

25 September 2017

# German Network Planning, Operation, and Costs Allocation

US-System Operator Tour to Germany

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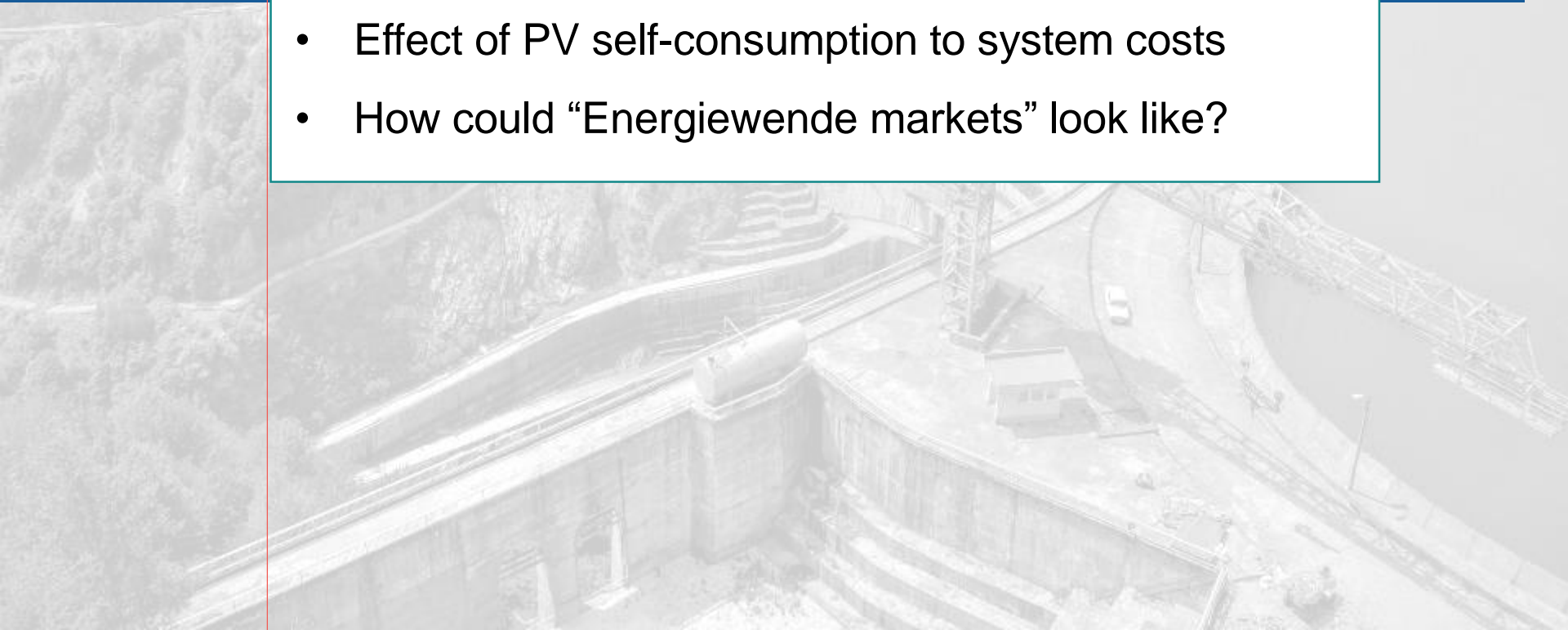
Agora Energiewende



# Agenda

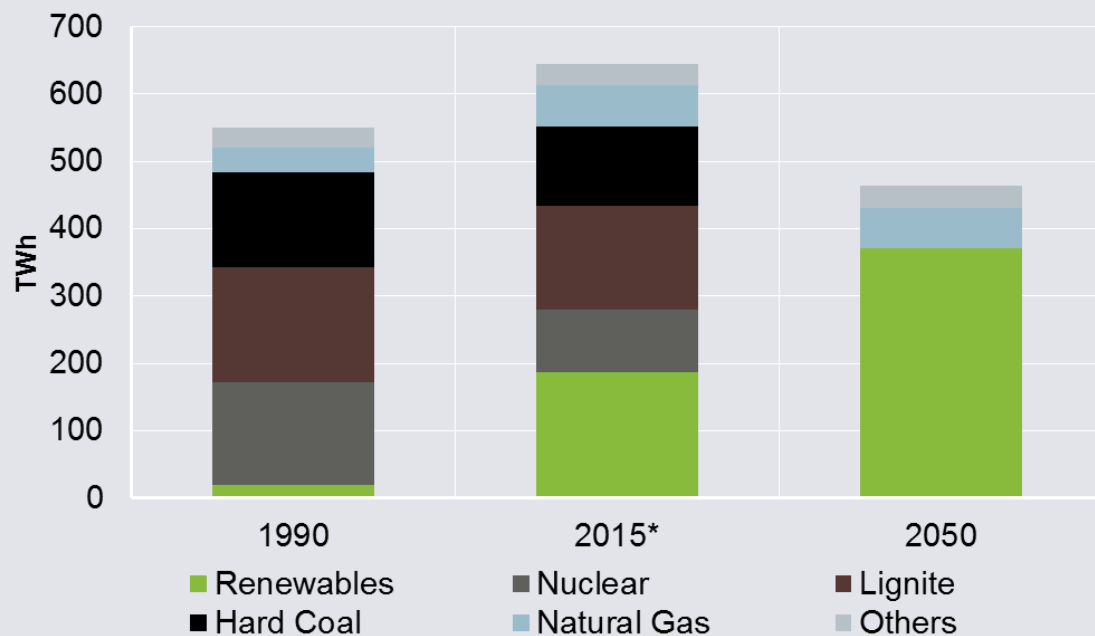
## **Electricity market design for the energy transition**

- Key challenges for the Energy Transition
- German power market design
- Network costs and cost allocation/tariff design
- Effect of PV self-consumption to system costs
- How could “Energiewende markets” look like?



# Energiewende in the power sector

Gross electricity generation 1990, 2016 and 2050



AGEB (2016), BReg (2010), EEG (2014), own calculations  
\* preliminary

## Phase out of nuclear power

Gradual shut down of all nuclear power plants until 2022

## Reduction of greenhouse gas emissions

Reduction targets below 1990 levels: - 40% by 2020; - 55% by 2030; - 70% by 2040; - 80% to - 95% by 2050

## Development of renewable energies

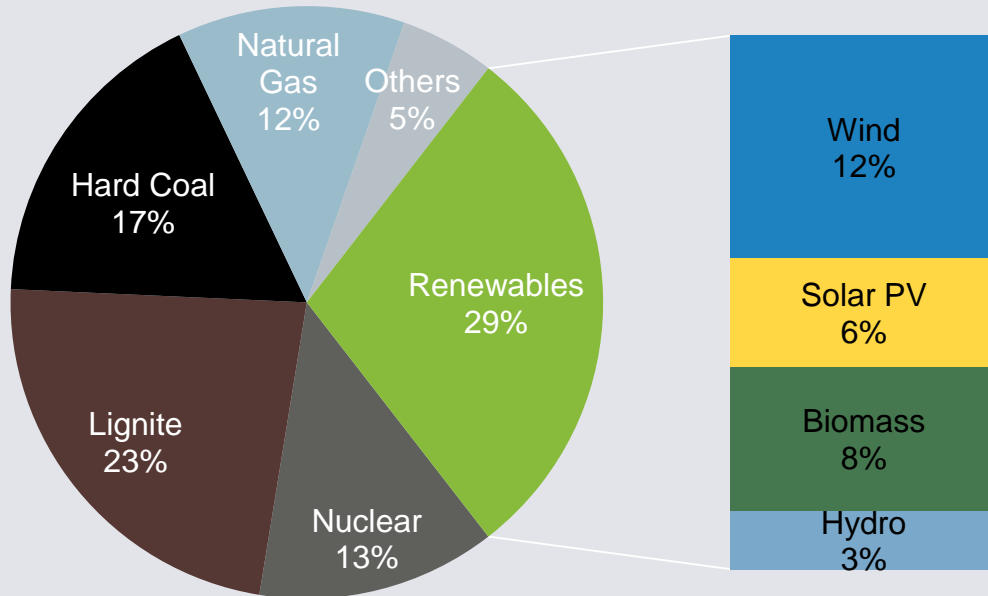
Share in power consumption to increase to: 40 - 45% in 2025; 55 - 60% in 2035;  $\geq$  80% in 2050

## Increase in efficiency

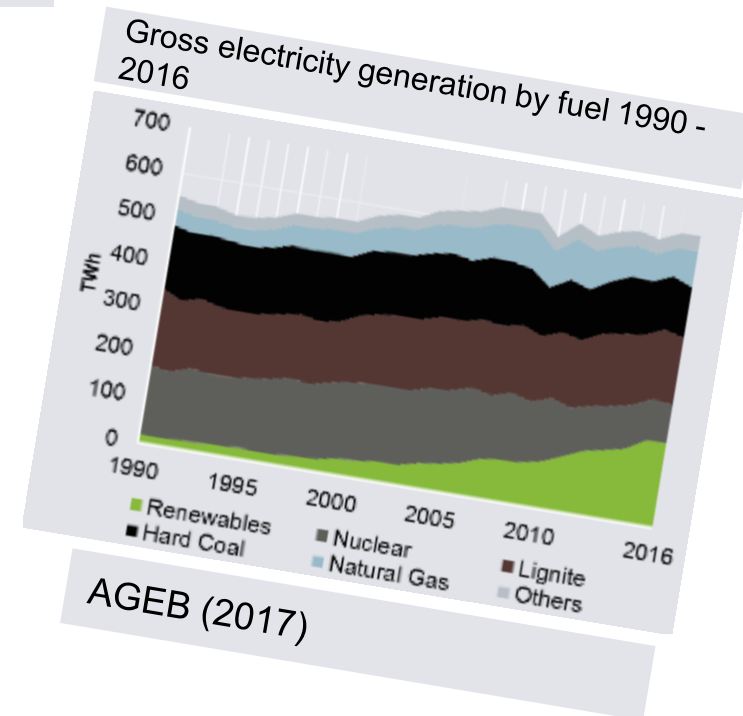
Reduction of power consumption compared to 2008 levels: - 10% in 2020; - 25% in 2050

