
The Liberalisation of Electricity Markets in Germany

History, Development and Current Status

STUDY

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The Liberalisation of Electricity Markets in Germany – History, Development and Current Status

WRITTEN BY

Prof. Dr.-Ing. Konstantin Lenz
Professor for Energy Economics
University of Applied Sciences Erfurt
Konstantin.Lenz@fh-erfurt.de

Erfurt University of Applied Science
Altonaer Strasse 25 | 99085 Erfurt
T +49 (0)361 6700-0
F +49 (0)361 6700-703
<https://www.fh-erfurt.de>

Thorsten Lenck
Senior Associate
Agora Energiewende
Thorsten.Lenck@agora-energiewende.de

Frank Peter
Deputy Executive Director
and Head of Team Germany
Agora Energiewende
Frank.Peter@agora-energiewende.de

Agora Energiewende
Anna-Louisa-Karsch-Straße 2 | 10178 Berlin
T +49 (0)30 700 14 35-000
F +49 (0)30 700 14 35-129
www.agora-energiewende.de

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Dear reader,

Many countries are committed to liberalising their energy markets. Invariably, the guiding rationale is to foster competition amongst market participants, enhance the efficiency of the market and achieve lower end-consumer prices. Furthermore, highly competitive short-term markets are a central tool for integrating wind and solar energy. In 1996, Germany became one of the first countries to transform its energy system from a monopoly to a liberalised electricity market. Today, Germany's wholesale power market is well-functioning, liquid, and integrated with most neighbouring markets in Europe. Liberalisation has delivered cost-reductions, and the German power sector remains one of the most reliable in the world. All in all, liberalisation has been a great success.

Nevertheless, the process is complex. Even after more than three decades, liberalisation is still ongoing.

In this report, we shed some light on market liberalisation in Germany. This study seeks to provide an introduction while also highlighting some important topics and developments. Our aim is to offer a succinct overview of market liberalisation for non-experts and to help them find answers to questions they may have in their own countries. We hope we have been successful in this endeavour.

Enjoy the read!

Markus Steigenberger
International Director, Agora Energiewende

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1 The idea of liberalising electricity markets

Electricity is a uniform product, which means that it is always the same provided that it is supplied in accordance with voltage and frequency standards. Competition between several generators will lower wholesale costs more efficiently than price regulation is able to achieve in a non-competitive market.

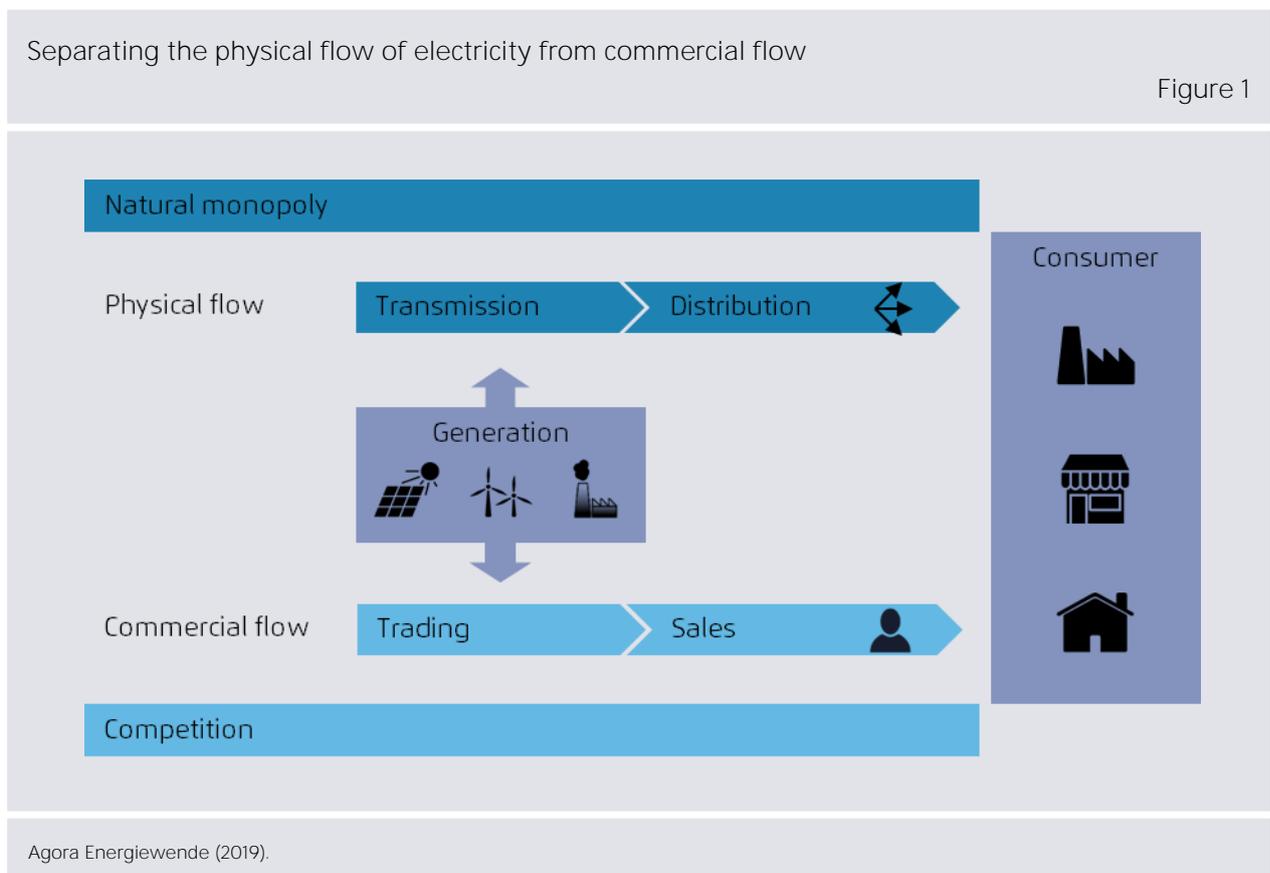
In addition, consumer prices are based on retail rates. Retail competition is an effective way to reduce costs for end-use customers. The delivery of electricity is tied to an electricity grid and is thus dependent on an existing infrastructure. Physically, electricity takes the shortest way to the consumer from the nearest generation facility. In a non-liberalised market, the nearest generator receives compensation for the electricity.

The basic idea of encouraging competition in the European single market was to separate the physical flow of electricity delivery from the commercial flow (Figure 1).

Without grid congestion, trading can take place on a copper plate, as it were. The physical electricity still comes to the consumer from the nearest generation facility – this is a physical law – but the consumer is able to choose his supplier freely, independent of location.

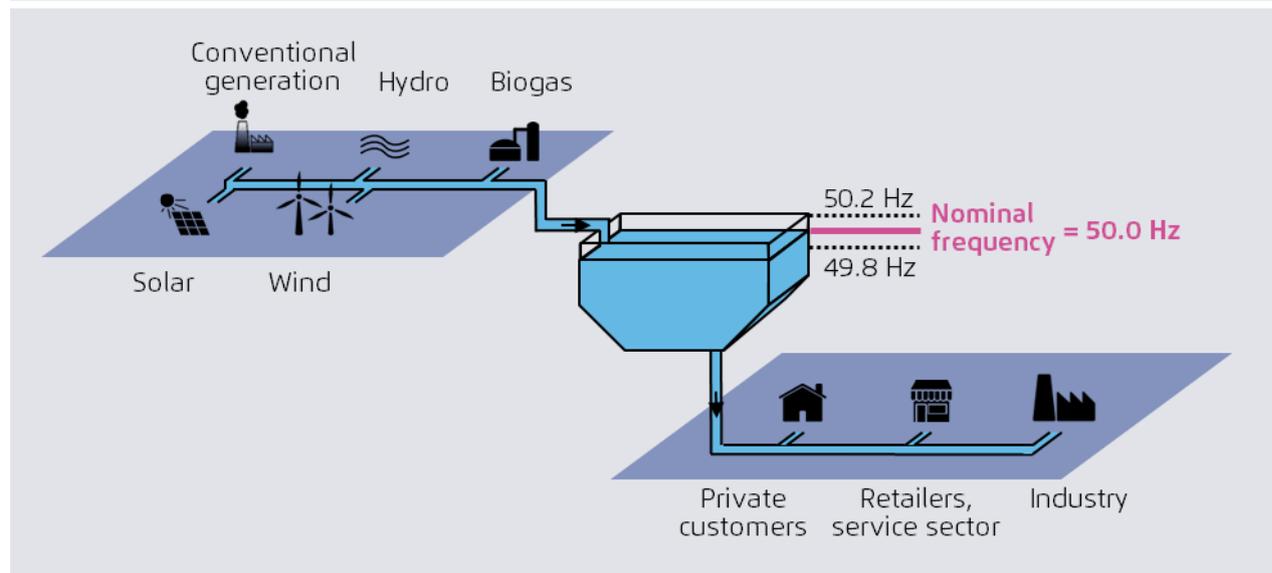
This separation of the physical and commercial flow of electricity creates competition for both generators and consumers.

The principle is comparable to a lake. The metaphor of an “electricity lake” is often used for electricity grids without congestion (Figure 2).



The "electricity lake"

Figure 2



Agora Energiewende (2019).

The electricity generators feed "water" into the lake; consumers withdraw it. It does not matter where the water enters or exits; it is only important that the

level of the lake remains constant. This means that every supplier fills as much electricity into the system as its customers withdraw.

2 The German electricity market before liberalisation

Before liberalisation, the German electricity market consisted of vertically integrated utilities with area monopolies. This system was based on the Energy Industry Act (*Energiewirtschaftsgesetz*, EnWG) from 1935, which remained in force until 1998. In Germany, the supply and retail business of electricity was regarded as a natural monopoly carried out by the following types of companies (Ströbele et al., 2012):

- vertically integrated big utilities with central power plants, transmission and distribution networks;
- vertically integrated but local utilities owned by municipalities or by the big utility companies. They owned the distribution networks, the retail

monopoly and some generation facilities, often CHP (combined heat and power) plants. Since cities often have advantageous conditions for centralized heat supply from CHP plants, they were able to compete with the electricity produced in large power plants.

- the German railway, with its track grid for supplying trains; and
- industrial and small auto producers producing electricity for their own use and feeding excess electricity into the public grid or taking excess electricity from the public grid.

Electricity consumers did not have the option of choosing their supplier. Retail rates were regulated, and utilities and consumers had to adjust to rate changes.

Area monopolists in 1997 and 2000

Figure 3



Agora Energiewende (2019).

Figure 3 shows the area monopolies of vertically integrated utilities in 1997. With German reunification in 1990, the electricity sector of the former German Democratic Republic was integrated into the newly founded Vereinigte Energiewerke AG (VEAG), and the electricity sector of East Berlin was added to the Berliner Städtische Elektrizitätswerke AG (BEWAG), which already supplied West Berlin.

There were a variety of corporate stakeholders for the area monopolists as well as stakeholders for local utilities, which in turn had municipal, i.e. state, shareholders.

As liberalisation began in the late 1990s, several mergers and acquisitions took place among the incumbents. Swedish Vattenfall acquired VEAG, BEWAG and HEW and formed Vattenfall Europe; Preussen Elektra and Bayernwerk merged to E.ON; EVS and Badenwerk formed EnBW; and

RWE and VEW merged and stayed with the name RWE. The result was that four utilities in Germany owned around 80 percent of the generation capacity. These four suppliers also owned the transmission grid in their areas and half of the end-user contracts.

Electricity from renewable energies such as hydro, wind and solar did not yet play a major role. Its share of electricity consumption at that time was still about five percent on average, based on hydro resources. However, a new law established the two cornerstones on which the increase of renewable electricity was based in the following decades. In 1990, the first Electricity Feed-In Act (Stromeinspeisungsgesetz) regulated the feed-in of renewable electricity. First, it required electricity utilities to permit electricity feed-in from renewable sources by third parties. Second, it obliged them to compensate producers with a regulated remuneration (flat volumetric fee).

