Integrated course „Energy Economics“
- Electricity Grid -

Chair of Energy Systems | Department of Energy Systems
Technische Universität Berlin

Outline

- Electricity grid (continued)
  - Congestion management
  - Grid access
  - Grid tariff regulation
  - Security of supply

- Retail markets

Congestion management

Congestion management relieves expected grid bottlenecks due to limited transmission capacity by correcting (cost-based) power plant dispatch decisions.

- Countertrading

TSO counter-trades against the flow of congestion between bidding zones.

- Redispatch

ramping up certain power plants while ramping down certain other power plants

- Feed-in management (Einsman)

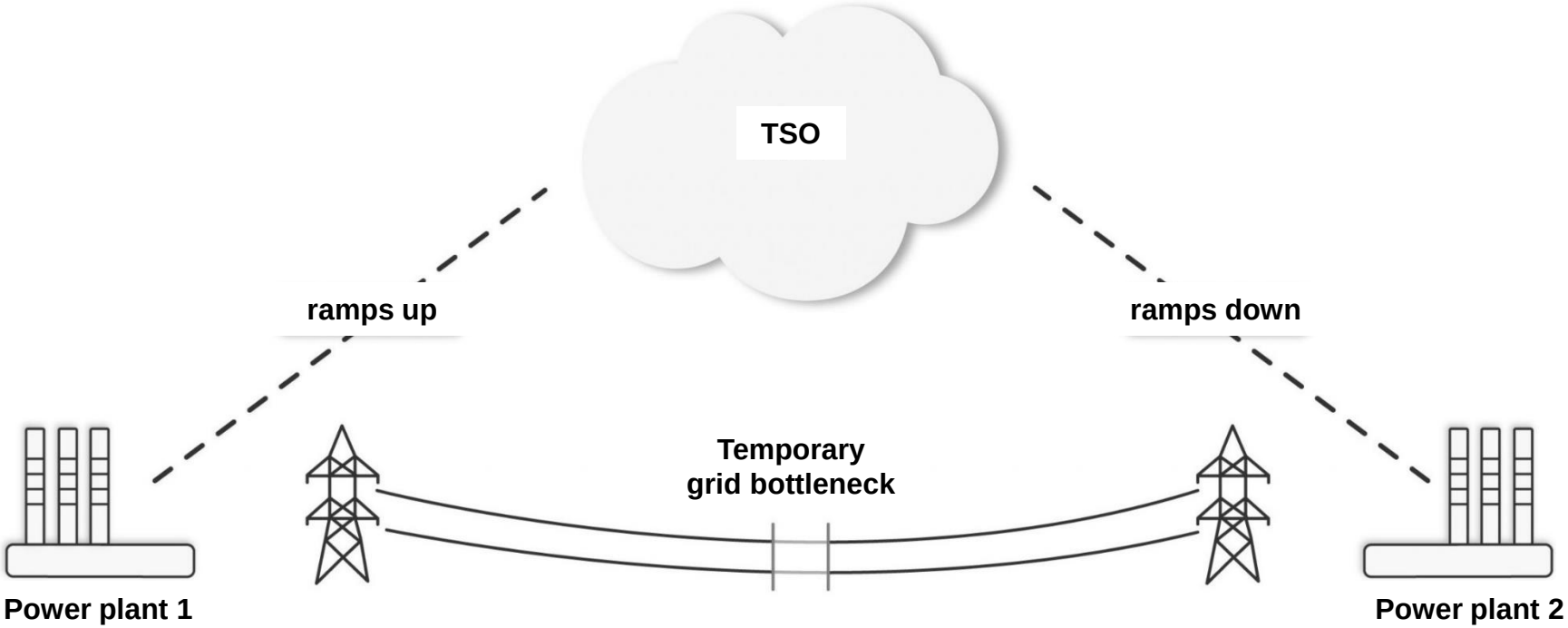
ramping down renewable power plants

- Grid reserve

power plants kept available for service but not operational

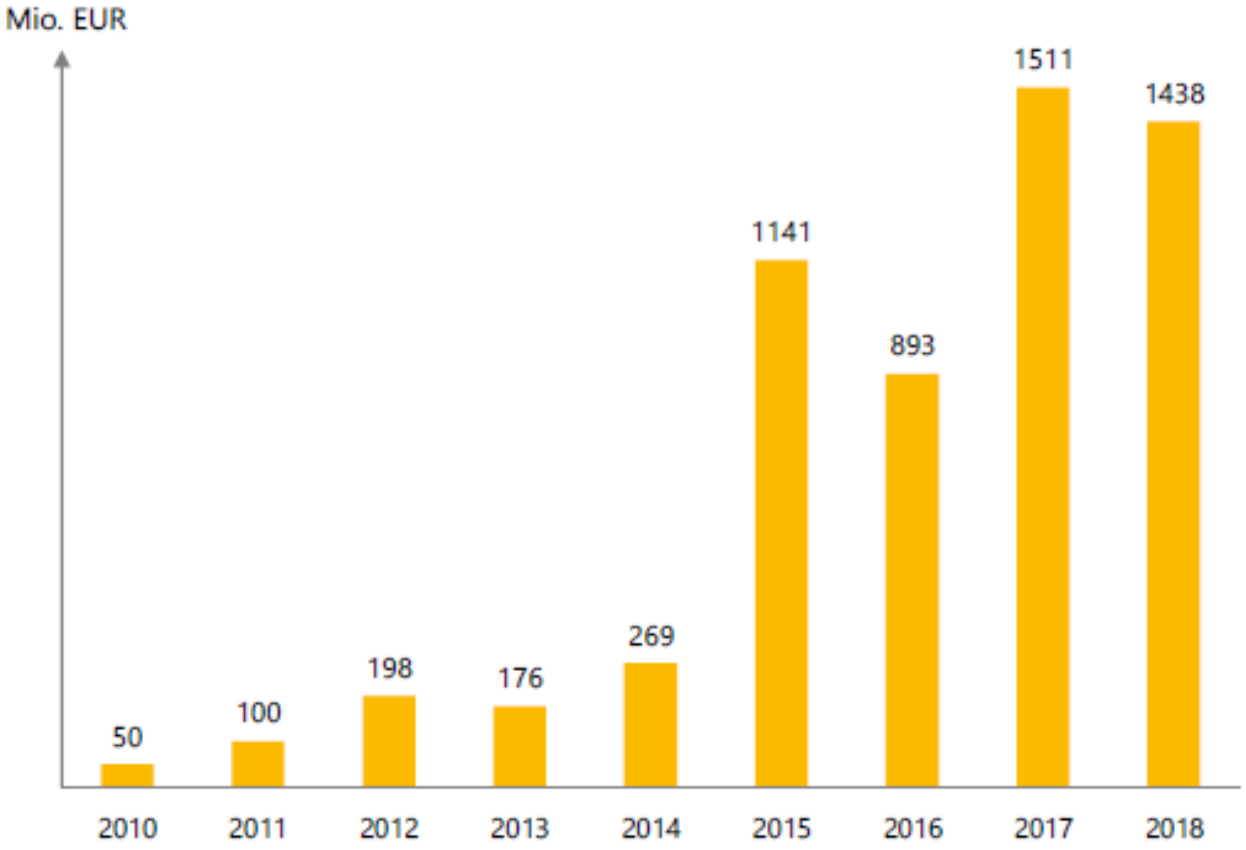
against remuneration

Redispatch: example



Source: Next Kraftwerke

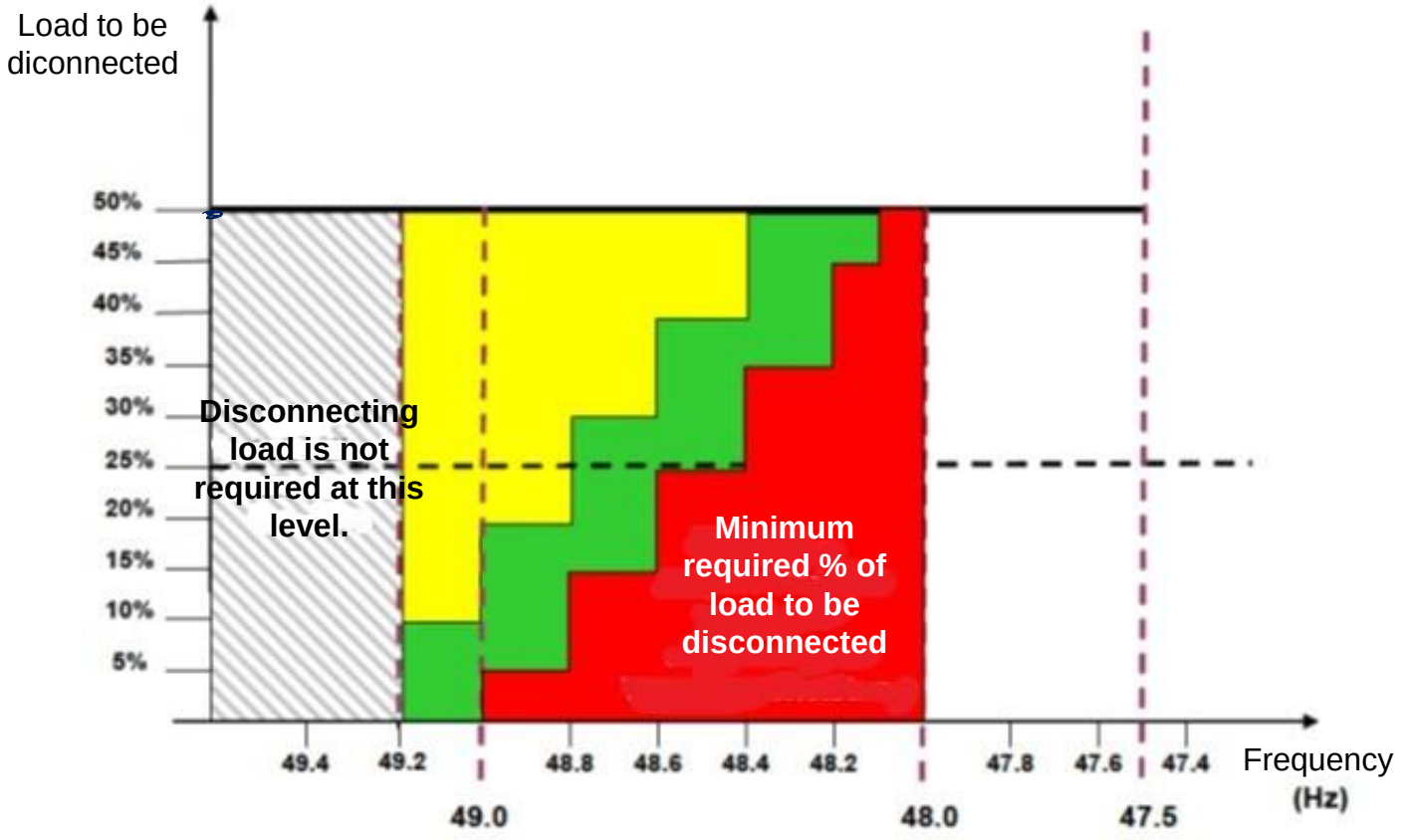
Rising redispatch cost 2010-2018



© NODES, E-Bridge and Pöyry
Source: BNetzA

Automatic frequency control

Automatic low frequency demand disconnection scheme



Source: VNN VDE

Grid restoration

Grid operator coordinates grid restoration after a black-out by step-by-step activation of generation units and matching (appropriate) loads.

