GTAI GERMANY TRADE & INVEST

GERMAN BATTERY STORAGE: MARKET AND APPLICATIONS

MIDWESTERN STATE LEGISLATORS' MEETING

OCTOBER 14TH, 2021

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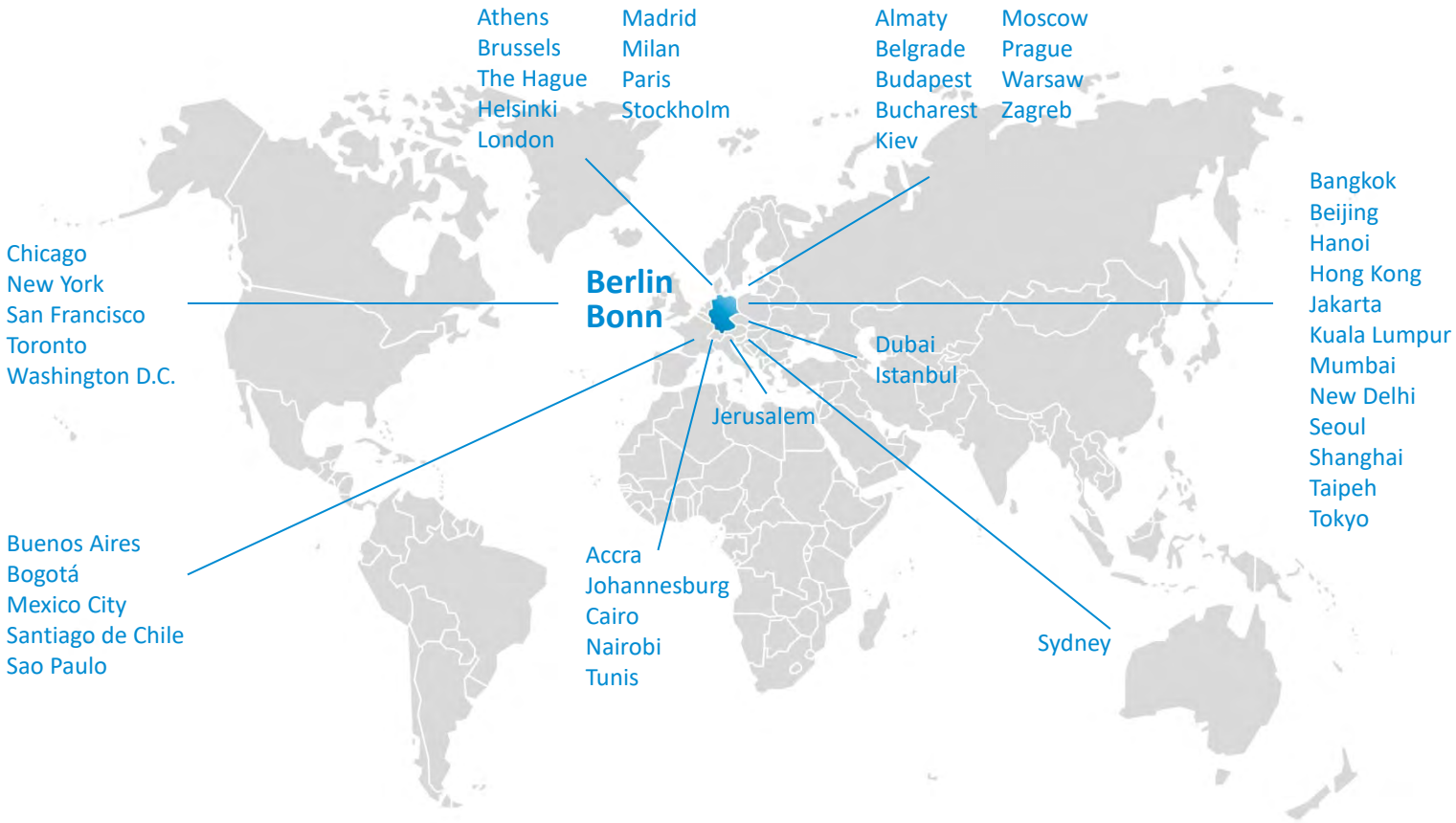
Energy, Environment & Resources
www.gtai.de

Germany Trade & Invest (GTAI) is the economic development agency of the Federal Republic of Germany.

We are on the spot for you worldwide - ensuring that you receive competent support.



What we do

International marketing of Germany as a business and technology location

Economic promotion of the new federal states and Berlin

Business location consultancy services for international investors

Export market information for the German economy

Our advisory services include:

- Market-entry strategy development support
- Tax and legal information and support
- Funding and financing options advice
- Location identification, location visit support

Intro Battery Market

Private applications

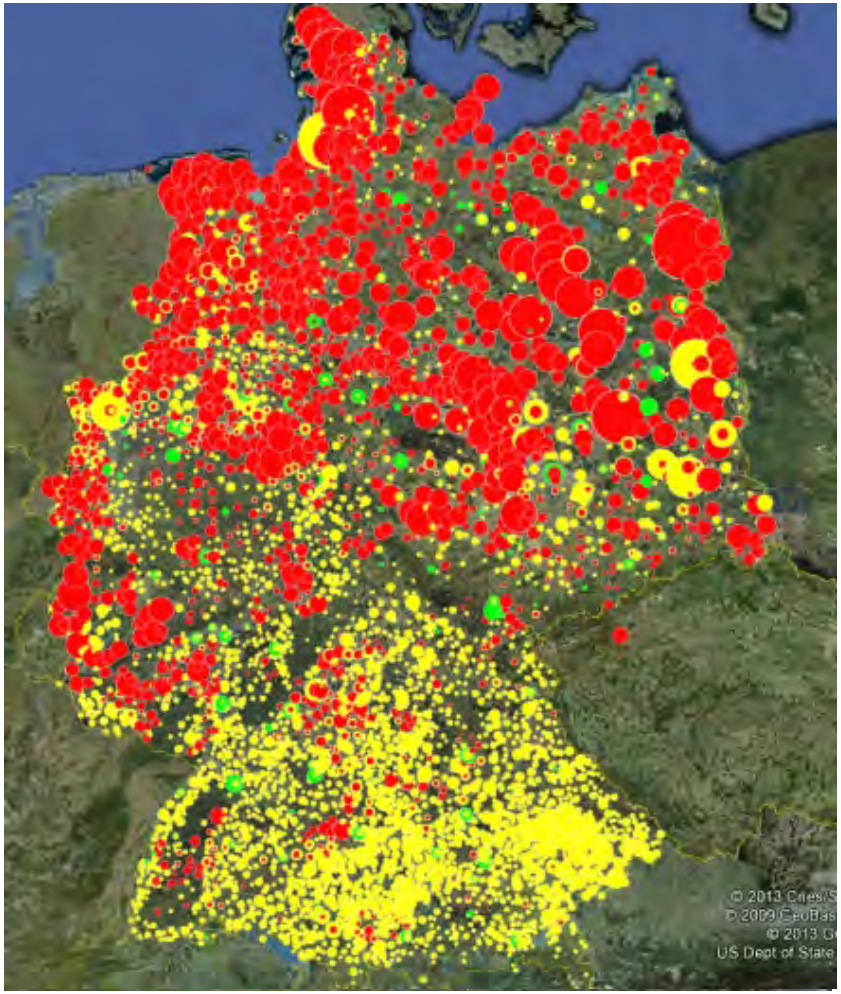
Grid applications

Industrial applications

Smart EV Charging

Development of Renewable Energy Systems

Feed-in-Tariff causing dynamic growth



Total capacity of renewables (2020)

> 1.8 million installations

- **Wind energy**
- **PV**
- **Biomass**

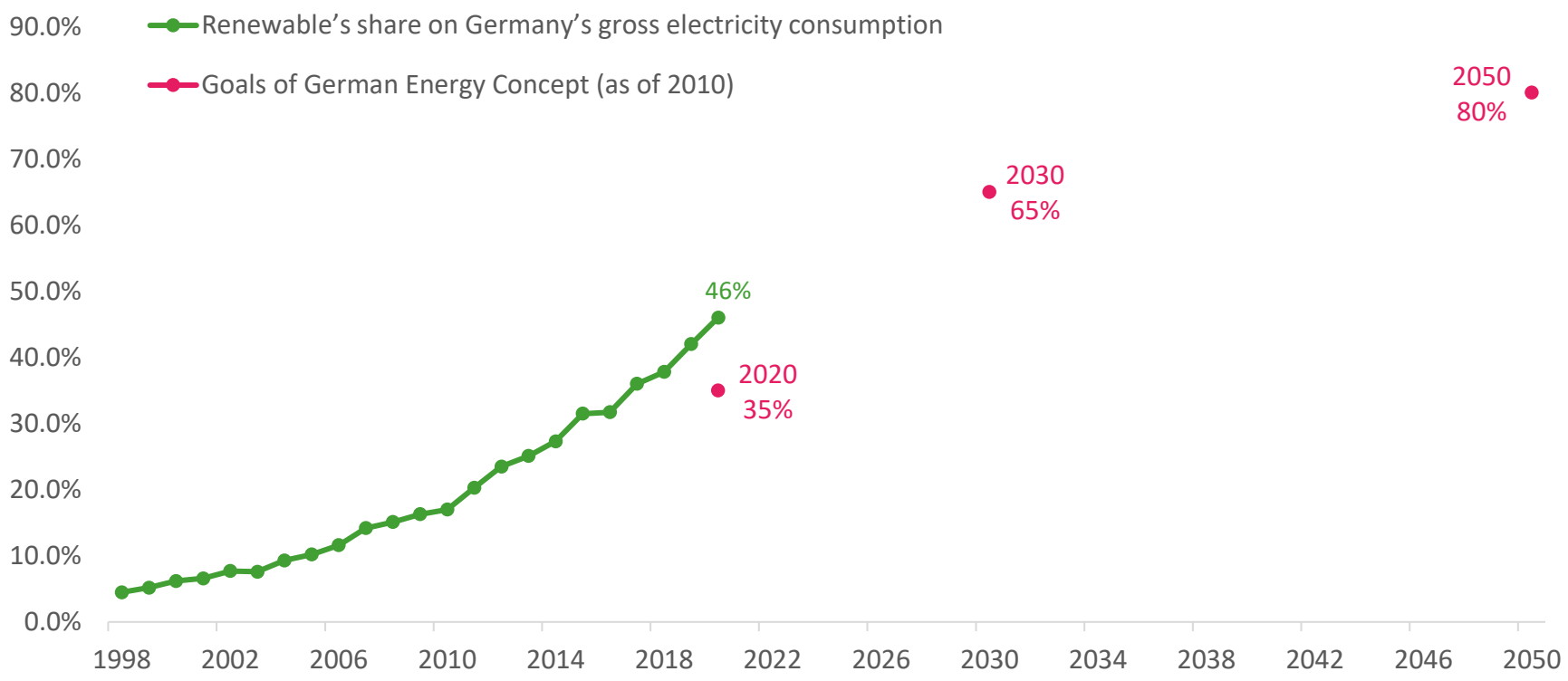
The circle **diameter** is proportional to the electrical capacity

Sources: 50HertzT, TenneT, Amprion, TransnetBW, internal data

On the generation side, we're well on track

Renewable's share on Germany's gross electricity consumption growing beyond expectations

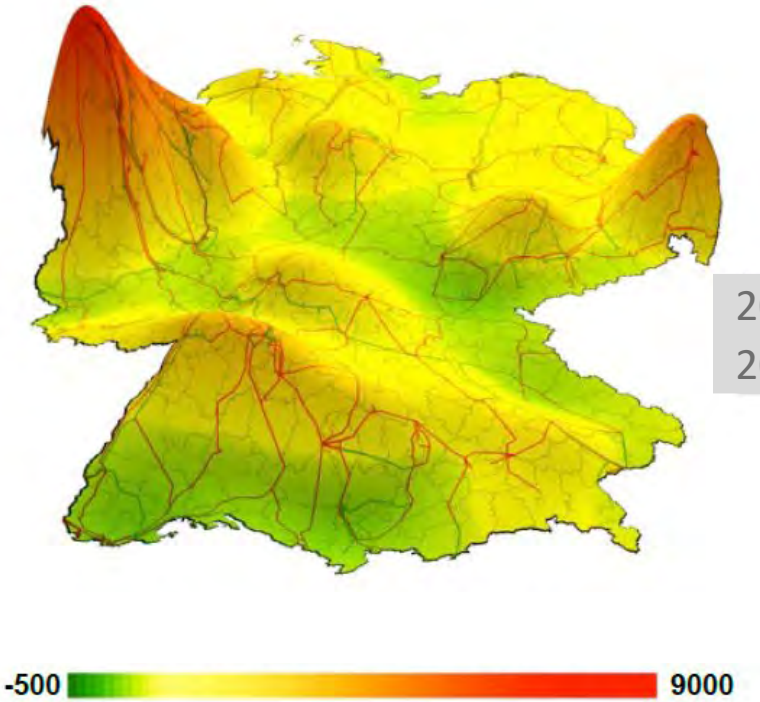
Renewable's share on Germany's gross electricity consumption vs. goals of German Energiewende



Sources: BMWi, BDEW 2020

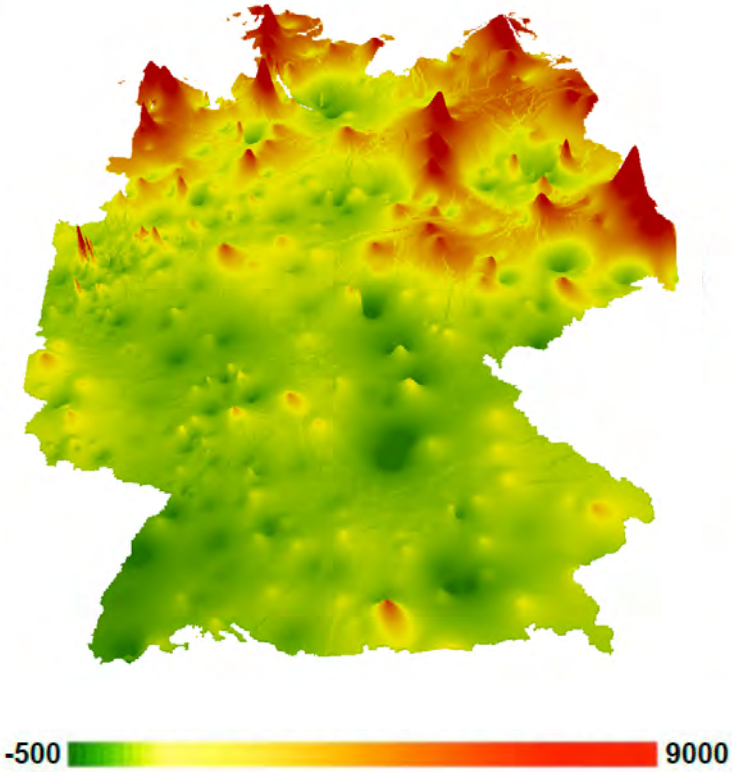
But: Need to change power structure fundamentally

New generation centers will be far from load centers



Power balance 2014

2014-
2024



Power balance 2024

Source: Bundesnetzagentur 2016

Many use cases for electrical energy storage

Providing grid services, helping industry reduce grid fees, and households increase their own-consumption of cheap PV energy.

Utility

- Control Reserve Power (3 kinds: Primary, Secondary, Tertiary)
- Redispatch
- Black-start capability
- ….