3 Objectives of the liberalisation of European electricity markets

The liberalisation of European Electricity markets started formally four years after the foundation of the European Union (EU) in 1996. The first energy directive of the EU was implemented by Member States in 1998.

In one sense, the EU has direct legislative authority over the member states; in another, it merely establishes the framework while the member states have a certain degree of freedom to implement EU guidelines within their national legal framework.

Before that, all European electricity systems were operated as regional monopolies with integrated utilities. Vertical integrated utilities owning generation capacities and grids had regional or country-wide monopolies for supplying customers. Customers had no right to choose their supplier and were bound to regulated tariffs. State authorities were in charge of price control and had to approve prices. This

contradicted the EU's philosophy of creating free, competitive and effective markets throughout the member states and the sectors (Ortlieb, 2016).

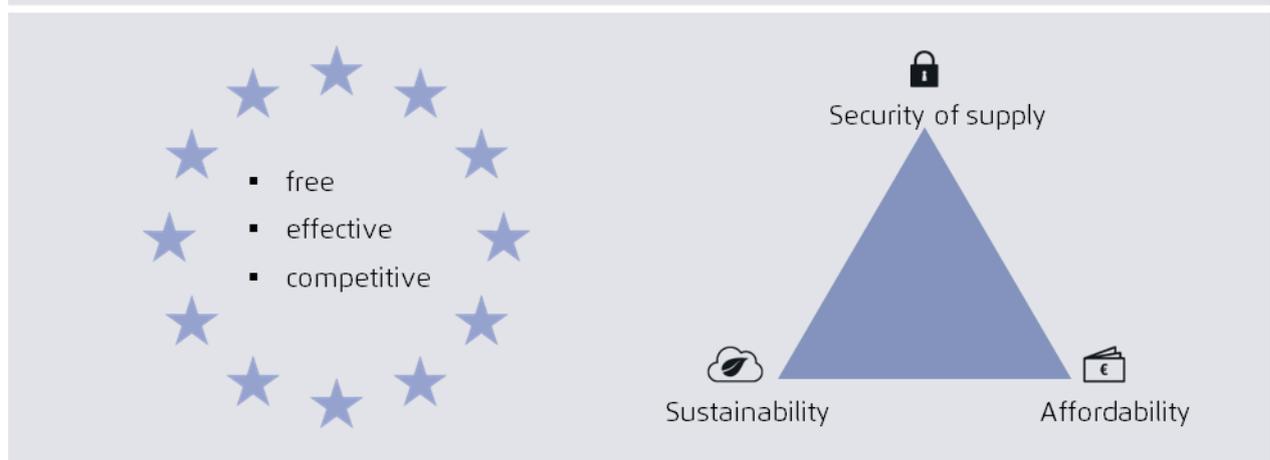
Security of supply, affordability and sustainability are the three targets of the energy policy triangle (Figure 4). Conflicts can arise between these achieving targets and compromises are therefore needed. For example, security of supply needs more investment in production and grid infrastructure, but improvements like these are expensive.

Electricity produced with wind and solar are climate friendly but their fluctuating character requires technological support for security of supply. Moreover, their high initial R&D costs required costly subsidisation. On the other hand, German lignite has low short-run marginal electricity generation costs¹ relative to other forms of thermal power generation and is available in large amounts as domestic fuel.

Lignite thus contributes to the security of supply, but it has the highest specific CO₂-emissions, releases

Target characteristics for the European single market and the energy policy triangle

Figure 4



Agora Energiewende (2019).

¹ This assumes no or low costs for CO₂ emissions, i.e., short-run marginal costs that ignore fixed cost items such as investment costs.

Investment expenditures are considered sunk costs and are thus not included in the calculation.

air pollutant emissions, impacts water resources and land use. Hence, lignite combustion is unsustainable from an environmental perspective.

The liberalisation of European electricity markets aimed “to build a more competitive, customer-centred, flexible and non-discriminatory EU electricity market with market-based supply prices” (Gouardères, 2019).

The legal framework established by the first EU energy package defined the roles and responsibilities of market participants and regulators and addressed the security of electricity supply and the development of European electricity grids. Customers' rights

such as freedom of choosing a supplier were strengthened and expanded.

Only the electricity grids remained in a regulated natural monopoly. Operating parallel infrastructures on a competitive basis would lead to higher costs for end consumers. To ensure non-discriminatory access to the network for all electricity generators and suppliers, it became necessary to unbundle the businesses with natural monopolies from those operating in competitive environments. This had significant consequences for vertical integrated utilities. Grid-related departments had to be separated from generation, trading and sales, all of which had to be in competition.

4 The legal framework for market liberalisation

4.1 The first step of liberalisation – the first EU Energy Package

The EU adopted three energy packages – in 1996, 2003 and 2009 (see Figure 5).²

The first energy package obliged member states to break up monopoly structures for electricity and gas supply and to replace them with competitive systems. Only the grid structures were exempted, which the European Commission saw as a natural monopoly. The member states were required to set up laws preventing grid owners from abusing their monopoly power and excluding third parties from the grid (Ortlieb, 2016).

The EU gave the legislative authorities of the member states a high degree of freedom when it came to implementing the guidelines at the national level. The member states were entrusted realising either negotiated or regulated grid access.

Regulated grid access is characterised by the implementation of a governmental regulation authority that supervises the natural monopoly of transmission and distribution grids. This authority is responsible for setting guidelines on the calculation of grid usage fees, the establishment of non-discriminatory grid access and on arbitration in disputes between market participants. Within this model, the legislator or the regulator sets the laws, rules and guidelines. That is to say, the government establishes the rules of the game.

Legal framework for the German electricity sector within the European single market

Figure 5

	Deregulation	Third-party access	Regulation	Unbundling of TSO/DSO	Grid development
§ First Act 1996/1998	Step-by-step (limited)	Negotiated, regulated or sole consumer	Every administration in charge	Accounting	
EnWG 1996/1998					
§ Second Act 2003	100%	Only regulated access	Independent national administration	Legal	
EnWG 2003/2005/2008					
§ Third Act 2009	Directive 2009/72/EC Directive 2009/73/EC	Regulation (EC) No. 713/2009 Regulation (EC) No. 714/2009 Regulation (EC) No. 715/2009	Coordination of administrations by ACER	Transmission system operators one unit	Ten-year grid development plans
EnWG 2011	ENTSO-E coordinate TSOs				

Agora Energiewende (2019) based on Ortlieb, B. (2016).

² The fourth energy package known as the Clean Energy for All Europeans Package advances the liberalised energy market. It was finally adopted in May 2019 as a major step towards completing the EU Energy Union. This package aims to establish a stable legal framework to facilitate a clean and fair energy transition for a carbon-neutral economy. The energy package primarily

comprises five elements: energy efficiency first, more renewables, a better governance of the Energy union, more consumer rights and a smarter and more efficient electricity market. These elements have far reaching implications for the power market design of the member states.

Negotiated grid access is characterised by a higher degree of freedom. The legislator provides only basic guidelines and leaves the organisation of market rules either to the negotiators of single grid usage contracts, or, as was initially taken in Germany, to market stakeholders such as grid operators, grid users and suppliers.

The first energy package also included unbundling requirements (see Figure 6), though they were quite limited compared with later legislation. Invoicing and accounting for grid operation in vertically integrated utilities were meant to be separated from competitive operations in generation, sales and trading. Grids had to be operated in specific ways without serving the interests of other business divisions. Moreover, cross-subsidisation between business units had to be eliminated.

4.2 The first steps of power system liberalisation in Germany

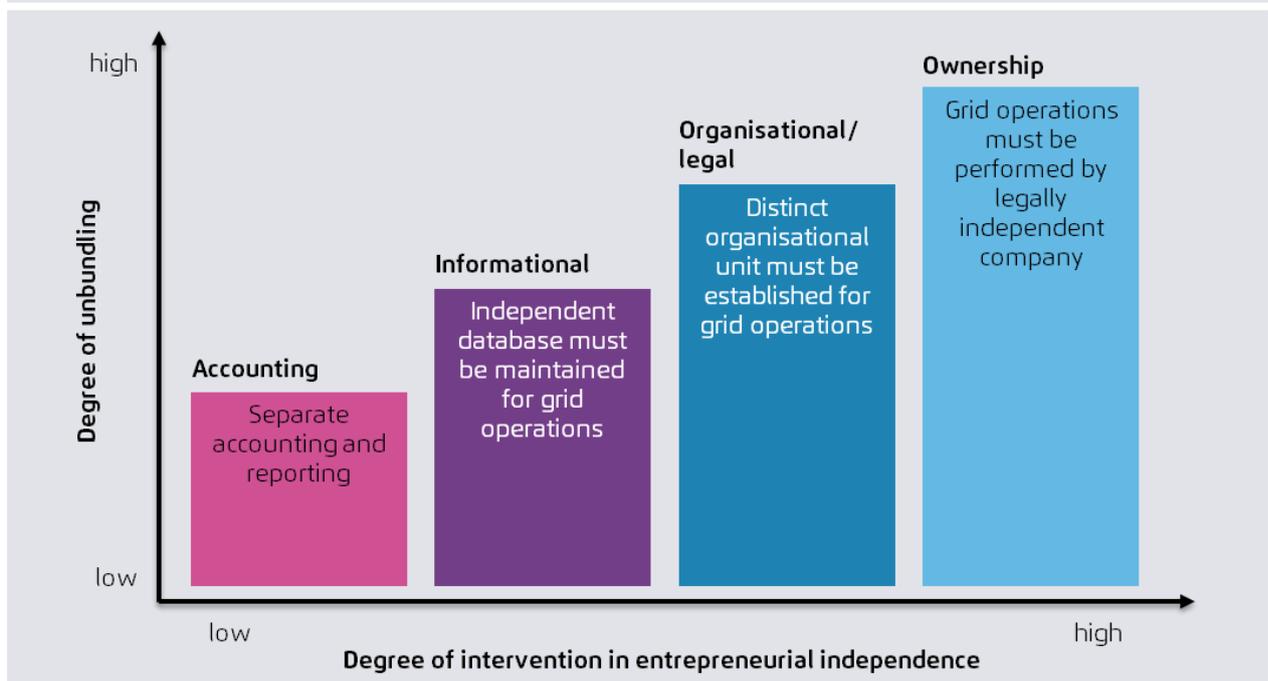
The reform of the Energy Industry Act (*Energiwirtschaftsgesetz, EnWG*) in 1998 incorporated the liberalisation of the electricity sector aimed at in the first EU energy package.

In 1998, former vertically integrated regional monopolies were limited to the grid. Generation and sales entered into competition with other companies, and customers finally had the right to choose their supplier. Notably, there was no transitional arrangement; competition in the electricity sector started immediately on 29 April 1998, the day the Energy Industry Act (EnWG) came into effect.

Germany was the only country in the EU to decide against a regulated approach and instead opted for negotiated grid access.

The four different tiers of unbundling

Figure 6



Agora Energiewende (2019).

The German Associations for Industry (BDI), the Association of the Electricity Industry (VDEW) and the German Association of Industrial Energy Users and Self-Generators (VIK) negotiated the conditions for the grid access in the first association agreement (Verbändevereinbarung I, VV I) in May 1998. This was followed by the second association agreement in December 1999 (VV II) and a third one in December 2001 (VV II+). The government and governmental organisations were not involved in these negotiations.

The first association agreement (VV I) established the concept of a negotiated grid access and of “point-to-point transit” (Bundesministerium für Wirtschaft und Arbeit, 2003). That means that transmission grid operators had to negotiate grid access for electricity transport from a generator located at point A to a consumer at point B. Competition on the wholesale market, not to mention the retail market, could not be achieved under these conditions (Bundesministerium für Wirtschaft und Arbeit, 2003). This brought about the second association agreement (VV II) in 1999. The VV II introduced the “access-point-principle,” whereby grid fees were paid to that grid operator and consumers received access to half of the German electricity market. An additional transmission fee was introduced only for north-south transport. But it was scarcely relevant for electricity withdrawal because electricity feed-in was free of charge. This was essential for establishing competition, especially for smaller consumers, and for setting up a B2C bulk business. VVII also introduced market rules for imbalances. Its assignment of balancing responsibilities and its balance-group system are still valid today (see Section 6.2 and 6.3) (Riemann, 2001).