Blackstart capability: while most power plants require electricity to get running after a black-out, certain generation units are able to start operation when disconnected from the grid.

Associated costs for blackstart capability provider:

- Maintenance
- Regular tests
- Personnel and training
- Documentation

Access to electrical grids

Grid operation is a natural monopoly, as network infrastructure is prohibitively costly to replicate.

As any monopoly, it is prone to eliminating newcomers (potential competition for affiliated generation/retail unit) by overcharging or denying technical feasibility.

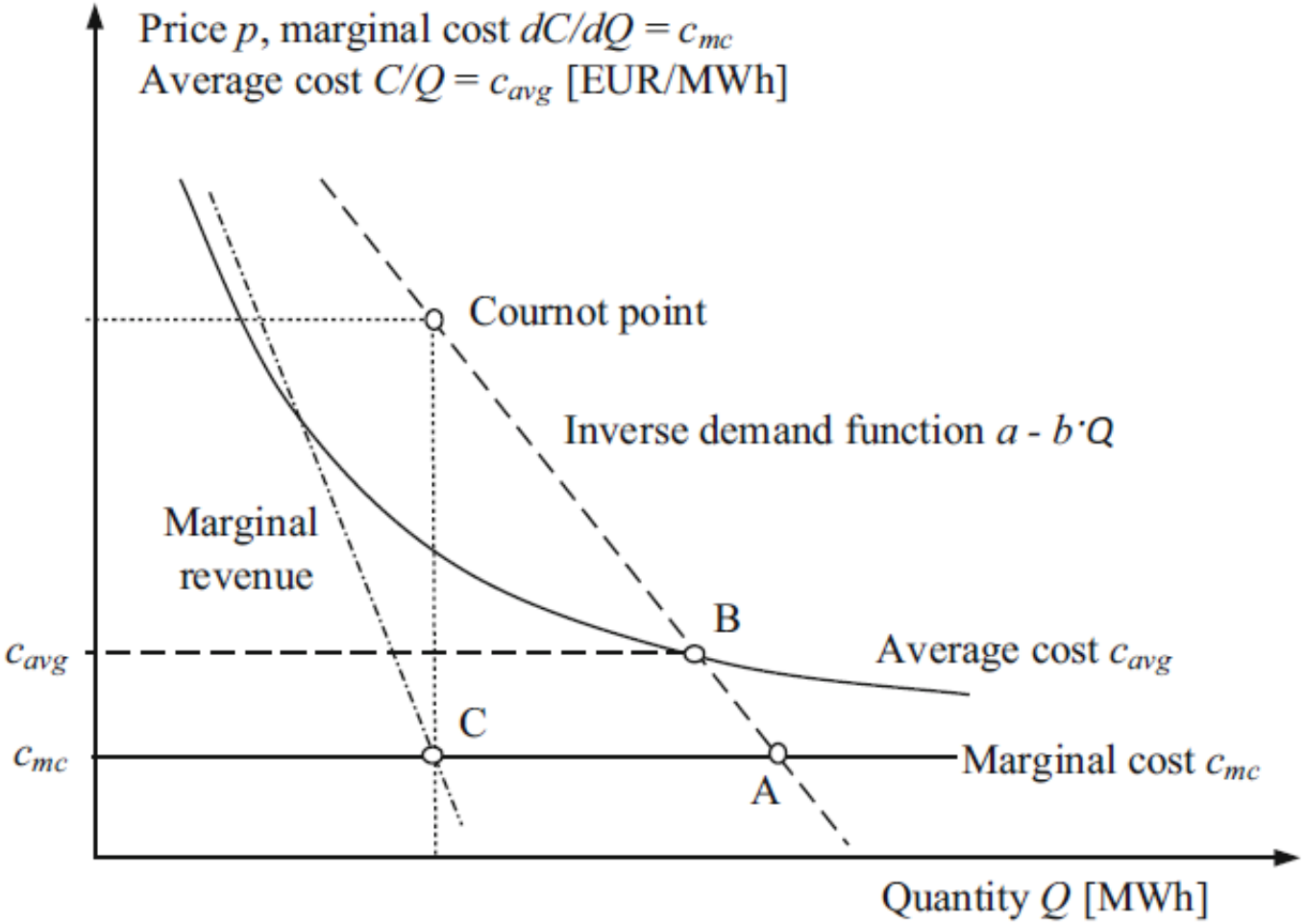
- Non-discrimination
- Transparency
- Cost recovery
- Cost reflectiveness

Source: Lévêque, 2010

Grid is an essential facility.

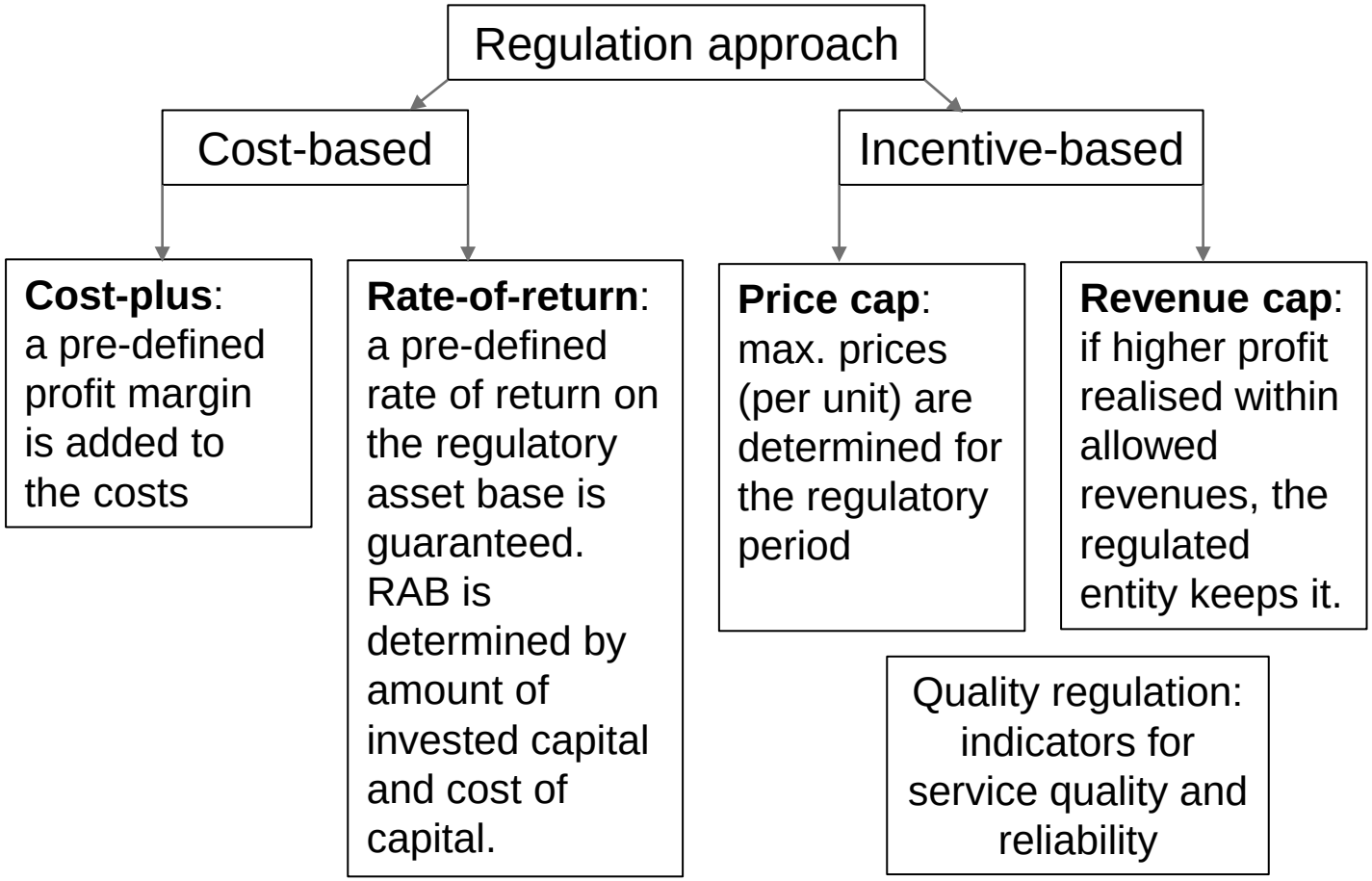
→ non-discriminatory third-party access

Electrical grid as a natural monopoly



Source: Zweifel / Erdmann / Praktiknjo, 2017

Grid tariff regulation: Regulation approaches



Averch-Johnson effect (1)

- Regulator cannot fully achieve the welfare optimum, but does always assume regulation shortcomings
- Examples
  - Cost-plus regulation: after determining the verified costs, the profit rate is fixed → Incentive to generate costs
  - Price-cap regulation: grid operator cannot increase price → Under-investment, lack of supply security
  - Revenue-cap regulation: grid operator cannot increase revenue → supply reduction

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Averch, H., Johnson, L. (1962): Behaviour of the firm under regulatory constraint, American Economic Review, 52, 1052-1069.

Averch-Johnson effect (2)

- Background for the *Averch-Johnson* effect:
  Information asymmetry
  - Grid operators are better informed about costs, reliability, system service requirements, investment needs and demand conditions than any external regulator
  - Dynamics of efficiency improvements, maintenance, investments etc.

- In addition, „strong control“ by the regulator implies
  - compliance costs for data collection, data verifying, legal disputes, supervising,
  - mismatch between business and regulation
  - hidden agenda of the regulator to become relevant

Incentive regulation in Germany

5-year regulatory period (current period 2019-2024)

Revenue that TSO/DSO is allowed to earn is fixed for the regulatory period at a level.

Revenue cap: total cost + depreciation + return on equity

Investment costs into grid extension are allowed above cap.