Industry

- Reduction of grid fees by reducing P_{max}
- Reduction of grid fees by shifting P_{max}
- Increased own-consumption from PV

Private

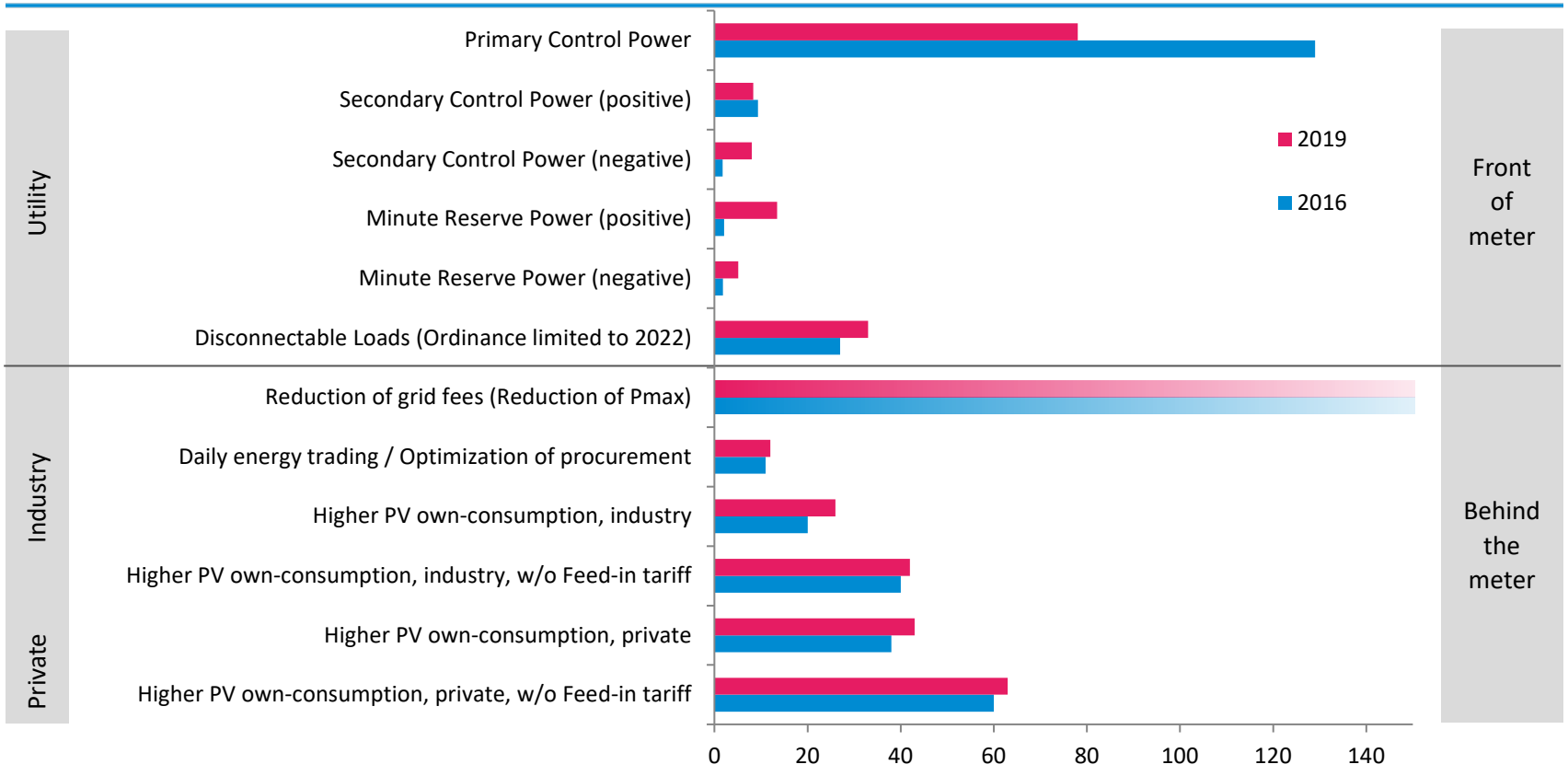
- Increased own-consumption from PV
- Special electricity rates for battery swarms
- More autarky

Courtesy: Younicos GmbH/Wemag AG, Tesvolt GmbH, Sonnen GmbH

Electrical storage: Potential income per use case

Utility and industrial applications generate highest income, currently. Solar-PV business cases become better every year, systematically.

Potential annual income for electrical energy storage per application, 2016 vs 2019*
(in EUR per usable kWh per year)



*GTAI calculation based on FITs, electricity prices and public tenders from 2016 and 2019

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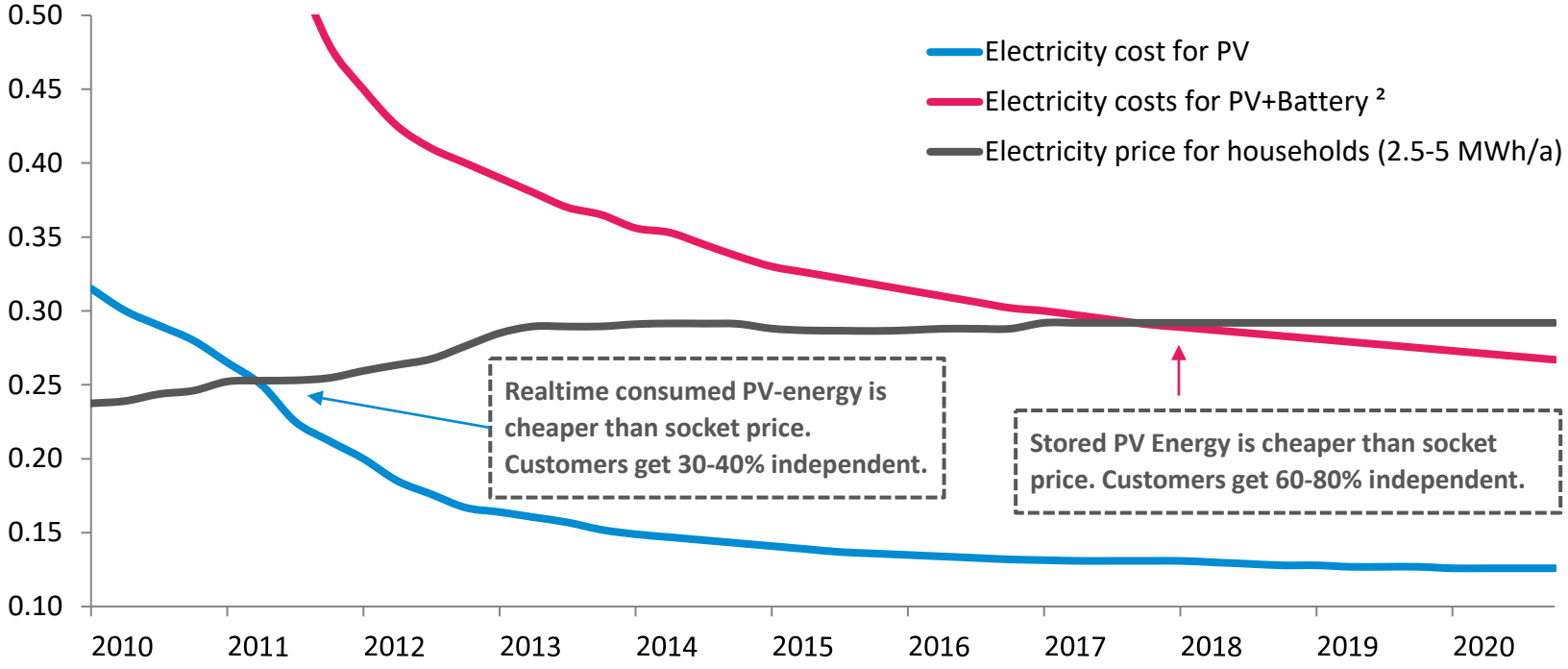
PV+Battery reached Grid-Parity in 2018

Saving energy costs while becoming 60-80% energy independent

Anticipated development of electricity costs for PV and PV+Battery [1]
(2010 – 2020, in EUR/kWh)

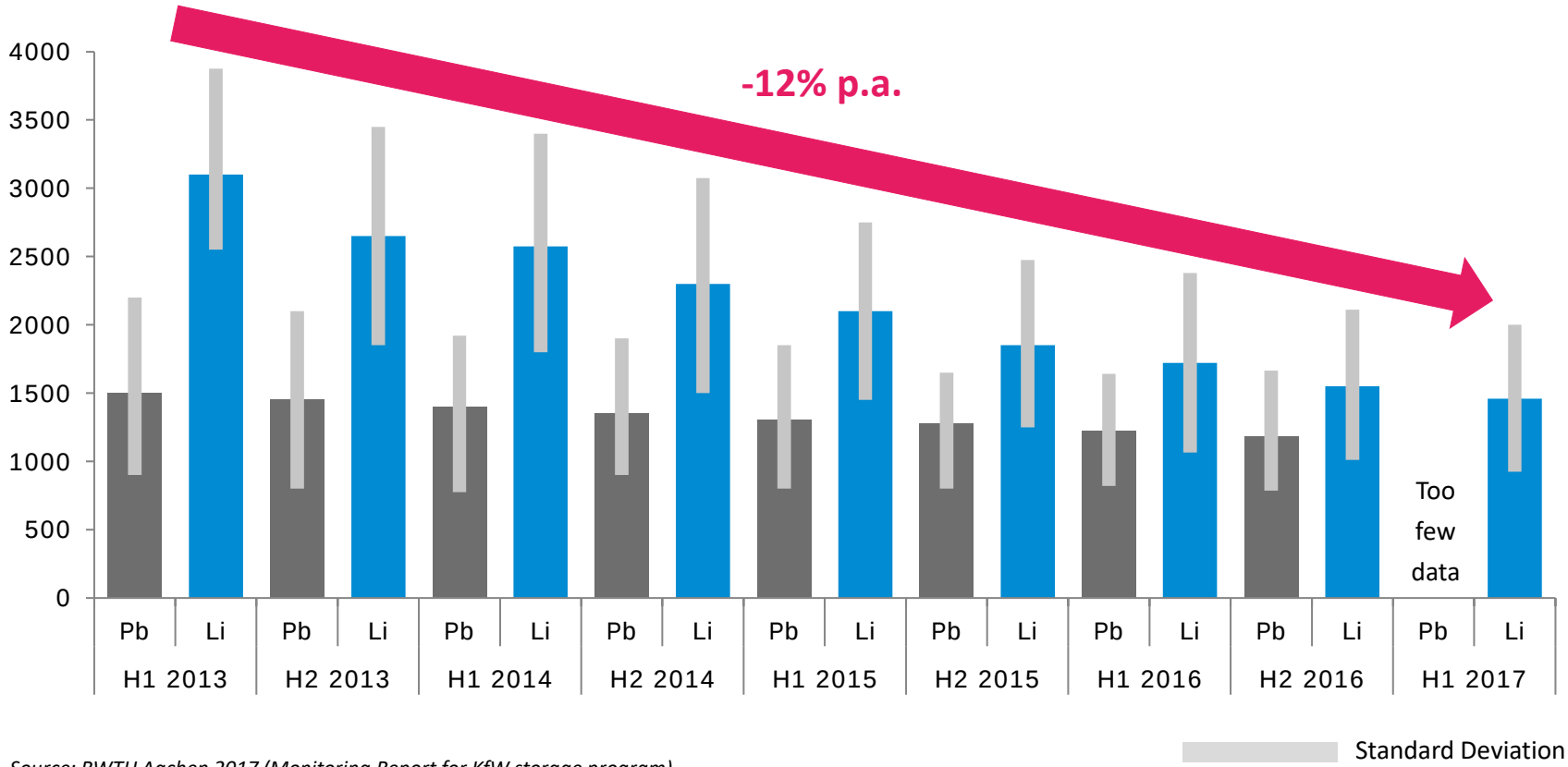


[1] Model calculation for rooftop systems, based on 802 kWh/kWp (Frankfurt/Main), 100% financing, 6% interest rate, 20 year term, 2% p.a. O&M costs. [2] based on 5,000 cycles, C2, 87% system efficiency. Sources: Own calculation; Model Calculation: Deutsche Bank 2010; Electricity Prices: BDEW 2018; thereafter: own estimate at 0.29 EUR/kWh.

Falling battery prices make storage profitable

End-customer prices of Li-systems have halved within the past 4 years

End-user system prices for private PV-batteries in Germany
(in € per Usable kWh, incl. VAT, excl. Installation)

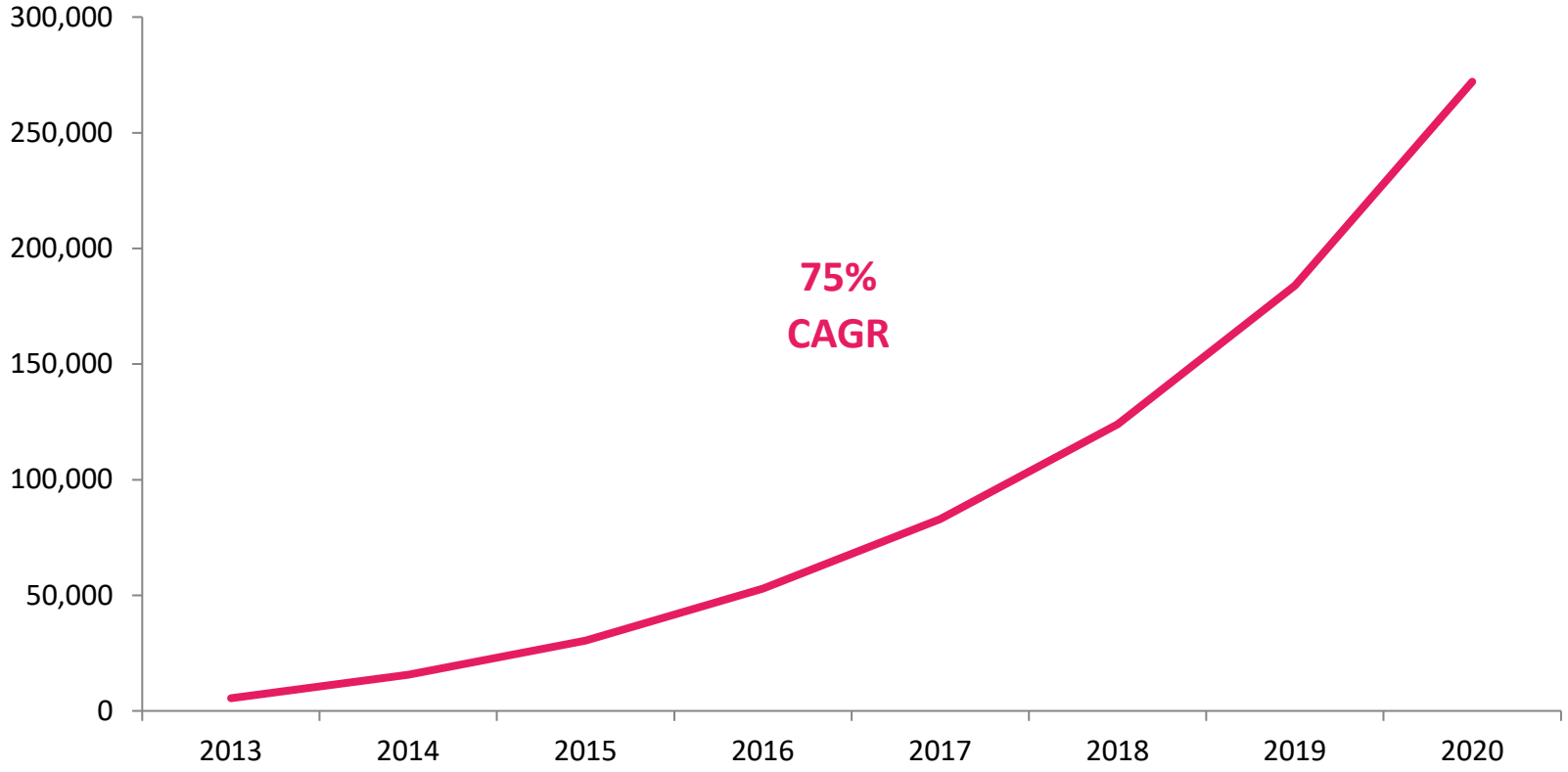


Source: RWTH Aachen 2017 (Monitoring Report for KfW storage program)

PV-Batteries in Germany: Strong market growth

88k systems sold in 2020. Majority of new PV systems come with ESS.