The update of the association agreement (VV II+) in April 2002 further improved competition. It introduced comparison proceedings in order to assess grid usage fees and to make them comparable between network operators. As a result, wholesale

competition arose on the basis of two power exchanges. But retail competition was still difficult.

4.3 The second EU energy package

The EU's second energy package in 2003 continued the process of market liberalisation. It required the unbundling of utilities' grid operation, made regulated third party grid access obligatory and obliged the member states to introduce national regulatory authorities (Bundesministerium für Wirtschaft und Energie, 2016). The background for these changes was the fact that only Germany had decided for negotiated grid access. The EU Commission feared that the German solo attempt could interfere with cross-border electricity delivery and believed that the competitive energy markets were not sufficient in Germany (Ströbele et al., 2012).

The second energy package increased standards for legislation concerning unbundling in EU member states. For utilities with grids supplying more than 100,000 grid customers, legal unbundling became obligatory.

Legal unbundling means that the grid operation of a utility has to be transferred to a separate legal entity. These grid companies are independently responsible for all aspects of grid operation. The stake-holding utilities are only allowed to intervene to ensure that grid companies retain their basic ownership rights or to make decisions not affecting the grid operation (Ortlieb, 2016). The necessity of ownership unbundling was not defined by the second energy package (see Figure 5).

4.4 Consequences of the second EU energy package for German legislation

As a result of the second EU energy package, a major amendment of the German Energy Act was passed in 2005 (EnWG 2005), making its requirements national law.

The main changes of the EnWG 2005 were as follows (Wikipedia, 2019a):

- Regulated grid access replaced negotiated grid access. Rules, standards and contracts became standardised.
- The cost-plus regulation of networks was introduced. The legal framework for revenue regulation and "incentive-based regulation" were established. Standards for network fee calculation were set.
- The regulating authorities were entrusted with the supervision of the grid operators.
- Bigger utilities with more than 100,000 grid customers (electricity and gas separated) had to unbundle the grid from competitive operations (Eickhof, Holzer, 2006). Exemptions were provided for minor grid operators.
- Meter operation was liberalised. In general, the grid access point owner was allowed to choose the meter device operator freely. (Later this applied to the grid access point user as well.) Previously, this service was tied to the local distribution grid operator.

4.5 The regulating authorities

In 2005, the Federal Network Agency (*Bundesnetzagentur*) became the regulator for the German Electricity market. As such, it serves as the German regulatory office for electricity, gas, telecommunications, post and railway markets and the federal government agency of the German Federal Ministry of Economics and Technology. It is headquartered in Bonn, Germany.

The Federal Network Agency describes its role as follows (Bundesnetzagentur, 2019):

The purpose of regulation is to establish fair and effective competition in the supply of electricity and gas. The responsibilities of the Federal Network Agency therefore include ensuring non-discriminatory third-party access to networks and policing the use-of-system charges levied by market players. It is the Federal Grid Agency's central task to create the prerequisites for functioning competition on the upstream and downstream markets by unbundling

and regulating the power and gas supply grids. The regulatory task of the Bundesnetzagentur covers ensuring non-discriminatory network access and the control of the network usage rates levied by the power supply companies. The Federal Network Agency's range of tasks also includes the supervision of anti-competitive practices and the monitoring of the regulations concerning the unbundling of network areas and the system responsibility of the supply network operators.

The Agency is not responsible for licensing energy companies. These tasks remain with authorities determined by State law. Grid areas with less than 100,000 connected customers and which do not cross the borders of German states are supervised by the regulation offices of the different German states.

An examination of end-customer prices does not fall into the Federal Grid Agency's sphere of responsibility. Objections to excessive rates for end customers will continue to be dealt with by the federal states or by the civil courts. The Federal Cartel Office (Bundeskartellamt) is responsible for verification in the case of the energy prices levied by energy suppliers operating on a nationwide basis.

The Federal Cartel Office (*Bundeskartellamt*), which has existed since 1958, describes its role as follows (Bundeskartellamt, 2019):

The Federal Cartel Office protects competition on markets that are upstream and downstream of the energy networks. These markets cover in particular the generation, trading and supply of energy to end customers. It intervenes in the areas of merger control, cartel and abuse proceedings and carries out corresponding sector inquiries.

Together with the Federal Network Agency the Federal Cartel Office monitors developments in the electricity and gas markets (Energy Monitoring). The Federal Cartel Office monitors in particular the degree of transparency, including that of wholesale

prices, and the degree and effectiveness of liberalisation as well as the extent of competition on the wholesale and retail levels and on the energy exchanges. The results of their monitoring activities are published by the Federal Network Agency and the Federal Cartel Office in an annual report.

In the future the Federal Cartel Office and the Federal Network Agency will monitor the electricity and gas wholesale markets within a joint Market Transparency Unit. The continuous monitoring of the trading sector shall ensure that electricity and gas wholesale prices are set by competition.

4.6 Finalising the liberalisation in the third EU energy package

The third EU energy package, introduced in 2009, expanded the legislative framework for an internal European Energy Market harmonisation between member states, and bestowed additional legislative power on EU authorities. The third energy package consists of the following key measures:

- It established the European Agency for the Cooperation of Energy Regulators (ACER) in Ljubljana, Slovenia. Operational since March 2011, ACER is mainly responsible for coordinating the activities of the national regulatory authorities at the regional and European levels. It monitors the development of the network and the internal electricity and gas markets. It also has the authority to investigate cases of market abuse and to coordinate the application of appropriate penalties with the EU member states. The responsibility for applying infringement-related sanctions lies in the hands of the member states (Gouardères, 2019).
- The third energy package gave member states the option of choosing between three unbundling options for Transmission System Operators (TSO):
- Full Ownership Unbundling: Full ownership unbundling would force integrated energy companies to sell off their gas and electricity grids and establish separate transmission system operators for handling all network operations. A supply and

production company may not hold a majority share in a transmission system operator.

- Independent System Operator (ISO): This option allows energy companies to retain ownership of their grids. Member States could, for example, oblige companies to hand over the operation of their grid to a designated separate unit known as the independent system operator.
- Independent Transmission Operator (ITO): This option preserves integrated supply and transmission companies but compels them to abide by certain rules to ensure that the two divisions operate independently.

The third energy package also contained regulations concerning:

- a default tariff for consumers,
- improved consumer rights and
- protecting vulnerable consumers.

4.7 Finalising today's structure of liberalisation in Germany

The Energy Industry Act 2011 was the last major amendment converting the requirements of the third EU energy package into German law (Schoon, Stolzenburg, 2011). The recently adopted Clean Energy for All Europeans package is the fourth EU energy package. It brought about the following changes:

- It requires grid operators with more than 100,000 grid customers to introduce separate branding, independently of the utility that owns the grid. This prevents the conflation of the grid operating company with a vertically integrated utility.
- The package introduces additional regulations for unbundling.
- It contains the first regulation governing intelligent measuring devices and smart meters. As a result, electricity consumers in Germany who use more than 6,000 kilowatt hours per year as well

- as new customers are to receive an intelligent measuring device.
- Clean Energy for All Europeans makes yearly updates of TSO grid development planning obligatory.
 - It introduces a mediation board.
 - It requires the institution of resource adequacy procedures.
 - It establishes the cross-border procurement of reserves.
 - The package implements the use of interconnection capacity.

It requires jointly operated transmission systems, reserves, redispatch, common webpages, etc. (based on member state law only.)

4.8 Further development of European and German legislation

The third EU energy package and the Energy Industry Act from 2011 established the key elements of electricity market liberalisation in the EU and in Germany. Though these basic principles are still in effect, the regulatory framework of the electricity market is constantly evolving. Hundreds of new laws, ordinances and regulations have since shaped the competition framework for the electricity and gas markets.

5 Replacing Monopoly Structures and Today's Players in the German Electricity Market

With the liberalisation of the electricity market the roles and tasks of market players changed more or less completely. Vertically integrated area monopolists unbundled their transmission grid operation, and three of four German TSOs were sold to other investors. Local utilities unbundled their grid operations and transferred these activities to a dedicated subsidiary. Generation and sales activities were transformed as they became the centrepiece of new companies that competed with one another. These new companies now focused on optimising production and administration costs while also seeking to acquire and retain customers.

New players with new roles were also established. Exchanges emerged for the wholesale trading of electricity, giving rise to new companies that engaged solely in energy trading and which did not possess generation assets. The revised legal framework also allowed for independent power producers, especially in the renewables sector, to feed electricity into the grid and market it themselves or through direct marketers.

In the first years after liberalisation, the established players, especially the former area monopolists, used their market power to delay third party market entry and thus prevent competition. They did this to maintain their established business models and revenues. New competitors were held at bay through strategic pricing that were subsidised by profits earned on grid operations, which are regulated monopolies and provide high margins. In some cases, the prices offered by the established utilities to end consumers generated negative profits following deduction of published grid fees, taxes and levies.

Another hurdle, especially for new players in the market, was the difficulty hiring qualified personnel. These companies were operating in a completely

Newcomer "Kom-Strom" – a case study

In 1998, at the beginning of liberalisation, several local utilities in Germany started a new company called Kom-Strom, which acted as a portfolio management company and as an energy supplier, acquiring electricity from the wholesale market. However, the company had limited success in its initial years of business, as it was not able to compete with the established utilities in terms of price. However, one product offered by the company did take off: education courses in energy portfolio management, especially for local utilities. With this newly gained knowledge, local utilities were in a much better position to trade competitively in the wholesale market and also frequently used Kom-Strom as a service provider.

new field of business, so there were few people with the right education or experience. The liberalised energy business required a mixture of expertise in engineering and economics. Traditional engineers tended to work in "real" technical fields, while economists often lacked the technical background needed to understand the physical needs of the market.

5.1 Transmission System Operators (TSOs)

The third EU Energy Package and the 2011 Energy Industry Act stiffened requirements regarding the independence of TSOs. One new requirement was a name and brand identity to distinguish TSOs from their parent companies. This triggered the sale of three of the four German TSOs (see Figure 7). The transmission grid of E.ON (E.ON Netz) was sold to the Dutch TSO Tennet and became Tennet TSO. Vattenfall's transmission grid, 50Hertz Transmission, was sold to the Belgian TSO Elia and an Australian investment fund. More recently, RWE transferred its transmission grid to Amprion and sold a 74.9 per cent stake to an investment fund run by Commerzbank. As in most places in Europe, the owner of the transmission grid now operates the system itself.

The activities performed by the TSOs are essential for the operation of the power system. In addition to maintaining the transmission grid, their core responsibility is to keep the grid stable and to coordinate the use and tendering of control and balancing energy in order to preserve grid frequency at 50 Hertz. The TSOs are also responsible for the coordination of balancing groups.

5.2 Distribution System Operators (DSOs)

According to (Bundesnetzagentur, Bundeskartellamt, 2019) the Federal Network Agency, there were 890 distribution system operators in Germany in 2018. Their core activity is to maintain and monitor distribution grids. In addition, they assign consumption points to balancing groups and invoice grid usage fees. The TSOs only invoice customers who are directly connected to the transmission grid, including distribution grids. Through this mechanism, all

customers connected to the distribution grid pay a share of transmission costs.

The distribution system operators were also unbundled, provided they had more than 100,000 consumers. Unbundling necessitated the establishment of a separate grid company with a unique brand identity.

5.3 Suppliers with their own generation assets
As a result of liberalisation, the former area monopolists and local utilities had to unbundle their grid operation from their supply and sales activities. Most of them separated generation, trading and sales into different profit centres; larger companies even frequently established separate legal entities for this purpose. Under these lines of separation, the sales department (or sales company) acquires the electricity from the trading department (or company) and generates profits through a margin on end customer

Transmission system operators (TSOs) in 2000 and today

Figure 7



Agora Energiewende (2019).

sales. The sales departments (or sales companies) are thus in price competition with each other.

