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Büro F

Batteries, Bits and Business:

Latest trends in the German energy transition

Market Report // December 2016 // Büro F & l°energy

Get an overview on the latest developments in Germany relating to direct energy supply from renewable sources

Market report “Batteries, Bits and Business” at a glance

Batteries and digitalization enable new business models for the direct supply of renewable energies. Storage together with digital linkage and control make it possible to match an intermittent renewable energy supply with demand. Get insights on the status of these technologies and the newest developments in Germany, one of the international indicator markets for the energy transition.

Battery storage

In 2016, lithium **home storage systems** and **large-scale battery storage** have gained momentum in the German market. Get an overview on the technologies, **suppliers, business models and prices** for lithium battery storage in Germany. Reasoned estimations on the future market development regarding prices, **sold units and usable storage capacities** in Germany complement the chapter on batteries.

Digitalization

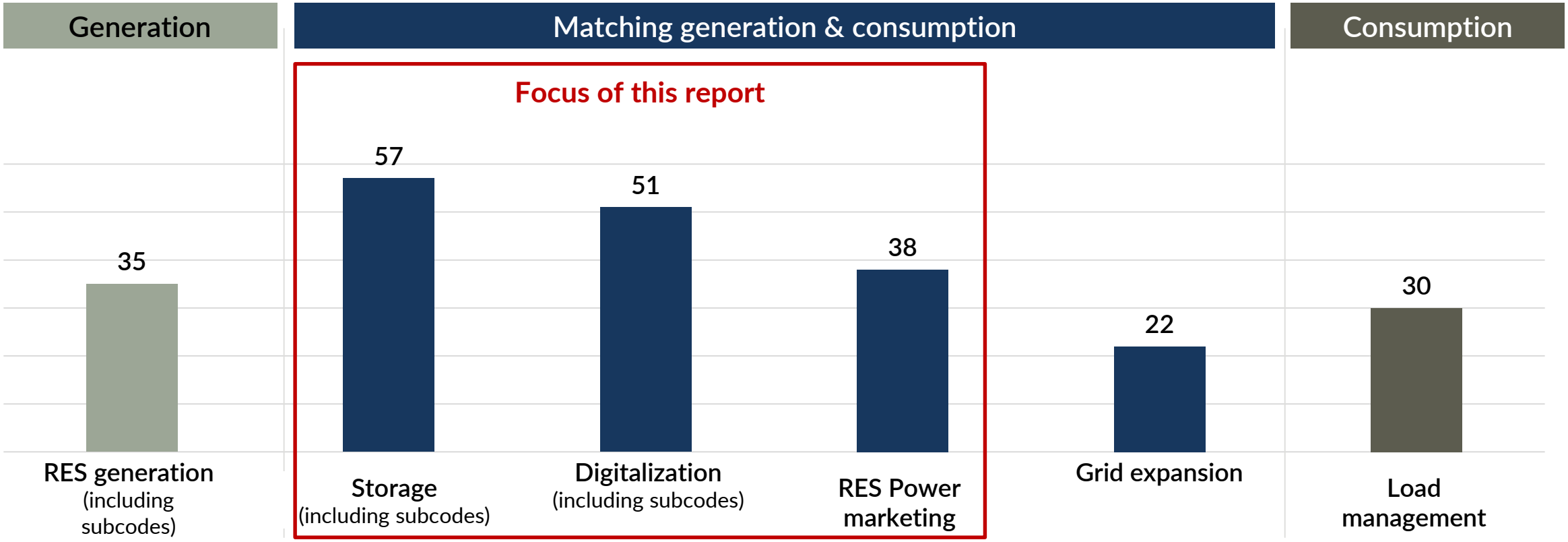
The aggregation of small-scale renewable energy plants into **virtual power plants (VPP)** is a given. Get the full list of **software providers** for VPP in Germany, including reference projects and indications on the portfolio. A newer trend is the discussion on direct **peer-to-peer electricity trade** through **blockchain technology**. This study provides you with all the information on status and evolving players in Germany you need to understand curent market dynamics.

Business models for direct power supply

The consumption of renewable electricity close to the generation site is the new paradigm of the energy transition. Many companies have developed **new business models**. The study covers in full the recent developments and presents the players in the following segments:
1) virtual community supply approaches of the storage system integrators (“**prosumer pooling”**),
2) shared solar approaches in multifamily buildings (“**tenant‘s supply**”) and
3) electricity tariffs with a defined share of electricity from regional generated renewable energy plants (“**regional supply”**).

Storage, digitalization and marketing of RE electricity are the most important trends in the German power sector

What are the most important trends, technical solutions and business models in the German power sector?



n=42, Multiple sampling. Büro F survey among energy market experts in Germany 2015. Categorization of all answers of survey participants to open-ended questions on trends, technical solutions and business models in the German power sector 2015-2020.

Storage markets have gained momentum with the cost decline of lithium battery systems

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

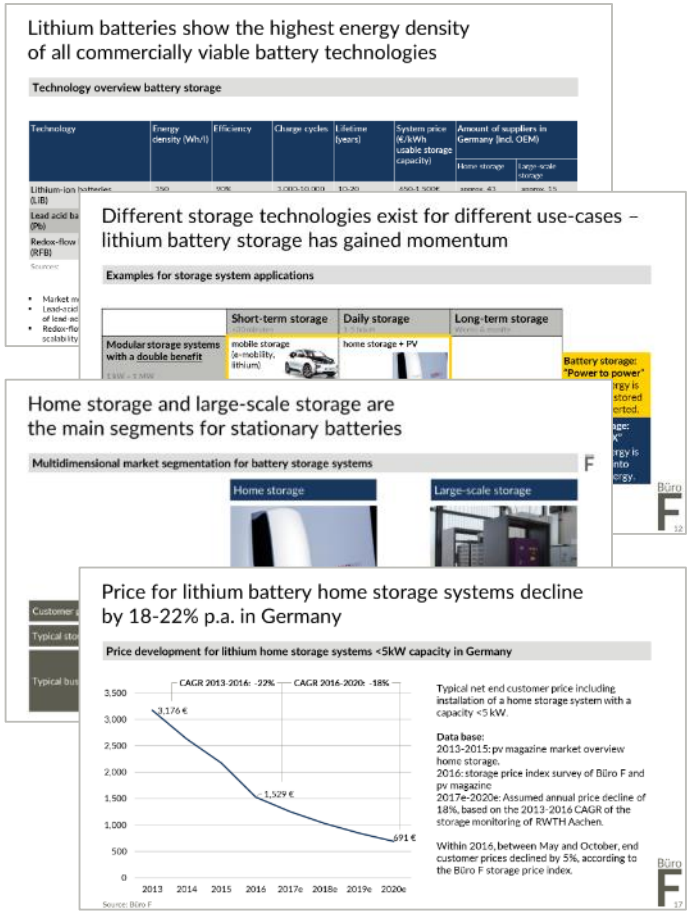
Wind power — Photovoltaics

220/380 kV	110 kV	10/20 kV	400 V
		Focus of this report	
pumped storage	P2X	large-scale batteries	battery home storage
P2G/hydrogen	demand side management	demand side management	electric vehicles
compressed air		P2X?	

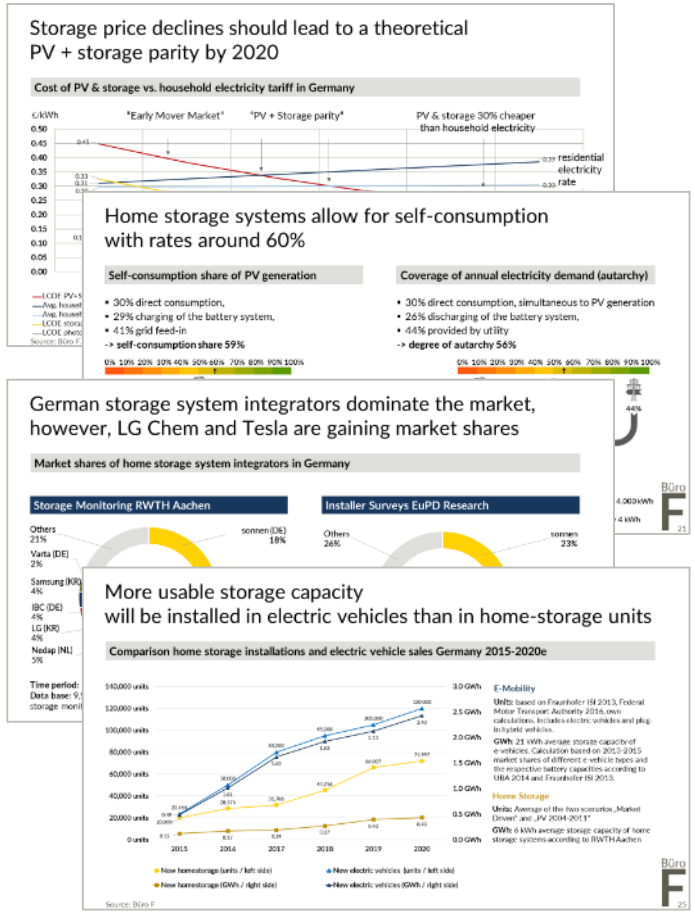
Source: Büro F, based on Prof. Dirk Uwe Sauer, RWTH Aachen

Updates on the current market and future perspectives of home storage and large-scale batteries in Germany

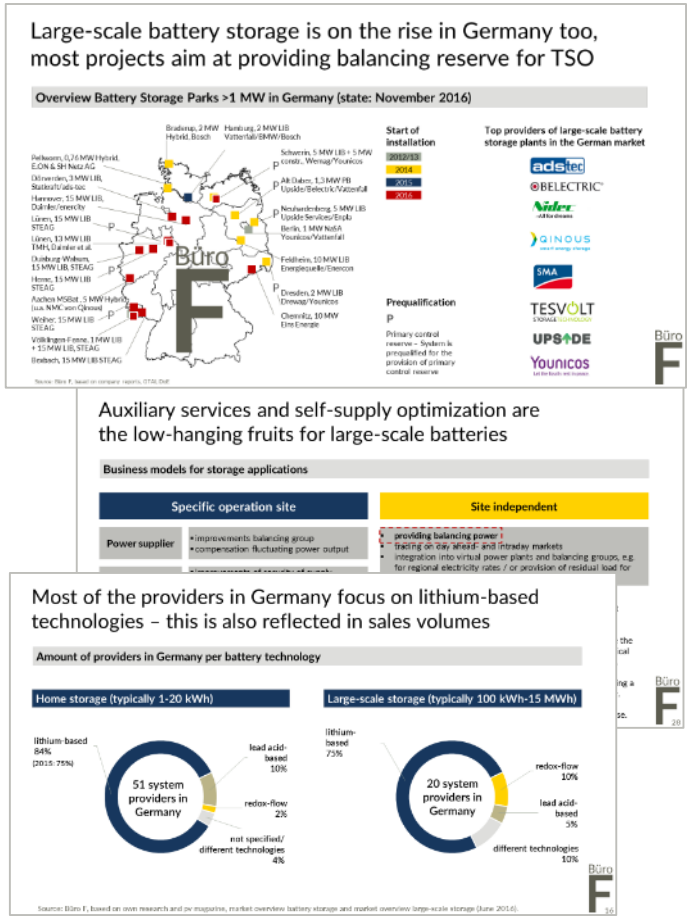
Battery technologies & prices



Home storage



Large-scale storage



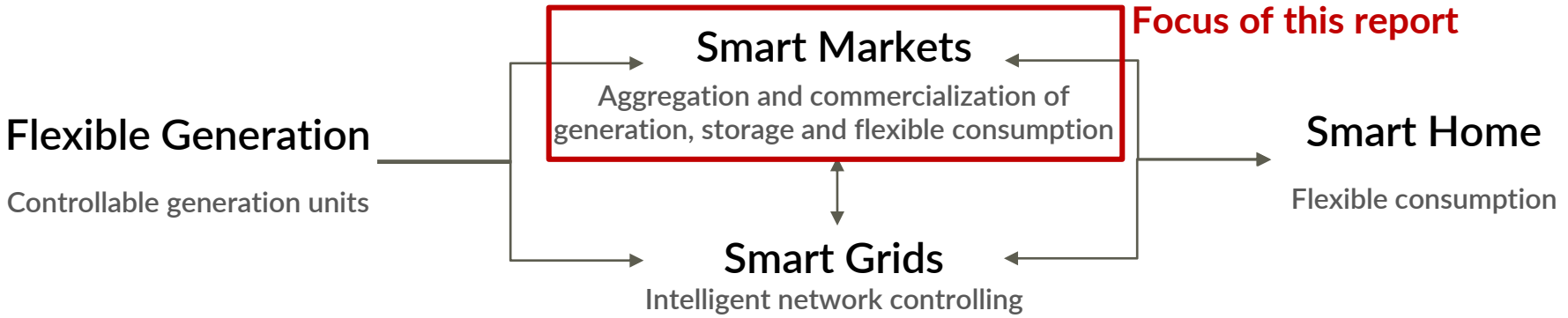
Digitalization makes communicative linkage & control of distributed generation possible

Areas of application in the digitalization of the energy industry

Generation	Matching generation & consumption	Consumption

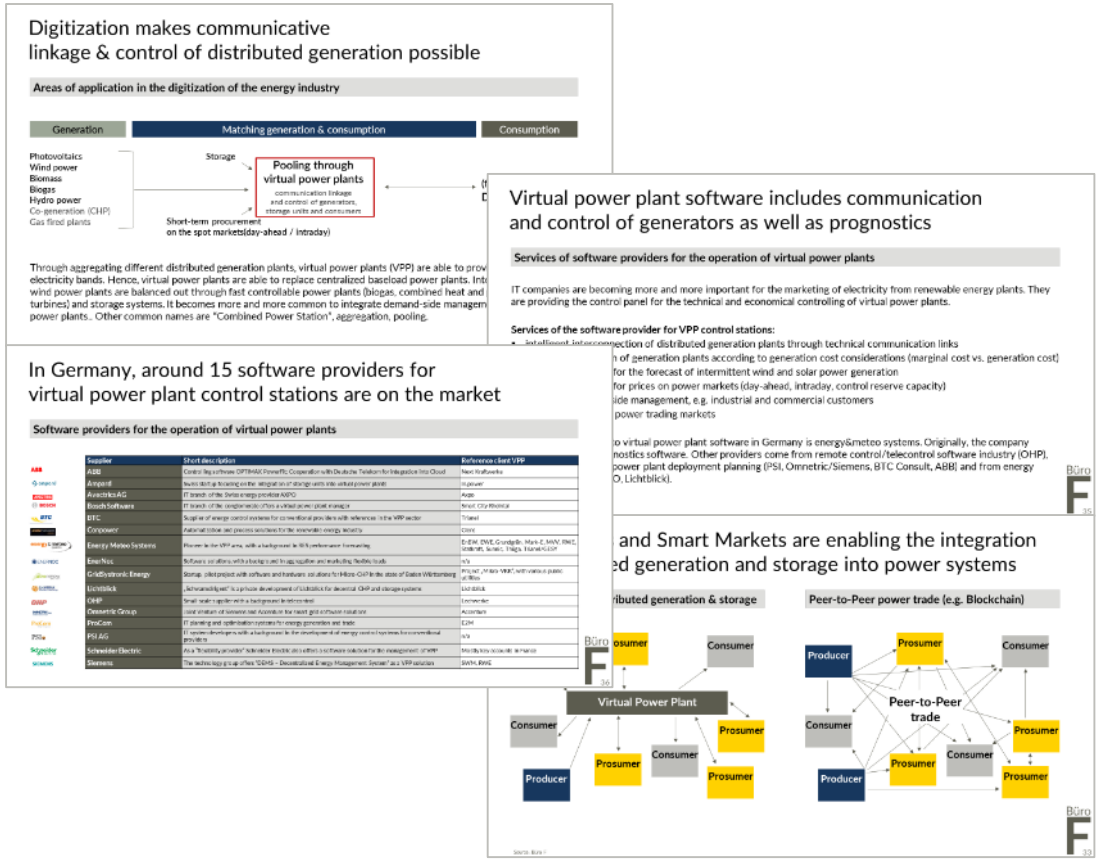
Digitalization of the power system

- 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”)

