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Energy Storage Technologies in Germany

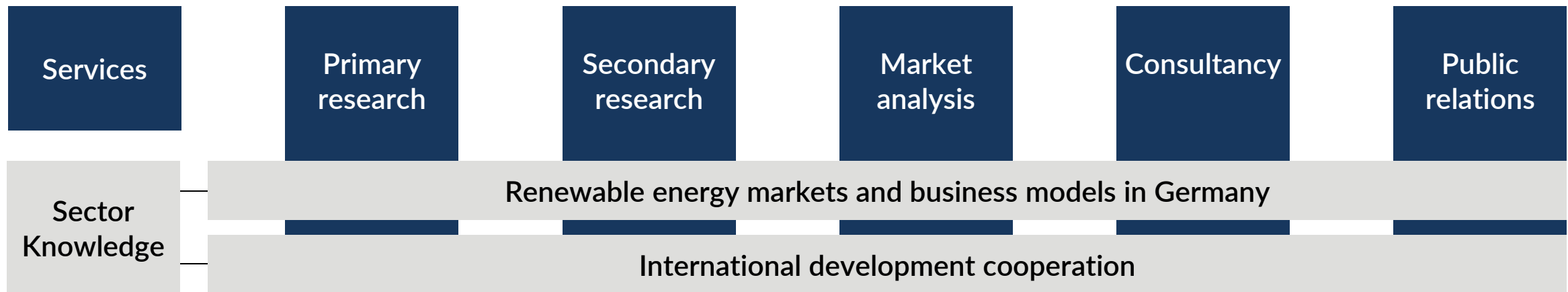
Germany and Taiwan – Energy Transition Forum

8 December 2016 // Taipei

Büro F does market analyses and consultancy on new business models in distributed power markets

Portfolio

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References



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Energy Storage Technologies in Germany

Relevance

Technologies

Home storage

Large-scale storage

Smart grid business models

2015 expert survey on the future of the energy industry with a special focus on distributed generation

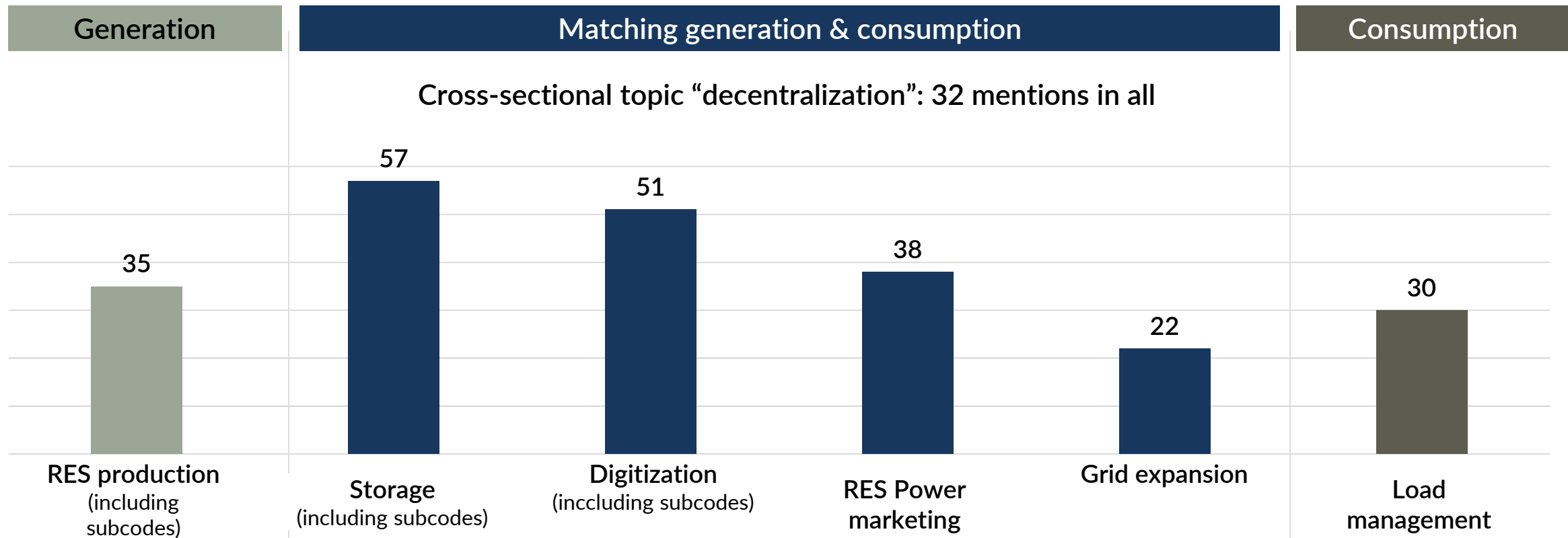
Expert survey in summer 2015 (n=42)

1. What are the most important trends in the energy sector in Germany 2015-2020?
2. What are the most important new technical solutions?
3. What are the new, interesting business models?