The generation department (or company) sells the electricity to the trading department (company) on a cost-plus basis. It competes with other providers of energy based on price. The trading department (or company) buys electricity either from the generation department or from the wholesale market, and sells it either to the wholesale market or to the sales department. It generates profits by optimising its portfolio and earning a margin on transactions. Under this division of activities, the individual stages of the value chain are geared to the market price. Opaque, inefficient and market-distorting cross-subsidisation is thus avoided. Furthermore, there are incentives to optimise each stage of the value creation chain.

The foregoing discussion focused on how departments typically collaborate within a supplier's organisational structure. However, different forms of collaboration are possible, especially within smaller utilities.

Running an in-house trading operation is costly (in terms of salaries, trading systems and marketplace access). Accordingly, a certain volume of transactions is needed to cover these fixed costs. As in-house trading is often not feasible for smaller utilities, they often outsource often these activities to independent portfolio management companies or the trading floors of larger utilities. Another option is for several smaller utilities to band together and start a trading service company.

5.4 Exchanges and brokers

There are three avenues for the trading of electricity:

- Trading cleared through an exchange,
- OTC trading through a brokerage platform, or
- Direct OTC trading.

Following liberalisation, the Leipzig Power Exchange (LPX) and European Energy Exchange (EEX) were soon merged to form the EEX, located in Leipzig.

Together with the French exchange Powernext, the spot market was later moved to the EPEX Spot, based in Paris. In Europe, there are also other exchanges where German power products can be traded (NASDAQ Commodities Europe, Nord Pool, Energy Exchange Austria, and ICE Futures Europe).

Several brokerage platforms are active in Germany; most of them are based in London and cover the European market.

5.5 Retailers without own generation asset

Following liberalisation, numerous suppliers without in-house generation assets were founded. They purchase their electricity exclusively on the wholesale market (exchange or OTC) and try to acquire market share through competitive prices or innovative products.

5.6 Independent power producers of renewable electricity

The German Renewable Energy Act (EEG), passed in 2000, and the Combined Heat and Power Act (KWKG), passed in 2002, led to a large increase in the number of small, independent power producers. These small-scale producers operate wind turbines, solar panels, biomass systems and/or small CHP plants. They have three options for marketing their electricity:

- They can receive subsidies directly through the feed-in tariff system and receive payment from the EEG-account administrated by the TSOs,
- They can market their electricity within the market premium model, either themselves or via a direct marketer, or
- They can sell their electricity directly to a utility or consumer covered by a Power Purchase Agreement (PPA).

5.7 Other independent power producers

Independent power producers without a customer base also have several options for marketing their electricity:

- Via exchanges, brokerage platforms or direct OTC sales, as scheduled or standard products, or
- Using a direct delivery contract to an end consumer or supplier.

5.8 Consumers

There are a large variety of electricity consumers in Germany, from small household consumers to large industrial enterprises with several terawatt hours of annual consumption. Smaller customers have usually full supply contracts with a fixed price per kWh, while larger consumers often engage in structured portfolio management, usually in cooperation with a utility company.

In the initial years of liberalisation, end consumer prices fell, but taxes and levies on electricity increased, offsetting this price decline. Today, household electricity prices are nearly twice as high as before liberalisation, but less than 50 per cent of this increase is related to increased procurement, transport or measurement costs; the majority is attributable to higher government taxes and levies.

In an effort to tap the benefits of increased competition, liberalisation strengthened the right of the consumer to switch suppliers. To ensure continuity of service in the event of supplier switch or the bankruptcy of a given supplier, a default supplier

(*Grundversorger*) is obligated to continue service within a given concession zone.

5.9 Service providers and consultants

With the establishment of a liberalised power sector, a new ecosystem of companies has sprung into being, including consultancies that offer project management services and specialised expertise; news providers that cover market activity; software companies that furnish new IT solutions; and portfolio management companies that manage assets and perform trading on behalf of smaller utilities.

5.10 The legislator

The legislator is an important player in the liberalised energy market. Due to the economic and political importance of the power sector, in combination with the German embrace of state-guided industrial policy, legislatures regularly amend existing laws and regulations. New regulations are often passed to address unwelcome developments triggered by previous regulatory intervention.

This constantly changing regulatory landscape is a clear challenge for market participants, particularly small-scale actors, who struggle to stay abreast of new developments and their legal implications.

6 The function of the liberalised electricity market

6.1 Special characteristics of the electricity market

As a commodity, electricity is fundamentally different from oil or coal. Most importantly, electricity must be transported through the electrical grid, but the grid is unable to store surplus energy, meaning that supply and demand always have to be in balance. Furthermore, all electricity, regardless of its source, is of the same quality. These particularities must be taken into account when designing liberalised electricity markets.

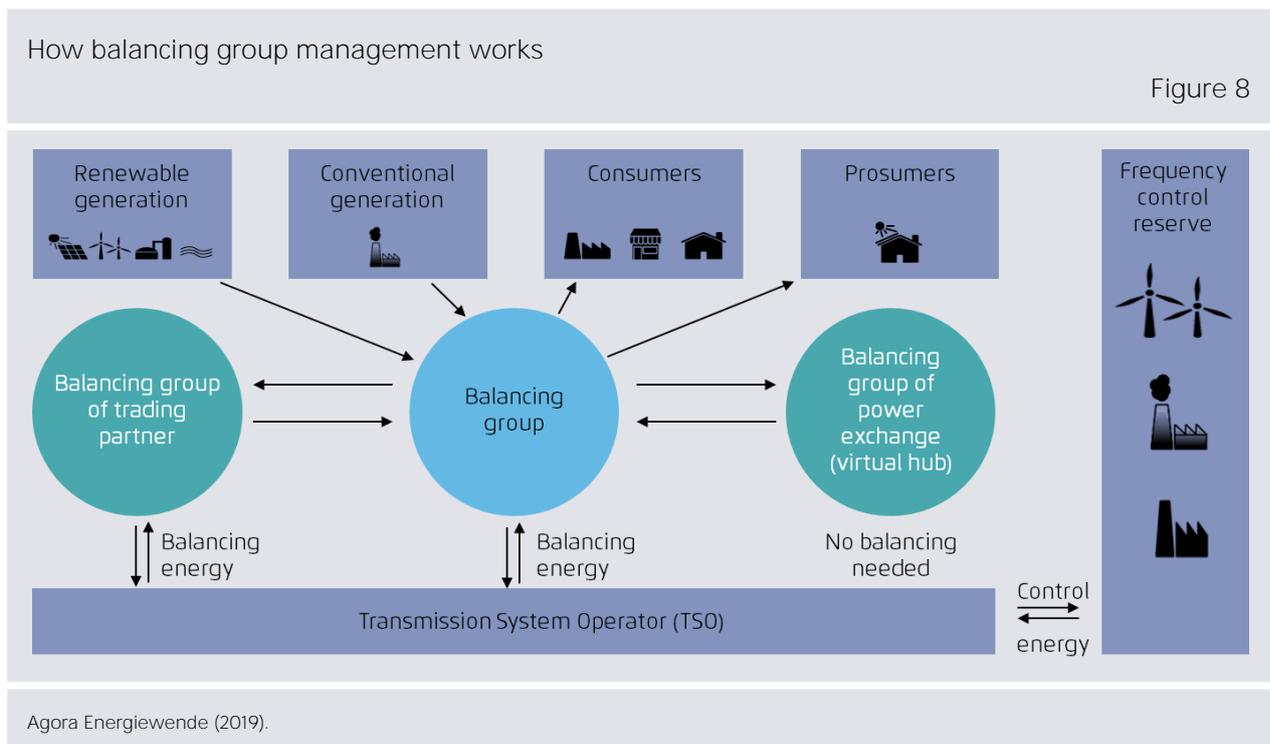
6.2 Balancing group management

The Second Association Agreement (VV II) of 1999 introduced the balancing group system as an essential feature of the new power market. Every consumer or producer of electricity in Germany is assigned to a balancing group, which is akin to an account for electricity (see Figure 8). Each electricity

supplier has a balancing group for its customers, which is based on a contract with the TSO responsible for the area in which consumers are located. If a supplier has consumers in all four German TSO areas, then it needs to operate in four balancing groups – one in each TSO area. In contrast to a centralised power system, the VV II introduced a decentralised system for balancing grid energy.

The TSO is obliged to sign a balancing group agreement with every interested party in order to allow non-discriminatory access to the electricity grid.

The balancing group system also takes electricity trading into account. Traded electricity is transferred from the balancing group of the seller to the balancing group of the buyer. However, the physical exchanges have their own balancing group in order to guarantee the anonymity of transactions. The seller delivers the sold electricity to the balancing group of the exchange and from there it is delivered to the balance group of the buyer.



6.3 Scheduling and balancing

Every balancing group operator has to inform the responsible TSO in advance about inflows and outflows of energy in its balancing group. To this end, the balancing group operator has to submit by 2:30 pm on a given day a schedule for the following day that details the expected electricity feed-ins and withdrawals with a resolution of 15 minutes. However, the balancing group operator may change the schedule up to 5 minutes before a scheduled hour. The ability to adjust the timetable at short notice is particularly important for successfully integrating variable renewable energy such as wind and photovoltaics.

This schedule contains all information about planned production and consumption in the balancing group as well as deliveries to and from other balancing groups. This information is then crosschecked by the TSO by comparing the schedules submitted by other balancing groups.

The schedule has a 15-minute resolution and for every quarter hour the sum of all inflows and production has to be equal to all outflows and consumption. This obligation, which also applies to variable renewables, is one of the core principles for ensuring security of supply and frequency stability.

Since there are usually deviations between scheduled and realised consumption and production, there is a need for balancing energy. This balancing energy is taken or delivered by the respective TSO into the balancing group. The price for that balancing energy depends on the status of the control area and the actual costs borne by the TSO.

The prices for balancing energy have a 15 minute resolution and are generally published within six weeks following a given month and subsequently invoiced by the TSO.

In late 2008, three of the four German TSOs agreed to coordinate their balancing energy activities in the

grid balancing network (Netzregelverbund) in order to improve efficiency, following legal protest by market participants. In 2010, Amprion, the fourth TSO, also joined this network. As a consequence, balancing energy prices are now the same in all four TSO areas in every 15-minute period.

6.4 Electricity trading

The trading of electricity in a wholesale market is another core aspect of a liberalised electricity market. Market participants can essentially take one of four roles in this market.

1. Buyer

The buyer goes to market to purchase a good – and seeks the lowest possible price.

2. Seller

The seller goes to market to sell a good – and seeks the highest possible price.

3. Speculator

The speculator goes to market to buy a good as cheaply as possible in order to sell it later at a higher price. If short selling is allowed, the speculator can also first sell a (virtual) good at a high price in order to buy it back later at a lower price. In both cases, the price difference between sale and purchase is the speculator's profit, which the speculator tries to maximise.

The speculator is therefore interested in low prices at the time of purchase, but high prices at the time of sale. For this reason, speculators can drive prices in both directions – up and down. The speculator alone bears the risk that the price difference between selling and buying is negative and that he might make losses on the transaction.

Usually speculators have no original physical interest in the speculative good. Furthermore, the fact that the balancing group must be balanced means that speculation in electricity

trading is limited. In derivative trading – i.e. purely financial transactions – there are no such inherent limits. Speculators provide additional liquidity to the market, which makes it easier for other market participants to find a trading partner.

4. Arbitrageurs

Similar to speculators, the arbitrageur seeks to make a profit from the purchase and sale of a good. In contrast to the speculator, the arbitrageur is by definition interested in low-risk transactions. By buying a product at a low price in one marketplace and selling the same good in another marketplace at the same time at a higher price, the arbitrageur can earn a risk-free profit (local arbitrage).

