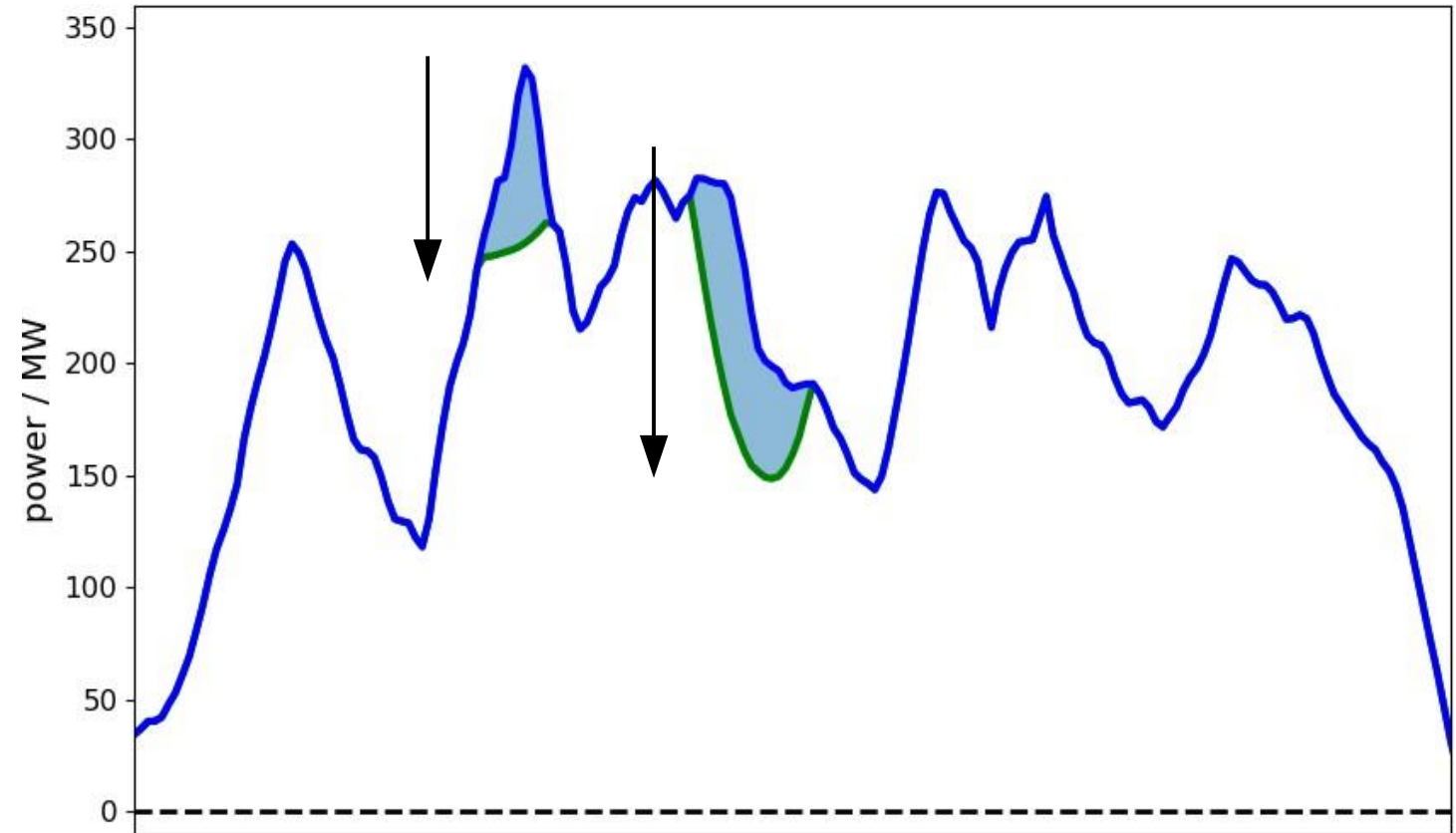


grey line: vertical grid load

- grid congestion leads to online **curtailment of renewable energies**

- day-to-day business in Germany „EinsMan“

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



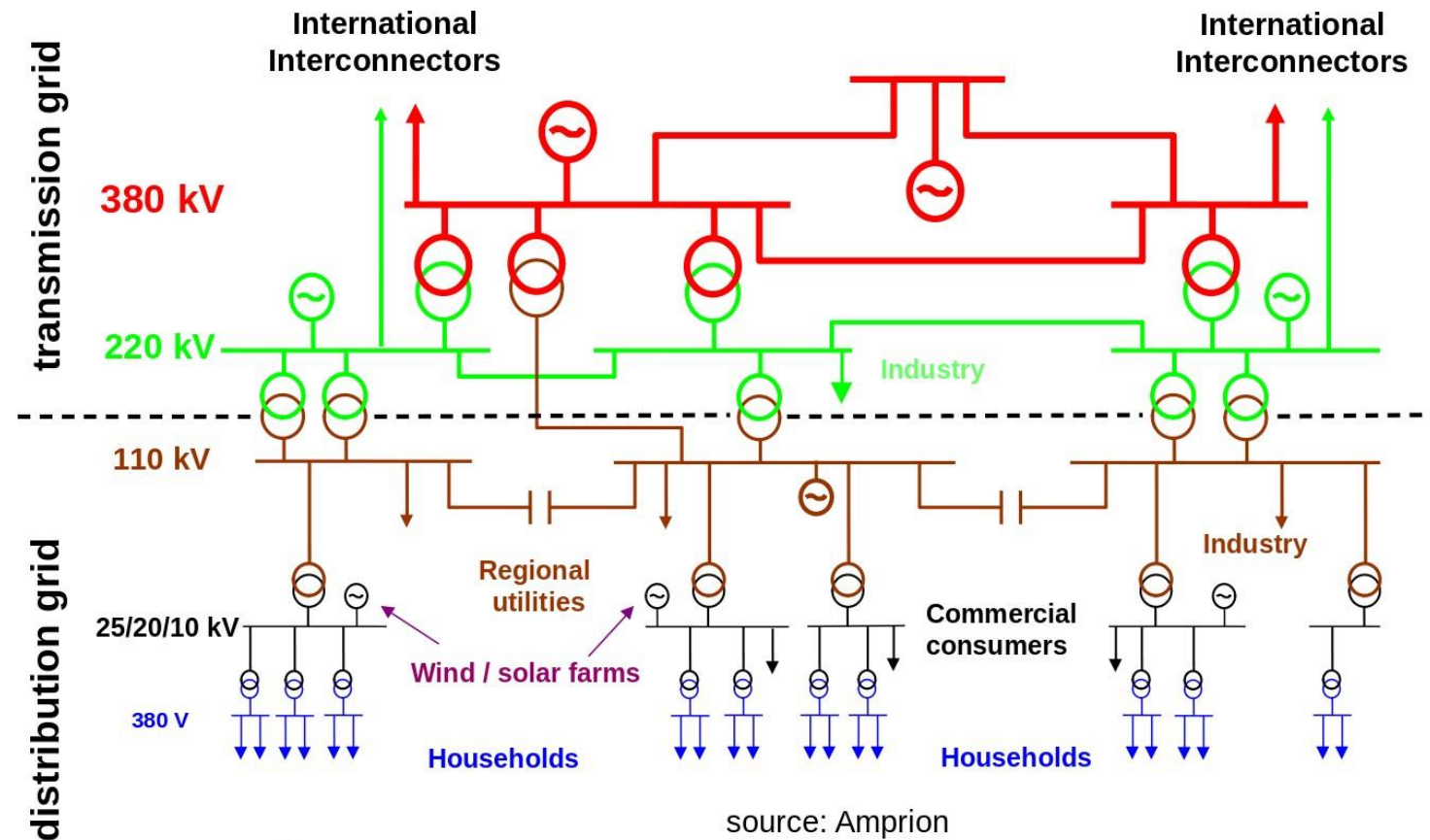