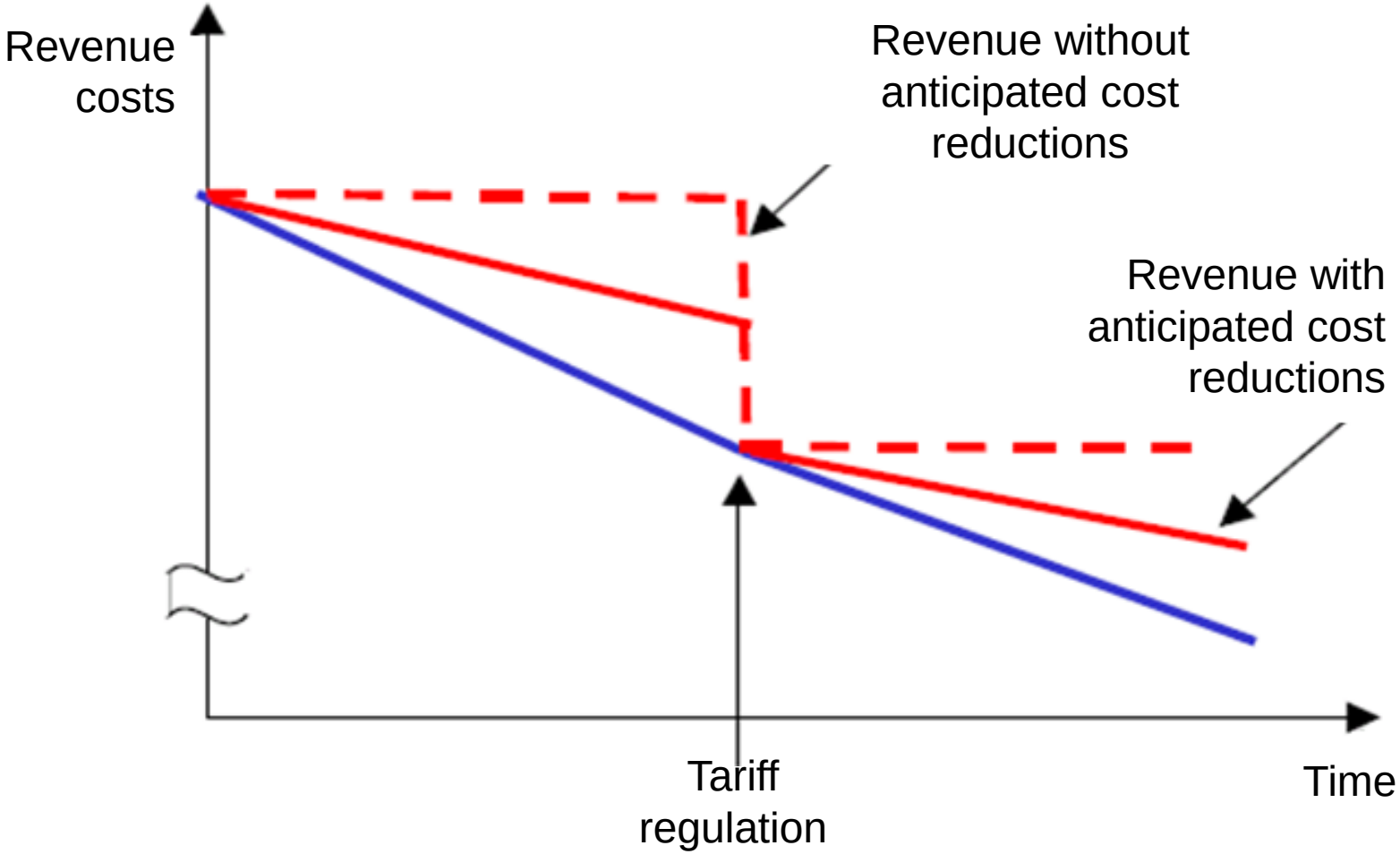
Costs:

- permanently non-controllable
- temporarily non-controllable
- controllable
- volatile

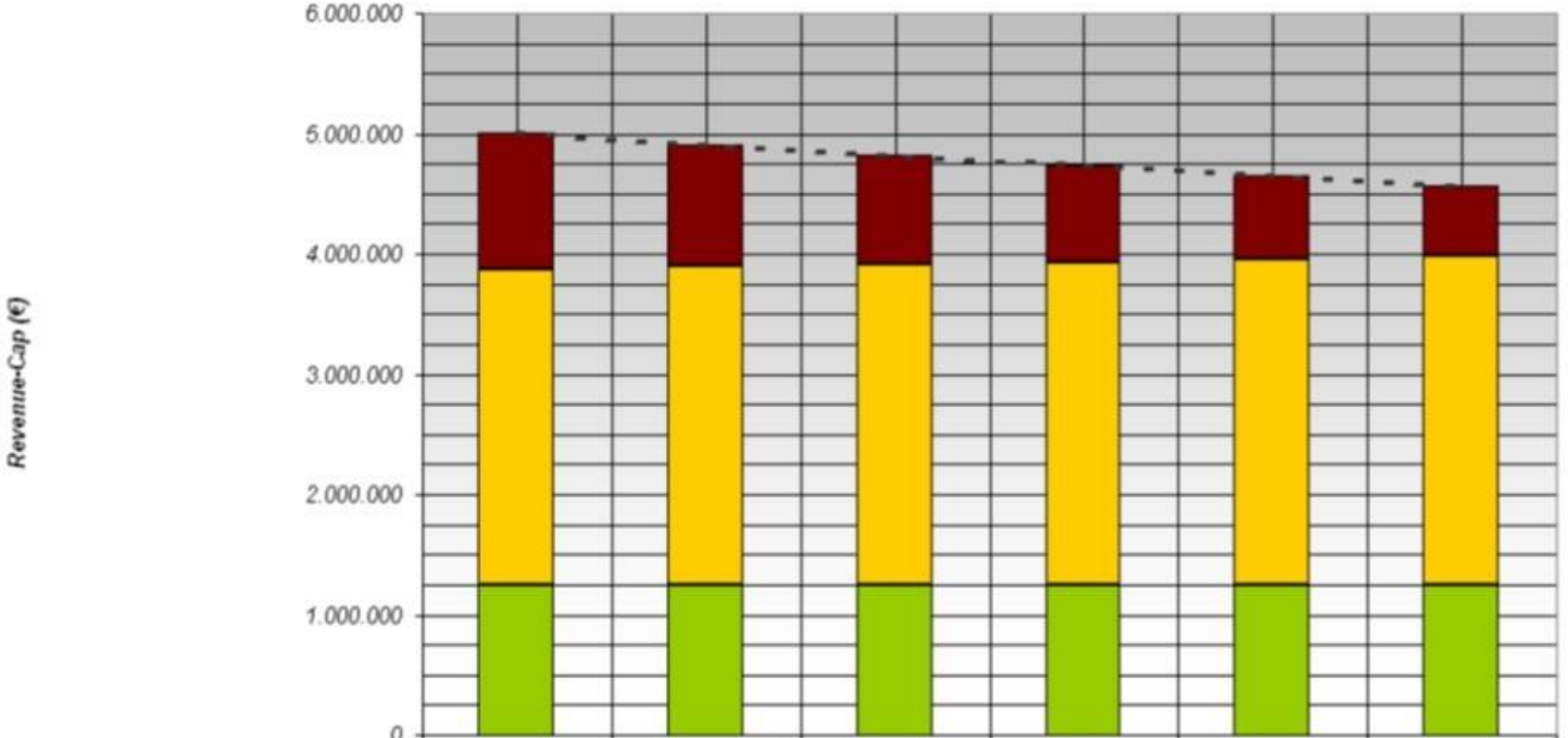
Efficiency benchmarking – based on cost examination and structural data validation of individual TSO/DSO

The most efficient entity serves as benchmark.

Incentive Regulation



Incentive Regulation in Germany (cont.)



	Base Level	2009	2010	2011	2012	2013
Controllable Costs	1.125.000 €	1.020.094 €	913.719 €	805.799 €	696.254 €	584.999 €
Temp. Non-Controllable Costs	2.625.000 €	2.644.688 €	2.665.015 €	2.685.998 €	2.707.653 €	2.729.996 €
Non-Controllable Costs	1.250.000 €	1.250.000 €	1.250.000 €	1.250.000 €	1.250.000 €	1.250.000 €
Revenue-Cap	5.000.000 €	4.914.781 €	4.828.734 €	4.741.797 €	4.653.907 €	4.564.996 €

Source: CEER/BNetzA (2014)

Composition of grid tariffs

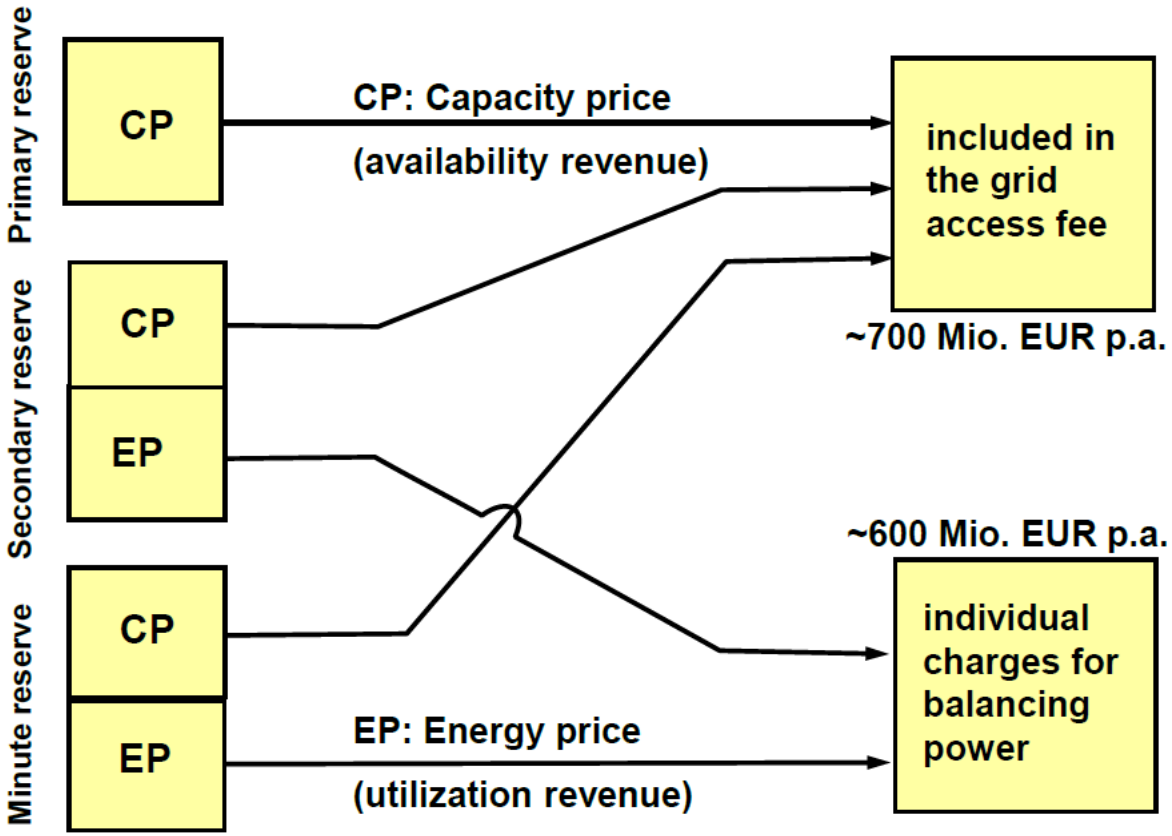
- O&M
- Grid extension
- Control power (capacity component)
- Feed-in management (Einsman)
- Redispatch
- Grid reserve
- Capacity reserve
- Security reserve (coal/climate reserve)
- Reactive power
- Grid losses
- Other