The most commonly mentioned categories refer to the matching of generation & consumption

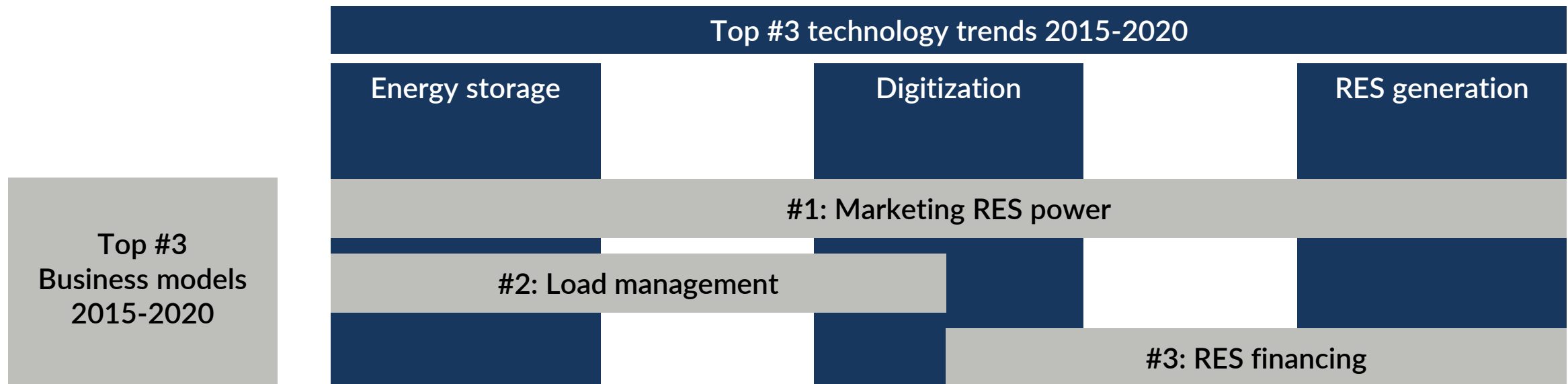
Overview of the expert statements according to categories (“codes”, entire survey)



n=42, Multiple sampling. Presentation of the answers, categorized in codes, to open-ended questions on trends, technical solutions and business models. Presentation of codes mentioned more than 20 times, including subcodes.

In a nutshell: Energy storage and digitization are the basis for new RES power marketing

The most important technical solutions & new business models according to the survey



The business models were assigned to the trends according to associative proximity in the expert statements. Load management was mentioned most frequently in connection with energy storage units, and financial solutions in connection with RES production (Code Relations).

Storage is the missing link of the energy transition

Storage in the power market

Power grids match generation and demand **geographically**.

Storage systems match generation and demand **temporally**.

In order to meet the rather **rigid demand**, **intermittent renewable energy generation** requires storage capacities.

Storage systems will become the **fourth pillar of the power system** – complementing generation, transmission/distribution and consumption.



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Different storage technologies exist for different use-cases – momentum is highest with lithium battery storage

Examples for storage system applications

	Short-term storage <30 minutes	Daily storage 1-5 hours	Long-term storage Weeks & months
Modular storage systems with a <u>double benefit</u> 1 kW – 1 MW	mobile storage (e-mobility, lithium) 	home storage + PV 	
Modular storage systems 1 kW – 100 MW	stationary storage (lithium/lead-acid) 	stationary storage (e.g. redox-flow batteries)	
Central storage systems 100 MW – 1 GW		pumped storage ("P2K"?) 	<ul style="list-style-type: none"> gas caverns (P2G) heat storage (P2H) fuel tanks (P2L)

Battery storage:
 "Power to power"
 Electric energy is converted, stored and reconverted.

Other storage:
 "Power to X"
 Electric energy is converted into storable energy.

Different generators match different storage technologies

Examples of energy storage technologies in relation to different scales of electricity generation