# Renewables are the most important source in electricity generation, followed by lignite and hard coal

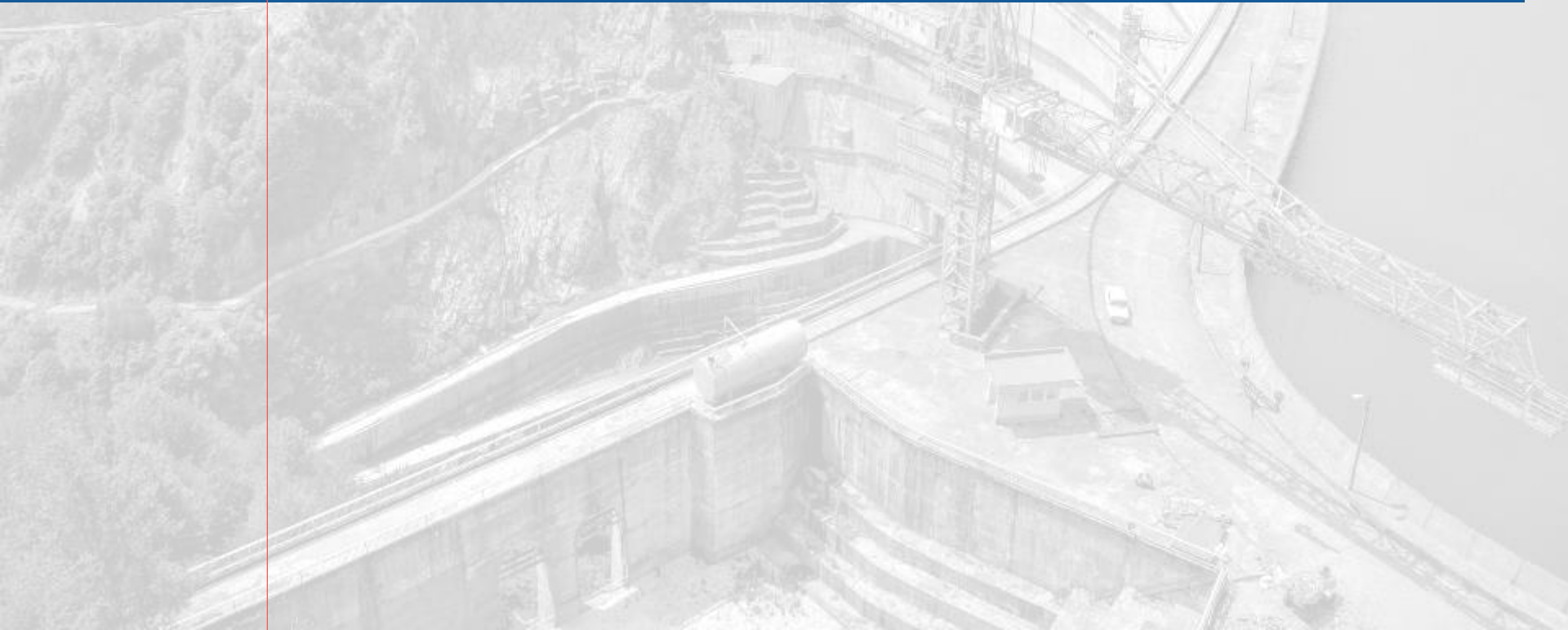
Share in gross electricity generation by fuel 2016



AGEB (2017)

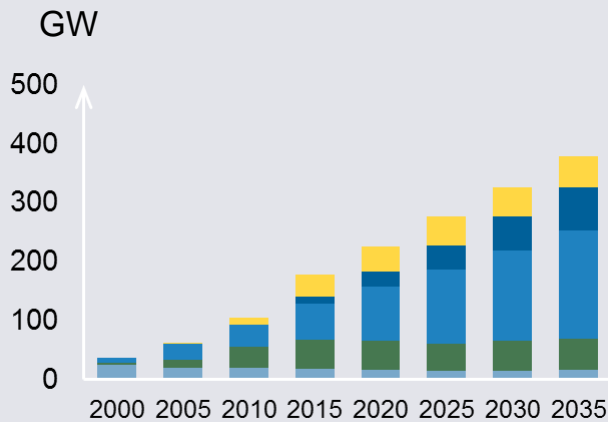


# Key Challenges for the Energy Transition



# Challenge 1: Wind energy and solar photovoltaic differ in their characteristics from conventional thermal generation – flexibility becomes key!

Gross electricity generation of renewable energies 2000 - 2035

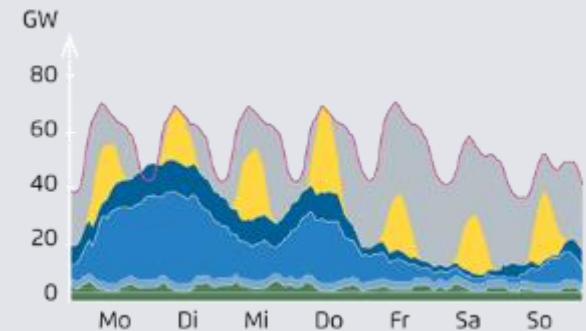


AGEB (2015a), BNetzA (2014), BNetzA (2015b), own calculations

## Specific characteristics of Wind and Solar PV

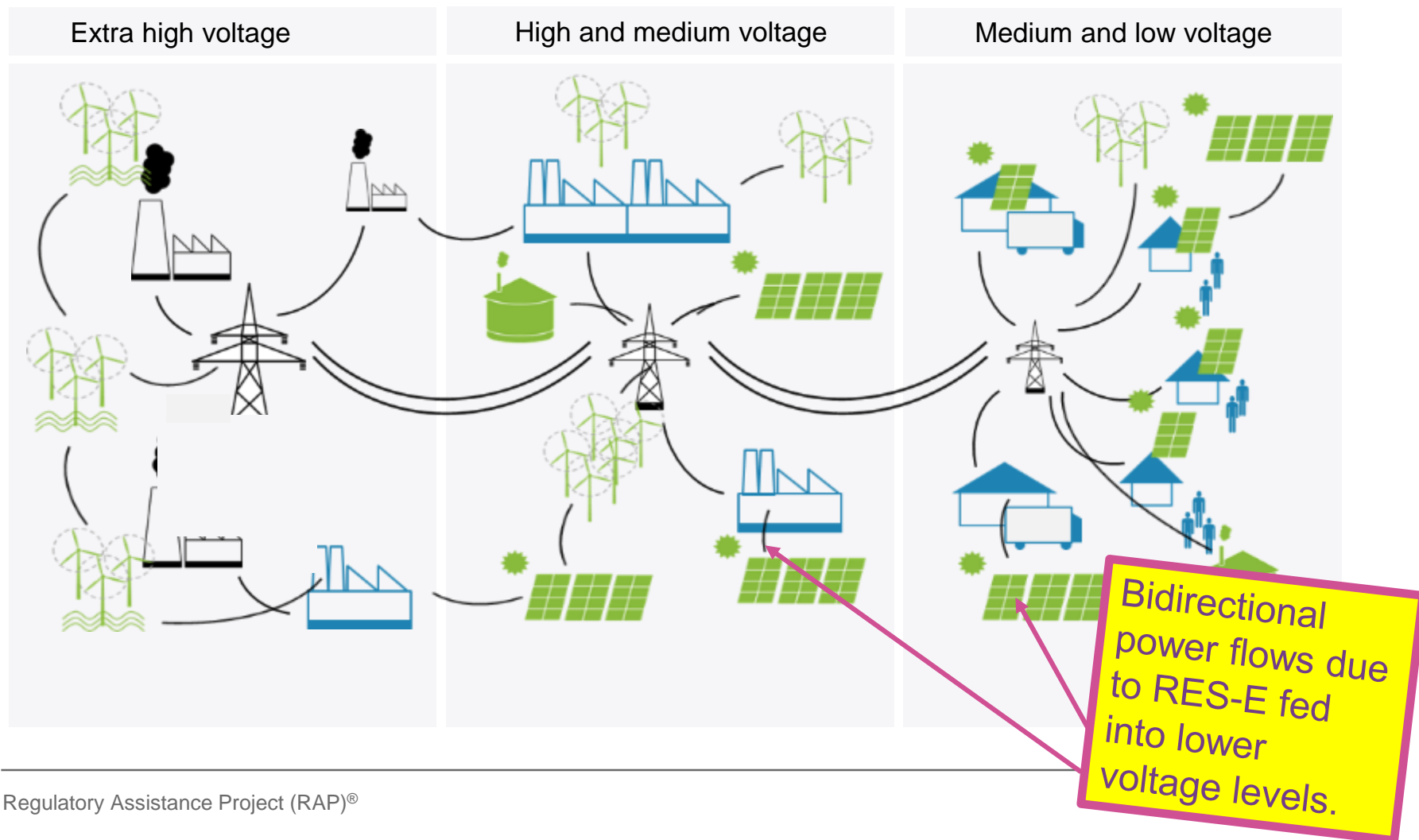
- 1 Intermittent
- 2 High capital costs
- 3 Very low variable cost

Electricity generation and consumption in a sample week 2023



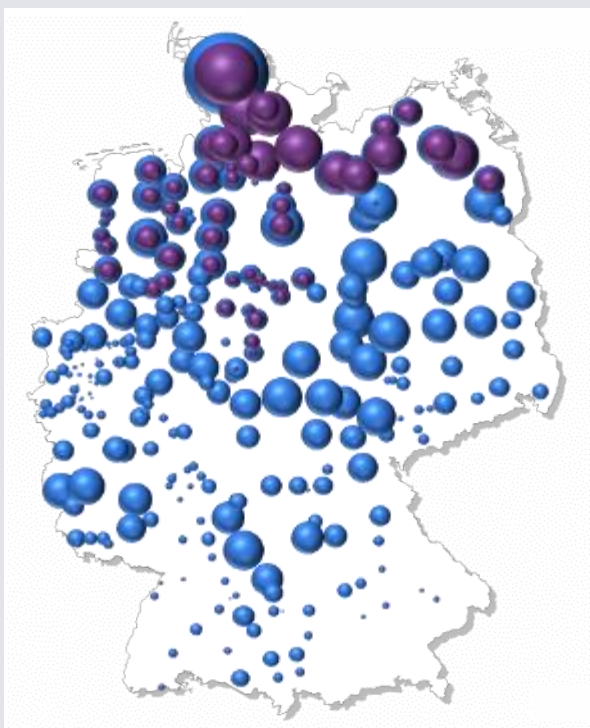
Fraunhofer IWES (2013)

## Challenge 2: Electricity is increasingly fed directly into the distribution grid – transition from a centralized “top-down“ to a more distributed system.