2017

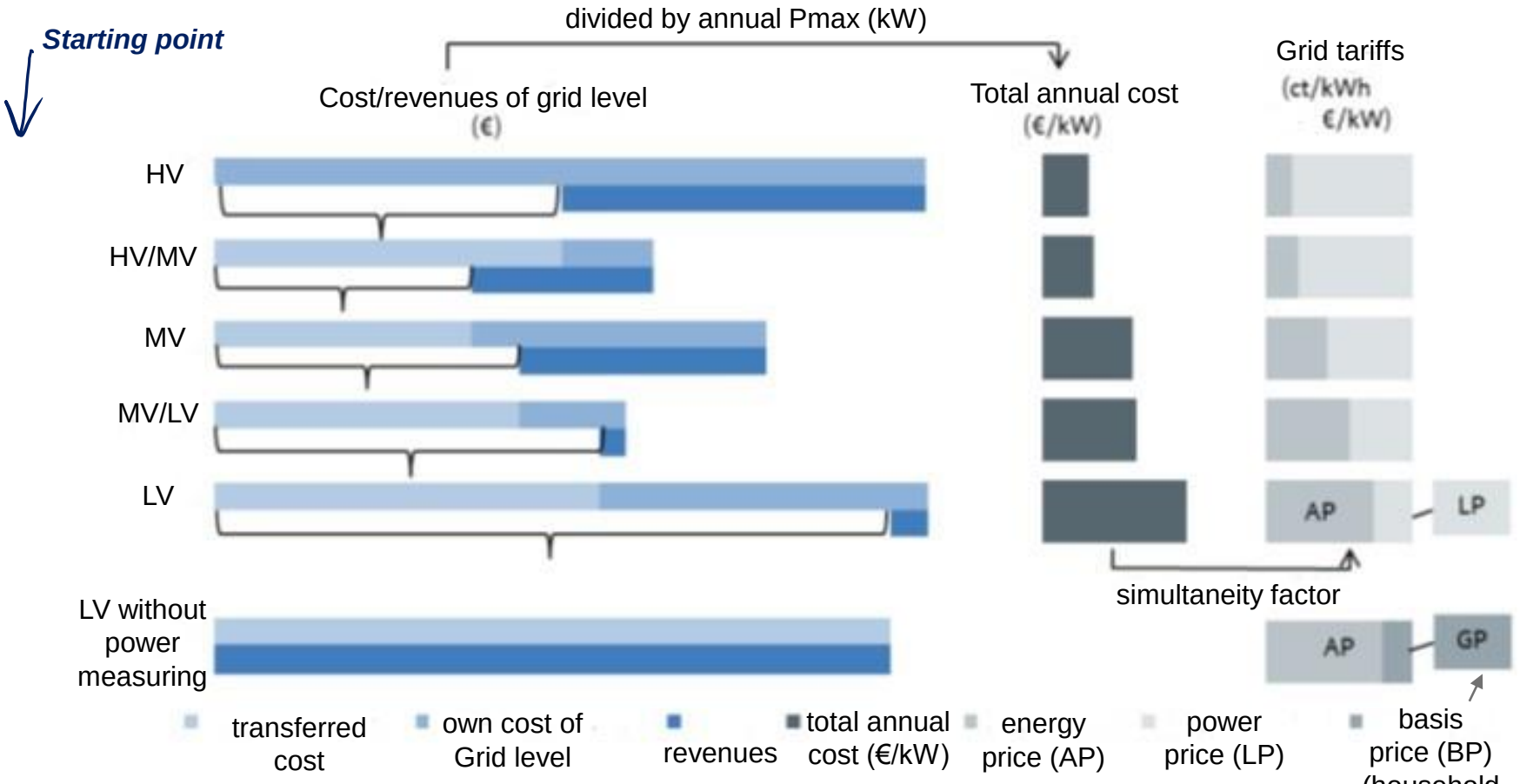
609,9 Mio €

901 Mio €

Cost allocation of control power



Grid tariffs structure

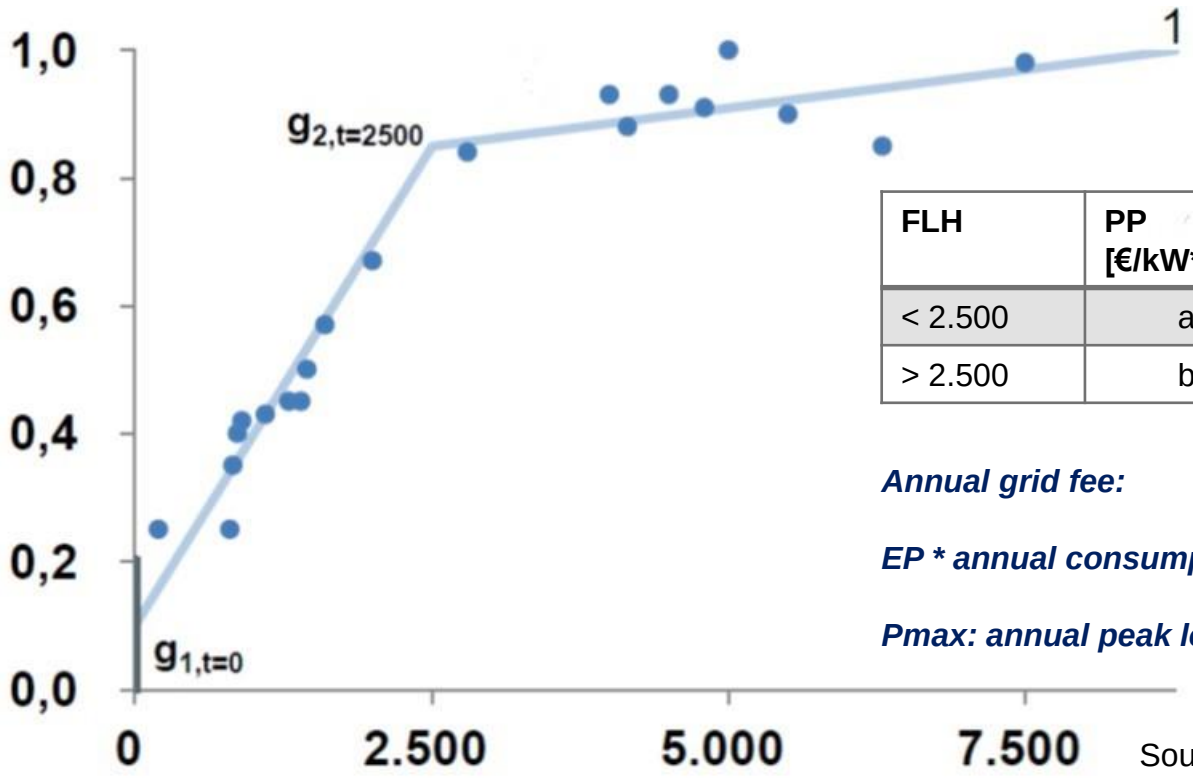


Starting from the highest voltage level, part of the grid costs (based on that level's aggregated annual consumption peak – Pmax) are paid by grid users connected to that grid level. The residue is transferred to the next voltage level and distributed after the same logic – etc.

Source: BNetzA, 2015

Simultaneity (diversity) function

- Grid users with low FLH pay lower power price (PP) and higher energy price (EP)
- Grid users with high FLH pay higher PP and lower EP



FLH	PP [€/kW*a]	EP [ct/kWh]
< 2.500	a	x
> 2.500	b	y

Annual grid fee:

EP * annual consumption + PP * Pmax

Pmax: annual peak load

Source: BNetzA, 2015

Security of supply indicators

- ENS – Energy Not Served – amount of demand not served
- LLD – Loss of Load Duration – number of hours of ENS
- LOLE – Loss of Load Expectation

0,06

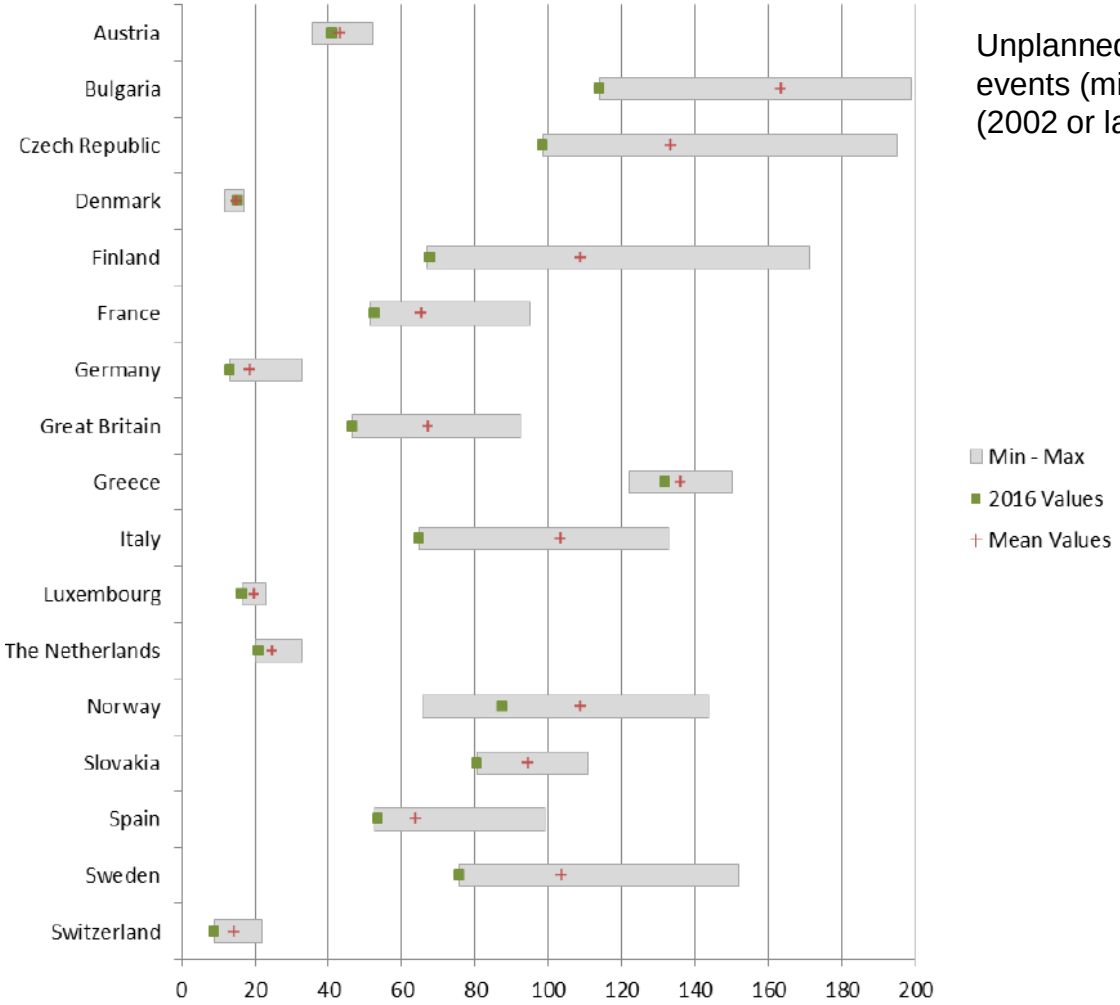
- SAIDI – System Average Interruption Duration Index
- SAIFI – System Average Interruption Frequency Index
- MAIFI – Momentary Average Interruption Frequency Index

$$\mathrm{SAIDI} = \frac{\sum_{i=1}^{U} n_i \cdot t_i}{N}$$

n_i : no. of customers affected by interruption i
t_i : duration of interruption i [min]
N : no. of customers
U : no. of interruptions

