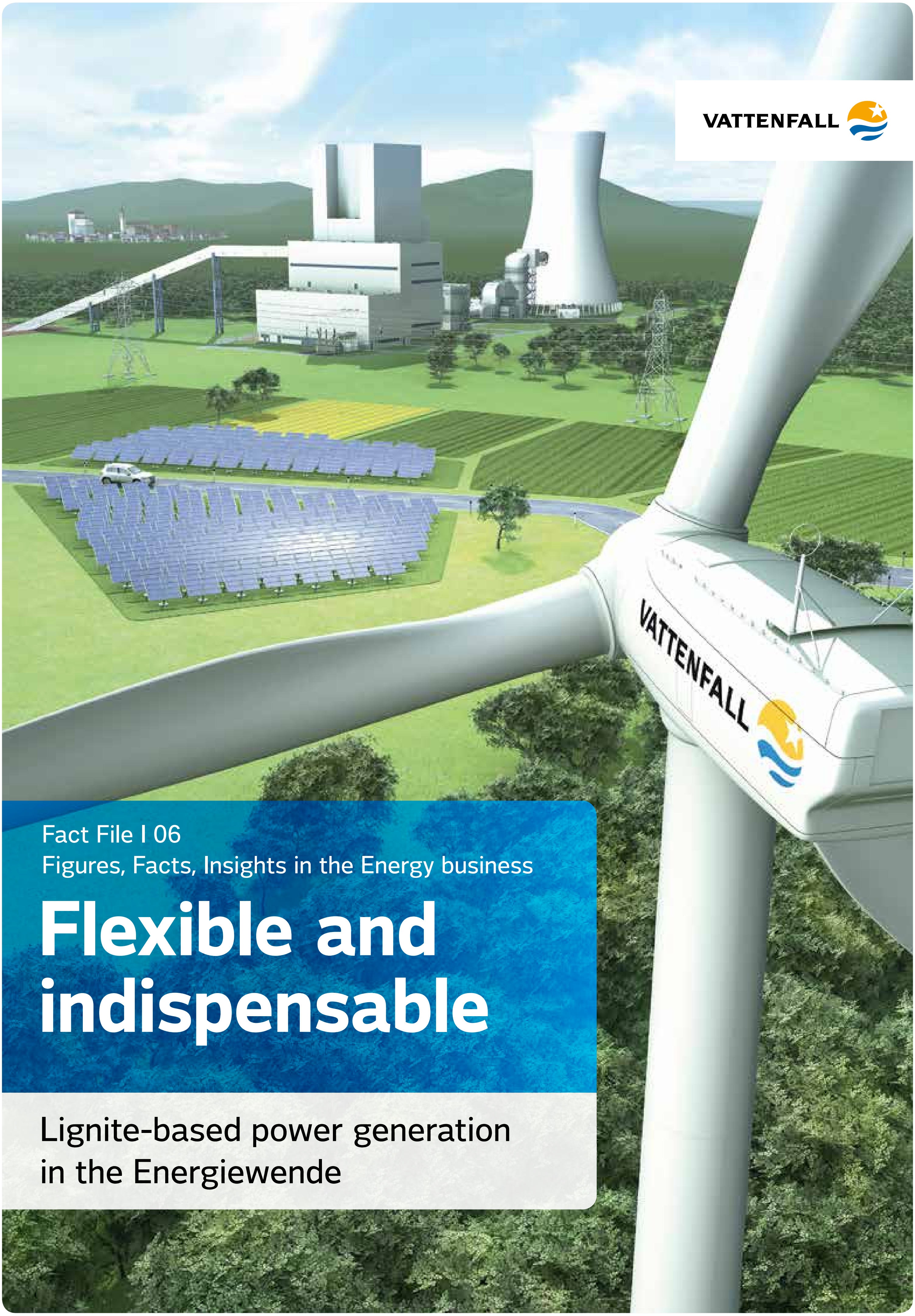


Fact File I 06

Figures, Facts, Insights in the Energy business

Flexible and indispensable

Lignite-based power generation in the Energiewende

„A secure, reliable and competitive energy supply is a condition for economic well-being and social progress."

Dr. Hartmuth Zeiß
Chairman of the Board
Vattenfall Europe Mining AG,
Vattenfall Europe Generation AG

The Energiewende: **We are working on it**

The aim of the German Energiewende is to restructure our electricity system and thereby completely transform our entire economy and society. It has diverse and wide ranging effects on the people of Germany. Each and every household feels the impact and this is particularly true regarding electricity.

The debate about who is to carry the costs of the Renewables Energies Act (EEG) and the increasing concern about the security of our daily electricity supply are only two aspects of the discussion in which we are trying to come to a common understanding of how we can successfully conclude this generations spanning project to a successful conclusion. The fundamental political understanding of the aims for 2050 seems to be established, but working out the details is going to be hard work.