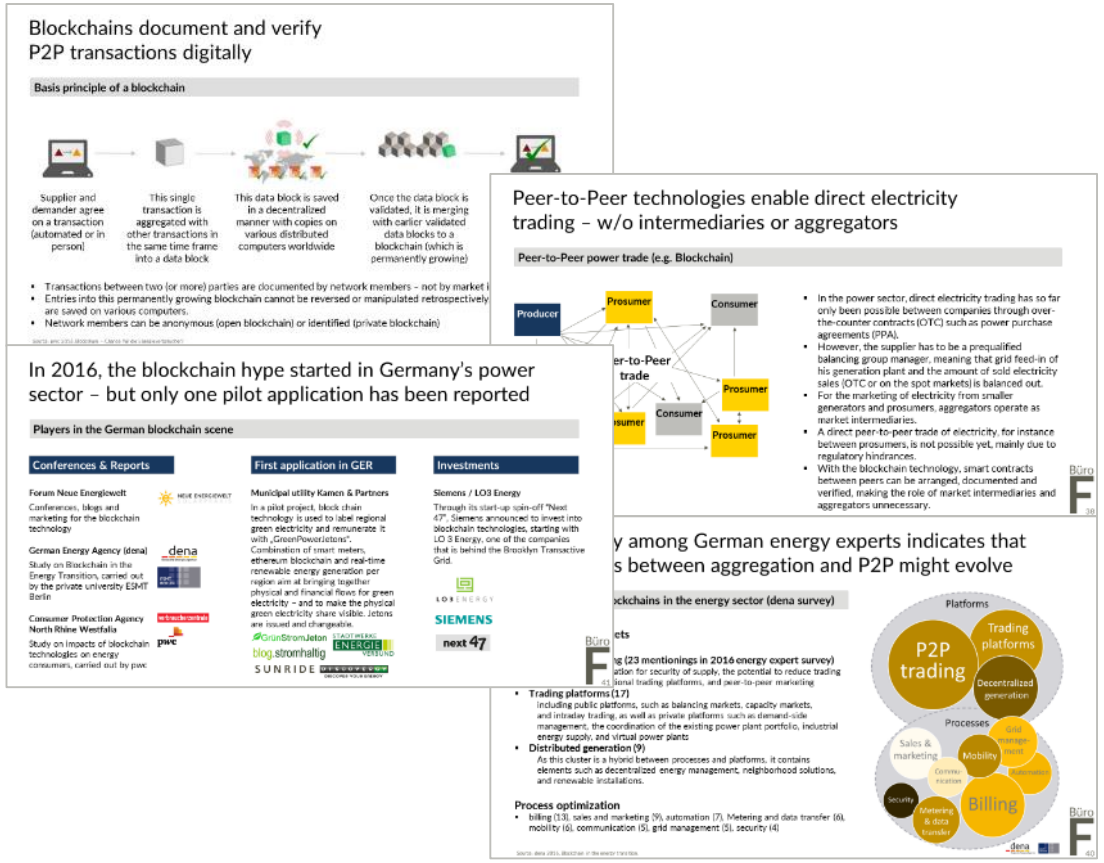


Comprehensive listing of software providers for virtual power plant software and the evolving blockchain scene

Aggregation / virtual power plants

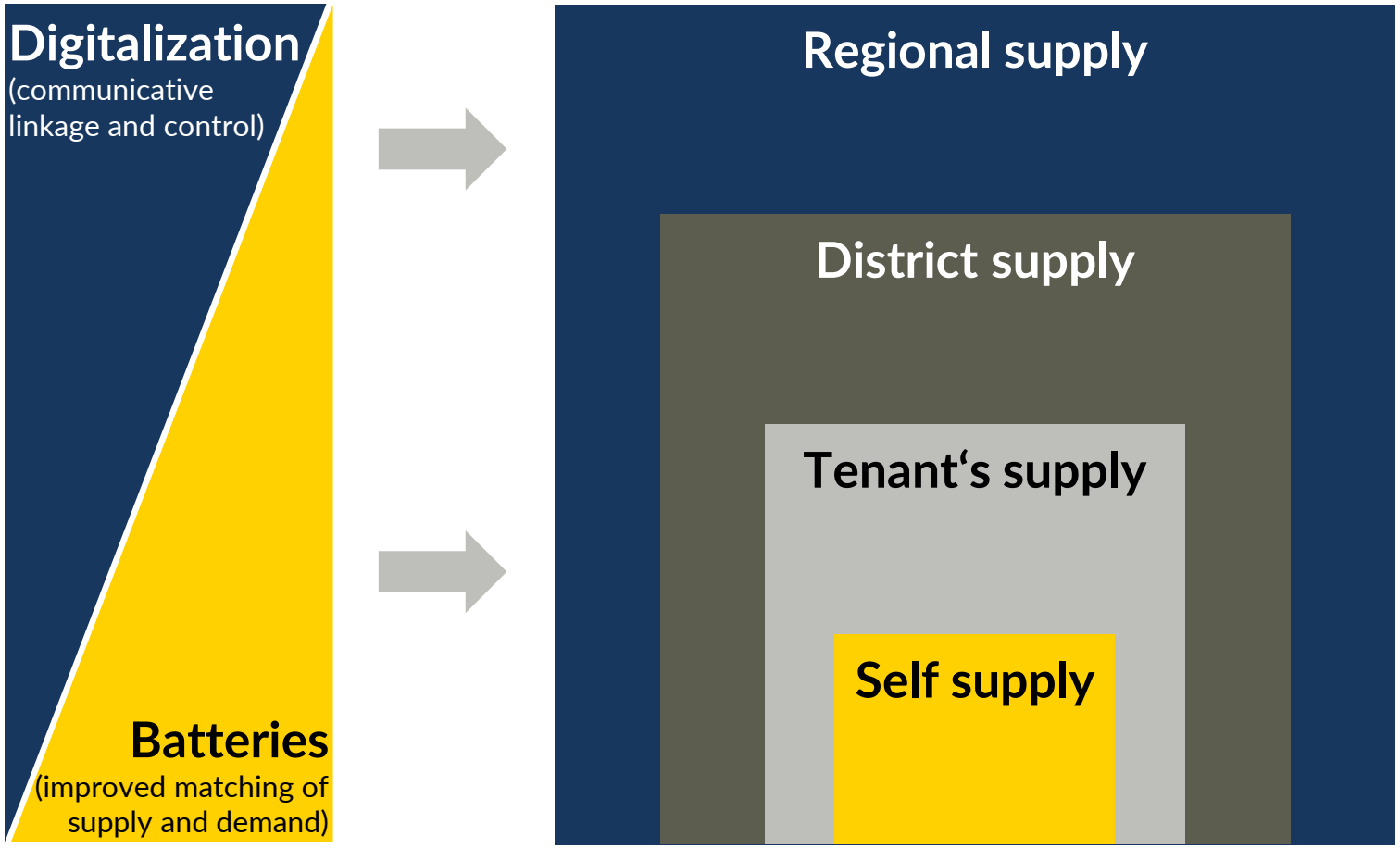


Peer-to-peer trade / blockchain



Battery storage and digitalized linkage and control of distributed plants lead to new business models

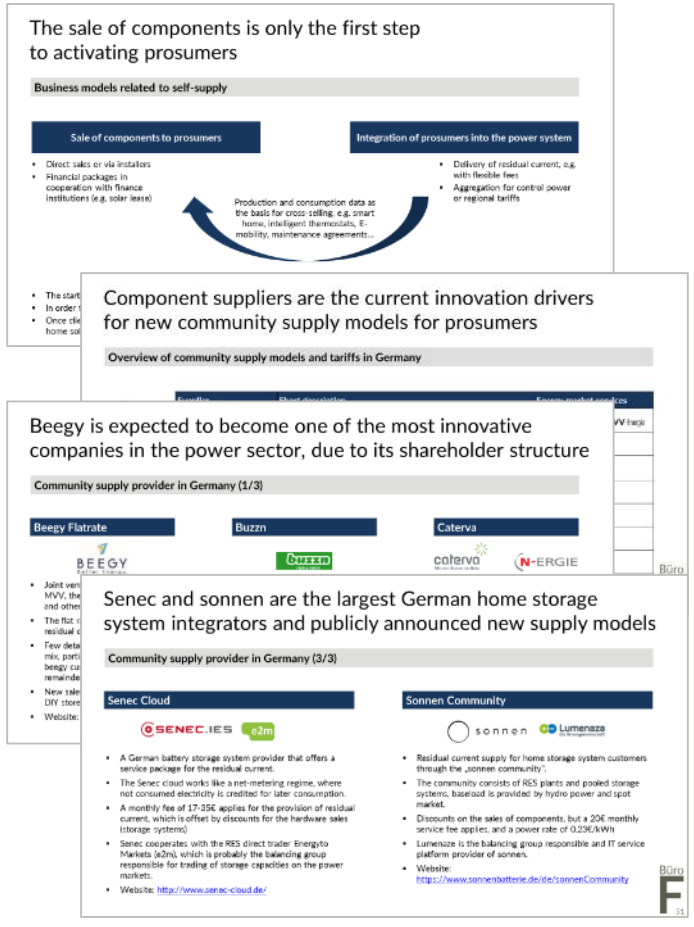
Interaction between batteries, bits and business models in the distributed power sector



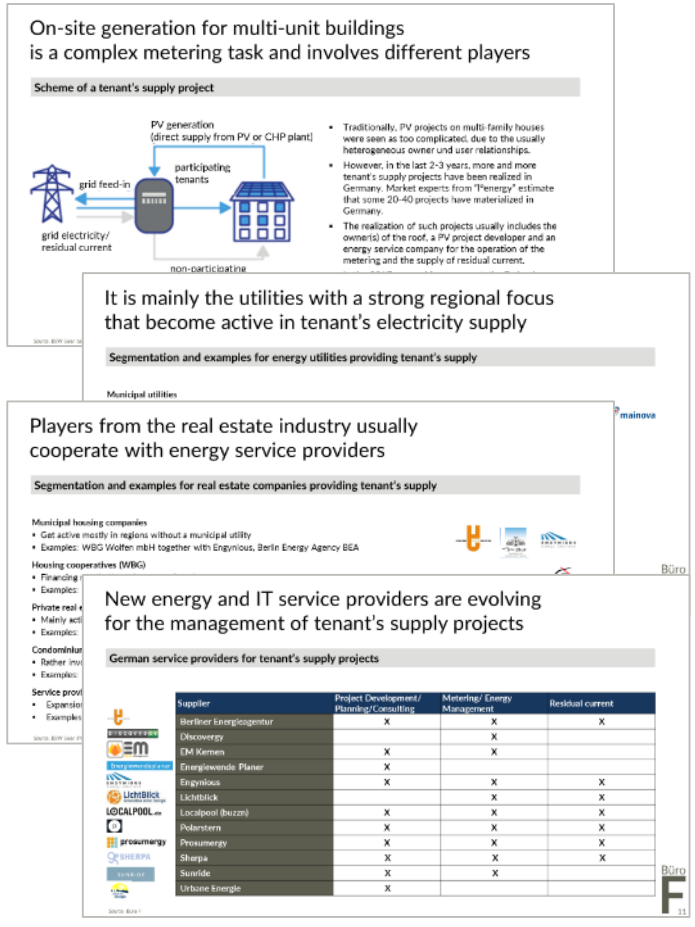
Lumenaza Die Stromgemeinschaft
naturstrom Energie mit Zukunft
Bürgerwerke Energie in Gemeinschaft
GRÜNSTROMWERK
Quartier Strom
Gewobag Die ganze Vielfalt Berlins.
MVV Energie
VATTENFALL
stadtwerke Schwäbisch Hall GmbH
LichtBlick Generation reine Energie
LOCALPOOL.de
HEG Heidelberger Energie Genossenschaft eG
IBC SOLAR
e·on
SolarWorld
SENEC.IES
sonnen
Hanwha Q CELLS
l'energy & Büro F

The study lists players and business models for direct electricity supply in Germany

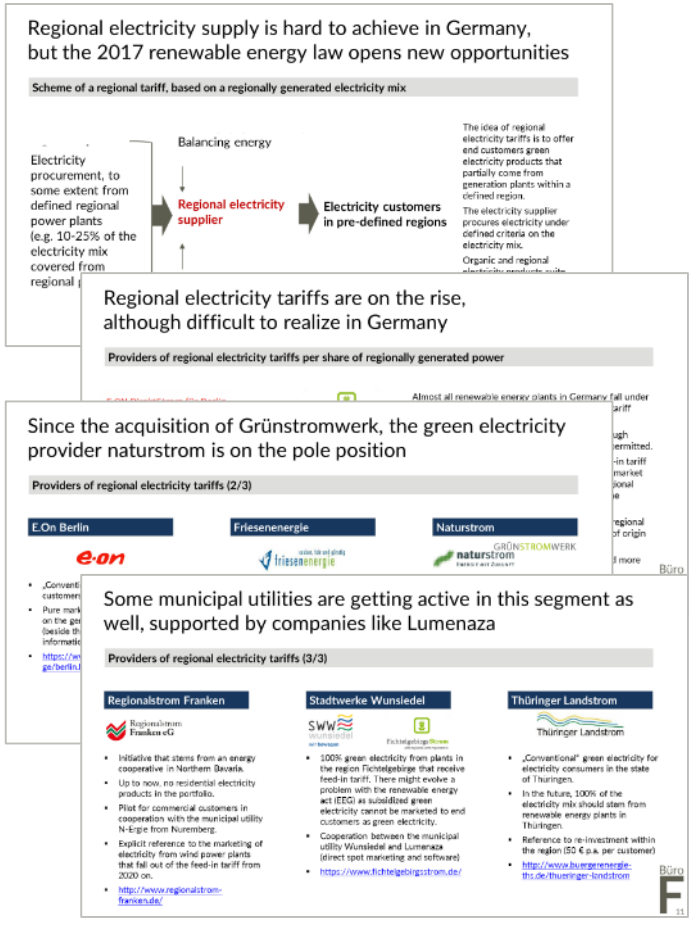
Prosumer pooling



Tenant's supply (shared solar)

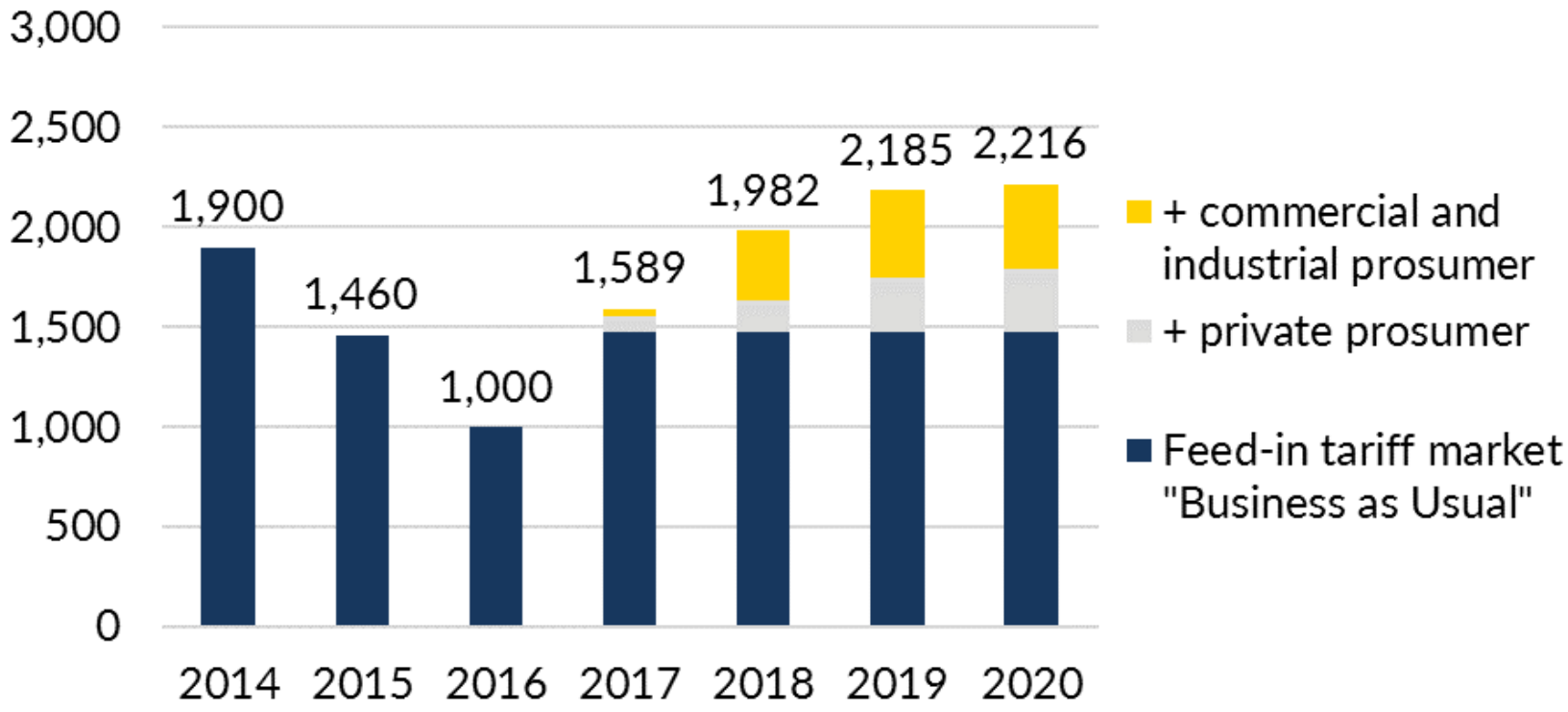


Regional electricity supply



The direct supply and prosumer business models are about to revive the German PV market in the coming years

New PV installations per year in MW in Germany



„FIT-Market „Business as Usual“: Mean of the new installations 2014-2016 applied for the new installations 2017-2020. A market activation in this segment stems from the tender process for large-scale PV.