For goods that are delivered continuously over a longer period of time, such as electricity, temporal arbitrage is possible by, for example, buying an annual delivery commitment at a low

price and selling the individual quarterly delivery commitments at a higher total price.

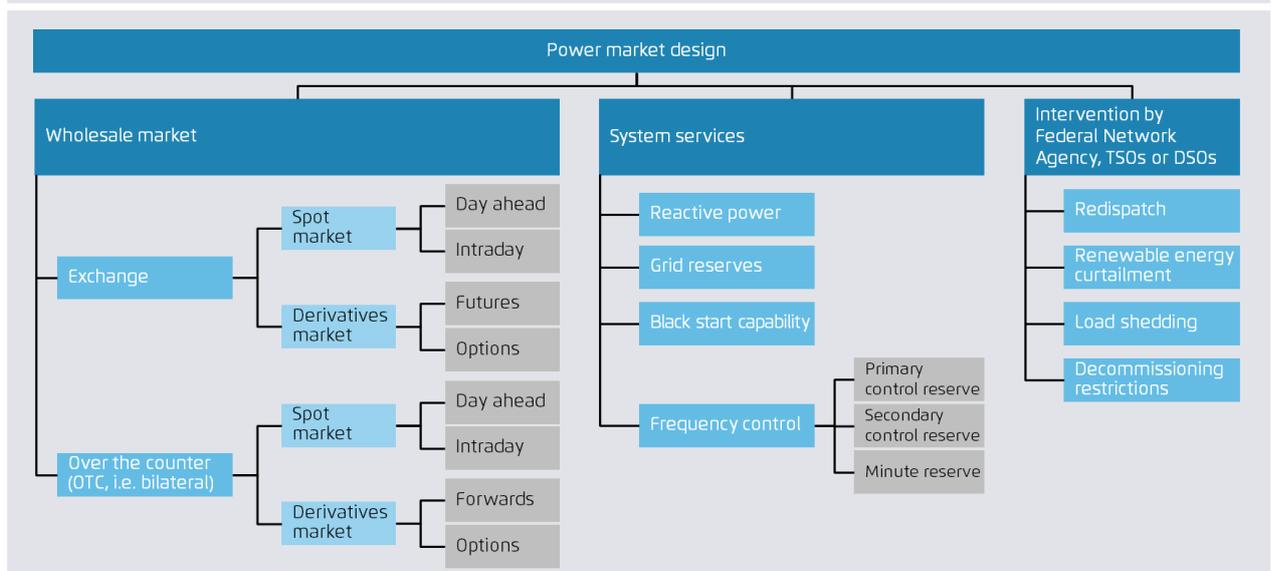
Arbitrageurs thus ensure through their trading activity that the prices for one and the same good are aligned between marketplaces (local arbitrage) and between different delivery periods (temporal arbitrage).

In general, the activity of market participants can be assigned to one of these four roles. However, some market participants can assume multiple roles at the same time.

Electricity trading can be performed through an exchange or over-the-counter (OTC), either directly or using a brokerage platform (see Figure 9). Depending on the time horizon of the traded electricity contracts, power trading is divided into spot and derivatives trading. Spot trading entails delivery no later than two days after trading.

Electricity market design in Germany

Figure 9



Agora Energiewende (2019) based on Next Kraftwerke (2019).

Physical spot trading takes place on the intraday market (for the same day) or on the day-ahead market. In the intraday market there is continuous trading of hours and quarter-hours up to 5 minutes before an hour starts. Trading for the day starts at 3:00 pm the day before.

At the EPEX Spot exchange, intraday trading started in 2006 but did not reach a significant level until the introduction of the market premium model in 2012. With the 2018 launch of the Cross-Border Intraday Market Project (XBID) – a collaborative exchange that covers eleven European countries – there is a common intraday order book and uniform price across numerous countries, which increases competition between exchanges.

Originally established in 2000, the day-ahead market uses an auction system. Participants place their orders for single hours or for blocks, e.g. base (0–24h)

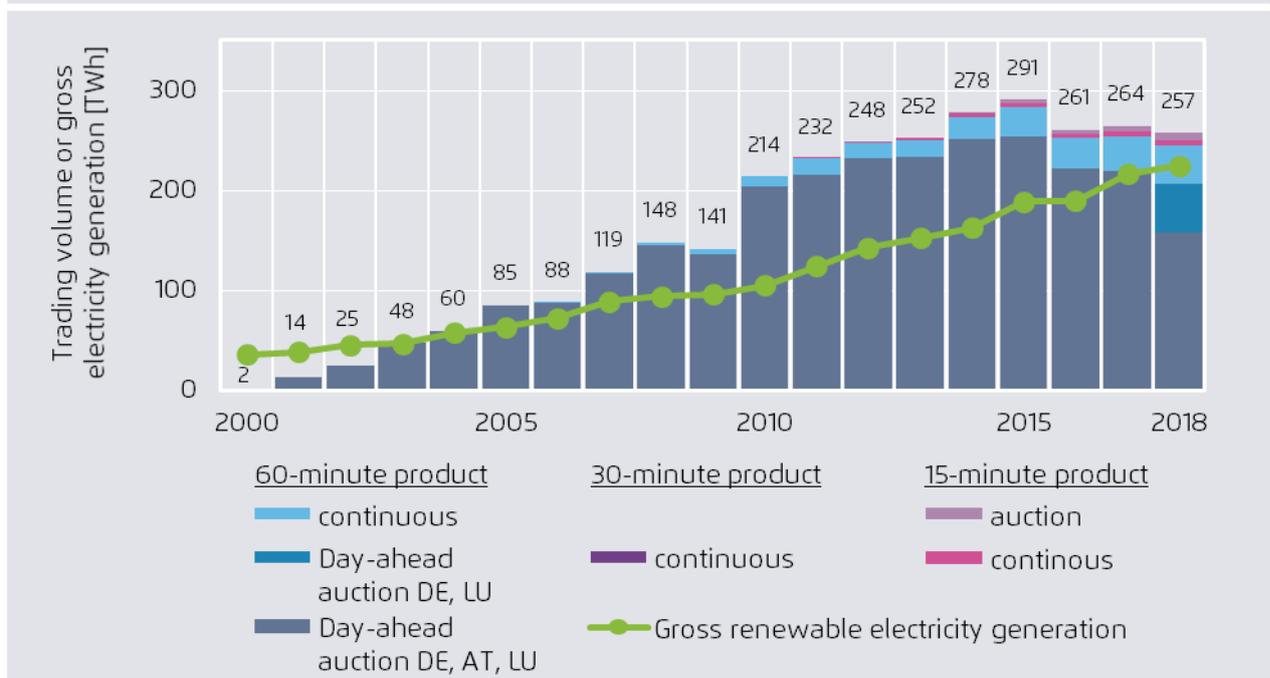
or peak (8–20h), by noon on the preceding day. The day-ahead market is the most important platform for spot trading in Germany. Nearly half of German consumption is traded on this market. The intraday market is smaller, accounting for nearly ten per cent of consumption (see Figure 10).

Based on the bid and ask orders logged in the system, the exchange calculates a supply and demand curve and, by extension, a market clearing price for every single hour. All electricity is then traded at that market clearing price (using marginal or uniform pricing). The purchased electricity is then delivered from the balancing group of the exchange to the balancing groups of the purchasing companies (see Figure 8).

The derivatives market in Germany is split into an OTC and an exchange market. In the OTC market physical forwards are traded, either directly or via brokers. Energy futures are also traded through

Traded volumes on EPEX Spot in Germany

Figure 10



Agora Energiewende (2019).

normal exchanges, where they can be redeemed for physical delivery. In both the OTC and exchange markets, continuous trading takes place; bids and offers are reconciled on an ongoing basis.

While the market actors registered with an exchange trade anonymously, the corresponding volumes and prices are published. The clearing of transactions is performed by the exchange's clearing house, which also covers counterparty risk. The exchanges are supervised by government authorities.

OTC trading is not performed anonymously, and usually necessitates a framework contract that is backed by credit lines and guarantees. The trading partners organise the clearing and assume the counterparty risk.

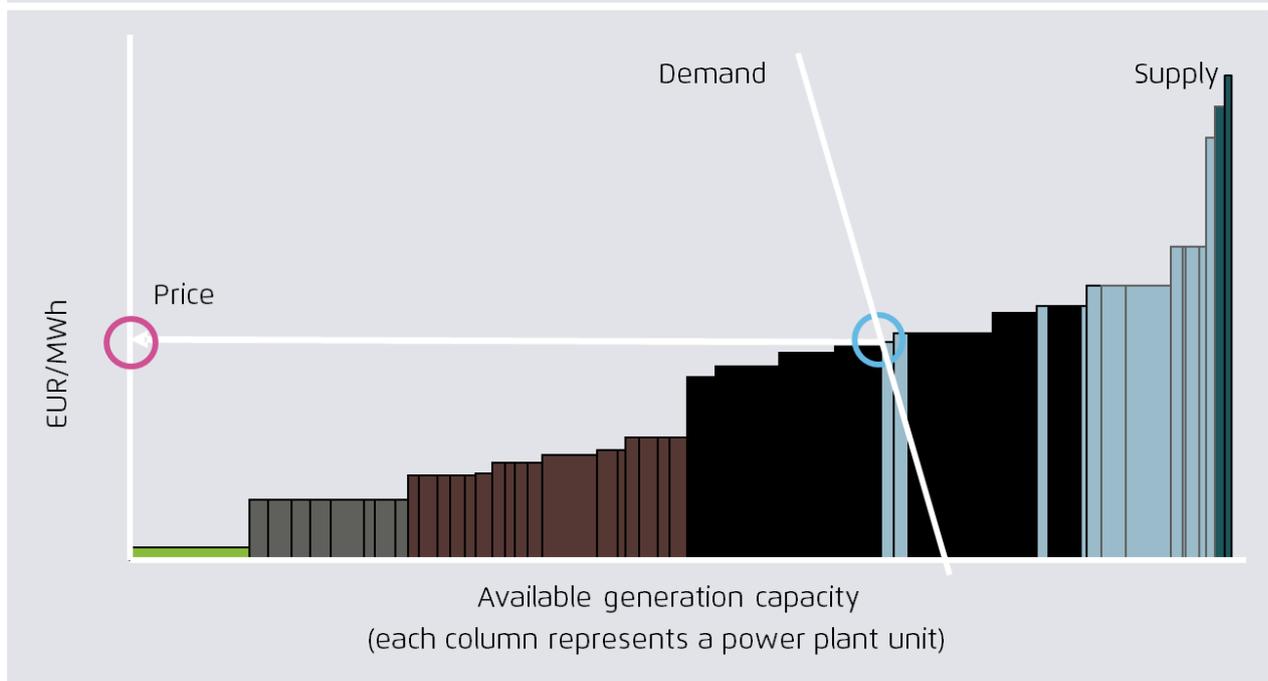
Price formation is based on supply and demand. On the supply side, available power is ranked based on

the merit order curve (see Figure 11), which sorts the power plants by their short-run marginal costs (SRMC). Cycling prices are also taken into consideration. The market price is determined based on where the demand curve, which is rather inelastic, bisects the supply curve. The SRMC of the last power plant required to cover the demand sets the price.

In an auction system, suppliers have an incentive to bid low and buyers have an incentive to ask high, as this increases the likelihood of a transaction taking place. The principle of uniform or marginal pricing encourages cost-optimised dispatch, because market participants have an incentive to offer power based on their marginal production costs. If a price premium is demanded, the supplier runs the risk of not finding a buyer, assuming there is a competitive market.

Merit order principle (illustrative)

Figure 11



Agora Energiewende (2019).

A unique feature of power markets is the possibility of negative prices. If electricity prices are negative, the seller must not only supply the electricity, but also pay the buyer for the purchase of the electricity. For the seller, this can make economic sense if the cost of non-transaction would be even higher, e.g. because switching off and restarting the power plant would be even more expensive.