It is not surprising that a project which starts with such high hopes and expectations is naturally also subject to criticism. As the experience of countless large projects shows it is always more expensive, takes longer and one or two unpleasant surprises are to be expected en route. This is entirely normal: a strategy that reaches 40 years into the future needs checks and balances that allow for corrections along the way.
There is a growing understanding that such a structural change can only be established on an economically stable foundation. The supply of electricity must continue to be reliable day and night - and at a price which will keep domestic jobs internationally competitive and affordable to all households. A secure, reliable and competitive energy supply is and will continue to be a necessity for economic wellbeing and societal progress.

This is where Germany's lignite comes into play. Its competitiveness is demonstrated daily in competition with natural gas, nuclear power and hard coal at the European Energy Exchange. As it is safe, reliable and and flexible it helps to integrate renewable energies. Lignite and renewable energies can maximise their respective strengths and compensate for their weaknesses using modern technology, farsighted strategies and consistent regulation.

Our lignite-fired power plants provide a stable and reliable supply of electricity and heat at four sites in eastern Germany, and ensure the stability of the electricity grid. In addition, they already provide a range of around 5,900 MW in order to be able to reliably integrate the fluctuating feed from wind and solar power plants into the electricity grid. The further expansion of renewables requires new technical solutions to increase asset flexibility, on which our committed employees are successfully working on.

So, I am quite confident that in the long-term our domestic lignite and its conversion into electricity in modern, efficient and flexible power plants will continue to play an important role as a partner to renewable energies and as a guarantee for security of supply, value creation and employment. I hope that this issue of our „Knowledge" series will help you gain a better understanding of some aspects of our daily work in this generation spanning Energiewende project.

Glück auf!

„Lignite and Renewables can maximize their own strengths and compensate their weaknesses by using new technologies, diplomatic policy and consistent regulation."

Lignite-based power generation in the Energiewende

A day in Germany's electricity world

In the early hours after midnight no one in the country is using much electricity. People are asleep and most household appliances are off. With the activities of the early morning, the grid kicks into action. **Page 6**

Behind the socket: the energy system in Germany

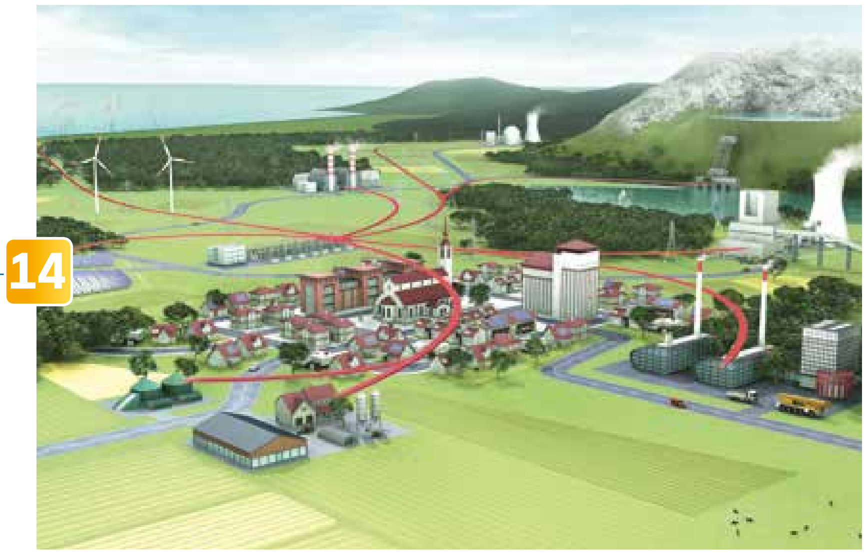
The German energy system is more complex than one expects. The way is long from generating of electricity, to feeding it into the grid through to the consumer **Page 8**

„The only way is to expand the grid"

The Energiewende is not only a challenge for the energy generators. Also the grid operators are facing a lot of work. Gunter Scheibner, Head of System Management at the transmission system operator 50Hertz in eastern Germany, explains what this involves. **Page 11**

Lignite-fired power plants in the Energiewende

The Energiewende means also a change in the role that lignite-fired power plants play in German energy supply. One of their most important tasks is now to react flexibly to the fluctuating feed-in of wind and solar power and to ensure grid stability. **Page 14**



The energy system of the future

What will the energy system of the future look like? One thing is clear: Many small puzzle pieces will need to be put together to make the energy supply ready for the future. **Page 20**

Modern lignite-based energy generation

Vattenfall´s lignite-fired power plants are characterised by a high level of efficiency, environmental sustainability and flexibility. They are state-of-the-art plants – and technically fascinating buildings. **Page 24**

Into the future with energy

In the Energiewende, research into power plant technology is primarily reduced to one thing: developing flexibility. Power plant engineers are working on making the systems even quicker and more variable than they already are. **Page 28**

A day in Germany's electricity world

A clear October night in Germany. The weather forecast on the radio promises a sunny autumn day with moderate wind force 3 – a day for flying kites.

