Grid Development for Renewable Energies

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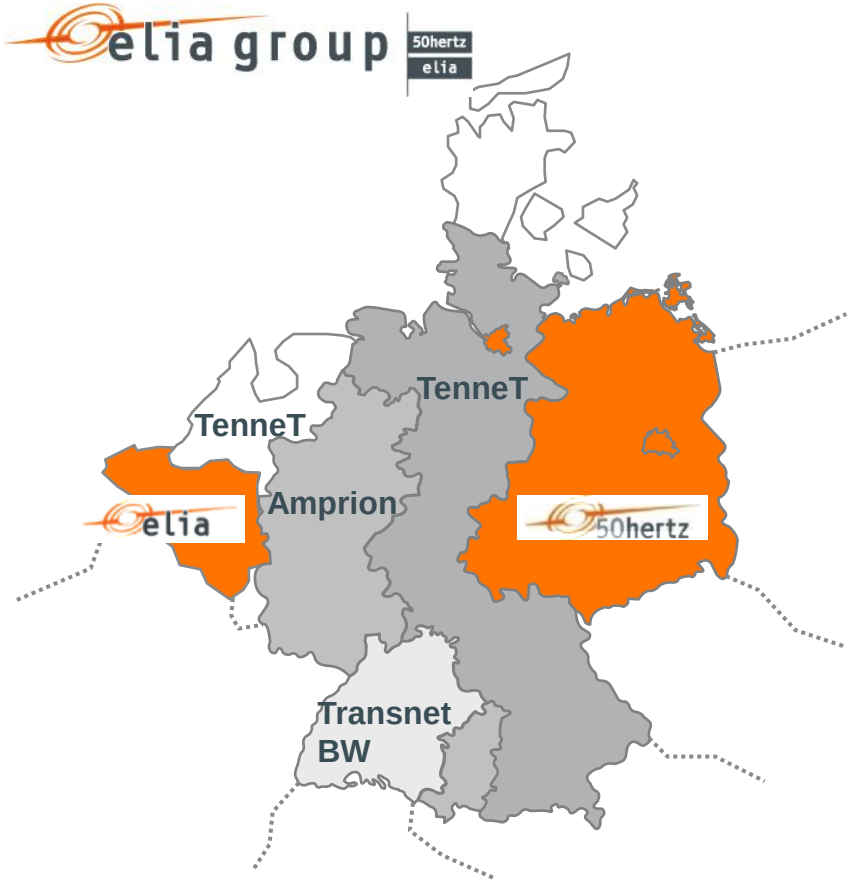
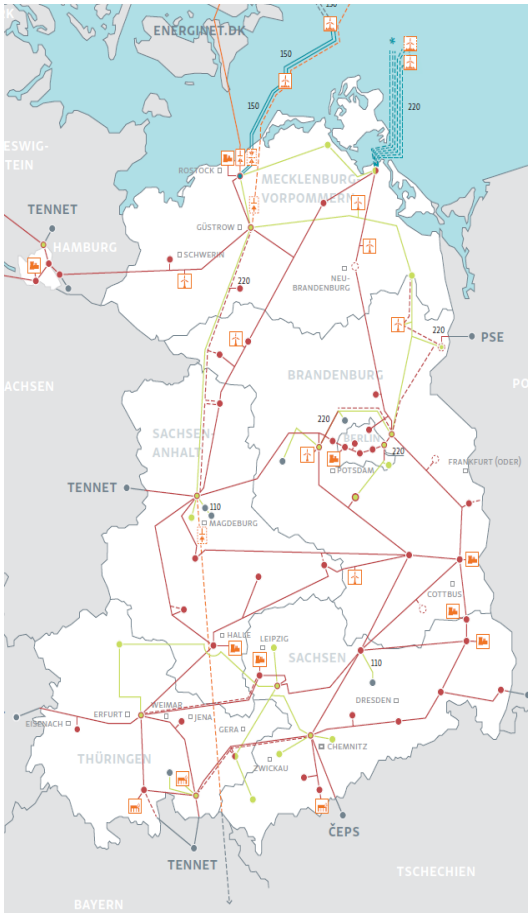
50Hertz – a fully unbundled European TSO



