FACT SHEET

The Energy Storage Market in Germany

ISSUE 2018

Energy storage systems are an integral part of Germany's *Energiewende* ("Energy Transition") project. While the demand for energy storage is growing across Europe, Germany remains the European lead target market and the first choice for companies seeking to enter this fast-developing industry. The country stands out as a unique market, development platform and export hub.

The German Energy Revolution

The German energy storage market has experienced a massive boost in recent years. This is due in large part to Germany's ambitious energy transition project. Greenhouse gas emissions are to be reduced by at least 80 percent (compared to 1990 levels) up until 2050. Germany will also gradually phase out all of its nuclear power plants by 2023 – and in doing so will revolutionize its energy infrastructure. Germany is already a front-runner in renewable energy development. Renewable energy sources currently produce around 36 percent of all electricity consumed in Germany. In line with the goals of the German government, this share is to be increased to at least 80 percent of electricity consumption by 2050. Solar power, onshore- and offshore wind power will be the main pillars of renewable energy production.

Grid Integration and Security

The *Energiewende* brings with it huge challenges. The integration of fluctuating renewable energies into the electricity grid demands innovative storage solutions and major investment in the transmission grid. Substantial and fast-reacting storage capacities are needed to balance out short-term fluctuations. Long-term storage solutions are needed to shift loads through the seasons. Germany's geographical makeup places restrictions on the possibility of developing new pumped storage capacity. This makes the use of new storage technologies and smart grids imperative. Energy storage systems – from small and large-scale batteries to power-to-gas technologies – will play a fundamental role in integrating renewable energy into the energy infrastructure to help maintain grid security.

Energy Storage Building Blocks – Electric Mobility

Electric vehicles play an important role in the success of the energy transition and integration of renewable energies into the grid. They can become zero-emission vehicles using renewable electricity sources. As such, fuel-cell cars that run on green hydrogen are also helping contribute to reach climate goals in the transportation sector. Furthermore, through energy storage innovations in the transportation and automotive sectors, electric vehicles can serve as storage units to balance out fluctuating electricity levels in the future.

Research and Development

Germany boasts a dense landscape of world-leading research institutes and universities active in the energy storage sector. They work closely together with industry to bring innovations to the market. The federal government supports research and development in the energy storage, hydrogen, fuel cell, and electric vehicle sectors. Public research and development incentives for EV and stationary battery research amount to between EUR 80 million and EUR 85 million every year.

Business Opportunities in a Pioneer Market

As the European lead market in the energy transition age, Germany provides the opportunity for companies to develop, test, define and market new energy storage solutions. Innovative sales strategies, system configurations, and integration processes are intrinsic components of the specialist expertise currently being developed in Germany. The country actively welcomes international enterprises seeking to participate in the changing energy market landscape.

Contact our industry specialists to explore the individual investment opportunities available to your business: renewables@gtai.com

Small-scale Battery Systems

Energy Self-Sufficiency

The German population supports the goals of the energy transition. Improved energy self-sufficiency in private households and commercial operations enjoys widespread acceptance. More than 1.7 million solar power plants, with a total capacity of more than 43 GWp (2018), have been installed in Germany over the past 25 years. The majority are solar power plants with a capacity below 30 kWp installed on residential rooftops. They build the foundation for the promising market development of small energy storage systems. On average, the own-consumption share of PV-generated electricity can be increased from 35 percent to more than 70 percent with the use of a battery.

The PV Storage Business Case

With falling PV system and battery costs, the business case for storage is gathering pace. By the middle of 2018, some 100,000 households and commercial operations had already invested in PV battery systems. The market is forecast to experience a massive deployment of energy storage systems in the next years as a response to decreasing battery costs. According to GTAI research, PV battery systems could reach an annual installation volume of around 50,000 systems by 2020.