ENTSO-E Mid-term adequacy forecast

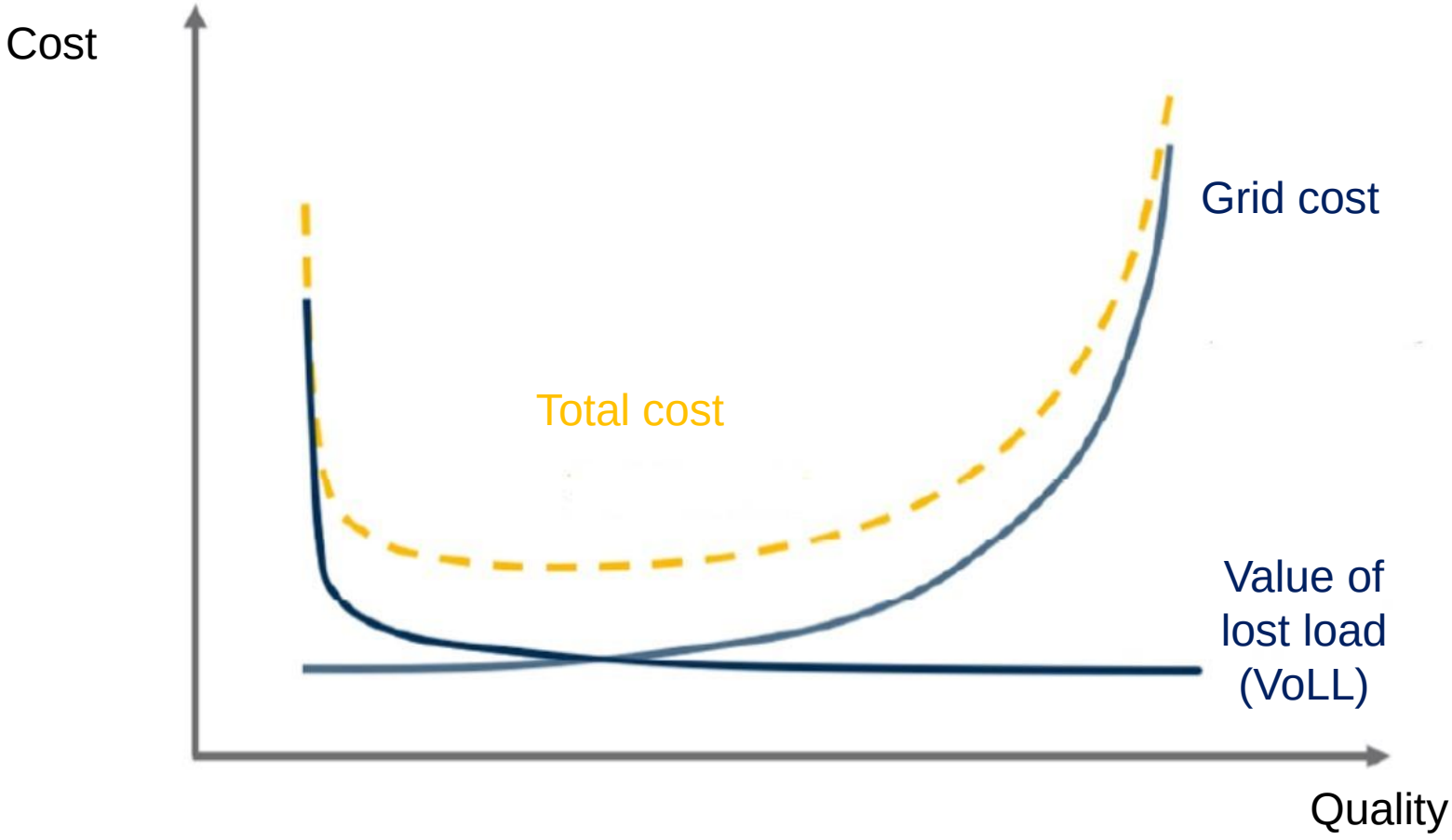
SAIDI – System Average Interruption Index



Unplanned SAIDI, including exceptional events (minutes per customer)
(2002 or later – 2016)

Source: CEER, 2018

Security of supply indicators

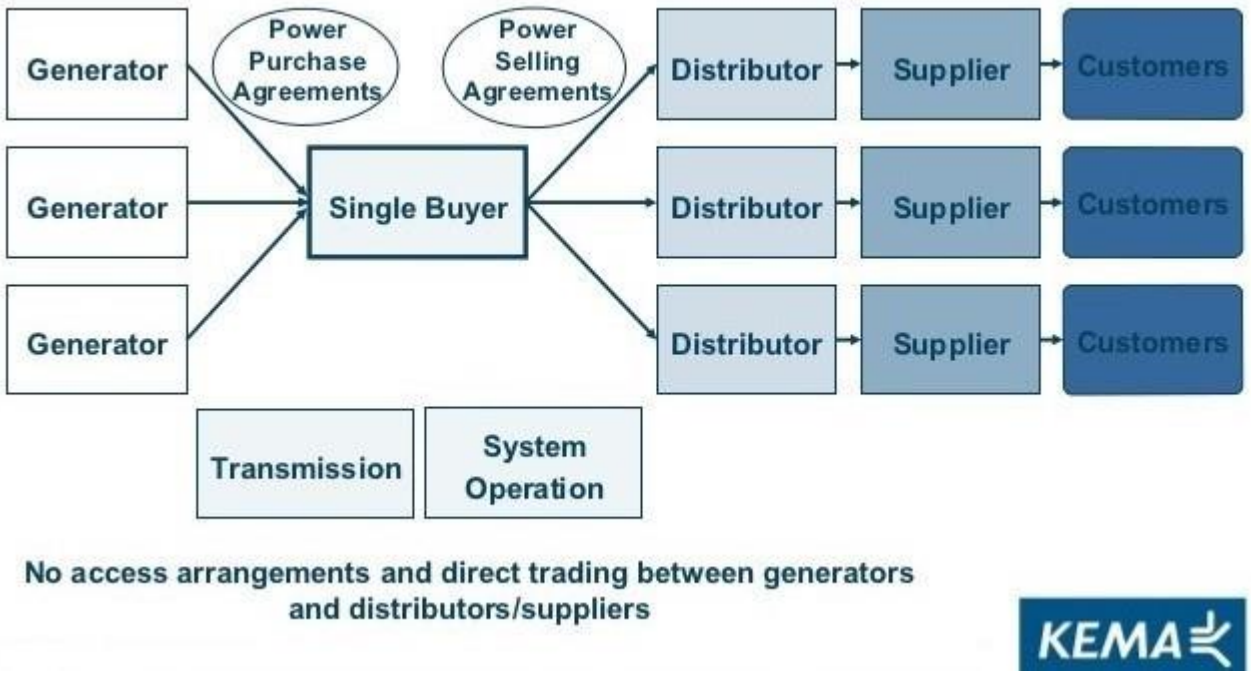


Source: E-Bridge, ZEW & FGH (2020)

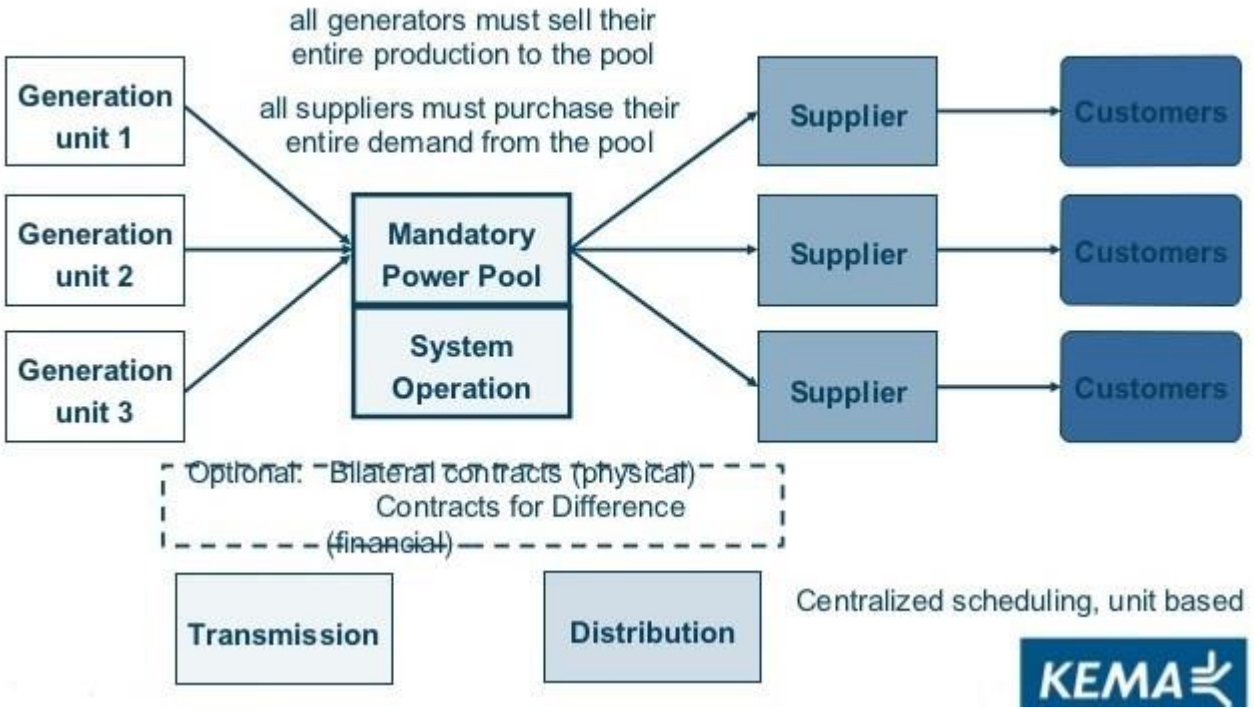
Recap: Electricity market structure types

- Single buyer
- Power pool
- Free wholesale competition
- Fully liberalised market with retail competition