03:00 In the early hours after midnight the grid is still at rest. Only a few streets and shop windows are illuminated. Nearly everyone is asleep and most of the household appliances are not in use. Only the nightshift staff in industry and in hospitals is working and needs electricity continously.

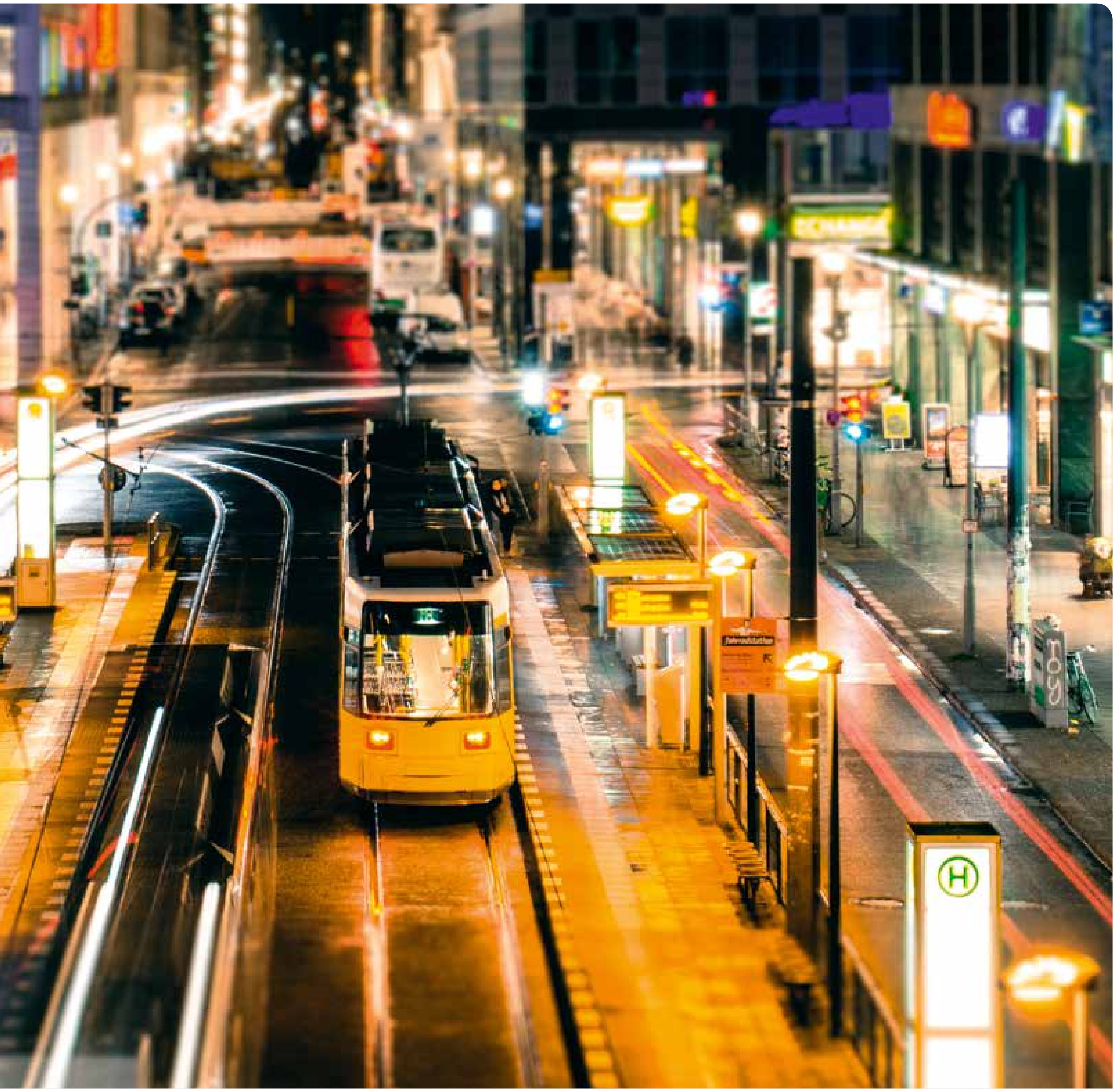
06:00 With the activities of the early morning, the grid requirements go up. Millions of kettles, coffee machines, cookers and microwaves are switched on and drawing electricity from the grid. The head office of the grid operator registers the higher demand for electricity, which is covered by increasing the output of conventional power plants that have only been using a fraction of their energy generating capacity during the night when the demand is low.

08:00 Lots of people are now starting work. Lights and computers are being switched on in offices, schools and shops. The demand for electricity has increased by almost 20,000 MW in just a few hours. In absolute terms, this increase corresponds to the capacity of more than 14 nuclear power plants. This morning, the sun is shining in an almost cloudless sky. Shortly after sunrise, photovoltaic plants also supply their first electricity, and by noon they will reach a peak of 15,000 MW that day.