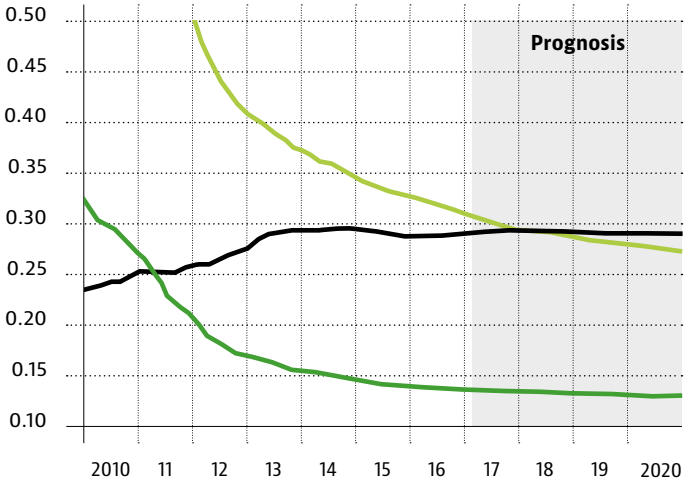
Retrofit Storage Installations

When the 20-year guaranteed feed-in tariff for older installations is phased out, retrofit installations will represent an additional driver for the household energy storage market. More than one million households already have a PV system on their roof and could be potential customers for retrofit batteries in the coming decade. The federal government makes PV battery system investment very attractive through the provision of unique incentives including low-interest loans and investment grants. A growing number of federal states in Germany also offer regional incentives, making investment in battery systems even more appealing.

PV Storage Trends: Service Solutions

Large and small utilities alike offer battery systems with discounted electricity tariffs to their clients. New business models arise from interconnecting several small household storage devices to create a centrally controlled unit. The resulting virtual power plants ensure grid stability by allowing renewables to be integrated into the grid in times of high energy fluctuation. Innovative rental and leasing models, as well as district storage solutions which allow private PV systems owners to feed their surplus energy into a central energy storage device, are also being developed.

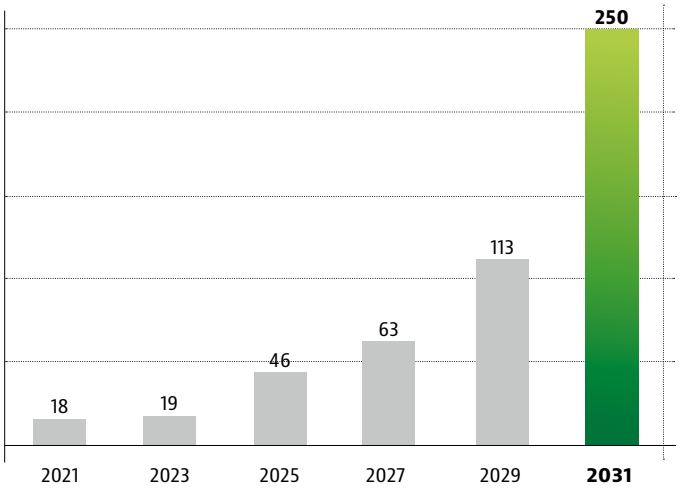
From PV Grid Parity to Battery Parity in 2018
in EUR/kWh



- Electricity price for households (2.5-5 MWh/a)
- Electricity costs for PV*
- Electricity costs for PV + Battery**

*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
** Based on 5,000 cycles, 87% efficiency
Sources: GTAI estimate; System Prices: BSW 2016; Model Calculation: Deutsche Bank 2010; Electricity Prices: BDEW 2017; Electricity Prices 2017-2020: GTAI estimate at 0.29ct/kWh

Battery Retrofit Potential: Installed PV Systems Exiting 20 Year Feed-in Tariff Period
in thousand



Source: Federal Network Agency, BSW 2017

Large-scale Battery Systems

Control Power Market

Large battery systems are playing an increasingly significant role in integrating and balancing large amounts of energy from wind and solar plants in real time. Fast reaction times mean that batteries are ideally suited to providing control power to stabilize grid frequency. The German and European control power markets are attractive for large battery-system manufacturers and operators. Around 1,250 MW of primary control power is traded in the coupled German, Belgian, Austrian, Dutch, French, and Swiss markets with around 3,000 MW in Europe. Prices for primary control power are determined through an auction system with individual prices varying accordingly. In the five years up to 2017, the mean weekly price for primary control power was around EUR 3,070 per MW, with accepted bids ranging on average from EUR 2,800 to 3,500 per MW. Assuming that the minimum attainable price drops to EUR 2,500 per MW, a battery system participating exclusively in the control power market could effectively recoup capital expenditure at system prices below EUR 870 EUR per kWh. This calculation is based on a capital interest rate of five percent, operating costs of two percent, and an amortization period of 10 years.