„+Prosumer“ 2017-2020 Additional market activation by prosumers, modelled here through the application of PV installation rates in the residential, commercial and industrial rooftop segments between 2003-2006 in Germany.

Source: Büro F based on BSW Solar, Fraunhofer ISE, company information

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

Portfolio of Büro F

Services	Primary& secondary research	Market analysis	Consultancy	Public relations	Market access	
Sector knowledge	Renewable energy markets and business models in Germany and Chile					
	International development cooperation					
References	Hanwha Q CELLS	BROCKHAUS PRIVATE EQUITY *Investing in Innovation Leaders.*	aspo	LichtBlick Generation reine Energie	STADT WERKE BURG	AHK Deutsch-Italienische Handelskammer Camera di Commercio Italo-Germanica
	BSW Bundesverband Solarwirtschaft	SENEC.IES	sonnen	Green City Energy	RWE	pv magazine
	giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH	BEE				
Cooperation partners	COMBINADO Trade & Invest Consult	kaltenbach energy consulting	DENKZENTRALE ENERGIE	l'energy		

The authors of the study have ten years of experience each in renewable energy market analysis and action

Stephan Franz, Büro F (author)

Professional experience in the energy sector

- since 2014: Büro F, Founder (Berlin) - www.burof.de
- GIZ/Chilean Ministry of Energy: Consultant Renewable Energies (Santiago)
- Q.CELLS SE: Senior Specialist Strategy (Bitterfeld/Berlin)
- German Energy Agency (dena): Consultant Renewable Energies (Berlin)
- EuPD Research: Research Analyst Energy and Utility (Bonn)

Higher education

Technical University Berlin: MBA Energy Management (degree 2017)
Universität Potsdam: M.A. Political Sciences and Economics

Fabian Zuber, l°energy (co-author)

Professional experience in the energy sector

- since 2016: Founder l°energy, local energy markets (Berlin)
- www.local-energy-markets.de
- Citizen‘s Energy Association: Managing Director (Berlin)
- First Solar: Director Public Affairs (Berlin)

Higher education

Universität Passau: Cultural and Economic Studies

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Büro F

Latest Trends in the German Energiewende

Batteries
Digitalization
Business Models

1. **Storage technologies**
2. Home storage: business models, players, forecasts
3. Large-scale storage: installations and business models

Different storage technologies exist for different use-cases – lithium battery storage has gained momentum

Examples of storage system applications

	Short-term storage <30 minutes	Daily storage 1-5 hours	Long-term storage Weeks & months
Modular storage systems with a double benefit 1 kW – 1 MW	**mobile storage** (e-mobility, lithium) 	**home storage + PV** 	
Modular storage systems 1 kW – 100 MW	**stationary storage** (lithium/lead-acid/redox-flow)		
Central storage systems 100 MW – 1 GW		**pumped storage** (“P2K”?) 	▪ 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.

Source: Büro F, based on Prof. Dirk Uwe Sauer, RWTH Aachen

Pumped storage and power to gas are more suitable for larger generators, lithium batteries for smaller plants

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

Source: Büro F, based on Prof. Dirk Uwe Sauer, RWTH Aachen

Home storage and large-scale storage are the main segments for stationary batteries

Multidimensional market segmentation for battery storage systems

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	Home storage		Large-scale storage	
	 Kaltenbach		 Younicos	
Customer group	Households	Commerce	Industry	Grid operators
Typical storage capacity	1-8 kWh	8-150 kWh	150 kWh – 2 MWh	100 kWh – 5 MWh
Typical business models	▪ Optimized self-consumption PV/CHP ▪ Uninterrupted power supply (UPS) ▪ Optimized marketing of RES electricity			Optimized grid operation
	Provision of balancing reserve (pooling)		Provision of balancing reserve (direct)	

Lithium batteries show the highest energy density of all commercially viable battery technologies

Technology overview of battery storage technologies

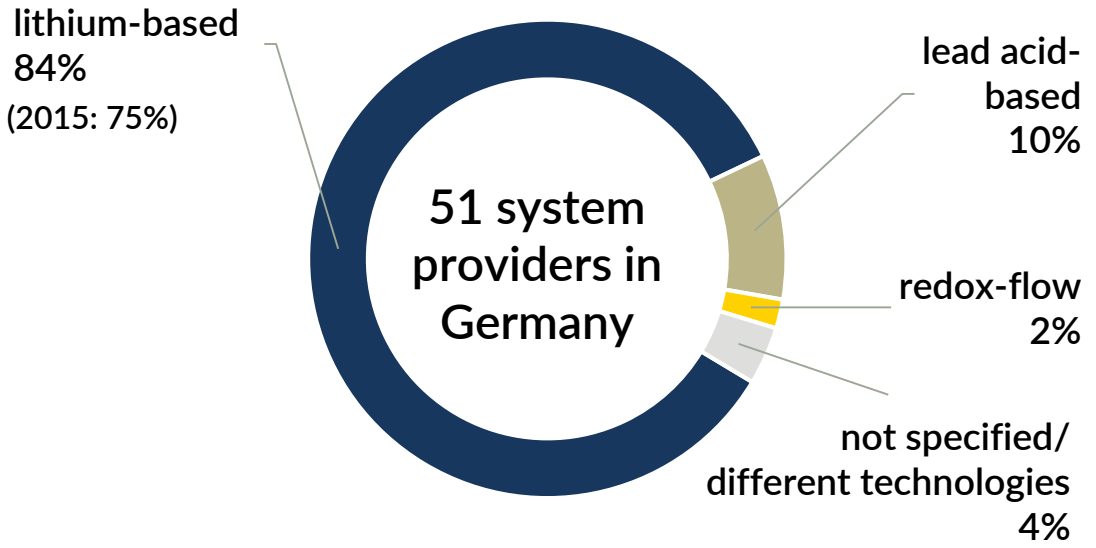
Technology	Energy density (Wh/l)	Efficiency	Charge cycles	Lifetime (years)	System price (€/kWh usable storage capacity)	Amount of suppliers in Germany (incl. OEM)	
						Home storage	Large-scale storage
Lithium-ion batteries (LiB)	350	90%	3,000-10,000	10-20	650-1,500€	approx. 43	approx. 15
Lead acid batteries (Pb)	70	85%	1,000-3,000	5-10	approx. 500-1,350 €	approx. 5	approx. 1-2
Redox-flow batteries (RFB)	170	75%	>10,000	10-15	approx. 2,000-3,000 €	approx. 1	approx. 2-3
Sources:	Fraunhofer ISI 2015	Fraunhofer ISI 2015	HTW Berlin 2015 (LiB/Pb) RWTH Aachen 2015 (RFB)		Büro F, RWTH Aachen (PB)	pv magazine Marktübersicht Batteriespeicher 2016, and Büro F research	

- Market momentum of lithium batteries has been accelerating over the last five years.
- Lead-acid batteries (PB) are the conventional batteries for smaller applications. However, energy density and lifetime are lower. The price advantage of lead-acid batteries over lithium batteries should be offset in the nearer future.
- Redox-flow batteries might become interesting for larger applications, for instance as an alternative to power-to-gas plants (P2G). Continuous scalability is an advantage of this technology, though the relatively high prices are a disadvantage at the moment.

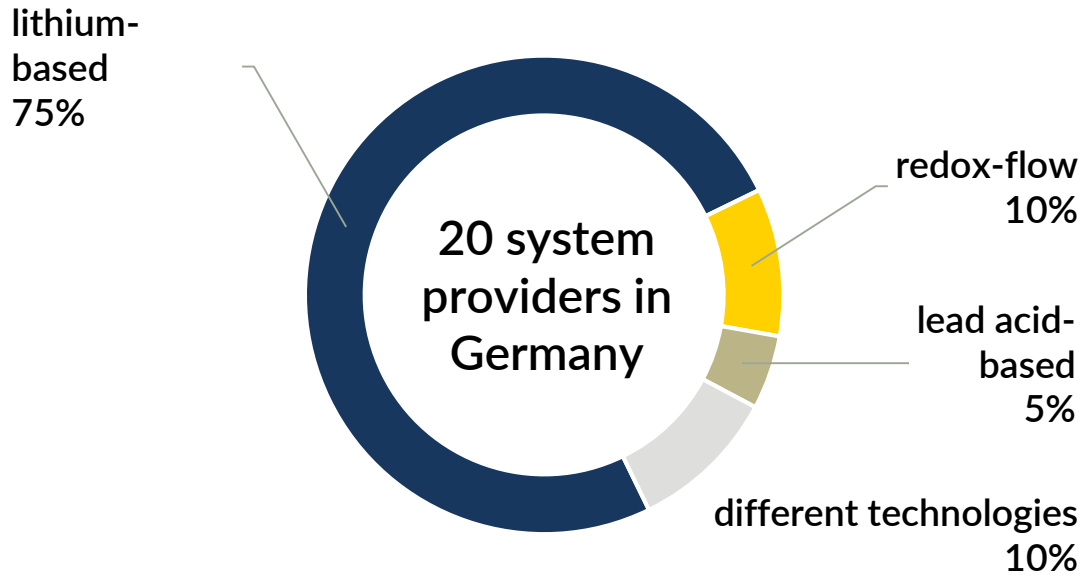
Most of the providers in Germany focus on lithium-based technologies – this is also reflected in sales volumes

Amount of providers in Germany per battery technology

Home storage (typically 1-20 kWh)



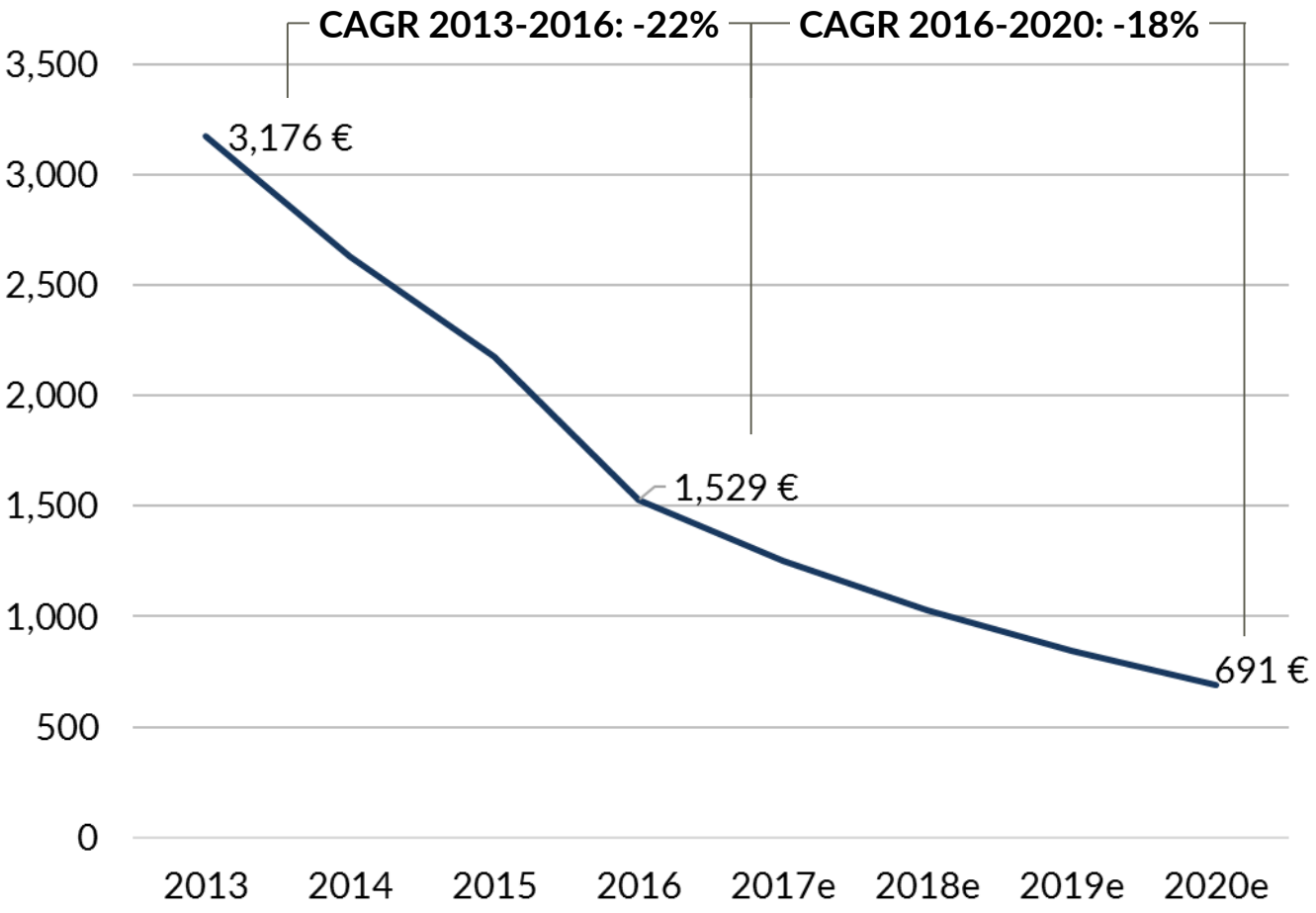
Large-scale storage (typically 100 kWh-15 MWh)



Source: Büro F, based on own research and pv magazine, market overview battery storage and market overview large-scale storage (June 2016).

Price for lithium battery home storage systems decline by 18-22% p.a. in Germany

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



Source: Büro F

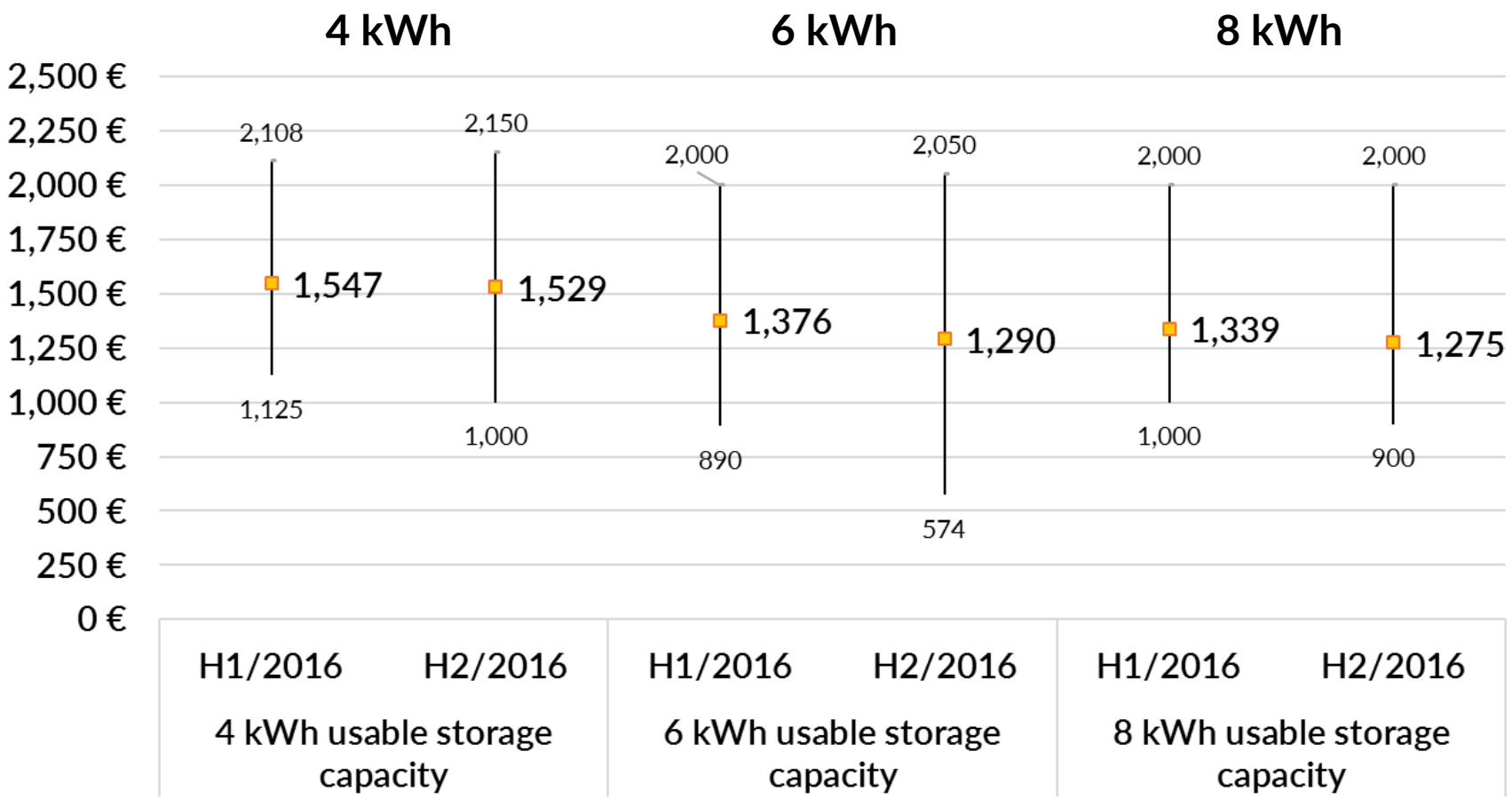
Typical net end customer price including installation of a home storage system with a capacity <5 kW.

