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Smart Grids in Germany

Focus: Baden-Württemberg and North Rhine-Westphalia

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1 Executive summary

The German energy transition depicts different challenges for Germany's sixteen federal states. North Rhine-Westphalia and Baden-Württemberg, the highest and third highest populated states in Germany have in common that they will need to import electricity generated in the North of Germany to cover future energy demand. While the German climate protection program provides a national framework for the energy transition both states have own climate acts and strategies adapted to regional challenges. Divided across five subfields, this report provides insights on smart grids in Baden-Württemberg and North Rhine-Westphalia:

1. Smart grid technology
2. Smart meters
3. E-mobility and charging infrastructure
4. Smart buildings and smart cities
5. Energy storage

Both in Baden-Württemberg and North Rhine-Westphalia progress has been achieved in all five areas but work has still to be done. Both states need to digitalize their distribution grids in order to enable efficient grid operation as higher shares of decentral renewable power are integrated into the grid. In Baden-Württemberg projects have emphasized the development of solutions for interconnected regional energy systems with a cellular structure and focus on PV integration. In North Rhine-Westphalia grid management projects have focused on the challenge to secure renewable power supply flexible to the large industrial load centers. In both states smart meters are seen as an important instrument for the digitalization of the grid. However, the mandatory smart meter roll-out in Germany has recently been stopped by a court decision and is thus stagnating. The numbers of battery electric vehicles show a strong increase in Baden-Württemberg and North Rhine-Westphalia that both are in need to further extend the private and public charging infrastructure. Further both states have old building stocks and face the challenge to achieve increased energy efficiency in buildings. The markets for smart home applications and home storage systems are expected to grow. When it comes to large-scale storage hydrogen is seen as a promising solution and promoted in both states.

Both in North Rhine-Westphalia and Baden-Württemberg Swedish companies can find multiple business opportunities. However, a market entry needs to be thoroughly prepared and time consuming bureaucratical processes as well as data security standards and certification requirements can depict hurdles that need to be overcome. Finding strategical partners in networks, cluster or initiatives has proven to be valuable when entering the German market.

2 Political framework

The energy transition “Energiewende” has in recent years gained increased attention in the public and political debate in Germany. Citizens are generally aware of the need for climate protection measures and broadly support the energy transition. However, as the system of feed-in tariffs to accelerate investments in renewable energy resulted in higher electricity prices this general support resulted in concrete dissatisfaction. Additionally, as regards installations of power lines, wind and solar plants the “nimby” (not in my backyard)-effect has frequently come up.

The German energy transition encompasses several aspects: the nuclear phase-out until the end of 2022, a renewable energy share of 65 percent by 2030, a reduction of greenhouse gas emissions by 55 percent by 2030, the coal phase-out until the end of 2038 and finally climate neutrality by 2050.[1]

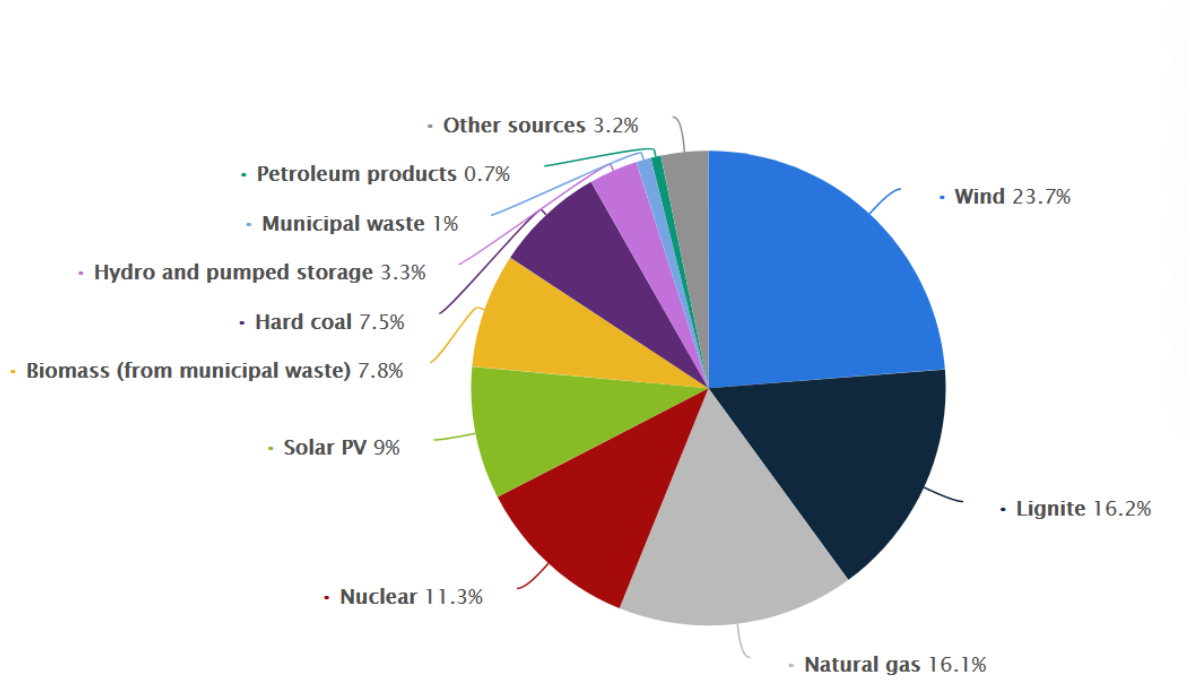

Figure 1: Distribution of energy sources used for gross electricity generation in Germany in 2020. Source: Statista

Even if Germany could reduce greenhouse gas emissions by 40,8 percent in 2020 compared to 1990 and thus reach its climate goal for 2020 (reduction of greenhouse gas emissions by 40 percent compared to 1990) there is still a long way ahead to reach the climate targets set in the climate change act which entered into force in 2019 and incorporated Germany’s climate targets into law. According to the *German Environment Agency* (UBA) one third of the emission reductions in 2020 were due to limited production and mobility during the corona crisis. Without the restrictions under the pandemic Germany would not have reached its climate target for 2020.[2]

[1] https://www.bundesregierung.de/breg-de/themen/klimaschutz/bundesregierung-klimapolitik-1637146
[2] https://www.tagesschau.de/inland/klimaziel-2020-101.html

Political measurements aiming to reach the climate goals in 2030 are bundled in the climate protection program 2030 that the German government decided on in 2019 and together with the climate change act that put German climate goals into law. It provides the framework for the German energy transition. Within this national framework Germany's 16 federal states have scope for action to accelerate the energy transition in their own states. For example, several state governments have passed climate protection acts that enshrine the state's climate target in law. Besides individual climate targets the federal states can influence the energy transition through juridical regulations. For example, the building code is decided on at state level enabling the federal states to set up requirements for installation of photovoltaic and wind power. Further, the federal states can use their competences within regional development to prioritize areas for the installation of renewable electricity generation.[3]

Both North Rhine-Westphalia and Baden-Württemberg have climate protection acts that specify the states' climate targets:

- Baden-Württemberg[4]: Reduction of greenhouse gas emissions by 43 percent by 2030 and by 90 percent by 2050
- North Rhine-Westphalia[5]: Reduction of greenhouse gas emissions by 55 percent by 2030, climate neutrality by 2050

As regards individual sectors the German climate change act specifies climate targets and obligates the responsible ministry to elaborate a measurement package in case the targets are missed. In the transport sector greenhouse gas emissions are to be reduced by at least 40 percent until 2030 and the German government currently supports the use of electric vehicles and the build-up of charging infrastructure through several support programs. In the last year support programs and legislation also addressed energy efficiency in buildings. In 2020, the building sector was the only sector that could not reach annual emission targets and experts are sceptic if the targeted CO_2 emission reductions of at least 66 percent by 2030 can be achieved.

In the current phase of the energy transition distribution and storage of electricity are major challenges that need to be approached. Hydrogen storage and sector coupling are on top of the agenda in this context. Thus, smart grids are seen as an important instrument for reducing grid extension need and integrating a rising number of decentral units efficiently into the grid.

Here, information and communication technology (ICT) plays a central role. Overall standards for information technology are provided on federal level. In January 2019 the Federal Ministry of Economic Affairs and Technology (*Bundesministerium für Wirtschaft und Energie* – BMWi) along with the Federal Office for Information Security (*Bundesamt für Sicherheit in der Informationstechnik* - BSI) presented a joint strategy for the standardization of digital technologies within the energy transition which is based on the Act on the Digitization of the Energy Transition (Gesetz zur Digitalisierung der Energiewende – GDEW). The strategy has four key pillars: (1) standardisation; (2) data privacy and

[3] https://www.foederal-erneuerbar.de/auf-einen-blick-detailseite/items/politik-und-gesetze-zur-energiewende-in-den-bundeslaendern
[4] https://um.baden-wuerttemberg.de/de/klima/klimaschutz-in-baden-wuerttemberg/klimaschutzgesetz/
[5] https://www.klimaschutz.nrw.de/instrumente/klimaschutzgesetz

data security (3) security of investment; and (4) public acceptance. It defines the concrete working plan for how to develop a digital communication platform for the energy transition.

3 Legal framework

Providing an understanding for legislation addressing the German energy transition as well as giving insights on legal developments in the last year following laws should gain attention:

Energy Act (Energiewirtschaftsgesetz, EnWG)
The most general act regarding energy. The law ensures annual grid expansion planning for the German high voltage grid.[6]

Grid Expansion Acceleration Act (*Netzausbaubeschleunigungsgesetz* - NABEG)[7]
The NABEG simplifies the planning of grid expansion projects which involve several federal states or cross national boundaries. It underwent several streamlining measures which passed through the German parliament in April 2019. These comprised changes in the current redispatch system referred to as Redispatch 2.0. As part of redispatch, transmission operators instruct generators to increase or decrease generation in order to change electricity flows in the grid and relieve congestion. With the new regulation in place generators with a minimum capacity of 100 kW as well as plants that can be remotely controlled by the grid operator are included in redispatch. So far generators under 10 MW were excluded. The redispatch 2.0 must be implemented by October 1st 2021. As redispatch 2.0 implies an increased use of planning data and forecasts main challenges for grid operators are: generating required data, establishing mechanisms for intense cooperation between grid operators at all levels, implementing cost-based compensation schemes for regulated generation facilities.

Climate Change Act (Bundes-Klimaschutzgesetz)[8]
Entered into force in 2019 the Climate Change Act enshrines in law some of the goals previously stated by the German government, such as the 55% reduction in greenhouse gases compared to 1990 by 2030. Additionally, climate targets are divided up between different sectors (i.e. energy, buildings, transport).

Renewable Energy Sources-Act (Erneuerbare Energien Gesetz, EEG)
The EEG is the key instrument for an annual quantitative steering and for bringing renewables closer to the market. With the reform of the law 2017 feed-in tariffs for electricity from wind, solar or biomass are no longer adopted by the state, but are instead for the most part determined through technology specific tendering in the marketplace. With the reform of the law in 2021 the share of renewable energy in electricity supply is to be increased to at least 65 percent by 2030.

Digitising the energy transition-Act (Gesetz zur Digitalisierung der Energiewende, GDEW)
In 2016 the law set the start signal for smart grids, smart meter and smart home in Germany. Most important elements of the act are the obligation for the smart meter rollout with a pre-defined pricing

[6] https://www.bmwi.de/Redaktion/EN/Artikel/Energy/electricity-grids-of-the-future-02.html
[7] https://www.bdew.de/energie/redispatch-20/
[8] https://www.bundesregierung.de/breg-de/themen/klimaschutz/kimaschutzgesetz-beschlossen-1679886

model according to consumption and regulation as regards data communication and security (see chapter 6.2).

Building Energy Act (Gebäudeenergiegesetz, GEG)[9]
Regulations for the energy efficiency of buildings are stated in the Building Energy Act (GEG) that brings together previous regulations, namely the Energy Saving Act (EnEG), the Energy Saving Ordinance (EnEV) and the Renewable Energy Heat Act (EEWärmeG). The law entered into force in November 2020.

Building Electromobility Infrastructure Act (Gebäude-Elektromobilitätsinfrastruktur-Gesetz, GEIG)[10]
GEIG is the transposition of the European Directive on the energy performance in building (2018/844) into German law. The law aims to accelerate the charging infrastructure in residential and non-residential buildings. The German Bundesrat approved the law in March this year.

4 Market structure

The federal Republic of Germany is made up of 16 federal states (Bundesländer) which have own state governments and state parliaments. In this report the focus lies on Baden-Württemberg and North Rhine-Westphalia, which both are characterized by large industrial sectors.

With 17.9 million inhabitants North Rhine-Westphalia is the most populous and most densely populated state in Germany. Its central location in Europe, a good infrastructure of roads, waterways and railways as well as many potential customers make the state a popular place for foreign companies. North Rhine-Westphalia is characterized by a large industrial sector including iron, steel, chemicals, automotive, industrial engineering and energy industries. The importance of the industrial sector can be underlined by the fact that every fifth euro of Germany´s total industrial turnover is generated in North Rhine-Westphalia.

Figure 2: Germany's federal states

Baden-Württemberg is located in southwestern Germany and the country's third most populous state. It is

[9] https://www.bundesrat.de/DE/plenum/bundesrat-kompakt/20/992/14.html?nn=14183366#top-14
[10] https://www.bmwi.de/Redaktion/DE/Artikel/Service/Gesetzesvorhaben/gebaeude-elektromobilitaetsinfrastruktur-gesetz.html

internationally known for its strong “Mittelstand” and market leaders within the automotive industry such as Daimler, Porsche and Bosch. Beyond automobile manufacturing key industries are mechanical engineering, electrical engineering, health care and medical technology. To keep up its leading position within this areas Baden-Württemberg spends more than five percent of its GDP on R&D.

4.1 TSOs, DSOs and utilities

In total there are ca 90 electricity generating companies, 903 grid operators and 1350 electricity suppliers in Germany. [11] In union with the provisions for the EU internal energy market and regulated by the *EnWG* the supply and the transmission and distribution of energy must not lie in the hands of the same company (unbundling). Thus, there are now four independent Transmission System Operators (TSO) in Germany: *TenneT, 50Hertz, Amprion, TenneT, Transnet BW*.