In Germany, negative electricity prices were introduced in 2008 with the aim of creating stronger incentives to reduce production when available supply is excessive. This occurs most frequently when wind and solar generation is high and electricity demand is low, e.g. during weekends and holidays. In 2018, there were 134 hours with negative day-ahead prices.

6.5 Electricity market segments and prices

Although electricity can already be traded years before delivery, thus fixing the quantity, price and delivery period well in advance, the different price segments of the electricity market can best be understood by looking first at the moment of delivery and going backwards in time (see Figure 12).

6.5.1 Balancing market

The balancing group system obliges suppliers to balance feed-in quantities in their balancing group and offtakes from their balancing group in each quarter hour. If this balancing is not possible (for example, due to unplanned fluctuations in electricity generation, such as technical malfunctions or fluctuations in consumption) the balancing group manager is charged for balancing energy by the TSO. In this way, the TSOs pass on the costs for control energy to the balancing group managers who caused the control energy demand.

Because balancing energy prices fluctuate over a wide range, from negative tens of thousands of euros to plus tens of thousands of euros per megawatt hour, the balancing group managers have a high balancing energy price risk. Aside from the balancing

obligation arising from their contract with the TSO, they have an interest in balancing out the balancing group in order to minimise this risk.

6.5.2 Intraday market

If balancing group deviations occur shortly before delivery, balancing group managers can try to balance the balancing group out by buying or selling electricity on the short-term spot market, the so-called intraday market. Trading transactions within a control area are currently possible up to 5 minutes before delivery. This so-called lead time has been gradually shortened – not least in order to enable balancing group managers with short-term fluctuations in renewables generation to avoid balancing group deviations. Just a few years ago, the lead time was more than one hour.

Because balancing groups are balanced in quarters of an hour, the smallest tradable delivery period in the intraday market is also the quarter hour. What all exchange products have in common is that electricity is always supplied with a constant output over the delivery period. The delivery capacity of many exchange products is one megawatt, so that one megawatt hour is delivered for an hour.

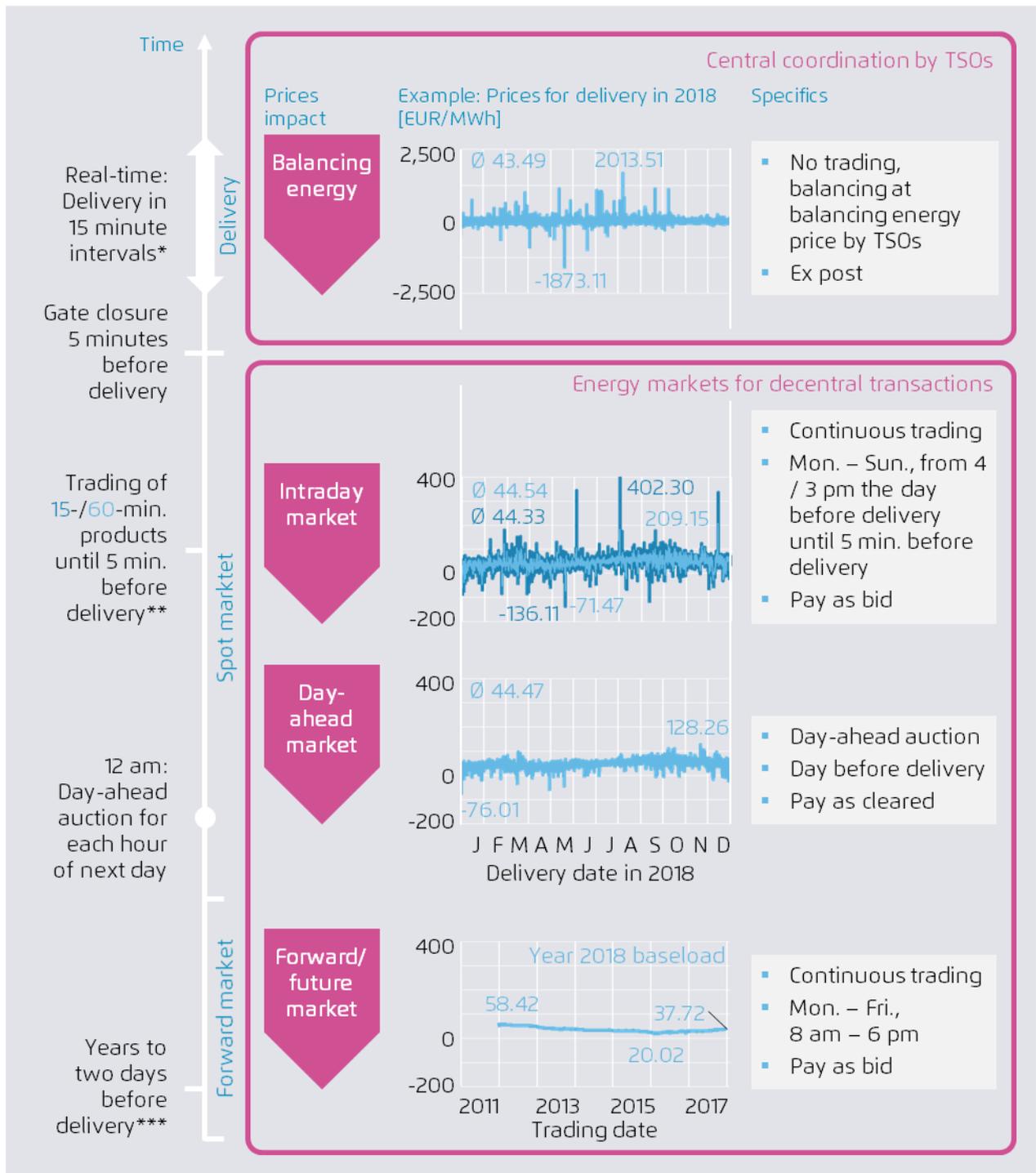
In addition to 15-minute delivery periods, 30 and 60-minute delivery periods are traded. Intraday trading on EPEX Spot starts the day before at 3 pm. Intraday prices can be several thousands of euros, positive or negative, per megawatt-hour. In continuous intraday trading on EPEX Spot, the technical price limits are +/- 9,9999.90 euros per megawatt hour.

6.5.3 Day-ahead market

Of the various spot markets, the day-ahead market is still the most liquid market segment. Most deviations from longer-term planning are traded here. On EPEX Spot, a two-sided auction with a closed order book and pay-as-cleared pricing mechanism takes place daily at 12 noon for the 24 delivery hours during the following day.

Sequence of market segments and price impact on the German electricity market

Figure 12



* Imbalance penalties incentivise market actors to match their generation/consumption as close as possible to their previous market trades
 ** ID3: Weighted average price of the last three hours prior to delivery *** Year Future Base 2018: Constant delivery of 1 MW
 EPEX Spot (2019), EEX (2019), Agora Energiewende (2019).

The market clearing price that applies to all executed bids is determined by the intersection of the supply and demand curves, sorted by price. This auction design is intended to encourage the market participants to offer their actual short-term marginal costs, as only the bids below and offers above the market clearing price win the auction.

Because the market premium, i.e. level of government subsidy for renewables, is measured on the day-ahead market, most electricity volumes from renewable sources are traded here. With increasing volumes of electricity that qualify for subsidy under the EEG's market premium model, the trading volume in this market segment is also rising.

The technical price limits in the day-ahead auction are minus 500 euros and plus 3,000 euros per megawatt hour. In recent years, prices have typically ranged from minus 100 euros per megawatt hour in times of a high renewable supply with simultaneously weak demand and up to 150 euros per megawatt hour with low renewable generation and simultaneously high demand. Previously, however, prices for individual hours were even more extreme, ranging from several hundred euros per megawatt hour in the negative range up to more than 1,000 euros per megawatt hour in the positive range.

Due to its high liquidity and trading volumes, the day-ahead market is regarded by many market participants as setting the benchmark price for electricity. Indeed, the day-ahead market has around five times more volume than the intraday market, and the day-ahead price is used as a basis for futures trading at various exchanges.

6.5.4 Derivatives market

Various types of futures are traded in power exchanges on a continuous basis. These futures can be traded for given days, weekends, weeks, months, quarters and years. In the case of annual products, trading can cover up to six years into the future,

although more near-term delivery periods are usually traded with greater liquidity.

Because spot prices depend on numerous factors that are only known in the short term, such as energy source prices, demand and weather, it is difficult to predict spot prices over the long term. With futures, it is possible to hedge prices in advance over the long term and thus minimize price risks. If, for example, a supplier has signed a contract with a new major customer to supply him with electricity at a certain price next year, the supplier can hedge against potential losses on the revenues he achieves with this customer by purchasing a corresponding futures contract.

Because longer delivery periods are traded on the futures market, prices on the futures market are less volatile than on the spot market. In recent years, futures prices have usually fluctuated between 20 and 60 euros per megawatt hour for base load.

6.5.5 Influence of prices across different market segments

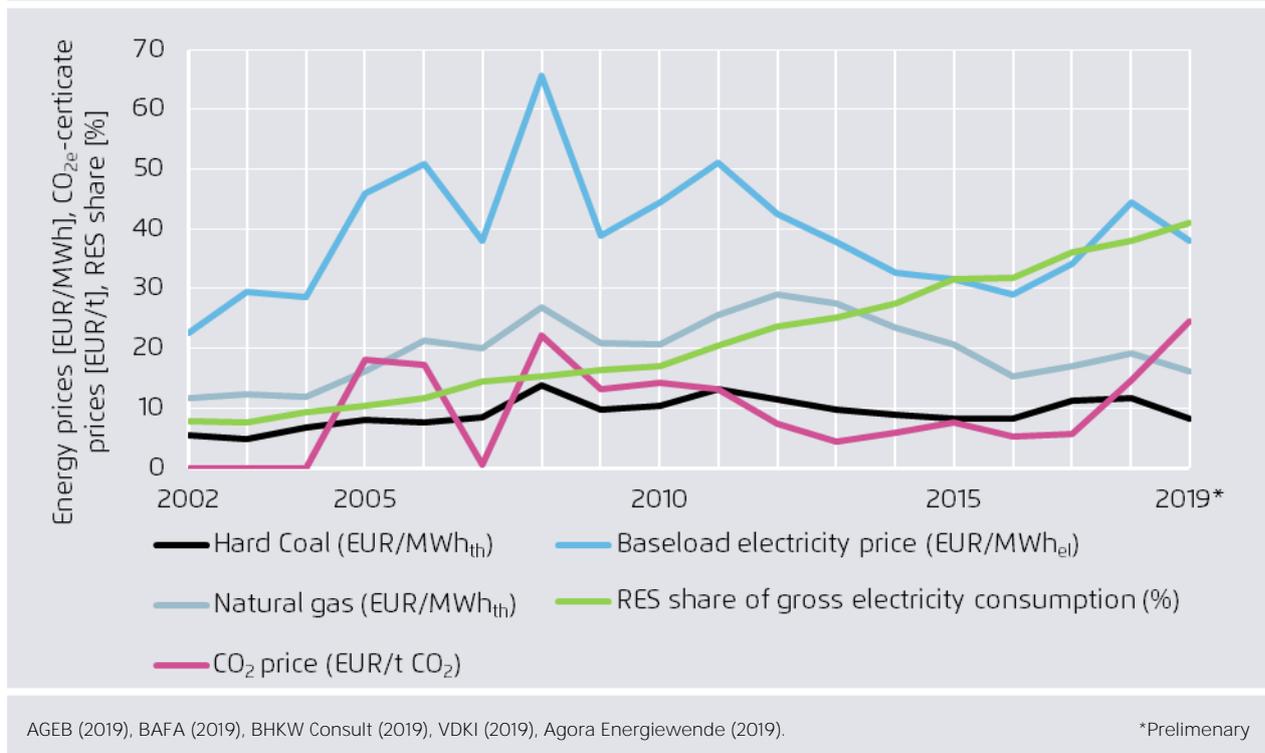
Trading on the futures market thus allows price hedging against possible price fluctuations on the spot market. The same applies to trading on the spot market, which hedges balancing group managers against balancing energy price risks. The expected prices for balancing energy therefore have an effect on the prices on the spot market. The price expectation for the spot market in a given delivery period therefore has an effect on price formation in the futures market. Assuming price competition and sufficient liquidity, the determined exchange prices are a reflection of traders' price expectations. Because prices on the exchange are also published transparently, they have a strong impact on electricity supply contracts concluded outside the exchange.