PV-battery systems installed in Germany
(Number of systems, cumulated)

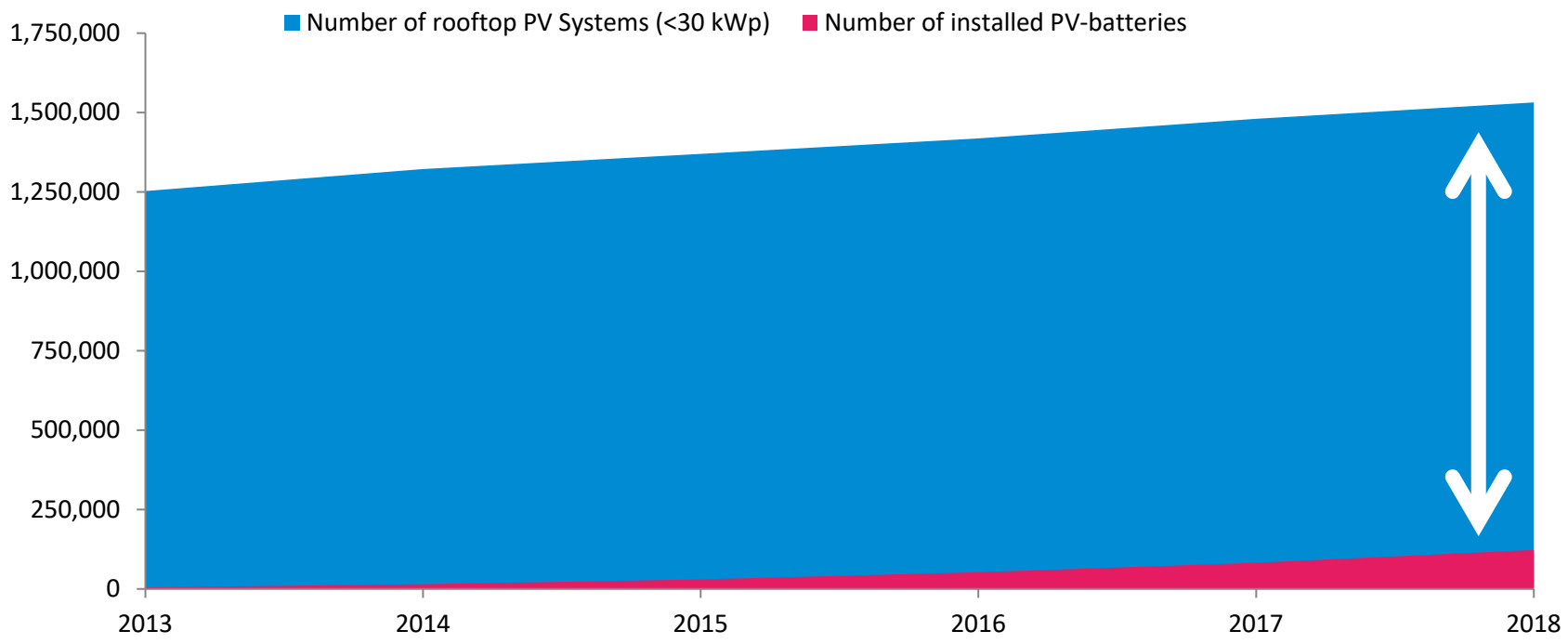


Note: BSW 2021

Still: Enormous potential for further growth

Only 8% of rooftop PV systems in Germany are equipped with a battery today – in 10 years it could be well over 80%.

Rooftop PV Systems (<30kWp) vs. PV-battery systems
(Number of systems, 2013 – 2018)

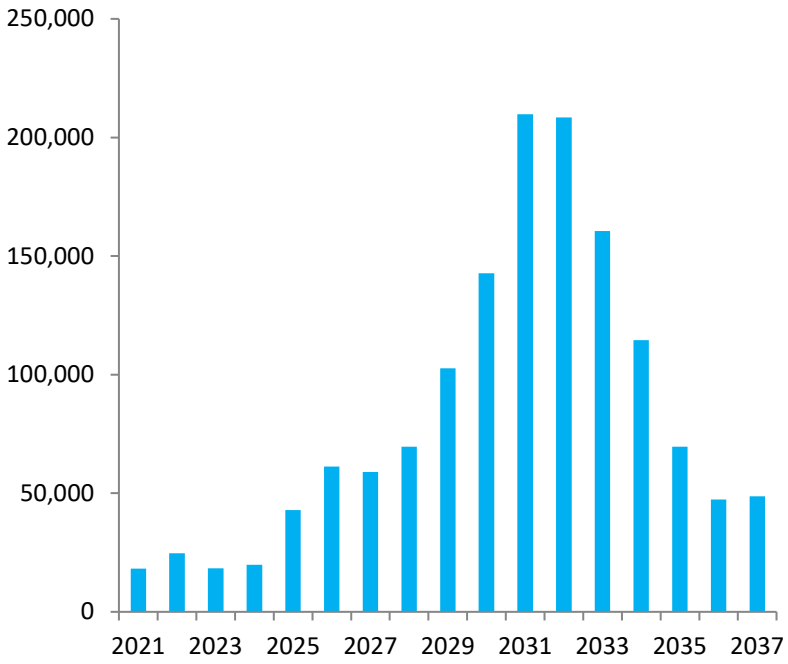


Note: „rooftop PV" is referring to PV systems < 30 kWp
Sources: Federal Network Agency 2017, BSW 2017, RWTH Aachen 2017

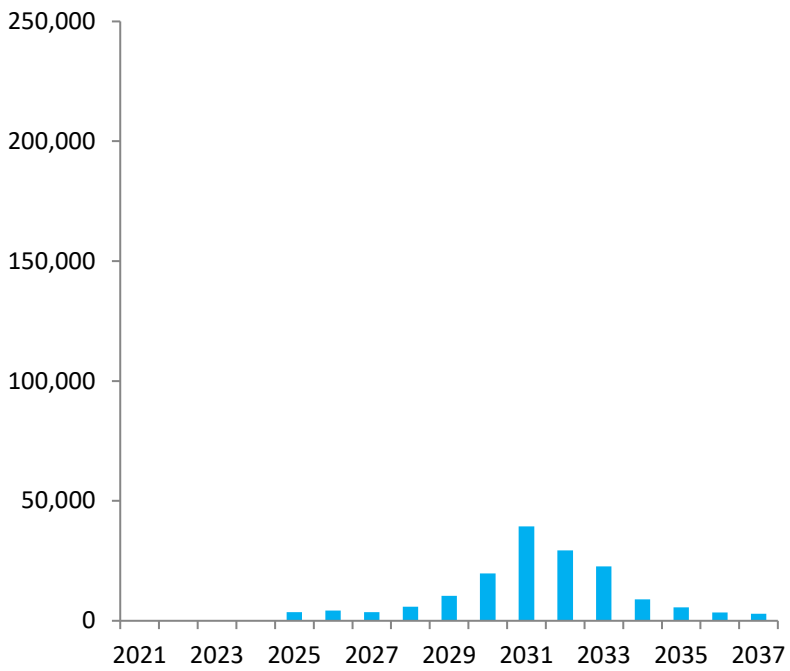
Gigantic PV-battery retrofit potential

More than 1 million existing PV systems could add storage from 2021

Private PV-Systems exiting Feed-in tariff
(Number of systems, < 30 kWp)



Commercial PV-Systems exiting Feed-in tariff
(Number of systems, > 30 kWp and < 750 kWp)



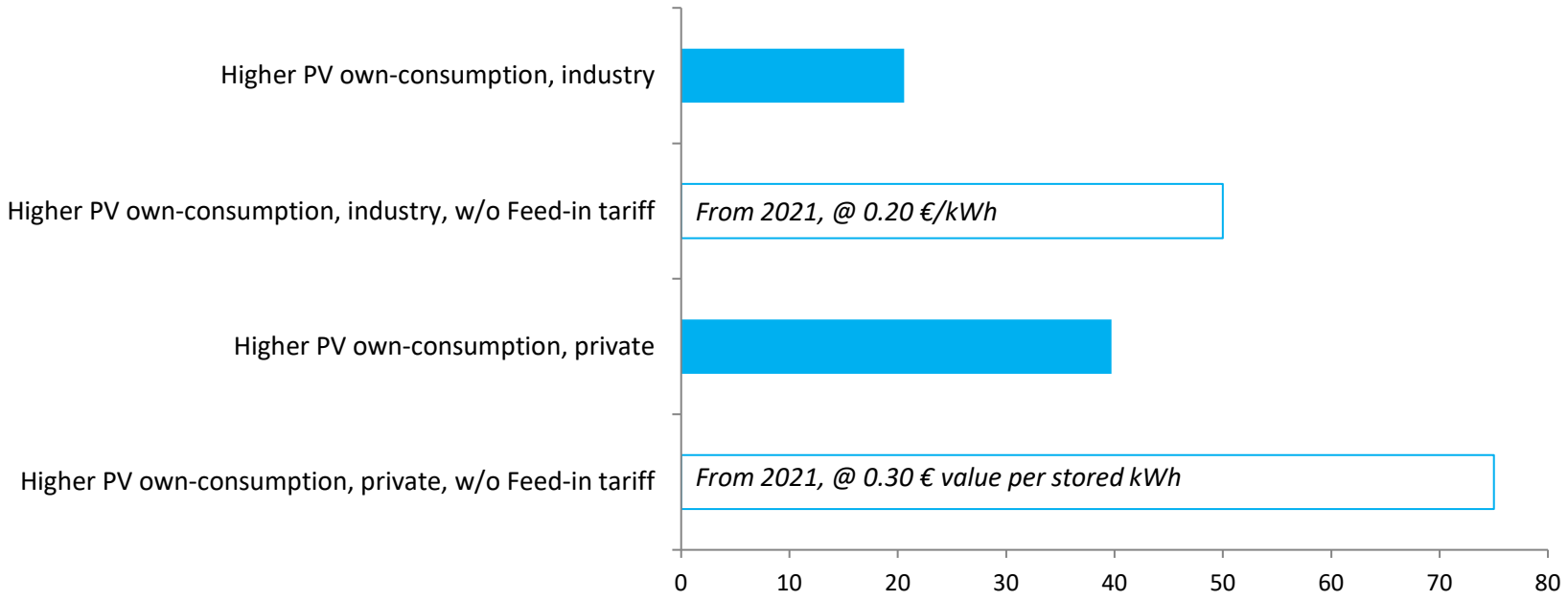
Source: Federal Network Agency, BSW, 2017

Potential annual income with PV storage in 2017

Based on 250 storage cycles per year and 0.08€ value per stored kWh for industrial, 0.16€ for private – value rising every year

Potential annual income for PV storage for the year 2020

(in EUR per Usable kWh, based on Feed-in tariffs and electricity prices in 2020)



*Industrial: FIT: **10 ct./kWh**, Electricity price**: 20 ct./kWh**, Storage system efficiency: 85% => Value per stored kWh = 20 ct./kWh – (10 ct./kWh / 0.85) = **8.24 ct./kWh***
*Private: FIT: **12 ct./kWh**, Electricity price: 3**0 ct./kWh,** Storage system efficiency: 85% => Value per stored kWh = 30 ct./kWh – (12 ct./kWh / 0.85) = **15.88 ct./kWh***

New electricity tariff models for Prosumers

New tariff and service models for PV/Storage clouds emerging

ESS Manufacturers

Sonnen
sonnenFlat

DEV
Senec.CLOUD

Caterva
Caterva-Sonne

E3/DC
ZERO

Utilities

Eon
Solar Cloud

ENBW
Solar Plus

Lichtblick
Schwarm-Batterie

Beegy
beegyLIVE

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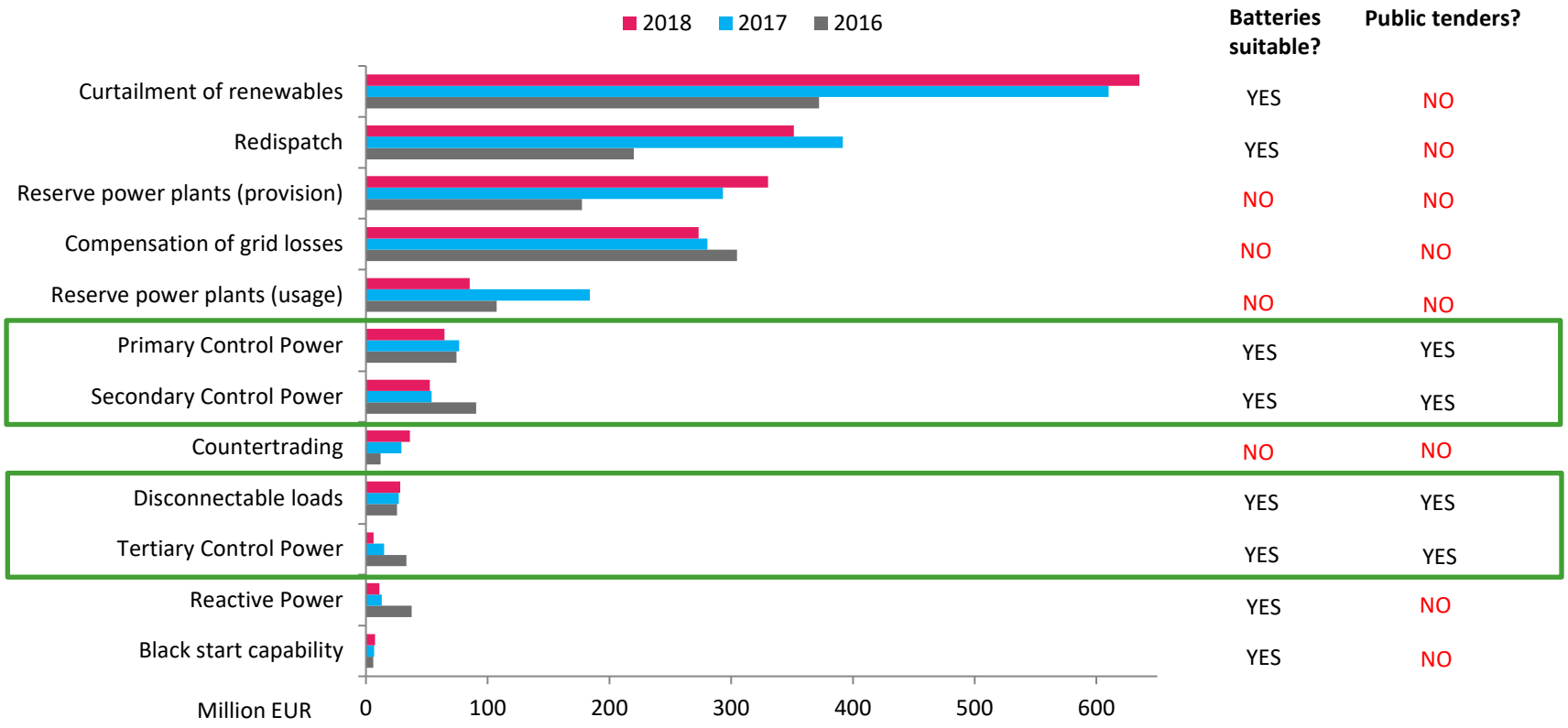
Public tenders for storage to stabilize the grid

Batteries are suitable for 8 out of 12 kinds of grid services. 4 are publicly tendered today. Others are based on bilateral agreements.