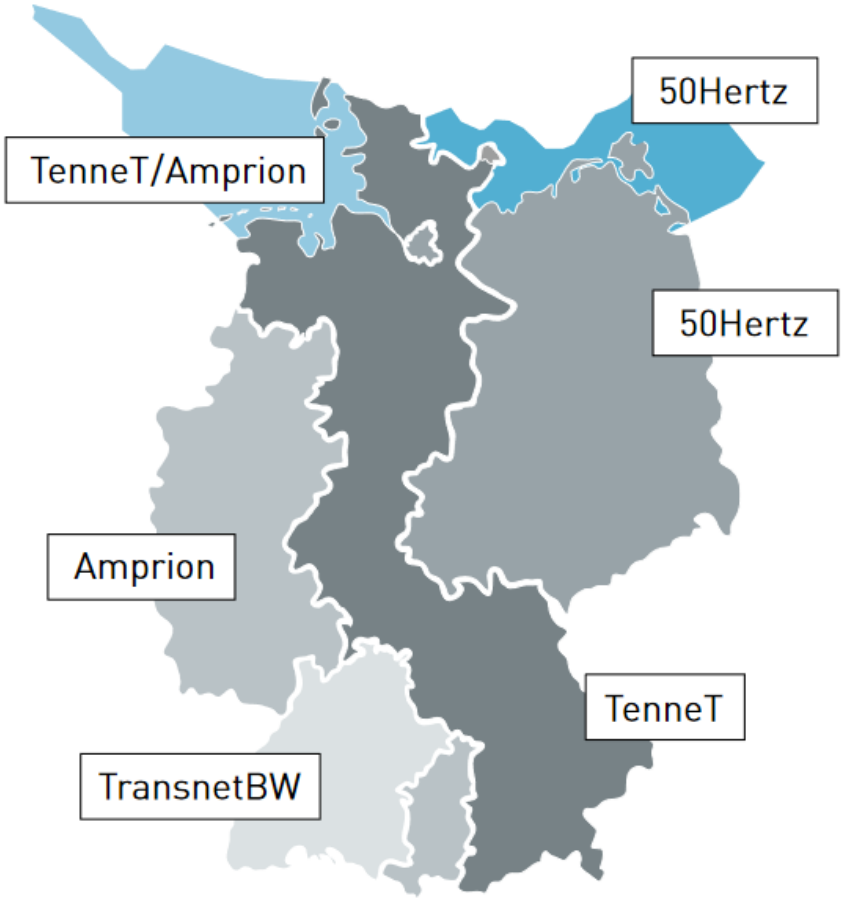

Figure 3: TSOs in Germany, source: Netzentwicklungsplan

The distribution grid accounts for 98 percent of the German grid. As regards the distribution grid operators (DSO) 20 percent of them have a market share of 60 percent. For most of them one of the major energy companies in Germany is their majority shareholder. In Baden-Württemberg there are around 120 DSOs with *Netze BW*, a subsidiary of Baden-Württemberg’s largest utility company *EnBW*, as the biggest player. In North Rhine-Westphalia the number of DSOs is around 90. *Westnetz*

[11] https://de.statista.com/statistik/daten/studie/173884/umfrage/zahl-der-unternehmen-in-den-einzelnen-marktbereichen-des-energiemarktes/

is by far the largest DSO in Western Germany. The company is a wholly owned subsidiary of *Westenergie*, which is on its part 100% owned by *E.On*.

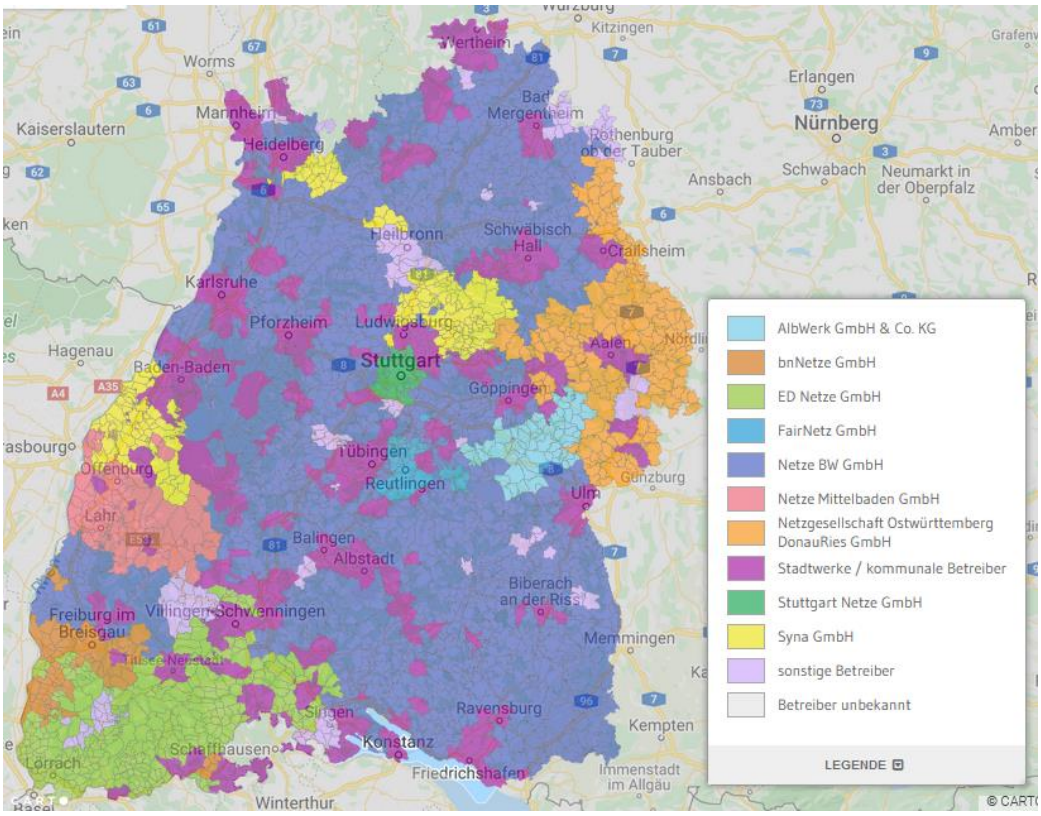

Figure 4: DSOs in Baden-Württemberg. Source: LUBW

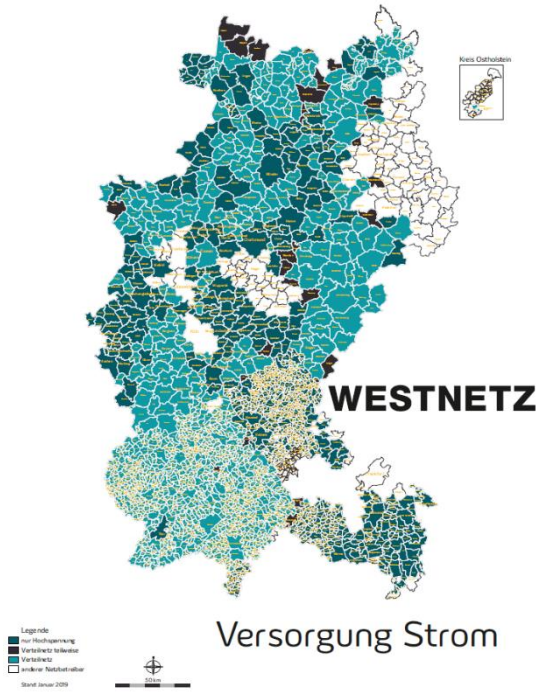

Figure 5: Areas with Westnetz as DSO. Source: Westnetz.

Among the 90 German electricity producers there are five major companies: *E.ON, RWE, EnBW, LEAG* and *Vattenfall*. Together the five major companies have a market share of 70 percent in total net electricity generation. Next to the five large companies it is municipal utilities (Stadtwerke) that are the most important players in the market. *EnBW* is the dominant player in Baden-Württemberg. Both *RWE* and *E.ON* have their headquarters in North Rhine-Westphalia.

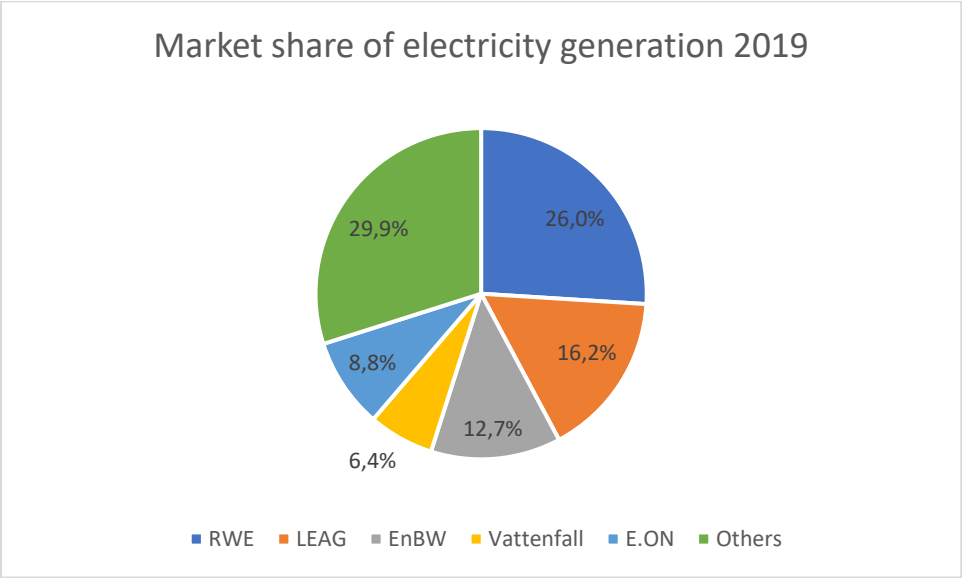

Figure 6: Market share of electricity generation 2019. Source: Monitoring report Bundesnetzagentur/ Bundeskartellamt

4.2 State actors and agencies

Two German ministries are mainly responsible for energy questions. Energy as a department lies in the Federal Ministry of Economics and Energy (*Bundesministerium für Wirtschaft und Energie, BMWi*). For energy research, however, the Federal Ministry of Education and Research (*Bundesministerium für Bildung und Forschung, BMBF*) is responsible. The Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (*Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit, BMUB*) is coordinating all activities in relation to climate protection. As regards electro mobility the Federal Ministry of Transport and Digital Infrastructure (*Bundesministerium für Verkehr und digitale Infrastruktur, BMV*) is in charge.

In North Rhine-Westphalia the Ministry of Economic Affairs, Innovation, Digitalisation and Energy (*Ministerium für Wirtschaft, Innovation, Digitalisierung und Energie, MWIDE*) is mainly responsible for energy questions. Activities around climate protection are coordinated by the Ministry for Environment, Agriculture, Conservation and Consumer Protection of the State of North Rhine-Westphalia (*Ministerium für Umwelt, Landwirtschaft, Natur- und Verbraucherschutz des Landes Nordrhein-Westfalen, MULNV*). In Baden-Württemberg the Ministry of the Environment, Climate Protection and the Energy sector (*Ministerium für Umwelt, Klima und Energiewirtschaft*) is mainly responsible for questions regarding energy and climate protection. As regards research and technological development the Ministry of Economic Affairs, Labour and Housing Construction *(Ministerium für Wirtschaft, Arbeit und Wohnungsbau*) is responsible.

In North Rhine-Westphalia the Christian Democrats (CDU) and Free Democrats (FDP) form a government coalition since the last election in 2017. The government is led by state premier Armin

Laschet (CDU) who will run as the party's chancellor candidate in this year's election. In Baden-Württemberg the Green Party and the Christian Democrats agreed to continue their coalition after the state elections in March this year. Winfried Kretschmann who is the state's prime minister since 2011 is Germany's first and so far only prime minister from the Green Party.

Other public players are the German energy agency (*DENA*), founded in autumn 2000, which describes itself as "Germany's centre of expertise for energy efficiency, renewable energy sources and intelligent energy systems", that brings "together partners from politics and industry across all sectors." *DENA* has its headquarter in Berlin. In addition, there are energy agencies at state level, namely the energy agency NRW (Energieagentur.NRW) and the climate protection and energy agency Baden-Württemberg *(Klimaschutz- und Energieagentur Baden-Württemberg*).

Another federal player within energy is the Federal Network Agency (*Bundesnetzagentur*) for Electricity, Gas, Telecommunications, Post and Railway, which "promotes effective competition in the regulated areas and ensures non-discriminatory access to networks."

4.3 Organisations

Industrial organisations are of utmost importance in Germany. The most important association within energy is the German association of energy and water industries (*Bundesverband der Energie- und Wasserwirtschaft, BDEW*). It represents 1800 companies. The BDEW heads a working group intelligent grids and meters. At state level the BDEW is represented by several sub-groups. In North Rhine-Westphalia the BDEW is represented by a local state association to the BDEW. The association of energy and water industries (*Verband für Energie- und Wasserwirtschaft, VfEW*) is the BDEW's local representative in Baden-Württemberg.

Besides this energy association there are several more focused associations. Among these is the association for renewable energy (*Bundesverband Erneuerbare Energie, BEE*) which is represented by the Renewable Energy Platform Baden-Württemberg (Plattform Erneuerbare Energien Baden-Württemberg) and the Regional Association for Renewable Energy NRW (Landesverband Erneuerbare Energien NRW, LEE) at state level. Other associations focused on energy are the association for wind energy (*Bundesverband Windenergie, BWE*) and the association for solar power (*Bundesverband Solarwirtschaft, BSW*). As regards electro mobility there is the association for electro mobility (*Bundesverband eMobilität, BEM*) which also has representatives for each state. An association of TSOs and DSOs does no longer exist. The former association of grid operators (*Verband der Netzbetreiber, VDN*) has been dissolved and integrated into the BDEW and the association for Electrical, Electronic & Information Technologies (*Verband der Elektrotechnik, Elektronik und Informationstechnik, VDE*) which is one of the largest technical and scientific associations in Europe. Another important association is the association of municipal companies (*Verband kommunaler Unternehmen, VKU*) which represents all municipal utilities. The central organisation for manufacturers is the *ZVEI*, the German Electrical and Electronic Manufacturers' Association (*Zentralverband Elektrotechnik- und Elektronikindustrie e.V., ZVEI)*.