Data base:
2013-2015: pv magazine, Marktüberblick Batteriespeicher 2016 (market overview home storage)
2016: Storage price index survey of Büro F and pv magazine
2017e-2020e: Assumed annual price decline of 18%, based on the 2013-2016 CAGR of the storage monitoring of RWTH Aachen.

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

Storage price index 2016 indicates: end customer price declines seem to be slowing down

Net end customer prices for lithium home storage systems incl. installation (€/kWh), May & October 2016



Storage price index

Joint project of pv magazine and Büro F.

Bi-annual online survey among German installers, project developers and others.

In October 2016, 27 companies participated in the survey, 12 of them had already participated in the pilot survey in May 2016.

Source: Büro F and pv magazine

1. Storage technologies
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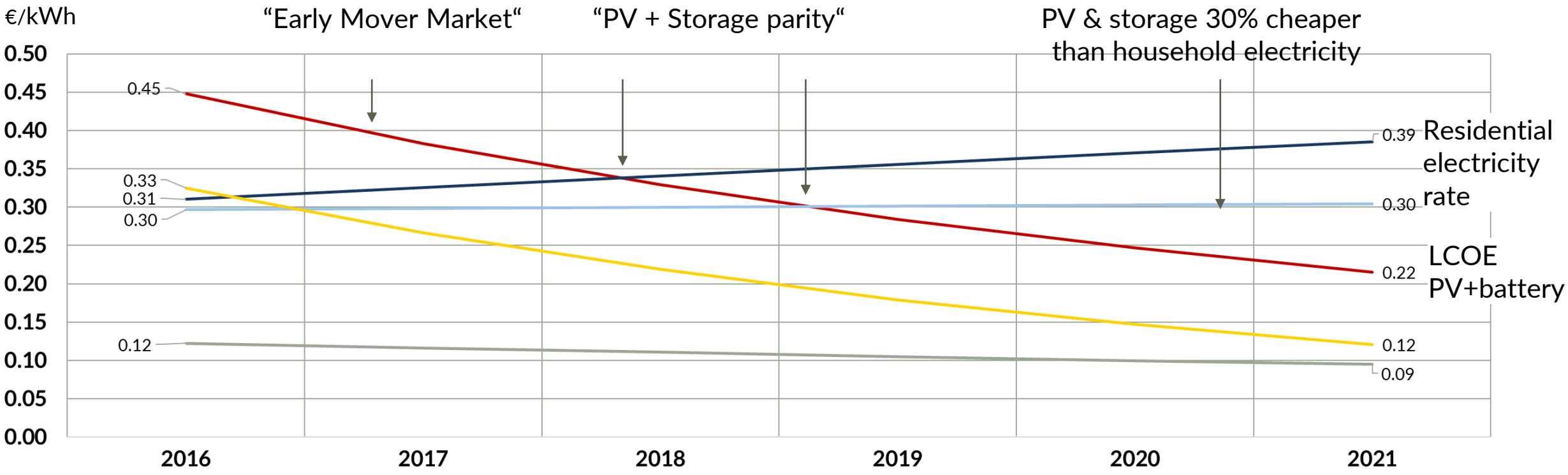
Storage price declines should lead to theoretical PV + storage parity by 2020

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. Calculation parameters in the annex.

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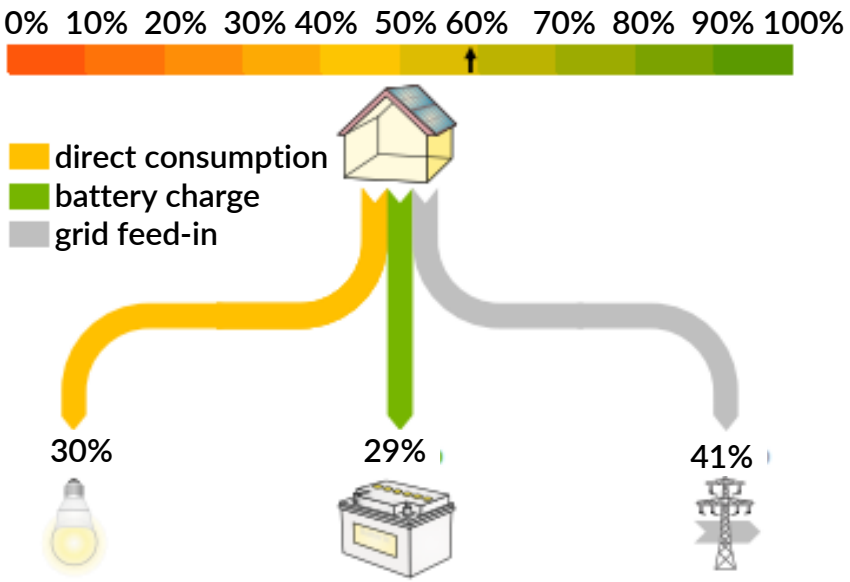
Home storage systems allow for self-consumption with rates around 60%

Self-consumption share of PV generation

- 30% direct consumption,
- 29% charging of the battery system,
- 41% grid feed-in

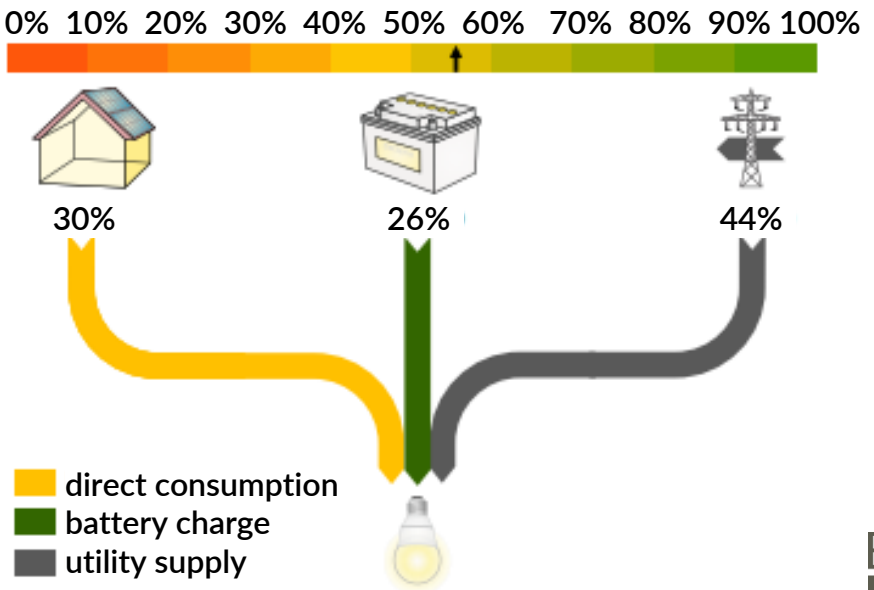
-> self-consumption share 59%



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%

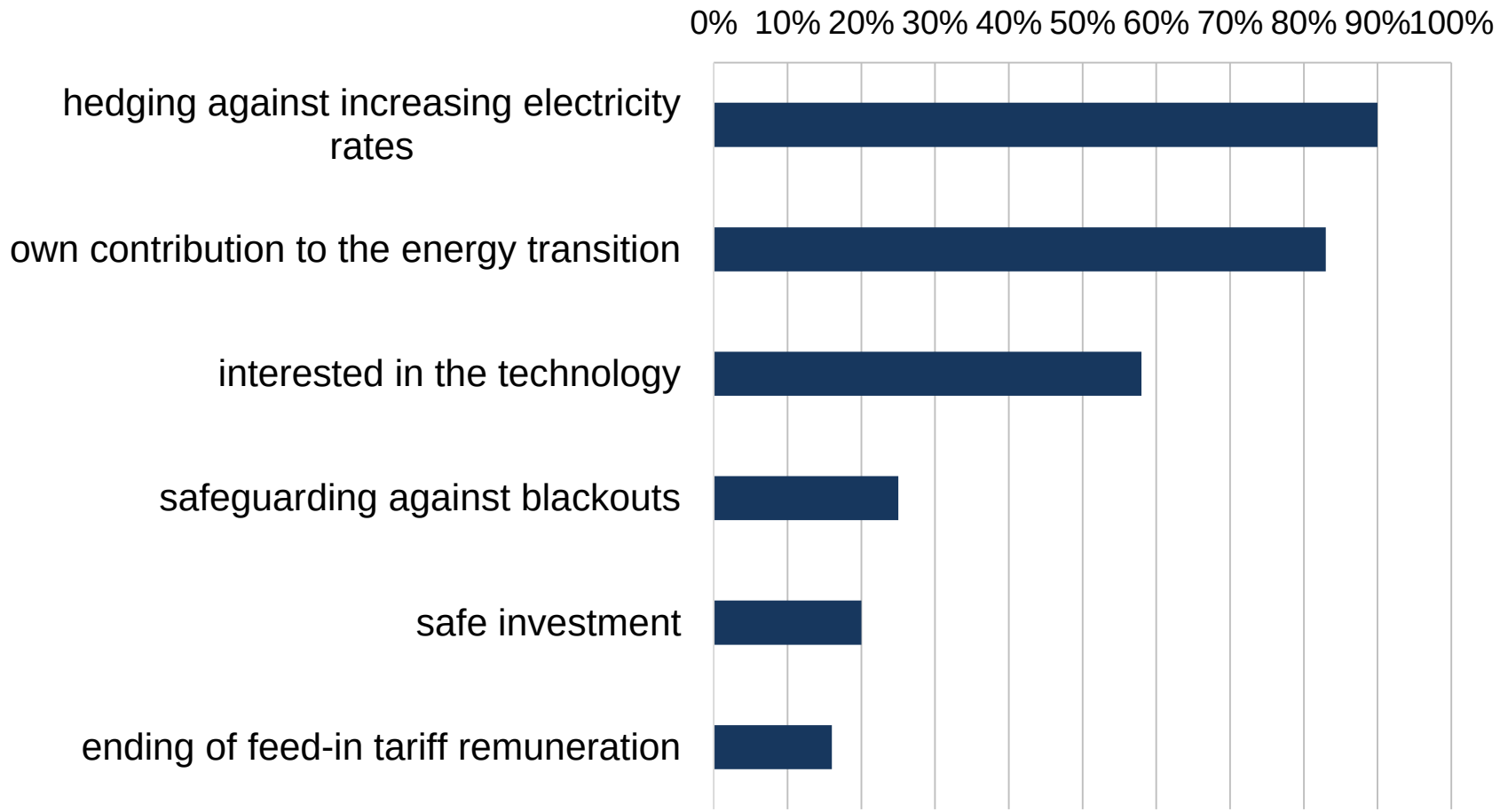


- annual power demand: 4.000 kWh
- PV capacity 4 kWp
- usable storage capacity 4 kWh

Source: HTW Berlin, 2015.

“Independence for early adopters” is the most important sales argument of home storage systems

End customer’s motivation behind the purchase of a home storage system



Source: RWTH Aachen Speichermonitoring 2015

Motivation of end customers is surveyed in the monitoring program of RWTH Aachen that accompanies the investment costs subsidy of the government bank KfW.

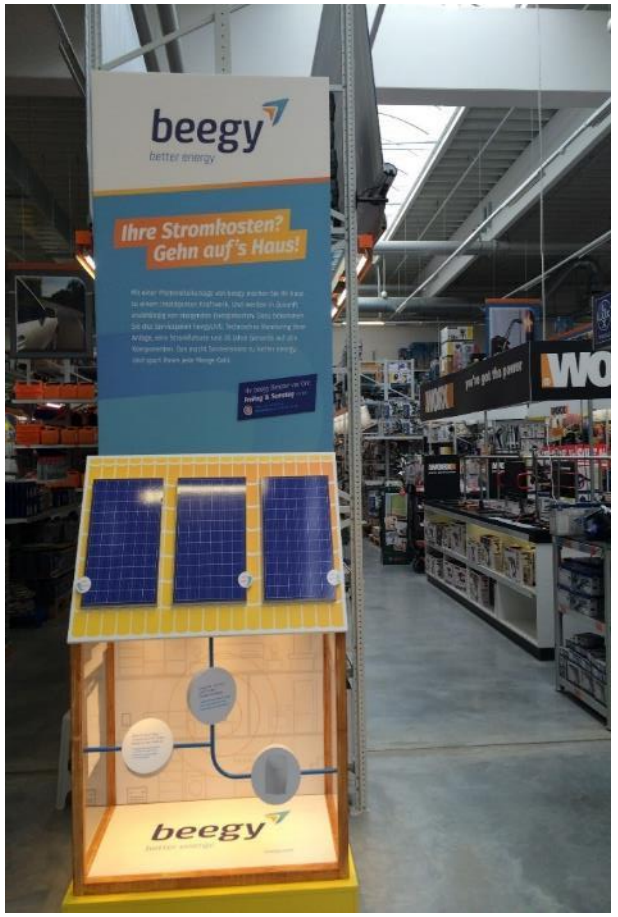
Investors of a residential PV plant would be better off optimizing their PV system for self-consumption (even when considering the investment cost subsidy of KfW). Nevertheless, some 50% of newly installed PV plants in the residential sector come with a home storage system.

This indicates the attractiveness of the combination of PV and storage for end users.

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.