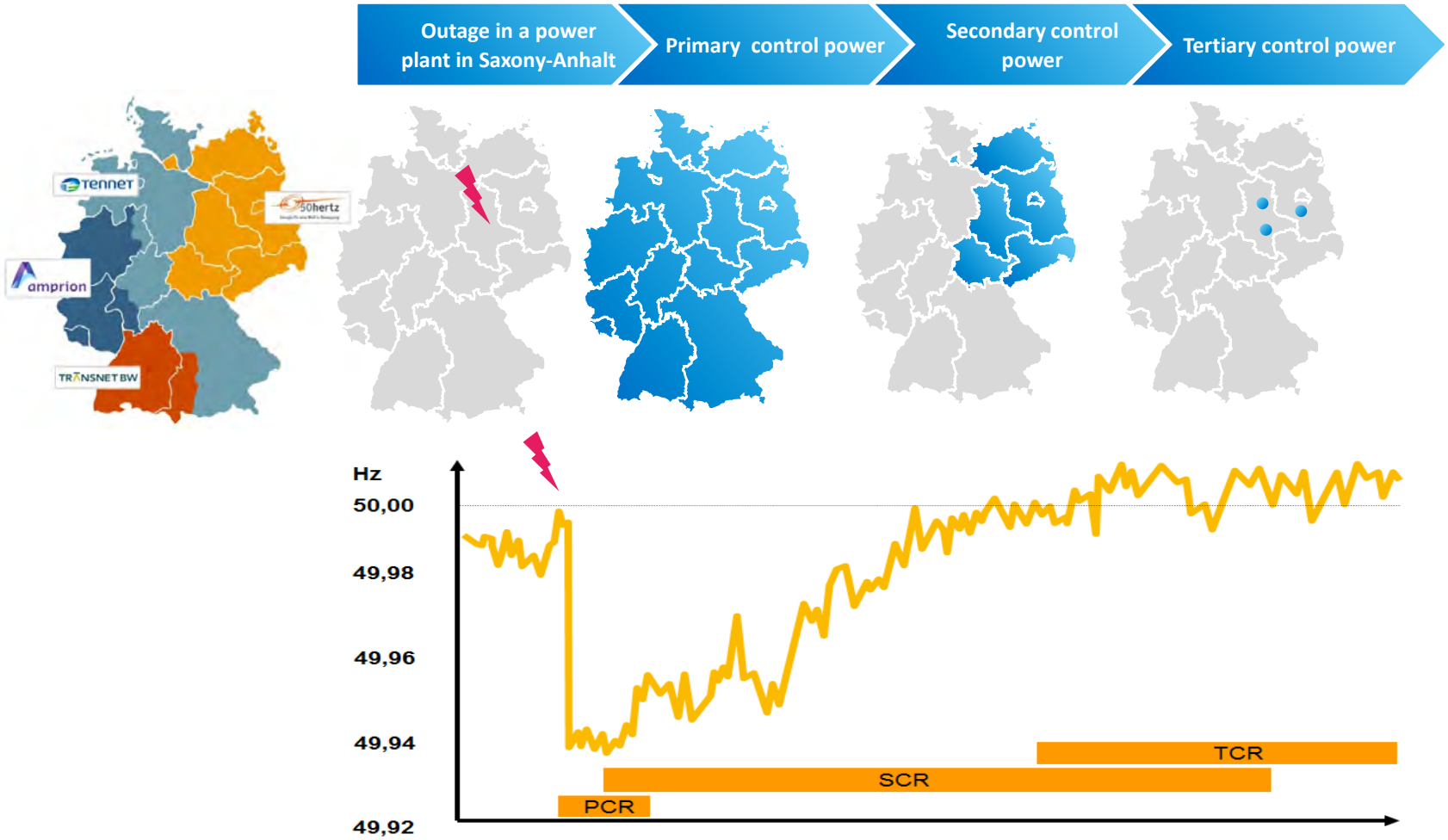
TSO's annual spendings for grid services in Germany



Source: Federal Network Agency 2020

The German Control Power Market

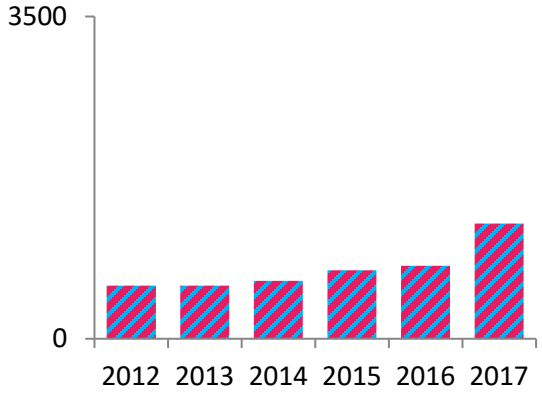
Interaction between primary, secondary and tertiary control power



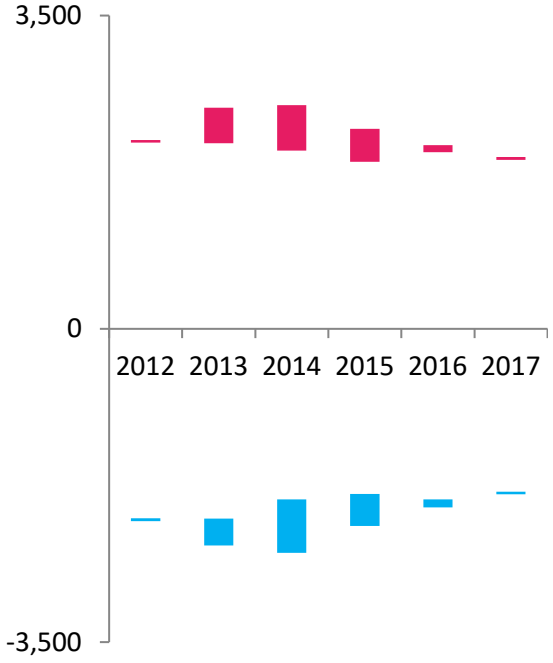
Demand for Control Power

Highest amount of power is required for TCR – Lowest for PCR

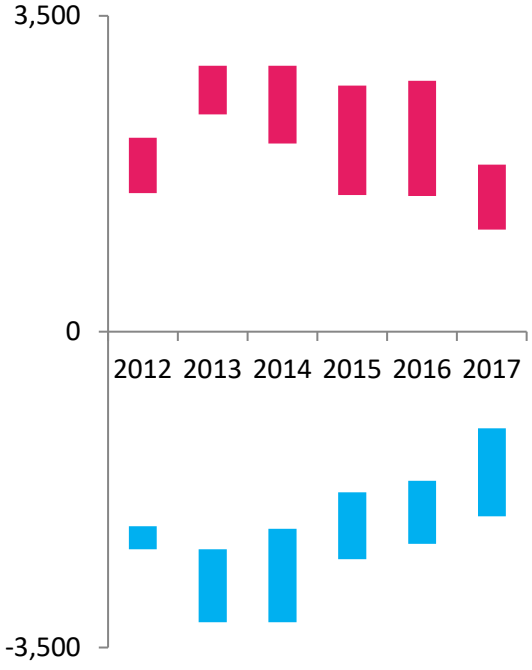
Demand for PCR-power*
(in MW)



Demand for SCR-power
(in MW)



Demand for TCR-power
(in MW)

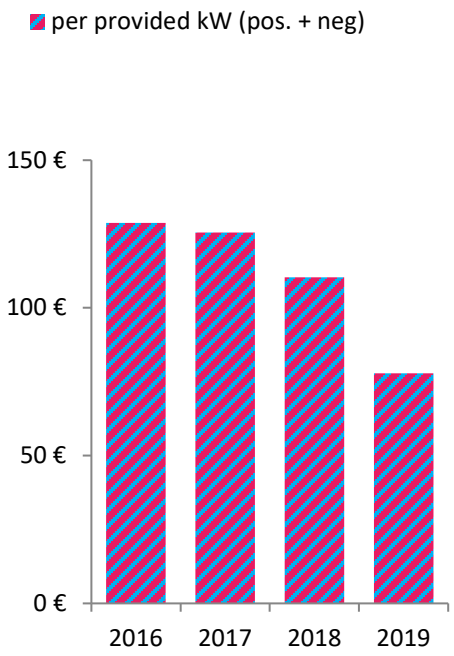


*Source: Federal Network Agency 2020 *in the coupled European markets Germany, Austria, Switzerland, The Netherlands, Belgium and France*

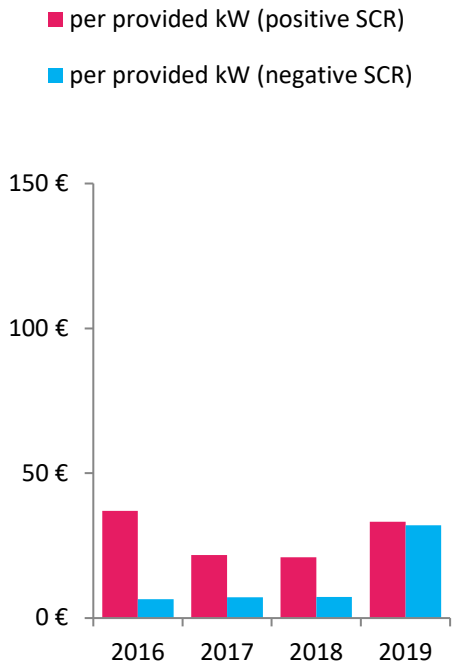
Prices for Control Power – in € per kW

Highest average power prices for PCR – Lowest for TCR

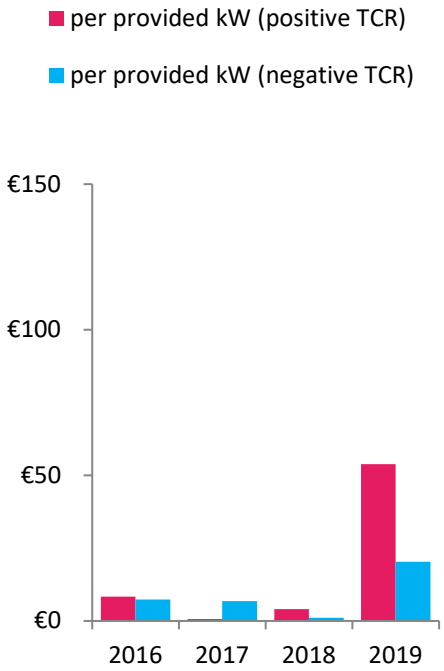
Annual income for PCR-power*
(in € per kW p.a.)



Annual income for SCR-power*
(in € per kW p.a.)



Annual income for TCR-power*
(in € per kW p.a.)

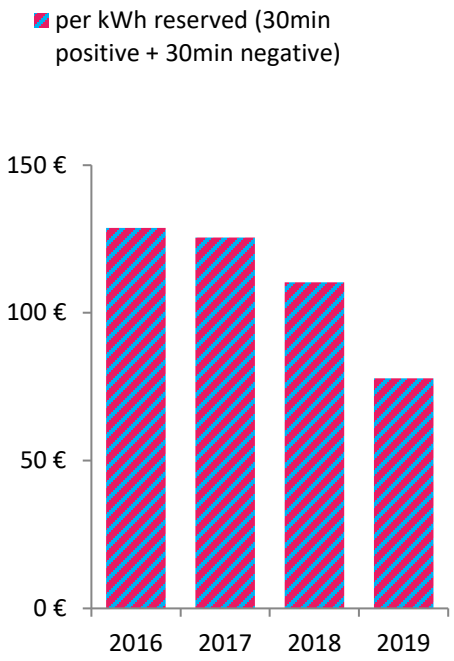


*Source: regelleistung.net, 2020. *Based on average prices of all tenders during respective year*

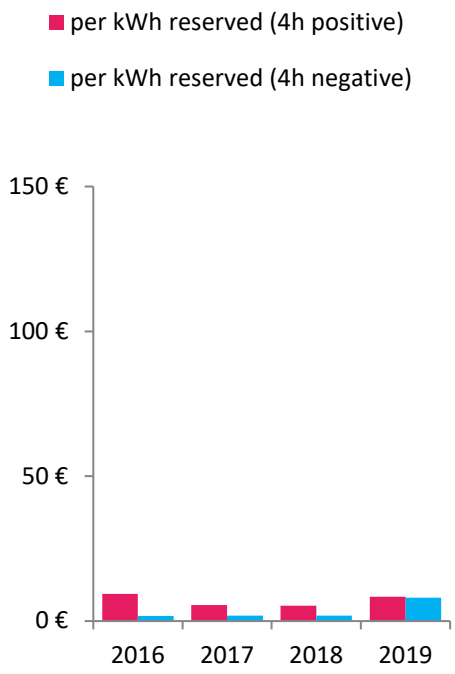
Prices for Control Power – in € per required kWh

PCR requires 30 min of capacity, positive AND negative.
SCR and TCR require 4 hours of capacity, either positive or negative.

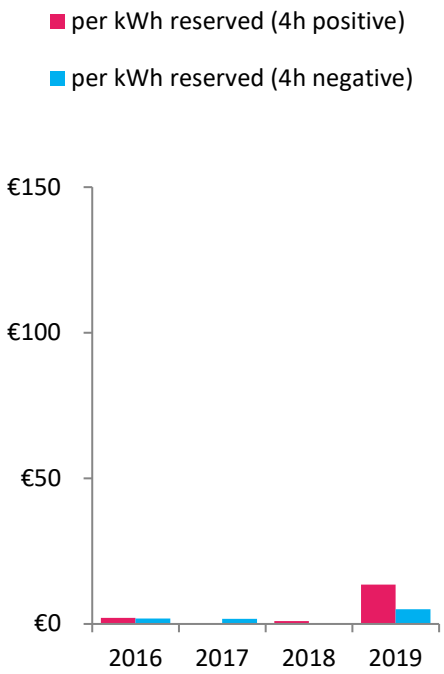
Annual income for PCR-power*
(in € per kWh required capacity)



Annual income for SCR-power*
(in € per kWh required capacity)



Annual income for TCR-power*
(in € per kWh required capacity)

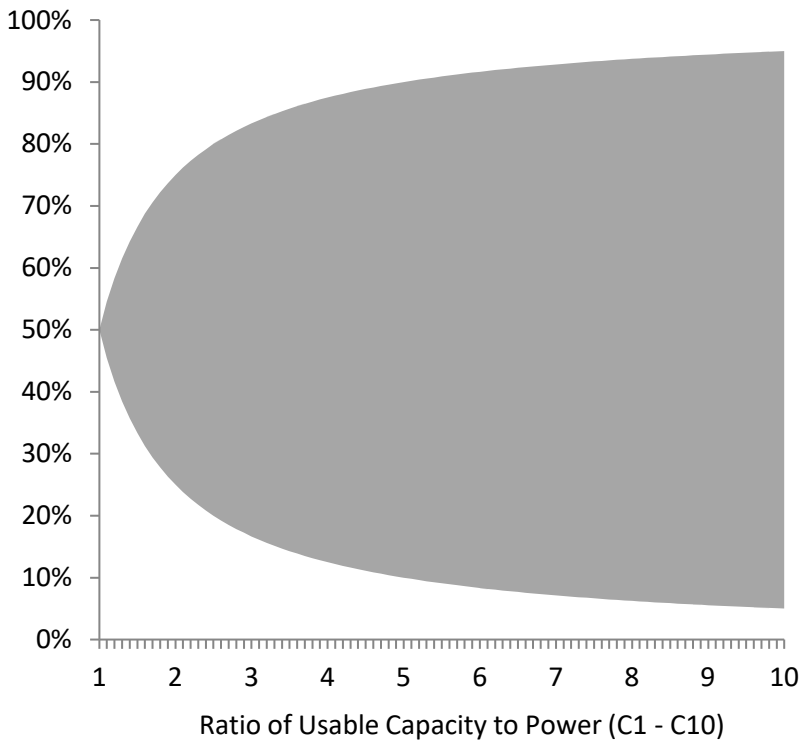


*Source: regelleistung.net, 2020. *Based on average prices of all tenders during respective year*

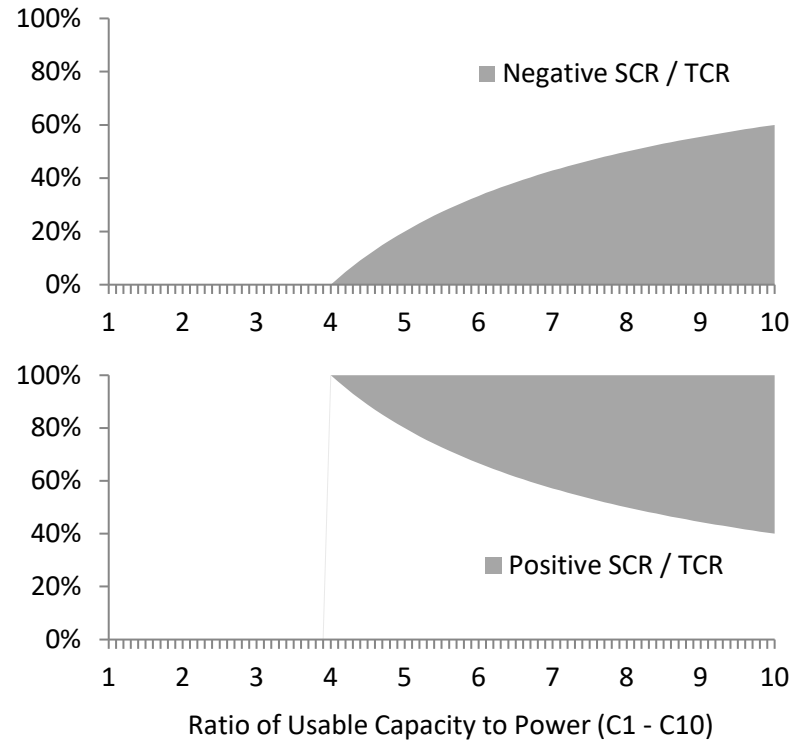
Capacity requirements for PCR vs. SCR and TCR

PCR requires 30 min of capacity, positive AND negative.
SCR and TCR require 4 hours of capacity, either positive or negative.