- 50Hertz is a fully unbundled TSO and part of **Elia Group.**
- Our shareholders are the Belgian TSO **Elia** (80% of shares) and the German state owned bank **KfW** (20% of shares).
- 50Hertz owns and operates the transmission grid for **18 million people** in Eastern Germany**.**
- Within Elia group, 50Hertz is committed to **international cooperation** and supports partners in grid operations, RES integration and market design.

Source: 50Hertz.

50Hertz at a glance



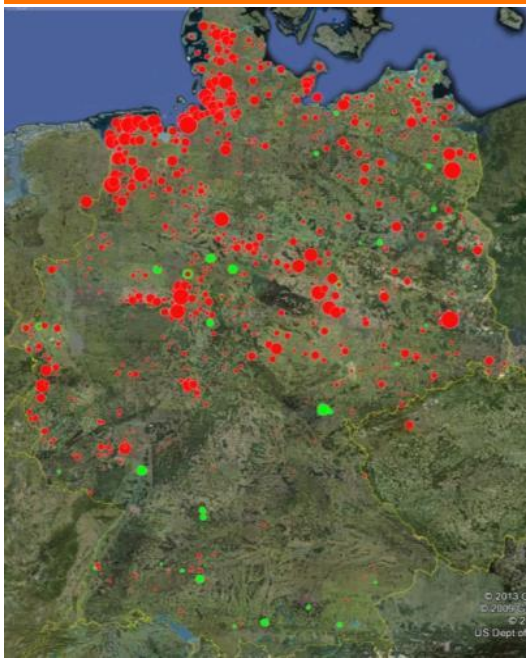
	2010 (share Germany)	2017/18 (share Germany)
Grid area	109,589 km² (~31%)	109,619 km²(~31%)[1]
Length of lines	9,800 km (~30 %)	10,200 km (~30 %)[1]
Max. load	~ 17 GW (~20 %)	~ 16 GW (~20 %)[1]
Power consumption (based on electricity supplied to end-consumers in acc. with Renewables Energy Law „EEG“)	~ 98 TWh (~20 %)	~ 96 TWh (~20 %)*
Installed capacities - of which Renewables - of which Wind	38,354 MW (~35%) 15,491 MW (~30%) 11,318 MW (~40%)	54,069 MW (~26%)[1] 32,352 MW (~29%)* 19,414 MW (~35%)*
RES share in power consumption	~ 25 %	~ 55.0 %*
Turnover - of which Grid	5.6 bn. € 0.6 bn. €	9.9 bn. €[1] 1.3 bn. €[1]
Employees	643	1,043[1]

Source: 50Hertz; [1]as of 31/12/2017; *preliminary data; as of 08/01/2019

RES Development in Germany

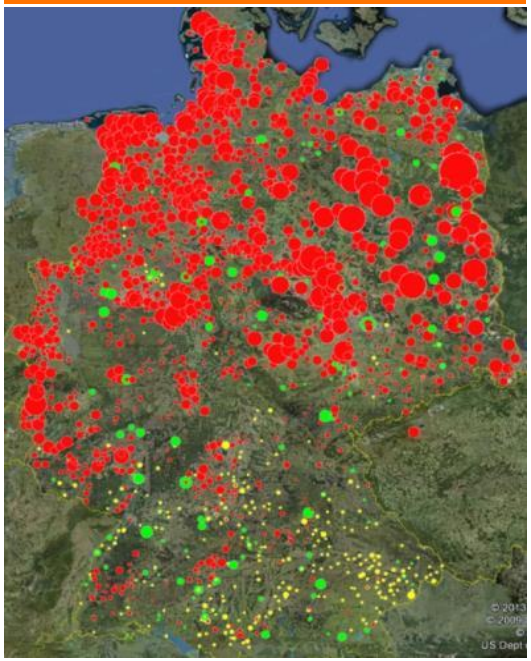
Area proportional to the installed capacities