Wind power

Photovoltaics

220/380 kV

110 kV

10/20 kV

400 V

pumped storage
P2G/hydrogen
compressed air

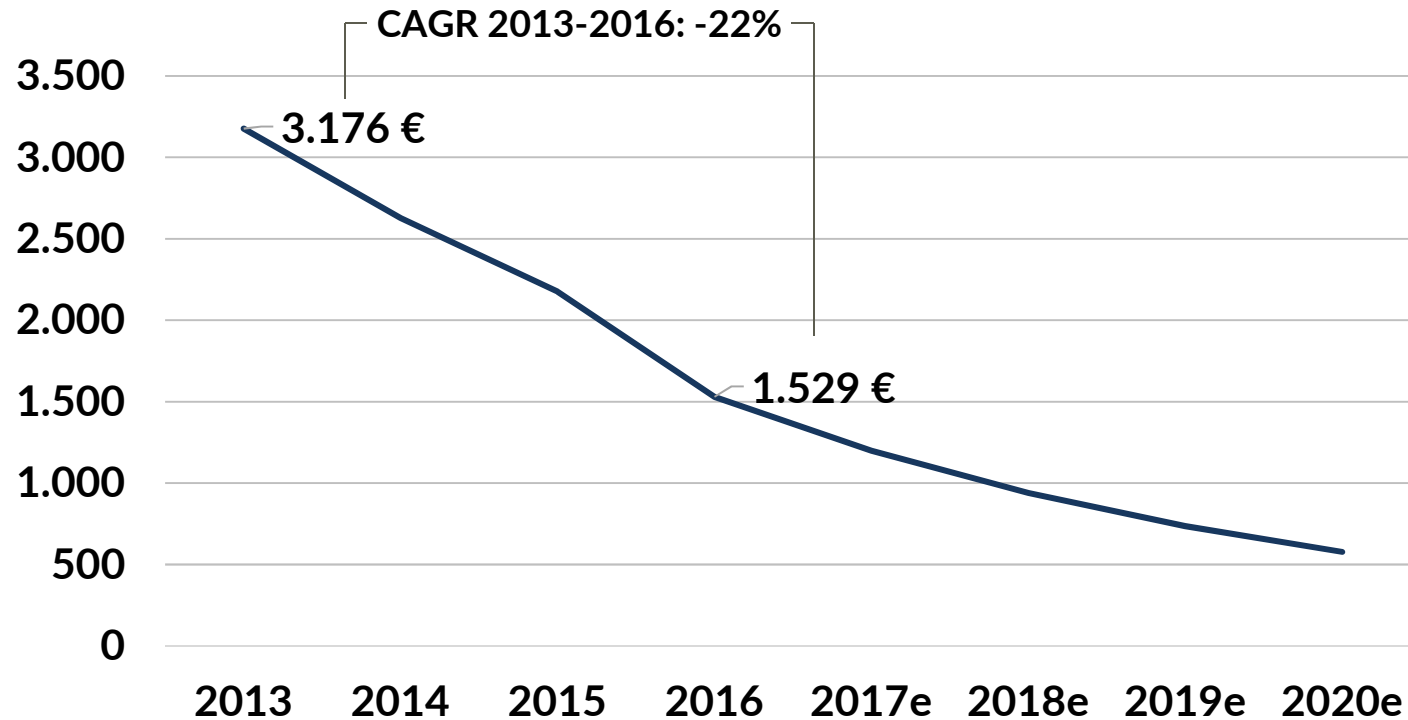
P2X
demand side management

large-scale batteries
demand side management
P2X?

home battery storage
electric vehicles

Strong price decline for lithium battery storage systems in Germany

Price development per kWh usable capacity for lithium home storage systems <5kW capacity in Germany



Based on the scientific storage monitoring of RWTH Aachen, average CAGR 2013-2016 is around -18%.

Between May and October 2016, end customer prices declined by 5%, according to the Büro F storage price index.

1. Different technologies for different applications exist.
2. Price decline is strongest at lithium battery storage systems.



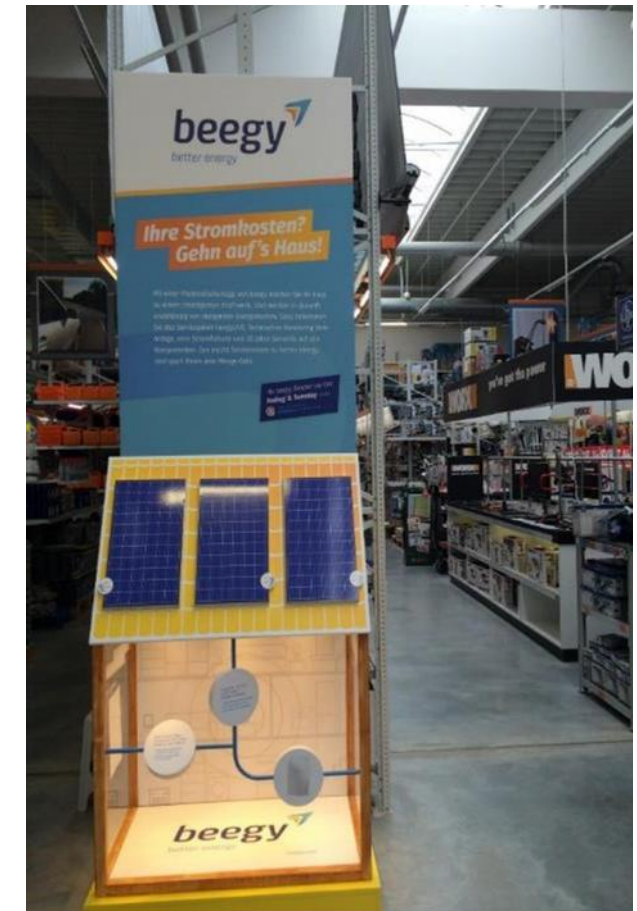
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Home storage systems are the latest fashion, some 50.000 units are already installed in Germany