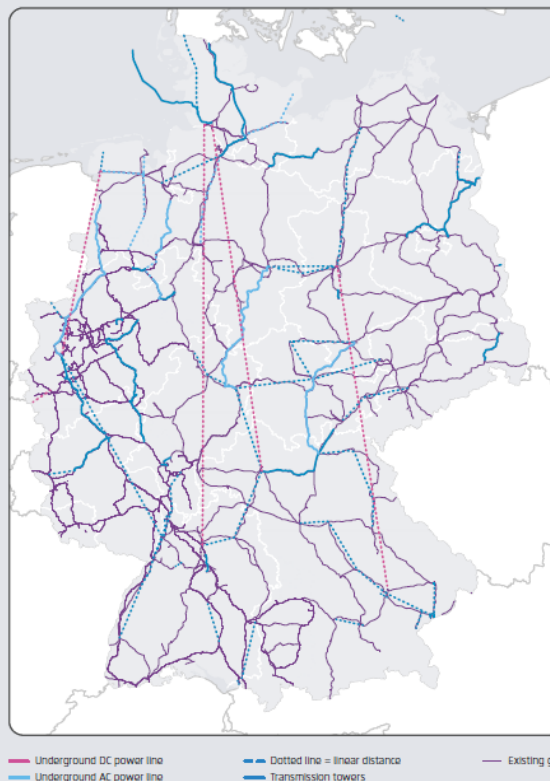
## Challenge 3: Grid expansion – in order to allow for balancing of power supply and demand across regions.

### Siting of new generation



Fraunhofer IWES (2013)

### Grid expansion



Agora Energiewende based on BNetzA (2016)

### Localization of new generation:

- Onshore wind energy particularly in the North of Germany
- Offshore wind energy in the North and Baltic Sea
- Solar PV particularly in the South of Germany

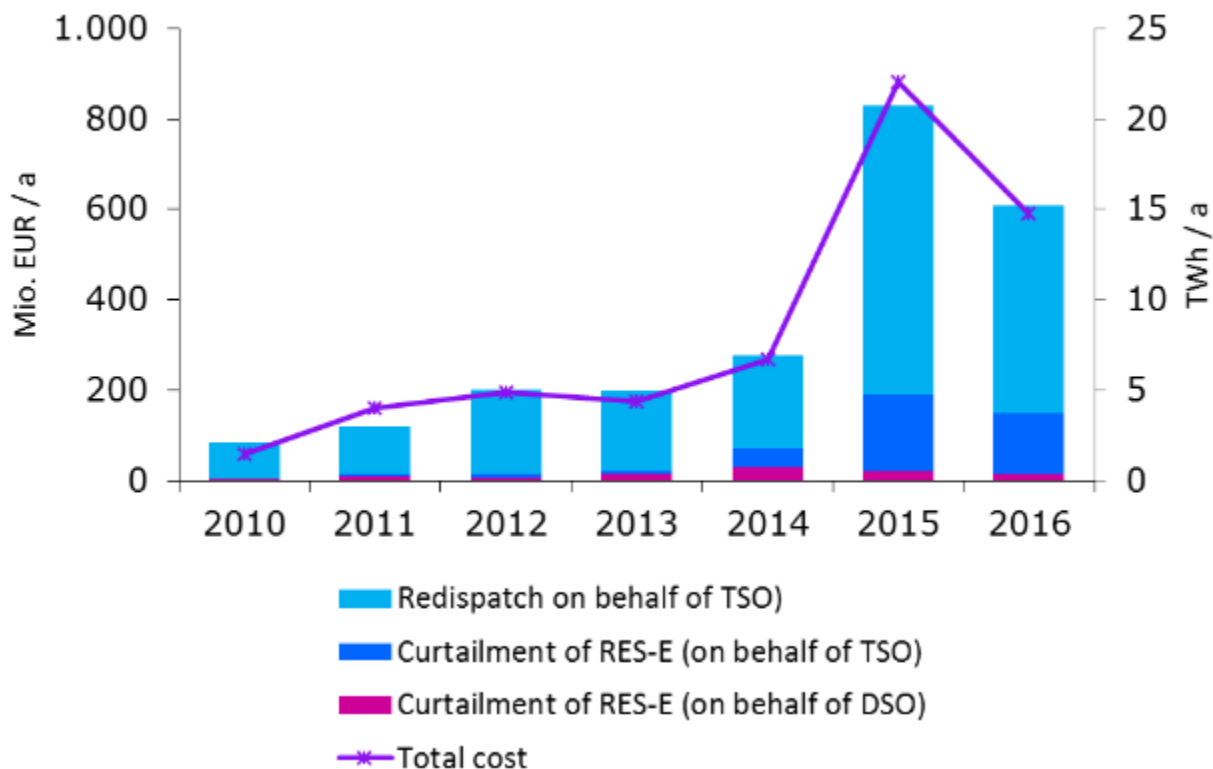
### New types of demand:

- Heat pumps, electric vehicles, power-to-heat.

Delays in grid expansion at the transmission level: 850 kilometers are realized by now (7,700 km are needed).



## Challenge 4: Grid congestion – *the volume of redispatch and curtailment has been increasing over the years.*



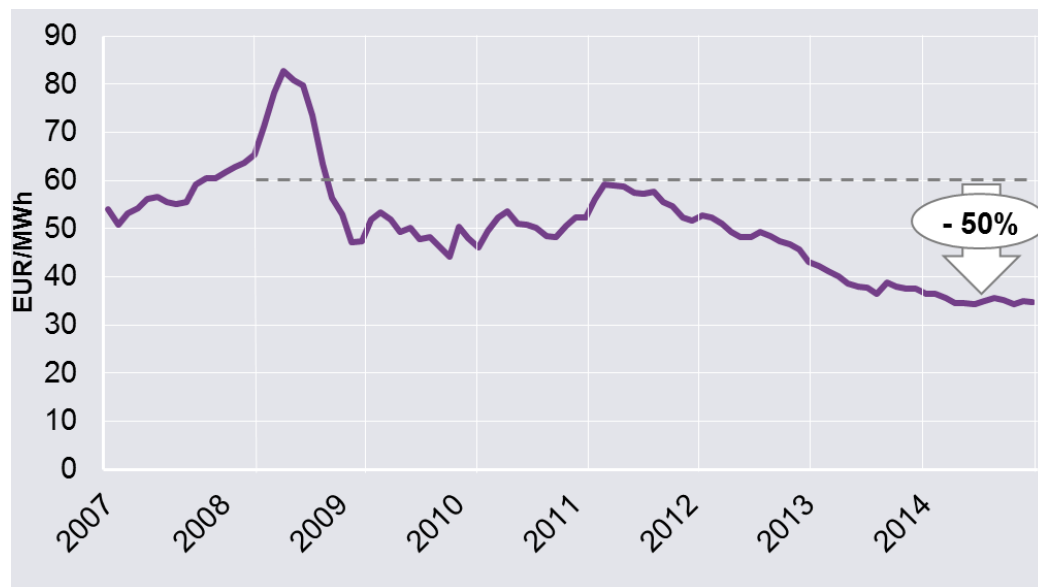
### Redispatch and curtailment:

- 3%-peak-shaving-approach in grid planning.
- Curtailment is a measure of last resort (RES-E generation and CHP).
- In the first two months of 2017 there has been an increase in redispatch measures taken by the TSOs (as compared to 2016).
- Most of RES-E generation is curtailed in the North of Germany (more than two thirds in the Federal State of Schleswig-Holstein).
- Costs for redispatch and curtailment are socialized among electricity consumers via network charges.