blue line: wind power

## 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



## Backup: downregulation of wind power



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

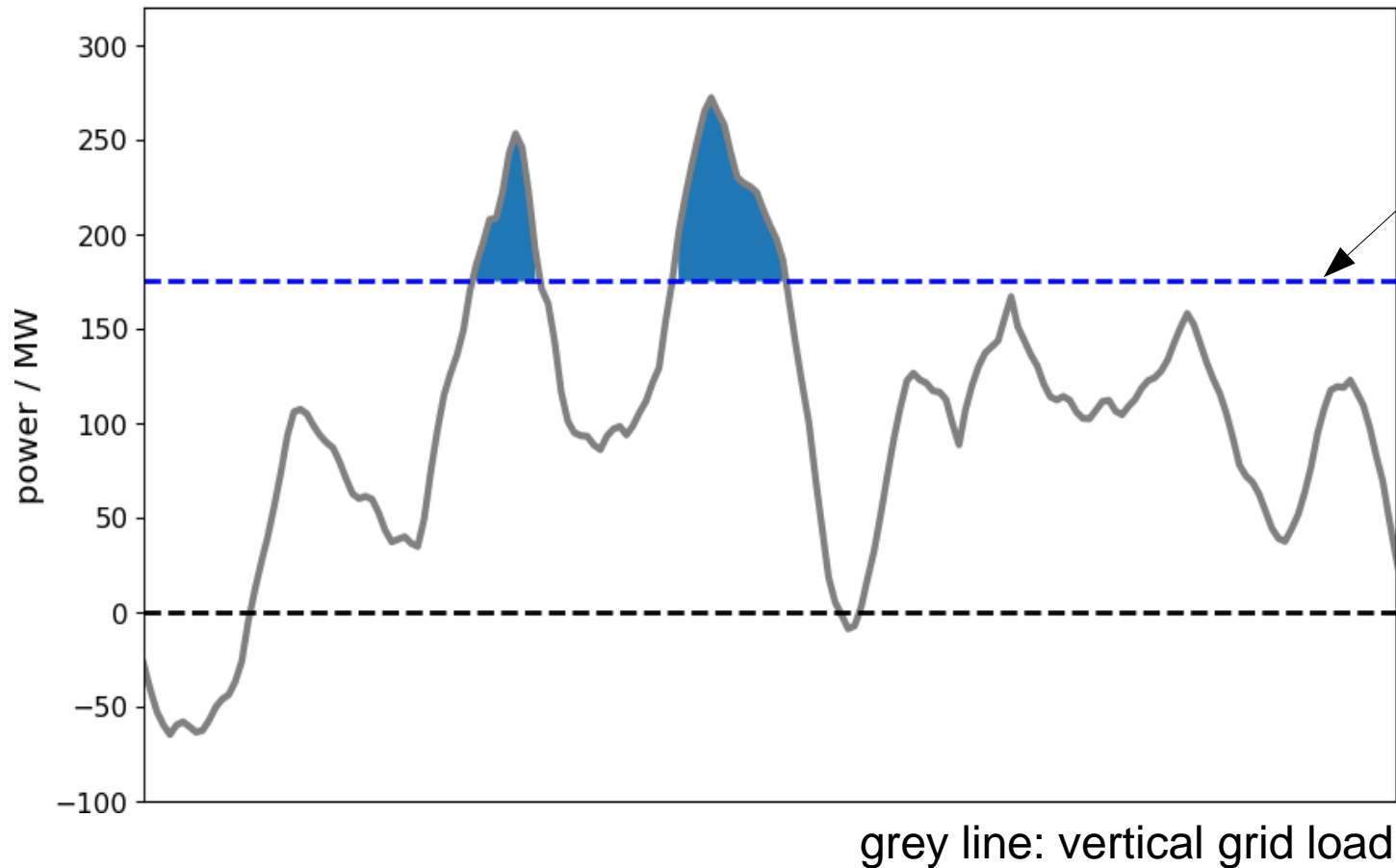
## State of the Art: Integration of renewable energies