Examples of home storage systems in the German market

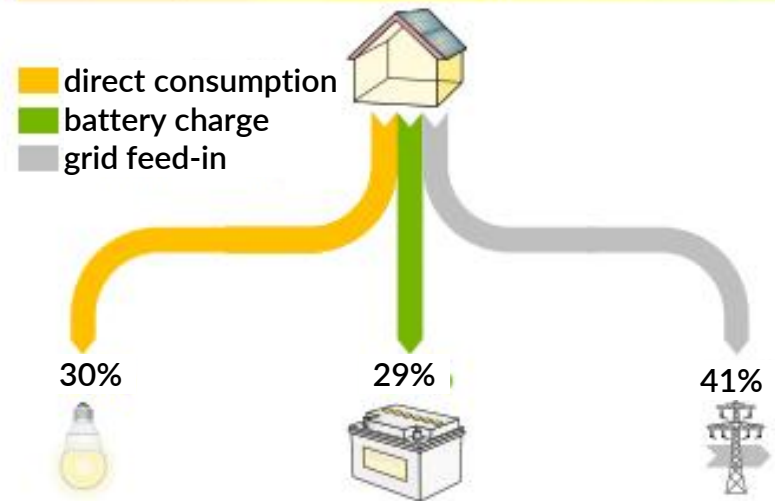
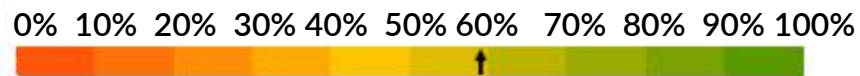
Around 50.000 battery storage systems <10 kWh usable storage capacity are installed in Germany.



Home storage systems allow for self-consumption with rates around 60%

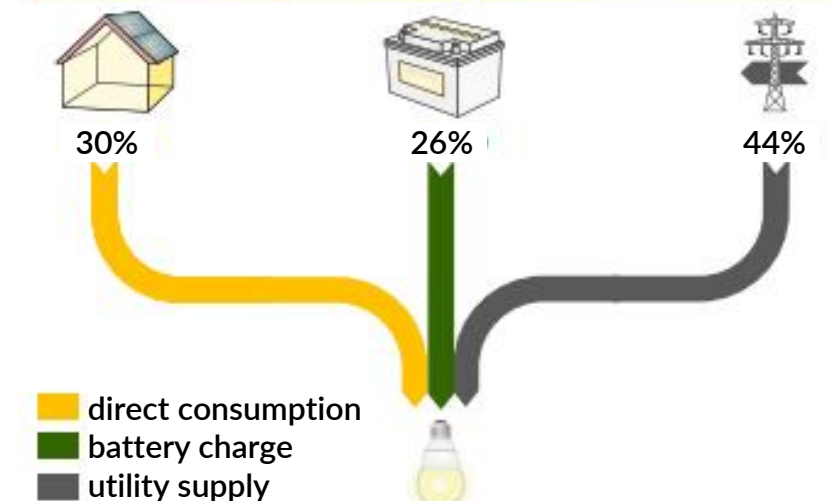
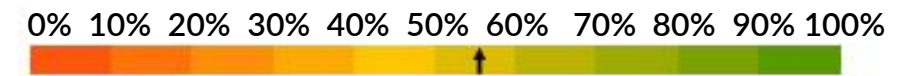
Self-consumption share of PV generation

- 30% direct consumption,
 - 29% charging of the battery system,
 - 41% grid feed-in
- > **self-consumption share 59%**



Coverage of annual electricity demand (autarchy)

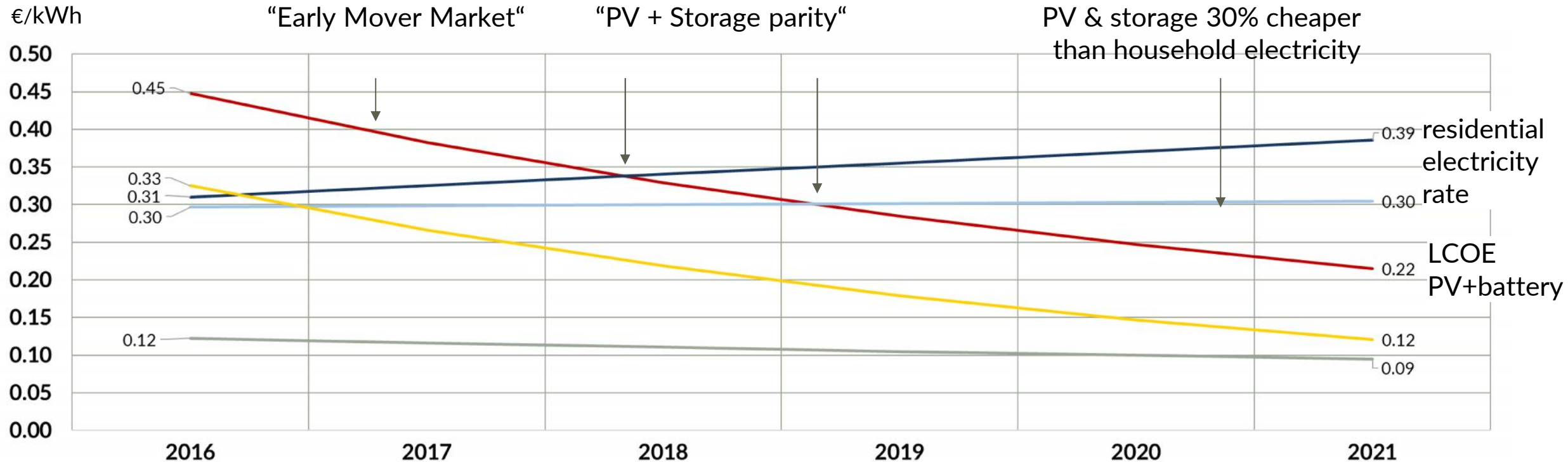
- 30% direct consumption, simultaneous to PV generation
 - 26% discharging of the battery system,
 - 44% provided by utility
- > **degree of autarchy 56%**