5 Focus areas

The increased use of renewable and decentral energy sources presents new challenges for efficient grid operation. Divided across a series of subchapters, the report examines trends and business opportunities in Baden-Württemberg and North Rhine-Westphalia.

5.1 Smart Grid Technology

A reliable and efficient electricity grid is crucial for the German energy transition. Germany has one of the most stable electricity grids in the world and is very keen to maintain high stability as increasing quantities of renewable energy sources are fed into the grid. With a proceeding electrification in the industry, heating and transport sector the gross electric energy consumption in Germany is expected to reach between 650 and 700 TWh in 2035[12] which is to compare with 570 TWh in 2019.[13] Consequently, new electricity power lines must be installed while information and communication technology need to be integrated into the current grid.

The extension of transmission lines plays an important role for securing renewable energy supply in the future. Especially the transportation of wind energy from the north to the load centers in western and southern Germany depicts a challenge in this context. Between 2009 and 2015 the German federal parliament has approved the refurbishment and construction of about 7700 km transmission lines.[14] However, according to the news agency *Wirtschaftswoche* only 1500 km have been completed by the third quarter of 2020. "The wind parks are there but the transmission lines are not", commented the TSO *Transnet BW* the slowly proceeding extension.[15]
However, beyond grid extension it is seen as a key task in Germany to digitalize the distribution grid. This aspect has been included in the project "Show case intelligent energy – digital agenda for the energy transition" (*Schaufenster intelligente Energie – Digitale Agenda für die Energiewende, SINTEG*) which the *Federal Ministry of Economics and Energy* funded with 600 million euros between 2016 and 2020. Within the *SINTEG* project five large-scale show case regions in Germany developed innovative grid technology and operating strategies with more than 300 companies, research institutes, municipalities and districts involved. As regards the number of partners and individual projects within the programme as well as the large funding provided it has been the most important promotion program for the *Energiewende* in Germany so far. Baden-Württemberg and North Rhine-Westphalia have been part of one show-case region each.

<u>Baden-Württemberg</u>
Baden-Württemberg located in the south of Germany with a large automobile industry and dense population will increasingly need to import electricity from Germany or abroad. According to the transmission grid operator in Baden-Württemberg, *Transnet BW*, the deficit in annual electricity supply and demand will increase from 8TWh in 2018 to about 60 TWh in 2050. Only half of the

[12] https://www.netzentwicklungsplan.de/sites/default/files/paragraphs-files/NEP_2035_V2021_1_Entwurf_Teil1.pdf
[13] https://www.netzausbau.de/Wissen/Ausbaubedarf/Szenariorahmen/de.html
[14] https://www.bmwi.de/Redaktion/DE/Downloads/M-O/netzausbau-schreitet-voran.pdf?__blob=publicationFile&tv=8
[15] https://www.wiwo.de/politik/deutschland/netzausbau-stell-dir-vor-der-wind-weht-aber-keiner-nimmt-den-strom/26851752.html

electricity demand in Baden-Württemberg will then be generated locally. At present large parts of the electricity in Baden-Württemberg are generated by hard coal and nuclear power plants. With the coal and nuclear phase out *Transnet BW* expects the net electricity generation of nuclear or fossil-fueled power plants to decrease from 38 TWh to 8.1 TWh by 2050. While having limited potential for wind power compared to north and central Germany, Baden-Württemberg has generally good conditions for installing photovoltaic systems. By 2050 half of the locally generated electricity in Baden-Württemberg will be generated by PV systems which then are expected to have a net nominal capacity of 22,2 GW which is to compare with 6 GW in 2018. [16]

Given the importance of solar power for the energy supply in Baden-Württemberg it is not surprising that the integration of PV systems has been a prioritized area in the context of smart grids. The federal government in Baden-Württemberg aims for making the state a show case region for smart grids and initiated the platform *Smart Grids BW* in 2012 to engage stakeholders in the energy sector in elaborating ideas on smart grid development.[17] Furthermore, in 2013 the state was first with presenting a smart grids-roadmap which is currently updated. Initiatives in Baden-Württemberg regarding smart grids have a strong focus on decentral load optimization and the integration of PV systems. Much of the development work done in the last years has taken place within the show-case project *C/sells* that was part of the program *"Showcase project smart energy – digital agenda for the energy transition" (SINTEG)*. The aim of the *C/sell* project was to demonstrate a cellular structured energy system where regional cells interact within a supra-regional network. A cell can be all from a single estate to a city or district and both produce and consume energy as well as provide flexibility for the grid. Energy supply and demand is primarily balanced within a cell. If energy cannot be used in the cell, where it is generated an exchange with other cells takes place to optimize the system as a whole. Regional energy trading, incentives for providing flexibility to the distribution grid and balancing energy with the transport and heat sector were central elements of the program.[18] The program which involved more than 50 partners from municipalities, research institutions, industry and business was completed in 2020. It showed that an energy system with an increasing number of private households and smaller companies acting as prosumers, as it is the case in Baden-Württemberg, needs innovative digital approaches to ensure efficient grid operation. Worth naming in this context is the need of information systems and automized grid coordination. Information systems that provide data on current consumption as well as forecasts are essential for efficient grid operation. Further, the today often manually performed coordination of grid operators must be automated to ensure fast and secure coordination as millions of decentral units feed in electricity into the grid. Especially in the light of the imminent Redispatch 2.0 (see chapter 4) grid operators need to upgrade grid analytics and coordination mechanisms.

Considering the issue of automation another project in Baden-Württemberg worth mentioning is the project *grid-control*. In the project which was funded by the German Federal Ministry for Economic Affairs and Energy with 4,8 Mio. EUR and completed in 2018, concepts and systems for future distribution grids which are integrated into one overall system were integrated and evaluated. [19] Besides new automation systems and electrical equipment the quota-based implementation of a

[16] TransnetBW study
[17] https://um.baden-wuerttemberg.de/de/energie/versorgungssicherheit/smart-grids/
[18] https://www.csells.net/en/about-c-sells/fakten.html
[19] http://projekt-grid-control.de/wp-content/uploads/2019/06/Abschlussbericht_grid-control_final.pdf

traffic light concept for distribution grids was central part of the project. If a bottleneck is predicted and a "yellow phase" occurs, intervention by the grid operator and the light color "red" should be avoided by using approval quotas for generation and consumption units in the systems. The system was tested in a field test in Freiamt (close to Freiburg in Baden-Württemberg). Between 2019 and 2022 the quota-based traffic light concept will be further developed in the follow-up project *flexQgrid* which is coordinated by *Netze BW*.[20] In the final report of *grid-control* it was highlighted that the concepts developed in the project require an "intensive upgrade" of measurement, control and communication technologies in distribution grids as well as algorithms that can handle unscheduled load and generation.

North Rhine-Westphalia

In North Rhine-Westphalia more energy is used and converted than in any other federal state in Germany. 30 percent of the national electricity demand is produced in North Rhine-Westphalia and 40 percent of the electricity used in German industry is consumed there. [21] The industrial centers in North Rhine-Westphalia are still mainly supplied with energy form coal. Around half of Germany's capacity of lignite-fired power plants is installed in North Rhine-Westphalia.[22] In 2019, around 16 percent of electricity consumption in North Rhine-Westphalia came from renewable energy sources (Germany in 2020: around 46percent share of renewable energy in gross electricity consumption).[23] With many coal-fired power plants and a relatively low share of renewable energies North Rhine-Westphalia faces drastic changes in future energy production compared to other federal states in Germany. While more electricity is consumed than generated from renewable sources in the conurbations on the Rhine and Ruhr, predominantly rural areas in North Rhine-Westphalia provide good potential for the generation of renewable power from wind and solar. According to the mid-scenario in the first draft of the German grid development plan (*Netzentwicklungsplan, NEP*) for 2035 where the coal phase out is assumed to be completed, the installed photovoltaic capacity is expected to reach 12,4 GW (4,6 GW 2018) and the installed wind onshore capacity to reach 8,5 GW (5,4 GW 2018).[2425]. In this context the extension of the distribution grid and balancing energy production in rural areas with the load centers in industrial areas are main challenges.[26] As coal-fired power plants will be phased out the federal state government expects that annual electricity imports of 25 TWh are needed until 2030.[27] In the current NEP high-voltage direct current transmission lines that transport about 8 GW offshore wind power capacity directly to North Rhine-Westphalia are suggested. This corresponds to the capacity that disappears with the closedown of stone coal-fired power.[28]

In its strategy for energy supply (*Energieversorgungsstrategie*) the Ministry of Economic Affairs, Innovation, Digitalisation and Energy in North Rhine-Westphalia describes the future energy market

[20] https://www.netze-bw.de/News/netze-bw-projekt-flexqgrid
[21] https://www.energieatlas.nrw.de/site/strom
[22] https://www.wirtschaft.nrw/sites/default/files/asset/document/evs_nrw_version_veroeffentlichung_final.pdf
[23] https://www.energieagentur.nrw/english/future_energies_region_no_1_nrw_data_facts_and_figures
[24] https://www.westfalenwind.de/erneuerbare-energien-bilanz-2019-fuer-nordrhein-westfalen/
[25] https://www.netzentwicklungsplan.de/sites/default/files/paragraphs-files/NEP_2035_V2021_1_Entwurf_Teil1.pdf
[26] https://www.energieagentur.nrw/netze/grid_im_ueberblick
[27] https://www.aachener-zeitung.de/nrw-region/stromerzeugung-aus-kohle-bis-2030-um-70-prozent-reduzieren_aid-42307773
[28] https://www.energieagentur.nrw/netze/ausbaubedarf_der_stromnetze_fuer_2035_und_2040

to be characterized by flexibility and digitalization leading to a system that is based on information technology and automation. The strategy paper emphasizes the aim to use flexibility potentials on the demand side to a higher degree and specifically names sector coupling as an important instrument for achieving higher flexibility. Moreover, virtual power plants and intelligent load management are presented as business areas that will become increasingly important for achieving stability in the grid. The strategy paper points out business opportunities for companies providing measuring, communication and remote-control technology. Furthermore, it is expected that innovative digital start-ups will increasingly enter the market, for example to develop smart services for customers in co-operation with energy providers in North Rhine-Westphalia.[29]

In the show-case project *DESIGNETZ* which was part of the program *"Showcase project smart energy – digital agenda for the energy transition "(SINTEG)*, blueprints for a secure and efficient future energy system in North Rhine-Westphalia that is based on high shares of renewable energy were developed. The project connected isolated solutions across different grid levels and regions to form a single system. Photovoltaics, wind energy, CHP plants, storage technologies, controllable loads and smart distribution grids that enable various elements to be linked have been central elements of the project. The project addressed the previously described challenge of surplus renewable power in rural areas and a high renewable power demand in conurbations as well as it took advantage of the good infrastructure in North Rhine-Westphalia when it comes to provide flexibility. This means a dense energy grid as well as various industrial sectors that can be used as consumers, producers or providers of controllable loads. [30]

5.2 Smart Metering

The previously described smart grid projects in Baden-Württemberg and North Rhine-Westphalia equally underlined the essential role of smart meters for connecting decentral energy systems in smart grids. However, the smart meter roll-out in Germany is proceeding slowly compared to other European countries. Main reasons for this have been data security concerns as well as certification standards and procedures. With a three year delay the smart meter roll-out in Germany has finally started in the beginning of 2020 after the Federal Cyber Security Authority (*BSI)* has certified smart meter gateways (*SMGW*) from three manufacturers and issued a corresponding market declaration. The *SMGW* is a communication unit added to the smart meter securing safe data transmission which is a major concern in Germany. However, in March this year the North Rhine-Westphalian Higher Administrative Court (*OVG*) in Münster has preliminary stopped the obligation to install *SMGW* from certain manufacturers. Hence, there are quite some uncertainties about the future smart meter roll-out in Germany.

The smart meter roll-out in Germany is driven by the EU-directive 2009/72/EC on common rules for an internal European electricity market. In German legislation the use of smart meters and smart meter gateways is regulated by the Measuring Point Operating Act (*Messstellenbetriebsgesetz, MsBG*). The *MsBG* is a national law regulating the use of smart meter gateways uniformly for all German federal states. It stipulates that smart meter gateways from at least three manufacturers need to be certified

[29] https://www.wirtschaft.nrw/sites/default/files/asset/document/evs_nrw_version_veroeffentlichung_final.pdf
[30] https://www.sinteg.de/schaufenster/designetz

by the *BSI* before the smart meter roll-out can begin which finally was the case in 2020. According to the law consumers with more than 6000 kWh yearly consumption, plant operators with an installed capacity of more than 7 kW or those who have a heat pump installed need to be equipped with intelligent metering systems by the meter operators.[31] Below these thresholds the employment of *SMGW* is optional (for the operator, not the consumer). The legislator has set a price cap for annual costs connected to *SMGW* in order to protect consumers from a high increase in costs.

The *OVG* in Münster motivated its decision to stop the obligation to install intelligent measuring systems from certain manufacturers by arguing that the intelligent measuring systems available on the market do not meet the interoperability requirements prescribed by the *MsbG*. Certain requirements on functionality that intelligent measuring systems need to fulfil according to the *MsbG* were not considered in the *BSI* certification process. The court argues that the "BSI's competence to change technical guidelines in line with technical progress does not go so far as to fall below the legally stipulated minimum requirements".[32] The case was taken to court after a company from Aachen that sells measuring systems sued against the obligation to install *SMGWs* from certain manufacturers. The decision was made in an urgent procedure and is not controvertible. Around 50 comparable complaints from meter operators, especially municipal utilities (*Stadtwerke*), were filed. The *BSI* reacted on the complaints by stopping the mandatory smart meter installation for the complaining companies.[33] The main proceedings are still pending at the Cologne Administrative Court.[34] After the decision of the *OVG* in Münster there is uncertainty in industry about future consequences for the smart meter roll-out. For now, the decision has direct consequences only for the complaining companies according to the lawyers representing the claimants.[35] However, it is uncertain, if legal adaptions in the *MsbG* will follow or if a general stop of the smart meter roll-out could be a consequence.