6.6 Price development after liberalisation

The EEX, Germany's leading electricity exchange, was founded in 2002. In the first year of trading, wholesale prices were initially less than 30 euros per

Energy prices in the German wholesale market after liberalisation

Figure 13



megawatt hour (see Figure 13). Overcapacity in the market led wholesale prices to stabilise at the marginal generation costs of fully depreciated large power plants. There was no market scarcity, and renewable energy accounted for less than 10 per cent of electricity consumption. As a result of low prices, power plant capacities were shut down in the early 2000s following liberalisation. This trend was bolstered by the introduction of a CO₂ price at the European level in 2005, which further reduced earnings by old and inefficient power plants. Rising natural gas prices ultimately led to wholesale electricity prices of 50 euros per megawatt hour in 2006.

At the end of the first CO₂ trading period, it became clear that the market was endowed with excessive certificates. Because the certificates could not be saved during the first trading period for later redemption, the price of CO₂ fell to zero in 2007. This, in turn, depressed wholesale electricity prices to

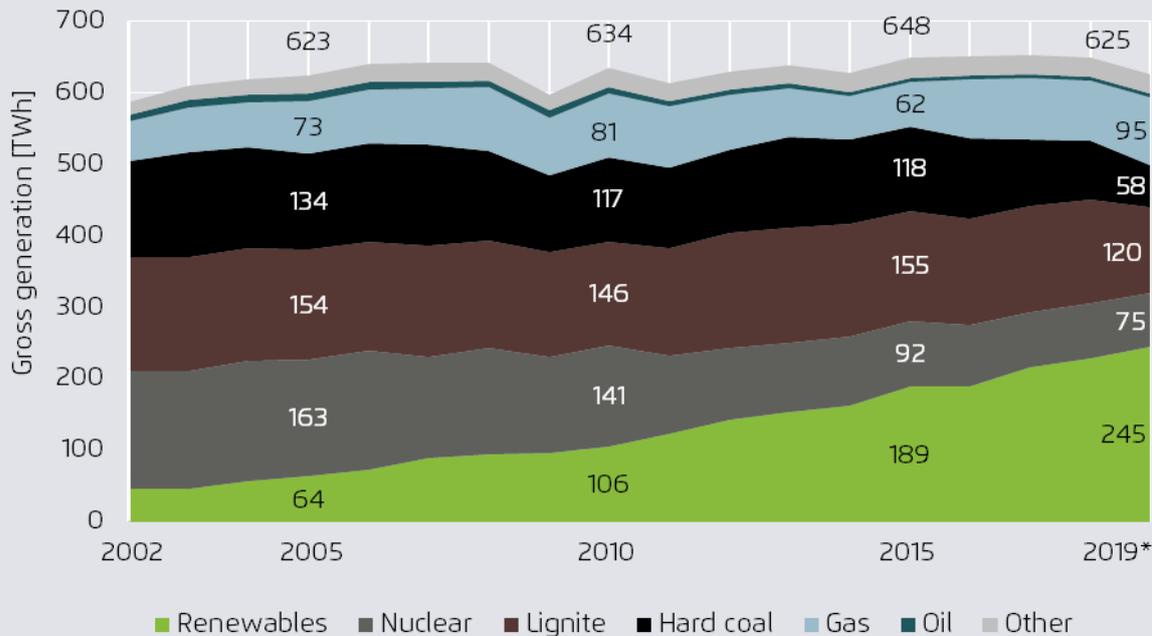
under 40 euros per megawatt hour. With the subsequent reform of the European CO₂ trading system – which, among other things, provided for certificates to remain valid over several trading periods – the CO₂ price rose again in 2008.

In 2008, several factors encouraged wholesale electricity prices to reach an all-time high. One of these factors was a significant reduction in overcapacity following the plant closures of the early 2000s. Wholesale prices ultimately rose to over 65 euros per megawatt hour. As a result of this development, numerous power plant projects were planned in Germany – yet only half of them were finally completed between 2012 and 2015.

In 2007 and 2008 there was a strong rise in all commodity prices, which reached its peak in the middle of 2008. With the collapse of Lehman Brothers in

Electricity generation by source in Germany's liberalised power market

Figure 14



AGEB (2019), Agora Energiewende (2019).

*Preliminary

September 2008 and the ensuing global recession, demand for energy fell significantly, depressing commodity prices. In Europe, the banking crisis turned into a full-blown sovereign debt crisis with lasting effects, especially in Southern Europe. As a result, there was a structural oversupply of CO₂ certificates, which resulted in low wholesale electricity prices. This effect was intensified by a rapid increase in the expansion of renewable energy in Germany and falling prices for natural gas and hard coal, which led to a significant drop in wholesale electricity prices. In 2016, prices once again stood at 30 euros and below per megawatt hour, a price level last witnessed at the start of liberalisation.

While the German government's decision in 2011 to phase out nuclear power following the disaster in Fukushima should have led to higher electricity prices, upward pressure on prices has been offset by the significant expansion of renewables. With the

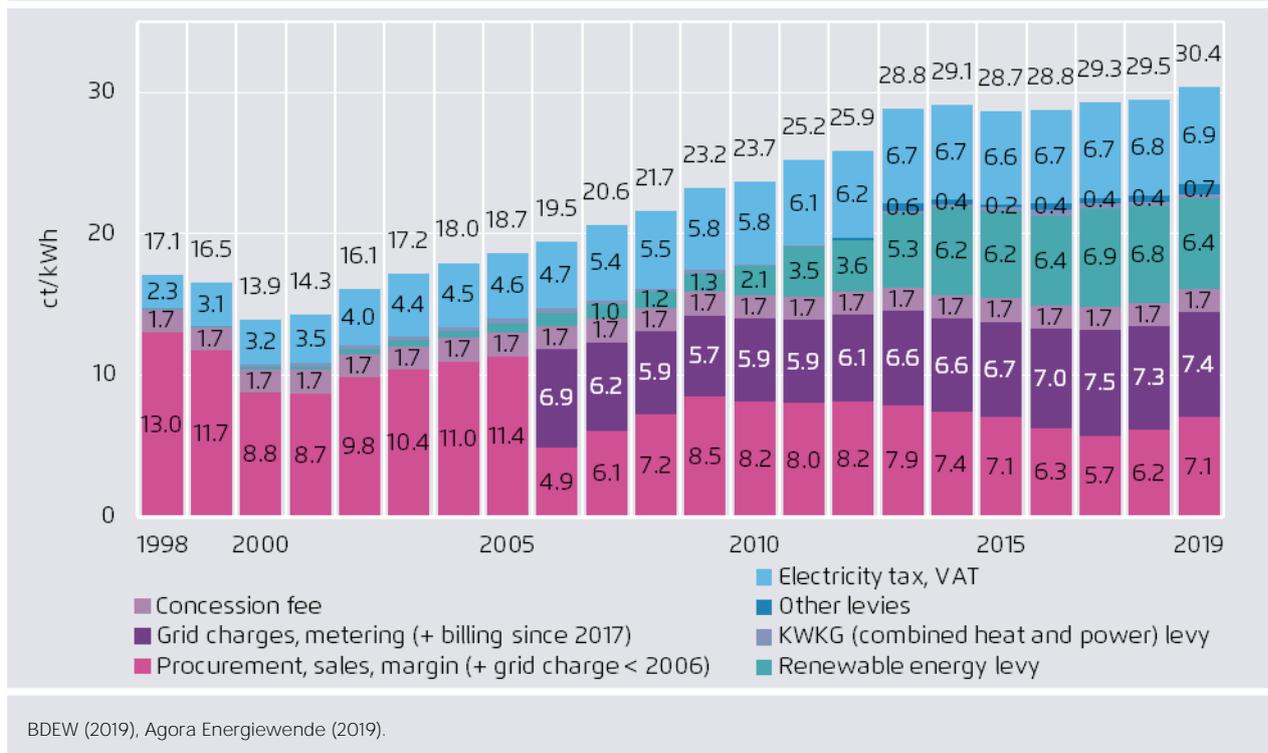
reform of European emissions trading in 2017 emissions prices have been rising once again, in turn driving higher wholesale prices for electricity. In 2019, however, falling natural gas and coal prices caused electricity prices to fall back towards the 40 euros level.

The creation of a spot market has led to the pricing of generation based on short-term marginal costs and has increased the efficiency of power plant dispatch. Yet it has also introduced other price signals. As a result, renewable energy can be integrated just as efficiently as the short-term shutdown of nuclear power plants. The gradual phase-out of coal-fired power generation (see Figure 14) is also currently taking place through wholesale price signals.

Looking at the development of end consumer prices since liberalisation in 1998, it can be seen that prices for households and industry dropped significantly in

Average electricity price for a household (annual consumption of 3,500 kWh)

Figure 15



the initial years (see Figure 15). Liberalisation had the desired effect: competition and transparent wholesale prices led to lower costs for consumers.

However, rising fuel prices and the introduction of new taxes and levies have exerted a significant countervailing pressure on prices. End consumer prices are nearly twice as high today as they were before liberalisation, particularly given the price impact of higher taxes and levies.

One key driver of higher prices is the government levy to subsidise the expansion of renewable electricity, which today represents around one quarter of the household electricity price and more than one third of the industry electricity price. However, some industrial consumers, particularly energy intensive firms, can take advantage of extensive exemptions from this levy.

The levy is used to pay for the renewable energy subsidy commitments that new plants receive for a period of 20 years. While this levy was a major driver of higher prices in past years, subsidy costs have fallen in recent years, and will fall even further from 2021 onwards, as the 20-year guarantee period begins to expire for the first (and most expensive) plants to qualify for the EEG subsidy.

6.7 Transparency

An essential prerequisite for a market to function is the confidence of market participants in that market. One source of confidence is the belief that prices on the market are fair, without favouring or discriminating against individual market participants. In order to confirm pricing is fair, sufficient information must be made available in a transparent manner. By contrast, lack of transparency creates knowledge

asymmetries that can be exploited to the disadvantage of some participants.

Exchanges publish traded volumes of electricity and electricity prices in anonymous form, such that trading partners are not named. This information is transparently accessible to everyone through the Internet. The commodity exchanges thus have a special influence on price formation in other exchanges and in over-the-counter markets. This is because market participants can take a cue from the exchange price, even during bilateral trading outside the exchange. In this way, commodity exchanges make an essential contribution to the proper function of a liberalised market and to the trust of market participants in that market.

With a view to electricity generation, transparency was a very controversial subject, especially in the first decade after liberalisation. Since supply and demand sets the wholesale price, the operating conditions faced by power plants are a highly relevant factor. However, only the operators of a given plant know about these conditions, so they naturally have an informational advantage. This allowed insider trading, which, in contrast to the stock market, was completely legal in the power market until 2011.

The temporary shutdown of larger power plants was often kept secret by the operator, leading to surprising price trends.

A first step to mitigate this information asymmetry was taken with the introduction of a transparency website administrated by the European Energy Exchange (EEX) in 2006. At the website, operators could announce the availability of their power plants on voluntary basis, but there were no binding rules (for example, regarding the timing of their announcement).

Various other types of important data were initially missing from this website. In the beginning, there

Excursus: How actors in a liberalised market can both encourage and resist transparency

The wholesale electricity price, especially in the short term, is strongly influenced by the condition and availability of the power plant fleet. Since outages or other downtimes were not communicated to the market in the first years after liberalisation, a company named Powermonitor came up with an innovative idea: They placed measuring devices under the power lines near power plants and measured the magnetic field. With this measurement, it was possible to determine the current output of the nearby power plant. For obvious reasons, the trading floors of larger utilities were highly interested in obtaining such information.