### 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)

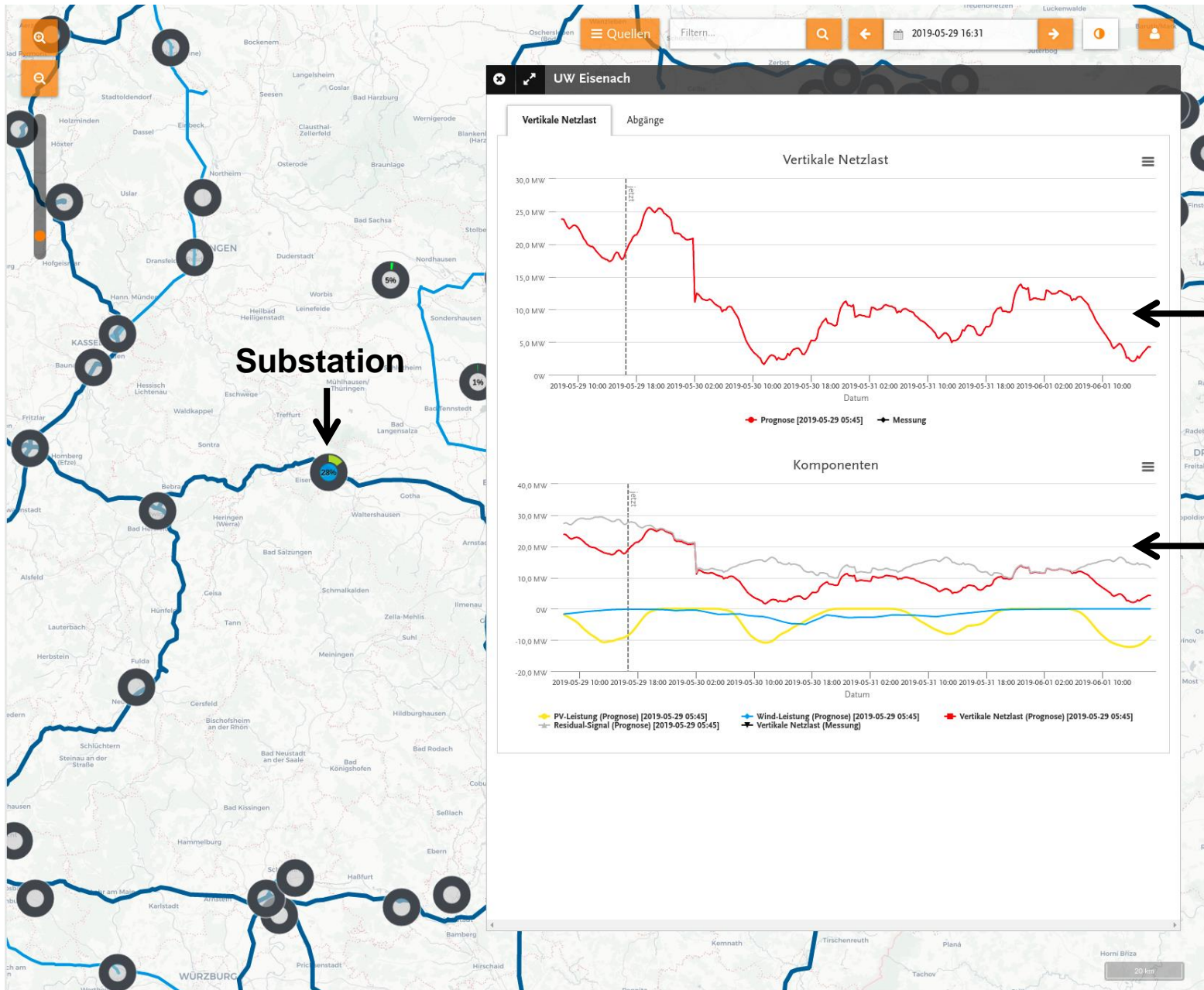


## example: grid congestions



- 