2000



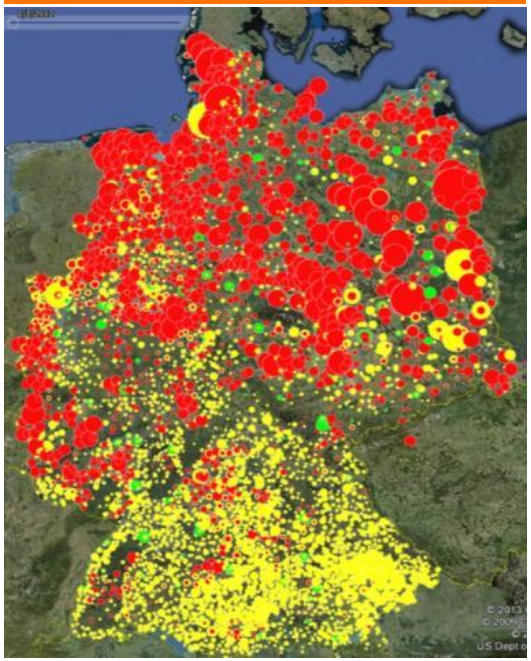
- ~30,000 plants
- 1,665 MW wind power

2006



- ~221,000 plants
- 2,233 MW wind power

2018

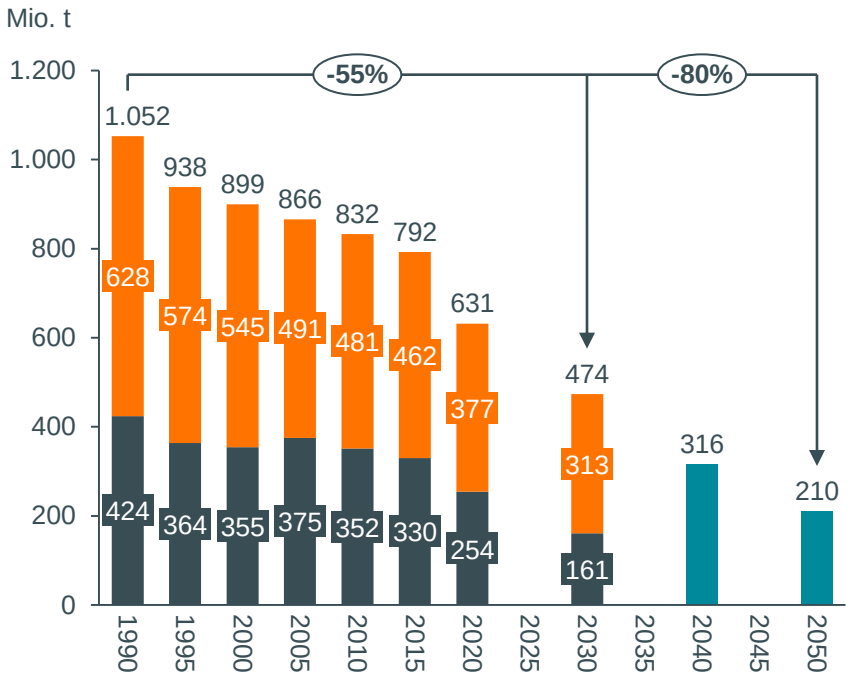


PV Wind Biomass

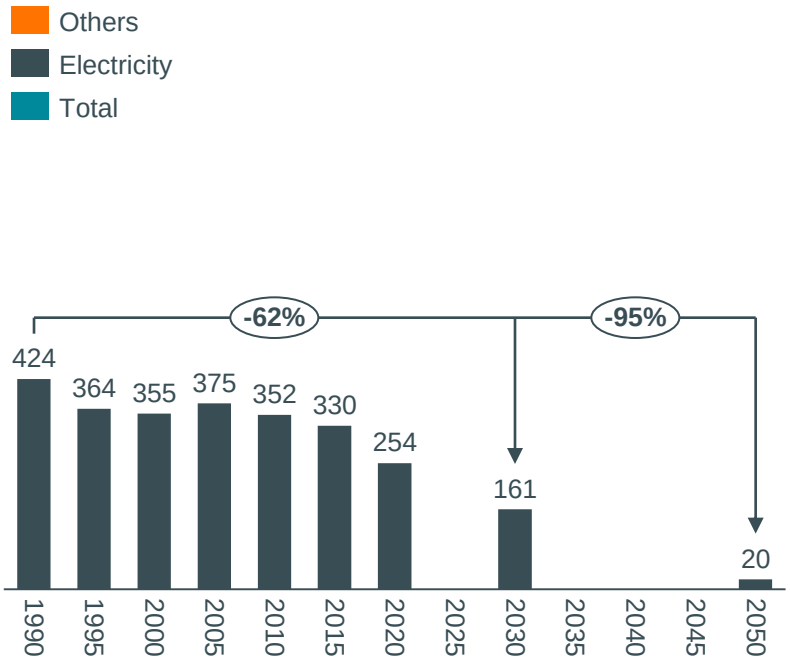
- > 1,600,000 plants
- 49,628 MW wind power
- 41,687 MW PV