Ecofys (2017) based on data by Bundesnetzagentur and MELUR (Smart-Market-Study on behalf of Agora Energiewende)

## Challenge 6: Power market design – *can wholesale power prices provide sufficient incentives for new generation capacity?*

Wholesale electricity prices\* 2007 - 2014



EEX (2015)

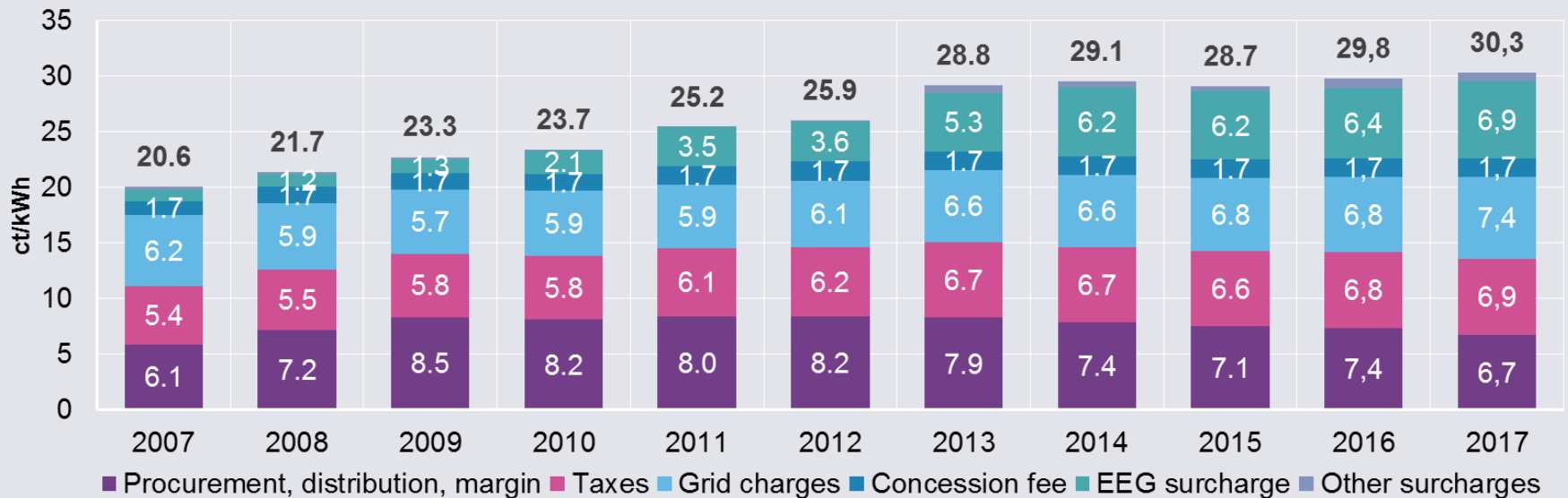
\* rolling annual futures

### Reasons for the decline in power prices

- **There is currently excess capacity**
- **CO<sub>2</sub> price dropped:** CO<sub>2</sub> prices in the EU Emissions Trading system dropped since 2008 by around 70% due to high amount of excess certificates
- **Falling resource prices:** Coal prices decreased by a third since 2008
- **Excess capacities:** Large quantities of lignite and coal power plants, low incentives for flexible gas power plants

## Challenge 7: Household power prices – grid fees, EEG-surcharge and levies have been subject of frequent debate.

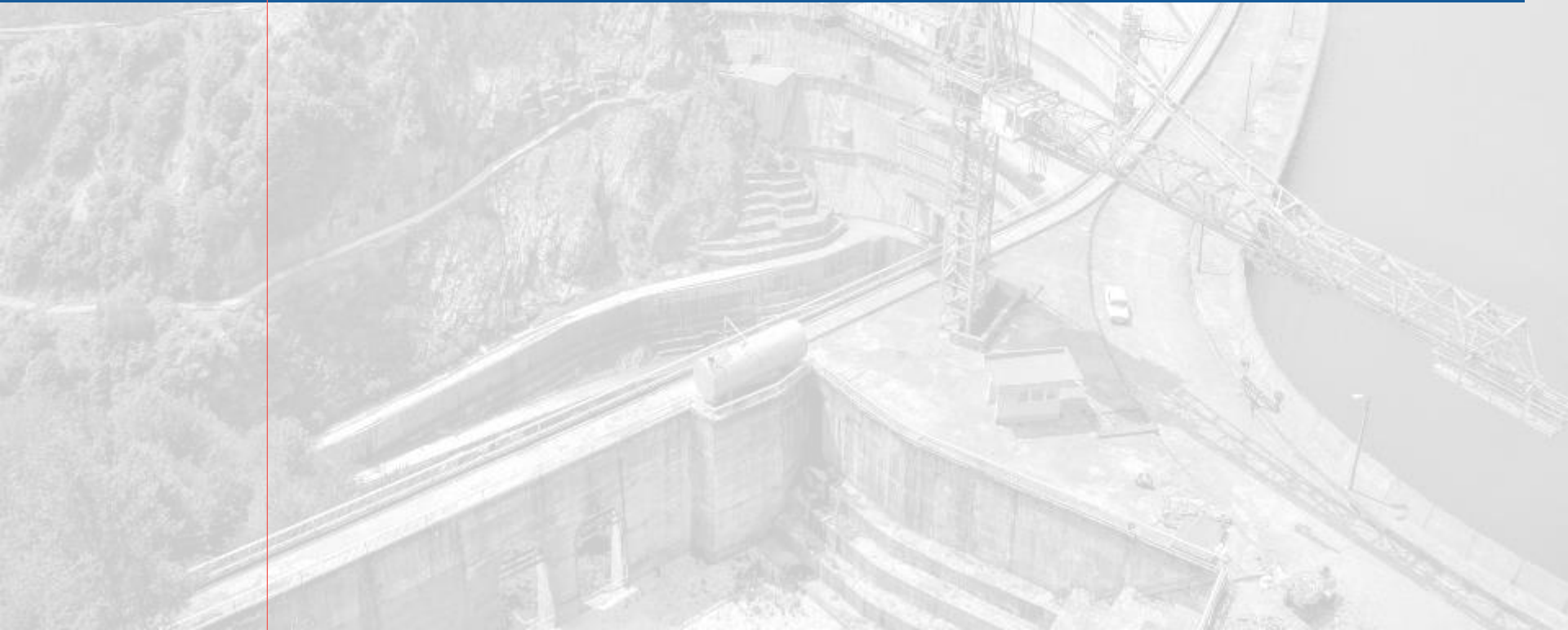
Average household electricity prices in a 3-person household 2007 - 2017



BNetzA (2016), own calculations

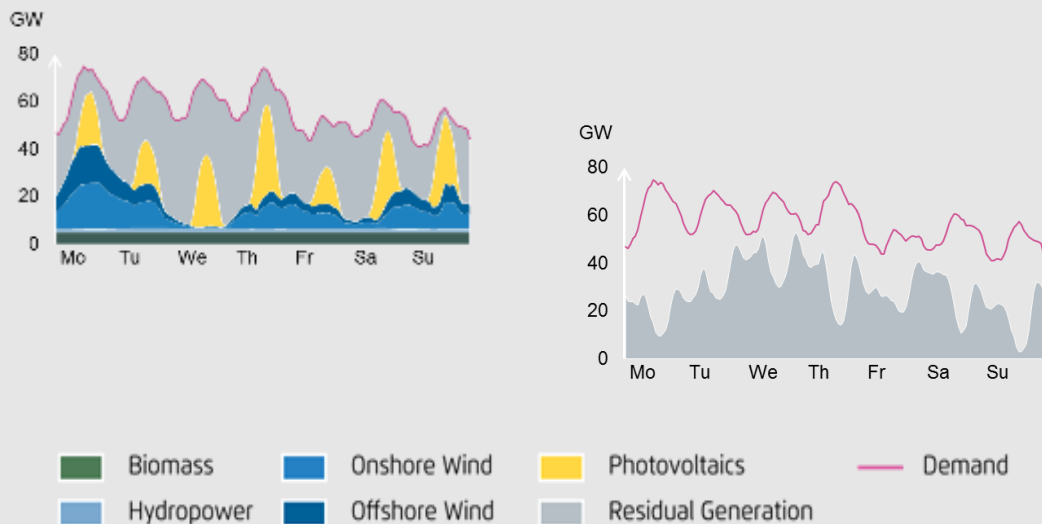
# German power market design

- EOM 2.0 “energy-only” market
- German/European set up



# Electricity Market 2.0

Electricity generation and consumption in a sample week with 50% RES share



Own calculations on basis of Agora Energiewende (2015b)

## Key features of Electricity Market Act

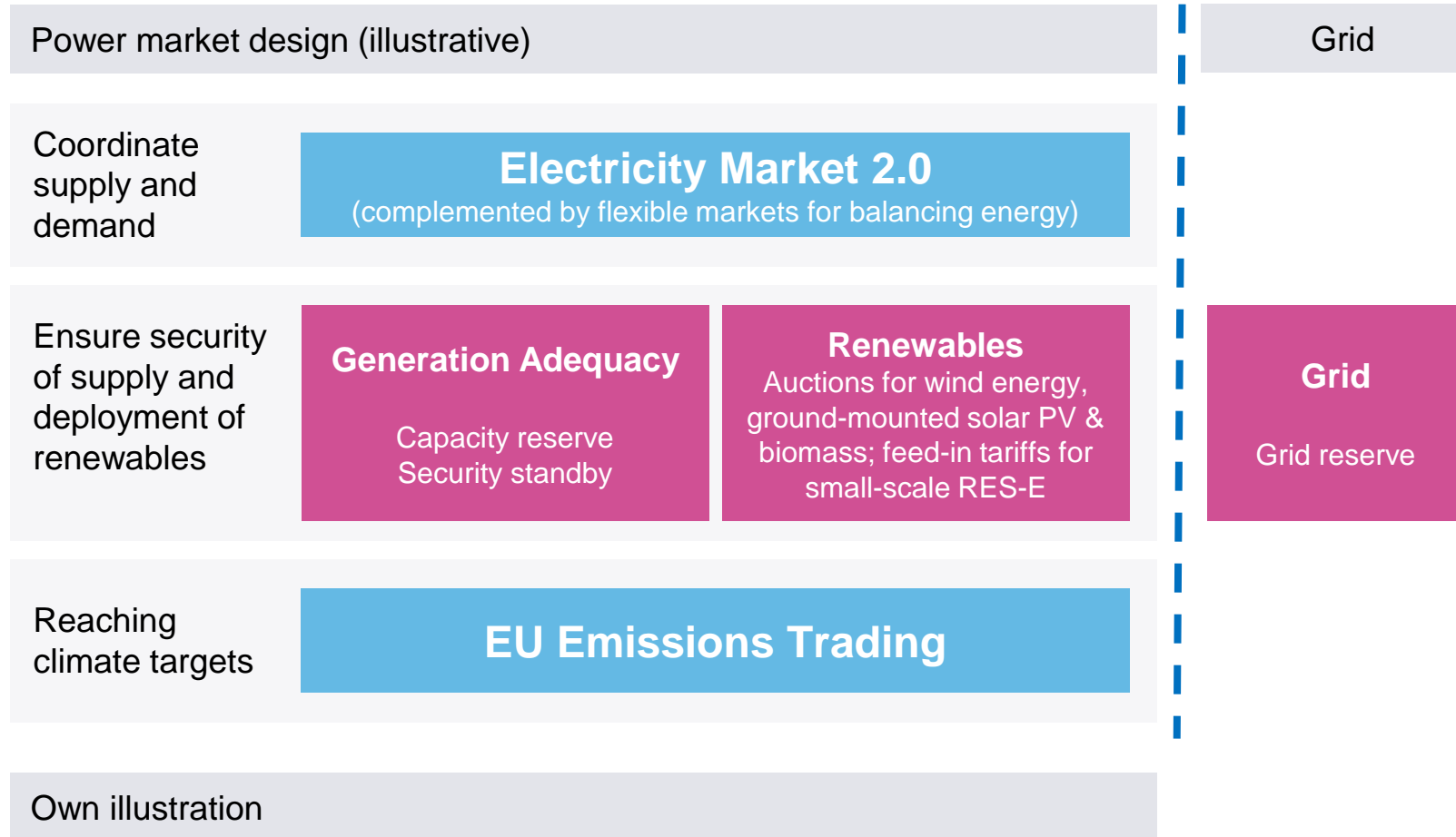
Transition towards system with increasing responsibility for RES-E

