



# Graph Use Cases in the Electrical Power Grid

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# A moment for safety

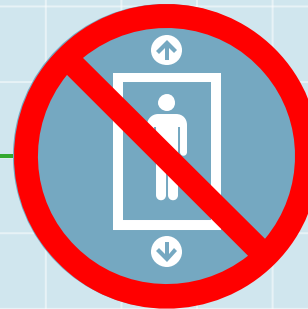
Together we provide a safe working environment. We learn from mistakes and sharing ideas, concerns and asking questions are a matter of course.



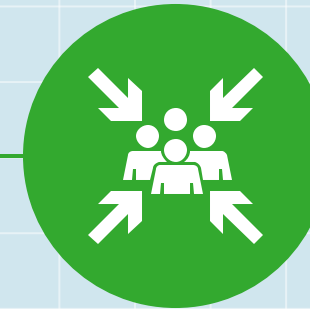
We also draw attention to the following safety measures in case of evacuation of the premises



Follow the escape route as indicated



Use the stairs instead of the lift



Go to the assembly point



Follow the instructions of the in-company emergency responder



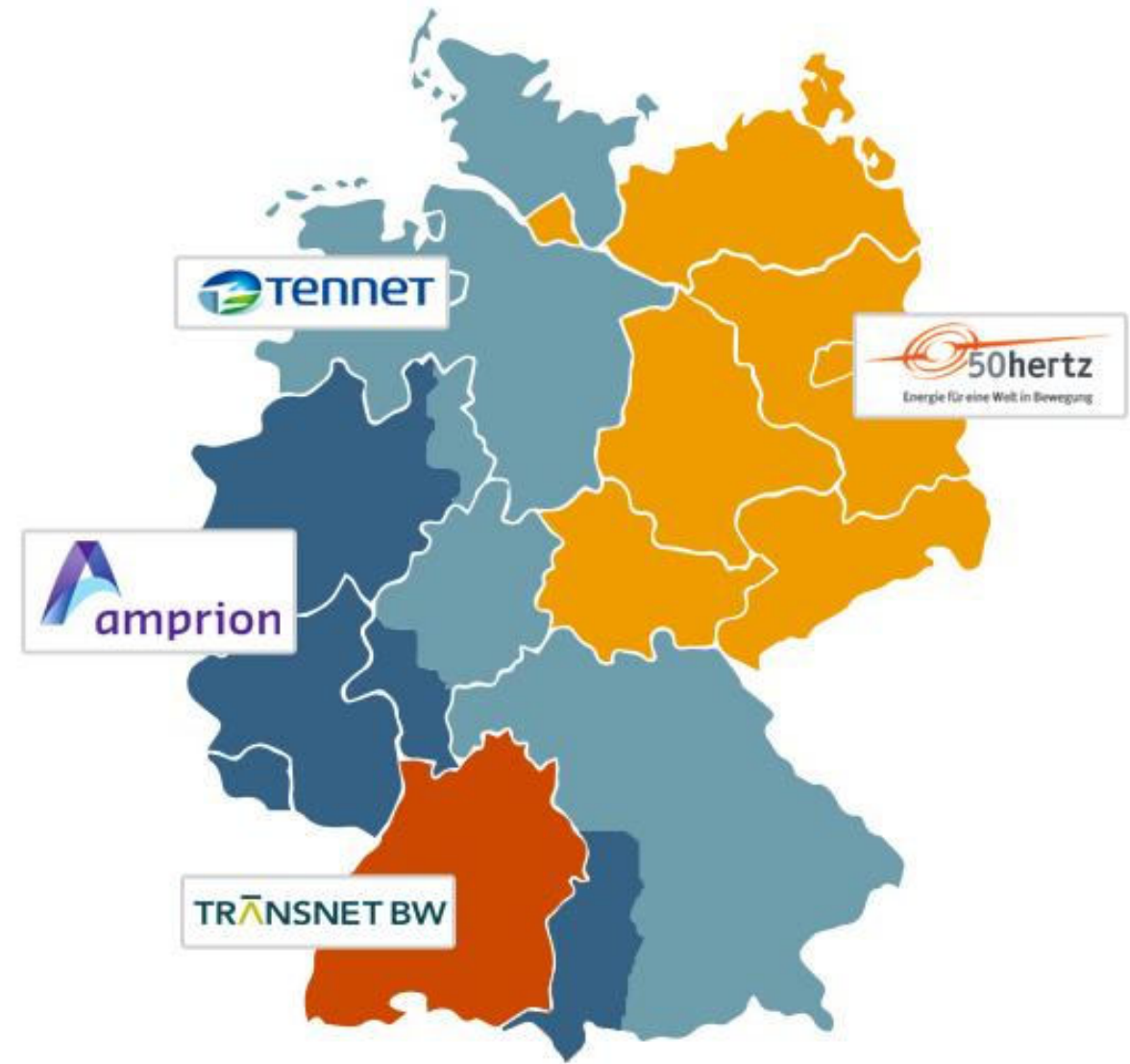
# Profile

05 Mai 2021

Confidentiality C1



# Operating the Electricity Grid at 220 kV and 380 kV



# TenneT at a Glance



Workforce

**4,913**

Employees



EBIT

**768**

EUR million



Assets

**21.8**

EUR billion



Investments 2019-2029

**35**

EUR billion



Grid

**99.99%**

Availability



Grid length

**23,555**

Km



Dutch State

**100%**

Shareholder



Footprint

**27.4%**

Greened

# TenneT at a Glance Germany

## Facts & figures

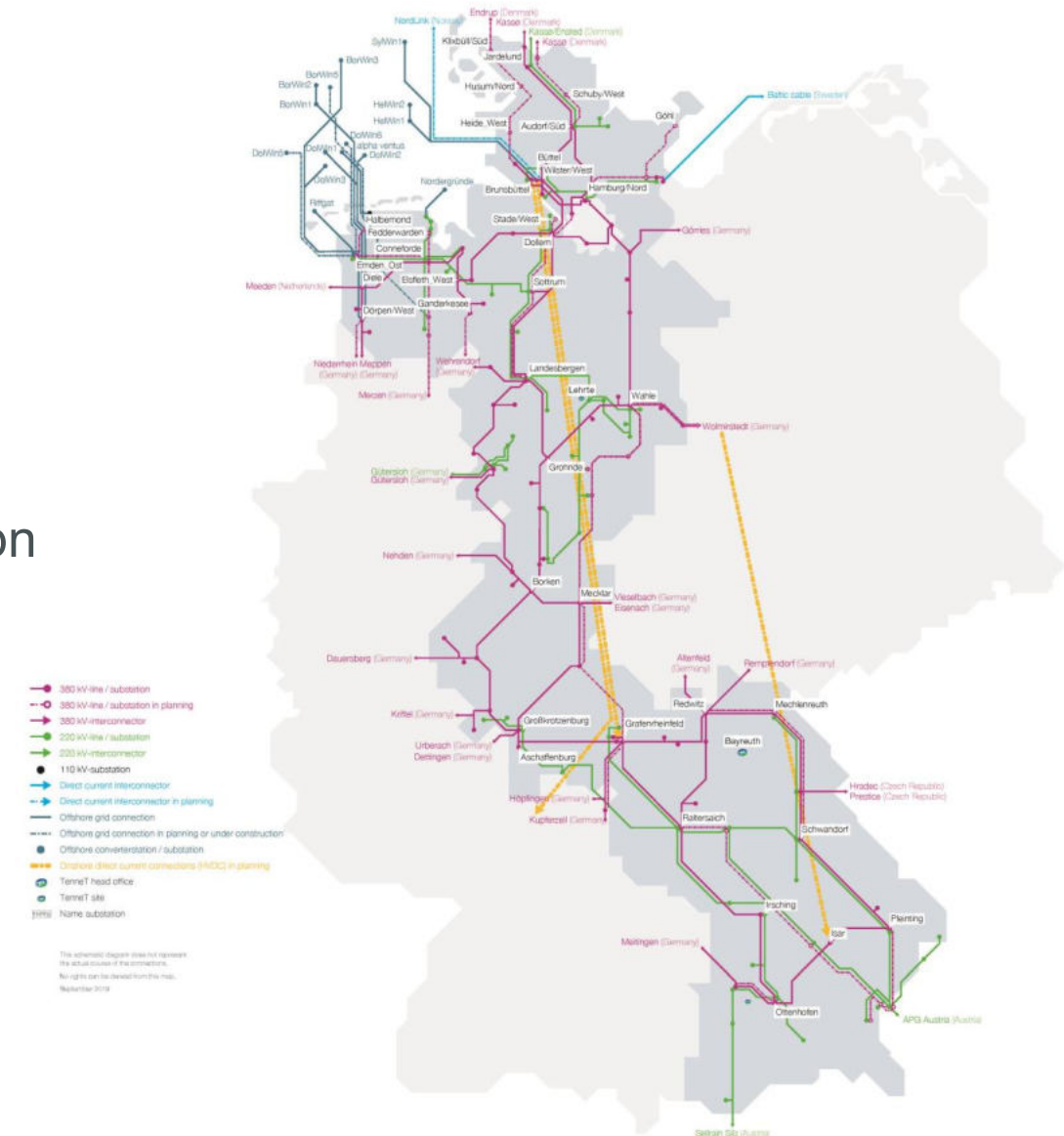
Employees (internal + external) 2,390

Assets EUR 16,067 bn

Total grid length 12,606 km

Transformer substations 129

Number of end-users 24.3 m





A low-angle photograph looking up at three workers on a complex metal lattice tower against a clear blue sky. The workers are wearing safety gear: yellow and red helmets, high-visibility vests, and harnesses. They are positioned on different levels of the tower's structure. The tower's metal beams create a dense geometric pattern.

# Our tasks

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# A grid operator's tasks

## Main tasks

### Transmission services

Ensure a robust and efficient high-voltage grid



### Market facilitation

Facilitate an efficient and stable electricity market

### System services

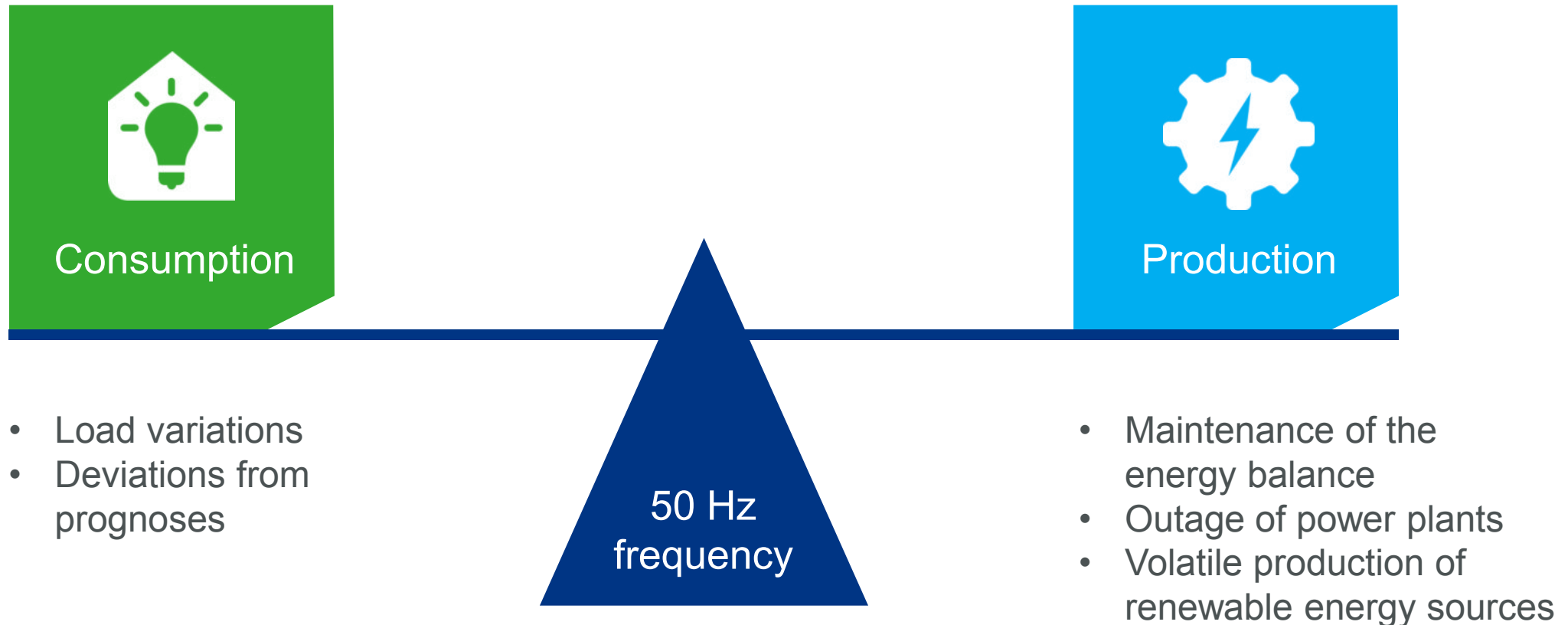
Maintain the balance of electricity, 24/7