Even before the decision by the *OVG* in Münster the smart-meter roll-out has come under criticism for massively delays in the certification process and *BSI*-certified gateways that are outdated by new solutions on the market. Data security is a key concern amongst German consumers and politicians which was highly reflected in the certification guidelines of the *BSI* for SMGW. The association of energy market innovators (*Bundesverband Neue Energiewirtschaft e.V., bne*) criticized the certification process as a procedure that "enormously slows down innovations" and further explains that the certified *SMGW* lack or are limited in grid-supporting operational applications, the ability to offer dynamic electricity pricing and the ability to perform generation and load management.[36]

Both Baden-Württemberg and North Rhine-Westphalia are officially promoting the use of *SMGWs*. In North Rhine-Westphalia's digital strategy intelligent metering systems are described as an important technology for pushing the digitalization of the energy system forward.[37] For *Smart Grids BW* the smart meter roll-out is one of four focus areas comprising activities around the communication and practical implementation of smart meters in projects. Indeed, there is a need to increase communication around

[31] https://www.dke.de/de/arbeitsfelder/energy/smart-meter-energiemanagement-digitalisierung-energiewende
[32] https://www.ovg.nrw.de/behoerde/presse/pressemitteilungen/18_210305/index.php
[33] https://www.behoerden-spiegel.de/2021/03/17/smart-meter-rollout-ausgesetzt/
[34] https://www.pv-magazine.de/2021/03/08/gericht-legt-smart-meter-rollout-vorlaeufig-auf-eis/
[35] https://www.50komma2.de/?p=21626
[36] https://www.bne-online.de/en/news/article/smart-meter-roll-out-the-german-case/
[37] https://www.digitalstrategie.nrw/digitalnrw/de/draftbill/54890/para/214;jsessionid=4460CFBDAC58B785D2435DD37D064907.liveWorker2

smart meters. A survey by Germany's digital association *Bitkom* among 1005 people in Germany showed that 42 percent have not heard or read about smart meters.[38] However, the survey which was published in December 2020 also showed that 41 percent would like to use a smart meter. In fact, while the mandatory roll-out is stagnating, voluntary installations are proceeding and energy companies are offering cheaper tariffs for those who agree to have a smart meter.

5.3 E-mobility and Charging Infrastructure

EVs still make up a small a proportion of registered vehicles in Germany (1,2 percent by the end of 2020).[39] However, in 2020 the number of newly registered battery electric vehicles (BEVs) in Germany tripled compared to the year before. The president of the motor vehicle authority (*Kraftfahrtbundesamt, KBA*), Richard Damm, regards e-mobility having become a "mainstream feature of the mobile society" and sees good opportunities to reach the national goal of seven to ten million registered electric vehicles in 2030, if the positive registration trend continues. [40] A contributing factor for the strong increase in newly registered vehicles are joint subsidies by the German government and the car industry. In the stimulus package that was approved by the German government in June 2020, the bonus for purchases of electric cars was doubled so that consumers can receive up to 9.000 Euros for the purchase of a BEV and up to 6750 Euro for plug-in hybrid electric vehicles (PHEVs).[41] Baden-Württemberg and North Rhine-Westphalia are among the three federal states with the highest number of new registrations (see figure 7). With 63.840 and 55.992 registered BEVs respectively by the end of 2020 North Rhine-Westphalia and Baden-Württemberg even belong to the top three federal states regarding the total number of registered BEVs.[42] Combined with the political willingness in both federal states to further increase the number of electric vehicles even the charging infrastructure needs to be extended.

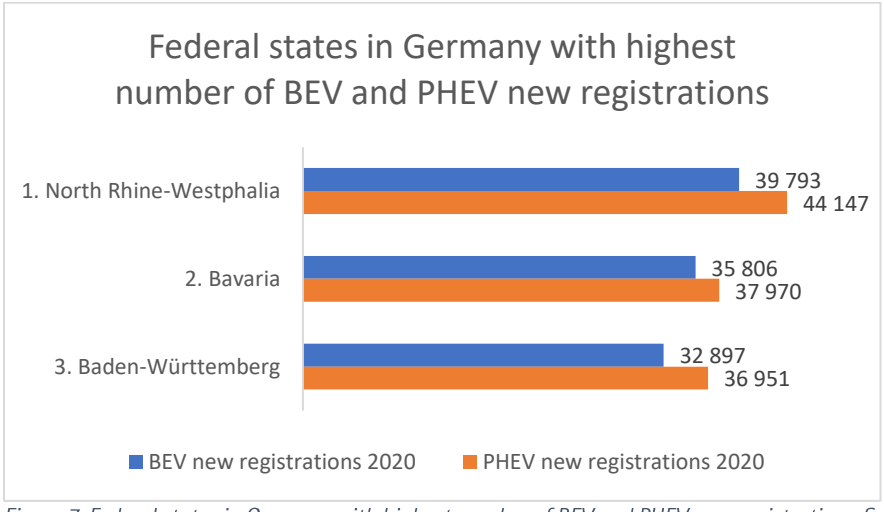

Figure 7: Federal states in Germany with highest number of BEV and PHEV new registrations. Source: Elektromobilitaet.NRW[43]

[38] https://www.bitkom.org/Presse/Presseinformation/Interesse-an-Smart-Metern-steigt
[39] https://www.electrive.net/2021/03/02/bestand-in-deutschland-waechst-auf-309-083-bev-pkw/
[40] https://www.kba.de/DE/Presse/Pressemitteilungen/2021/Allgemein/pm01_2021_E_Antrieb.html
[41] https://www.bundesregierung.de/breg-de/themen/energiewende/kaufpraemie-fuer-elektroautos-erhoeht-369482
[42] https://www.elektromobilitaet.nrw/fileadmin/Daten/Download_Dokumente/Zahlen_Daten_Fakten/Zahlen-Daten-Fakten_2020_Bilanz.pdf
[43] https://www.elektromobilitaet.nrw/fileadmin/Daten/Download_Dokumente/Zahlen_Daten_Fakten/Zahlen-Daten-Fakten_2020_Bilanz.pdf

Considering the total number of charging points in Germany's federal states, Baden-Württemberg and North Rhine-Westphalia are among the states with most public charging points. However, comparing the rate of electric vehicles per public charging point North Rhine-Westphalia and Baden-Württemberg show higher rates than almost all other federal states. With 15,2 EVs per charging point in North Rhine-Westphalia and 16 EVs per charging point in Baden-Württemberg both states exceed the 10:1 ratio suggested in an EU-guideline.[44]

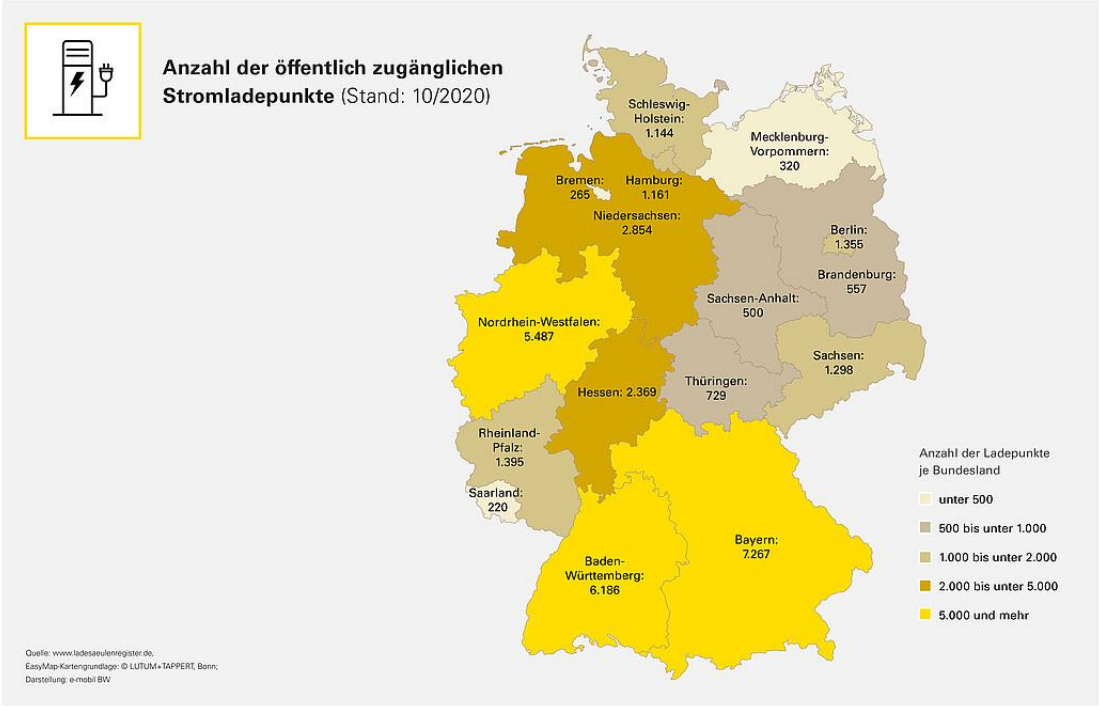

Figure 8: Map of public charging points by federal state. Source: e-mobilbw[45]

According to the federal government's masterplan for charging infrastructure "*Masterplan Ladeinfrastruktur*" 1 million public charging points shall be installed until 2030. That is to compare with 35 076 charging points registered in Germany in March 2021.[46] The president of the *German Association of the Automotive Industry*, Hildegard Müller, states that around 2000 new public charging stations weekly are required to reach this aim. Currently, only 200 public charging points are installed per week, though.[47] The need to extend the private and public charging infrastructure is also highlighted by the energy industry group *Bundesverband der Energie- und Wasserwirtschaft* (BDEW). [48] According to *BDEW* 85 percent of charging happens at home or at work. However, with national legislation that promotes the installation of charging points in buildings and subsidies for private

[44] https://www.autobild.de/artikel/ladestation-fuer-e-autos-oeffentliche-ladepunkte-anzahl-regionale-verteilung-bildplus--18630173.html
[45] https://www.e-mobilbw.de/themen/ladeinfrastruktur
[46]https://www.bundesnetzagentur.de/DE/Sachgebiete/ElektrizitaetundGas/Unternehmen_Institutionen/HandelundVertrieb/Ladesaeulenkarte/Ladesaeulenkarte_node.html
[47]
[48] https://www.bdew.de/media/documents/BDEW_10-Punkte-Plan_zur_Elektromobilit%C3%A4t.pdf

charging points in place the BDEW regards the development of private charging in Germany on a good way.

As federal states with a strong vehicle construction industry both North Rhine-Westphalia and Baden-Württemberg are striving to be pioneers in electro mobility. Besides support programs for EVs and charging infrastructure on national level both states promote e-mobility at federal state level. Regarding the support programs for private charging, it is required that the charging point is equipped with smart charge control enabling applications such as vehicle-to grid solutions in the future.

In North Rhine-Westphalia activities promoting charging infrastructure and e-mobility are organized by the platform "*Elektromobilität NRW*"[49] which acts on behalf of the Ministry of Economic Affairs and Energy in North Rhine-Westphalia. Current support programs focus among others on charging infrastructure in companies and municipalities as well as on charging points combined with new photovoltaic systems and battery storage. In 2020 North Rhine-Westphalia approved applications for support of charging infrastructure worth 50 million Euro comprising around 26 000 applications for funding of charging stations installed in homes and at work. The number of public and semi-public charging points has increased with 1 800 compared to the year before.[50]

In the light of skyrocketing numbers for electric vehicles the Minister for Environment, Climate protection and the Energy sector in Baden-Württemberg, Franz Untersteller, means that there is an urgent demand to extend the charging infrastructure: "The charging infrastructure needs to keep pace to not inhibit this positive development." Baden-Württemberg could increase the number of public charging stations by 51 percent in 2020 and expects a demand of up to two million private and 200.000 public charging points until 2030. The expected demand is based on the assumption that 2 million electric cars will be in use by 2030 (20 percent of the national aim of up to 10 million vehicles until 2030). According to Baden-Württemberg's strategy for charging infrastructure especially non-public charging stations will be promoted in support programs by the state.[51]

5.4 Smart homes and smart cities

In Germany buildings account for around 35 percent of total energy consumption and around 30 percent of CO2-emissions. Residential buildings account for the largest share of energy consumption in buildings: Detached and semi-detached houses account for 39 percent and apartment houses for 24 percent of the energy consumed in buildings. The remaining 37 percent of energy consumption in buildings is for non-residential buildings. [52] According to Germany's climate action plan primary energy requirements in buildings are to be reduced by 80 percent until 2050, which would lead to a largely climate neutral building sector. The climate action plan further specifies to bring CO2-emissions from buildings to 70 million tonnes by 2030. However, according to studies by the Federal Ministry of the Environment, the Federal Ministry of Economic Affairs and the *Alliance for Building*

[49] https://www.elektromobilitaet.nrw/mediathek/foerderantraege/
[50] https://www.land.nrw/de/pressemitteilung/elektromobilitaet-nordrhein-westfalen-legt-kraeftig-zu-foerderanpassung-bei
[51] https://vm.baden-wuerttemberg.de/de/politik-zukunft/elektromobilitaet/ladeinfrastruktur/
[52] https://www.dena.de/themen-projekte/energieeffizienz/gebaeude/

Energy Efficiency there could still be a lack of eight to 17 million tons CO2-emissions between the targeted and actual emission level in 2030 even if measures in the climate action plan are followed.[53] Consequently, more needs to be done to mitigate the impact of the sector.