Strengthen market mechanisms - "Electricity Market 2.0" - strong electricity price signals **without a capacity market**

Safeguard **security of supply** - Capacity reserve and cooperation with European neighbors

Enhance **competition** between all electricity producers and **flexibility options**

# German electricity market design



# Security of supply and generation adequacy

## Grid Reserve

- Security of supply and grid reliability (accounting for congestions in the grid, voltage stability, redispatch)

*In order to rely on free price formation on markets, capacity reserve comes first into play – if necessary – after gate closure of power markets.*

## Capacity reserve

- Security of supply (2 GW p.a., auction-based mechanism)
- Activated after market closure (only if no clearing prices on day-ahead)

## Security standby

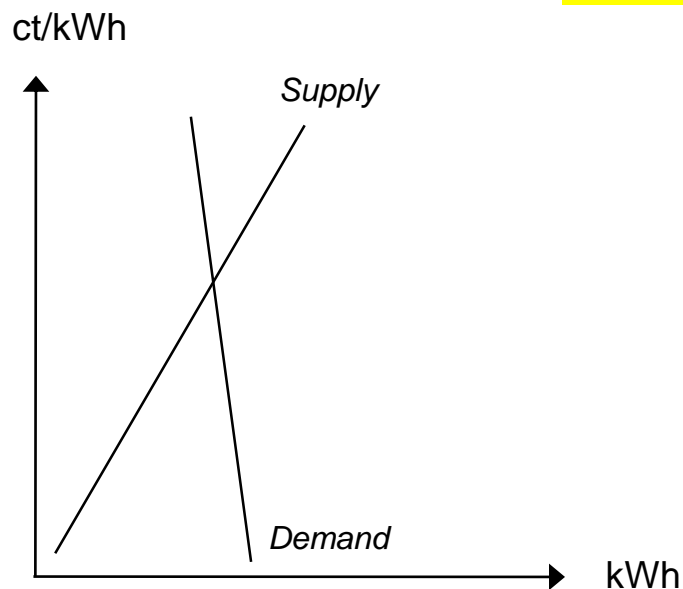
- Transition period as of 2016: 2.7 GW lignite plants for four years as security standby. Thereafter, retirement of plants. It contributes to reduction in emissions as well.

## “Mediating” between the power market and the grid

– in order to allow for balancing of power supply and demand across regions.

The power market (“financial”) and actual operation of the grid (“physical“)

### Power market: “copper plate“



### Grid operation

- Bottlenecks in distribution and transmission grid: no more “copper plate“ in real time. Local congestions may occur.
- Avoid exceeding limit values (current, frequency, voltage).
- Provision of ancillary services in order to ensure grid stability and reliability.

### Grid planning

- If there are delays in grid expansion, more grid bottlenecks occur.
- 3%-approach: peak shaving included in grid planning.

### Grid operation

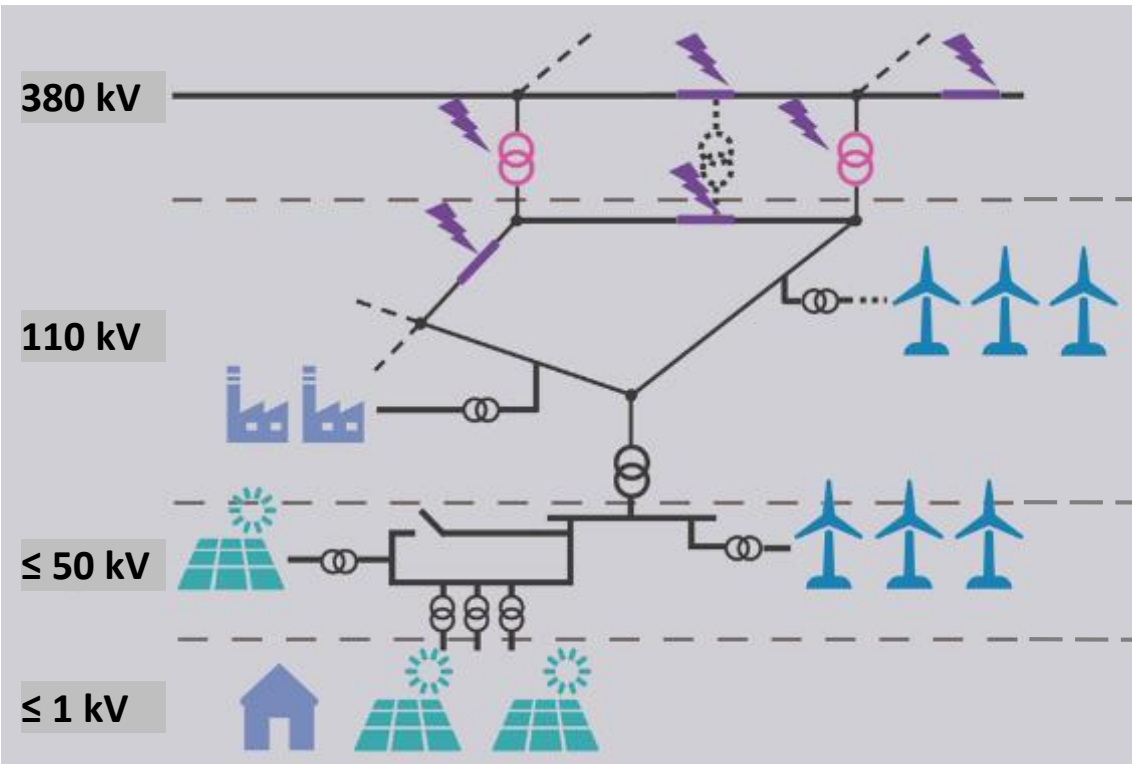
- In case of congestion grid operators may have to curtail generation to ensure system stability.
- First: redispatch of conventional power plants.
- Curtailment of RES-E as measure of last resort.

Own illustration



# Grid congestion – illustration of interplay of different voltage levels.

Grid congestion in Northern Germany (illustrative example)



## Curtailment...

... where bottleneck occurs	...where measures are taken
95%	<1%
5%	99%

Ecofys und Fraunhofer IWES (2017): *Smart-Market-Study*

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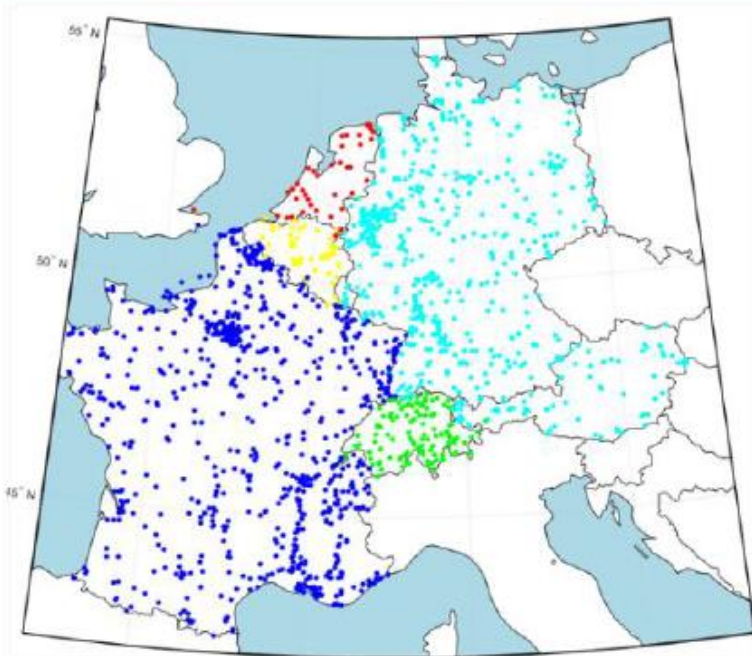
# Did we miss anything?

**Are there differences between  
European and US power markets?**

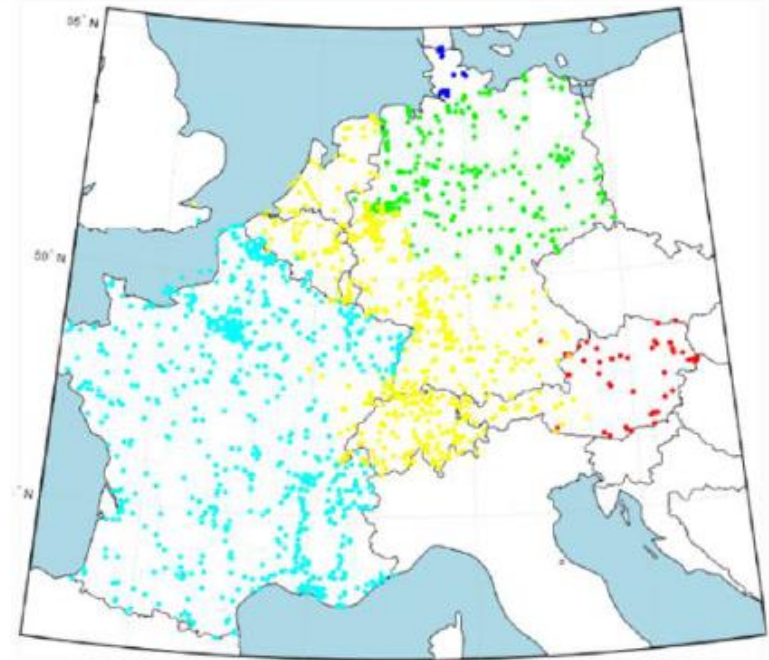
There are differences...