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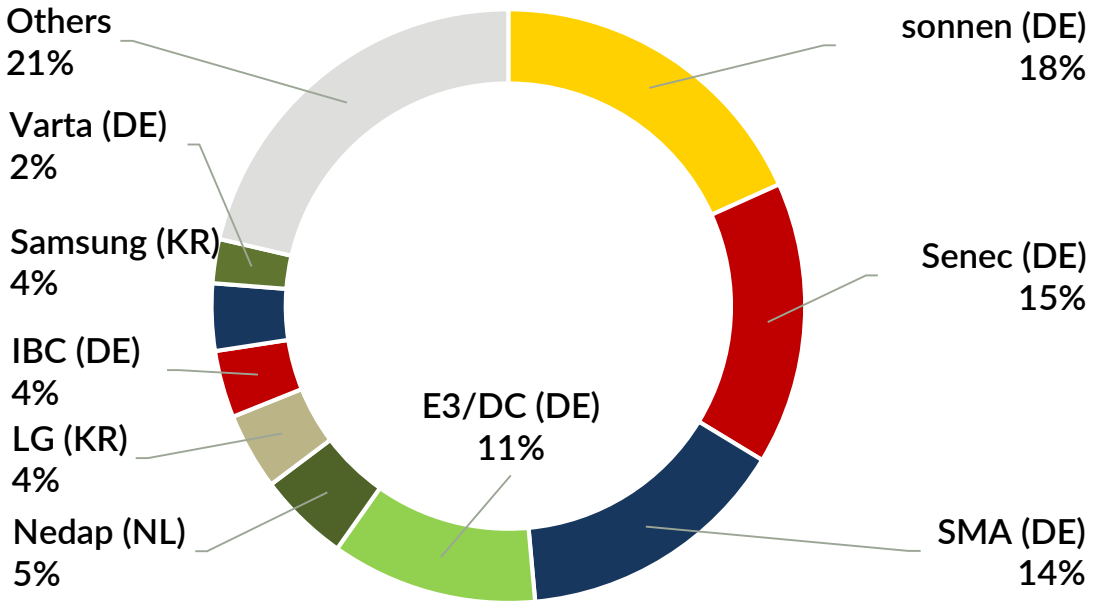
German storage system integrators dominate the market, however, LG Chem and Tesla are gaining market shares

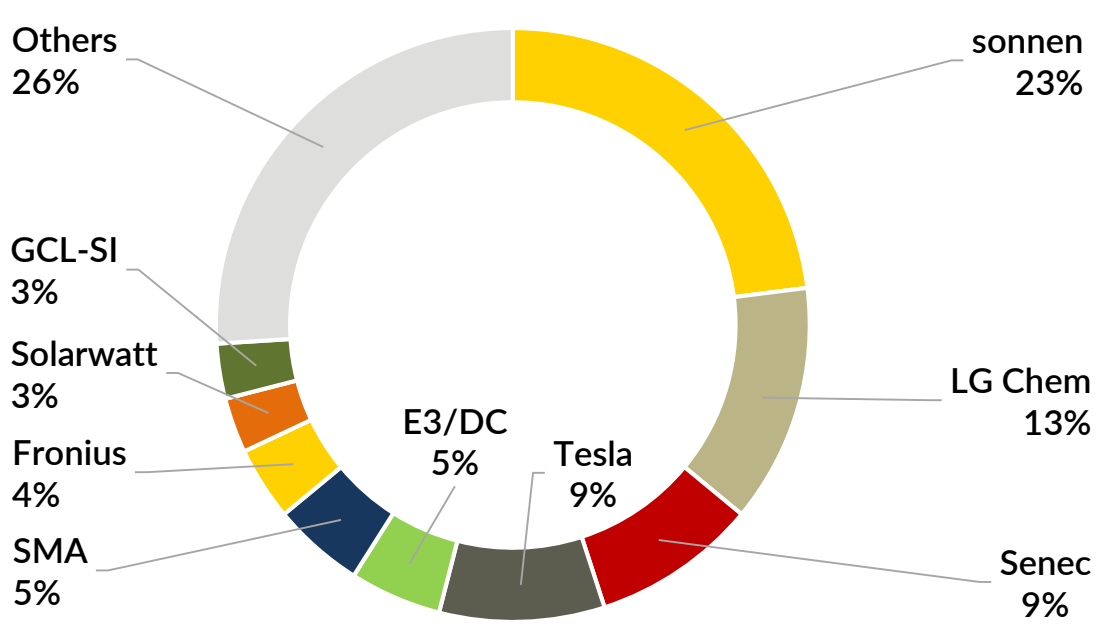
Market shares of home storage system integrators in Germany

Storage Monitoring RWTH Aachen



Time period: May 2013 – March 2016
Data base: 9,906 registered home storage systems in the KFW storage monitoring program of RWTH Aachen

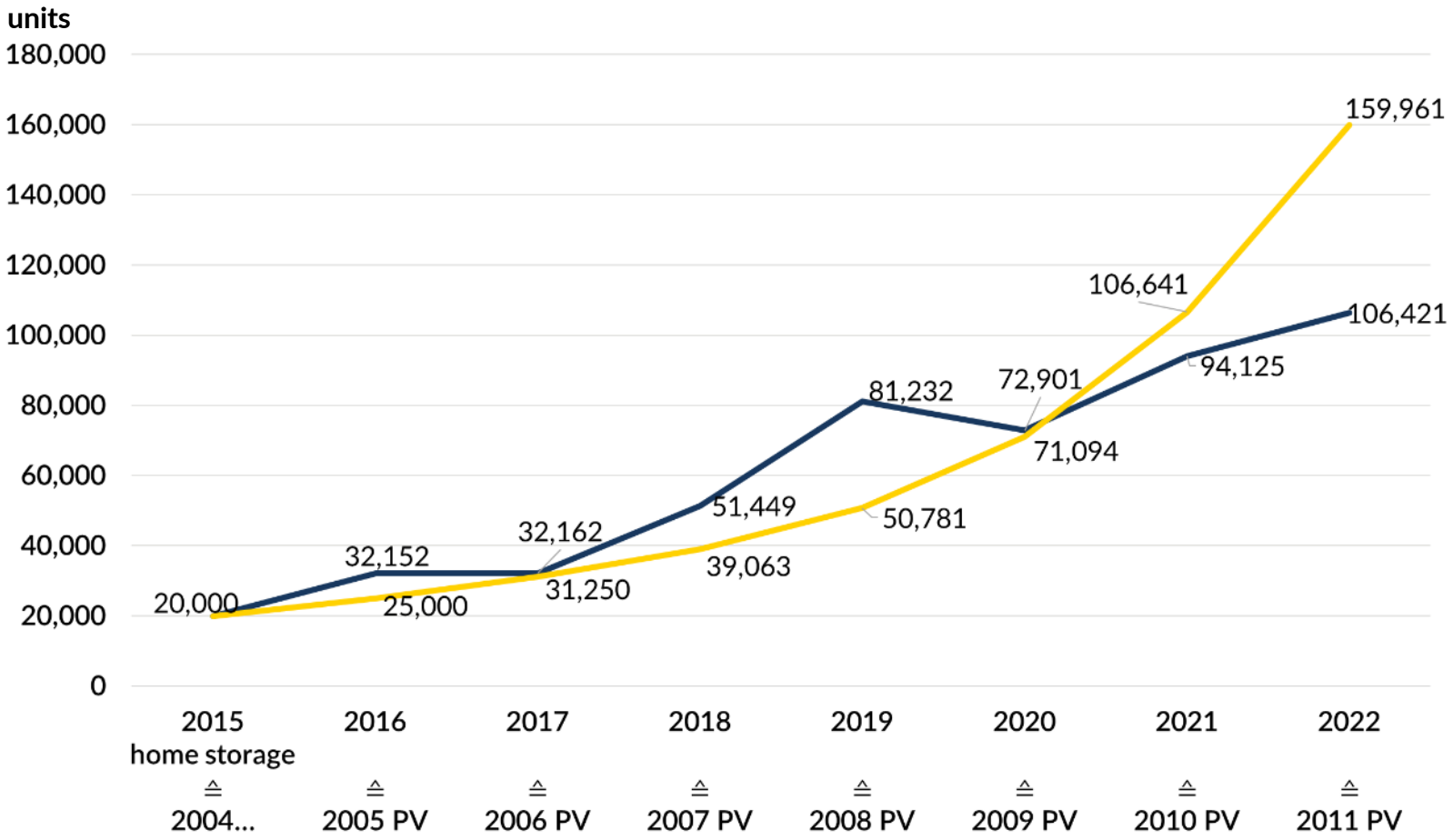
Installer Surveys EuPD Research



Time period: First half of 2016
Data base: Surveys with installers in Germany by EuPD Research

Market growth for home storage systems is likely to accelerate from 2018 on

Newly installed home storage systems in Germany 2015-2022e (units)



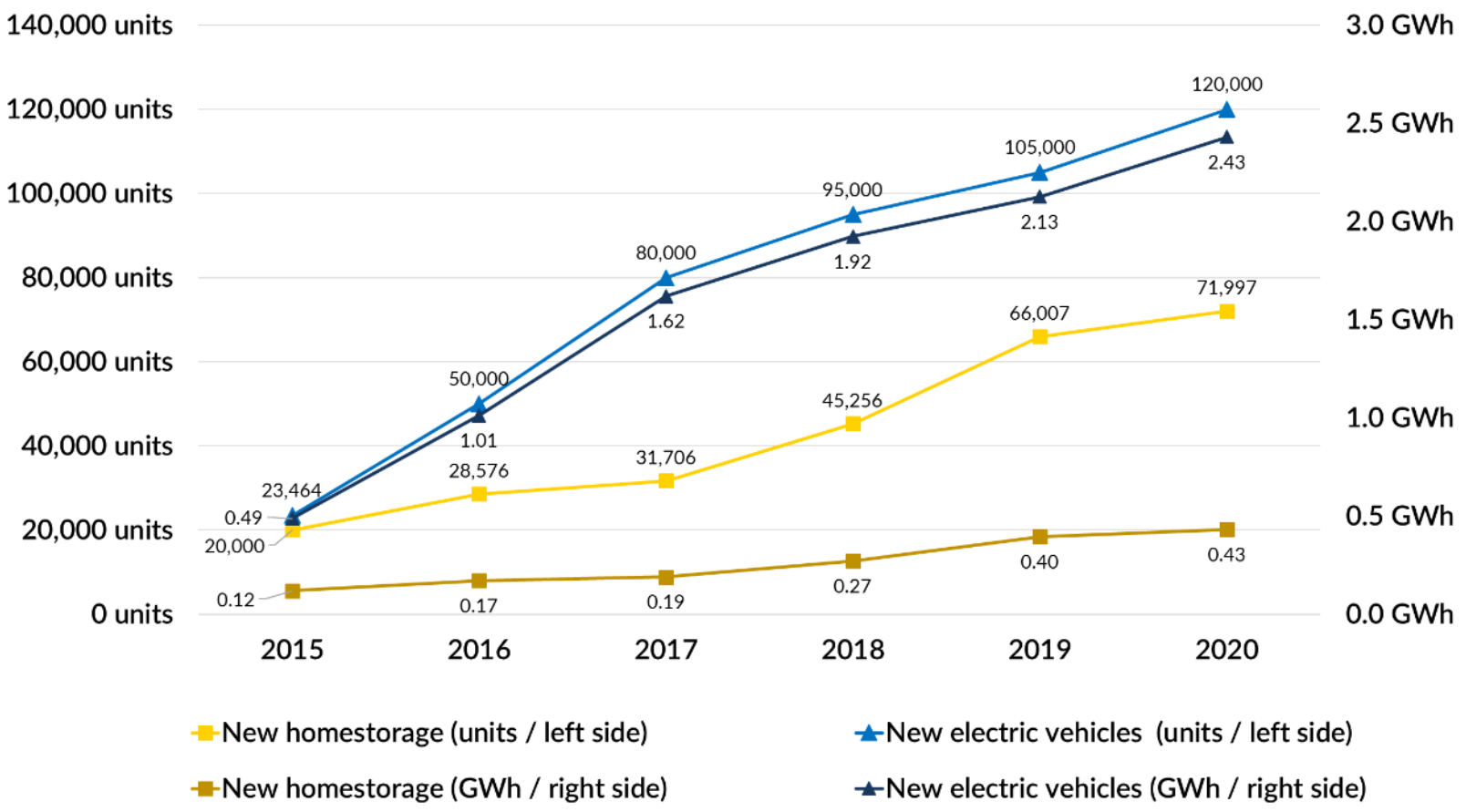
Scenario "Market-Driven"
Annual market growth of 25% 2016-18. Acceleration with storage parity from 2019 on. Annual growth rates of 50% in 2021/22 as new use-cases become feasible with falling prices.

Scenario "As PV 2004-11"
Amount of newly installed home storage systems per year in 2016-2022 is identical to the installation rate of residential PV plants 2004-2011 in Germany.

Source: Büro F

More usable storage capacity will be installed in electric vehicles than in home-storage units

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



E-Mobility

Units: based on Fraunhofer ISI 2013, Federal Motor Transport Authority 2016, own calculations. Includes electric vehicles (EV), plug-in hybrid vehicles (PHEV) and range-extended electric vehicles (REEV).

GWh: 21 kWh average storage capacity of e-vehicles. Calculation based on 2013-2015 market shares of different e-vehicle types and the respective battery capacities according to UBA 2014 and Fraunhofer ISI 2013.

Home Storage

Units: Average of the two scenarios “Market Driven“ and “PV 2004-2011“

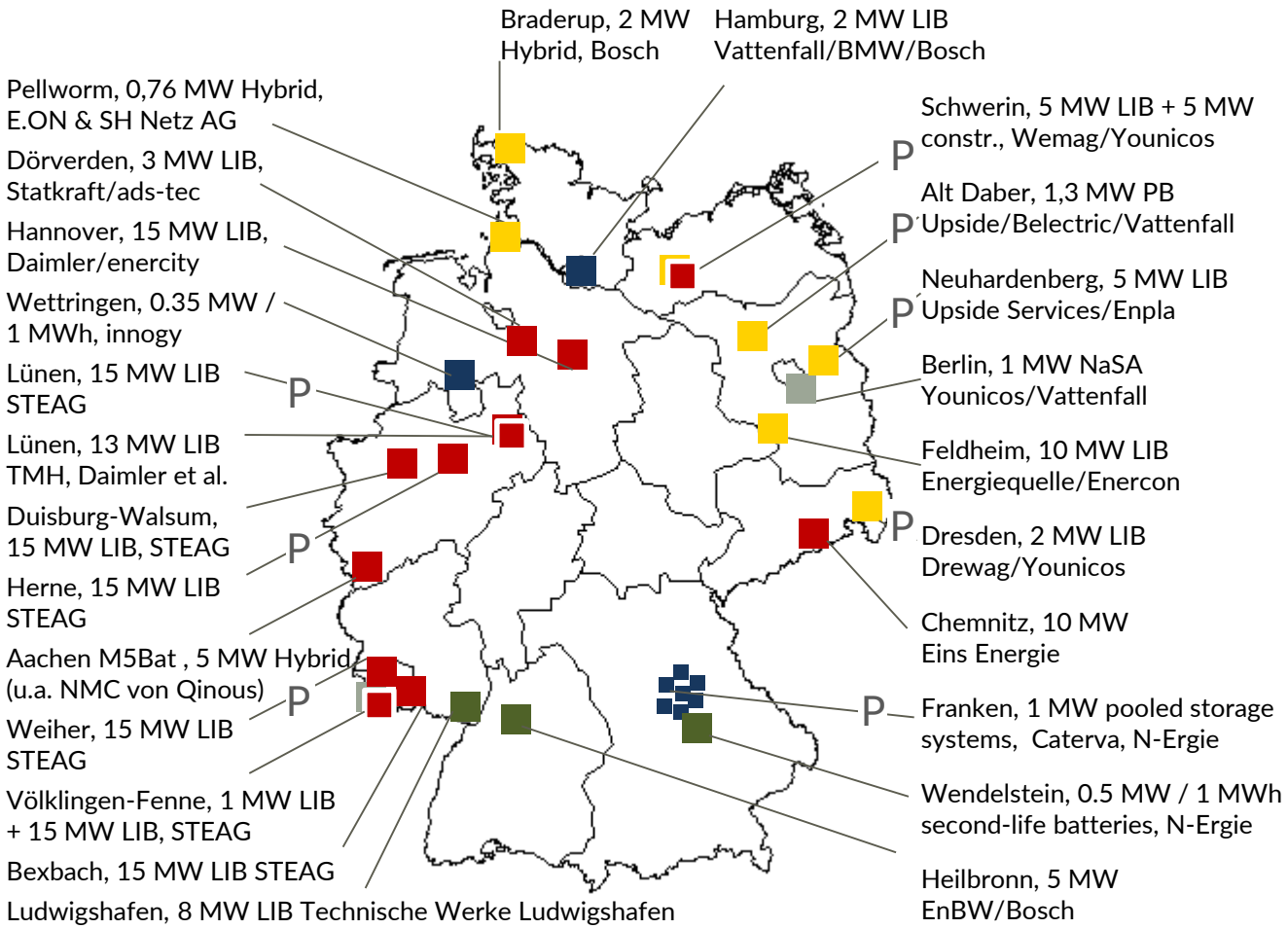
GWh: 6 kWh average storage capacity of home storage systems according to RWTH Aachen

Source: Büro F

1. Storage technologies
2. Home storage: business models, players, forecasts
3. **Large-scale storage: installations and business models**

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

Overview Battery Storage Parks >1 MW in Germany (state: February 2017)



Start of installation

- 2012/13
- 2014
- 2015
- 2016
- 2017

Prequalification

P

Primary control reserve – System is prequalified for the provision of primary control reserve

Top providers of large-scale battery storage plants in the German market

adstec
BELECTRIC
BOSCH
LG Chem
Nidec – All for dreams
QINOUS smart energy storage
SMA
TESVOLT STORAGETECHNOLOGY
UPSIDE
Younicos Let the fossils rest in peace.

Source: Büro F, based on company reports, GTAI, DoE

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

Business models for storage applications

	Specific operation site	Site independent
Power supplier	▪ improvements balancing group ▪ compensation for fluctuating power output	▪ **providing balancing power** ▪ trading on day ahead- and intraday markets ▪ integration into virtual power plants and balancing groups, e.g. for regional electricity rates / provision of residual load for prosumers
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	

Most of the large-scale storage plants >1 MW capacity aim at participating in the markets for primary control reserve.

The current boom may lead to a cannibalization effect where the increasing numbers of market participants with a rather identical offer result in an over-supply situation and hence falling prices.

Appliances for commercial and industrial customers are becoming a more and more important segment, but profitability is unclear.

Peak shaving for distribution grid operators is still in pilot phase.