- annual power demand: 4.000 kWh
- PV capacity 4 kWp
- usable storage capacity 4 kWh

PV + storage parity might be reached in Germany within the next two years

Cost of PV & storage vs. household electricity tariff in Germany



- LCOE PV+Storage
- Avg. household electricity rate increases at about 5% p.a. (avg. 2009-2014)
- Avg. household electricity rate increases at about 2% p.a. (2013-2014)
- LCOE storage (-18% p.a.)
- LCOE photovoltaics (-5% p.a.)

Source: Büro F

Sum-Up

1. Battery storage is a perfect complement for PV prosumers
2. Impact of PV capacity on distribution grids can be minimized

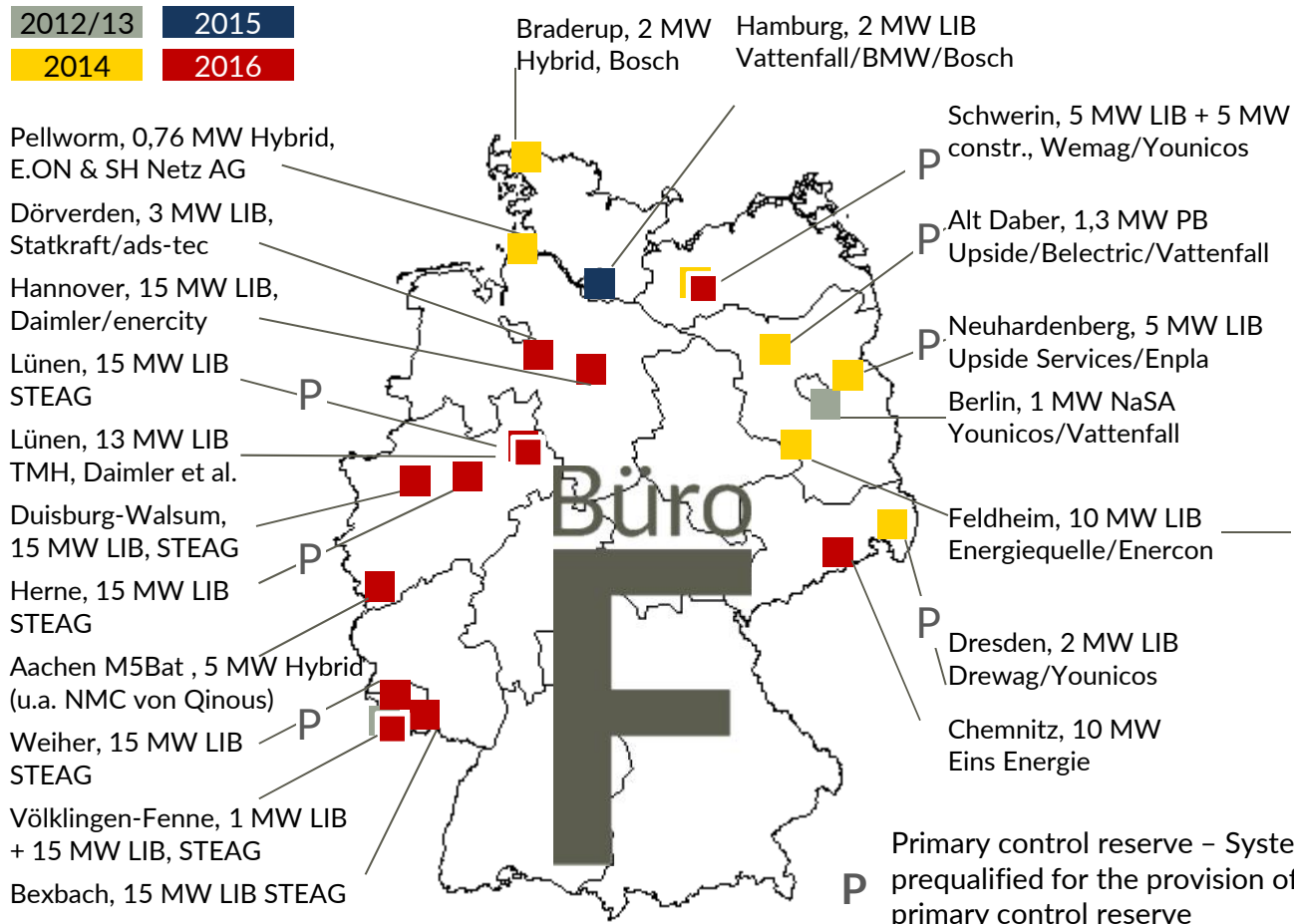


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Large-scale battery storage is on the rise in Germany, most projects aim at providing balancing reserve for TSO

Overview Battery Storage Parks >1 MW in Germany (state: November 2016)



Auxiliary services and self-supply optimization are the low-hanging fruits for large-scale batteries

Business models for storage applications

Specific operation site

Power supplier

- improvements balancing group
- compensation fluctuating power output

Power consumer

- improvements of security of supply
- voltage quality
- peak load management
- reduction of network charges
- load shedding
- reactive power

Prosumer

- increase of self-consumption share

Grid operators

- better utilization of existing grid infrastructure / peak shaving
- black start services
- congestion management
- reduction of redispatch services

Site independent

- providing balancing power
- trading on day ahead- and intraday markets
- integration into virtual power plants and balancing groups, e.g. for regional electricity rates / or provision of residual load for prosumers

Sum-Up

1. Large-scale storage systems are on the rise in Germany
2. Most of them provide primary reserve (or aim at doing so)
3. Many other business models for battery systems are possible



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Digitization will enable more business models for battery storage systems

Areas of application in the digitalization of the energy industry

Generation

Matching generation & consumption

Consumption

Digitization of the power system

- Technical communication link
- Controllability of production and consumption
- Pooling of small producers, storage units and flexible consumers for commercialization on power markets
- Controlling of networks and storage systems (“Smart Grids”)