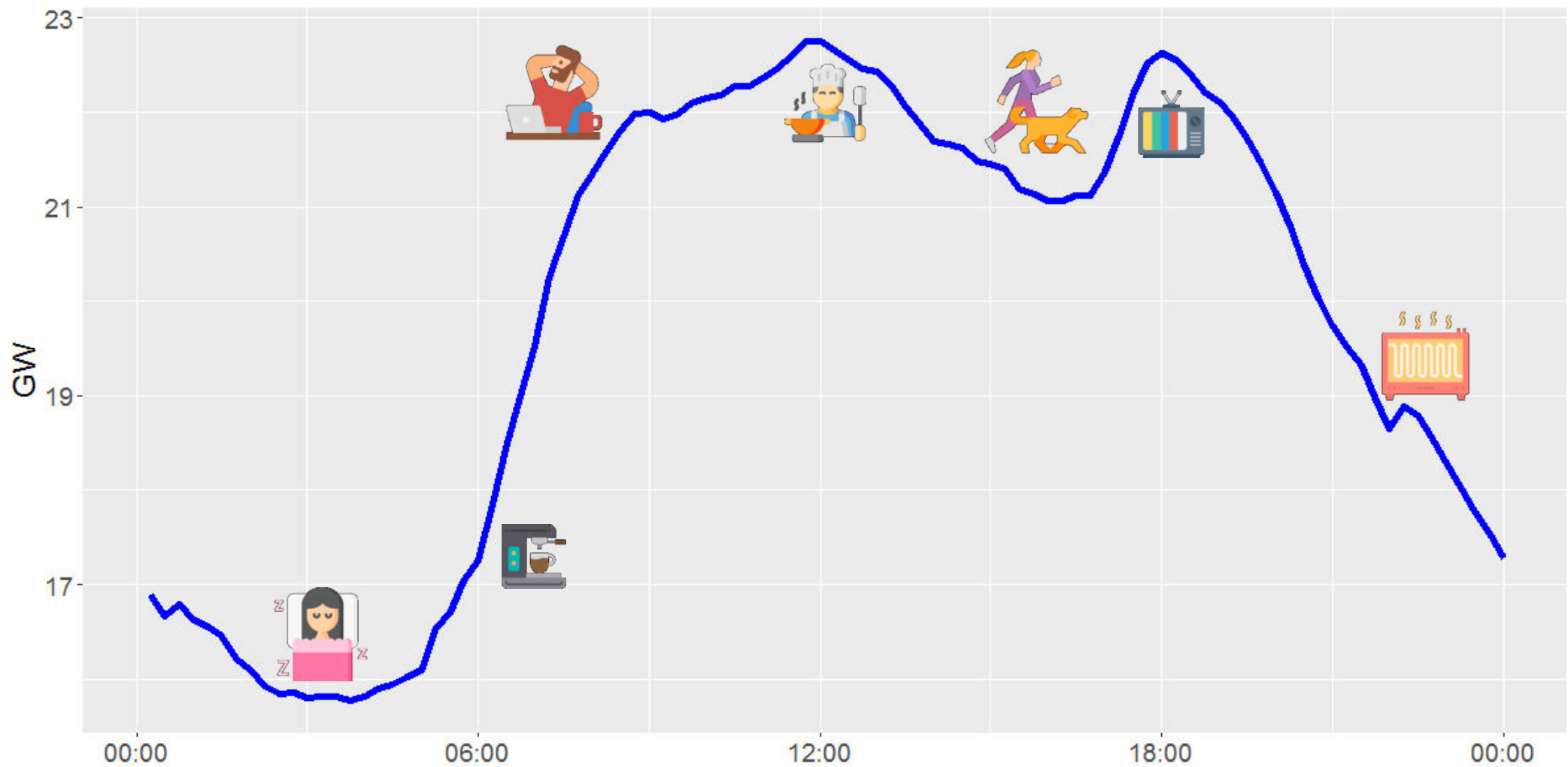
# Maintaining the balance

Maintenance of the energy balance: the amount of electricity produced must always exactly match the amount of electricity consumed.



# Load in Control Area TenneT

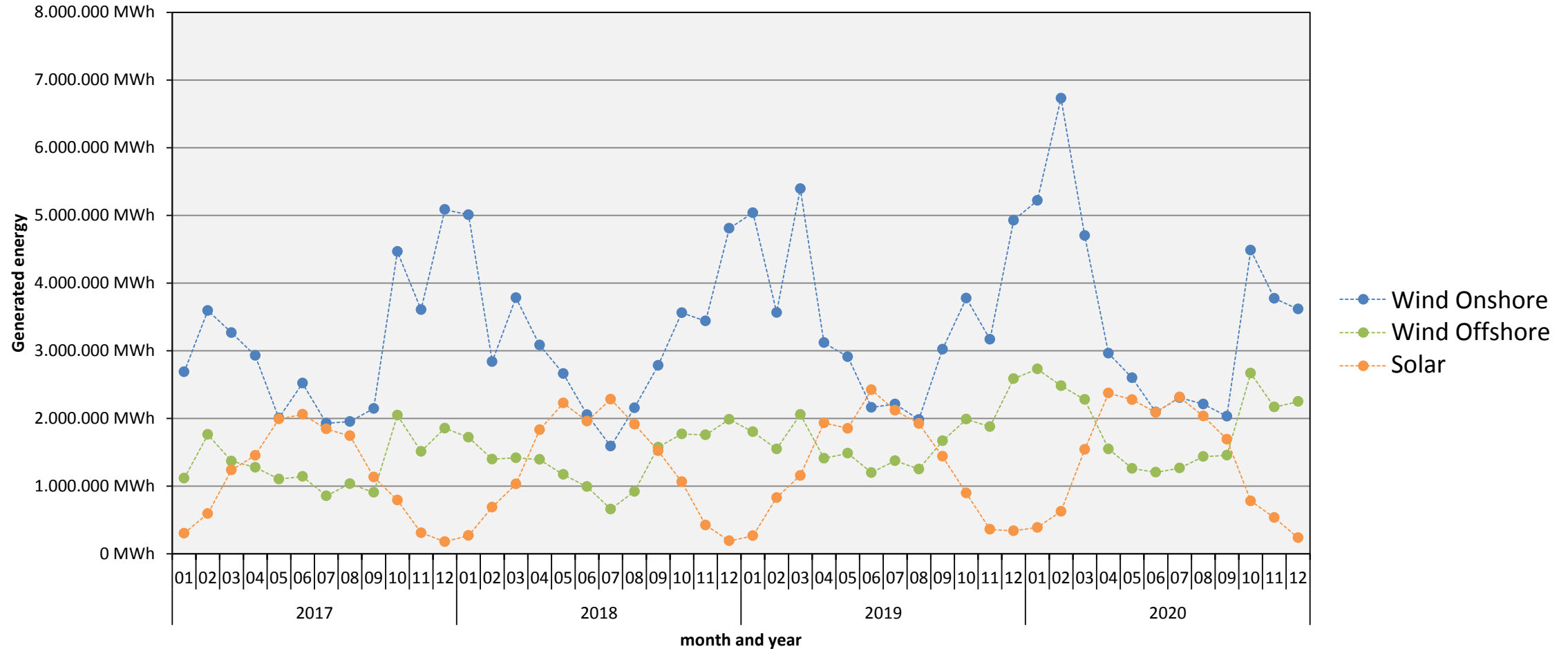
## Total consumption of a day



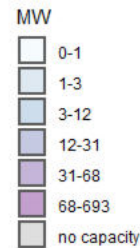
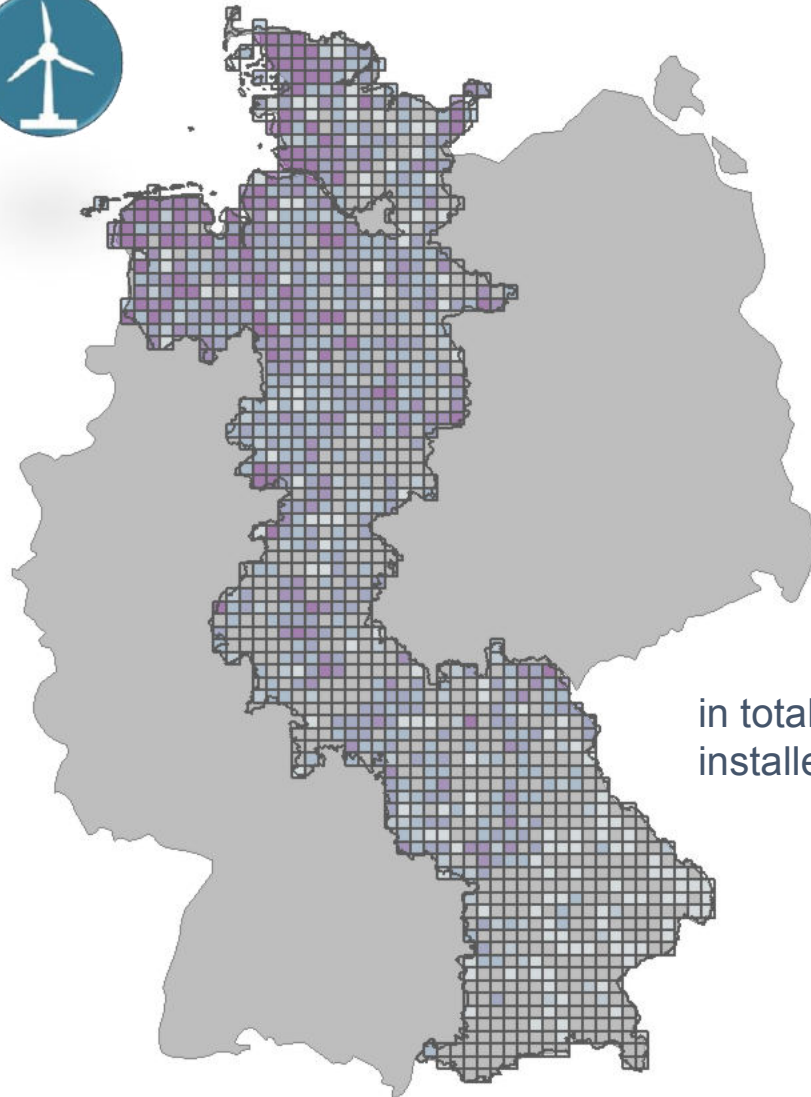