CO_2-Reduction Path in Germany

Total CO_2-emissions in Germany



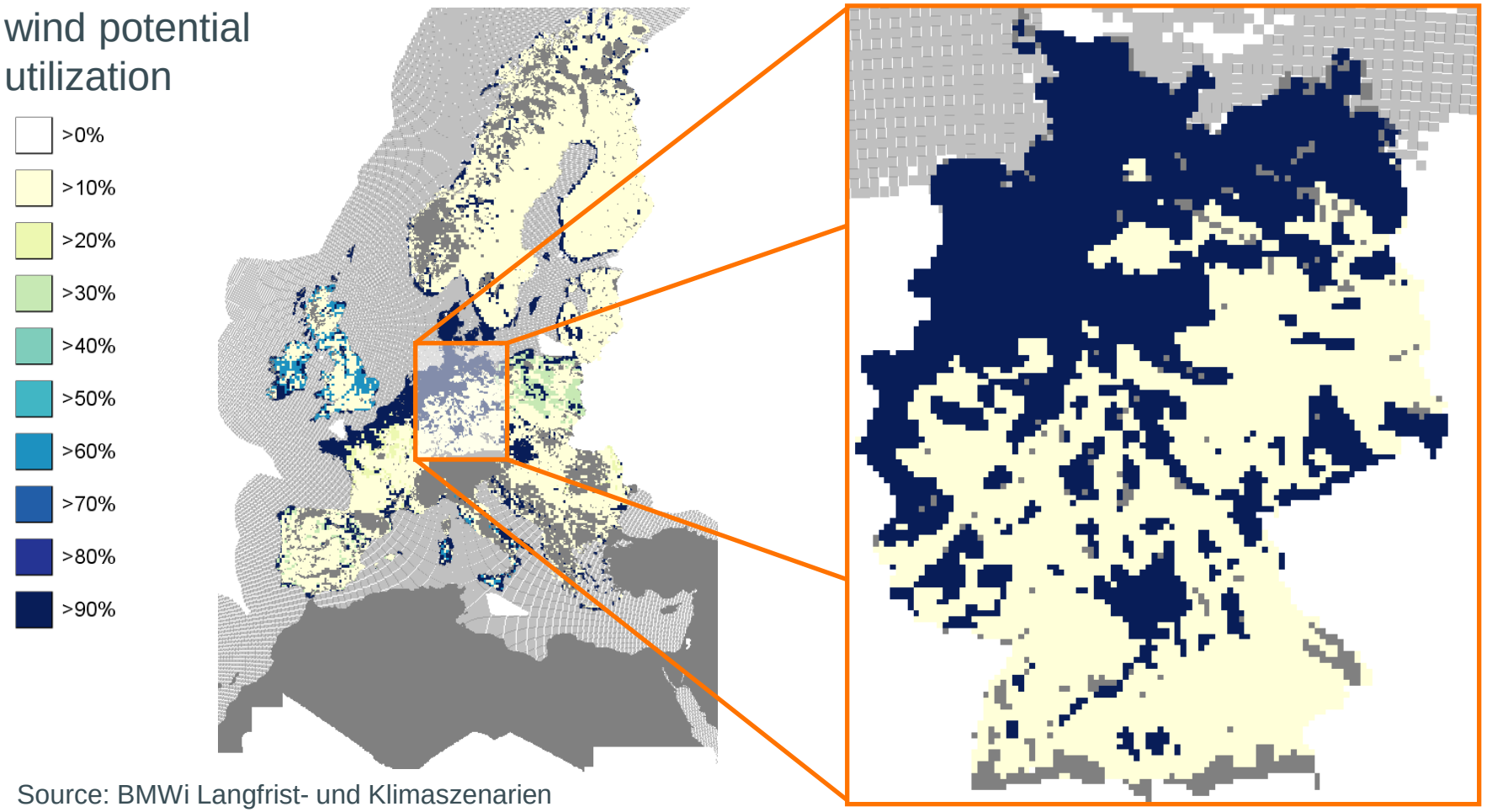
…thereof in the electricity sector



High reduction aim of 95% in 