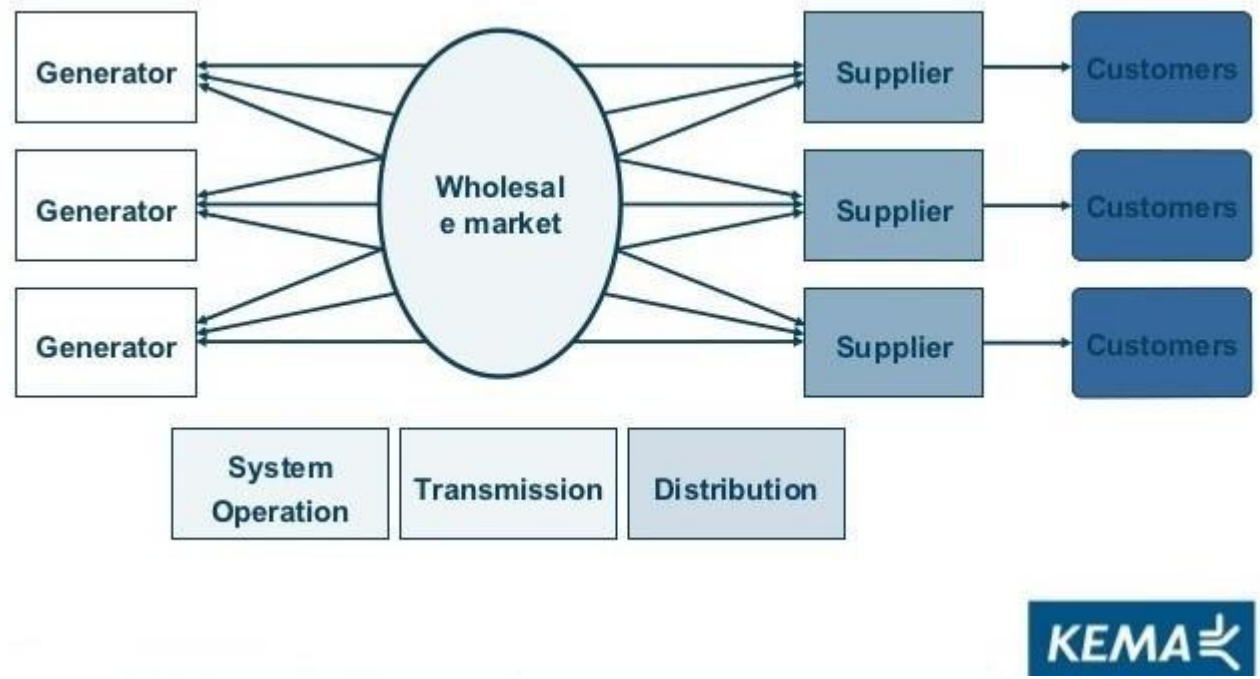
Electricity market structures: Single buyer



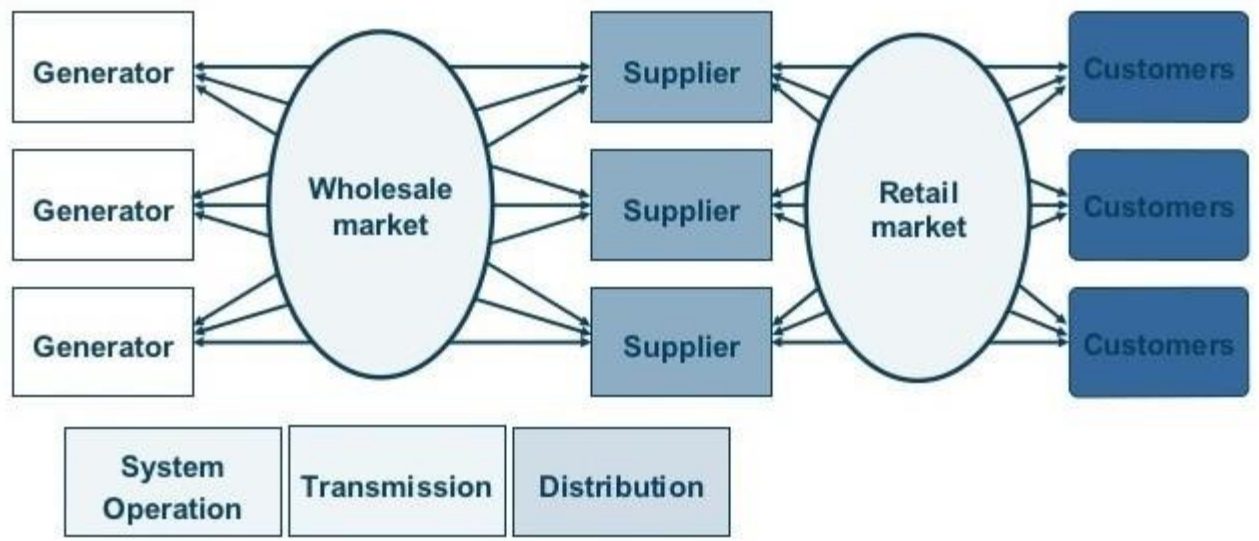
Electricity market structures: Power pool



Electricity market structures: Wholesale competition



Electricity market structures: Retail competition



Electricity retail under different market structures

- Single buyer → regulated retail prices
- Power pool → regulated retail prices;
- Free wholesale competition → large consumers may be eligible to participate in the wholesale market
- Fully liberalised market → retail competition
  unregulated retail prices

Retail competition

The ultimate rationale of liberalisation/restructuring of the electricity sector is the prospect of lower prices for electricity consumers achievable through competition.

The option for final customer to switch supplier creates a competitive pressure for market players along the electricity supply chain.

Categories of suppliers in the German market

- Large vertically integrated utilities: E.ON, RWE, Vattenfall, EnBW
- Municipal utilities
- Retailers with mixed ownership structure
- Small independent retailers

Electricity retail markets are regional: distribution network level.

Default supplier is the designated supplier obliged to supply any customer in their supply area (in Germany: the entity supplying the largest number of grid connection points).

Apart from the baseline contract, the default supplier can offer alternative tariffs.

Categories of final customers

- Industrial
- Commercial
- Residential

- Household customers: up to 10.000 kWh yearly consumption
  - residential & small commercial
  - standard load profile (SLP) - approximation
- Non-household customers: all other
  - commercial (> 10.000 kWh yearly consumption) & industrial
  - registered load profile measurement (RLM): >100 GWh p.a.

Contractual set-up for electricity consumer

- Contract with supplier
  - Types:
    - default supply
    - alternative tariff with default supplier
    - alternative supplier
  - Typically, supplier has BRP role.

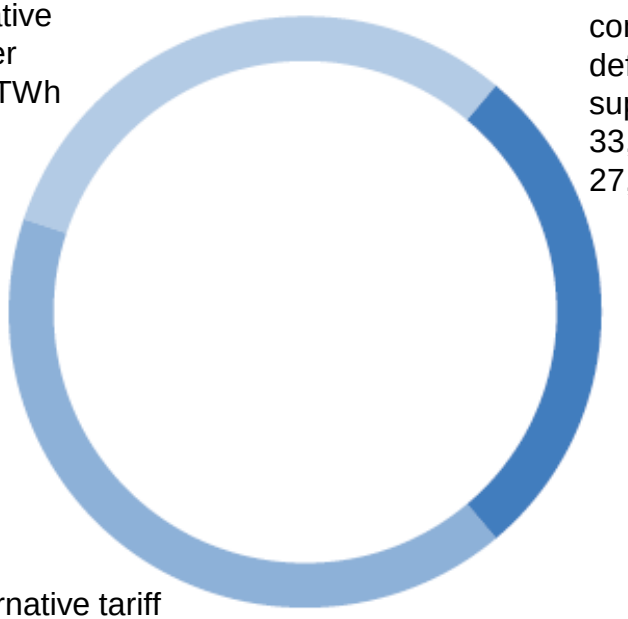
- Contract with the grid operator (Network contract)
  - Grid tariffs
  - Metering and metering charges

Metering responsibility:
- ***by default – grid operator***
- ***by opt-in – independent metering company***

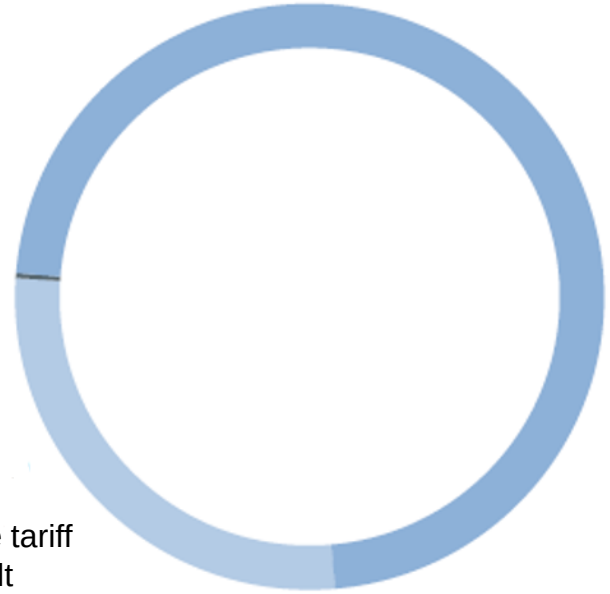
- Network connection contract – technical connection to the grid.

Supplier structure: Industrial and household customers

Household customers



RLM customers

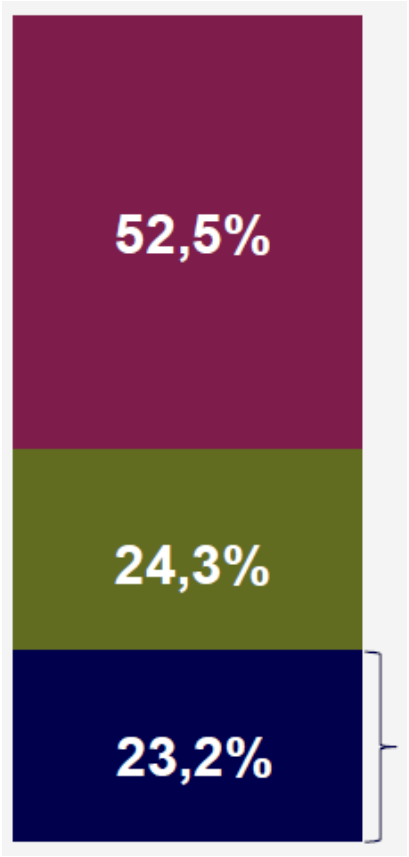


Source: BNetzA, 2018

Retail price composition: Household customers

Average composition of electricity price for a German household with an annual consumption of 3.500 kWh (2019)