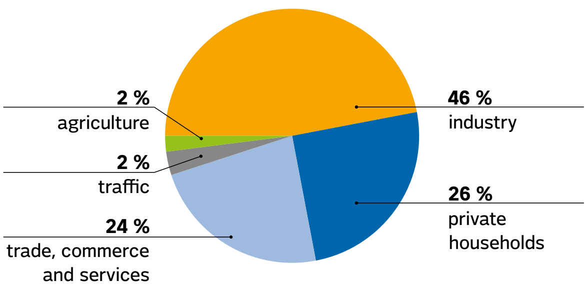
11:00 The demand of electricity decreases slightly in the late morning. In addition, due to the increasing generation of solar power energy supply from conventional power plants decreases. But even now they are playing an important role. By throttling their production, they give way for renewable energy in the grid and keep it stable this way. The electricity demand increases again at lunchtime.

19:00 In the evening, the grid operators record another peak with a demand of more than 66,000 MW between 18:00 and 20:00: housework and cooking; televisions and tumble dryers demand the maximum. Once again the electricity consumption mostly has to be covered by conventional power plants and pump storage plants. The wind is still blowing, but the sun has disappeared below the horizon a long time ago.

22:00 With the first street lights going off, the grid activity calms down on this October day. The night shift starts up.

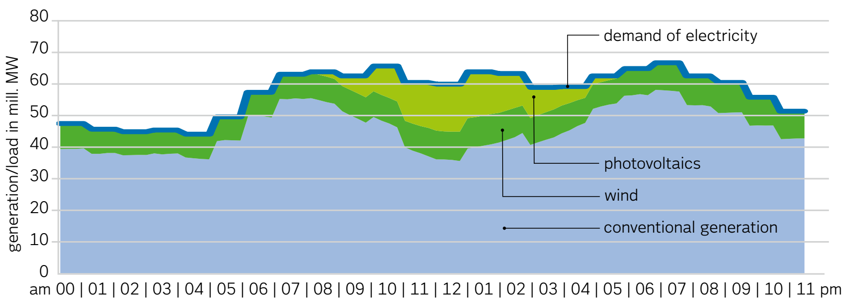


Electricity consumption in Germany



Source: BDEW, from 02/2014

Electricity demand and generation in the course of a day



Energy consumption in Germany can fluctuate by more than 25.000 MW within a single day. A rise and fall in demand is seen not only in the change between day and night, but also on days of the week and in different seasons. The highest demand for electricity in Germany is generally during the early evening of a week day in winter. The total electricity consumption is termed as the load.

Source: European Energy Exchange, ENTSO-E, 02/2013

Behind the socket: the energy system in Germany

In our modern society we take electrical energy, in short electricity, for granted. We are usually not fully conscious of the fact that electricity is one of the key foundations for our high standard of living.

We are used to electricity always being available in a functioning infrastructure, for industrial production, to support our daily work and for leisure activities. But "behind the socket" there is a complex energy system, which involves the technical generating of electrical energy to feeding it into the electricity grid through to transporting it to the various consumers.

The electricity supply in Germany is based on a mix of conventional and renewable energy sources. Conventional energy sources are understood to be lignite and hard coal, natural gas and oil and nuclear power. Today, they cover three quarters of Germany's electricity consumption. The renewable energies primarily include wind power, photovoltaic (PV), biomass and running water. Renewables as well as lignite are domestic energy resources. The remaining fossil energy resources (hard coal, oil and gas) and uranium for the nuclear power plants largely need to be imported from abroad.

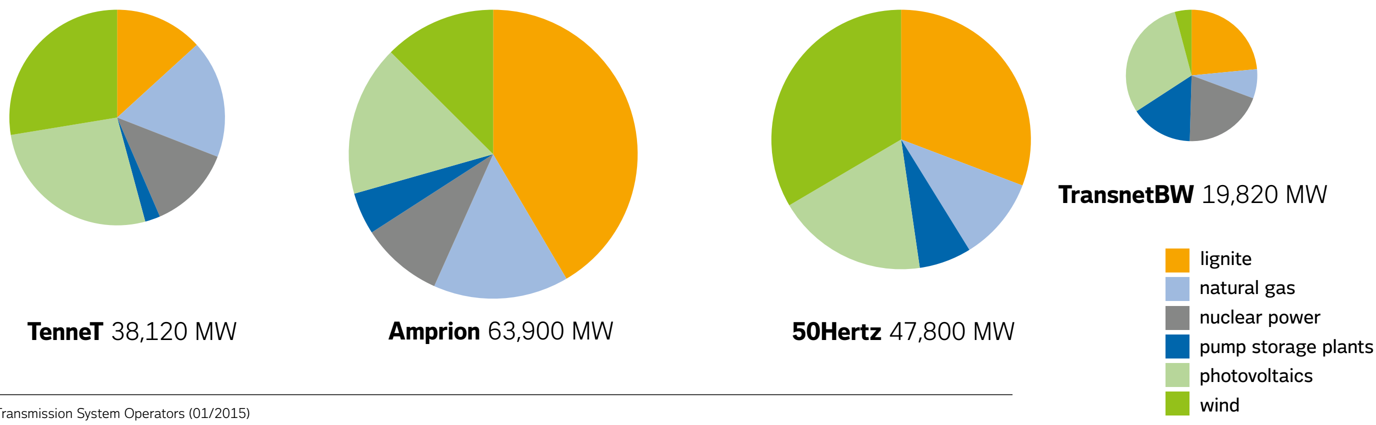
Basically the rule for a stable electricity system is that exactly the amount of electricity which is needed must be generated at any moment round the clock. Only then we will have electrical energy at the time and in the quality that we need it. Therefore there must always be equilibrium between generation, transport, storage and consumption on the balance sheet. This way voltage and frequency of the electricity keeps stable and the electricity grid operates safely and reliably. The possibilities for storing electricity, and therefore creating a time "buffer" between generation and consumption, are very limited. In fact, pump storage plants are currently the only industrially available solution for storing electrical energy. A pump storage capacity of around 7.000 MW is installed in Germany.