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

Karten-Optionen

Inhalt

Nur steuerbare Knoten

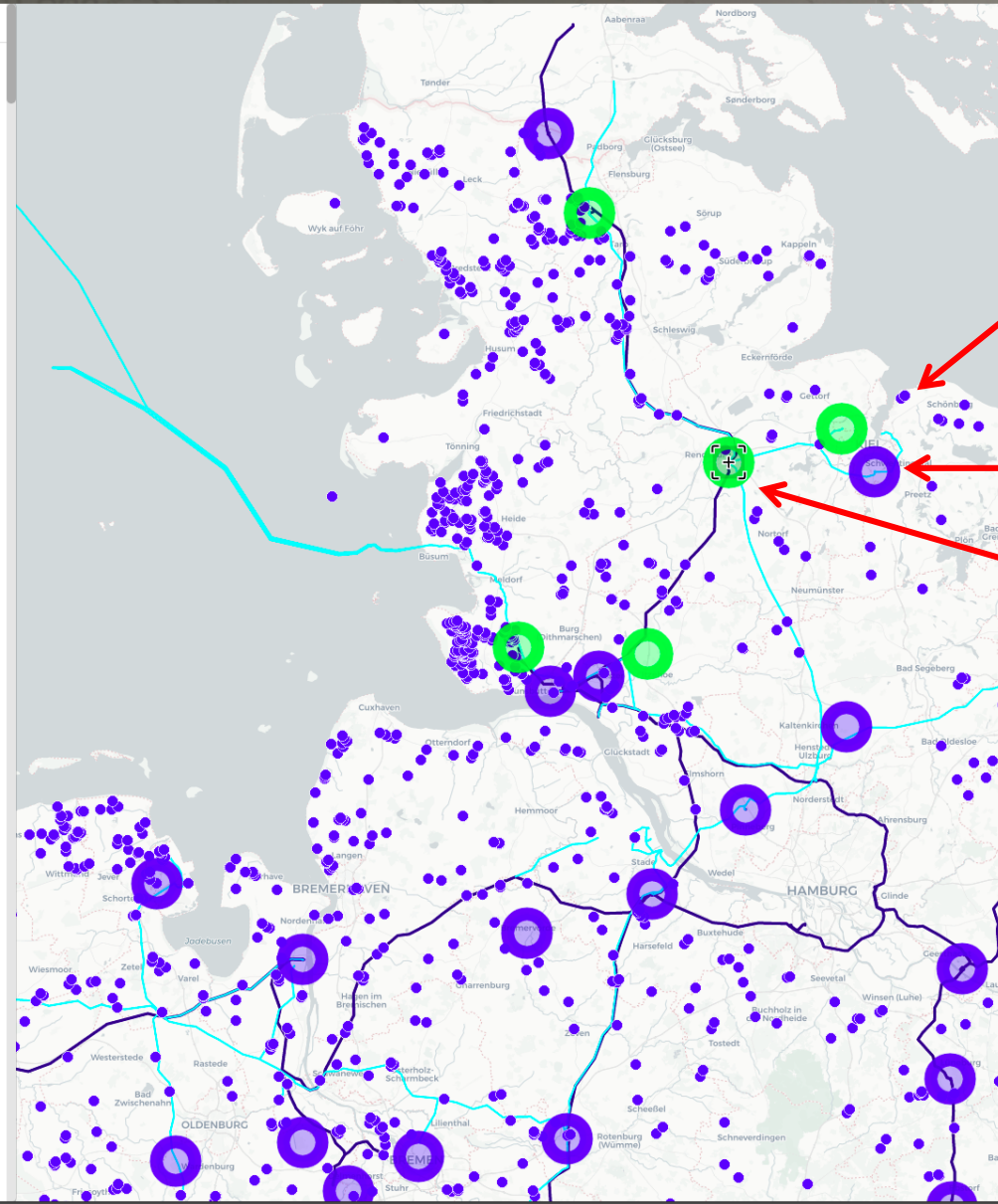
Suchen...