# Renewable Energy Sources in Control Area TenneT

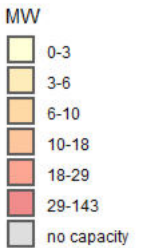
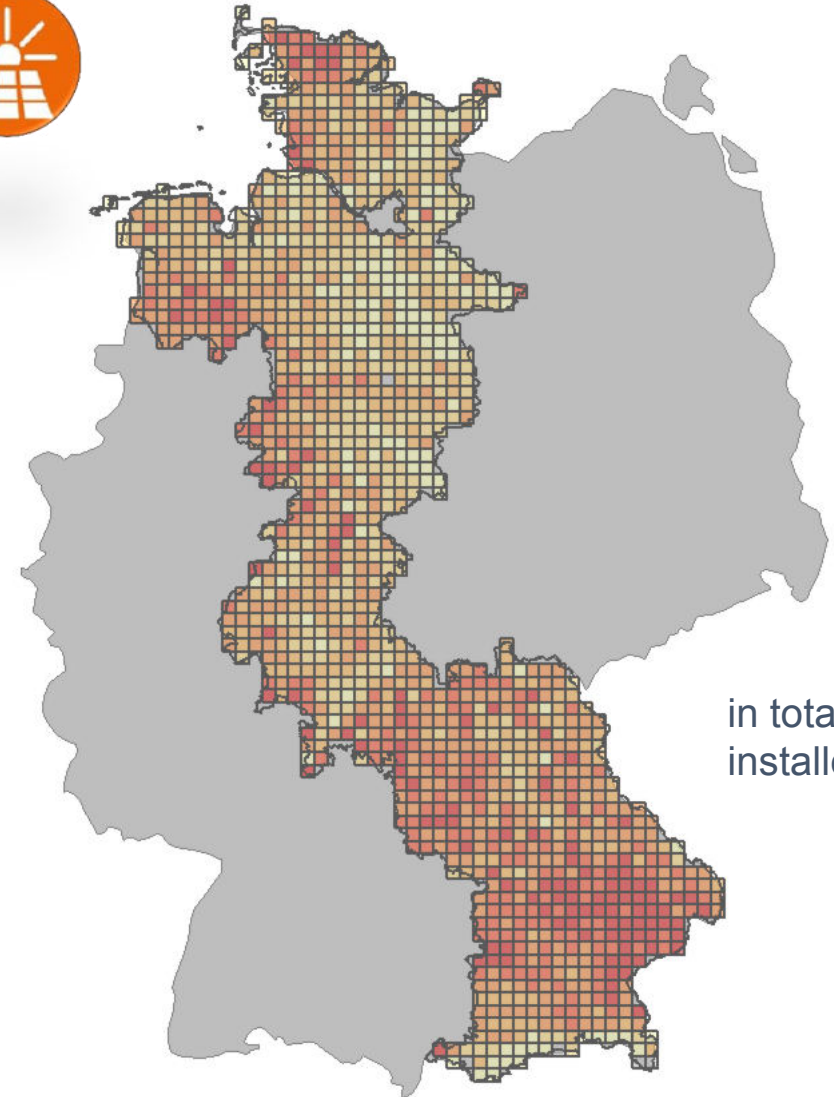
## Generated energy per month



# Installed Capacity Wind Onshore and Solar



in total 22.8 GW  
installed capacity



in total 19.2 GW  
installed capacity



# Offshore capacity in Germany and The Netherlands

## 9.832 GW in 2026 (GER)

## 5.6 GW in 2026 (NL)



alpha ventus – 62 MW – AC  
Riffgat – 113 MW – AC  
Nordergründe – 111 MW – AC



SylWin1 – 864 MW – DC  
HelWin1 – 576 MW – DC  
HelWin2 – 690 MW – DC



DolWin1 – 800 MW – DC  
DolWin2 – 916 MW – DC  
DolWin3 – 900 MW – DC  
DolWin5 – 900 MW – DC  
DolWin6 – 900 MW – DC



BorWin1 – 400 MW – DC  
BorWin2 – 800 MW – DC  
BorWin3 – 900 MW – DC  
BorWin5 – 900 MW – DC



Borssele Alpha – 700 MW – AC  
Borssele Beta – 700 MW – AC  
Hollandse Kust (zuid) Alpha – 700 MW – AC  
Hollandse Kust (zuid) Beta – 700 MW – AC  
Hollandse Kust (noord) – 700 MW – AC  
Hollandse Kust (west) Alpha – 700 MW – AC  
Hollandse Kust (west) Beta – 700 MW – AC  
Ten noorden v.d.W., – 700 MW – AC

### Future projects (DE):

<b>BorWin6</b> 930 MW 2027	<b>BalWin1</b> 2000 MW 2029
<b>BalWin2</b> 2000 MW 2030	<b>BalWin3</b> 2000 MW 2030

**16.7 GW**  
**until 2030**

### Future projects (NL):

**IJmuiden Ver Alpha**  
2000 MW 2027

**IJmuiden Ver Beta**  
2000 MW 2029

**9.6 GW**  
**until 2030**

# Offshore Grid Connections (DE)

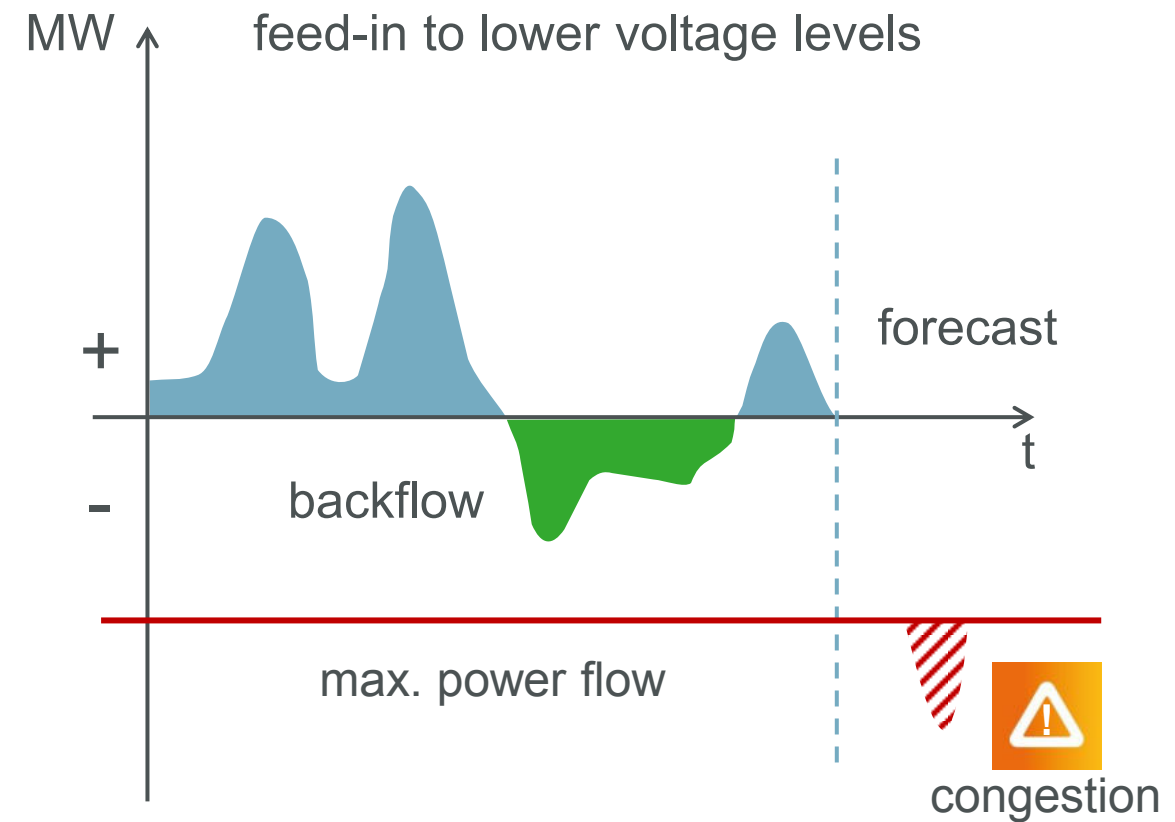
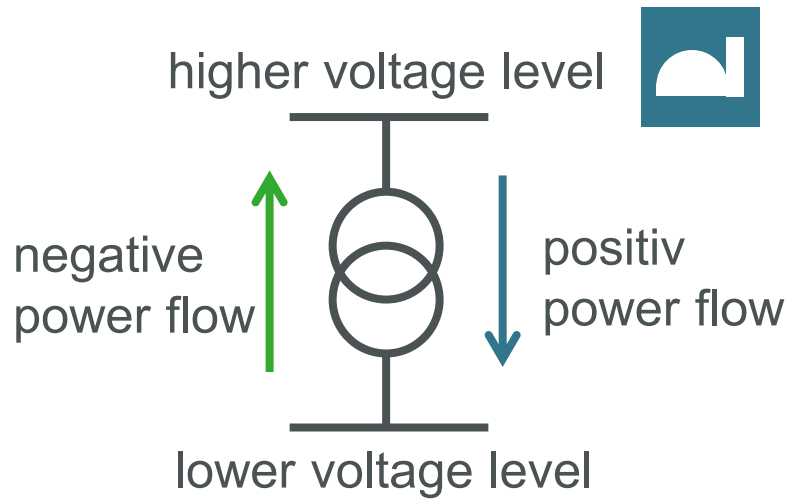
Project	Capacity (MW)	Commissioning
<b>Operational</b>		
alpha ventus	62	2009
BorWin1	400	2010
BorWin2	800	2015
DolWin1	800	2015
DolWin2	916	2016
DolWin3	900	2018
HelWin1	576	2015
HelWin2	690	2015
Nordergründe	111	2017
Riffgat	113	2014
SylWin1	864	2015
BorWin3	900	2019
<b>Under construction</b>		
DolWin6	900	2023
DolWin5	900	2024
BorWin5	900	2025
<b>Σ</b>	<b>9,832</b>	
<b>To be built</b>		
BorWin6	900	2027
<b>Σ</b>	<b>10,732</b>	