From Pilot to Commercial Projects

A number of public and private initiatives in Germany are currently cooperating on the development of energy storage technologies. Demonstration projects have been operational in Germany for a number of years, many of which were funded as part of the Federal Ministry for Economic Affairs and Energy's EUR 200 million energy storage funding initiative. Companies can find a large pool of potential partners to optimize their technology on the road to commercialization. Europe's first commercial battery storage system went online in Germany in September 2014. The 5 MW/5 MWh lithium-ion unit participates in the primary frequency regulation market. In 2016, power station operator STEAG built six new large-scale 15 MW lithium-ion batteries alongside existing power stations. Subsequent to their prequalification, the systems went online in November 2016 and now provide primary frequency regulation. To be prequalified, a technical unit must demonstrate that it meets the transmission system operator's (TSO) reliability requirements for the secure supply of frequency response. Many existing battery storage systems have proved successful in improving the reliability of transmission networks – even during heavy fluctuation periods (e.g. generator or interconnector trip).

New Trends and Developments

Further large battery system applications include uninterrupted power supply and black start capabilities. In recent years these have been used as a buffer for PV and wind generators to offset quick shutdowns in the event of surplus energy in the grid. New trends in the large-scale battery segment include the development of district storage and rental and leasing models. District storage involves storing surplus electricity from private local generation plants, such as rooftop PV systems, in a central battery. The stored electricity is released to the end consumer as soon as energy demand exceeds electricity generation levels. This concept is being tested as part of several projects currently using a 100 kW battery at 40 households in the German community of Walldorf. Car manufacturers are also entering the stationary battery market, building storage systems from retired car batteries. In cooperation with other partners, Daimler has launched a 13 MW "second use" project in the German town of Lünen, and a 15 MW project in Hanover. BMW, Vattenfall and Bosch have also set up a 2 MW testing facility, using 2,600 battery modules from electric cars.

Installed Battery Capacity in Germany for Primary Control Power 2016-2017

Installed Capacity	Type of Project	Operated by
15 MW	Li-Ion second life	Daimler, enercity
6 x 15 MW	Li-Ion	STEAG (different sites)
13 MW	Li-Ion second life	Daimler
6 MW	Li-Ion	SWW, Siemens
5 MW	Hybrid: Li-Ion, high-temperature, lead-acid	Eon Energy Research Centre
5 MW	Li-Ion	Upside Group
5 MW	Li-Ion	Younicos, Wemag
3 MW	Li-Ion, ads-tec	Statkraft
2 MW	Li-Ion second life	Vattenfall, BMW, Bosch

Power-to-Gas

Long-Term Energy Storage Solution

Hydrogen and power-to-gas technologies occupy a prominent place in the long-term energy storage plans and future mobility and fuel strategy of the German government. Large amounts of surplus energy from fluctuating renewable sources can be stored as hydrogen gas in the country's extensive gas grid. A number of power-to-gas pilot plants are already in operation. In 2014, a network of around 100 local and regional utilities in Germany opened a power-to-gas energy storage pilot plant to feed hydrogen directly into the gas grid without a compressor. A series of tests during the first project phase confirmed a high overall efficiency level of 77 percent (load range 50-325 kW). According to the study, required energy storage levels could reach 17 TWh in 2020 and up to 50 TWh by 2050. In May 2016, further tests demonstrated that the plant also meets the requirements to provide primary control power.