Flexible Generation

Controllable generation units

Smart Markets

Pooling and commercialization of production, storage and flexible consumers

Smart Grids

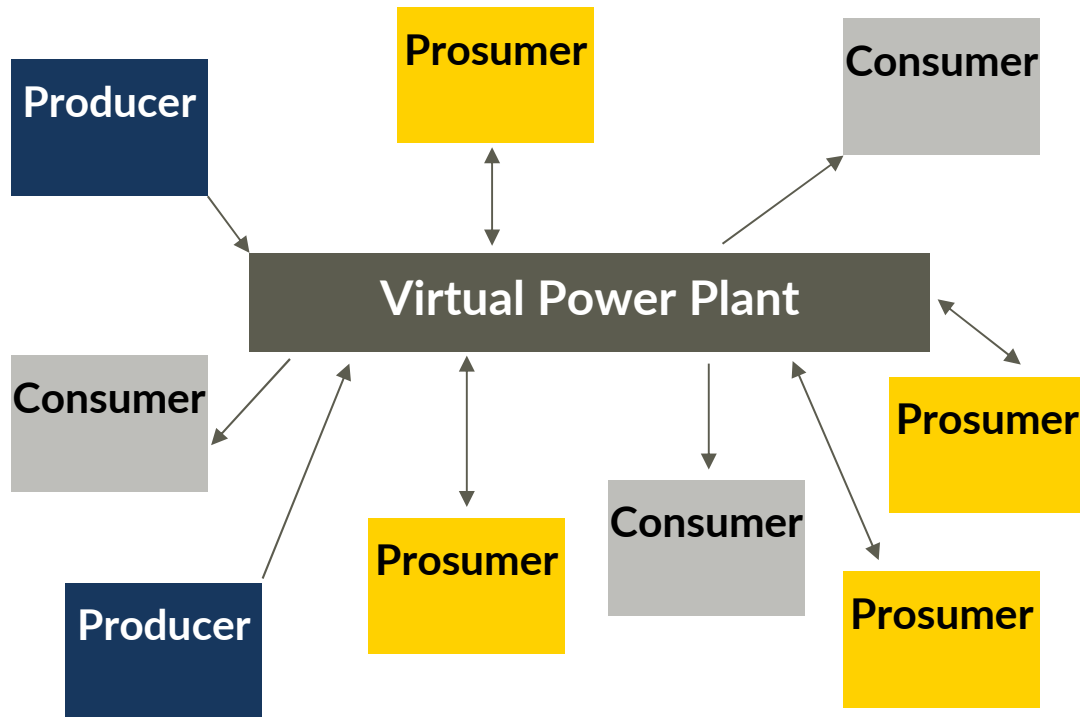
Intelligent network controlling

Smart Home

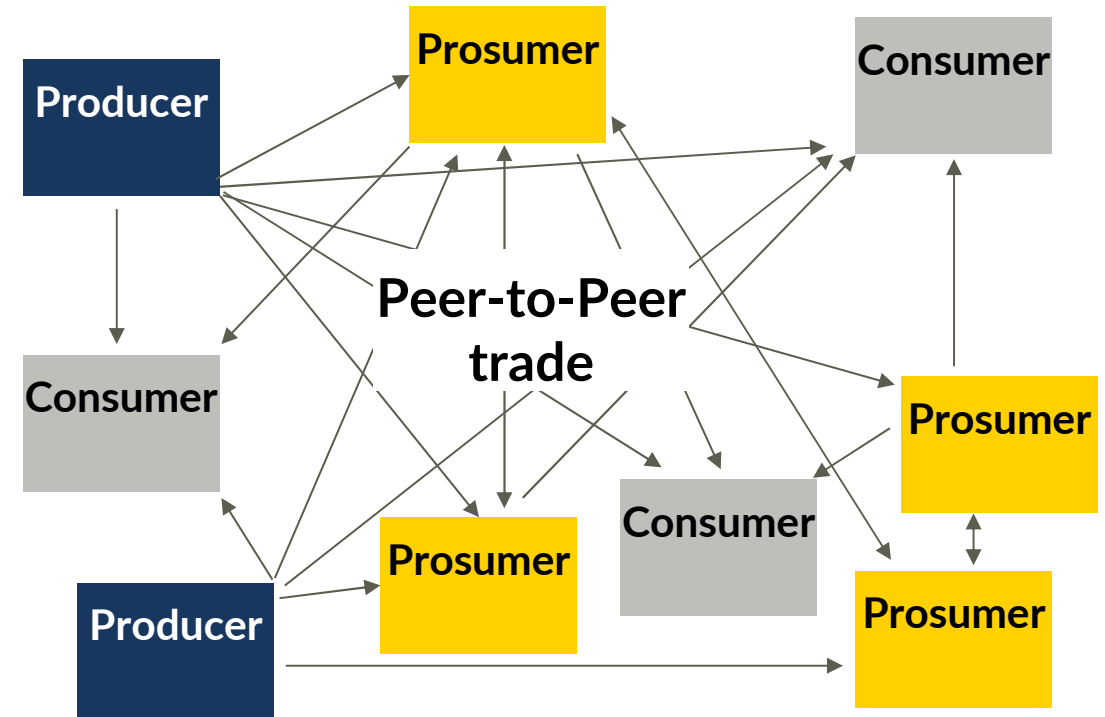
Flexible consumption

Smart Grids and Smart Markets are enabling the integration of distributed generation and storage into power systems

Aggregation of distributed generation & storage



Peer-to-Peer power trade (e.g. Blockchain)



Sum-Up

1. Battery storage is the missing link of the energy transition
2. Lithium-ion batteries show the strongest momentum
3. Many new possibilities and business models arise around the integration of distributed generation and storage units

Thank you for your time



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New sales channels might evolve through the involvement of the automotive industry