There is significant potential in the building sector for saving energy. In Germany around 63 percent of residential buildings were constructed before 1979 and thus before the First Thermal Insulation Ordinance was introduced. In North Rhine-Westphalia this applies for 75 percent of residential buildings. According to a study by *dena* older houses consume up to five times as much energy as buildings constructed after 2001. The experts from *dena* emphasize that it is necessary to double the rate of energy-efficient building refurbishments from today one to at least two percent to reach the aim of climate neutrality in buildings by 2050. [54]

Considering energy efficiency in buildings heating is a huge concern as more than two-thirds of the energy consumed in private households is used for space heating. [55] Both in North Rhine-Westphalia and Baden-Württemberg natural gas is the most common household heat source. Compared with the German average Baden-Württemberg still has a high number of oil-fired heating systems. As these systems often are old and the installation of new oil heating systems will be largely prohibited in Germany by 2026 there is a high need for alternative heating systems.

	Gas heating	Oil heating	Individual heating systems	District heating	Average age of heating systems	Number of apartments
Germany	45,5%	25%	6,1%	13,9%	17 years	40,6 million
North Rhine-Westphalia	54,8%	23,9%	4,9%	9,1%	15,6 years	8,7 million
Baden-Württemberg	37,1%	33,3%	10%	8,1%	18,8 years	5,1 million

Figure 9: Main sources for heating in German households in 2019. Source: BDEW

Compared to other European countries installations of heat pumps in Germany have proceeded slowly so far. While just 2,3 heat pumps per 1000 households were installed in Germany in 2017 the corresponding number for Sweden was 22,7. According to the business consultancy *PWC* there is a huge potential in Germany for replacing heating systems with heat pumps in existing buildings and thus reducing emissions from heating in existing properties.[56] In new buildings heat pumps already accounted for 41 percent of the installed heating systems in 2019.[57] However, in 2020 installations of heat pumps have seen an increase even in old buildings. According to statistics by the storage association *BVSE* the number of newly installed heat pumps could increase by 40 percent in 2020. Almost 25 percent of the heat pumps installed in 2020 replaced old oil-fired heating systems. The association for heat pumps in Germany (*Bundesverband Wärmepumpen e.V*) regards the national

[53] https://www.dena.de/fileadmin/dena/Publikationen/PDFs/2020/dena-MARKTMONITOR_Gebaeudesektor.pdf

[55] <https://www.bmwi.de/Redaktion/DE/Publikationen/Energie/energieeffizienz-in-zahlen-2020.pdf?__blob=publicationFile&v=20

[56] https://www.pwc.de/en/energy-sector/the-german-heating-sector.html

[57] https://de.statista.com/statistik/daten/studie/237364/umfrage/bedeutung-der-waermepumpen-im-neubau-in-deutschland/

support programs promoting the exchange of old heating systems as a driver for this development.[58] For 2021 the BVSE expects the positive trend to continue and forecasts an increase in installations of heat pumps by 40 percent.[59]

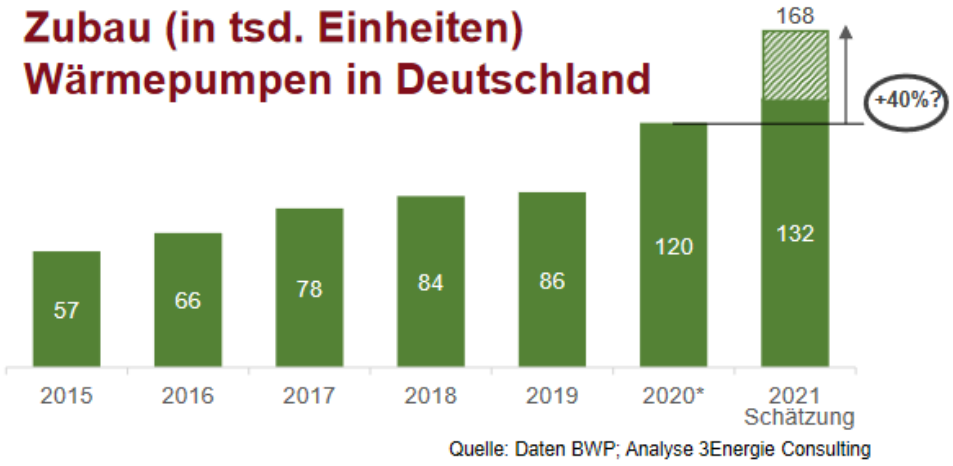

Figure 10: Installations of heat pumps in Germany between 2015 and 2021, forecast for 2021. Source: BVSE.

Regulations for building energy efficiency are stated in the Building Energy Act (*GEG*). The *GEG*, which entered into force in November 2020, implements the European Union's energy performance of buildings directive (*EPBD*). The *EPBD* was revised in 2018, primarily to ensure improvements in building automation. Requirements in following categories were stated in the EPBD 2018: installation of monitoring systems, connections to upstream intelligent networks, intelligent charging for electric vehicles in buildings, introduction of Smart Readiness Indicator (SRI). Even if the *EPBD* was revised in 2018 the new regulations were not fully included in the *GEG* which will make future adaption in German legislation necessary. The main change in the *GEG* compared to previous legislation is that the level of automation will be used for energy performance certificates even in residential buildings. Residential buildings using smart home applications, for example for heating, can now account for it in the energy performance certificate.[60]

Even if adaptions in the *GEG* still are to be expected, support programs for energy efficient building which also include subsidies for building automation such as monitoring equipment and intelligent heating systems, are in place, both at federal level and in Baden-Württemberg and North Rhine-Westphalia. On federal level subsidies can be received via the "Federal Funding for efficient Buildings" (*BEG*) which started in the beginning of the year (2021) and combines previous programs to promote energy efficiency and renewable energies in buildings. The *BEG* will be funded with almost six billion euros in 2021 to subsidize modernizations of buildings and heating systems. Both Baden-Württemberg and North Rhine-Westphalia are offering complementary support programs through their state development banks *L-Bank* and *NRW.BANK*.

[58] https://www.waermepumpe.de/presse/pressemitteilungen/details/positives-signal-fuer-den-klimaschutz-40-prozent-wachstum-bei-waermepumpen/#content
[59] https://www.bves.de/wp-content/uploads/2021/03/2021_BVES_Branchenanalyse.pdf
[60] https://www.tga-fachplaner.de/normen-und-verordnungen/gebaeudeenergiegesetz-geg-anforderungen-die-gebaeudeautomation

Smart home applications, broadly defined as remote controlled or intelligent solutions within heating, lighting or otherwise have been increasingly used in Germany in recent years and according to German's digital association, *Bitkom*, the positive trend will continue. A representative study conducted by *Bitkom* in 2020 showed that 4 of 10 consumers in Germany already use smart home applications. Planned investments in smart home applications mainly regard applications for higher energy efficiency and two-thirds of the respondents want to see intelligent energy supply in new buildings.[61] Forecasts provided by *statista* show that smart home applications within energy management will be used in 15 million households in Germany in 2025 which is almost three times as much as today.[62] In North Rhine-Westphalia and Baden-Württemberg the share of households using smart home applications was 11,5 and 12,7 percent respectively in 2018. As previously mentioned, both North Rhine-Westphalia and Baden-Württemberg, the highest and third highest populated states in Germany, have old building stocks that need to become more energy efficient to achieve a virtually climate-neutral building stock by 2050. In this context, both states will be interesting markets for companies providing smart energy management systems.

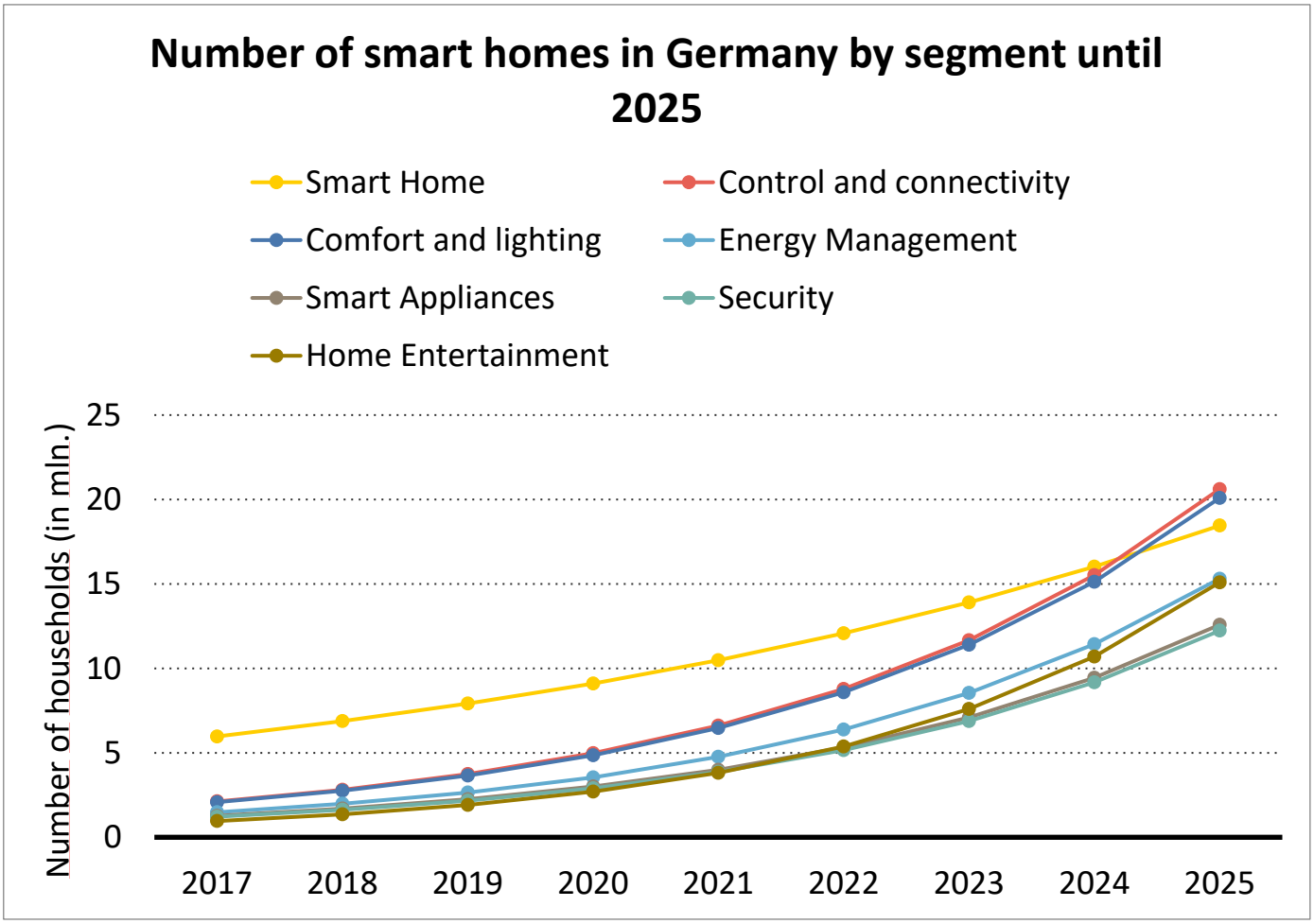

Figure 11: Number of smart homes in Germany by segment until 2025. Source: Statista

[61] https://www.bitkom.org/sites/default/files/2020-09/200922_studienbericht_smart-home.pdf
[62] https://www.statista.com/outlook/dmo/smart-home/germany#smart-homes

As regards challenges to increase energy efficiency in buildings and districts the concept of smart cities is widely applied in Germany. On a federal level dialogue on smart city development is promoted by the platform *Smart City Dialogue* driven by *The Federal Ministry of the Interior, Building and Community*.[63] Every year Germany's digital association *Bitcom*, presents a *Smart City Index* on the level of digitalization in Germany's large cities. According to the *Smart City Index* 2020 almost half of the 81 German cities examined in the study are testing intelligent street lightning and almost all of them spend high efforts on extending charging infrastructure. Compared to 2019 the number of charging points in the 81 big German cities increased by 60 percent. Further 93 percent of the cities are now using LoRaWAN-Gateways that allow fast data transmission. Compared to 2019 this corresponds to an increase by 24 percent. Carsharing, bikesharing, smart parking and intelligent waste containers are other concepts which are increasingly used in Germany's cities.[64]

Both in North Rhine-Westphalia and Baden-Württemberg various initiatives focus on making cities and quarters smarter. In the context of energy supply sector coupling in smart quarters is of high interest in both states. In Baden-Württemberg smart quarters are a prioritized area within the platform *Smart Grids BW* and solutions regarding the use of digital technologies for efficient electricity and heat supply in quarters are explored in various regional projects across the state.[65] For example, in the beginning of the year the project "*Smart East*" has started aiming to transform a district in the eastern part of Karlsruhe into a smart quarter. In the project digital technologies and sector coupling are used to connect the quarter's local energy systems in residential and office buildings and production facilities in order to optimize the energy supply in the quarter and connect it to the city's grid infrastructure. Besides optimizing energy supply and interconnection in the district by using digital tools the project has a focus on developing business models for energy co-operations between local actors. The project is funded by the *Ministry of the Environment, Climate Protection and the Energy sector* in Baden-Württemberg and is part of the energy strategy by the *Karlsruhe Technology Region (TRK)* an action group promoting sustainable energy systems in the region.[66]

In North Rhine-Westphalia, where half of the population lives on 14 percent of the state's area, the development of smart quarters and cities is needed to secure a sustainable energy supply in the future. The state government provides financial support for projects regarding the development of urban energy solutions via programs such as *progress.nrw* and *EnergieSystemWandel.NRW*. In 2020 the *BMWi* announced *SmartQuart* as the first initiative within the "*real-life laboratory of the energy turnaround*" a funding program launched one year before. *SmartQuart* is developed by a consortium of ten partners under the leadership of E.ON and aims to transform energy consumption in districts in three German cities. Until 2021 all partners will invest a total of 60 million euros for developing and testing solutions in the selected districts. With Bedburg and Essen two of three selected cities are located in North Rhine-Westphalia. In both districts digital solutions are used to optimize the use of locally available renewable energies both at street level and in the private sphere. The intelligent energy management system *SmartQuart-Hub* is used to ensure that energy is efficiently used and shared. In Bedburg the project aims at building a new housing district with optimized energy supply. PV-systems are to be installed on the roofs of the houses to cover part of their own electricity demand and surplus electricity from the PV-systems is provided to the whole district. In the quarter heat is generated by sewage heat recovery systems and distributed through an innovative LowEx heating network. In order to largely cover the quarter's electricity demand by locally generated energy, central storage systems are planned for storing surplus electricity and making it available for

[63] https://www.smart-city-dialog.de/en/startseite-en
[64] https://www.bitkom.org/sites/default/files/2021-02/210216_studienbericht_smart_city_index.pdf
[65] https://smartgrids-bw.net/smarte-quartiere/demonstrationsprojekte-smarte-quartiere/
[66] https://smartgrids-bw.net/projekte/forschungsvorhaben-smart-east/

the whole quarter. Further, carsharing offerings and charging points on public parking spaces are part of the project in Bedburg. While the project in Bedburg regards a new-built area, in Essen an energy management system for a quarter in a metropolitan area is tested. As well as in Bedburg, PV-systems on rooftops, central storage systems, LowEx heating networks and carsharing are part of the project. Moreover, there are plans to add fuel cells and a hydrogen infrastructure to the quarter's energy concept.[67]

5.5 Energy storage

Energy storage systems play an important role for maintaining grid security as higher shares of renewable energies are integrated into the grid causing enormous fluctuations. As Germany's potential for developing new pumped storage capacity is limited new storage technologies as well as solutions for smart integration of storage units into the grid are highly needed.