Potential Operating range for a Battery in PCR
(% State of Charge, based on Usable Capacity)



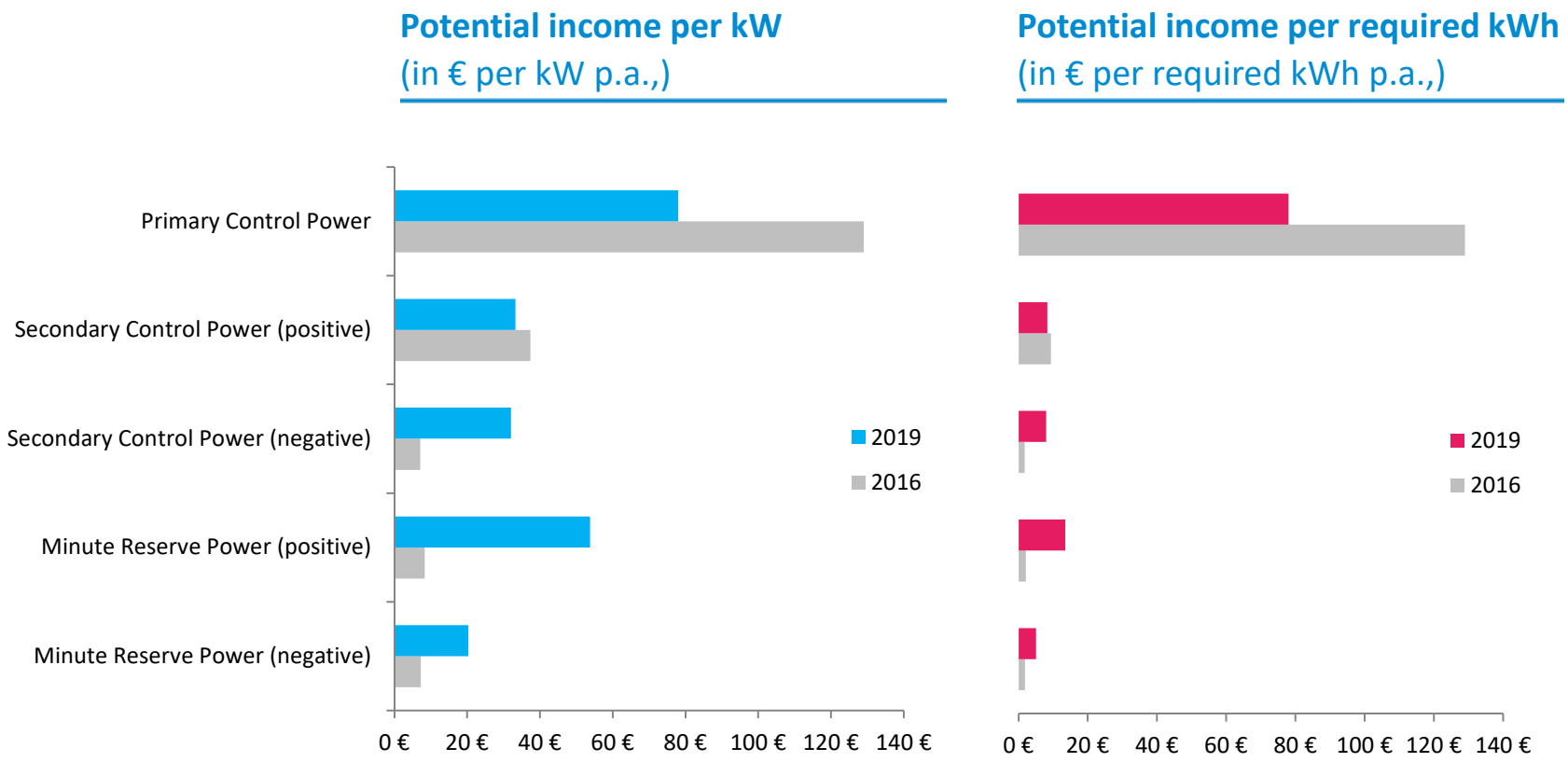
Pot. Operating range for a Battery in SCR / TCR
(% State of Charge, based on Usable Capacity)



Source: regelleistung.net

Potential income providing Control Power

PCR and Disconnectable loads provide same income per kW and kWh. SCR and TCR get 4 times more income per kW, than per kWh capacity.



*Source: regelleistung.net, 2020. *Based on average prices of all tenders during respective year*

Intro Battery Market

Private applications

Grid applications

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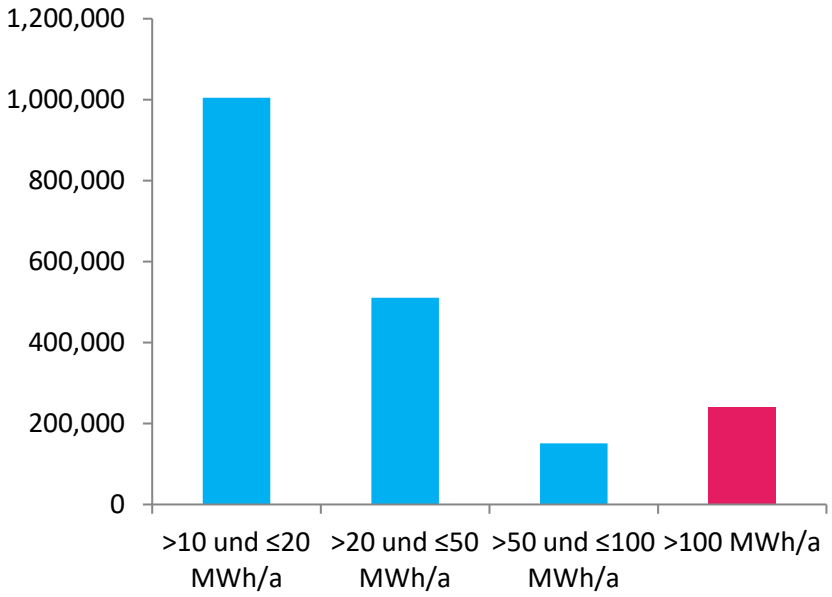
Smart EV Charging

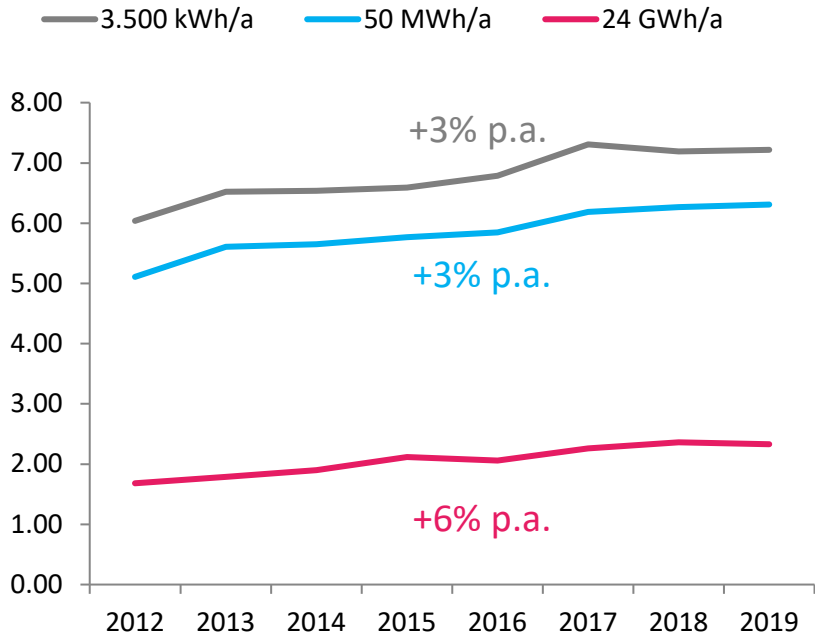
Development of grid fees in Germany

Grid fees have been increasing 4-7% p.a. on average since 2011. Energy storage systems can help industry reduce these costs.

Industrial electricity consumers
(Number of metering points, 2019)



Development of grid fees
(EURct. per kWh)

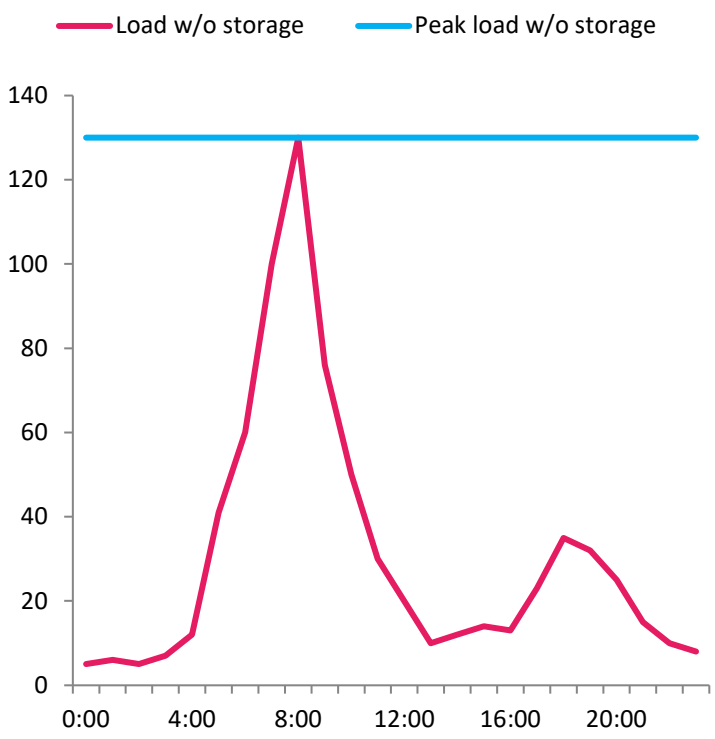


Source: Federal Network Agency 2017

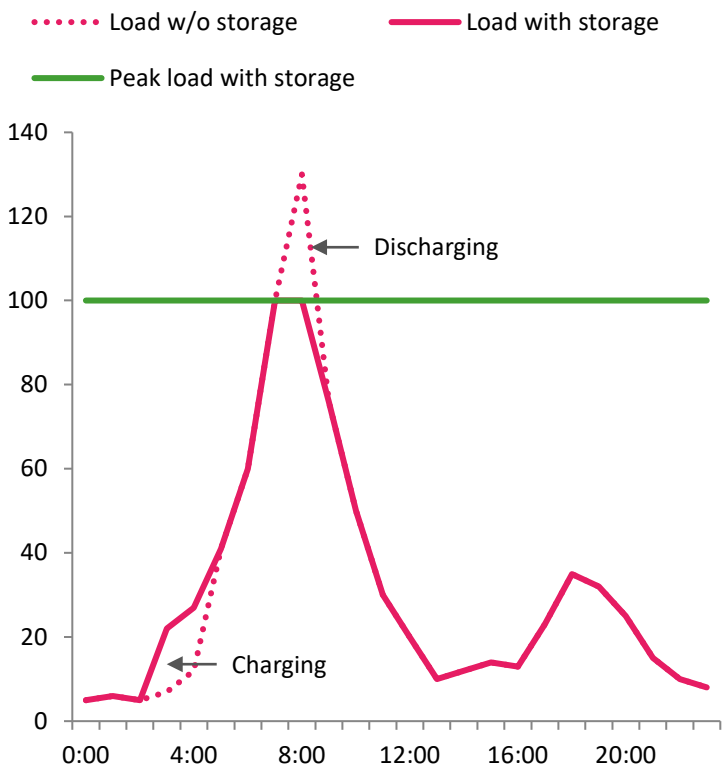
Reducing grid fees by: Peak shaving

Power prices are part of a company's grid fees. They range between **20 and 100+ € per kW**, depending on region / DSO.

Example: Load profile of a milking business
(in kW)



Cutting peak by 30 kW / 30 kWh storage
(in kW)



Reducing grid fees by: Increasing "Usage hours"

Annual Usage hours = Annual energy consumption / Annual peak power

⇨ High usage hours are rewarded by lower grid fees

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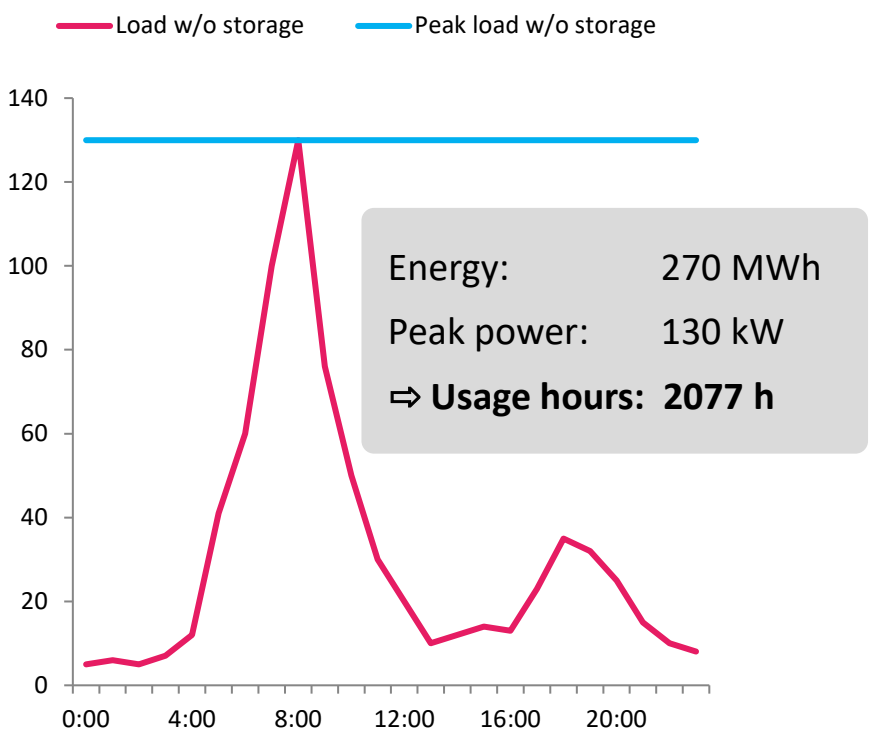

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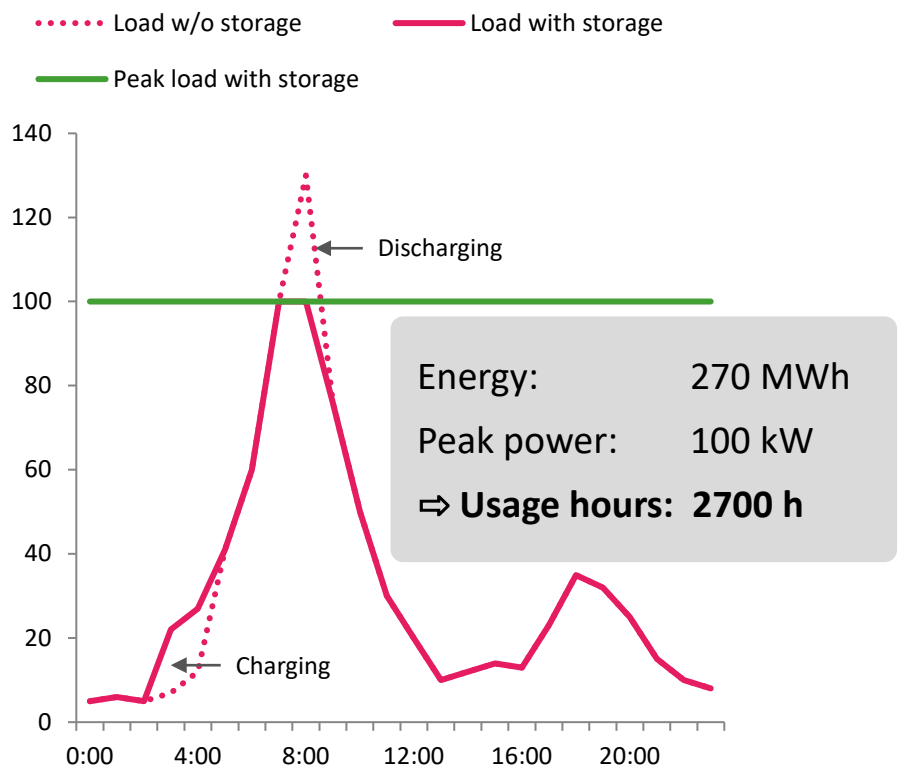