2050 in the electricity sector due to lower specific costs of CO2-reduction

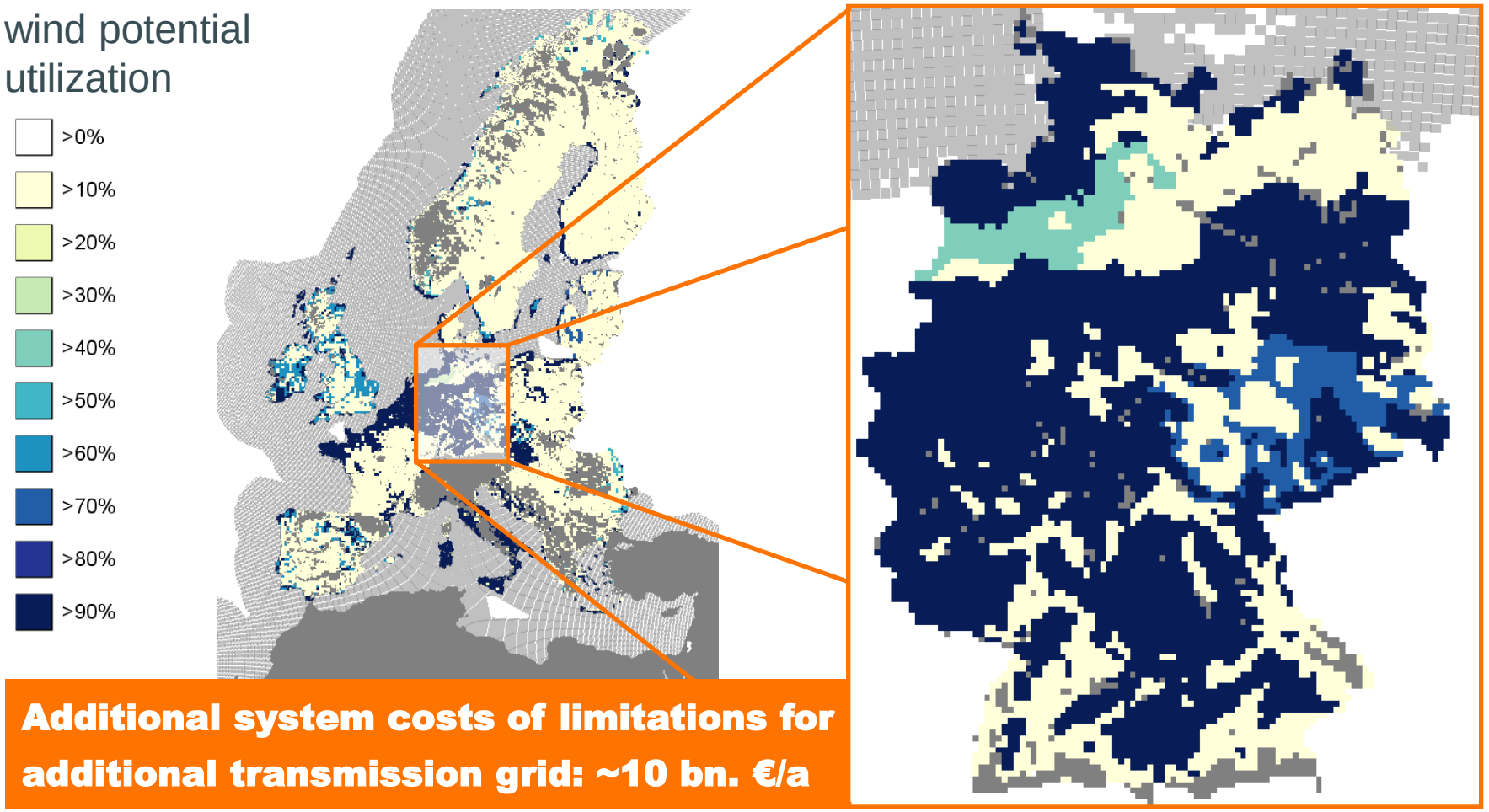
Quelle: Energiekonzept (2010), Projektionsbericht (2015)