The Energiewende

With the background of climate protection, and following the Fukushima reactor accident in Japan, Germany decided to carry out a fundamental reorganisation of its energy system - the "Energiewende". The key aims include the definitive phasing out of nuclear power by 2022, a massive increase in energy efficiency and accelerated expansion of renewable energies. The driving force behind this expansion is the Renewable Energies Act (EEG). This systematically promotes renewable electricity generation, which should therefore be gradually prepared for the market. The central principles of the Renewable Energies Act are the priority feeding of electricity from renewable sources into the electricity grid and a 20-year guaranteed feed-in tariff for plant operators.

The "preferential feed" of electricity generated from renewable sources in the German grid creates additional challenges for the energy system as we know it: wind turbines and photovoltaic systems do not feed the electricity grid according to the demand. Their generation depends on the time of day and the weather. They are therefore often described as "volatile" (fluctuating). The fluctuations in production have to be balanced out by the other power generating facilities to keep the

Installed Capacity in control areas



Source: Transmission System Operators (01/2015) necessary balance between electricity generation and consumption. In addition, there are just not enough power lines for the transport of electricity which is generated in the windy north of Germany by new wind power plants onshore and offshore to the densely populated and high-consumption southern and western areas. Due to the Energiewende the expanding of the grid is often mentioned. But how does the electricity get to the consumer?

The paths of electricity

The German electricity grid consists of several grid levels which are connected via substations:

- The national distribution of electricity from large power stations is carried out via the extra-high voltage grid.
- Further regional distribution is initially carried out by the high voltage grid (e.g. in metropolitan areas and for major industries) and then by the medium voltage grid (e.g. to trade and industry).
- Finally, private households get their electricity from the low-voltage grid. Overall, our electricity grid is around 1.8 million kilometres long and is usually above but sometimes also underground.

The four grid operators Amprion, TransnetBW, Tennet TSO and 50Hertz Transmission are responsible for the operation of the German extra-high voltage grid in their respective regions (control areas). The balance between electricity generation and consumption is controlled in these areas. This requires close cooperation with the neighboring German and also European transmission system operators. As a result of corresponding agreements with power plant operators, they also keep reserves ready in order to be able to balance out fluctuations in frequency and voltage at any time.

How is the electricity price worked out?

The electricity price originates from the energy exchange. All electricity generating companies offer their electricity there at a particular price. The decisive factor is the costs for the fuels used for energy generation, which are lowest for hydropower plants, lignite-fired power plants and nuclear power plants. These are followed by hard coal power plants and gas utilities. Pump storage plants are situated in the middle.

The way the so-called "Merit Order" functions is, that first the cheapest producing power plant is connected and then the next most expensive one until the demand is completely covered. The last electricity generation offer (most expensive) to cover the demand is used to determine the electricity price.

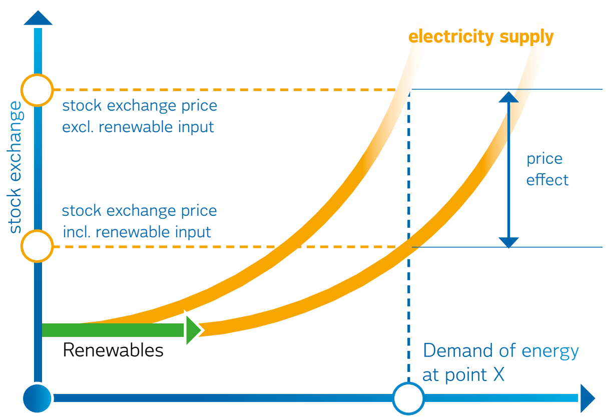
Therefore the price for electricity is determined by the price of the last and therefore most expensive power plant that is still needed to cover the electricity demand.