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1. **Aggregation through virtual power plants**
2. Peer-to-Peer through blockchains

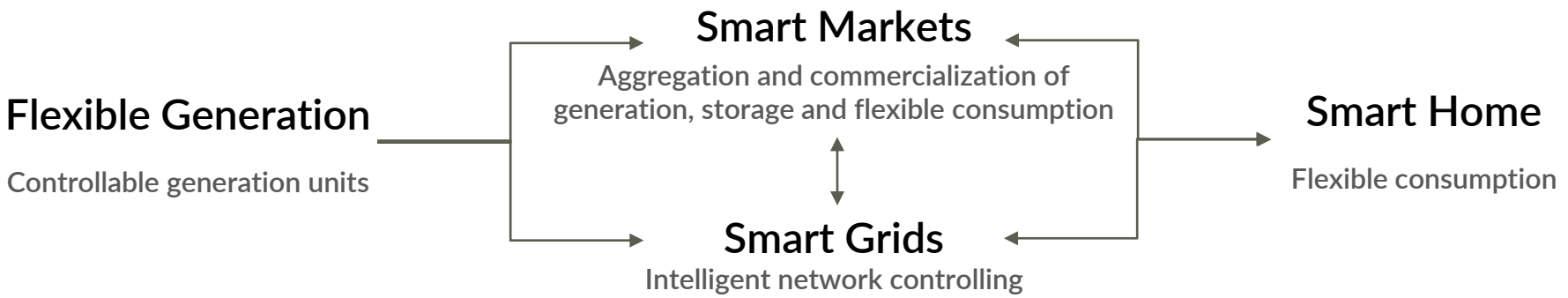
Digitalization makes communicative linkage & control of distributed generation possible

Areas of application in the digitalization of the energy industry

Generation	Matching generation & consumption	Consumption

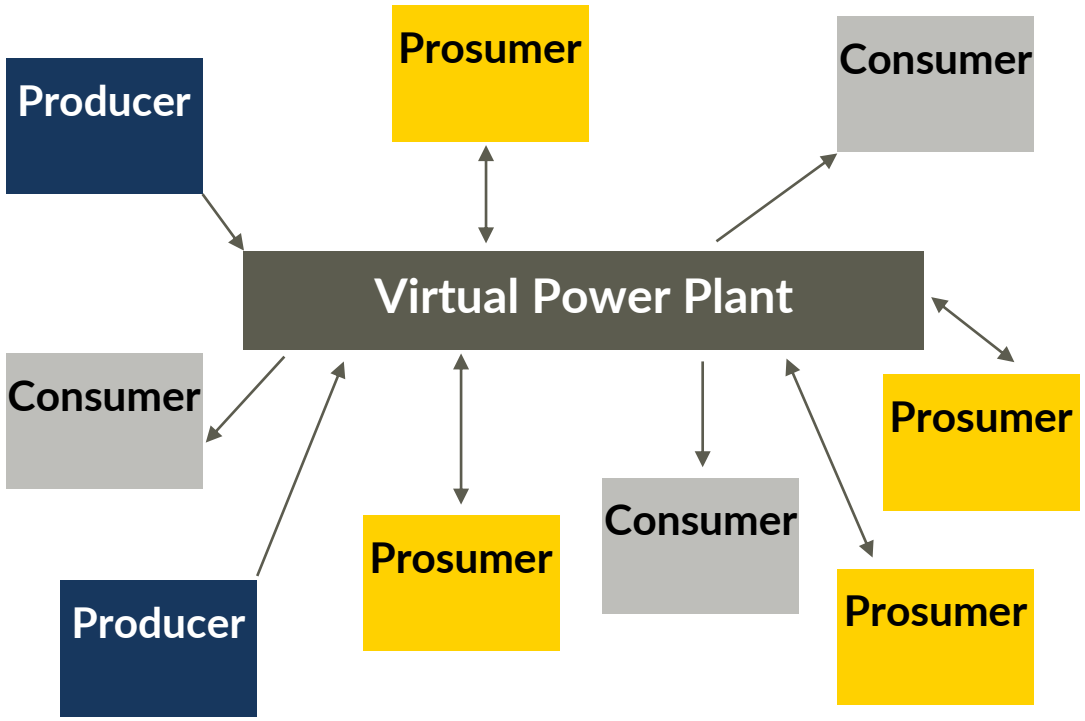
Digitalization of the power system

- 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”)

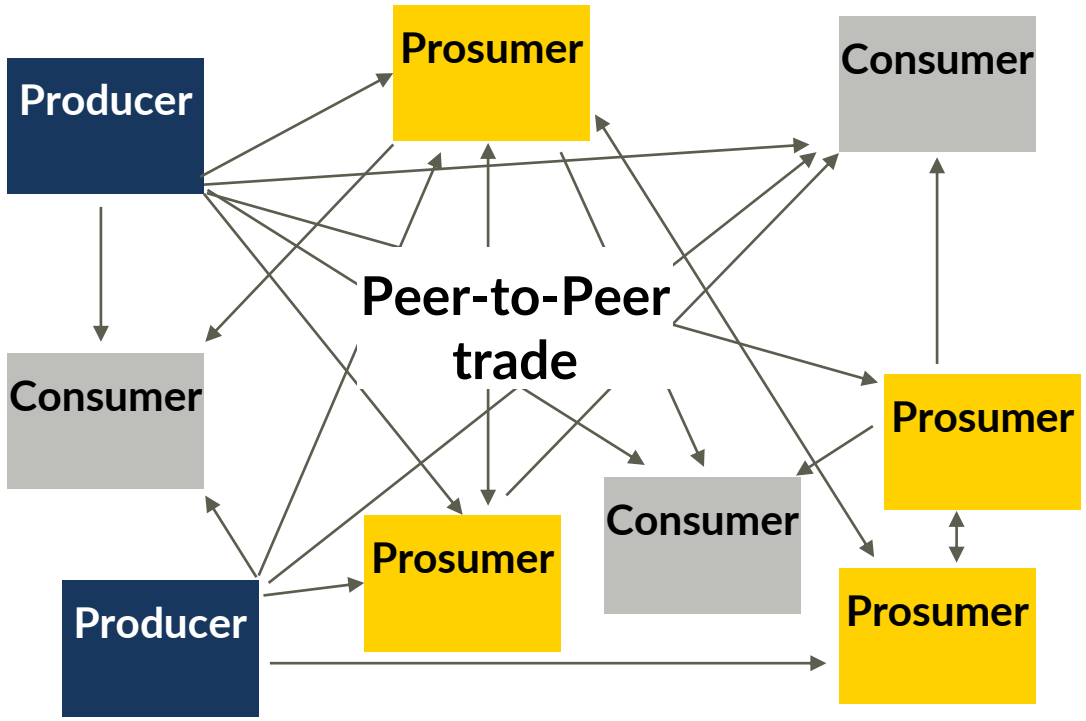


Smart Grids and Smart Markets are enabling the integration of distributed generation and storage into power systems

Aggregation of distributed generation & storage



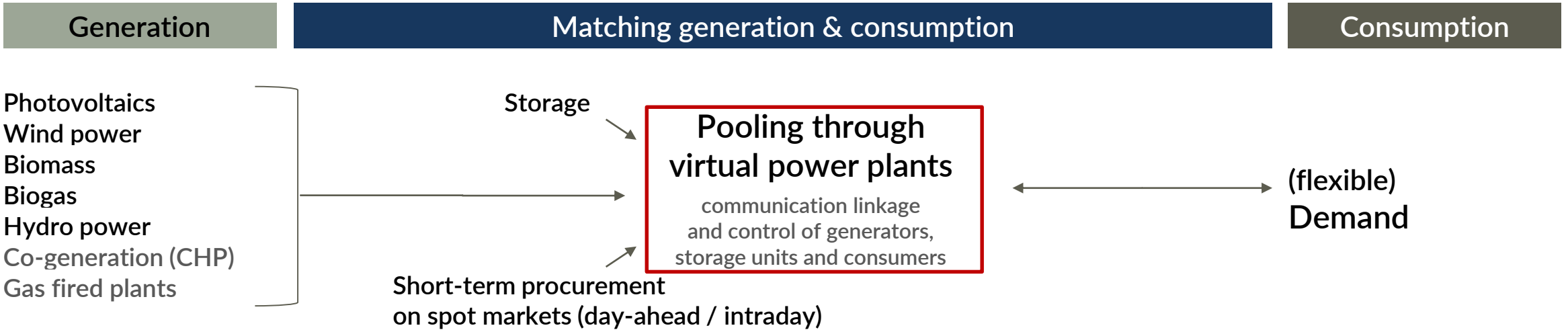
Peer-to-Peer power trade (e.g. Blockchain)



Source: Büro F

Virtual power plants aggregate small-scale renewable energy generators, storage plants and flexible demand

Operating principle of a virtual power plant



By aggregating different distributed generation plants, virtual power plants (VPP) are able to market complete electricity bands on the power markets. Hence, virtual power plants are able to replace centralized baseload power plants. Intermittent PV and wind power plants are balanced out through fast controllable power plants (biogas, combined heat and power - CHP, natural gas turbines) and storage systems. It is becoming more and more common to integrate demand-side management into virtual power plants. Other common names are combined power station, aggregation, and pooling.

Virtual power plant software includes communication and control of generators as well as prognostics

Services of software providers for the operation of virtual power plants

IT companies are becoming more and more important for the marketing of electricity from renewable energy plants. They are also providing the panel for the technical and economical controlling of virtual power plants.

Services of the software provider for VPP control stations:

- intelligent interconnection of distributed generation plants through technical communication links
- optimized operation of generation plants according to generation cost considerations (marginal cost vs. generation cost)
- prognosis software for the forecast of intermittent wind and solar power generation
- prognosis software for prices on power markets (day-ahead, intraday, control reserve capacity)
- optimized demand side management, e.g. industrial and commercial customers
- interface to power trading markets

A pioneer with regard to virtual power plant software in Germany is energy&meteo systems. Originally, the company provided weather prognostics software. Other providers come from the remote control/telecontrol software industry (OHP), conventional power plant deployment planning (PSI, Omnetric/Siemens, BTC Consult, ABB) and energy utilities (Avectrics/AXPO, Lichtblick).

Source: Büro F

In Germany, around 15 software providers for virtual power plant control stations are on the market

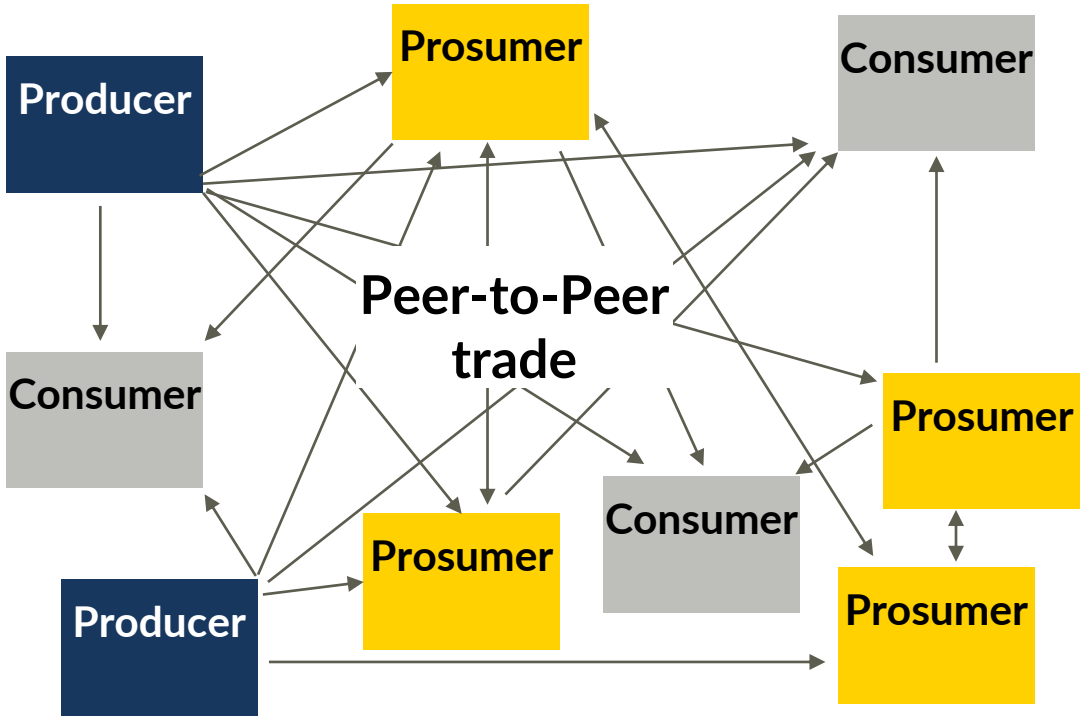
Software providers for the operation of virtual power plants

Supplier	Short description	Reference client VPP
ABB	Controlling software OPTIMAX PowerFit; Cooperation with Deutsche Telekom for integration into Cloud	Next Kraftwerke
Ampard	Swiss startup focusing on the integration of storage units into virtual power plants	in.power
Avectrics AG	IT branch of the Swiss energy provider AXPO	Axpo
Bosch Software	IT branch of the conglomerate offers a virtual power plant manager	Smart City Rheintal
BTC	Supplier of energy control systems for conventional providers with references in the VPP sector	Trianel
Conpower	Automatization and process solutions for the renewable energy industry	Clens
Energy Meteo Systems	Pioneer in the VPP area with a background in RES performance forecasting	EnBW, EWE, Grundgrün, Mark-E, MVV, RWE, Statkraft, Sunnic, Thüga, Trianel/GESY
EnerNoc	Software solutions with a background in aggregation and marketing flexible loads	n/a
GridSystronic Energy	Startup, pilot project with software and hardware solutions for Micro-CHP in the state of Baden Württemberg	Project “Mikro-VKK“, with various public utilities
Lichtblick	“Schwarmdirigent“ is a private development of Lichtblick for decentral CHP and storage systems	Lichtblick
OHP	Small-scale supplier with a background in telecontrol	Lechwerke
Omnetric Group	Joint Venture of Siemens and Accenture for smart grid software solutions	Accenture
ProCom	IT planning and optimisation systems for energy generation and trade	E2M
PSI AG	IT system developers with a background in the development of energy control systems for conventional providers	n/a
Schneider Electric	As a ”flexibility provider“ Schneider Electric also offers a software solution for the management of VPP	Mostly key accounts in France
Siemens	The technology group offers “DEMS – Decentralized Energy Management System“ as a VPP solution	SWM, RWE

1. Aggregation through virtual power plants
2. **Peer-to-Peer through blockchains**

Peer-to-Peer technologies enable direct electricity trading – w/o intermediaries or aggregators

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



- In the power sector, direct electricity trading has so far only been possible between companies through over-the-counter contracts (OTC) such as power purchase agreements (PPA).
- However, the supplier has to be a prequalified balancing group manager, meaning that grid feed-in from his generation plant and the amount of sold electricity sales (OTC or on the spot markets) is balanced out.
- For the marketing of electricity from smaller generators and prosumers, aggregators operate as market intermediaries.
- A direct peer-to-peer trade of electricity, for instance between prosumers, is not possible yet, mainly due to regulatory hindrances.
- With blockchain technology, smart contracts between peers can be arranged, documented and verified, making the role of market intermediaries and aggregators unnecessary.

Blockchains document and verify P2P transactions digitally

Basis principle of a blockchain

Supplier and consumer agree on a transaction (automated or in person)

This single transaction is aggregated with other transactions in the same time frame into a data block

This data block is saved in a decentralized manner with copies on various distributed computers worldwide

Once the data block is validated, it is merged with earlier validated data blocks to a blockchain (which is permanently growing)

The transaction is verified for both parties

- Transactions between two (or more) parties are documented by network members – not by market intermediaries.
- Entries into this permanently growing blockchain cannot be reversed or manipulated retrospectively, as all transactions are saved on various computers.
- Network members can be anonymous (open blockchain) or identified (private blockchain)

Source: pwc 2016, Blockchain – Chance für die Energieverbraucher?