▼ TenneT

- > Alfstedt (Stichanbindung)
- > Algermissen
- > Altheim
- Aschaffenburg
- > Asslar

▼ Audorf/Süd ✓

100%	E418780200000E007A0029319334
77%	E2079301EA01000000000722653
68%	E2079301EA01000000000568995
66%	E2079301EA01000000000894016
59%	E2079301100000000000039430
59%	E2079301EA10000000000621846
54%	E2079301800000000000036970
54%	E2079301EA01000ALBEE000786879
54%	E2079301EA01000000000814178
54%	E2079301EA01000ALBEE000786879
50%	E2026001HSA0000000KAMPE02000
50%	E20793012000000000000038180
46%	E2079301EA01000000000772272
44%	E206890110000000000952210980
43%	E20793017000000000000037690
43%	E20793010000000000000039030
43%	E20793010000000000000043200
43%	E20793017000000000000037690
43%	E20793011000000000000043270
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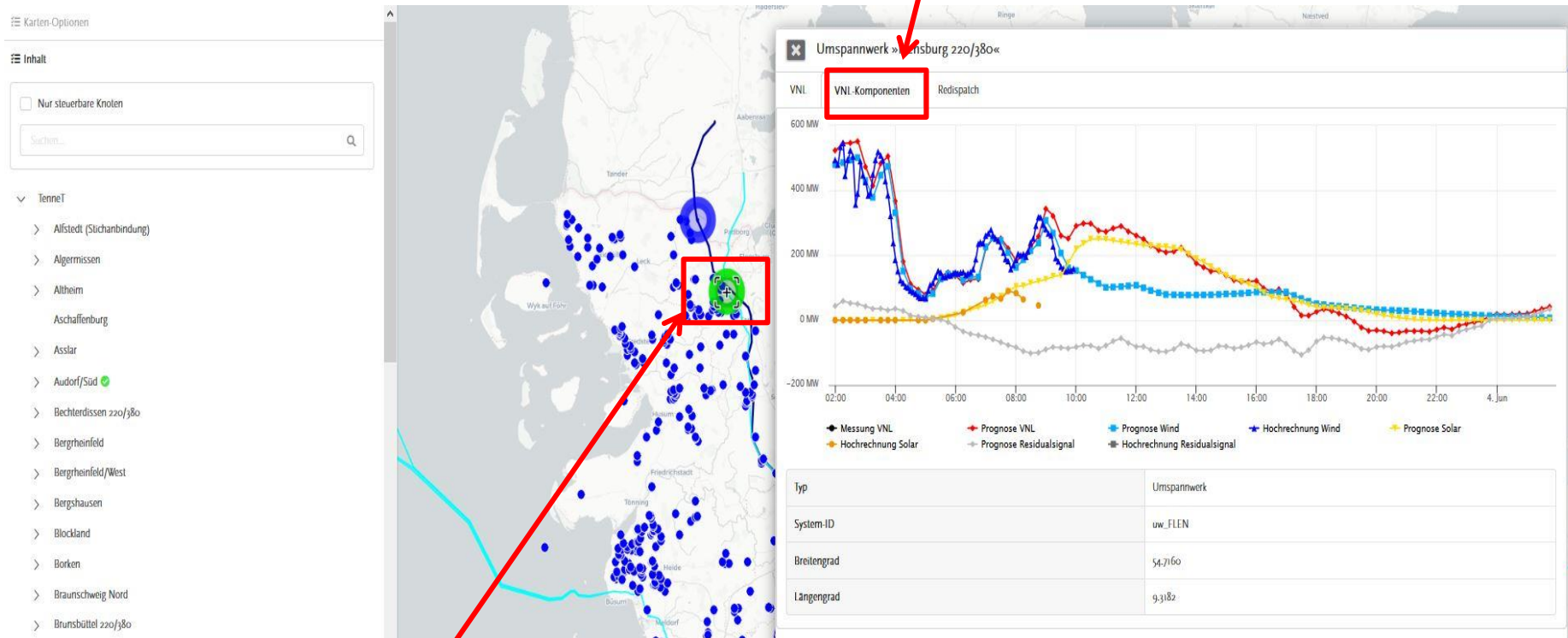
Small blue dots = wind farms