Renewable energies are also included in this pricing model. As they take precedence in being fed into the electricity grid according to the Renewable Energies Act (EEG), renewable electricity generation is being awarded in the pricing at the exchange. This means that the entire supply curve shifts to the right.

This means fewer power plants with higher production costs need to be used to cover the same demand for electricity. The exchange electricity price falls.

The fact that the electricity price for private households is currently increasing in spite of this is due to the consumer bearing the difference between the market value of the renewable electricity (exchange price) and the guaranteed acceptance price for the plant operator via the Renewable Energies Act contribution.

In addition the German Association of Energy and Water Industries (BDEW) has determined that in 2014 on average only around 25 per cent of the electricity price will be determined by the market, namely electricity procurement and sales. The remaining expenses will come from regulated grid charges (around 23 per cent) as well as taxes and duties (around 52 per cent). These taxes and duties include amongst others VAT and the Renewable Energies Act contribution.



„The only way is to expand the grid“

Gunter Scheibner, Head of System Management at 50Hertz, on the challenges of the Energiewende from the perspective of grid operators and the role of lignite-fired power plants in grid stability

Gunter Scheibner in the „Transmission Control Centre“ Neuenhagen, the heart of the extra-high-voltage grid in the new German federal states

Compared to other European countries the German electricity supply was seen as secure until now. Now we hear that the number that the number of „critical grid situations“ is increasing. What lies ahead for us?
We can assume that there will be a fundamental change in the supply situation during the Energiewende. Until now electricity has largely been generated where it was needed. Today, the largest electricity consumers are located in the south and west of Germany. However, the majority of nuclear power plants that have been and will be shut down are also in the south of Germany.

The areas with the weakest load are in the north and north-east of Germany, i.e. the control area of 50Hertz. In return, in our control area we now have the highest concentration of renewable energies available. We have only 20 per cent of the German load but, for example, we have 40 per cent of the wind power capacity installed in Germany. This results in large amounts of electricity which have to be transported from the north to the German load centers in the south and west.

How can the supply be secured in all areas of Germany in the future?
From a long-term perspective, the expansion of the grids is the only way. A well developed electricity grid is needed in order to be able to transport the electricity from one corner of Germany to the other. In recent months the burden on the grid has been slightly relieved in the 50Hertz control area, as in December 2012 the line connecting Hamburg was commissioned. This has benefited winter operation in the Hamburg area.

In the south, we continue to work on a connection through the Thuringian Forest. However, this project will still take some time. These are all pieces of a puzzle which will lead to an improvement of the grid situation. However, with these “small” steps we are chasing after the rapidly growing feed in of renewable energies.

Why is the grid expansion not moving faster?
It takes up to ten years to construct a power line in Germany, above all due to the extended timescales for approvals. In the current situation regarding the Energiewende this is far too slow. Although, there are signs of momentum in the grid expansion issue for some time.

Could we possibly taken the second step before the first one in Germany: created renewable energy capacities without having appropriate grid structures available?
Indeed, we are actually travelling at two speeds which do not match. What was originally intended as a jump start for climate neutral electricity generation has now developed into an independent branch of the economy and is gathering unexpected momentum. The success has overwhelmed everyone involved. For example, in 2012 there were plans for 3.500 MW solar plants; 6.000 MW were installed.

To date the forecasts for the expansion of renewable energies have been surpassed every year without exception. I think that the legislator simply underestimated this development.

When will the grids be developed to the extent that the Energiewende can be successful?
This is hard to predict; the changes originated from the Energiewende are too complex to do this. The development of the electricity grid and the transmission and distribution network levels is one of these changes; another is the reliable availability of electricity. Anyone who thinks that we will be able to secure the full energy supply with wind or solar plants in the foreseeable future is wrong. The sun doesn't shine at night ...

What possibilities do you think exist for balancing out the fluctuations in the energy supply?
A healthy energy mix will continue to be indispensable in the future. In addition to the very volatile wind and solar power plants we also need extremely flexible "other energy generation". Currently there are lignite-fired power plants and gas utilities, pump storage plants and still a couple of nuclear power plants available for this purpose; however, the latter will have to be decommissioned by 2022.

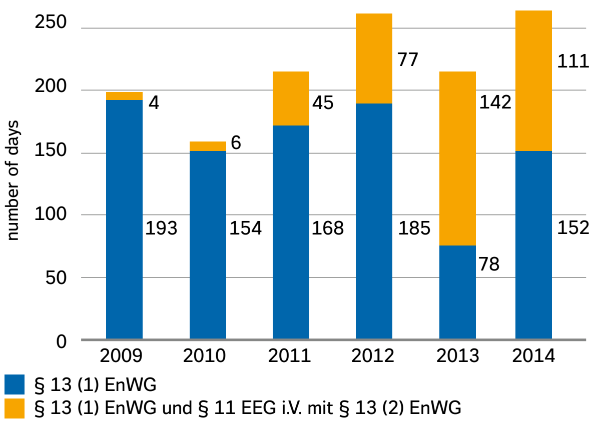
What can conventional power plants contribute that wind and photovoltaic plants cannot?
Above all we need power plants that balance out the deficits during the course of a day, which cannot be balanced out using volatile energies. There are still a considerable number of these.