Results of Co-Optimization of RES and Grid Extension in Europe without Limitations for additional Grid, 2050



Source: BMWi Langfrist- und Klimaszenarien

Results of Co-Optimization of RES and Grid Extension with Limitations for additional Transmission Grid in Germany, 2050



Additional system costs of limitations for additional transmission grid: ~10 bn. €/a

Paradigm Shift in Transmission Grid Planning

Conventional system

The transport of the primary energy source is cheaper than the transport of electricity.

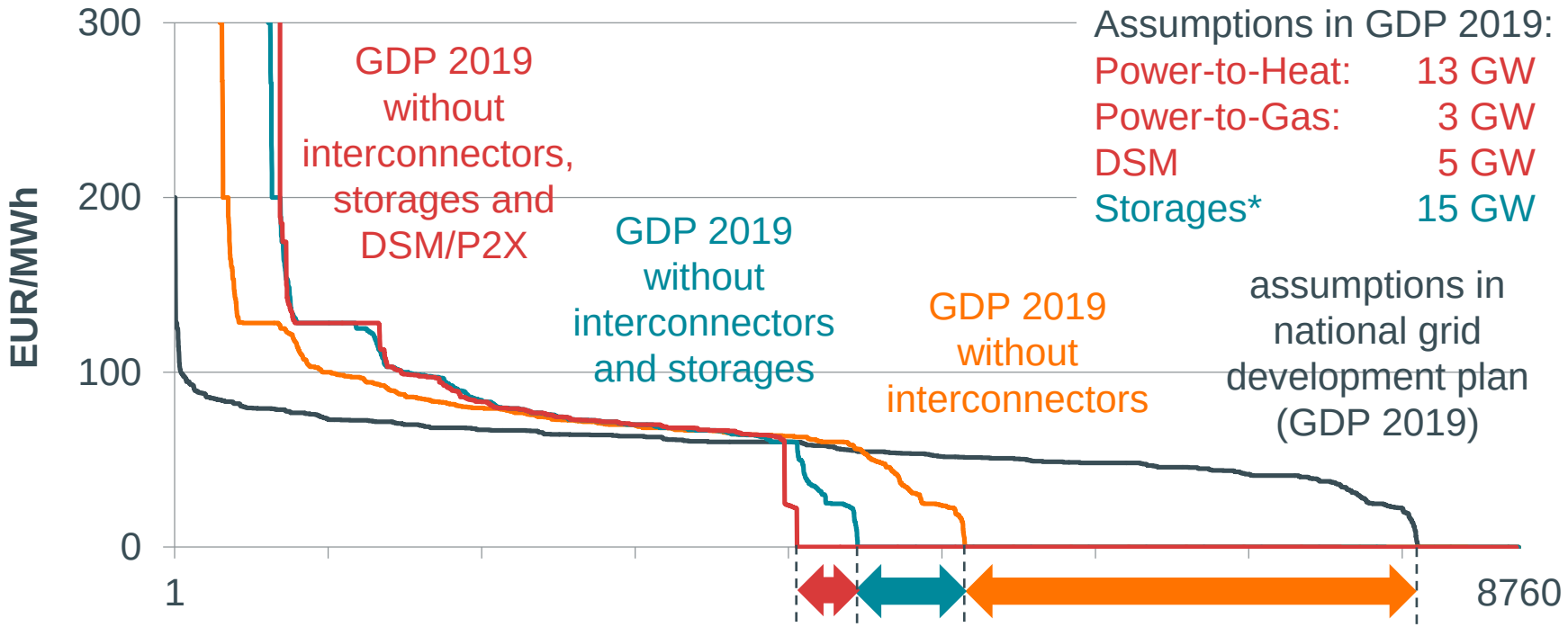
RES-dominated system in Europe

The yield-optimal placement of RES and the transport of electricity is up to a large extend cheaper than decentralised RES or any other option like power-to-gas.

Main drivers for this paradigm shift:

- **High yield-difference of RES within Germany and over Europe**
- **Increased availability of RES with new paradigm because of**
  - **higher full load hours of RES at yield-optimal places**
  - **high probability of different weather situations in Europe**
- **Access to existing large scale storages by additional grid**

System Integration of Renewables
Annual Price Duration Curve, Germany, 2035



*without PV-batteries (12 GW that are not optimized in the market)

The Enery Transition is a European project.
The transmission grid has a central role.

Consequences of this Insight

- **Need for tools to steer RES at optimal places in Europe**