# Power market configuration along national borders – without LMP

Current Configuration



Optimized 5-zone Configuration



Source: CREG (Belgium Regulator 2016)

# Transmission: Bundled ownership and operation



25% owned by RWE-utility

100% owned by EnBW-utility

Distribution:  
Nominally unbundled network ownership from retail (legally, by organization, or just by information)

Source: KWH-Netz

# Competitive retail markets

- bilateral contracts
- retailers are responsible
  - to provide demand side flexibility to the market
  - to offer specific products to customers

The screenshot displays the Verivox website interface for energy price comparison. At the top left is the Verivox logo, and at the top right is the phone number 0800 80 80 890 with a 'Kostenlose Hotline' label and a phone icon. The main heading reads 'Risikolos wechseln – mit Sicherheit sparen: Tarifvergleiche von Verivox'. Below this, there are two main comparison sections: 'Strompreisvergleich' and 'Gaspreisvergleich'. Each section includes a 'Ihre Postleitzahl' field with '01234' entered, and a selection for 'Anzahl Personen oder kWh/Jahr' (for electricity) or 'Wohnungsgröße oder kWh/Jahr' (for gas). The electricity section shows a selection of 3500 kWh/Jahr, and the gas section shows a selection of 10000 kWh/Jahr. Both sections have a 'Jetzt vergleichen!' button. To the right of these sections is a 'Sicherheitscheck' section titled 'Strom- und Gasanbieter wechseln ohne Risiko durch 3-fach Sicherheitscheck'. It features a circular seal with 'SICHERHEITSCHECK 3-FACH VERIVOX.DE' and a list of three points: '1. Sichere Anbieter', '2. Sichere Tarife', and '3. Sichere Abwicklung', with a link to 'Unsere Garantie'.

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# Decentralized dispatch

Balancing responsible parties are in charge  
TSO balancing by reserves after gate close

Balance of private portfolios via

- OTC
- private power exchange e.g.

**EPEXSPOT**  
EUROPEAN POWER EXCHANGE

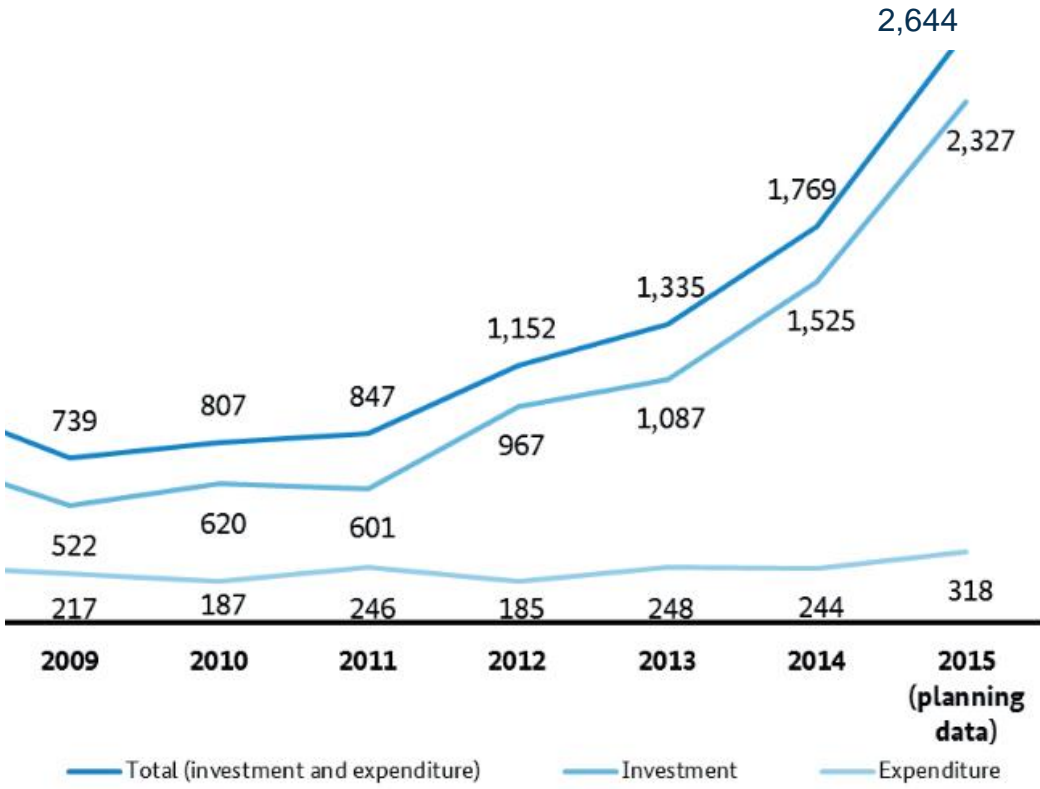
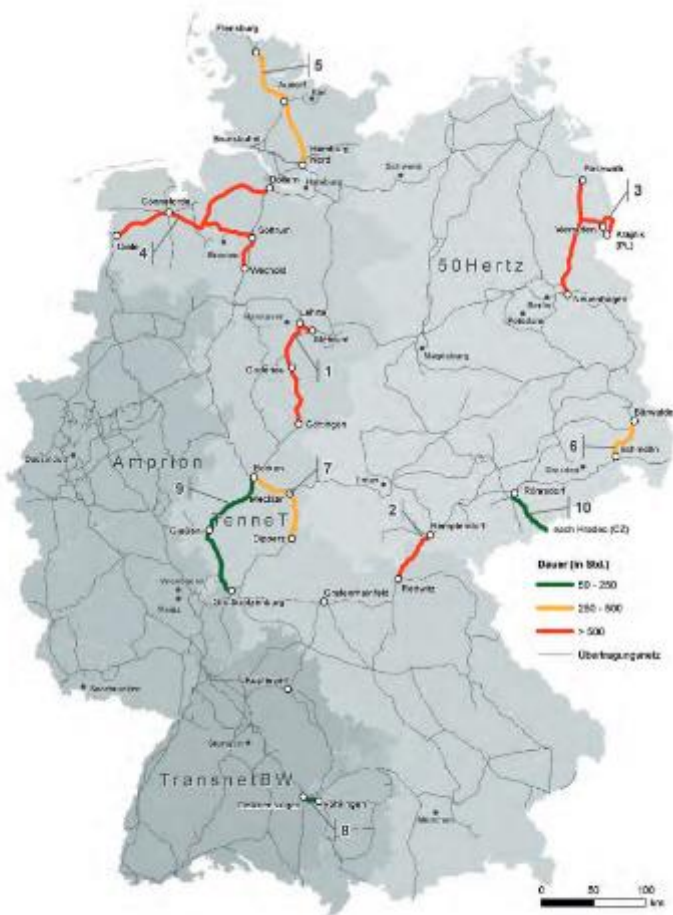
⇒ Revenues from European market coupling (via EPEX etc.) aren't regulated well...