Home storage systems have seen a large increase in Germany during the past two years and according to forecasts by the storage association *BVES* who presented statistics and forecasts for the German energy storage market in March this year the number of home storage systems could increase with 60 percent in 2021.[68] The strong market growth for home storage systems in 2020 was according to BVES also driven by the removal of the 52 GW solar cap which would have stopped feed-in tariff payments for new PV systems with a generation capacity of up to 750 kW. Germany passed 52 GW installed solar capacity in 2020 which initially was set as a cap for the subsidies. Almost 70 percent of the PV systems are nowadays installed together with home storage systems. According to *BVES* the expected market growth for home storage systems will be driven by an increased demand in electromobility and high PV installation rates. Besides new batteries for home storage systems, the retrofit-market for batteries is likely to grow as current PV-systems are updated with storage systems.

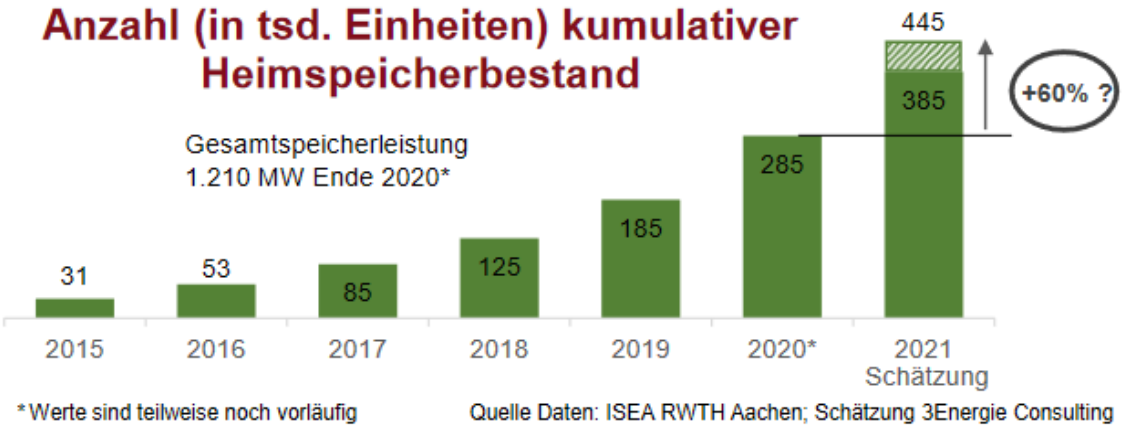

Figure 12: Number (thousands) of home storage systems, cumulative per year, source: BVES

Both Baden-Württemberg and North Rhine-Westphalia have seen a strong increase in electric vehicles (see chapter 6.3) and also PV-systems are deemed to have good market potential in both states. Only Bavaria has more installed PV capacity and higher PV capacity installed in 2020 than

[67] https://www.energieagentur.nrw/blogs/erneuerbare/beitraege/smartquart-sucht-wege-fuer-eine-erneuerbare-energieversorgung-von-quartieren/
[68] https://www.bves.de/wp-content/uploads/2021/03/2021_BVES_Branchenanalyse.pdf

Baden-Württemberg and North Rhine-Westphalia. With 625 MW newly installed PV capacity in 2020 the installed capacity in Baden-Württemberg has increased with around 35 percent compared to 2019.[69] Baden-Württemberg aims to double the installed capacity of its largest renewable energy source to 11 GW until 2030. From 2022 installation of PV will be compulsory for non-residential buildings applying for building permission in Baden-Württemberg. The federal state is first in Germany integrating compulsory PV installations in its legislation.[70] In April this year Baden-Württemberg launched a funding program for PV battery storage systems "*Netzdienliche PV-Batteriespeicher*" with a budget of 10 million euros for 2021 and 2022.[71] The aim of the program is to stimulate investments in PV and reduce the load in the distribution grids. With 620 MW new installed PV capacity in 2020 North Rhine-Westphalia could increase annual PV new installations by 30 percent compared to 2019.[72] According to the State Agency for Nature, Environment and Consumer Protection North Rhine-Westphalia, *LANUV*, 68 TWh solar power could be generated on 11 million rooftops in the densely populated state. However, only 4 TWh have been realized as of today. [73] North Rhine-Westphalia wants to employ unused PV capacity and aims at doubling the installed PV capacity from 4,6 GW in 2018 to 11,5 GW in 2030 according to its energy supply strategy.[74] Through the program "*proges.NRW*" subsidies can be received for the installation of battery storage in combination with a new PV system even in 2021. In 2020 the program provided funding worth 30.8 million euros.[75]

While the market for home storage systems could grow in 2020 the turnover for commercial and industrial storage systems decreased by 20 percent due to cancelled or shifted orders during the corona crisis. For 2021 the BVES expects a slow recovery of the market driven by e-mobility and higher CO_2 prices. In the long term the German Hydrogen Strategy which aims at 5 GW installed capacity in 2030 will lead to an increased demand for electrolysis and the use of hydrogen in industry. In the existing grid infrastructure pumped storage systems are still the only technology being able to store electricity on a large scale. The employment of large battery systems is still slowing down mainly due to falling revenues from the provision of Primary Control Reserve (PRC). According to BVES the use of so-called "grid boosters" large scale batteries that boost the capacity of existing power lines reducing the need for grid expansion and cutting redispatch costs – could lead to increasing turnovers in the large-scale battery segment from 2022. However, the future demand of large-scale batteries for grid stabilization will rather be limited. In the last years improvements in weather forecasts as well as innovations in electricity trading reduced the need of large-scale batteries for grid stabilization according to *GTAI*. Instead, long-term storage systems, namely hydrogen storage systems are highly needed.

[69] https://www.solarbranche.de/ausbau/bundeslaender-photovoltaik/baden-wuerttemberg?jahr=2020
[70] https://www.energiezukunft.eu/erneuerbare-energien/solar/baden-wuerttemberg-wird-erstes-bundesland-mit-solarpflicht/
[71] https://um.baden-wuerttemberg.de/de/energie/informieren-beraten-foerdern/foerdermoeglichkeiten/pv-speicher/
[72] https://www.solarbranche.de/ausbau/bundeslaender-photovoltaik/nordrhein-westfalen?jahr=2020
[73] https://www.energieagentur.nrw/blogs/erneuerbare/beitraege/studie-mehr-pv-dachanlagen-koennten-energiewende-schneller-voranbringen/
[74] https://www.wirtschaft.nrw/sites/default/files/asset/document/evs_nrw_version_veroeffentlichung_final.pdf
[75] https://www.land.nrw/de/pressemitteilung/klimaschutz-ab-sofort-wieder-antraege-fuer-das-programm-progresnrw-markteinfuehrung

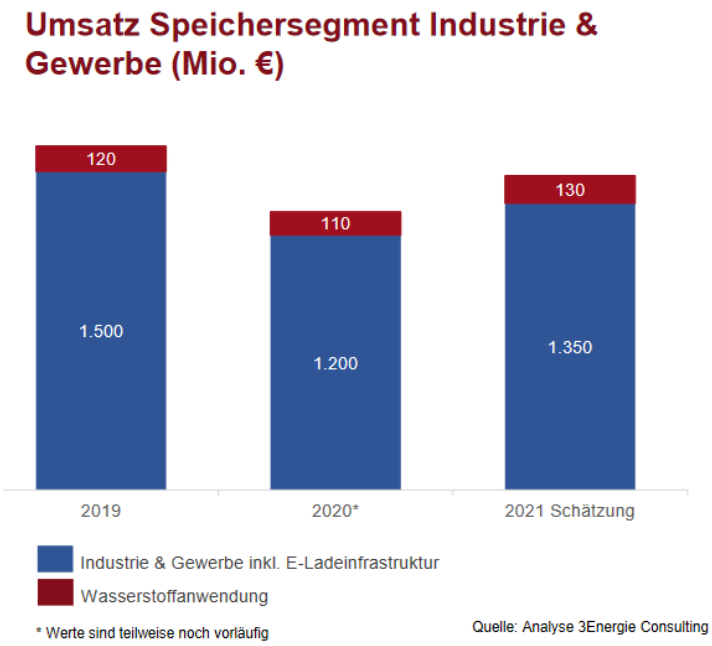

Figure 13: Turnover for commercial and industrial storage systems and hydrogen applications (in million euros). Source: BVES

As Germany´s coal state number one North Rhine-Westphalia has traditionally exported electricity to other federal states and European neighbors. With the ongoing energy transition this will change as import of wind energy from the North and local electricity generation from renewable energy sources will be used to cover the state's demand. As previously named the situation of high production potential in rural areas and high demand in the conurbations along Rhine and Ruhr depicts a challenge for the electricity system in North Rhine-Westphalia. Storage systems will play a vital role for providing flexibility in this context. Further, storage systems are needed as North Rhine-Westphalia, with its central geographical location in Germany and Europe, aims to be a hub for distributing large amounts of electricity coming from the North. Indeed, the infrastructural conditions in North Rhine-Westphalia for huge power storage facilities are beneficial. Decommissioned power plants provide the infrastructure needed for large storage facilities, i.e. existing power lines. As regards long-term storage hydrogen is high up on the political agenda in North Rhine-Westphalia. In November last year the state published a hydrogen roadmap that presents targets for a hydrogen infrastructure and the use of hydrogen in industry and for transportation. For example, by 2030 240 km of totally 1300 km hydrogen pipelines in Germany are to be built in North Rhine-Westphalia according to the roadmap.[76] With a well-developed natural gas network North Rhine-Westphalia has good conditions for building a hydrogen infrastructure. The cross-sectoral use of hydrogen is a prioritized area also in Baden-Württemberg which – as well as North Rhine-Westphalia - published a hydrogen roadmap by the end of last year. The state also started a support program for hydrogen "*Modellregion Grüner Wasserstoff*" providing funding worth 35 million euros for the implementation of a hydrogen economy in selected areas between 2021 and 2027.[77]

[76] https://www.land.nrw/de/pressemitteilung/wasserstoff-roadmap-fuer-nordrhein-westfalen-vorgestellt
[77] https://um.baden-wuerttemberg.de/en/wirtschaft/ressourceneffizienz-und-umwelttechnik/wasserstoffwirtschaft/foerderprogramm/

Besides power-to-gas technology both Baden-Württemberg and North Rhine-Westphalia intensively support research and development of batteries. With a high density of research institutions and companies in the field of battery technology together with a strong automotive industry as potential customer Baden-Württemberg and North Rhine-Westphalia are important locations as battery cell production capacities are increasingly built up in Germany. The Center for Solar Energy and Hydrogen Research Baden-Württemberg (*ZSW*) and the research facility for battery cell production *FBB* ("*Forschungsfertigung Batteriezelle*") in Münster, North Rhine-Westphalia are examples for important German research institutions for battery technology.

6 Conclusion

6.1 Business Areas and opportunities

Overall, business opportunities for Swedish smart grid companies in the above presented areas can be regarded as good. However, it has to be born in mind that the German market is characterized by strong competition which requires a clearly defined USP, good communication and argumentation as well as active marketing and visibility in the market. Thorough preparation is needed before entering the market and it is highly recommended to look for a local partner.

To sum up, following business areas and trends should be observed by Swedish companies that are about to enter the German market:

Smart grid technology
As mentioned above digitalizing the electricity grid and making it smarter is of high interest for securing efficient grid operation and grid stability. Thus, there is a demand for both hardware and software solutions at all levels of the grid. However, data security concerns may depict a barrier in this context. Given the structural conditions in both states smart grid solutions addressing grid management in areas with large industrial centers may find higher market potential in North Rhine-Westphalia.

Smart metering
Regarding the market growth in segments such as electric vehicles and PV-systems business cases for the use of smart meters are given. Thus, even though the mandatory roll-out is stagnating hardware and software solutions within the smart meter segment are representing a growing market. However, it must be considered that grid operators are rather reluctant when it comes to the voluntary installation of smart meters.

E-mobility and charging infrastructure
E-mobility has picked up speed and an expansion of charging infrastructure is highly needed. In this context business solutions regarding smart charging as well as pricing and billing find a growing market segment. In the future vehicle-to-grid is seen as a promising solution for providing flexibility to the grid. For companies providing solutions which require close collaboration with the automotive industry Baden-Württemberg is a preferable market due to its large automotive industry and high R&D density within this field.

Smart home and smart cities
The urgent need to improve energy efficiency in buildings is reflected in adjusted legislation and numerous support programs incentivizing investments in energy efficient solutions. In combination with a rising interest for smart home solutions business solutions for smart applications and energy management systems face a growing market.