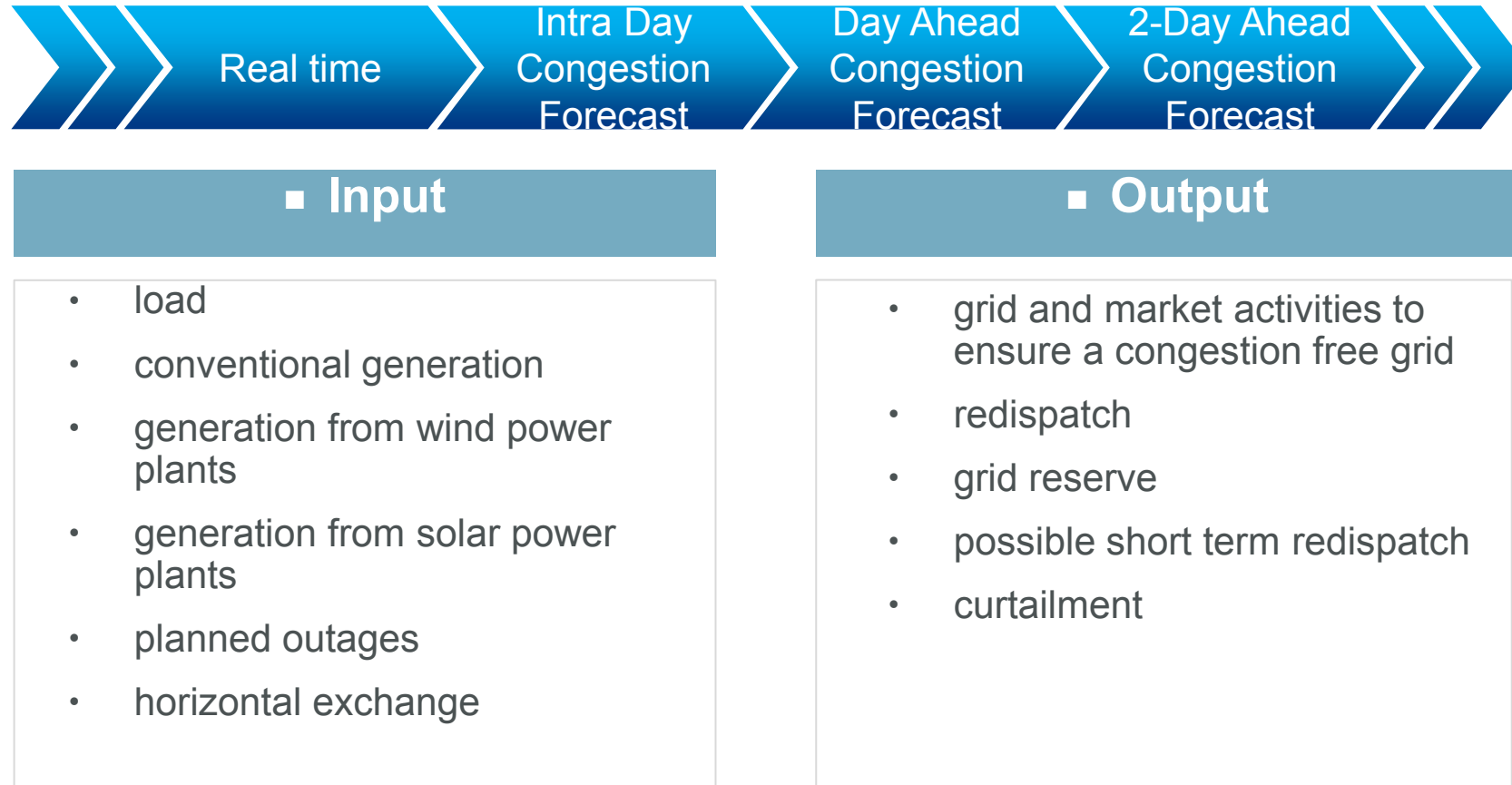
# Planning Processes and Congestion Forecast

## Keep your assets save



Use forecasts of the generation and consumption to determine possible congestions in the grid

# Planning Processes and Congestion Forecast

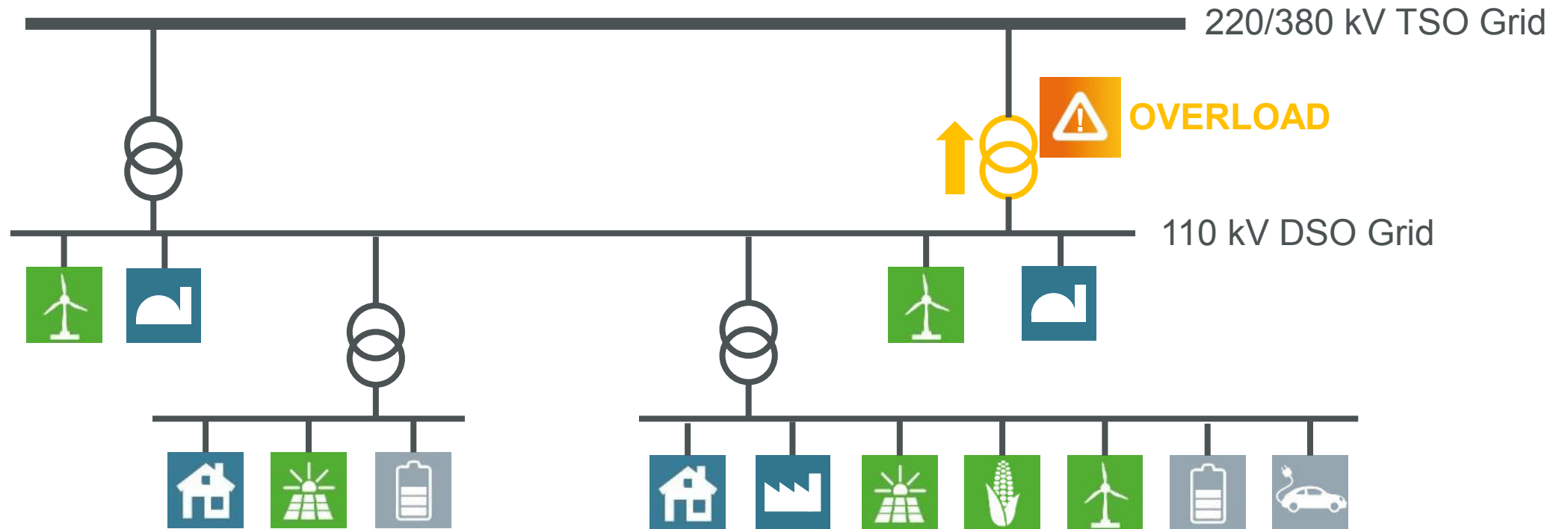


Congestion forecasts are national and european processes.