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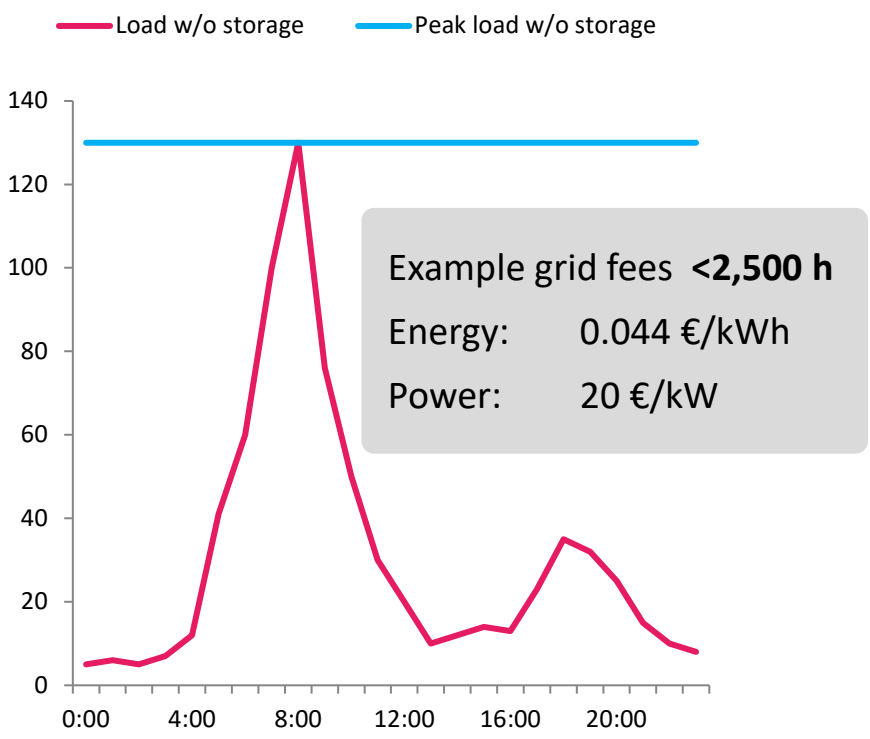

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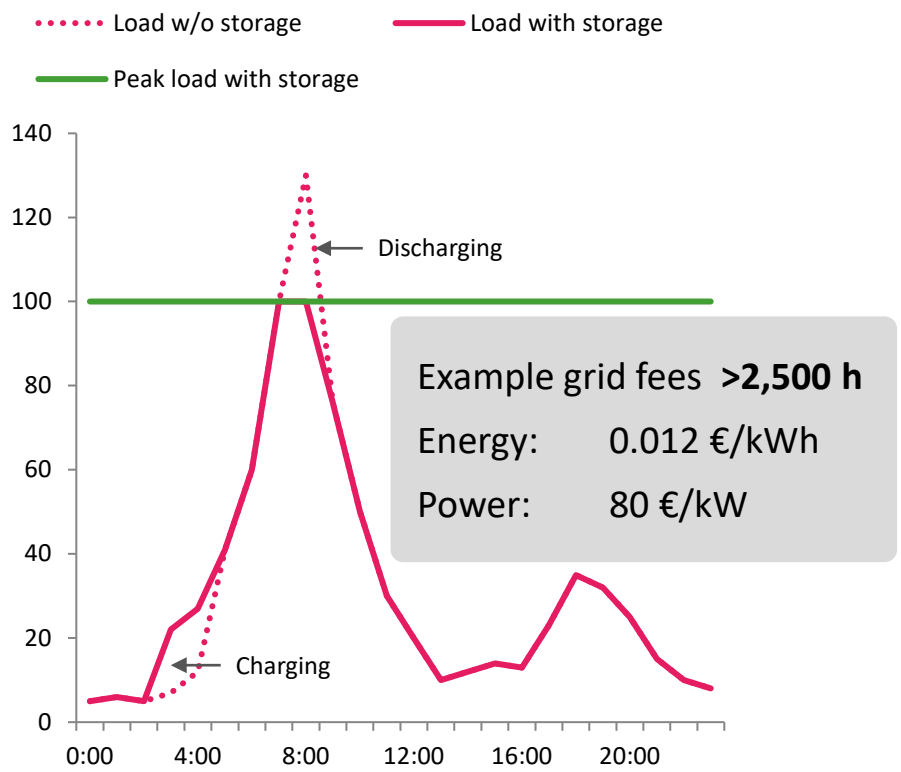

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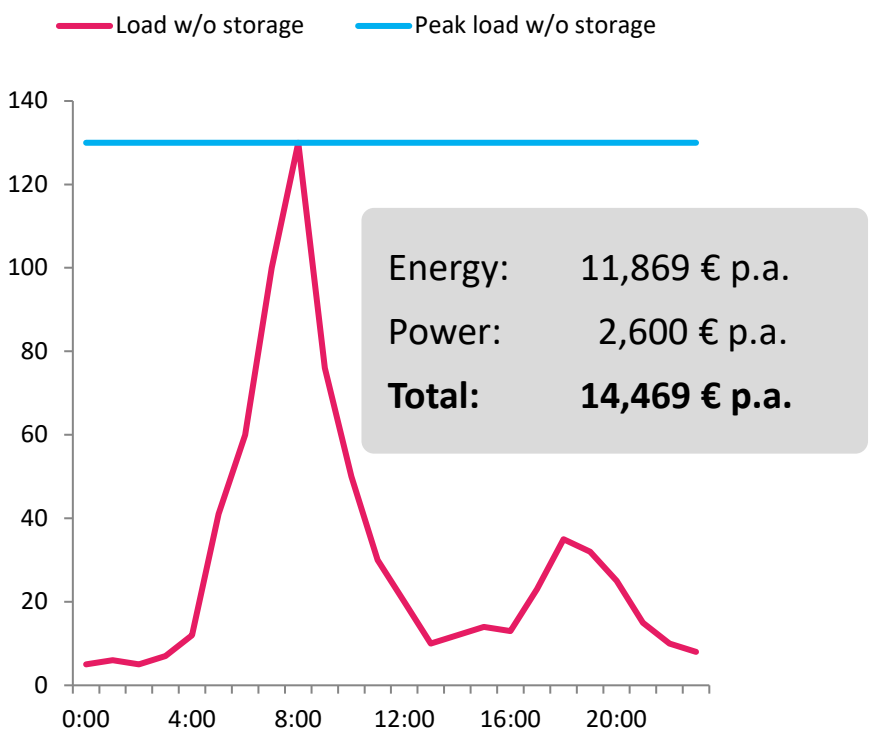

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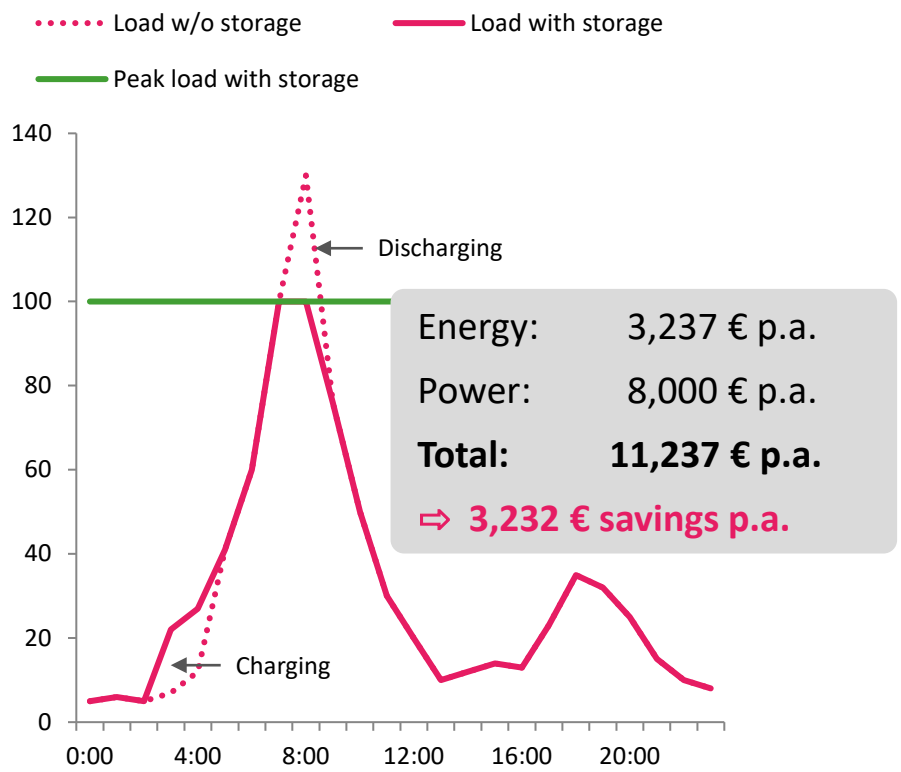
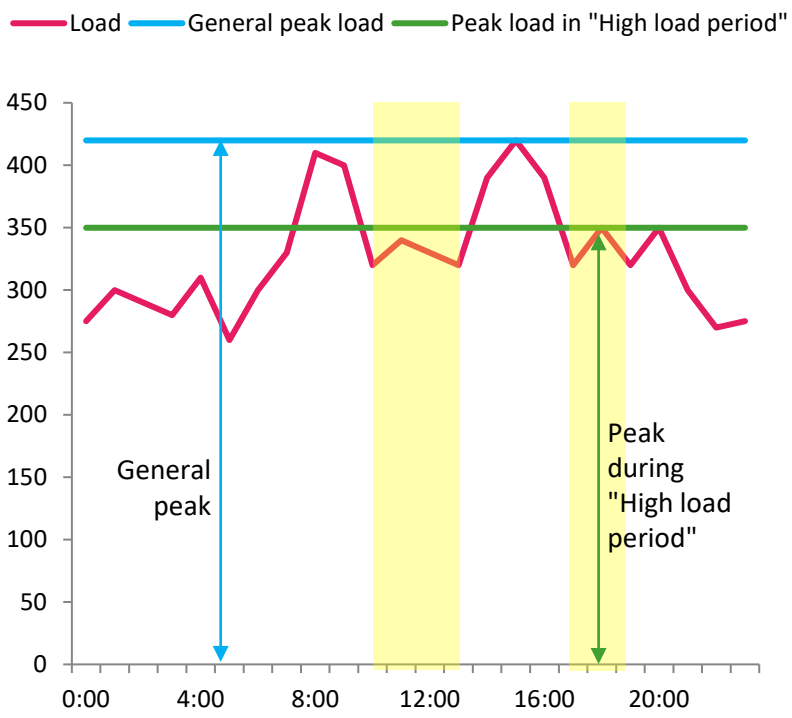


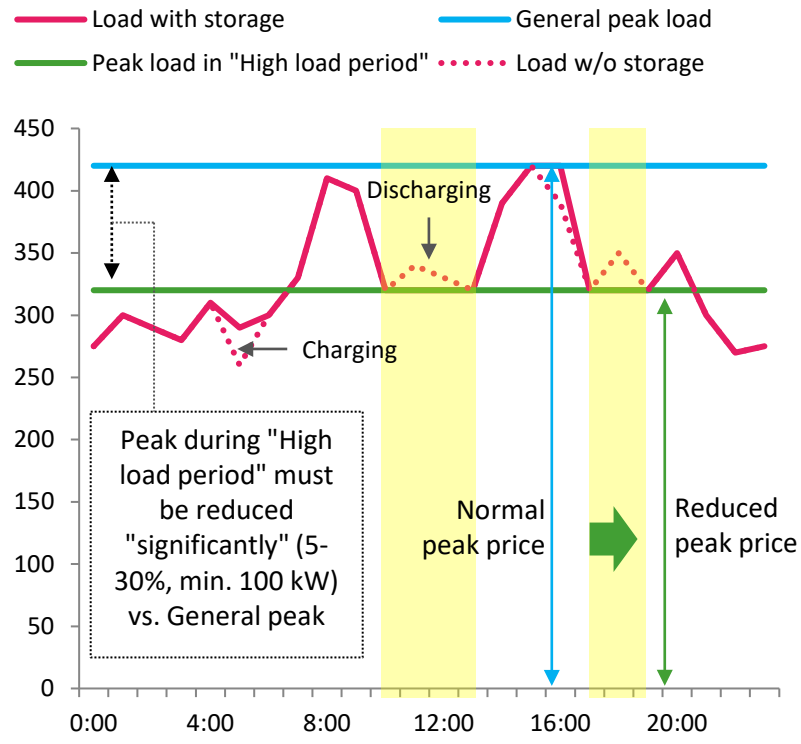
Reducing grid fees by: Load shifting

"Atypical grid usage" allows the reduction of grid fees up to 80%

Example: Load profile of a molding business
(in kW)



Shifting load by 30 kW / 30 kWh storage
(in kW)



Source: Federal Network Agency, September 2011:
Leitfaden zur Genehmigung von individuellen Netzentgelten nach § 19, Abs. 2 S. 1 StromNEV und von Befreiungen von den Netzentgelten nach § 19 Abs. 2 S. 2 StromNEV

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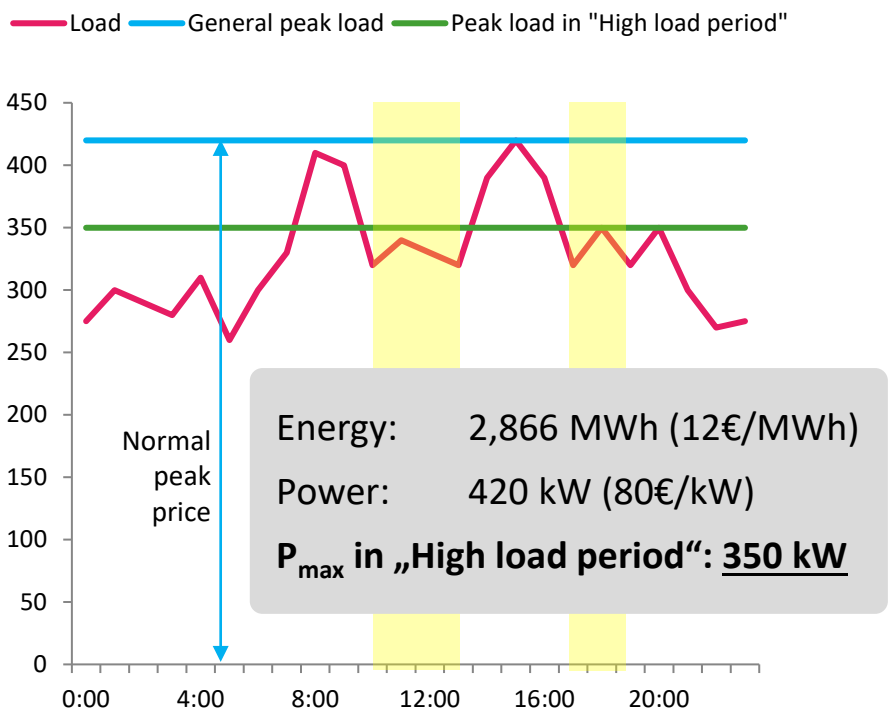

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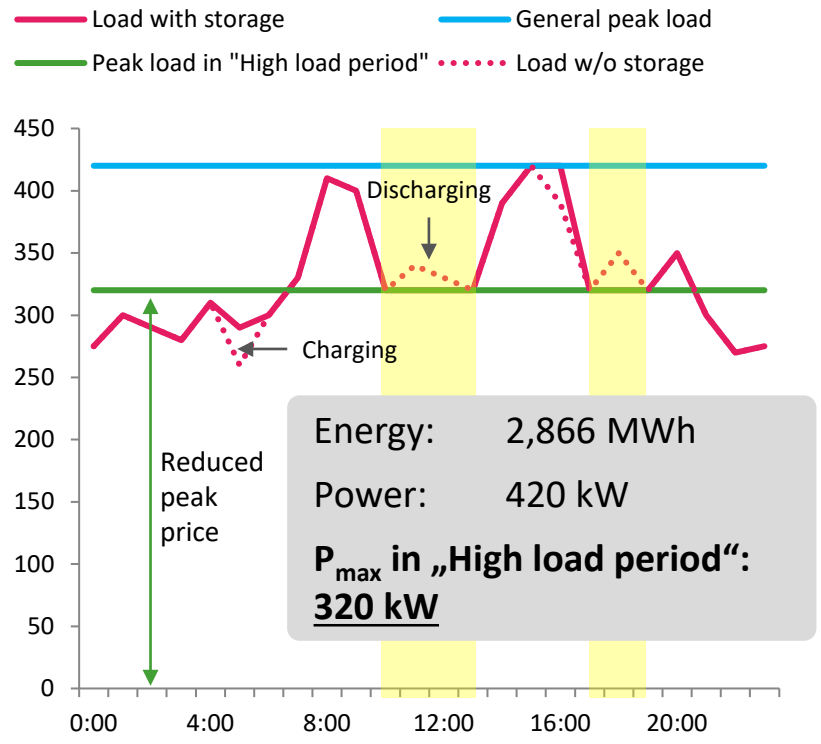