One of the large German utilities, EnBW, fiercely resisted such measurement activity and accused the company of industrial espionage. In one instance, the bomb squad of the German police was even called in to remove the measurement devices, despite EnBW being previously informed of their presence.

EnBW took the matter to court but ultimately lost the case. The court asserted that industrial secrets have to be sufficiently protected, and that if an average technician is able to acquire such data with standard equipment from an electronics store, the industrial secret is not sufficiently protected. The case garnered a great deal of attention and ultimately encouraged enhanced power market transparency.

was no official list of power plants operating in Germany.

The Federal Network Agency started publishing a regularly updated list of power plants in Germany just a few years ago.

In 2011, the EU adopted the Regulation on Wholesale Energy Market Integrity and Transparency (REMIT). This regulatory provision aims to (Wikipedia, 2019b):

- prohibit insider trading and market manipulation,
- oblige market participants to register with their competent National Regulatory Agency,
- oblige market participants to report wholesale energy market transactions and to publish insider information and
- authorise the Agency for the Cooperation of Energy Regulators (ACER) to implement REMIT, in

particular to monitor the market, to collect transaction reports and to register market participants, and to

- strengthen cross-border wholesale competition and extend border interconnections in order to limit the market power of domestic generators.

REMIT obliges producers larger than 10 megawatts to publish installation and production data as well as planned production and outages. Operators usually publish these data via the EEX transparency website, and via their own websites.

7 Renewables in the Liberalised Power Market

7.1 The Renewable Energy Act

Since 2000, the Renewable Energy Act (Erneuerbare-Energien-Gesetz, EEG) has been the central instrument for the promotion of electricity from renewable sources in Germany. On average, the EEG has been amended every third year since adoption. Its three main provisions are:

- an obligation for the grid operator (TSO or DSO) to connect renewable energy systems to the grid immediately and as a matter of priority,
- an obligation of the grid operator (TSO or DSO) to give priority to the feed-in, transmission and distribution of renewable electricity, and
- the payment of fixed, technology-specific feed-in compensation for a period of 20 years.

7.2 The tendering system

The 2017 Renewable Energy Act (EEG 2017) introduced a tendering system for wind, ground-mounted PV and biomass. Planned installations larger than 750 kilowatt (biomass > 150 kilowatt) have to take part in a tendering procedure that is conducted by the German Network Agency (BNetzA) several times a year. The regulator asks for bids for a certain total capacity, and interested parties bid by citing their required subsidy rate. The regulator accepts the lowest bids meeting the total tendered amount in this paid-as-bid auction format.

The costs associated with the EEG subsidy are passed on to consumers in form of a levy, while industrial consumers are eligible to apply for exemptions if they fulfil certain requirements.

7.3 Market integration of renewable energy

In 2012, the market premium model was introduced as a new instrument for integrating renewable power into the market. It allows third parties to receive electricity from renewable energy systems and to sell it on an exchange or deliver it directly to end customers. The market premium model is mandatory

for installations larger than 100 kilowatts that came in operation after 2014.

With the market premium model, operators of renewable installations are able to market their electricity and receive proceeds from the power market. Thus, instead of a guaranteed feed-in tariff, the producer receives a premium calculated as the difference between the plant specific feed-in tariff and the reference market value (capture price), which is calculated ex post as a technology specific monthly average price of the EPEX Day-Ahead price, weighted based on the total production of that specific renewable energy technology. Additional income in excess of the market value can be retained by the operator.

A small example demonstrates how the market premium works: Assume an existing onshore wind installation previously received an EEG feed-in tariff of 9 cent per kilowatt hour. Under the market premium model, in May 2019 it receives a technology specific reference market value of 3.564 cent per kilowatt hour. It then receives a payment from the EEG account of 5.436 cent per kilowatt hours. The market value and the EEG payment add up to the 9 cent per kilowatt hour.

More than 90 per cent of onshore wind capacity and nearly 100 of offshore wind capacity fall under the market premium model. PV has only a coverage rate of around 20 per cent, since rooftop installations are not covered by the market premium model.

Since the first EEG came into force in 2000 and subsidies are paid for 20 years plus the first year of operation, in 2021 the first old installations will leave the subsidy system and will have to sell their electricity either directly to the market or will need a Power Purchase Agreement (PPA) with a consumer or utility.

In the coming years, ever more renewable capacity will leave the subsidy system. Some of them might

continue running as long as possible, while others might be repowered with new installations, thus allowing participation in the tendering process run by the Federal Network Agency. In other cases, a decision might be made to shut the facilities down (Wattsight, 2019).

7.4 The impact of an increasing share of renewables

Renewables have two major impacts on the electricity market. One (now widely known) impact on the electricity price is the merit-order effect, which leads to falling wholesale electricity prices in times of high feed-in from renewables. The generation costs of variable renewables are low in comparison to generation by thermal power plants, because the wind and sun do not have any fuel costs. This is also true of short-run marginal costs, which are relevant for electricity trading and do not take fixed costs

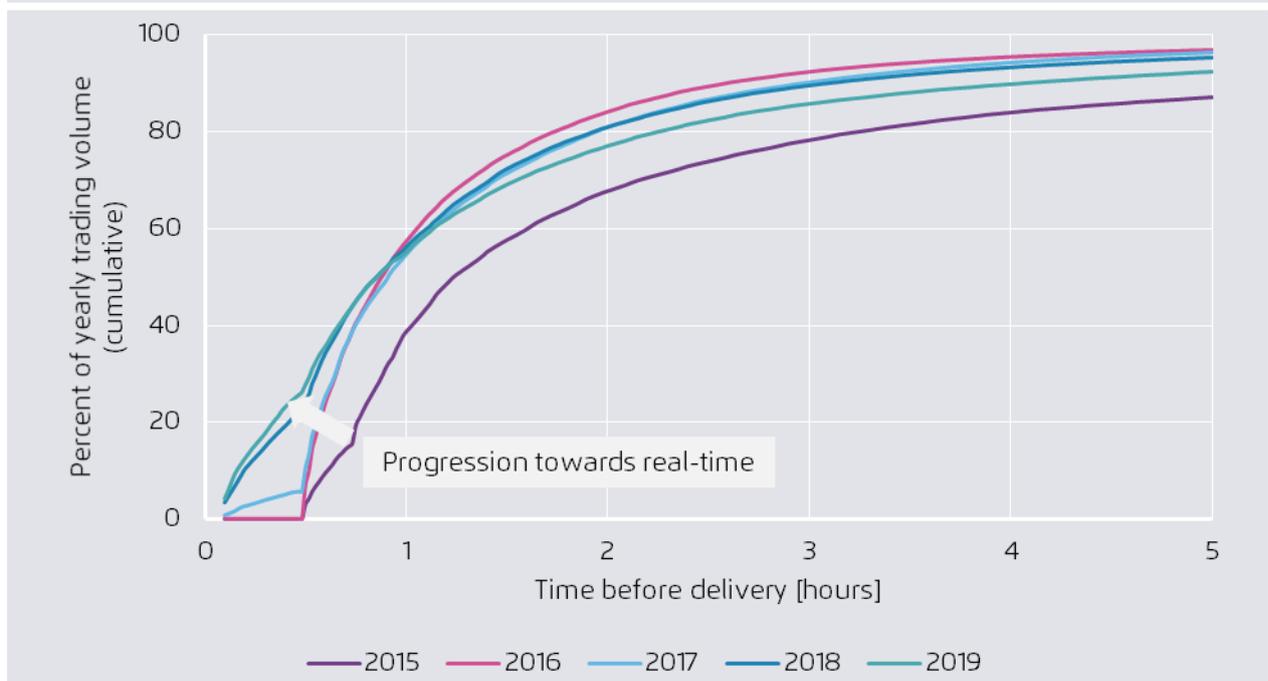
into account, such operational overhead or cost of capital.

The short-run electricity generation costs of variable renewables are close to zero (or even negative when the renewable energy plant is paid a market premium). In the merit order, cheap renewable generation displaces more expensive thermal power plants, thus lowering the price of electricity. If the sun is shining or the wind is blowing, many plants can generate electricity at the same time, which can have a very pronounced merit-order effect – especially at midday, when the sun is at its zenith. But this also means that variable renewable systems “cannibalise” each other, by lowering the price when feed-in is high, thus decreasing their market value.

The second impact relates to the fact that variable renewable generation is difficult to predict in comparison to that of thermal power plants,

Energy trading becomes more real-time through variable renewables

Figure 16



EPEX Spot (2019), Agora Energiewende (2019).

predominantly due to the uncertainty of atmospheric conditions. Since a balancing group has to be balanced (see Sections 6.2 and 6.3), fluctuations in renewables feed-in must be offset by corresponding trading transactions. If there is too little generation, electricity has to be bought from the market; if there is too much generation, the excess electricity has to be sold to the market. This explains why trading in recent years has become increasingly short-term and is approaching real-time (see Figure 16). When large quantities have to be traded

simultaneously due to forecast deviations, sharp price fluctuations can occur in the short-term intra-day market (see Figure 12).

In such situations, market participants with flexible supply or demand capacity – e.g. flexible generation assets, energy storage or demand-side flexibility – can enter the market. In this way, price signals enable the coordination of flexible capacities with variable generation from renewables. Market actors offering flexibility can profit from volatile price movements by following the first principle of the market: buy low, and sell high.

8 Conclusion

Twenty years after the start of liberalisation in the German and European electricity markets, a new set of interrelationships has been established between electricity suppliers, consumers, retailers and grid operators. By breaking up monopoly control over the power sector, liberalisation, acting in tandem with the Renewable Energy Act, has paved the way for a dramatic increase in the deployment of renewable energy.

Power grid management remains a monopoly industry, and is therefore strictly regulated. As a result of liberalisation, power suppliers decide when and how to operate their generation assets while responding to a floating wholesale price that is uniform throughout Germany. Only after the market price has been determined do grid operators intervene as necessary, re-dispatching or curtailing renewable generation in order to ensure the physical transport of electricity.

Thanks to the market premium model, renewable energy systems can even offer their electricity at negative prices, which gives them high priority in dispatch. Negative electricity prices provide incentives for controllable producers to make generation more flexible, as inflexible assets exacerbate the magnitude of negative prices. Consumers can also play their part, "bidding" flexibility by shifting demand to low-price periods.

Both on the supply and demand side, liberalisation has established competitive forces that promote a more cost-effective power system. Consumers are free to choose their electricity supplier and thus create competition between energy providers.

For household customers, liberalisation has led to a lasting reduction in the costs associated with generating and transporting electricity. While the final price paid by household customers is now approximately twice as high as it was before liberalisation,

this is attributable to higher taxes and levies, particularly for subsidising the expansion of renewables.

The road to liberalisation has been bumpy at times, requiring various stopgaps and compromises between stakeholders. In some cases, special exemptions and grandfather clauses have created hurdles for the further refinement of the system.

The electricity sector is a highly regulated branch of the economy and is regularly the subject of political debate. Further regulatory changes and adjustments will certainly be necessary in the years ahead as the power sector continues to evolve. Some promising developments that are already emerging include:

- the EU Commission's recently announced Green Deal for a climate neutral Europe,
- Germany's coal phase-out, which is supposed to be completed by 2038,
- renewable energy systems that no longer require subsidies, with renewables comprising 65 per cent of gross electricity consumption by 2030,
- increasing electricity demand in the heating and transport sectors, e.g. for heat pumps and electric vehicles,
- the expansion of power storage capacities, including the expanded use of hydrogen as fuel.

These developments will necessitate further innovation in all segments of the electricity sector, as solutions both big and small are deployed to usher in a power system that is ever-more sustainable while also remaining affordable and secure.

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Agora Energiewende
Anna-Louisa-Karsch-Straße 2 | 10178 Berlin
P +49. (0) 30. 7001435-000
F +49. (0) 30. 7001435-129
www.agora-energiewende.de
info@agora-energiewende.de