2016 survey among German energy experts indicates that mixed forms between aggregation and P2P might evolve

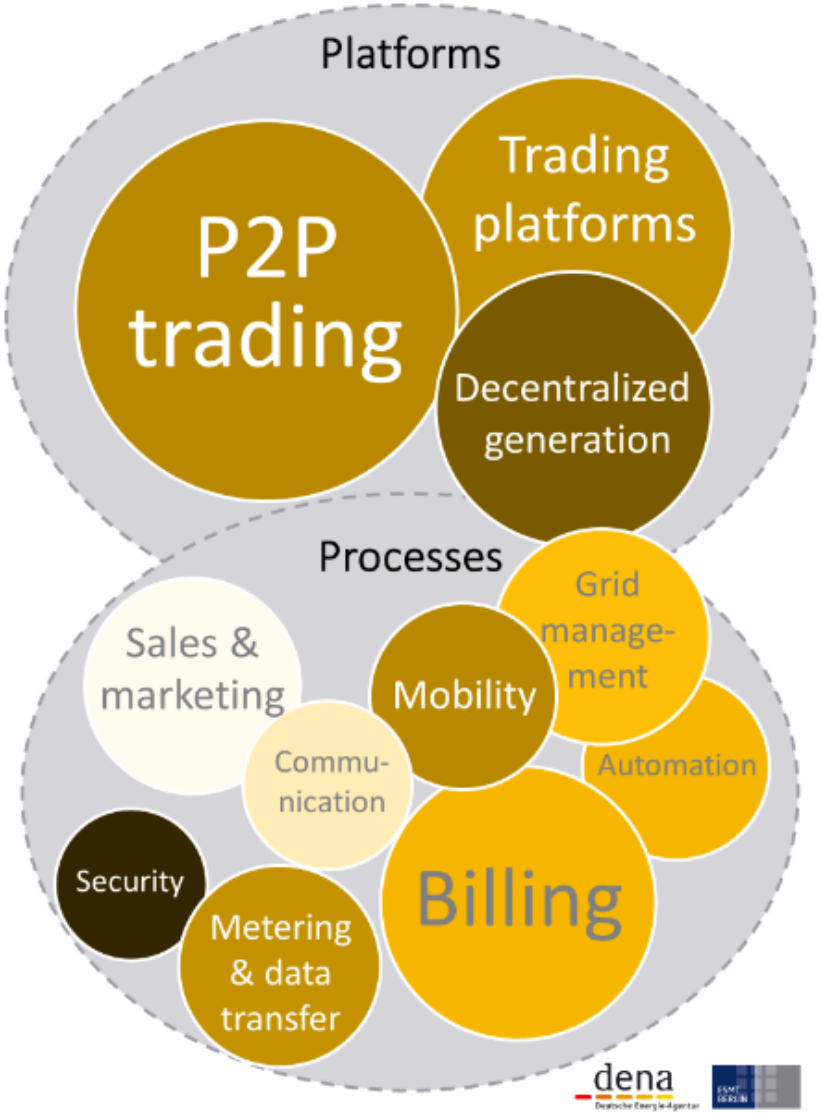
Applications for blockchains in the energy sector (dena survey)

Platforms and Markets

- **Peer-to-Peer trading (23 mentionings in 2016 energy expert survey)**
  including communication for security of supply, the potential to reduce trading volumes on conventional trading platforms, and peer-to-peer marketing
- **Trading platforms (17)**
  including public platforms, such as balancing markets, capacity markets, and intraday trading, as well as private platforms such as demand-side management, the coordination of the existing power plant portfolio, industrial energy supply, and virtual power plants
- **Distributed generation (9)**
  As this cluster is a hybrid between processes and platforms, it contains elements such as decentralized energy management, neighborhood solutions, and renewable installations.

Process optimization

- billing (13), sales and marketing (9), automation (7), Metering and data transfer (6), mobility (6), communication (5), grid management (5), security (4)



Source: dena 2016, Blockchain in the energy transition.

In 2016, the blockchain hype started in Germany's power sector – but only one pilot application has been reported

Players in the German blockchain scene

Conferences & Reports

Forum Neue Energiewelt

Conferences, blogs and marketing for the blockchain technology

German Energy Agency (dena)

Study on Blockchain in the Energy Transition, carried out by the private university ESMT Berlin

Consumer Protection Agency North Rhine-Westphalia

Study on impacts of blockchain technologies on energy consumers, carried out by pwc

First application in GER

Municipal utility Kamen & Partners

In a pilot project, blockchain technology is used to label regional green electricity and remunerate it with "GreenPowerJetons". Combination of smart meters, ethereum blockchain and real-time renewable energy generation per region aim at bringing together physical and financial flows for green electricity – and to make the physical green electricity share visible. Jetons are issued and changeable.

Investments

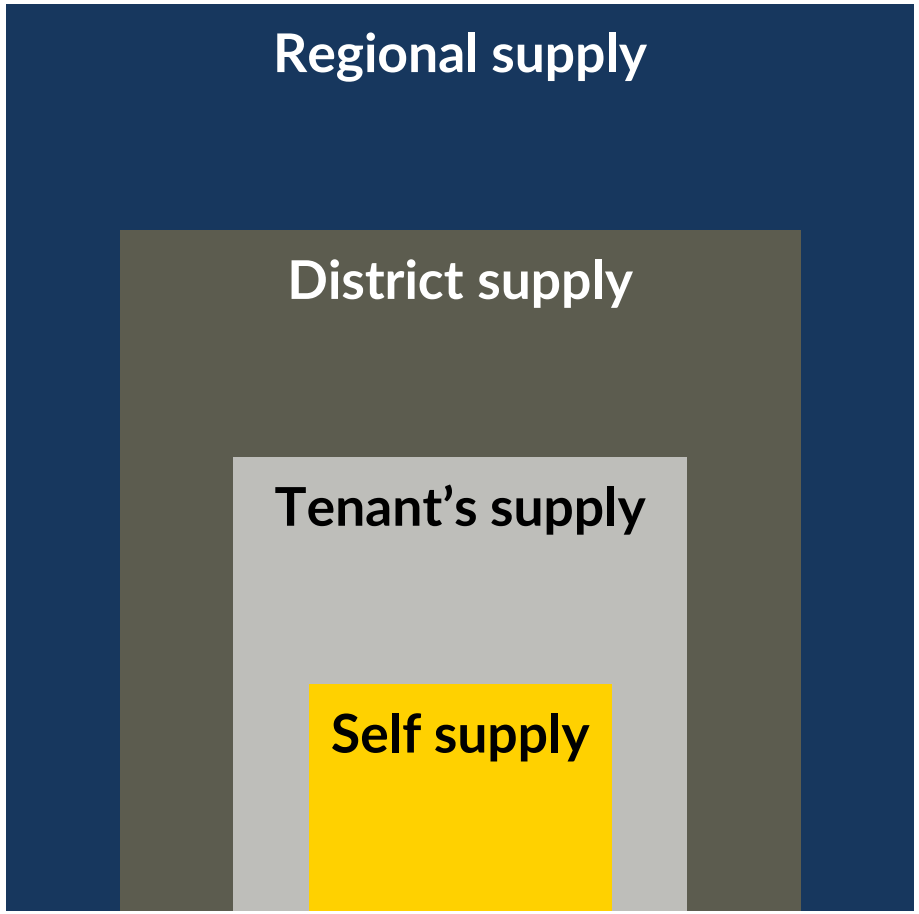
Siemens / LO3 Energy

Through its start-up spin-off "Next 47", Siemens announced to invest in blockchain technologies, starting with LO 3 Energy, one of the companies that is behind the Brooklyn Transactive Grid.

1. **Self-supply and prosumer pooling**
2. Tenant‘s supply
3. Regional supply

Different forms of direct marketing of distributed generation are establishing themselves in the German power market

Direct power supply models with a local reference (typology by l°energy & Büro F)



Regional supply
Electricity tariffs with a share of electricity generated from specific plants within a defined region (between 0%-100%).

District supply
Expansion of the tenant's supply model to entire districts, including the usage of the public grid.

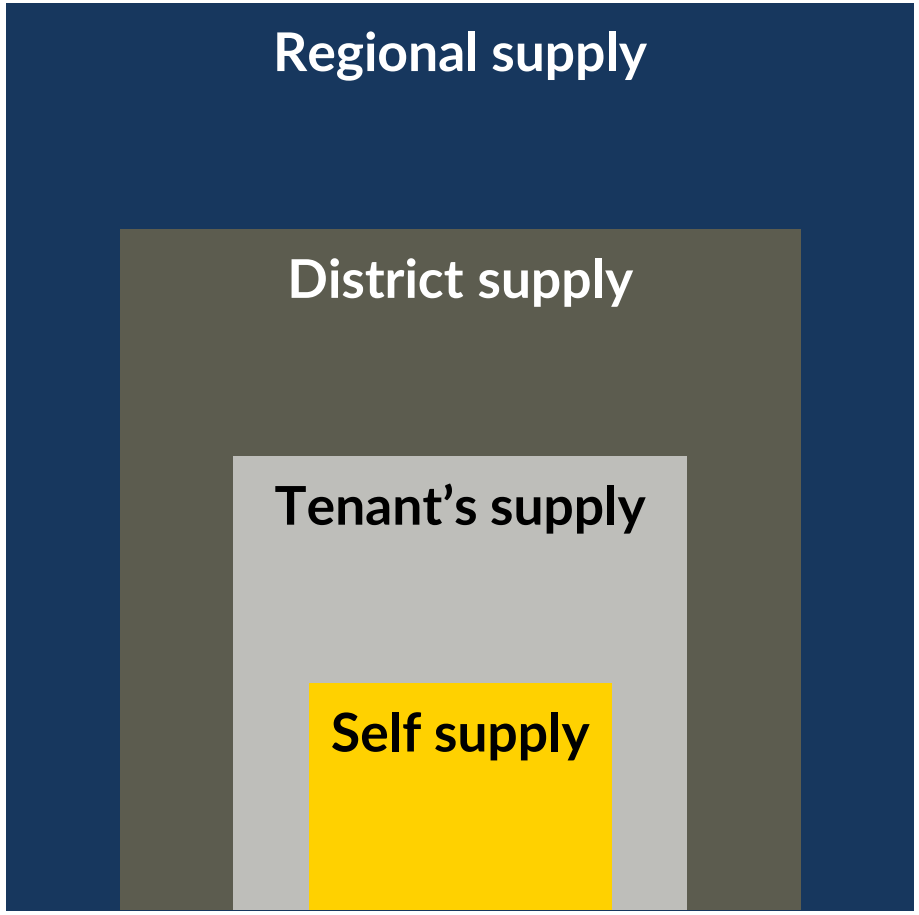
Tenant's supply
Marketing of on-site generated PV and CHP power to tenants in multi-family houses. No feed-in into the public grid.

Self-supply
Direct consumption of on-site generated electricity, no grid feed-in, no marketing.

l°energy & Büro F

Innovation drivers are IT-service provider, green power suppliers, energy cooperatives and even conventional utilities

Direct power supply models with a local reference (typology by l°energy & Büro F)



Regional supply

Fichtelgebirgs Strom · Lumenaza Die Stromgemeinschaft · Bürgerwerke Energie in Gemeinschaft · GRÜNSTROMWERK · naturstrom Energie mit Zukunft

District supply

Quartier Strom · Gewobag Die ganze Vielfalt Berlins. · VATTENFALL · MVV Energie

Tenant's supply

p · Stadtwerke Konstanz · stadtwerke Schwäbisch Hall GmbH · LOCALPOOL.de · HEG Heidelberger Energie Genossenschaft eG · LichtBlick Generation reine Energie

Self supply

IBC SOLAR · Wagner Solar · e·on

l°energy & Büro F

The sale of components is only the first step to activating prosumers

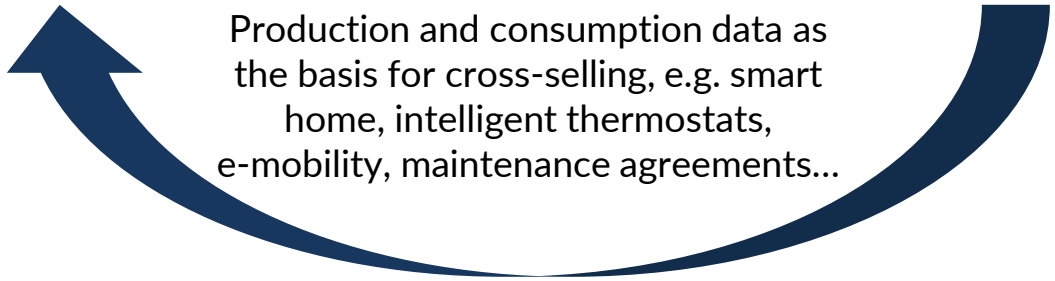
Business models related to self-supply

Sale of components to prosumers

- Direct sales or via installers
- Financial packages in cooperation with finance institutions (e.g. solar lease)

Integration of prosumers into the power system

- Delivery of residual current, e.g. with flexible fees
- Aggregation for control power or regional tariffs



- The starting point is the sale of components and installation services to power prosumers.
- In order to cover the residual current of the prosumers, battery storage components are often combined with specific electricity rates.
- Once clients are “activated“, products requiring intensive explanation can be offered to them, such as load management services, smart home solutions, thermostats, alarm systems, e-bikes and maintenance agreements...

Büro F

Component suppliers are the current innovation drivers for new community supply models for prosumers

Overview of community supply models and tariffs in Germany

Supplier	Short description	Energy market services
Beegy Flatrate	Joint venture between the municipal utility MVV, the RE project developer BayWa r.e. and others. Main target is to develop and test new business models.	BayWa r.e. renewable energy, MVV Energie
Buzzn	Direct marketing of electricity from renewable energy power plants to end customers. Founded 2009.New business as a service provider for tenant‘s supply.	
Caterva	A Siemens spin-off selling storage systems to end customers. Pioneer in integrating pooled small-scale storage units into the power markets.	N-ERGIE
Fenecon Energy Pool	Distributor of the Chinese storage system provider BYD. The storage system comes with 1000 kWh p.a. for the provision of residual current for PV prosumers.	ampard
Lichtblick Schwarm	One of the first and largest providers of green electricity in Germany, with an electricity customer base of around 550,000 . Since 2009 operation of a VPP.	
Lumenaza	Development of trading platform for producers and consumers of green electricity. Aims at become a regional platform provider for P2P electricity trade.	
Senec Cloud	A German battery storage system provider that offers a service package for the residual current. The Senec cloud works like a net-metering regime.	
Sonnen Community	Residual current supply for home storage system customers through the “sonnen community“. The community consists of RES and storage plants, plus hydro power.	Lumenaza Die Stromgemeinschaft

Beegy is expected to become one of the most innovative companies in the power sector, due to its shareholder structure

Community supply provider in Germany (1/3)

Beegy Flatrate

- Joint venture between the municipal utility MVV, the RE project developer BayWa r.e. and others
- The flat rate includes the provision of residual current for buyers of a PV system
- Few details disclosed on the electricity mix, partially from pooled plants from Beegy customers („Beegy community“), remainder from BayWa r.e.
- New sales channels are being tested, in DIY stores
- Website: http://www.beegy.com/flatrate/

Buzzn

- Direct marketing of electricity from renewable energy power plants to end customers. Founded in 2009
- Operation of a balance group, but personalized marketing of electricity with “power givers“ and “power takers“
- New business field is the provision of residual current and metering point operation in tenant‘s electricity projects
- Website: http://www.buzzn.net

Caterva

- A Siemens spin-off selling storage systems to end customers
- The offer includes a financial 100% self-consumption rate for owners of a PV plant over one year
- Pooling of >1 MW of distributed home storage systems and participation in spot markets and control energy
- Cooperation with the municipal utility N-Ergie, cooperation with Vattenfall announced
- Website: http://caterva.de/

Lumenaza has become one of the leading IT service providers for direct electricity supply models

Community supply provider in Germany (2/3)

Fenecon Energy Pool

- Distributor of the Chinese storage system provider BYD
- The storage system comes with 1000 kWh p.a. (residual current for PV prosumers)
- Pooling of storage systems in order to charge them in case of negative electricity prices on spot markets
- The energy management system for integration into the power market comes from the Suisse company Ampard
- Website: https://fenecon.de

Lichtblick "Schwarm"

- One of the first and largest providers of green electricity in Germany, with a electricity customer base of around 550,000 (households, C&I)
- Since 2009 operation of an own virtual power plant for the integration of CHP plants of the car manufacturer Volkswagen
- Component sales starts with storage systems from Tesla
- Company is active in tenant's supply projects as well
- Website: http://www.lichtblick.de/

Lumenaza

- Development of trading platform for producers and consumers of green electricity
- Aims at becoming a regional platform provider for P2P electricity trade
- Offers software services for utilities (e.g. Fichtelgebirgsstrom for Stadtwerke Wunsiedel) Operates the sonnen community as well
- Website: http://www.lumenaza.de

Senec and sonnen are the largest German home storage system integrators and publicly announced new supply models

Community supply provider in Germany (3/3)

Senec Cloud

- A German battery storage system provider that offers a service package for the residual current
- The Senec cloud works like a net-metering regime, where unconsumed electricity is credited for later consumption
- A monthly fee of 17-35€ applies for the provision of residual current, which is offset by discounts for hardware sales (storage systems)
- Senec was the first storage system provider that offered systems that came with an extra cash flow for their customers through the integration into the energy market (2014, Econamic Grid)
- Website: http://www.senec-cloud.de/