Big blue dots = substations

Big green dots = remote controllable substations

# Grid Operator Control Room

## View of Vertical Grid Load components

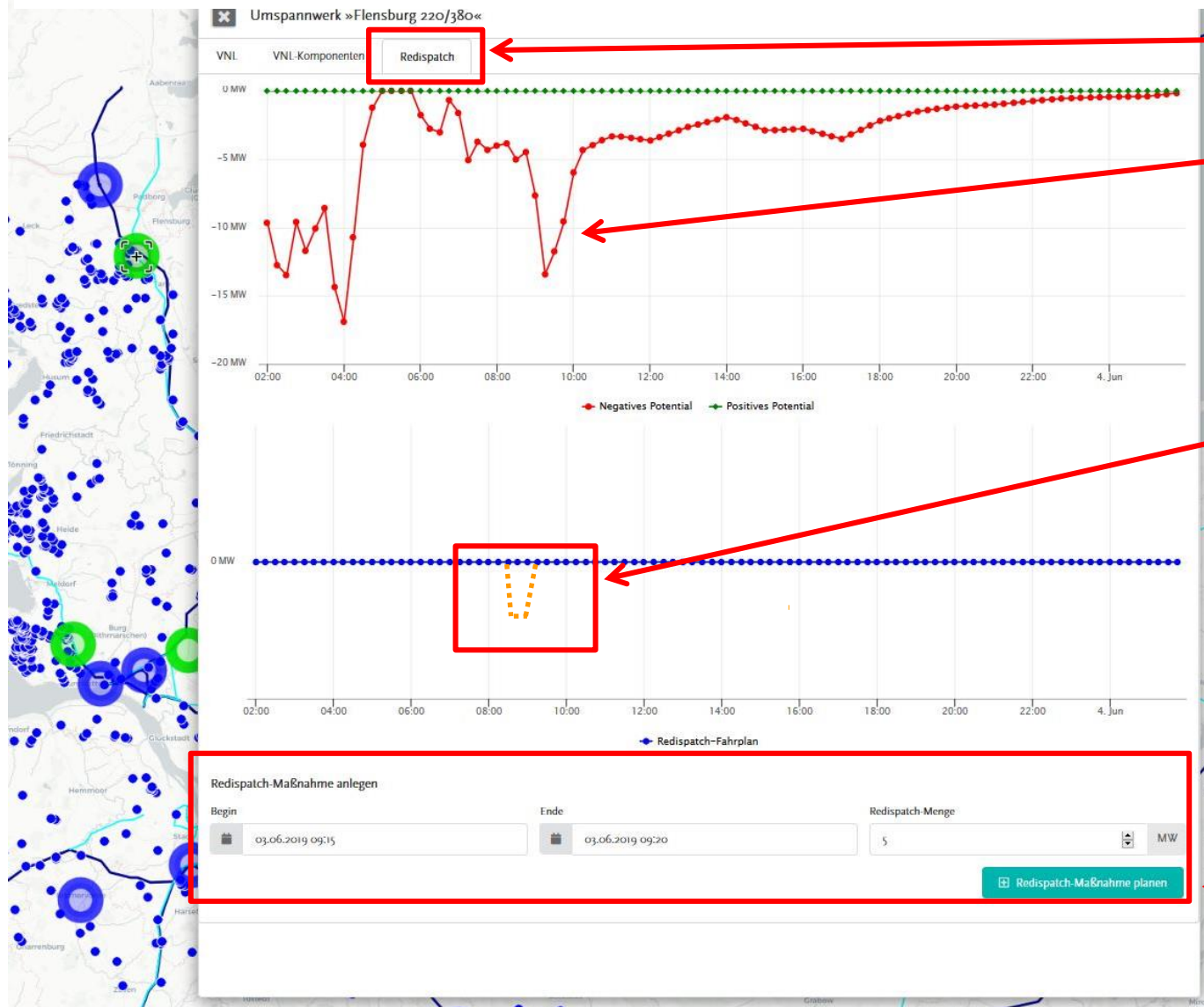


Selected controllable substation



## 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



# Grid Operator Control Room

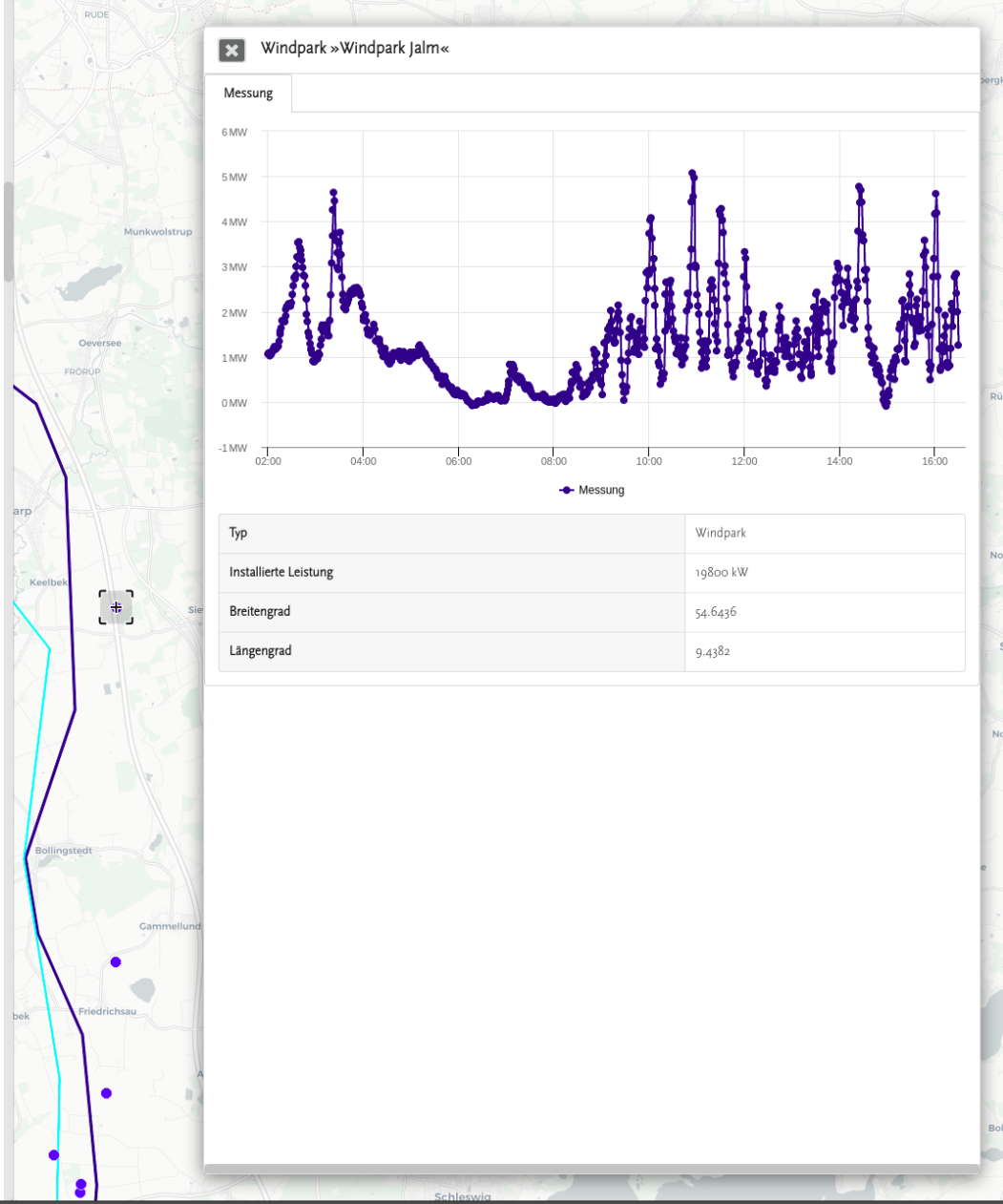
## Action matrix

e&m NETZLEITWARTE		Übersicht	Maßnahmen-Matrix	Datenanalyse															
Zuletzt aktualisiert:		1. Jun. 2019, 09:20:00			 Hilfe														
		3.6.2019	3.6.2019	3.6.2019	3.6.2019	3.6.2019	3.6.2019	3.6.2019	3.6.2019	3.6.2019	3.6.2019	3.6.2019	3.6.2019	3.6.2019	3.6.2019	3.6.2019	3.6.2019		
		09:00	09:15	09:30	09:45	10:00	10:15	10:30	10:45	11:00	11:15	11:30	11:45	12:00	12:15	12:30	12:45		
 Audorf/Süd																			
 Flensburg 220/380		5 MW																	
 Itzehoe West																			
 Kiel West																			
 Süderdonn																			