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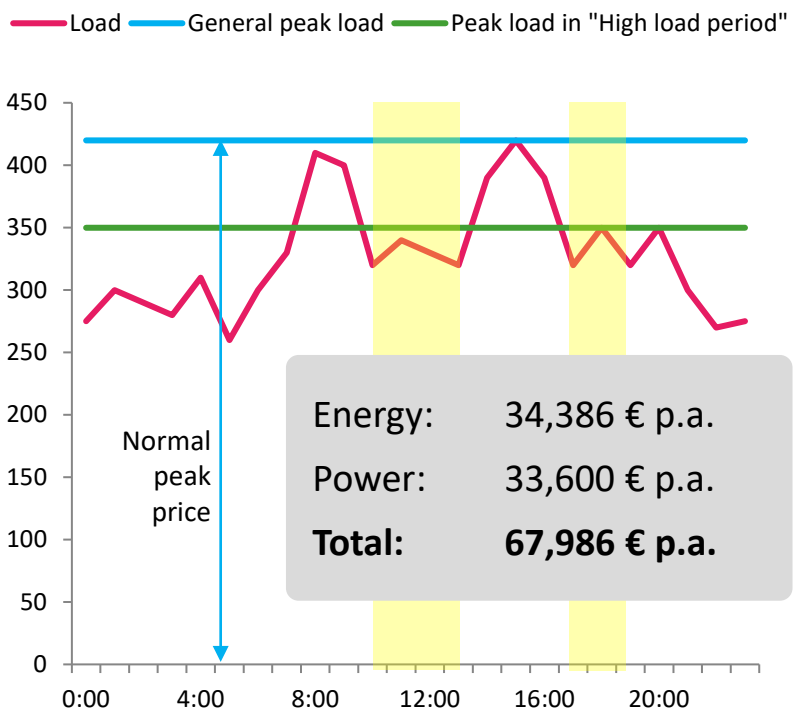
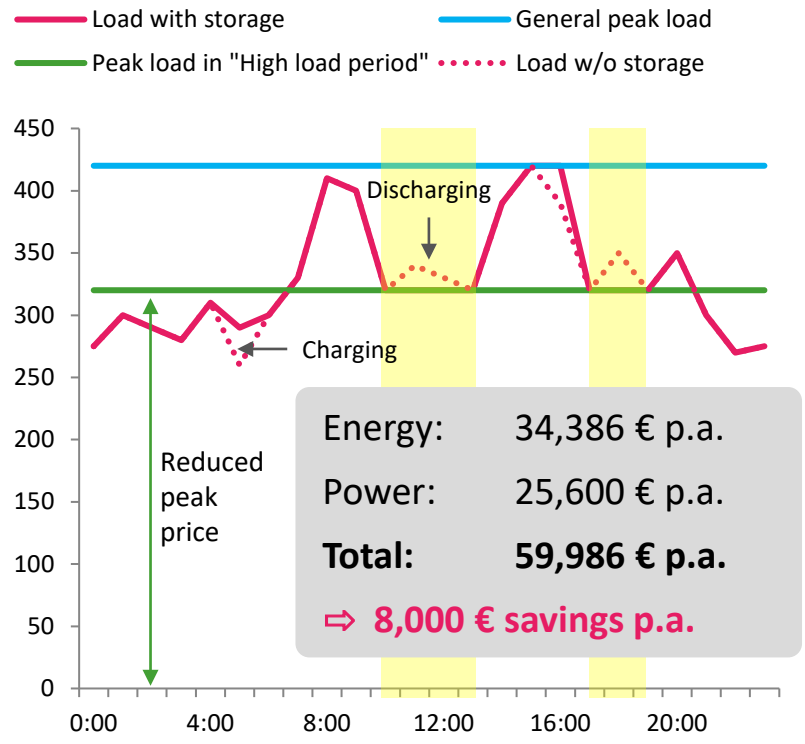
Example: Load profile of a molding business
(in kW)



Shifting load by 30 kW / 30 kWh storage
(in kW)

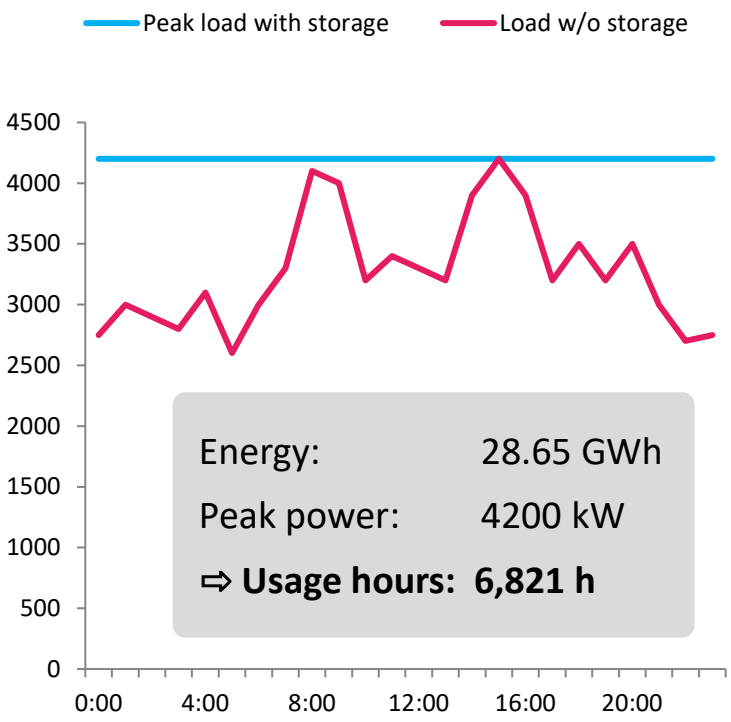


Source: Federal Network Agency, September 2011:
Leitfaden zur Genehmigung von individuellen Netzentgelten nach § 19, Abs. 2 S. 1 StromNEV und von Befreiungen von den Netzentgelten nach § 19 Abs. 2 S. 2 StromNEV

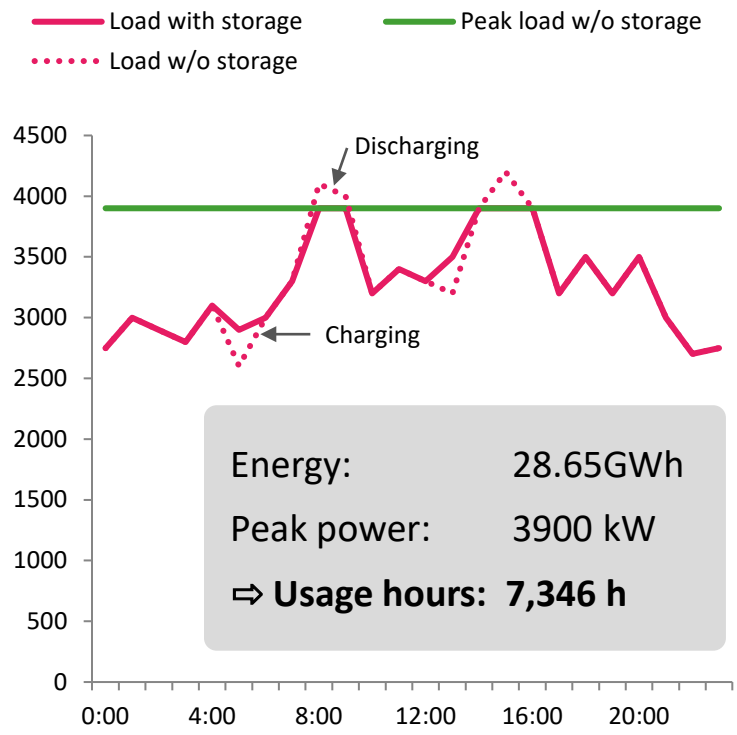
Reducing grid fees by: Increasing "Usage hours" II

"Energy intensive consumers" (> 10 GWh/a) can further reduce grid fees up to 80%, in case they reach more than 7,000 usage hours p.a.

Example: Load profile of a (big) molding corp.
(in kW)



Cutting peak by 300 kW / 300 kWh storage
(in kW)

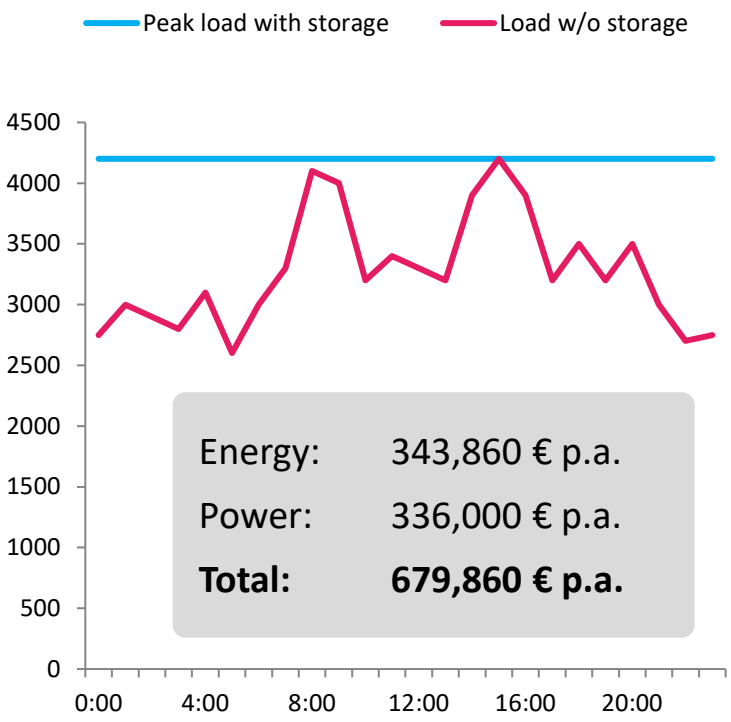


Source: Stromnetzentgeltverordnung („StromNEV"), §19, Abs. 2, S. 2 & 3

Reducing grid fees by: Increasing "Usage hours" II

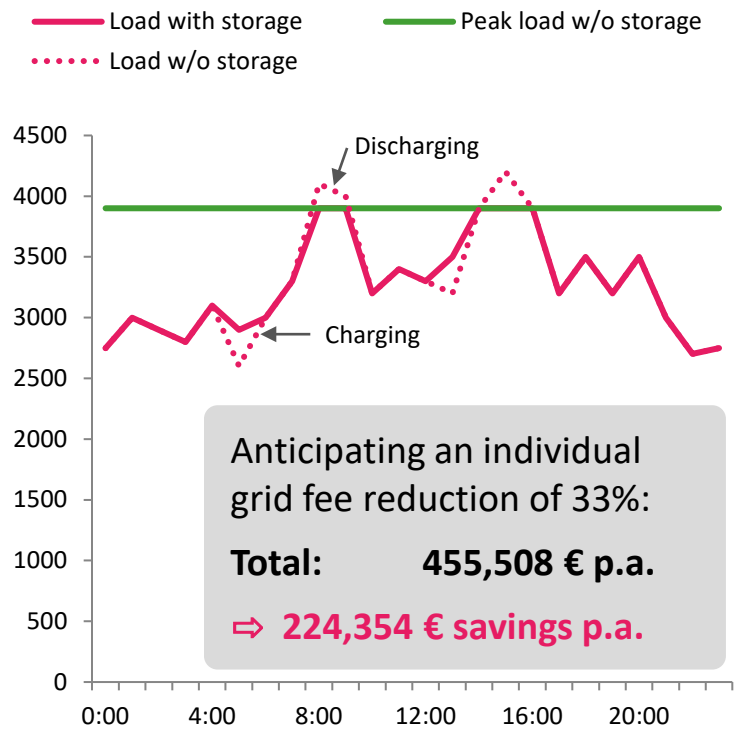
"Energy intensive consumers" (> 10 GWh/a) can further reduce grid fees up to 80%, in case they reach more than 7,000 usage hours p.a.

Example: Load profile of a (big) molding corp.
(in kW)



Energy:	343,860 € p.a.
Power:	336,000 € p.a.
Total:	**679,860 € p.a.**

Cutting peak by 300 kW / 300 kWh storage
(in kW)



Anticipating an individual grid fee reduction of 33%:

Total: 455,508 € p.a.

⇨ **224,354 € savings p.a.**

Source: Stromnetzentgeltverordnung („StromNEV"), §19, Abs. 2, S. 2 & 3

Intro Battery Market

Private applications

Grid applications

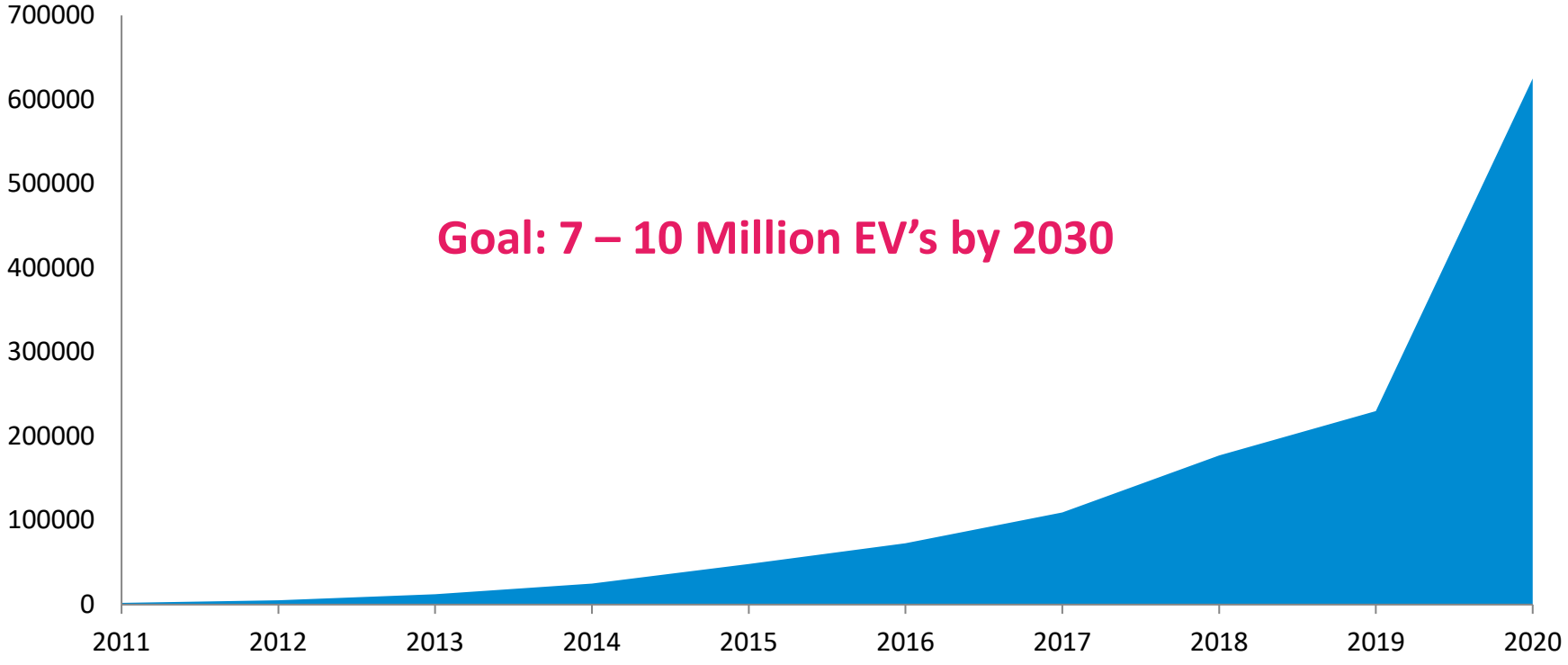
Industrial applications

Smart EV Charging

EV development in Germany

2020: Market break-through for PHEV + BEV in Germany

Electric vehicles (PHEV + BEV)
(Number of units, 2011 – 2020)