  - Pro: Optimized RES support scheme in use in Germany that steers RES at yield-optimal places, controls volumes, minimizes risks for investors, sets incentives for optimal RES design and minimizes windfall profits due to yield-differences of RES
  - Con: No harmonized European RES support schemes
    ➔ no optimal RES-distribution over Europe
- **Plan and realize efficient extension of transmission grid**
  - Pro: Ten Year Network Development Plan (TYNDP) is made together by all European TSOs
  - Pro: Sophisticated legal processes in place in Germany that allow transmission grid extension
  - Con: Speed of grid extension is still too slow
  - Neutral: Decision for cabling of DC-lines increased acceptance but also costs

Future Challenges for TSOs

- Realize needed grid extension as fast as possible
  - Intensify involvement of politics and public and make use of new technologies to find acceptable solutions
- Increase loading of existing grid
  - Increase use of assets that can steer power flows (e.g. phase shifting transformers)
  - Sophisticated dynamic line rating and other operational innovations
- Manage congestions efficiently
  - Appropriate market design
  - Increase quality of forecasts and intensify regional cooperation
- Ensure secure grid operation
  - Introduce new assets and concepts to avoid regional blackouts after outages due to large regional power imbalances and missing synchronous generators

Up to now RES could be integrated into the grid without significantly changing proven concepts. This is changing now.

Thank you for your attention!