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

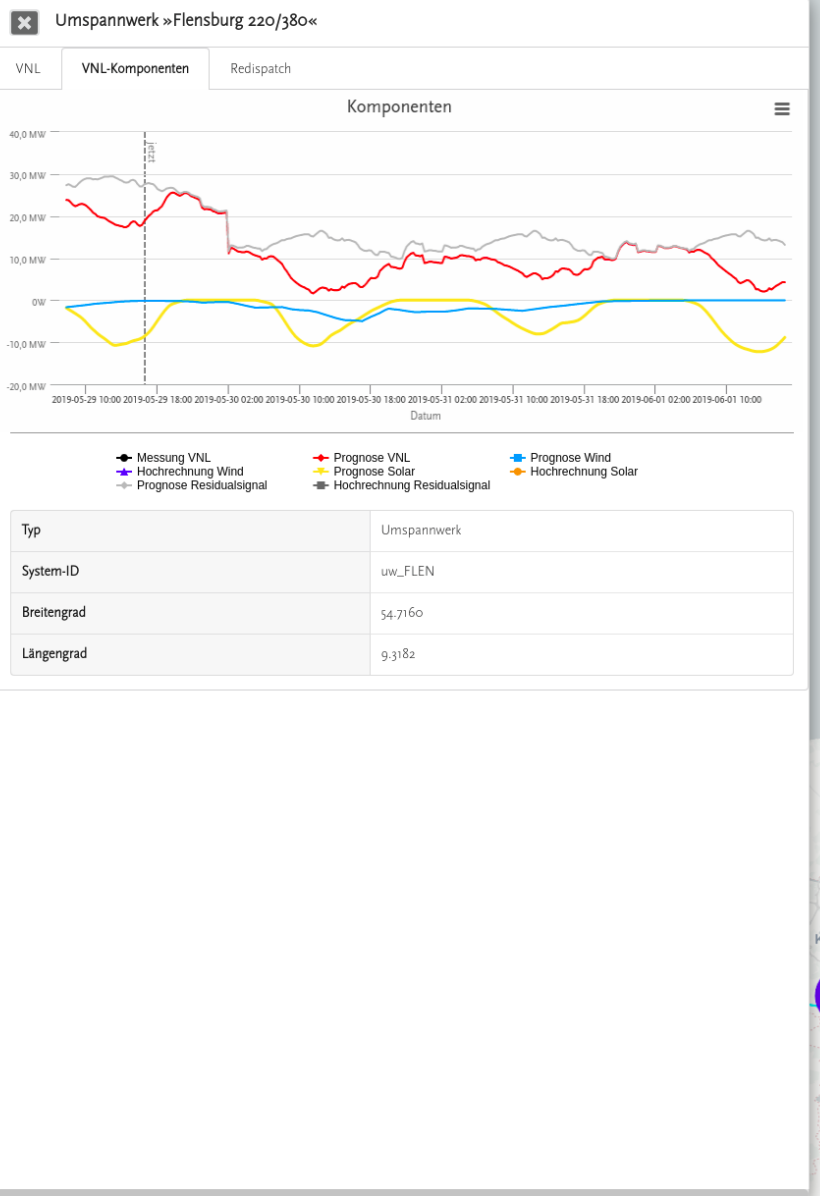
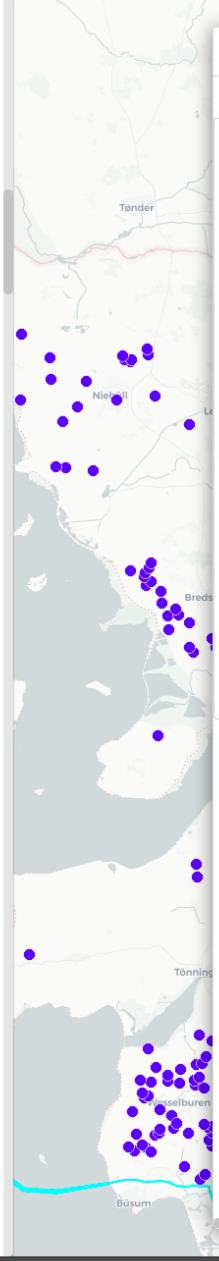
Gr

- 28% E230190100001065000180005100
- 28% E2079301EA010000000000879485
- 28% E207930130000000000000042850
- 27% E207930190000000000000033360
- 27% E20793010000000000000034760
- 27% E2325401HRA000000HUSUME00007
- 27% E20793013000000000000034800
- 26% E2026001HRA000000HUSUME00007
- 26% Windpark Jalm
- 26% E2079301EH01000000000760642
- 26% E2079301000000000000041530
- 26% E2079301000000000000041530
- 26% E20793010000000000000213713
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- 23% E2079301300000000000022910
- 23% E2079301900000000000002830
- 23% E2026001HRA000000GOEHLE00007
- 23% E2079301900000000000042400
- 23% E207930190000000000004370
- 23% E207930190000000000004350
- 22% E2079301000000000000001200



Gr

- 28% E230190100001065000180005100
- 28% E2079301EA010000000000879485
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- 27% E2325401HRA000000HUSUME00007
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- 26% Windpark Jalm
- 26% E2079301EH010000000000760642
- 26% E20793010000000000000041530
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- 23% E20793019000000000000004350
- 23% E20793010000000000000001200



## 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