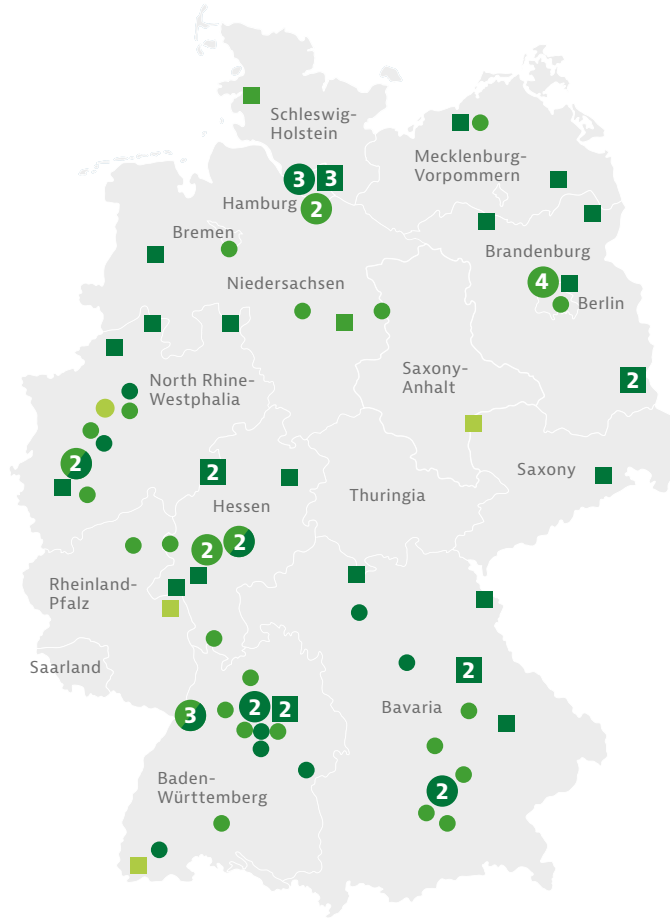
Green Hydrogen in the Transportation Sector

The introduction of power-to-gas technologies is imperative as the German government seeks to meet its climate targets and reduce primary energy demand in the transportation sector. These goals include a 40 percent reduction of energy consumption in the transportation sector and greenhouse gas emission reductions of 80 percent until 2050 (compared to 2005 levels) in all sectors. Substantial reductions of power demand and emissions in transportation are only achievable with high fuel-demand coverage with renewable hydrogen in combination with drive-train electrification (battery and fuel-cell electric engines).

Nationwide Hydrogen Infrastructure

Around 300 German companies – from the automotive and supplier industries, utility providers, specialty chemical industry, and machinery and equipment producers – have plans to invest more than EUR 2 billion through to 2024 in order to activate the market for sustainable, secure and economic hydrogen mobility. Munich, for example, is home to the world's first hydrogen-only car sharing fleet, run by German engineering company Linde Group. More plans to promote the expansion of nationwide hydrogen infrastructure are already under way. One notable example is the H_2 Mobility Initiative, which is committed to establishing a large network of hydrogen fueling stations throughout Germany. Thanks to its strong industrial base in the relevant technology application fields, Germany is the ideal location for attracting participants to this market. The German government also provides funding for research and development in hydrogen and fuel cell development.

Power-to-Gas (P2G) Demonstration Projects and Hydrogen Gas (H_2) Filling Stations in Germany



Note: Map shows the approximate locations of the pilot projects/filling stations in Germany.
Source: dena, NOW 2016

High Investment Potential

Power-to-gas technology creates investment potential along the entire supply chain: from long-term storage, production and trading to electrolyzer production, gas compression, and smart gas metering. Within Europe, Germany boasts the lion's share of European fuel cell and hydrogen technology demonstration projects. Thanks to internationally recognized certification institutions, the large number of players, and regional and international activities, Germany is developing and setting tomorrow's global technical framework and standards.