In addition, transmission system operators need regulating power in order to ensure grid stability. This is currently predominantly provided by conventional power plants. A key condition for the supply is that the product, i.e. the generated electricity, is available round the clock.

What role will lignite-fired power plants and gas utilities play in Germany in the future?
The development of renewable energies will not be able to be curbed. The trend of energy generation divided into small units will continue. I am sure that we will need the majority of the power plant capacities currently available for some time to come in order to have a secure electricity supply in Germany. How-

How is the electricity grid controlled

Number of „days of intervention and exposure" with actions reg. Energy Economy Act



Source: TSO 50 Hertz 01/2015

Transmission system operators are obliged to counteract overloading and shortages in the electricity electricity grid by law. These result when too much or too little energy is fed into the electricity grid. As regenerative energies are fed in irrespective of the actual need for electricity, critical grid situations are increasing. The grid operators are facing tremendous challenges.

For example, the section 13(1) of the EnWG (Law on energy management) says that "grid and market-related measures" have to be taken in the event of a critical situation. "Grid-related measures" are understood to be technical steps which the grid operators can take themselves in order to remove any risk from the grid. This can be carried out, for example, by redirecting in the own grid area.

ever, it is already clear that the future requirements of coal-fired power plants will change considerably. This is mainly in respect to their flexibility in regulating the output.

What exactly does that mean?
The requirements in this area are already very high today. But it is clear that with increasing amounts of electricity from renewable energies, the coal-fired power plants will have to react even more flexibly: the number of balancing interventions will increase; they will have to become quicker at increasing and reducing output. Essentially it is all about the minimum capacity at which power plants will be able to be operated at in the future? This is the challenge for power plant engineers.

„I am sure that we will need the majority of the power plant capacities currently available for some time to come in order to have a secure electricity supply in Germany.“

“Market-related measures”, on the other hand, concern the grid customers i.e. the electricity producers: Accordingly, depending on whether there is too little or too much electricity in the grid, the grid operator can request an increase or decrease in production from the power plant operators.

If a risk or a disruption to the security of supply cannot be avoided using these measures, then according to section 13(2) the transmission system operators are obliged to adjust “all energy feed-in, transits and removal” to the requirements. For example, the grid operator may reduce the energy fed into the grid if there is a risk that this will become too high and this could overload elements of the grid. The same applies for electricity from regenerative energy plants. For example, section 13(2) of the EnWG allows for an exception for the precedence for renewable energies because the security of supply is seen as being more important. The grid operators also need flexible “electricity suppliers”, who can balance out the fluctuating energy production from wind and solar plants in short-time. At present, this can only be reliably carried out by conventionally operated power plants.

In 2013 there had been more days more days overall with interventions as per section 13(2) of the EnWG (Energy Economy Act) then in the years 2009-2012 sumed up. Without conventional power plants it will not be possible to reliably ensure the grid stability and the supply of energy to consumers and industry.

Lignite-fired power plants in the Energiewende

With the Energiewende, there will also be a change in the role that lignite-fired power plants play in German electricity supply.

Before the accelerated expansion of renewable energies, they were primarily reliable base load generators. This means that, together with nuclear power, they contributed to covering continous electricity requirements, for example from major industry, data centres and permanent consumers in households, in the most cost-effective manner possible. Accordingly, they supplied at a relatively constant level round the clock throughout the year. They had only been shut down and disconnected from the grid for scheduled routine maintenance and modernisation work.

With the dynamic growth of renewable energies and their prioritised feeding into the electricity grid according to the Renewable Energies Act, the tasks which the lignite-fired power plants have to cover for the security of supply and grid stability are expanding. Whereas they were previously primarily required for the reliable generation of a constant amount of electricity, today their ability to be adjusted is increasingly needed.. The difference between the fluctuating electricity consumption of consumers on the one hand and the fluctuating feed in from renewably generated electricity on the other hand needs to be balanced out round the clock. Covering this difference, which is called the "residual load", is extremely significant in keeping the electricity grid stable.

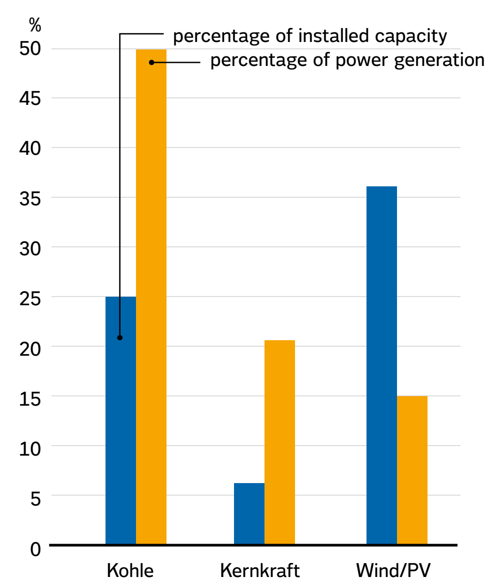
Electricity generation from the sun and wind cannot be controlled according to the demand. In spite of considerable progress inweather forecasts, especially in wind, it is only roughly predictable also not permanently available. .