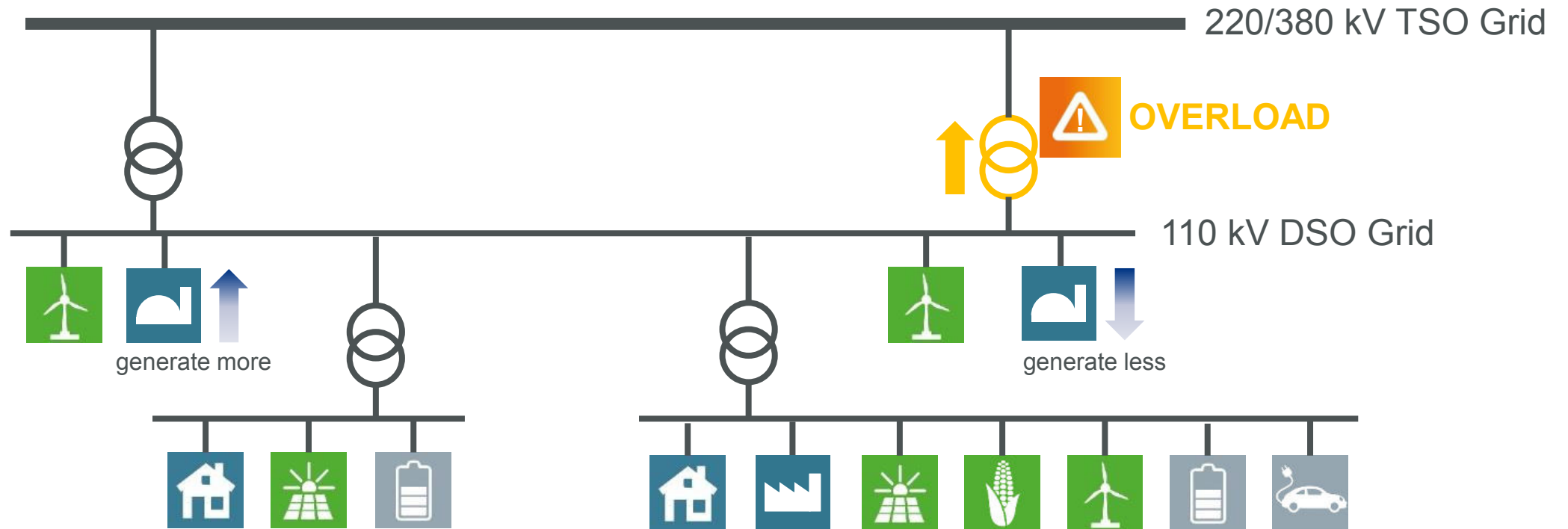
# Planning Processes and Congestion Forecast