# 3

## Facts and Figures about the German Networks and its Fees

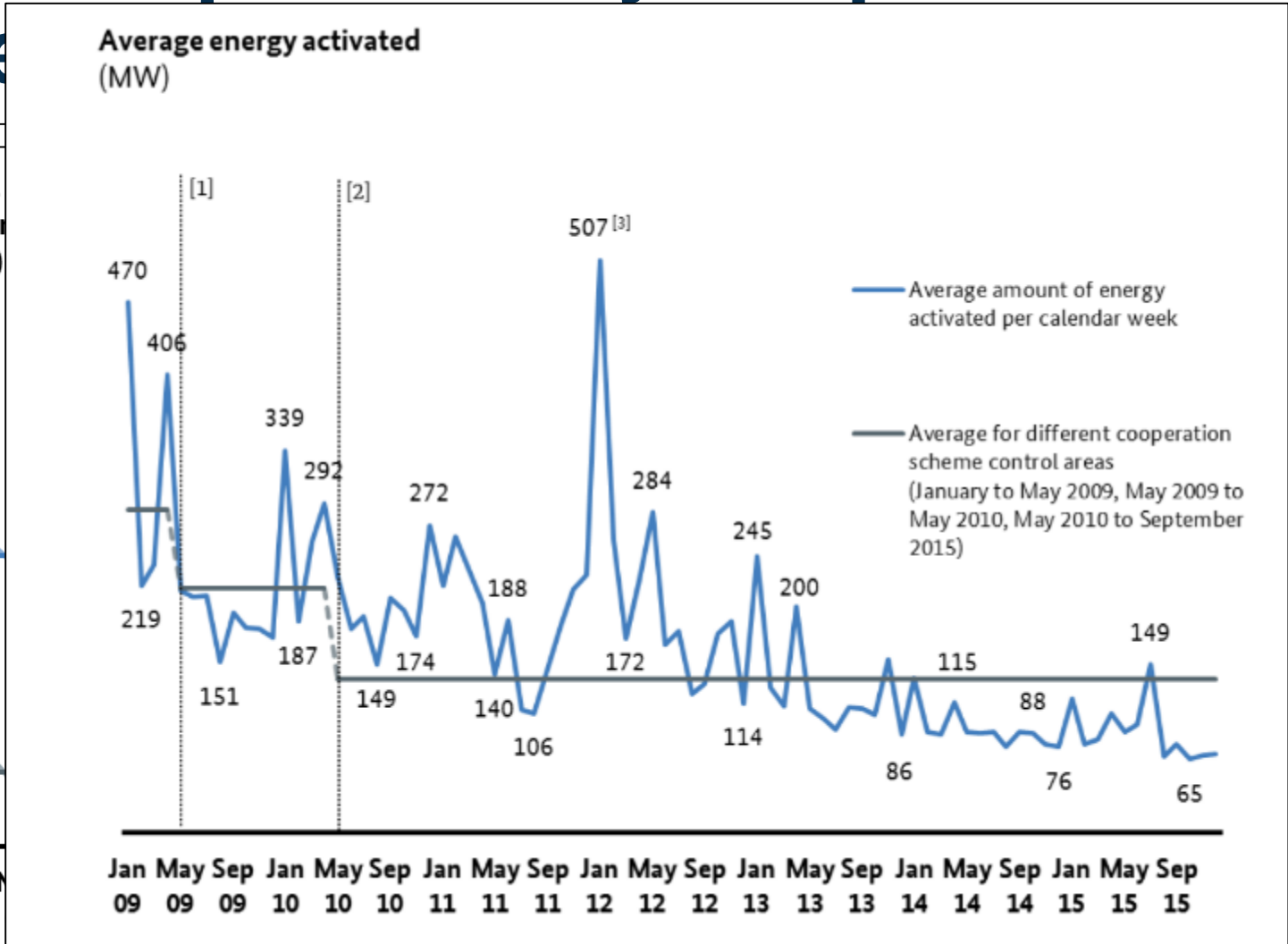
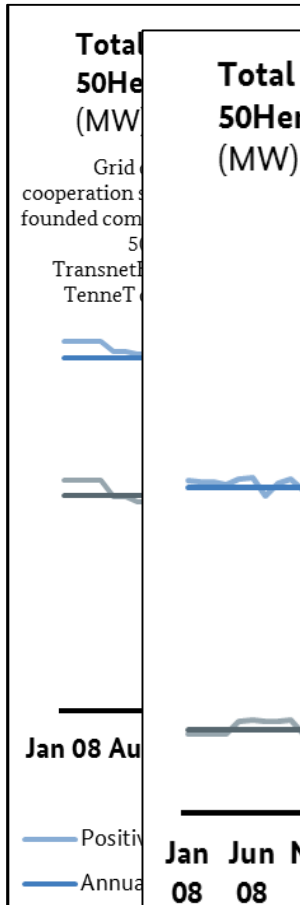


# Transmission network constraints and investments by TSO (€ Million)





# Improved operation by cooperation reduced



Regulatory

— Positive tertiary control reserve  
 — Annual average of positive tertiary control reserve  
 — Negative tertiary control reserve  
 — Annual average of negative tertiary control reserve

Source: NRA

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# Power network costs in Germany

Regulated network revenues in 2017:

- ~ 24 billion Euro paid by consumers only
- Transmission: 6 to 7 billion Euro
- Distribution: 17 to 18 billion Euro

Network costs increased by 25% in 6 years through

- Investments for grid extension
- Dispatch/redispach - reserves and curtailment increased to 600-900 million Euro/year

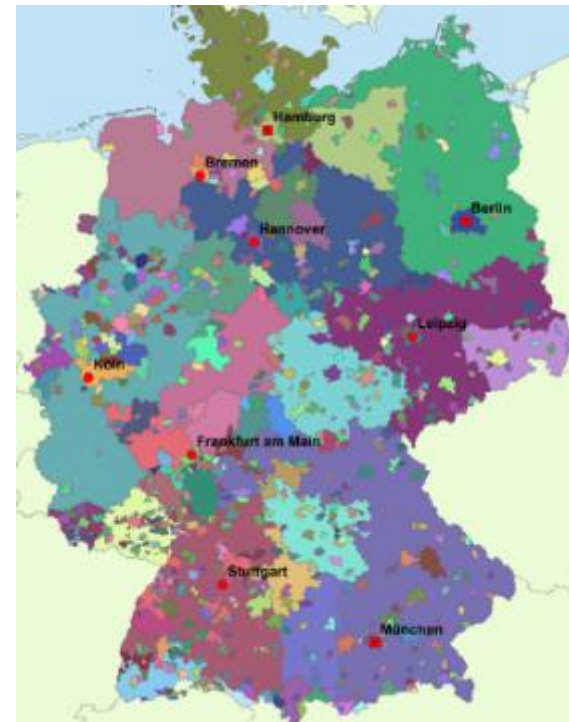
# Grid costs are allocated locally by

4 transmission networks

- 220 to 380 kV

860 distribution networks

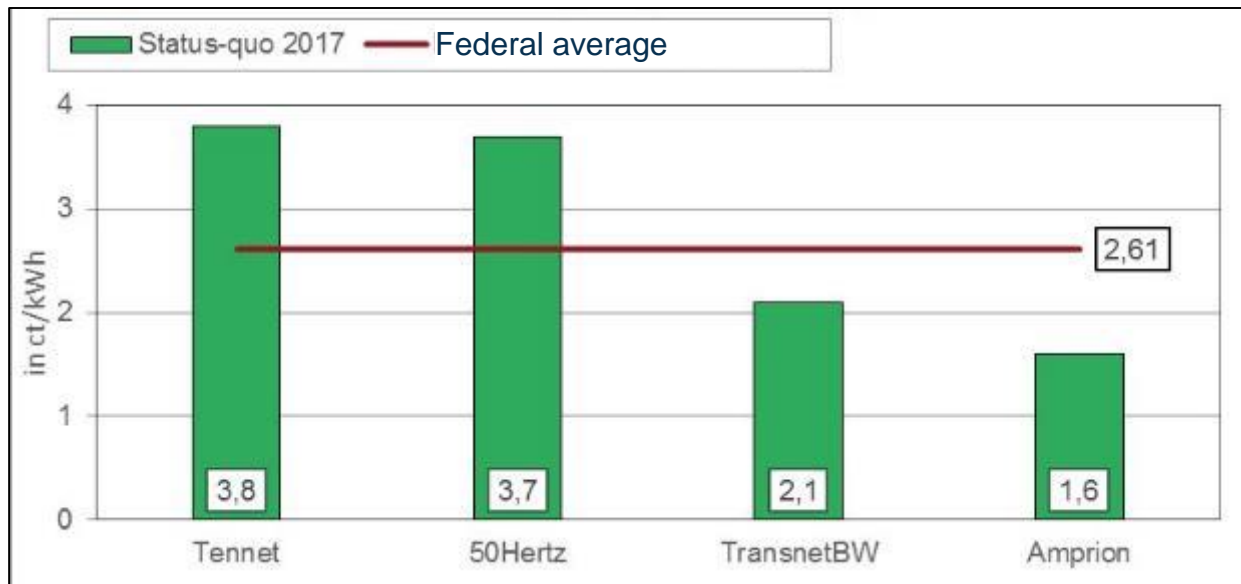
- 110 kV and below



Sources: Wikimedia Commons and Deutsche Gesellschaft für Sonnenenergie e.V.

# June 2017: Federal decision to harmonize transmission fees by 2023

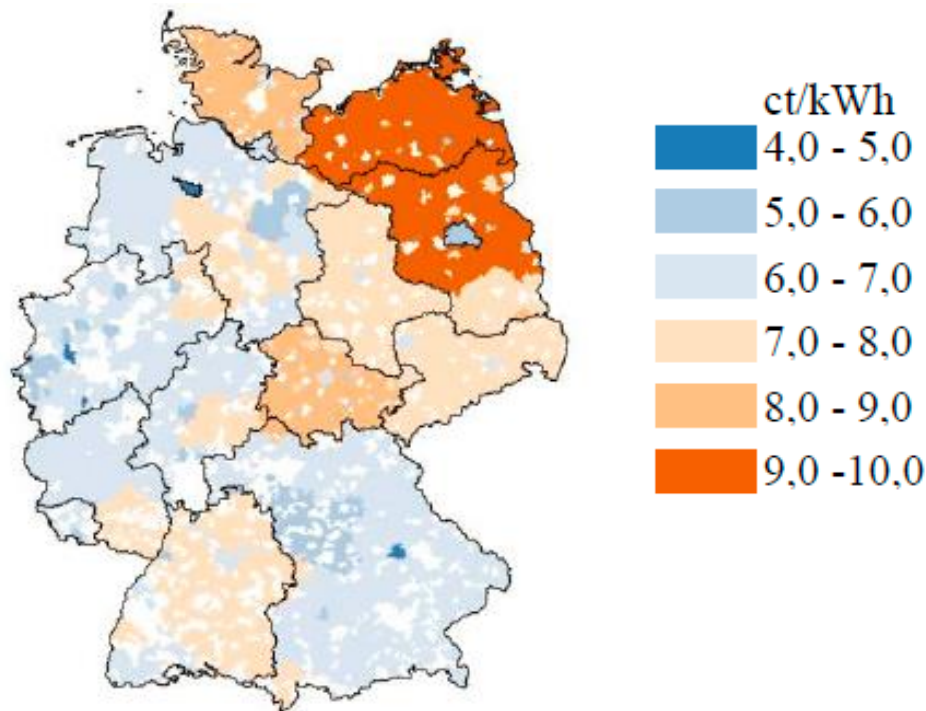
States (Länder): „Differences in transmission fees are an unfair (dis-)advantage to local economy“



Source: 50Hertz, Vereinigung sächsische Wirtschaft

# Price differences on distribution level increasing further

Grid fees for household in 2015 (at 3500 kWh)



Source: NRA

- ⇒ Rural networks with high RE-penetration and low demand becoming more and more expensive
- ⇒ Demand in cities far from supply is affected less and stays cheaper

# 4 Regional Operation Centers

From a national to a European approach?