Hypothetical sales channels for home storage systems

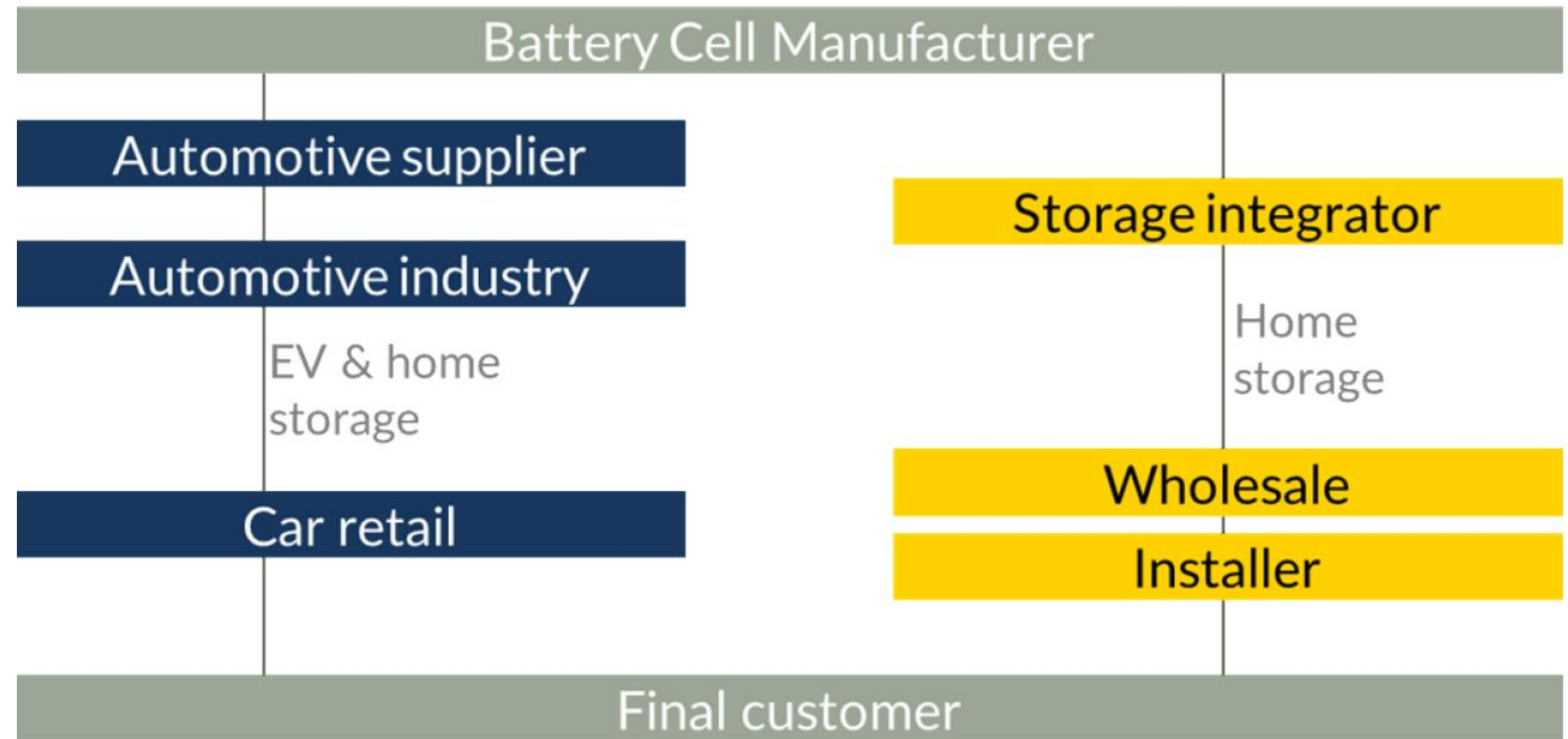
DAIMLER



TESLA

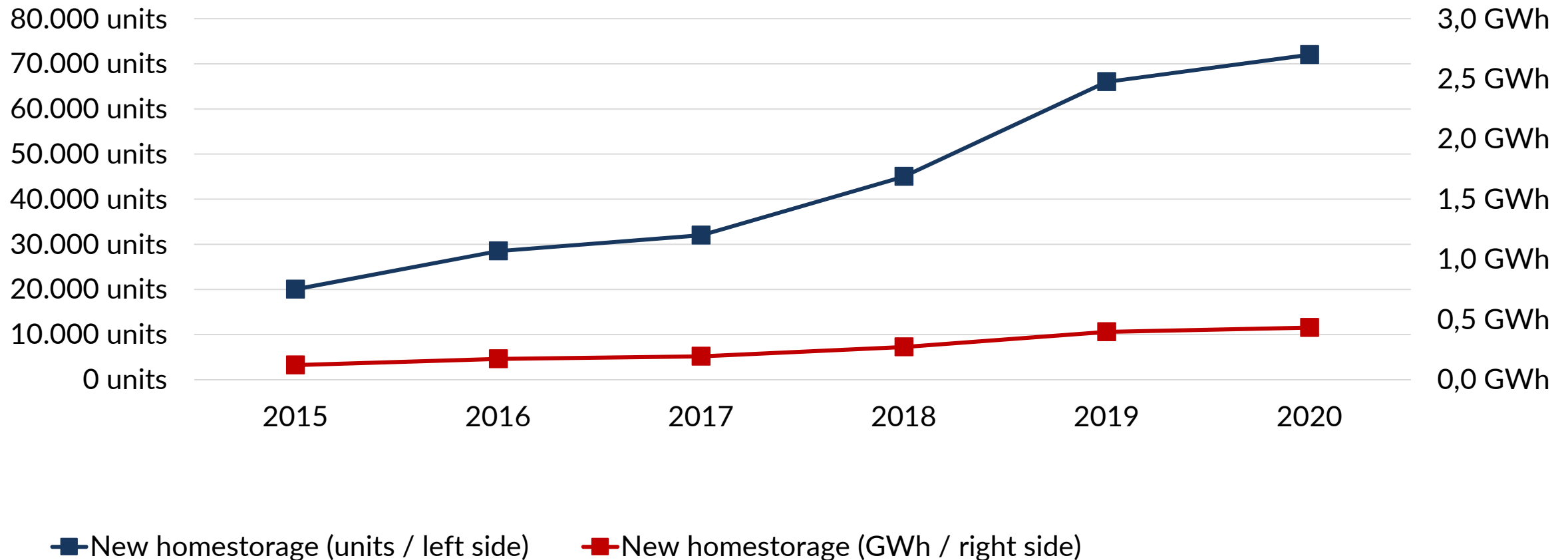


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By the end of 2020, around 300,000 home storage units might be installed in Germany (cumulated)

Newly installed home storage systems in Germany 2015-2020e



However, more usable storage capacity will be installed in electric vehicles

Comparison home storage installations and electric vehicle sales Germany 2015-2020e