## Redispatch and curtailment



# Planning Processes and Congestion Forecast

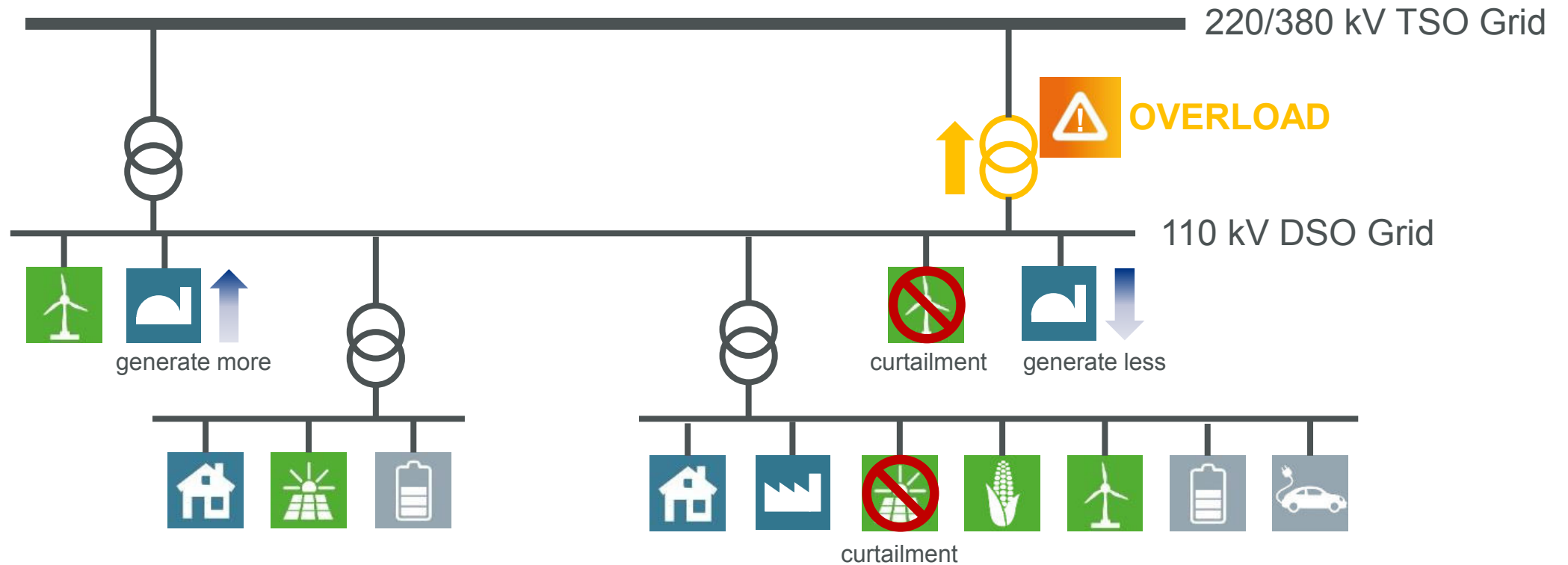
## Redispatch and curtailment





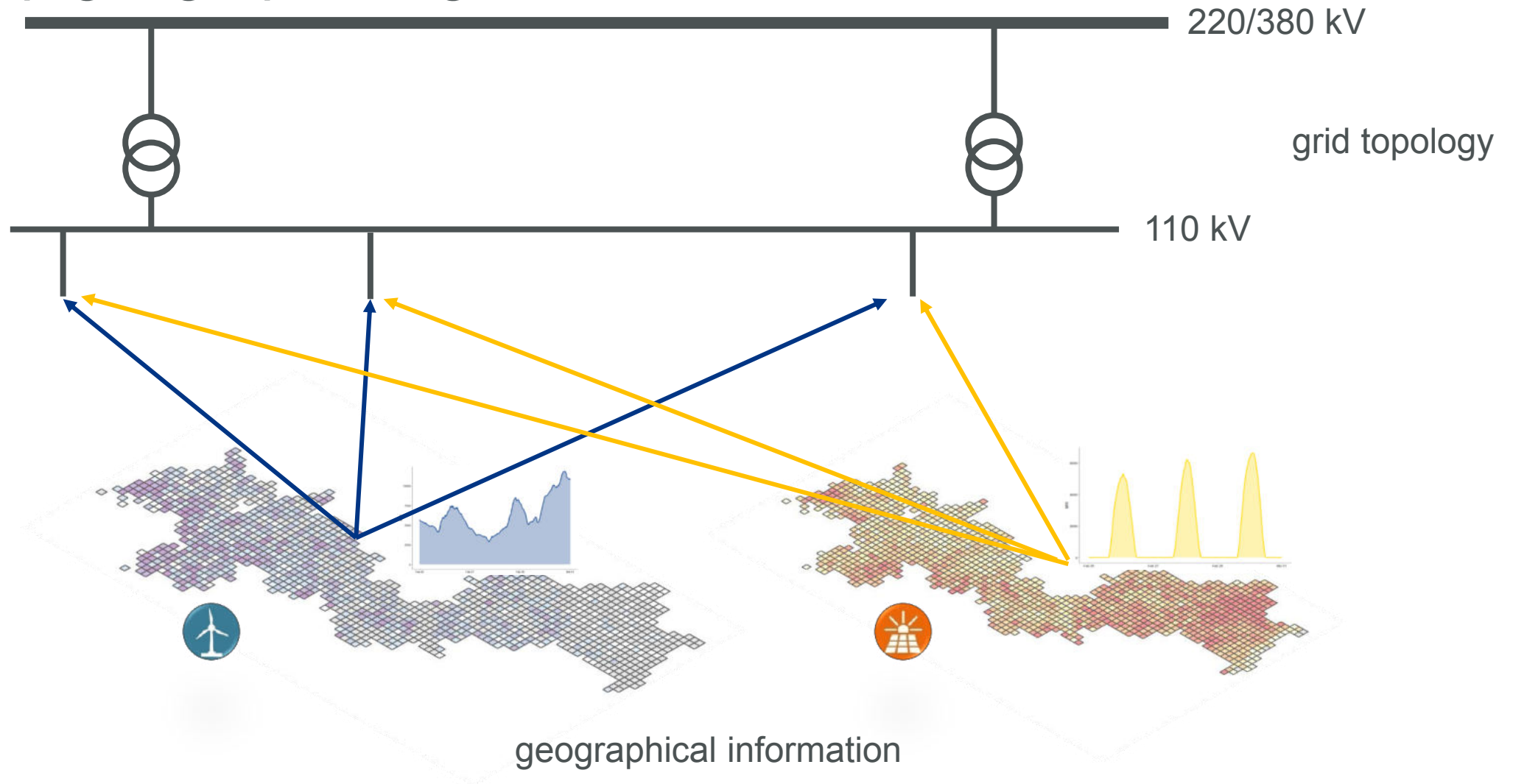
# Planning Processes and Congestion Forecast