Average price:
30,43 ct/kWh



Taxes and levies — State-induced

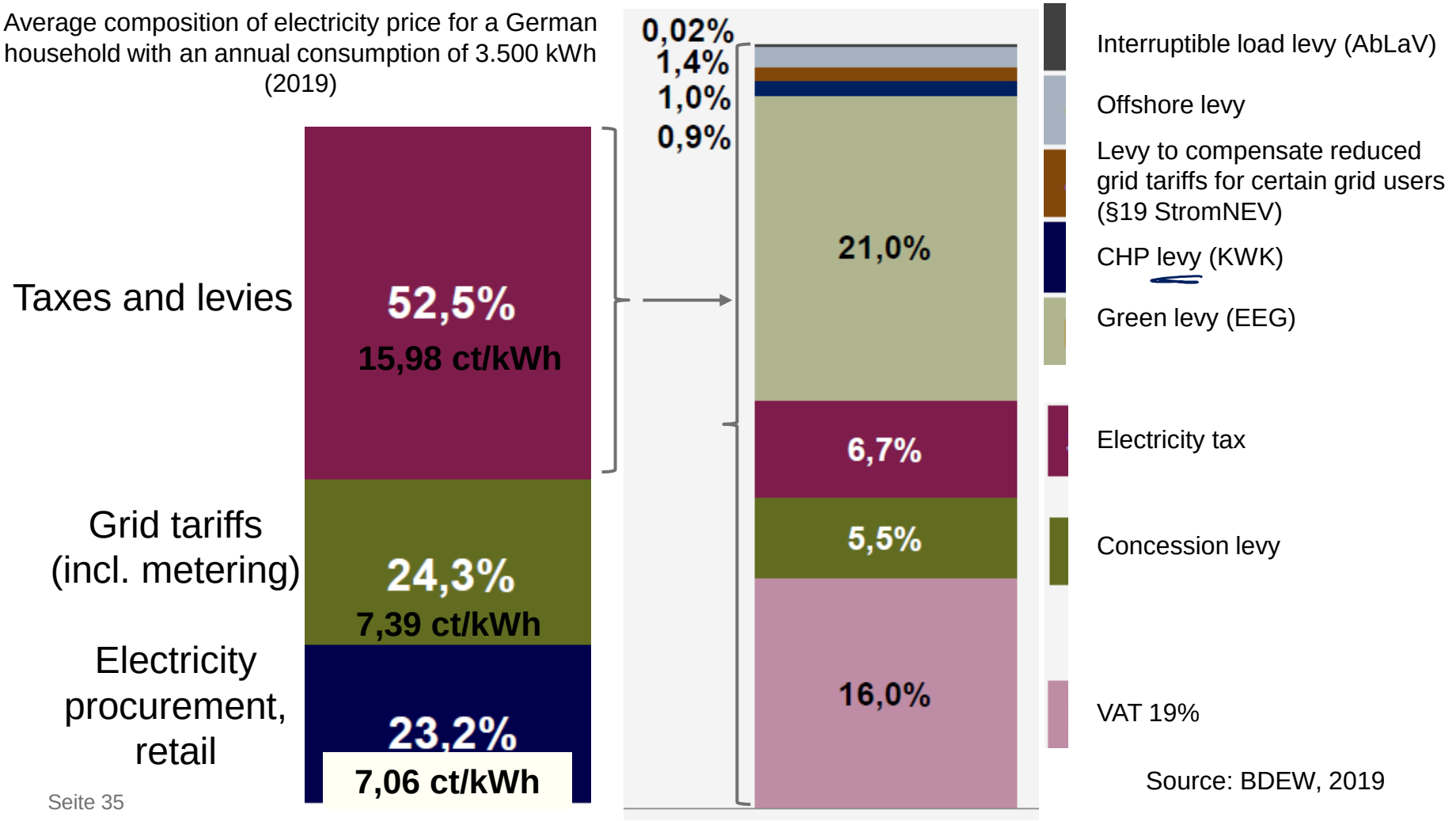
Grid tariffs (incl. metering) — Regulated

Electricity procurement, retail — Market-based

Source: BDEW, 2019

Retail price composition: Household customers

Average composition of electricity price for a German household with an annual consumption of 3.500 kWh (2019)



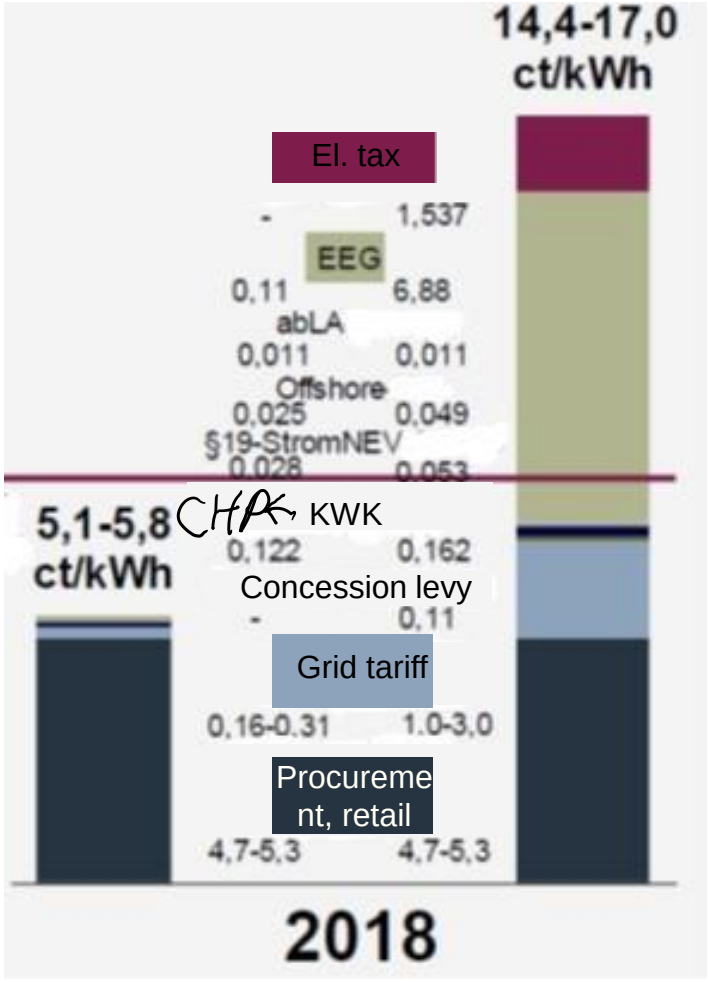
Source: BDEW, 2019

Retail price composition: Industrial consumers

Range of electricity prices for large industrial consumers with an annual consumption of 100 GWh/a:
Max. available cost relief vs. No cost relief

Average price 2018:
8,96 ct/kWh

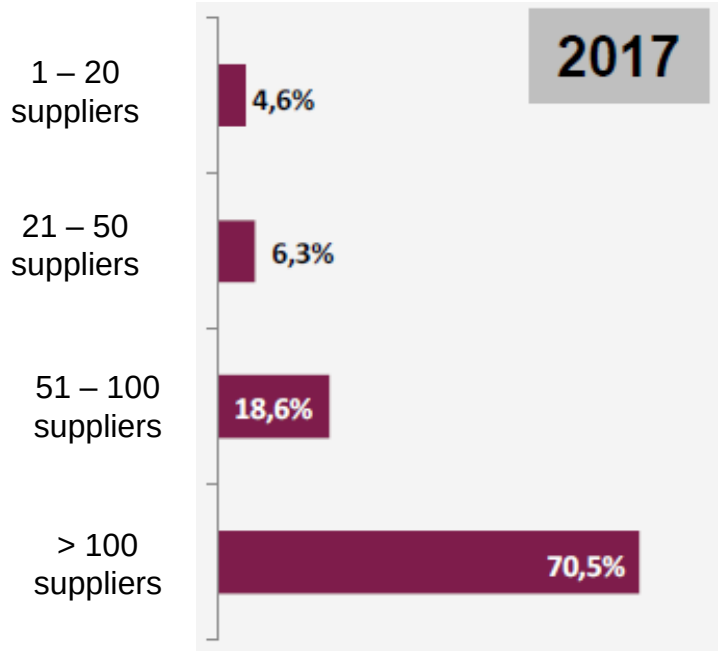
Source: Eurostat



Source: BDEW, 2019
(with reference to Eurostat)

Retail competition

% of grid areas with given number of suppliers:

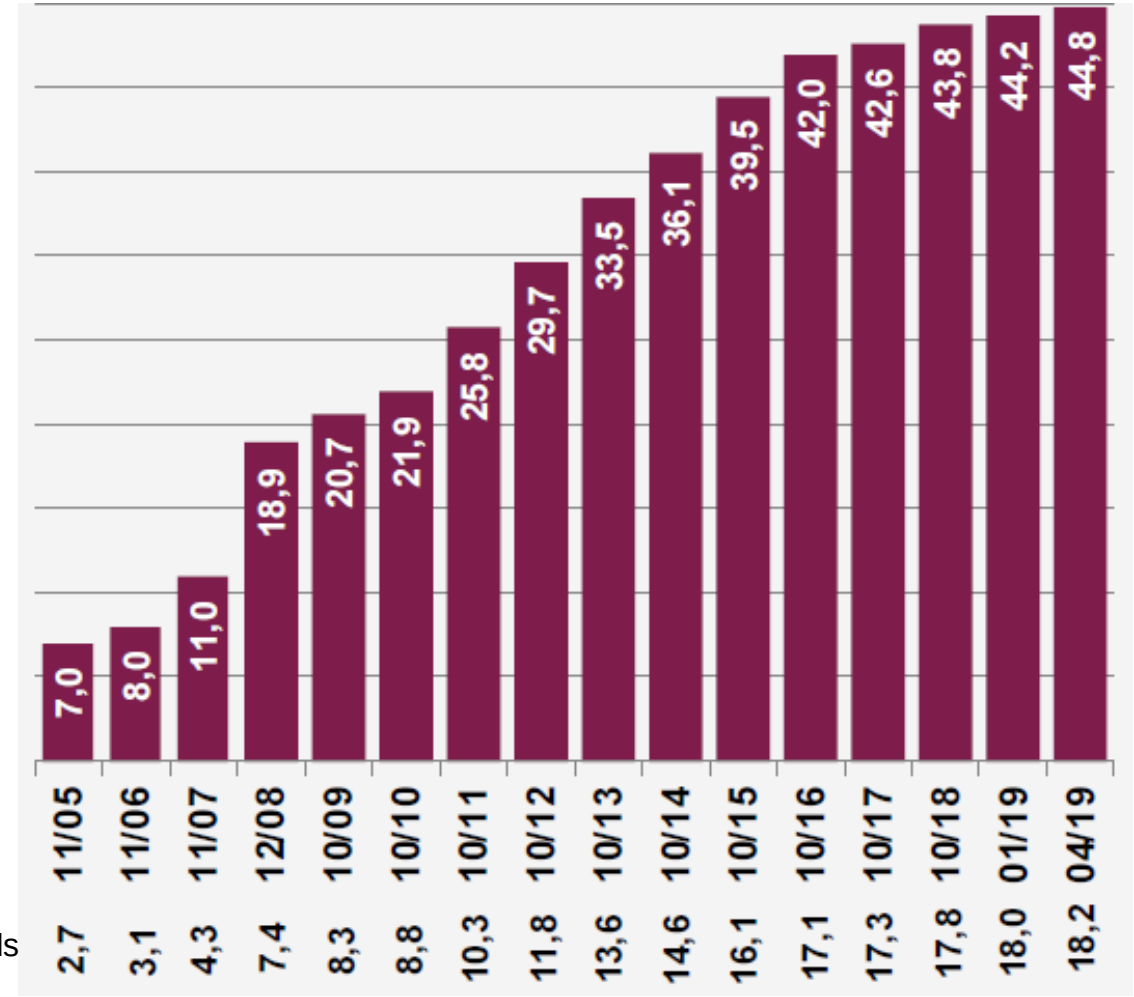


In almost all grid areas the number of operating suppliers is more than 20.

In approx. 90% of grid areas more than 50 suppliers are operating.