Batteries for Electric Vehicles

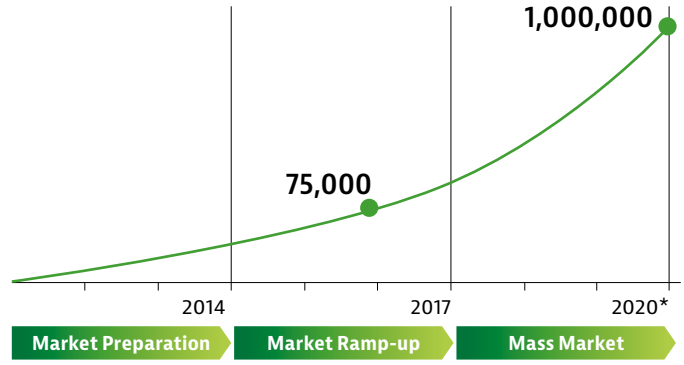
E-Mobility: Central Pillar of the Energy Transition
The transport industry – alongside the energy and industry sectors – is one of the world's biggest producers of greenhouse gases. Within Europe and Germany, it is responsible for around one fifth of CO_2 emissions. E-mobility represents a central pillar of Germany's energy transition. At the start of 2018, there were around 120,000 electric vehicles – supported by an infrastructure of around 7,100 AC and more than 300 DC charging stations – on German roads. In 2017, around 54,500 new e-vehicles were registered, equivalent to an increase of almost 100 percent compared to 2016.

The National Electromobility Development Plan has set a target of one million fully and partially battery-powered electric vehicles by 2020 as Germany seeks to establish itself as a lead market and supplier for e-mobility solutions. In order to achieve this ambitious objective, the German federal government introduced a purchase bonus of EUR 4,000 for BEVs and EUR 3,000 for PHEV. The total incentive volume of EUR 1.2 billion is split equally between car OEMs and the government. Additionally, the government will invest a further EUR 300 million into the expansion of the public charging infrastructure (including 5,000 new DC charging stations) up to 2020.

The Battery: The Key to Electric Mobility
The battery represents the key component in an electrified drive train. The battery system – comprising the cells, battery management system, electrical and sensor systems, safety elements, cooling periphery, and housing – determines vehicle efficiency and counts as the single vehicle element with the greatest wealth creation share (direct share of value added of up to 40 percent).

Ongoing Technology Improvement
Developments made to date in first- and second-generation cells and battery systems have helped create energy density levels of around 200 Wh per liter for today's battery packs. Energy and power density levels will continue to improve, with further marked developments expected in terms of safety (crash resistance) and service life. The federal government supports e-mobility R&D activities with around a quarter billion euros annually. The further improvement of battery technology and recycling remains one of the country's main e-mobility areas of R&D activity. As part of the technological development of third- and fourth-generation batteries, battery density by volume levels of 310 Wh per liter are predicted by 2025. In combination with expected economies of scale, battery system prices are predicted to fall below USD 150 per kWh.

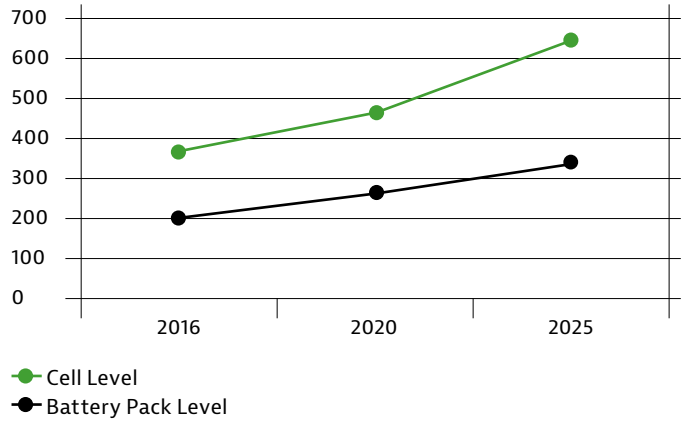
Number of Electric Vehicles in Germany



*as planned
Source: National Electric Mobility Platform 2014, GTAI Research 2017

Battery Technology Development Roadmap

energy density in Wh/l



Source: National Electric Mobility Platform 2016

World-Class Automotive Industry
Germany is synonymous with world-class automotive innovation. A number of studies attest to the fact that Germany is already one of the world's leading electric vehicle technology supply markets. By the beginning of 2017, German OEMs had released more than 30 different e-models (EV, PHEV and REEV). By 2025, Mercedes plans to offer 10 all-electric vehicles. The Volkswagen group also plans to build its first battery plant in Germany and to offer more than 30 all-electric vehicle models by 2025.

About Us

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