## Redispatch and curtailment



# Grid Node Forecast

Map geographical generation to 110 kV busbar



# Impact on Wind Forecasts



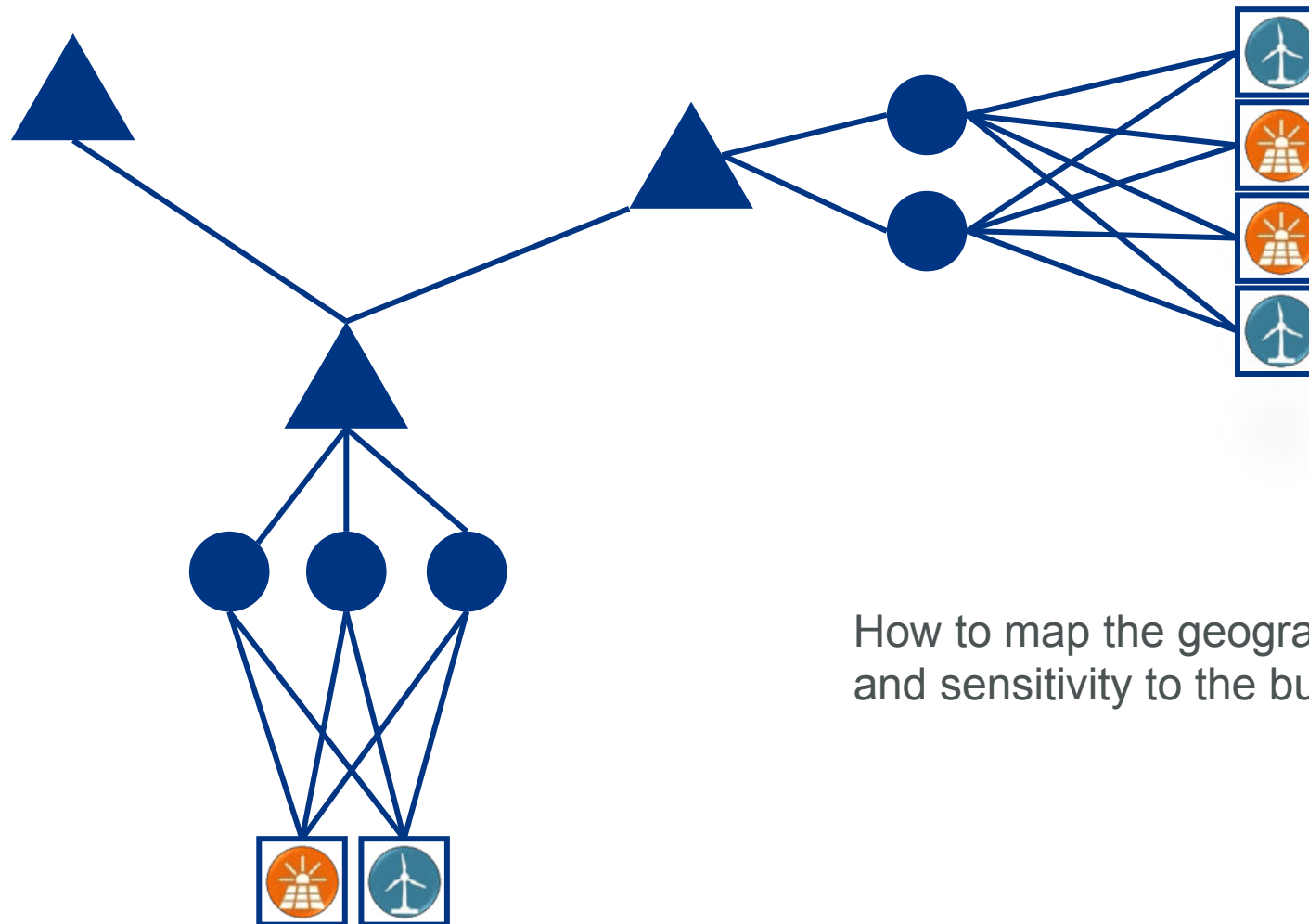


# Impact on Solar Forecasts



# Grid Node Forecast

## Misty graphs

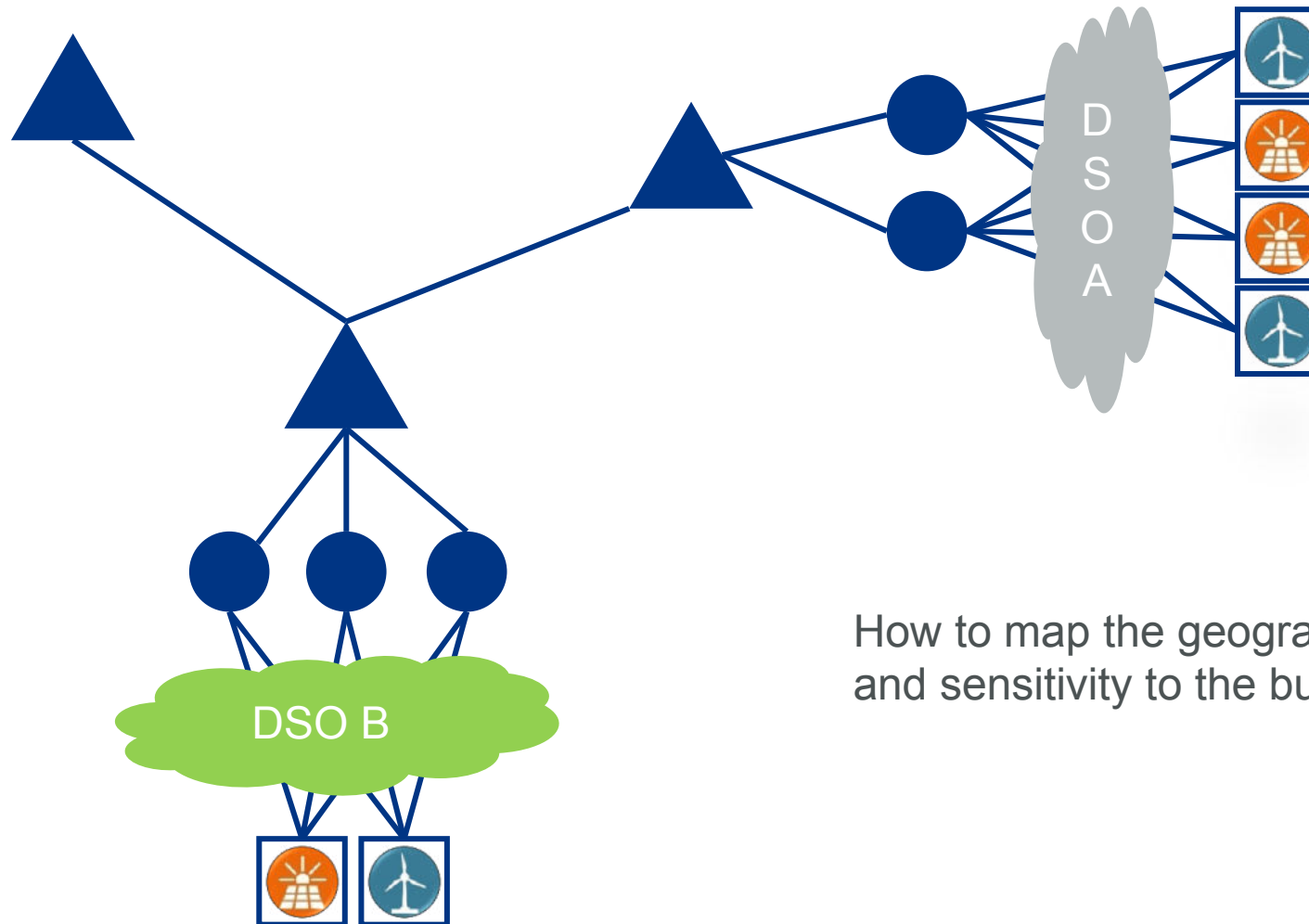


- ▲ Transformer
- 110 kV Busbar
- Geographical grid plane

How to map the geographical generation and sensitivity to the busbars?

# Grid Node Forecast

## Misty graphs

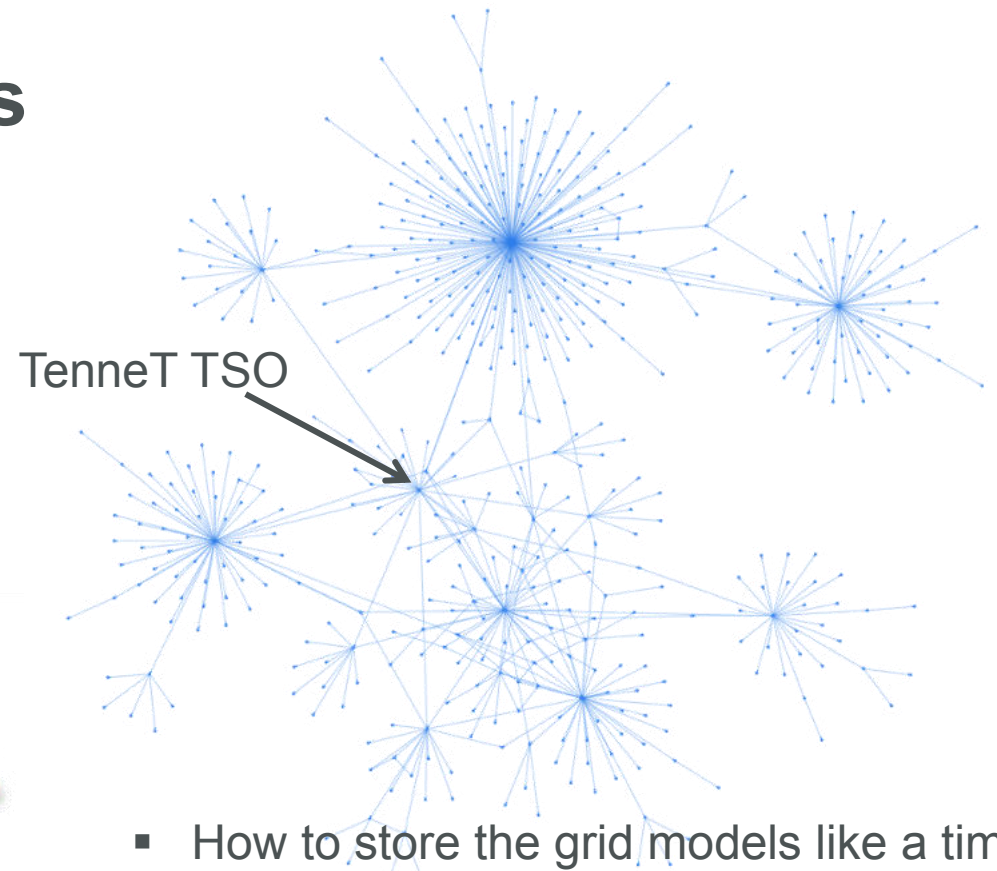
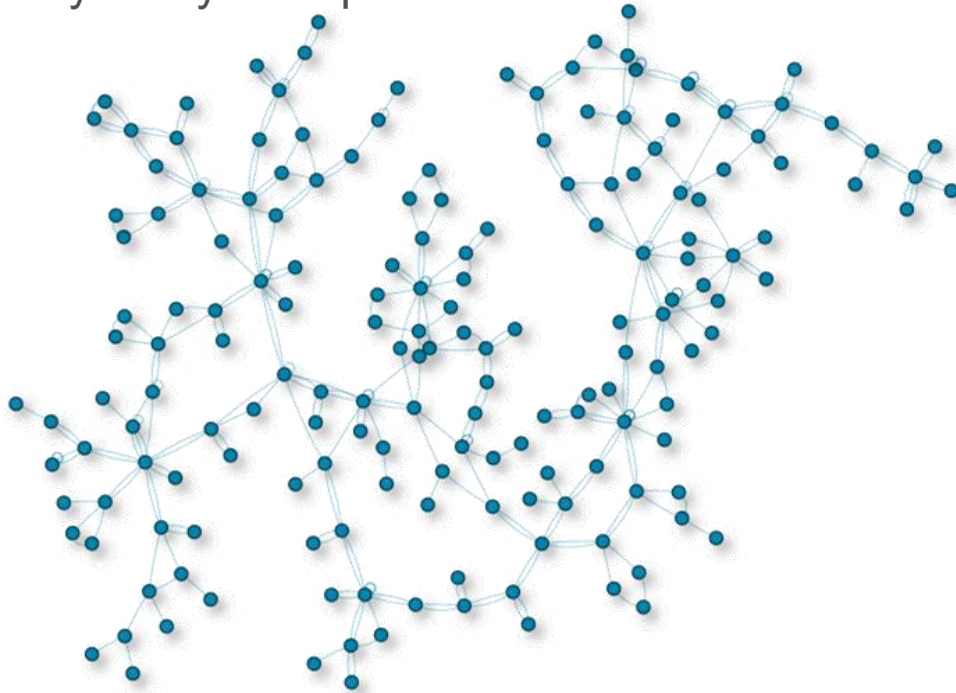


How to map the geographical generation and sensitivity to the busbars?



# Grid Models and other Graphs

- Grid models are exchanged between the operators using the *Common Grid Model Exchange Standard (CGMES) Library* or in *UCTE format* on different forecast (d+2, d+1, intraday, snapshots) horizons
- The different models are merged and grid security analysis is performed



- How to store the grid models like a time series for e.g ex-post analysis?
- Are there typical switching states in dependency of the weather?
- Where to set new assets?
- How to performe grid restoration and synchronisation?
- ...

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