Source: BDEW, 2019 (after BNetzA, 2018)

Supplier switching among household customers



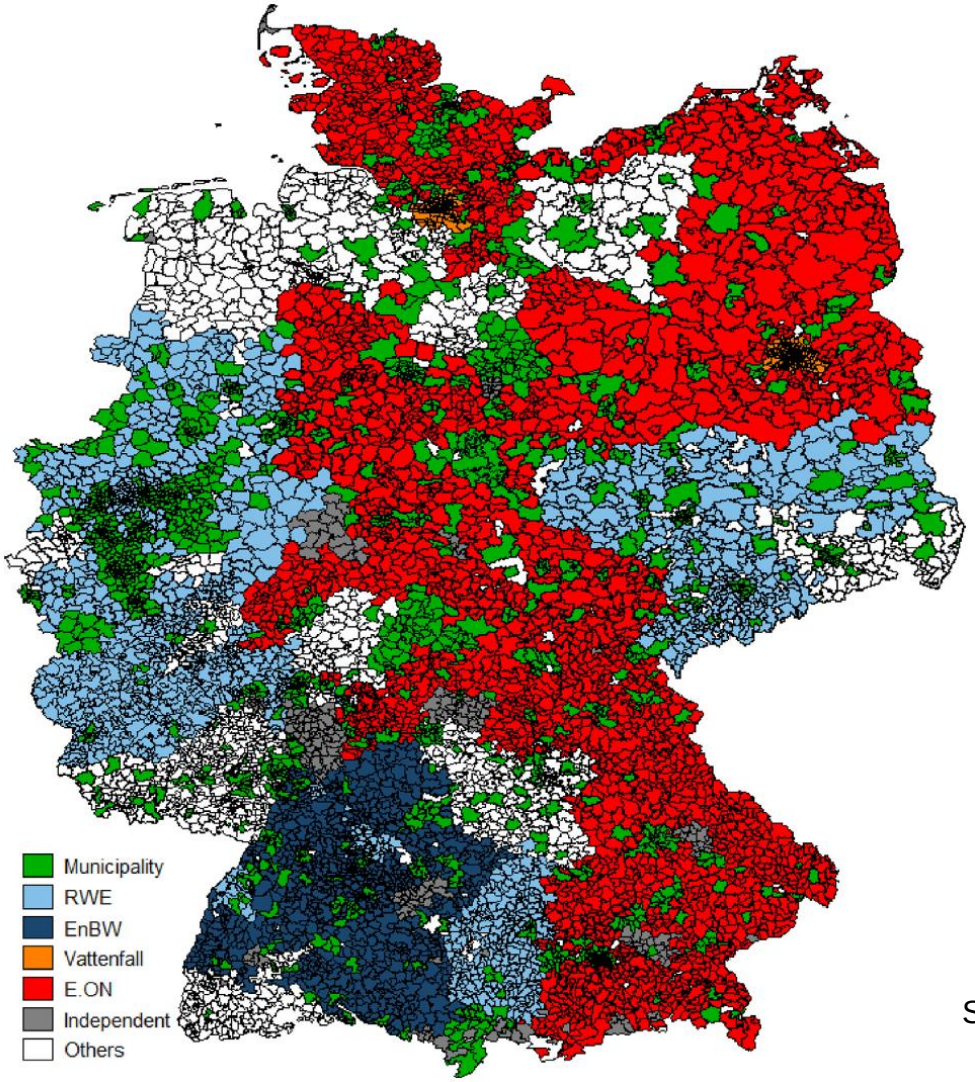
Cumulated switching rate since liberalisation

Souce: BDEW, 2019

Retail competition: Pass-through rate

- Pass-through rate is the percentage to which an electricity retailer passes on a change in their cost to their customers/ electricity consumers.

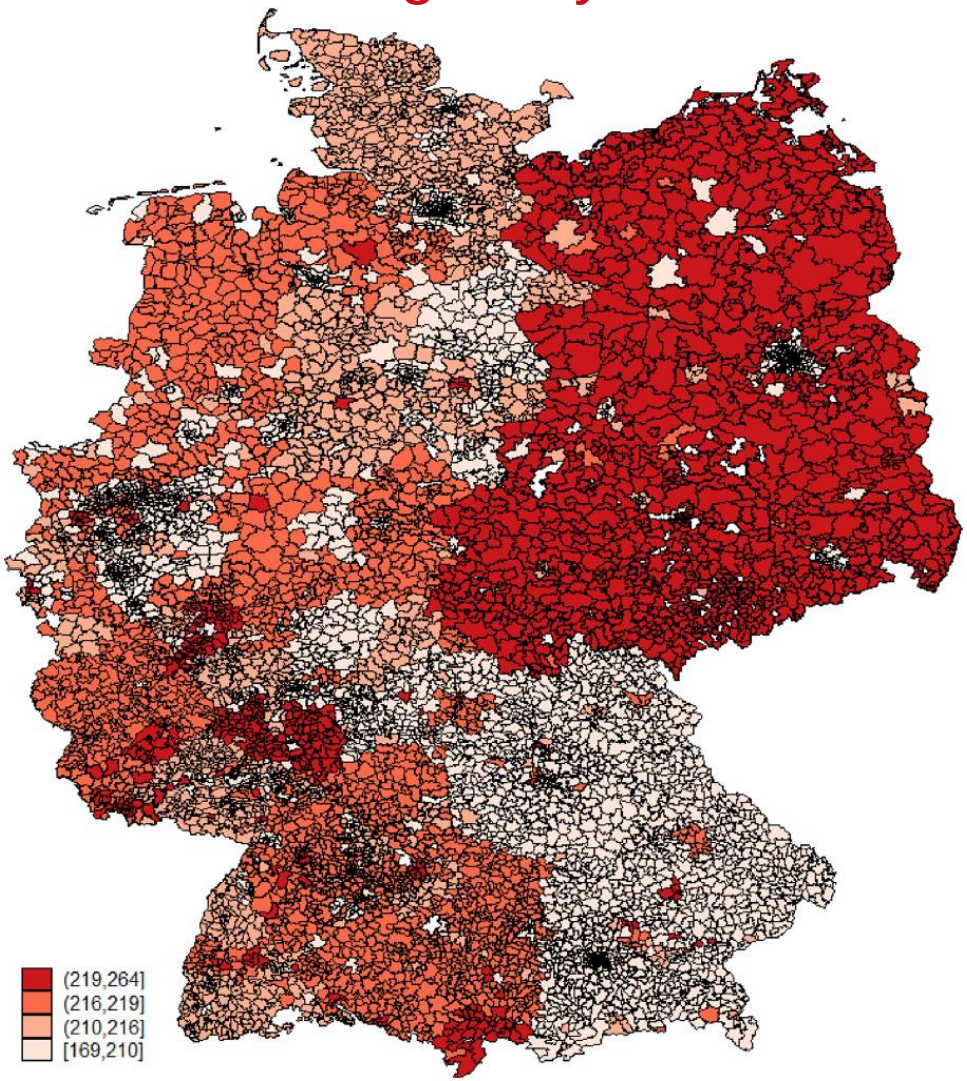
Retail market: Pass-through rate



Incumbents in regional retail markets in Germany in 2010

Source: Duso / Szücs, 2017

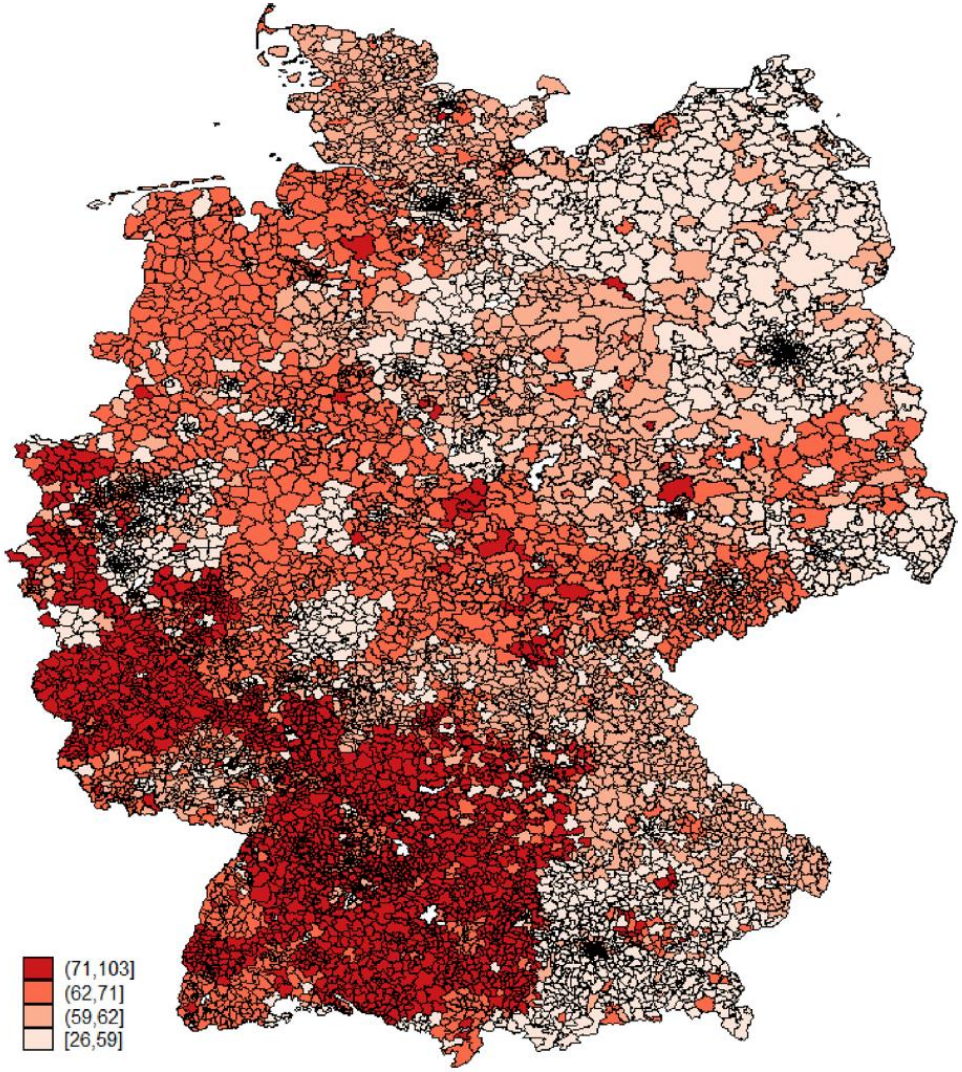
Retail market: Heterogeneity in baseline tariffs



Baseline tariff in € per MWh at 2800 kWh yearly consumption

Source: Duso / Szücs, 2017

Retail market: Within-network price dispersion (2010)



Difference between baseline and best-available tariff in € per MWh at 2800 kWh yearly consumption

Source: Duso / Szücs, 2017

Pass-through rate in the German retail market

Duso and Szücs / European Economic Review 98 (2017) 354-372

Summarised findings:

- Supplier and customer types
  - Pass-through rate to baseline tariffs is quite similar across firms.
  - Pass-through rate to competitive tariffs is 12-23% higher for independent suppliers.
  - Thus, the pass-through rate depends on the customer segment, rather than supplier segment.
- Time differentiation
  - Pass-through rates to baseline tariffs remain stable over time.
  - Pass-through rate to the best available tariff increases to almost unity.

Ability to switch supplier is the main driving factor for pass-through.