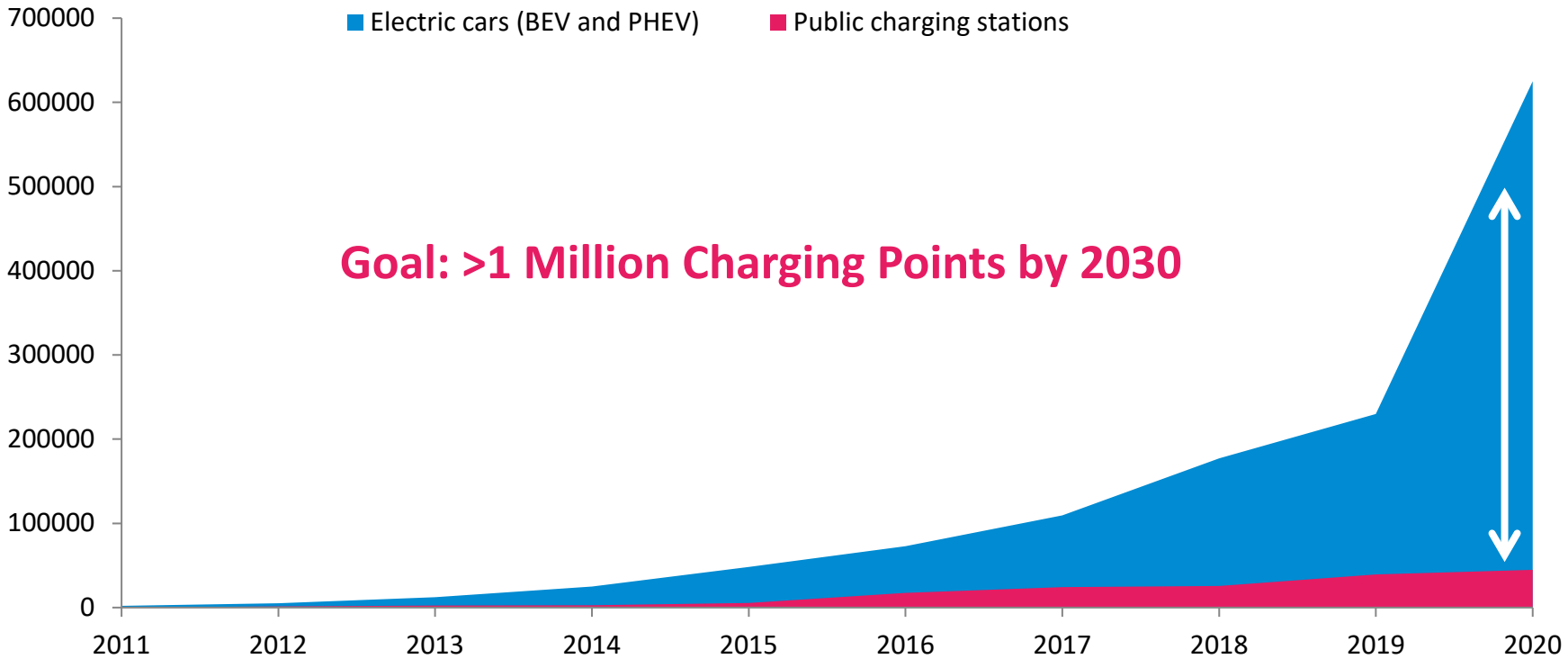


Sources: IEA 019, KBA 2021

EV Charging Infrastructure

Growth in the EV market causes demand for charging stations – potentially equipped with batteries and smart grid technologies

Electric vehicles (PHEV + BEV) vs. public charging stations
(Number of units, 2011 – 2020)



Sources: IEA 019, KBA 2021, EAFO 2021

Vehicle-to-Grid: new standards on the way

2018: First Nissan Leaf got prequalified for primary control power.
2020: General V2G communication standards under development.

Co-Project by

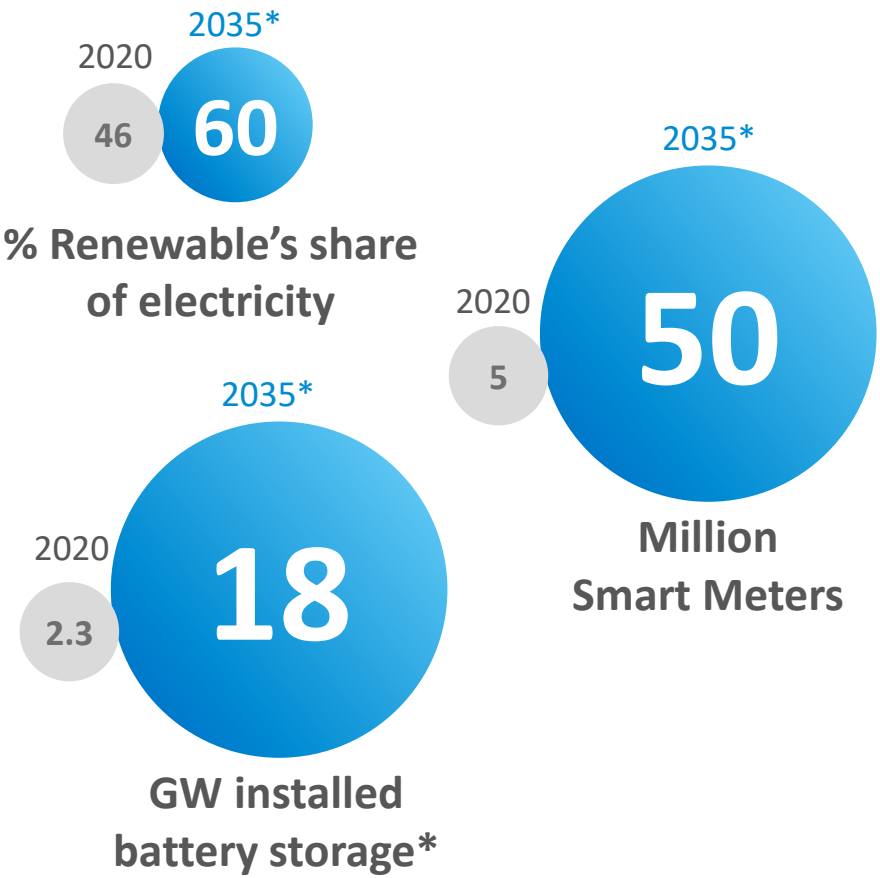
- The Mobility House (energy management technology)
- ENERVIE (energy supplier)
- Amprion (transmission system operator)
- Nissan (V2G vehicle)

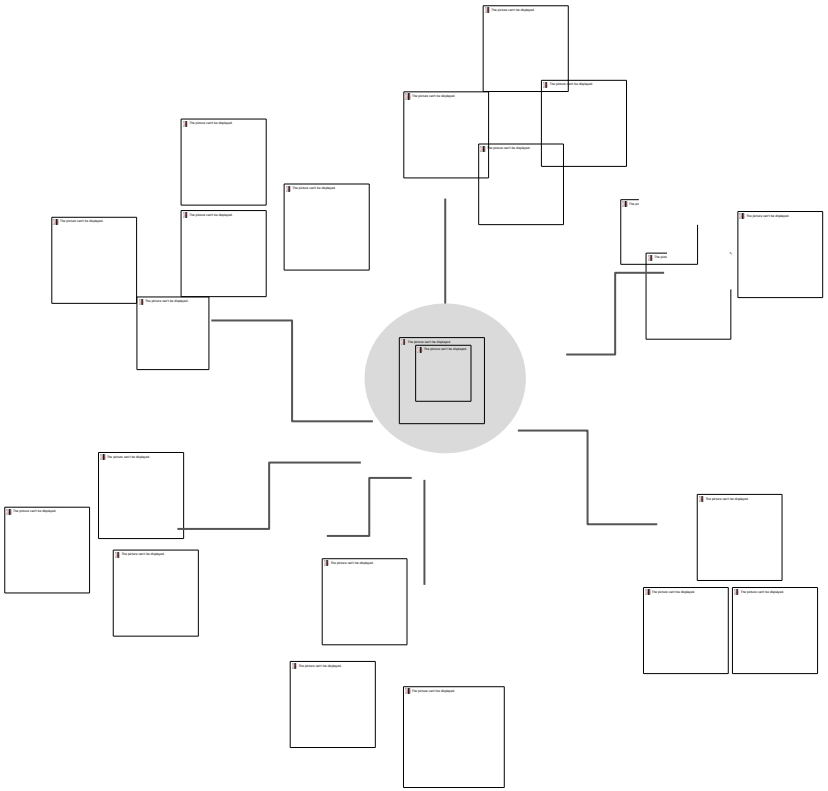
Source: Nissan, Oct. 2018

SUMMARY

Smart Cities: Boosting the Energy Transition

Smart meters and flexible consumption will allow more usage of Renewables

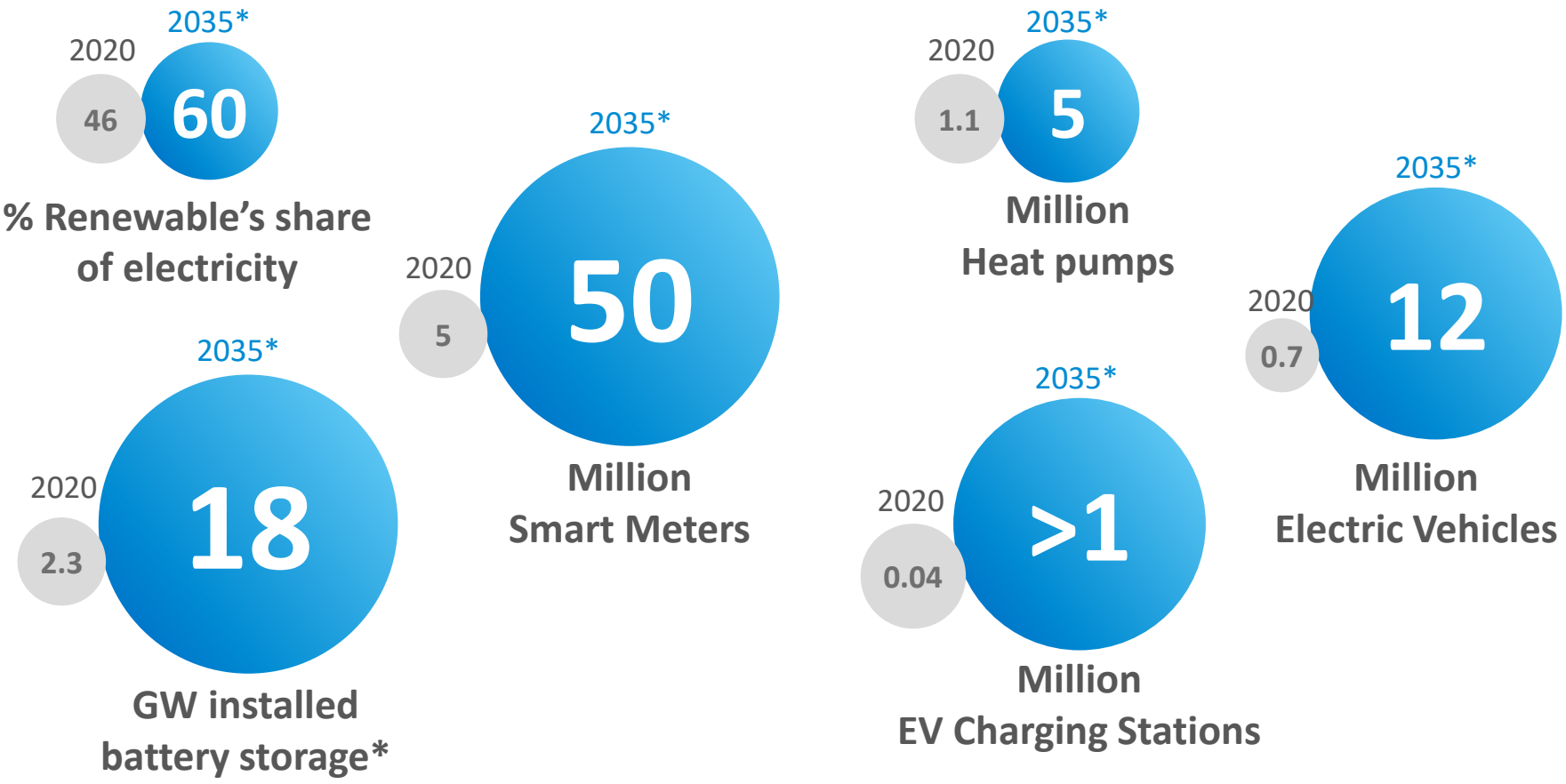




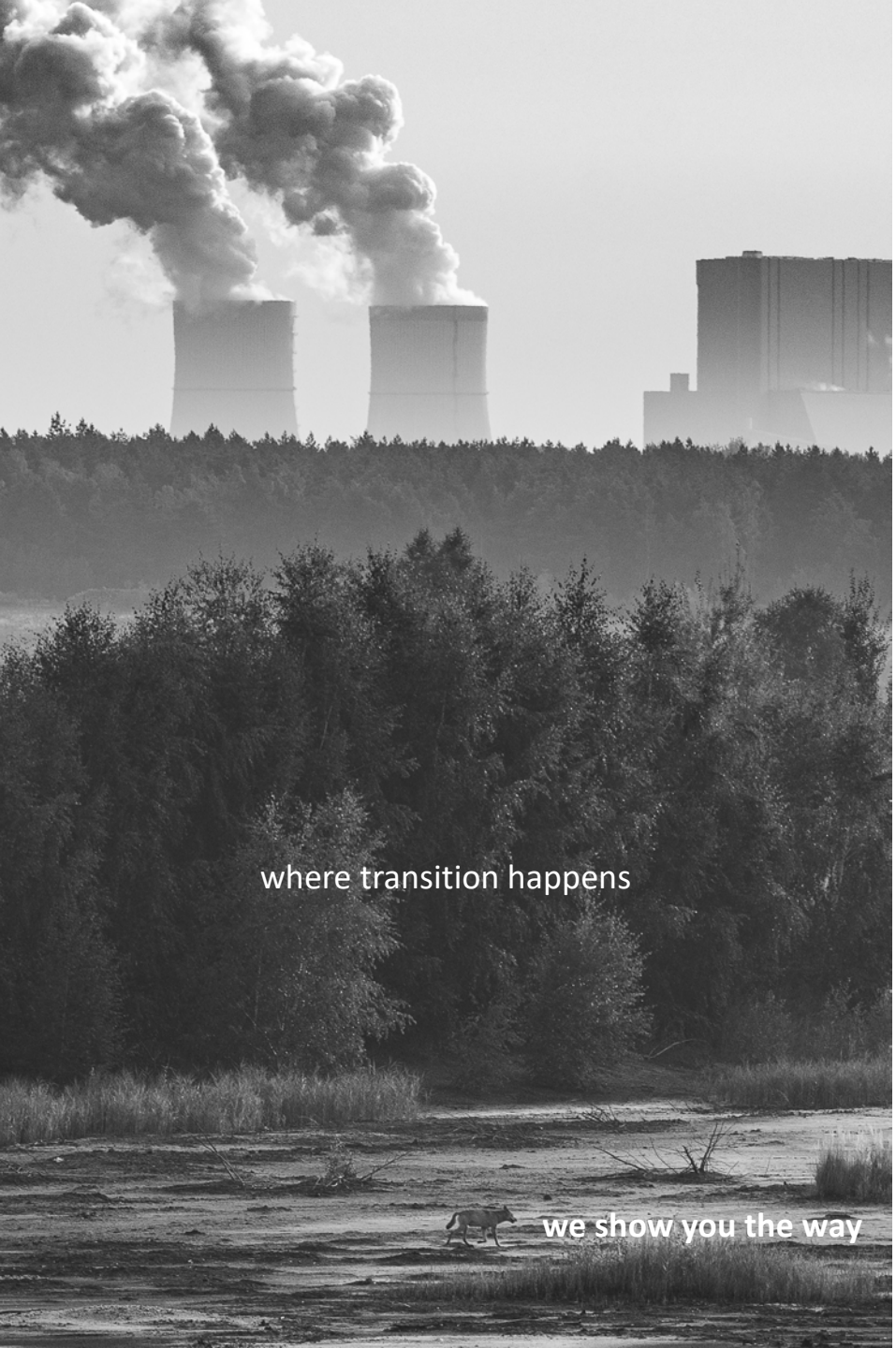
Source: BNetzA, 20201 Prognosis Scenario B Netzentwicklungsplan; Graph: GTAI*

Smart Cities: Boosting the Energy Transition

Smart energy distribution enables coupling renewables with transport and heating



Source: BNetzA, 20201 Prognosis Scenario B Netzentwicklungsplan; Graph: GTAI*



GTAI supports international companies entering German market:

- Deep info on your market an entry strategy support
- Screening funding and financing options
- Finding the best location for your requirements support
- Tax and legal info for smooth applications and quick setup

Free of charge

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Germany Trade & Invest is the economic development agency of the Federal Republic of Germany. The company helps create and secure extra employment opportunities, strengthening Germany as a business location. With more than 50 offices in Germany and abroad and its network of partners throughout the world, Germany Trade & Invest supports German companies setting up in foreign markets, promotes Germany as a business location and assists foreign companies setting up in Germany.

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