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# European Commission proposes Regional\* Operation Centers

- Establish Regional Operational Centres (ROCs) to enhance coordination in near real time activities at a regional level.
- Cover designated geographic regions to “compliment the role of TSOs by performing functions of regional relevance”
- Have decision-making authority in limited circumstances

\* above national/TSO responsibility

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# European Debate: „Why ROCs are necessary?“

- **To maintain system reliability at the lowest reasonable cost while integrating increasing shares of vRES**
- Response to the increasing regionalisation of electricity markets  
⇒ Allow efficient market operation by maximising available grid capacity
- Provide a regional focus to ensure solutions that are in the best interests of a region, rather than of a particular country





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# Aren't ROCs a win-win option?

## Concerns

- ROCs would have a decision-making role rather than simply being service providers. TSOs, and by implication NRAs, would need to give up some authority
- Temporal responsibility split between near real-time and real-time activities, regulatory regime to support ROC responsibility for near-real time activities is not in place
- If successful, ROCs responsibility could be increased by lowering national control further
- If ENTSO-E (European TSOs) accepts something like ROCs, isn't a more ambitious setup necessary, e.g. an ISO?

# 5

## German Facts on Rooftop PV and Network Fees



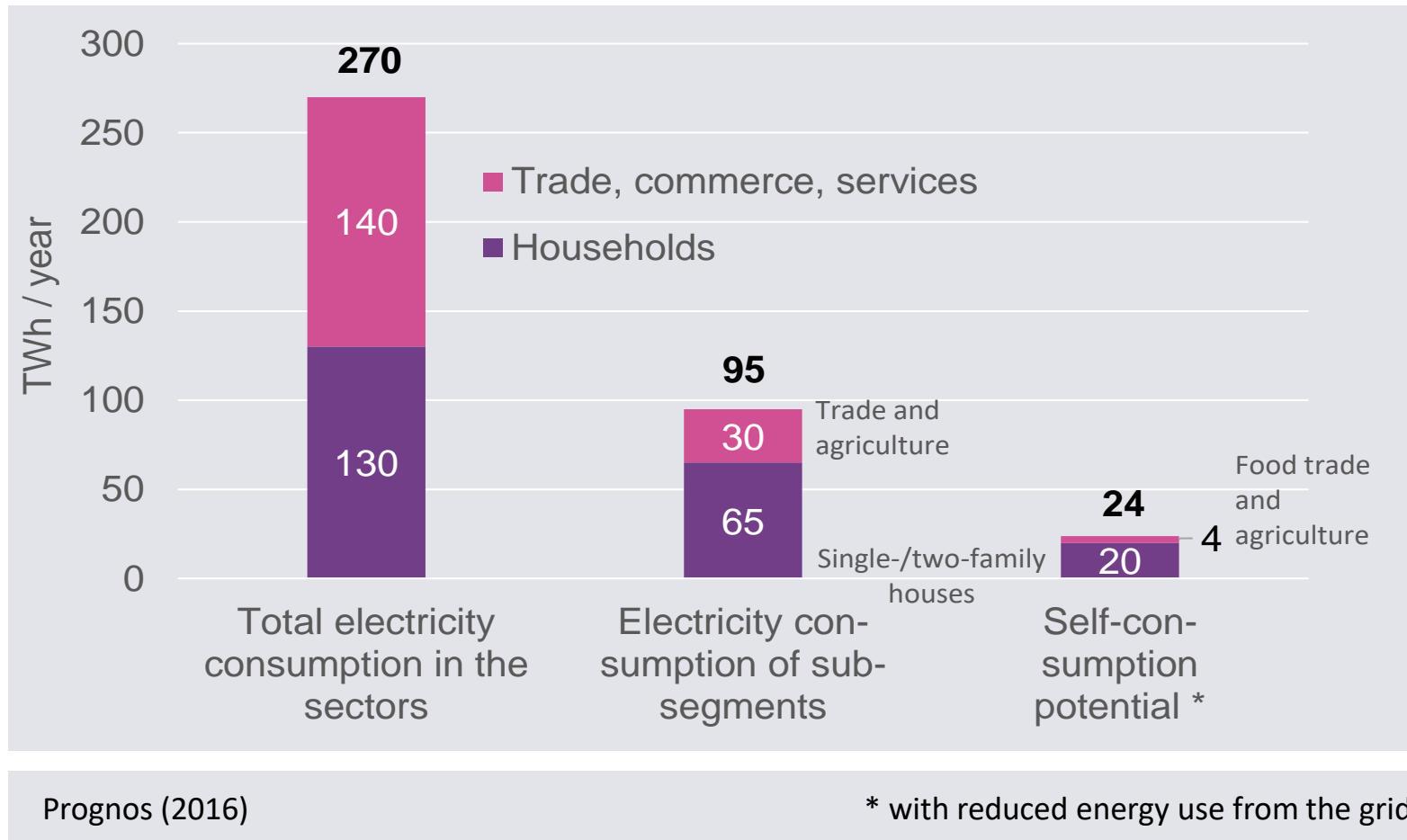
# PV self-consumption outlook with low PV and battery costs



## Questions

- What are the relevant PV rooftop groups/sectors?
- What amount of rooftop PV can be expected (2035)?
- What will be the decrease in power taken from the grid?
- What are the effects on network revenues and other customers?

# Potential for PV self-consumption is limited, even in commercial and residential sector



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# PV self-consumption potential for Germany in 2035

- PV self-consumption can be max. 44 TWh/a
  - Incl. 24 TWh for heat demand
  - 20 TWh less power taken from network (600 TWh total)
- 5% reduction of total demand would increase average volumetric network charge for household by max. 1 €Ct/kWh (approximately 12%)

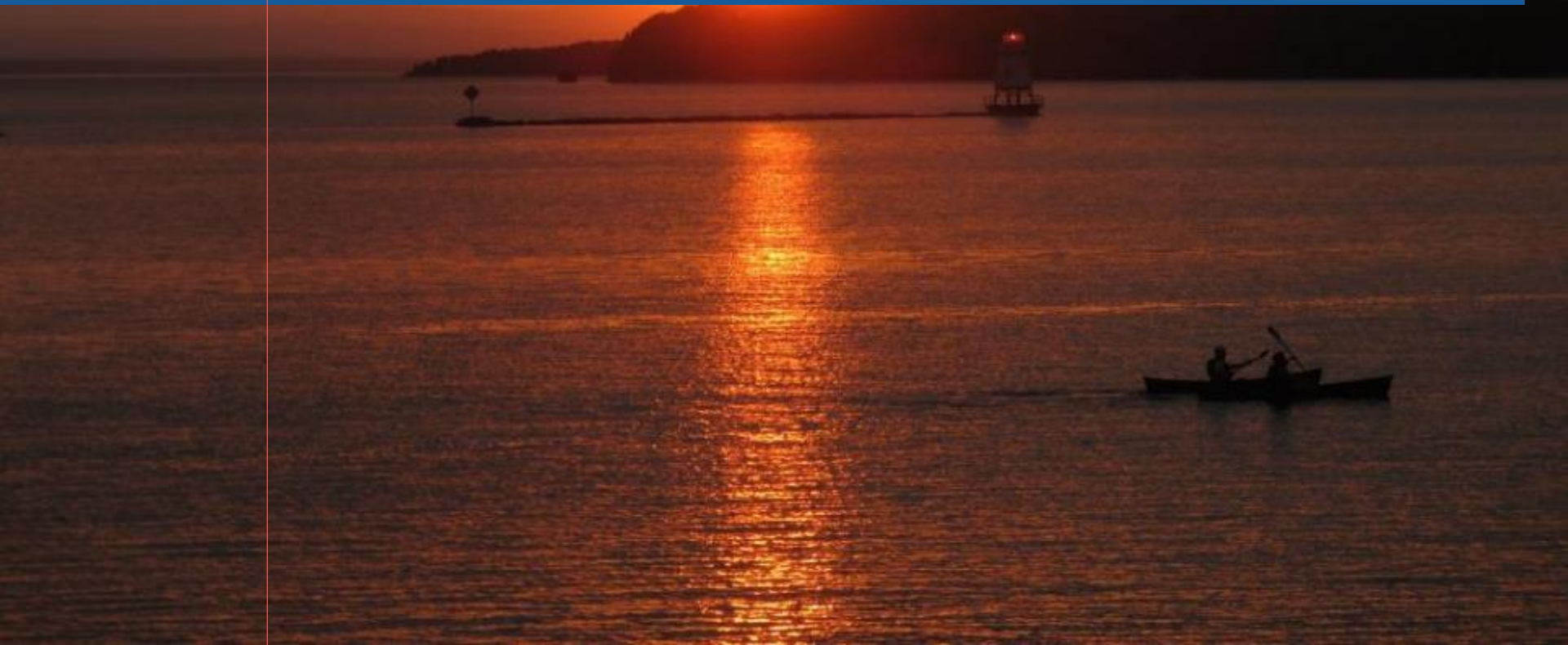
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# PV self-consumption isn't a big deal

- German power system is a winter-peaking system (as in most EU states)
  - No cost-efficient displacement of winter demand by PV, not even with large roofs or cheap batteries
    - ⇒ Seasonal storage would be required
- ⇒ Self-consumption won't drive the transition or risk cost allocation / network revenues

6

What could “Energiewende markets” look like?



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# What could “Energiewende markets” look like?

- Recognize and procure new, important flexibility services in the balancing markets
- Apply reserve shortage opportunity costs and/or co-optimize energy and reserves markets to ensure fully marginal-cost-reflective energy pricing
- Plan and operate networks independent from ownership
- Incentivize flexibility and location requirements by markets, based on grid constraints (LMP instead of national bidding zones)
- Translate emission targets into tradeable caps to minimum costs
- Use strategic capacity reserves as back up, only



# About RAP

The Regulatory Assistance Project (RAP)<sup>®</sup> is an independent, non-partisan, non-governmental organization dedicated to accelerating the transition to a clean, reliable, and efficient energy future.

Learn more about our work at [raponline.org](https://raponline.org)



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