Energy storage
Installations of home storage systems have increased significantly during the last year and the positive trend is expected to continue. In addition, the retrofit market for storage systems represents a growing segment. A main driver for market growth in these segments is the increasing number of PV-systems. As regards long-term storage hydrogen is high on the agenda in both Baden-Württemberg and North Rhine-Westphalia. Especially North Rhine-Westphalia depicts a promising

market due to its existing infrastructure in form of power lines and gas pipelines as well as large industries which will be in need of hydrogen.

	NEEDED TECHNOLOGIES	PARTNER	COMMENT
Smart grid technology	• DSM • Grid automation solutions • Data collection and analysis (measurement tools) • Remote-control technology • Communication technology • Virtual power plants	• DSOs • TSOs • Energy companies / Public utilities (Stadtwerke)	NRW Solutions addressing grid management in areas with large industrial centers BW Solutions for interconnected regional energy systems with a cellular structure and focus on PV integration
Smart metering		• DSOs • Energy companies /Public utilities	
E-mobility and charging infrastructure	• Charging infrastructure • Solutions for pricing and billing • Vehicle-to-grid solutions	• Electrical Wholesalers • Energy companies / Public utilities (Stadtwerke) • Charge Point Operator • Parking operator • Real estate companies	BW Large automotive industry
Smart home and smart city	• Energy management systems • Heat pumps • Building automation • Sector coupling	• Facility management • DSOs • Project development • TGA-engineers	
Energy storage	• Hydrogen storage • Home storage systems	• Electrical wholesaler • Energy companies /Public utilities (Stadtwerke) • Installation companies • Real estate companies • Gas companies	NRW Good infrastructural conditions for use of hydrogen

Figure 14: Overview over business opportunities in the report's focus areas with suggestions on possible partners and comments on Baden-Württemberg (BW) and North Rhine-Westphalia (NRW)

STRENGTHS	WEAKNESSES
• Stable political conditions • Free and open market • Strong and various networks in the energy sector • Excellent research and development • Europe's largest market • Well-established trade relationships between Sweden and Germany	• Time consuming bureaucratic processes • Rather slow adaption of digital technologies • Hierarchical structure in organizations • Rather conservative attitude as regards modernization of grids • Regulatory incentives as regards modernization of the grid
OPPORTUNITIES	**THREATS**
• Promotion programs in various fields of the energy transition both at federal and state level • Need to extend charging infrastructure • Old building stock that needs to become more energy efficient • Increase in installations of PV-systems and home storage systems • Need for large-scale storage • Need for digitalizing the grid	• High requirements on data security • Many emerging local competitors • Unsecure future of mandatory smart meter roll-out • Intercultural misunderstandings

Figure 15: SWOT analysis for smart grids in Germany

6.2 How to approach the German market

When entering the German market it needs to be considered that there are some aspects that companies should be aware of:

1. **Time aspect**
   The German energy market can be described as conservative and rather reluctant. As seen in the case of smart meter gateways new solutions are thoroughly evaluated before use. Thus, certification standards and requirements on data security are important parameters to be aware of when entering the German market. Depending on the partners' ability to implement new solutions in the organization and the individual level of preparation, for example regarding the adaption to current standards on the German market, the time to market can be roughly estimated to be between 12 and 24 months.
2. **Become a local**
   To successfully enter the German market local partner and networks are key. Associations, platforms, innovation labs and expert groups are valuable for establishing networks in Germany. Further, representation at place through a subsidiary or staff that is familiar with the German business culture and language is important in order to be able to actively approach relevant partners.
3. **Bureaucracy**
   Entering the German market includes often to be confronted with numerous regulations and instructions that are seldom available in English. Companies approaching the German market should be aware of that handling the bureaucratical part is time consuming and that many processes are not digitalized. As regards support in the bureaucratical processes little service is provided.
4. **Privacy**
   Privacy issues are taken very serious in Germany and violation against GDPR can quickly lead to a lawsuit. Swedish companies should be aware of that information is handled

confidentially in Germany. Compared to Sweden information that is freely available is very limited.

Before entering the German market make sure that you are prepared and can tick off following aspects:

- ✓ Do you have a well-proven technology?
- ✓ Do you have customers and references in Sweden?
- ✓ Can you deliver?
- ✓ Do you have the workforce and financial resources needed to enter the German market?
- ✓ What is your product's USP?
- ✓ Do you know the German market and your competitors?
- ✓ Which region, which segment and which target group do you address?
- ✓ Are you aware of the juridical framework?

6.3 Annex: relevant cluster, networks, initiatives, institutions and companies (table)

Chambers of Commerce in **North Rhine-Westphalia**

Organisation	**Contact**
IHK - NRW	https://www.ihk-nrw.de/
Industrie- und Handelskammer Arnsberg, Hellweg-Sauerland	http://www.ihk-arnsberg.de/
Industrie- und Handelskammer zu Dortmund	https://www.dortmund.ihk24.de/
Industrie- und Handelskammer Nord Westfalen	https://www.ihk-nordwestfalen.de/
Industrie- und Handelskammer Ostwestfalen zu Bielefeld	https://www.ostwestfalen.ihk.de/
Industrie- und Handelskammer Bonn/Rhein-Sieg	http://www.ihk-bonn.de/
Niederrheinische Industrie- und Handelskammer Duisburg - Wesel - Kleve zu Duisburg	http://www.ihk-niederrhein.de/
Südwestfälische Industrie- und Handelskammer zu Hagen	https://www.sihk.de/
Industrie- und Handelskammer Siegen	http://www.ihk-siegen.de/
Industrie- und Handelskammer zu Düsseldorf	https://www.duesseldorf.ihk.de/
Industrie- und Handelskammer zu Köln	https://www.ihk-koeln.de/
Industrie- und Handelskammer Aachen	http://www.aachen.ihk.de/
Industrie- und Handelskammer Mittleres Ruhrgebiet	http://www.bochum.ihk.de/
Industrie- und Handelskammer Lippe zu Detmold	http://www.detmold.ihk.de/
Industrie- und Handelskammer für Essen, Mülheim an der Ruhr, Oberhausen zu Essen	http://www.essen.ihk24.de/
Industrie- und Handelskammer Mittlerer Niederrhein	http://www.mittlerer-niederrhein.ihk.de/
Bergische Industrie- und Handelskammer Wuppertal-Solingen-Remscheid	http://wuppertal.ihk.de/

Chambers of Commerce in **Baden-Württemberg**

Organisation	**Contact**
Baden-Württembergischer Industrie- und Handelskammertag e. V.	info@bw.ihk.de https://www.bw.ihk.de/
IHK Bodensee-Oberschwaben	http://www.weingarten.ihk.de
IHK Hochrhein-Bodensee	http://www.konstanz.ihk.de/
IHK Schwarzwald-Baar-Heuberg	http://www.schwarzwald-baar-heuberg.ihk.de/
IHK Südlicher Oberrhein	http://www.suedlicher-oberrhein.ihk.de/
IHK Nordschwarzwald	http://www.nordschwarzwald.ihk24.de/
IHK Reutlingen	http://www.reutlingen.ihk.de/
IHK Ulm	http://www.ulm.ihk24.de/
IHK Ostwürttemberg	http://www.ostwuerttemberg.ihk.de/
IHK Region Stuttgart	http://www.stuttgart.ihk.de/

IHK Karlsruhe	http://www.karlsruhe.ihk.de/
IHK Heilbronn-Franken	http://www.heilbronn.ihk.de/
IHK Rhein-Neckar	http://www.rhein-neckar.ihk24.de/

Authorities in North Rhine-Westphalia

Organisation	Short profile	Contact
Ministerium für Wirtschaft, Innovation, Digitalisierung und Energie	The Ministry of Economy, Innovation, Digitization and Energy	https://www.wirtschaft.nrw/
Landesamt für Natur, Umwelt und Verbraucherschutz	State Office for Nature, Environment and Consumer Protection	https://www.lanuv.nrw.de/
Ministerium für Umwelt, Landwirtschaft, Natur- und Verbraucherschutz	The Ministry of Agriculture, Nature and Consumer Protection	www.umwelt.nrw.de
ElektroMobilität NRW	E-mobility NRW	https://www.elektromobilitaet.nrw/

Authorities in Baden-Württemberg

Organisation	Short profile	Contact
Ministerium für Umwelt, Klima und Energiewirtschaft Baden-Württemberg	The Ministry of Environment, Climate Protection and Energy Sector Baden-Wuerttemberg	http://um.baden-wuerttemberg.de/de/startseite/
Ministerium für Inneres, Digitalisierung und Migration	Ministry of the Interior, Digitization and Migration	http://im.baden-wuerttemberg.de/de/startseite/
Landesagentur für neue Mobilitäts-lösungen und Automotive Baden-Württemberg	The State Agency for New Mobility Solutions and Automotive	https://www.e-mobilbw.de/
Verkehrsministerium Baden-Württemberg	The Ministry of Transport in BW	http://vm.baden-wuerttemberg.de/de/startseite/

Initiatives, cluster, incubators, co-working spaces and science parks in **North Rhine-Westphalia**

Organisation	Short profile	Contact
Energieagentur NRW	Energy agency in NRW	www.energieagentur.nrw
CEF Cluster Energieforschung	The EnergyAgency.NRW has been working on behalf of the ministry of economic affairs of North Rhine-Westphalia since 1990 as an operative platform with a wide range of competencies in the energy domain: from energy research, technical development, demonstration and market launch through to initial energy consulting and occupational further training.	https://www.energieagentur.nrw/forschung/cef EnergieRegion.NRW (www.energieregion.nrw.de)
Jülich Forschungszentrum	Jülich Forschungszentrum conducts research to provide comprehensive solutions to the grand challenges facing society in the fields of energy and environment, information and brain research.	https://www.fz-juelich.de/portal/EN/Research/EnergyEnvironment/_node.html
ZENIT GmbH - Centre for Innovation and Technology in NRW	ZENIT GmbH, founded in 1984, is a public-private partnership with around 60 employees and the agency for innovation and European affairs of the German State of North Rhine-Westphalia.	https://www.zenit.de/
Grüner Strom Label e.V.		www.gruenerstromlabel.de

TechnologieZentrumDortmund	One of the leading technology centers in Germany	https://www.tzdo.de/en.htm
Das Fraunhofer-Institut für Umwelt-, Sicherheits- und Energietechnik UMSICHT	Fraunhofer Institute for Environmental, Safety, and Energy Technology	https://www.umsicht.fraunhofer.de/
Münster Electrochemical Energy Technology	Battery Research Center	https://www.uni-muenster.de/MEET/en/

Initiatives, cluster, incubators, co-working spaces and science parks in Baden-Württemberg

Organisation	Short profile	Contact
Smart Grids-Plattform Baden-Württemberg e.V.	Network of key players in the energy sector, plant manufacturers, network operators, IT, politics and interested individuals	https://smartgrids-bw.net/
Clusternetzwerk "Energie und Umwelt"	Alliance for the Rhine-Neckar region, companies which are active in the areas of energy efficiency and renewable energies.	https://www.m-r-n.com/was-wir-tun/themen-und-projekte/projekte/clusternetzwerk-energie-und-umwelt
EnergieForum Karlsruhe	A strong competence network of active companies, start-ups, research and development institutions and established players in the financial sector - for a future-oriented energy strategy.	www.energieforum-karlsruhe.de
fokus.energie e. V.	The development and implementation of innovative and sustainable technologies is supported through cooperation between actors and educational offers. The network offers targeted help and funding to support business start-ups.	Info@fokusenergie.net www.fokusenergie.net
Morgenstadt – city of the future	The Fraunhofer "Morgenstadt Initiative" is a network of Fraunhofer Institutes, municipalities and companies. It was founded in 2012 by the Fraunhofer Institute for Industrial Engineering (IAO) to think ahead, develop and test innovations for the city of tomorrow.	https://www.morgenstadt.de/
Cluster Elektromobilität Süd-West	In the Electromobility South-West cluster, automobile manufacturers, system suppliers and medium-sized companies cooperate with research institutions. The aim of the cluster is to advance the industrialization of electromobility in Germany and to make Baden-Württemberg a major provider of new mobility solutions.	www.emobil-sw.de
StoREgio Energiespeichersysteme e. V.	StoREgio develops system solutions and business models	www.storegio.com

	for the use of energy storage systems for the supply of electricity, heat and mobility with renewable energies.	
Cluster Brennstoffzelle BW	The aim of the cluster is to advance the industrialisation of mobile and stationary fuel cell applications	www.e-mobilbw.de/de/aufgaben/cluster-wasserstoff-brennstoffzellentechnologie.htm
Cluster Green City Freiburg	The Freiburg economic region - consisting of the City of Freiburg and the administrative districts of Breisgau-Hochschwarzwald and Emmendingen - maintains an innovative business development cluster with a special focus on the environmental and renewable energy sectors.	www.greencity-cluster.de
Automotive Engineering Network	The Automotive Engineering Network is an initiator, mediator and accelerator of innovations. As a neutral institution, we bundle relevant expert knowledge, especially for small and medium-sized companies, as well as start-ups, so that they can successfully implement their innovations.	www.ae-network.de
ifeu - Institut für Energie- und Umweltforschung Heidelberg gGmbH	ifeu conducts research and provides a worldwide consultancy service in relation to all major environmental and sustainability issues.	https://www.ifeu.de/en/
ZSW - Center for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW)	The ZSW was established in 1988 by the German state of Baden-Württemberg, together with universities, research institutions, and commercial firms. It is a non-profit foundation under the civil code. Topics: Grid integration of renewable energy sources and Smart Grid.	https://www.zsw-bw.de/
Stiftung Energieforschung Baden-Württemberg	Research funding in the field of regenerative energies, the rational use of energy and the energy industry.	www.sef-bw.de
Technologiepark Karlsruhe (TPK)	The Technology Park Karlsruhe is the top location for international high-tech enterprises.	https://www.techpark.de/en
Stuttgarter Engineering Park (STEP)	In one of the economically strongest regions in Germany, STEP offers over 110,000 m2 of state-of-the-art office space. Numerous scientific institutions provide an ideal environment. Over 140 interdisciplinary companies have already settled in STEP	https://www.step-gmbh.com/