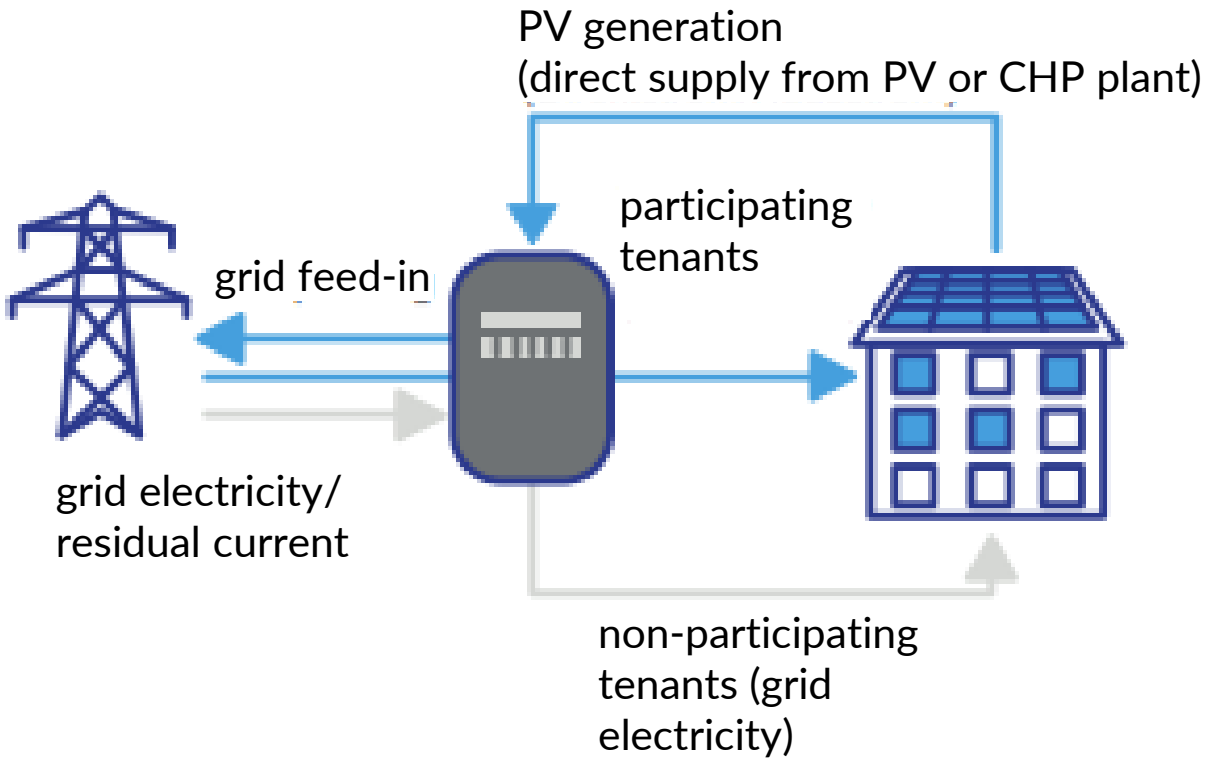
Sonnen Community

- Residual current supply for home storage system customers through the ”sonnen community“
- The community consists of RES plants and pooled storage systems, baseload is provided by hydro power and spot market
- Discounts on the sales of components, but a 20€ monthly service fee applies, and a power rate of 0.23€/kWh
- Lumenaza is the balancing group responsible for sonnen and IT service platform provider
- Website: https://www.sonnenbatterie.de/de/sonnenCommunity

1. Self-supply and prosumer pooling
2. **Tenant‘s supply**
3. Regional supply

On-site generation for multi-unit buildings is a complex metering task and involves different players

Scheme of a tenant's supply project



- Traditionally, PV projects on multi-family houses were seen as too complicated, due to the usually heterogeneous owner und user relationships.
- However, in the last 2-3 years, more and more tenant's supply projects have been realized in Germany. Market experts from *l°energy* and *Urbane Energie* estimate that some more than 40 projects have materialized in Germany.
- The realization of such projects usually includes the owner(s) of the roof, a PV project developer and an energy service company for the operation of the metering and the supply of residual current.
- In the 2017 Renewable Energy Act, the Federal Ministry of Economics and Energy is commissioned to improve conditions for tenant's electricity projects by a ministerial decree. The precise regulation is expected in the first quarter of 2017.

Source: BSW Solar based on Grünstromwerke

l°energy & Büro F

Players from the real estate industry enter the energy market but usually cooperate with energy service providers

Segmentation and examples for real estate companies providing tenant's supply

Municipal housing companies
- Get active mostly in regions without a municipal utility
- Examples: WBG Wolfen mbH together with Engynious, Berlin Energy Agency BEA

Housing cooperatives (WBG)
- Financing mostly through cooperative shares
- Examples: Wagnis eG and Wogeno eG (Munich) together with localpool/buzzn

Private real estate companies
- Mainly active in new building projects in order to fulfill efficiency standards
- Examples: GVD Immobilien-Neubau in Aubing (Munich), together with Polarstern

Condominium owner groups (WEG)
- Rather involved in tenant‘s electricity project in new buildings
- Examples: WEG GbR (Munich) together with Energiewende Planer GmbH, meter operation from buzzn

Service provider for the real estate industry
- Expansion of the service portfolio with electricity supply products
- Examples: techem, urbana

Source: BSW Solar (l°energy and urbane energie)

It’s mainly the utilities with a strong regional focus that become active in tenant’s electricity supply

Segmentation and examples for energy utilities providing tenant’s supply

Municipal utilities
- Sometimes in cooperation with municipal housing companies
- Examples: Stadtwerke Burg, Mainova, Schwäbisch-Hall, Konstanz, Stadtwerke München…

New energy industry
- Realization of prominent pilot project through green electricity providers
- Examples: Lichtblick 2012 (Gelbes Viertel/Berlin), Naturstrom 2014 (Regensburg)

Energy cooperatives
- Increasing expansion of the traditional business model of financing RE plants
- Examples: Mieterstrom HEG (Heidelberg), Bürgerenergie Berlin

Conventional energy industry
- Few projects up to now, field is mainly covered by municipal utilities.
- Example: EnBW already developed pilot projects

Source: BSW Solar (l°energy and urbane energie)

New energy and IT service providers are evolving for the management of tenant's supply projects

German service providers for tenant's supply projects

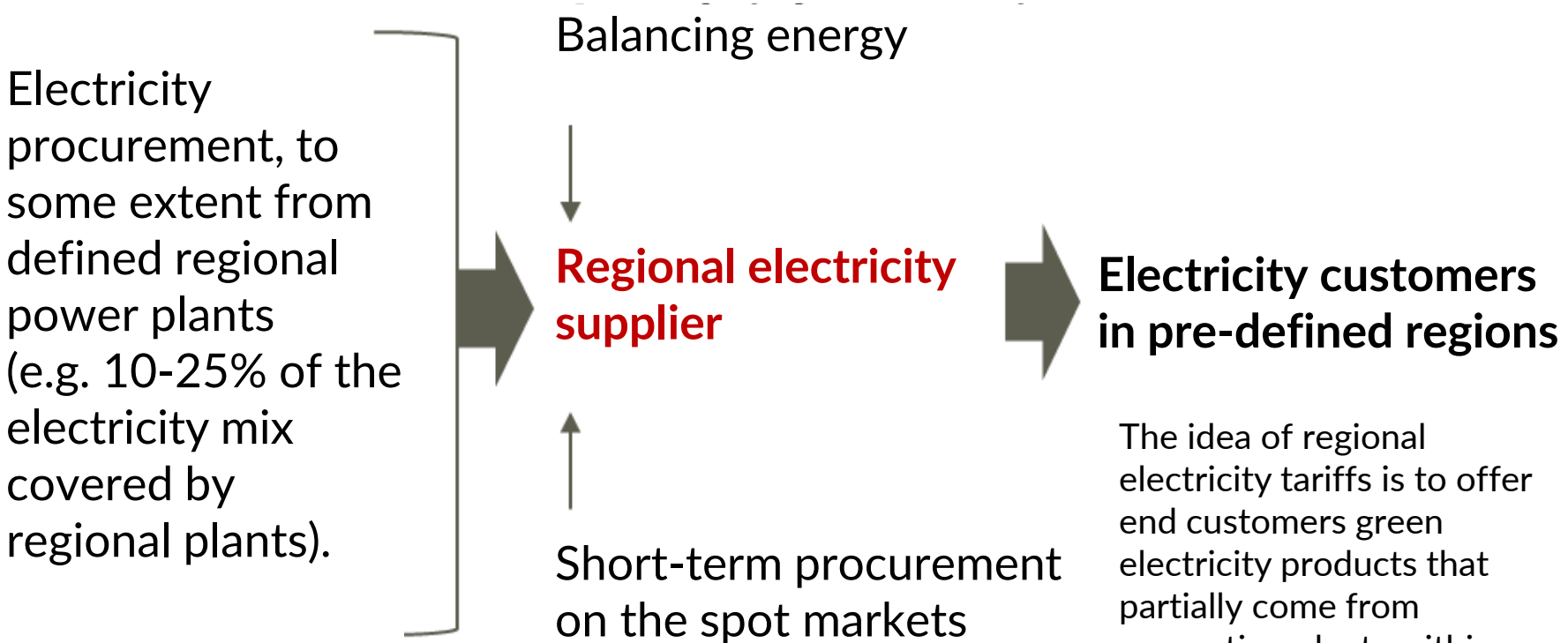
Supplier	Project Development/ Planning/Consulting	Metering/ Energy Management	Residual current
Berliner Energieagentur	X	X	X
Discovergy	X	X	
EM Kernen	X	X	
Energiewende Planer	X		
Engynious	X	X	X
Lichtblick		X	X
Localpool (buzzn)	X	X	X
Polarstern	X	X	X
Prosumergy	X	X	X
Sherpa (SW Schwäbisch-Hall)	X	X	X
Sunride	X	X	
Urbane Energie	X		

Source: Büro F

1. Self-supply and prosumer pooling
2. Tenant‘s supply
3. **Regional supply**

Regional electricity supply is hard to achieve in Germany, but the 2017 Renewable Energy Law opens new opportunities

Scheme of a regional tariff, based on a regionally generated electricity mix



The idea of regional electricity tariffs is to offer end customers green electricity products that partially come from generation plants within a defined region.

The electricity supplier procures electricity under defined criteria on the electricity mix.

"Organic" and regional electricity products fit into the overall trend towards a sustainable lifestyle. Furthermore, acceptance for the energy transition may be altered. Due to expected shortage of grid capacity in Germany, the regional use of electricity is gaining political momentum.

l'energy & Büro F

Regional electricity is so far basically a matter of Marketing, becoming easier with new certificates of origin

Large variety of providers of regional electricity tariffs with different products on the market

Products vary from pure marketing with local focus to offers with regionally produced electricity. Some players mix up to 25% of regional electricity (that gets no EEG remuneration) into their balance and product.

Almost all renewable energy plants in Germany fall under the Renewable Energy Act (EEG) and get feed-in tariff remuneration. Up to now, the marketing of EEG electricity through green electricity rates or regional rates was not supported.

Direct electricity sales are economically usually not attractive when using the public grid. Therefore, building PV and wind power plants without feed-in tariff remuneration is not feasible due to the low spot market price level in central Europe. Hence, realizing regional supply models in Germany is rather difficult at the moment. However, the 2017 EEG allows for a labeling of regional EEG electricity. A certificate of origin is to be introduced. It is likely that with this new regulation, more and more regional electricity tariffs will be offered.

Many players from NGO's and cooperatives are active in developing regional supply models

Providers of regional electricity tariffs (1/3)

Bürgerenergie Bayern

BÜRGER ENERGIE BAYERN e.V.

bavariastrom

- Electricity product for residential end users in Bavaria
- Minimum 25% share from regional PV and wind power plants, operated by energy cooperatives. The remainder comes from hydro power plants in Bavaria
- Cooperation between Bürgerenergie Bayern e.V. and Grünstromwerk/naturstrom
- Exclusive sales channel: regional energy cooperatives in Bavaria
- https://www.bavariastrom.de/

Bürgerwerke

Bürgerwerke Energie in Gemeinschaft

- Mainly a service provider for regional rate projects and energy cooperatives
- Offers 100% green electricity from German plants, mainly PV and wind parks from energy cooperatives. Base load is provided by Bavarian hydro power plants
- Reference to supply from plants "whenever possible from your region", and investments in regional value creation
- https://buergerwerke.de

BUND / EWS

BUND FRIENDS OF THE EARTH GERMANY

EWS ElektrizitätsWerke Schönau

- "Conventional" green electricity mix for electricity customers in the state of Baden-Württemberg
- Cooperation between EWS Elektrizitätswerke Schönau and the nature conservation NGO "BUND"
- Reference to re-investments within the region of 1 Eurocent per kWh
- http://www.bund-regionalstrom.de/

l'energy & Büro F

Since the acquisition of Grünstromwerk, the green electricity provider naturstrom is on the pole position

Providers of regional electricity tariffs (2/3)

Friesenenergie

- Green electricity mix from Austrian hydro power plants for end customers in Northern Germany
- Details on the specific generation plants disclosed, but no regional reference
- http://friesenenergie.de/

Naturstrom

- One of the leading German green electricity suppliers, Naturstrom acquired the specialized service provider Grünstromwerk in 2015
- Grünstromwerk manages 14 regional rates in Germany (e.g. Aachen, Nordoberpfalz, Rostock, Süderelbe…)
- Green electricity from Germany with a 10% blend of regionally generated electricity
- https://www.gruenstromwerk.de

Nordgröön

- Northern German RE direct marketer, offering regional tariffs for end customers with a specific RE share from specified generators within the region (mainly biogas)
- Recently acquired by the Norwegian Agder Energi
- http://nordgroon.de

Some municipal utilities are getting active in this segment as well, supported by companies like Lumenaza

Providers of regional electricity tariffs (3/3)

Regionalstrom Franken

Regionalstrom Franken eG

- Initiative that stems from an energy cooperative in Northern Bavaria
- Up to now, no residential electricity products in the portfolio
- Pilot for commercial customers in cooperation with the municipal utility N-Ergie from Nuremberg
- Explicit reference to the marketing of electricity from wind power plants that fall out of the feed-in tariff from 2020 on
- http://www.regionalstrom-franken.de/

Stadtwerke Wunsiedel

SWW wunsiedel wir bewegen

FichtelgebirgsStrom echt regional. echt regenerativ.

- 100% green electricity from plants in the region Fichtelgebirge that receive feed-in tariff. A problem with the Renewable Energy Act might arise as subsidized green electricity cannot be marketed to end customers as green electricity
- Cooperation between the municipal utility Wunsiedel and Lumenaza (direct spot marketing and software)
- https://www.fichtelgebirgsstrom.de/

Thüringer Landstrom

Thüringer Landstrom

- "Conventional" green electricity for electricity consumers in the state of Thüringen
- In the future, 100% of the electricity mix should stem from renewable energy plants in Thuringia
- Reference to re-investment within the region (50 € p.a. per customer)
- http://www.buergerenergie-ths.de/thueringer-landstrom

Büro F – Future Power Markets

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Calculation parameters for the PV + storage parity

Item	Value	Unit	Source
cost for a typical 6 kWh home storage system (gross)	7998	Euro	storage price index of Büro F & pv magazine, average H1/16 and H2/16 for 6kWh systems
capacity	6	kWh	
charging cycles	4100	amount	Solarwatt
efficiency rate	93%	percent	Solarwatt
total amount of stored energy over the lifetime	24600	kWh	*calculation*
kWh-price for usable storage capacity	1333	Euro	*calculation*
scost of storage per kWh	0.33	€/kWh	*calculation*
annual price decline for home storage systems	-18%	CAGR	RWTH Aachen 2016 (Speichermonitoring, LIB)
generation cost PV (LCOE)	0.12	€/kWh	Basis: system price <5 kWp 2016: 1,400€/kWp, annual irradiation 1,250 kWh/m²/a
annual price decline for PV systems	-5%	CAGR	avg. price decline utility scale PV according to IEA, IHS, EU PVTP, Fraunhofer ISE, Bloomberg, ITR PV
total costs PV + storage	0.45	€/kWh	*calculation*
average household electricity rate incl. all taxes 2015/1	0.30	€/kWh	BMWi Energiedaten, sheet 30a, 3.500 kWh annual electricity consumption
development household electricity rate per kWh	5.1%	percent	extrapolation CAGR 2005-2015
development household electricity rate per kWh	0.5%	percent	extrapolation CAGR 2013-2015

Source: Büro F