Business-Park Göppingen GmbH	The traditional industrial city of Göppingen has a special focus on mechatronics in the greater Stuttgart area.	https://businesshaus-gp.de/

Investment promotion agencies in **North Rhine-Westphalia**

Organisation	**Contact**
NRW invest	https://www.nrwinvest.com/de/startseite/
Verband der Wirtschaftsförderungs- und Entwicklungsgesellschaften NRW e.V. (VWE)	http://www.wirtschaftsfoerderung-online.de/
AGIT Aachener Gesellschaft für Innovation und Technologietransfer mbH	https://www.agit.de/de/startseite.html
Bergische Struktur- und Wirtschaftsförderungsgesellschaft mbH	https://bergische-gesellschaft.de/
En Agentur	https://en-agentur.de/

Investment promotion agencies in **Baden-Württemberg**

Organisation	**Contact**
Baden-Württemberg International – Gesellschaft für internationale wirtschaftliche und wissenschaftliche Zusammenarbeit mbH	info@bw-i.de https://www.bw-invest.de/
Wirtschaftsförderung Alb-Donau-Kreis	wirtschaft@alb-donau-kreis.de https://www.alb-donau-kreis.de/startseite.html
Wirtschaftsförderung Landkreis Biberach	poststelle@biberach.de https://www.biberach.de/
Bodensee Standort Marketing GmbH	info@b-sm.com https://www.standort-guide-bodensee.com/en/
Metropolregion Rhein-Neckar GmbH	gmbh@m-r-n.com https://www.m-r-n.com/
Standortagentur Tübingen – Reutlingen – Zollernalb GmbH	info@neckaralb.de https://www.neckaralb.de/
TechnologieRegion Karlsruhe GmbH	info@technologieregion-karlsruhe.de https://technologieregion-karlsruhe.de/startseite
Wirtschafts- und Innovationsförderungsgesellschaft Landkreis Ravensburg mbH	info@wir-rv.de https://www.wir-rv.de/
Wirtschaftsförderung Bodenseekreis GmbH	info@wf-bodenseekreis.de https://www.wf-bodenseekreis.de/wirtschaftsfoerderung/
Wirtschaftsförderung Region Stuttgart	info@region-stuttgart.de https://wrs.region-stuttgart.de/
Wirtschaftsförderung Nordschwarzwald GmbH	info@nordschwarzwald.de https://www.nordschwarzwald.de/
Wirtschaftsförderungsgesellschaft mbH Region Ostwürttemberg (WIRO)	wiro@ostwuerttemberg.de https://www.ostwuerttemberg.de/
Wirtschaftsförderungsgesellschaft Schwarzwald-Baar-Heuberg mbH	info@wifoeg-sbh.de https://wirtschaftsfoerderung-sbh.de/wirtschaftsfoerderung/was-wir-tun/
Wirtschaftsregion Heilbronn-Franken GmbH	info@heilbronn-franken.com https://www.heilbronn-franken.com/home.html
WRO Wirtschaftsregion Offenburg/Ortenau GmbH	info@wro.de https://www.wro.de/
Wirtschaftsregion Südwest GmbH	info@wsw.eu https://www.wsw.eu/
Wirtschaftsförderung Region Freiburg e.V.	info@wrf-freiburg.de https://www.wrf-freiburg.de/
Steinbeis-Stiftung für Wirtschaftsförderung	stw@steinbeis.de https://www.steinbeis.de/de/

Energy companies in **North Rhine-Westphalia**

Organisation	**Contact**
RWE AG	https://www.group.rwe/en#

RheinEnergie AG	https://www.rheinenergie.com
Klickenergie	https://www.klickenergie.de/
Yello Strom	https://www.yello.de/
Extraenergie	https://www.extraenergie.com/
Uniper	https://www.uniper.energy/
NATURSTROM AG	www.naturstrom.de
Stadtwerke Düsseldorf	https://www.swd-ag.de/
EWV Energie- und Wasser-Versorgung GmbH	https://www.ewv.de
STEAG GmbH	https://www.steag.com

Energy companies in **Baden-Württemberg**

Organisation	**Contact**
EnBW Energie Baden-Württemberg AG	https://www.enbw.com/
MVV Energie AG	https://www.mvv.de/de/
Badenova	https://www.badenova.de/
Pfalzwerke	https://www.pfalzwerke.de/privatkunden
SWU Energie GmbH	http://www.swu-energie.de/
Süwag	https://www.suewag.de
Eprimo	http://www.eprimo.de/
ENRW Energieversorgung Rottweil GmbH & Co. KG	https://www.enrw.de
EGT Energie GmbH	http://www.egt-energie.de/
Stadtwerke Karlsruhe GmbH	http://www.stadtwerke-karlsruhe.de/

Distribution grid operators North Rhine-Westphalia

Organisation	**Contact**
Westnetz Gmbh	https://iam.westnetz.de/
regionetz GmbH	https://www.regionetz.de/
Enervie AssetNetWork GmbH	https://www.enervie-vernetzt.de/Home.aspx
Westfalen Weser Netz GmbH	https://www.ww-netz.com/
Swbnetz	https://www.swbnetz.de/startseite.html
Rheinische NETZGesellschaft mbH	https://www.rng.de/cms/
NEW Netz GmbH	https://www.new-netz.de/
Rhein-Sieg Netz	https://www.rhein-sieg-netz.de/
Netze Duisburg	https://www.netze-duisburg.de/
AVU Netz GmbH	www.avu-netz.de
BEW Netze GmbH	https://www.bew-netze.de/
Dortmunder Netz GmbH	https://www.do-netz.de/
GELSENWASSER Energienetze GmbH	https://www.gw-energienetze.de/index.php?id=home

Distribution grid operators in Baden-Württemberg

Organisation	**Contact**
Netze BW GmbH	https://www.netze-bw.de/
AlbWerk GmbH & Co. KG	https://www.albwerk.de/home/
bnNetze GmbH	https://bnnetze.de/
ED Netze GmbH	https://www.ednetze.de/
FairNetz GmbH	https://www.fairnetzgmbh.de/de

Netze Mittelbaden GmbH	https://www.uewm.de/
Netzgesellschaft Ost-württemberg DonauRies GmbH	https://www.ng-o.com/
Stuttgart Netze GmbH	https://www.stuttgart-netze.de/
Syna GmbH	https://www.syna.de/corp

Corporates within automotive

Organisation	**Contact**
Audi	https://www.audi.de/de/brand/de.html
Daimler	www.daimler.com
Dr. Ing. h.c. F. Porsche AG	www.porsche.com
Ford-Werke GmbH	www.ford.de
Robert Bosch GmbH	www.bosch.de
ZF Friedrichshafen AG	www.zf.com
Continental	https://www.continental.com/en
Mahle	https://www.mahle.com/
Schaeffler	https://www.schaeffler.com/fork/
Thyssenkrupp Automotive	https://www.thyssenkrupp.com/en/products/automotive
Hella KG Hueck	https://www.hella.com/hella-com/de/index.html
Brose Fahrzeugteile	https://www.brose.com/de-en/
Eberspächer	https://www.eberspaecher.com/
Dräxlmaier	https://www.draexlmaier.com/en/

Charge Point Operators in Germany

Organisation	**Contact**
Allego, Berlin	https://www.allego.eu/
The New Motion Deutschland GmbH (TNM), Berlin	http://www.thenewmotion.de
Stromnetz Hamburg GmbH, Hamburg	http://www.stromnetz.hamburg/
EnBW Energie Baden-Württemberg AG (EnBW)	http://www.enbw.com
smartlab Innovationsgesellschaft mbH, Achen	http://www.smartlab-gmbh.de
E-WALD GmbH, Teisnach	http://e-wald.eu/
Innogy SE (RWE), Essen	https://www.rwe-mobility.com
SWM Versorgungs GmbH (SWM), München	http://www.swm.de/
IONITY GmbH, München	
Digital Energy Solutions GmbH & Co KG, München	https://www.digital-energysolutions.de/de
innogy eMobility Solutions GmbH, München	https://ionity.eu/de
RWE (RWE), Dortmund	https://www.group.rwe/en#
chargeIT mobility, Kitzingen	http://www.chargeit-mobility.com/de/home/

TGA-engineers and **Facility Management companies** in Germany

Organisation	**Contact**
Henne & Walter GbR	https://www.henne-walter.de/
Transsolar Energietechnik GmbH	https://transsolar.com/
WINTER Beratende Ingenieure für Gebäudetechnik	https://www.winter-ingenieure.de/
Köster Planung GmbH	https://www.koester-planung.de/
Drees & Sommer	https://www.dreso.com/de/
HL-Technik Engineering Partner GmbH	https://www.hl-technik.de/
Ingenieurbüro Hausladen GmbH	https://www.ibhausladen.de/
ebök Planung und Entwicklung GmbH	https://www.eboek.de/
SCHREIBER Ingenieure Systemplanung GmbH	http://www.schreiber-ingenieure.de/
INOVIS Ingenieure GmbH	https://www.inovis-ingenieure.de/
Spie Deutschland & Zentraleuropa GmbH, Ratingen;	https://spie.de/
Apleona GmbH, Neu-Isenburg	https://www.apleona.com/
Wisag Facility Service Holding GmbH, Frankfurt am Main	https://www.wisag.de/
Strabag Property and Facility Services GmbH, Frankfurt am Main	https://www.strabag-pfs.com/
Gegenbauer Holding SE & Co. KG, Berlin	https://www.gegenbauer.de/

Engie Deutschland GmbH, Köln	https://www.engie-deutschland.de/de
Compass Group Deutschland GmbH, Eschborn	https://www.compass-group.de/
ISS Facility Services Holding GmbH, Düsseldorf	https://www.de.issworld.com/
Piepenbrock Facility Management GmbH + Co. KG, Osnabrück	https://www.piepenbrock.de/en/
Dussmann Service Deutschland GmbH	https://www.dussmann.com/

Associations in Germany

Organisation	**Short profile**	**Contact**
Verband für Energie- und Wasserwirtschaft	Association for Energy and Water Management	https://www.vfew-bw.de/
Verband kommunaler Unternehmen e.V.	The Verband kommunaler Unternehmen e.V. (VKU) is the German Association of Local Utilities of municipally determined infrastructure undertakings and economic enterprises	https://www.vku.de/
BDEW - Bundesverband der Energie- und Wasserwirtschaft	Federal Association of Energy and Water Management	https://nd.bdew.de/
Bundesverband Erneuerbare Energie e.V. (BEE)	German Renewable Energy Federation	https://www.bee-ev.de/
BEMD – Bundesverband der Energiedienstleister	Federal Association of Energy Market Service Providers	www.bemd.de
BNE – Bundesverband Neue Energiewirtschaft	Federal Association for the New Energy Industry	www.bne-online.de
Bundesverband eMobilität	Federal Association emobility	www.bem-ev.de
BVFE – Bundesverband zur Förderung der Energieeffizienz e.V.	Federal Association for the Promotion of Energy Efficiency e.V.	www.bvfe-online.de
BVES – Bundesverband Energiespeicher	German Energy Storage Association	www.bves.de
Bundesverband Smart City e.V.	Federal Association Smart City	www.bundesverband-smart-city.de
Dena – Deutsche Energie-Agentur	German Energy Agency	www.dena.de
eaD – Bundesverband der Energie- und Klimaschutzagenturen Deutschlands e.V.	Federal Association of Energy and Climate Protection Agencies in Germany	www.energieagenturen.de
EDNA Bundesverband Energiemarkt & Kommunikation e.V.	Ffederal association Energy Market & Communication e.V.	www.edna-bundesverband.de
Forum für Zukunftsenergien e.V.	Forum for future energies	www.zukunftsenergien.de
GEE – Gesellschaft für Energiewissenschaft und Energiepolitik e. V.	Society for Energy Science and energy policy e. V.	www.gee.de
GRE – Gesellschaft für Rationelle Energieverwendung e.V	Society for the rational Energy use e.V	www.gre-online.de
HEA – Fachgemeinschaft für Effiziente Energieanwendung e.V.	Professional community for efficient people Energy application e.V.	www.hea.de
MEW – Mittelständische Energiewirtschaft Deutschland e.V.	medium-sized energy industry Germany e.V.	www.mew-verband.de
VDI-Gesellschaft Energie und Umwelt	Society for Energy and Environment	www.vdi.de/technik/fachthemen/energie-und-umwelt/
VKU – Verband kommunaler Unternehmen e.V.	German Association of Local Utilities of municipally determined infrastructure undertakings and economic enterprises.	www.vku.de

Verband der Energiehändler	Association of German Energy Traders	https://www.efet-d.org/

Property development companies in Baden-Württemberg and North Rhine-Westphalia

Organisation	**Contact**
Zech Gruppe (Deutsche Immobilien Holding AG)	https://www.zech-group.com/en/
Consus Real Estate AG	https://www.consus.ag/?lang=en
Bonava	https://www.bonava.com/en
Instone	https://www.instone.de/
BPD	https://www.bpd-immobilienentwicklung.de/
Gross & Partner	https://www.gross-partner.de/en/
Pandion	https://www.pandion.de/
Project Immobilien	https://www.project-immobilien.com/
Büschl	https://www.bueschl-gruppe.de/
Otto Wulf	https://www.otto-wulff.de/
EEW GmbH Gesellschaft für Grundbesitz und Projektentwicklung, Sindelfingen	https://www.eew-gmbh.de/
FAY Projects GmbH, Mannheim	https://www.fay.de/en/home/
LBBW Immobilien Development GmbH, Stuttgart	https://www.lbbw-immobilien.de/de/development
Art-Invest Real Estate Management GmbH & Co. KG (Köln)	https://www.art-invest.de/en/
BAUWENS GmbH & Co. KG (Köln)	https://www.bauwens.de/
GERCHGROUP AG (Düsseldorf)	https://www.gerchgroup.com/en/home
CORPUS SIREO Real Estate GmbH, Köln	https://www.corpussireo.com/en

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