The differences in terms of time and location between wind intensity and solar radiation and the limited capacities for electricity storage mean that the capacity that can be reliably provided from wind and photovoltaic plants is considerably lower than it is for conventional power plants. It amounts to less than ten per cent of the installed capacity, whereas around 90 per cent is achieved in coal-fired power plants.

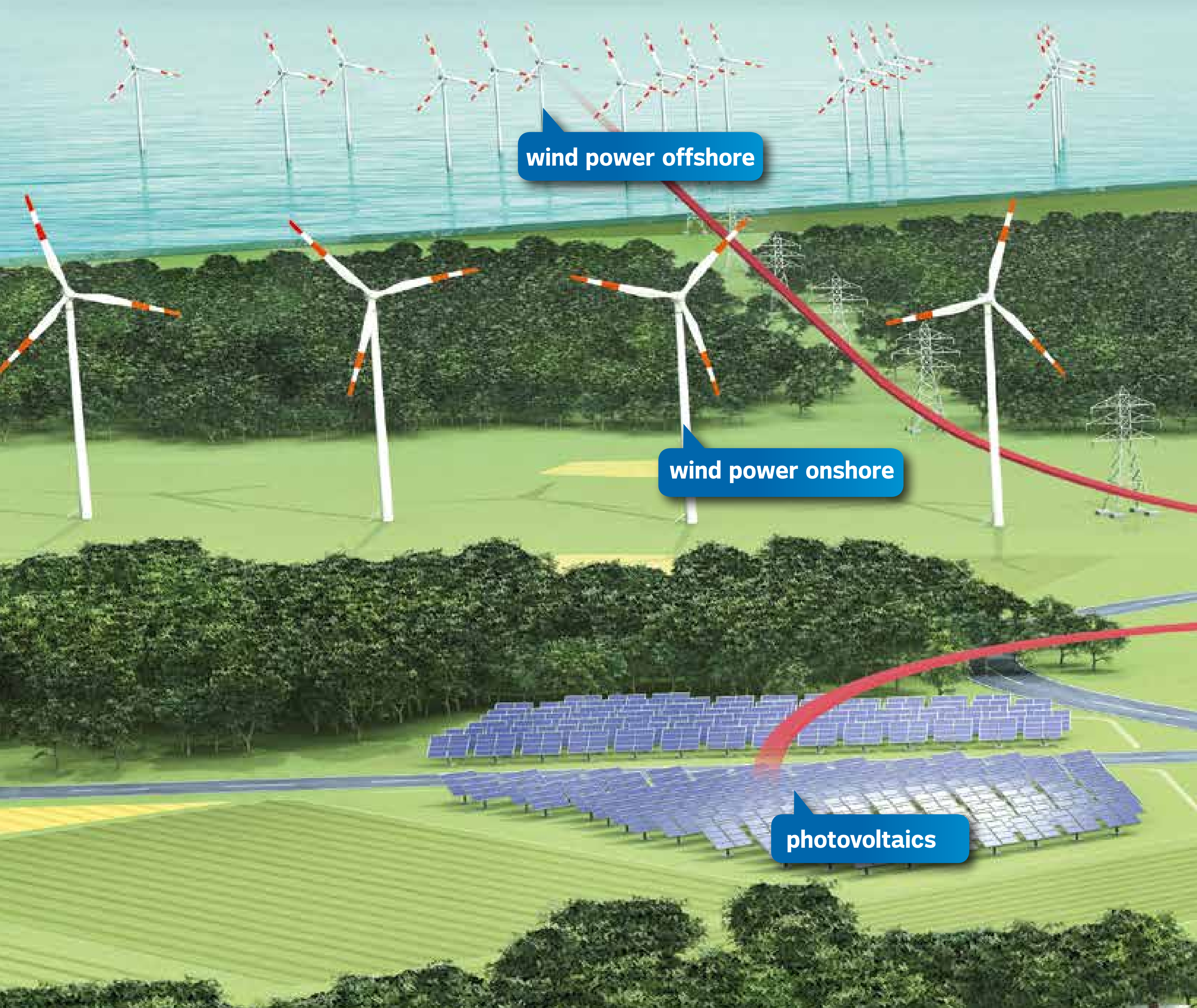
Together with differing usage hours, this has considerable effects on the ratio between installed capacity and electricity generation.

Due to their flexible mode of operation, modern lignite-fired power plants help to balance out the fluctuating feed from renewable energies in the grid.

Installed capacity and power generation



Sources: consortium energy balancing 09/2014; Federal Network Agency, 10/2014, selected energy sources

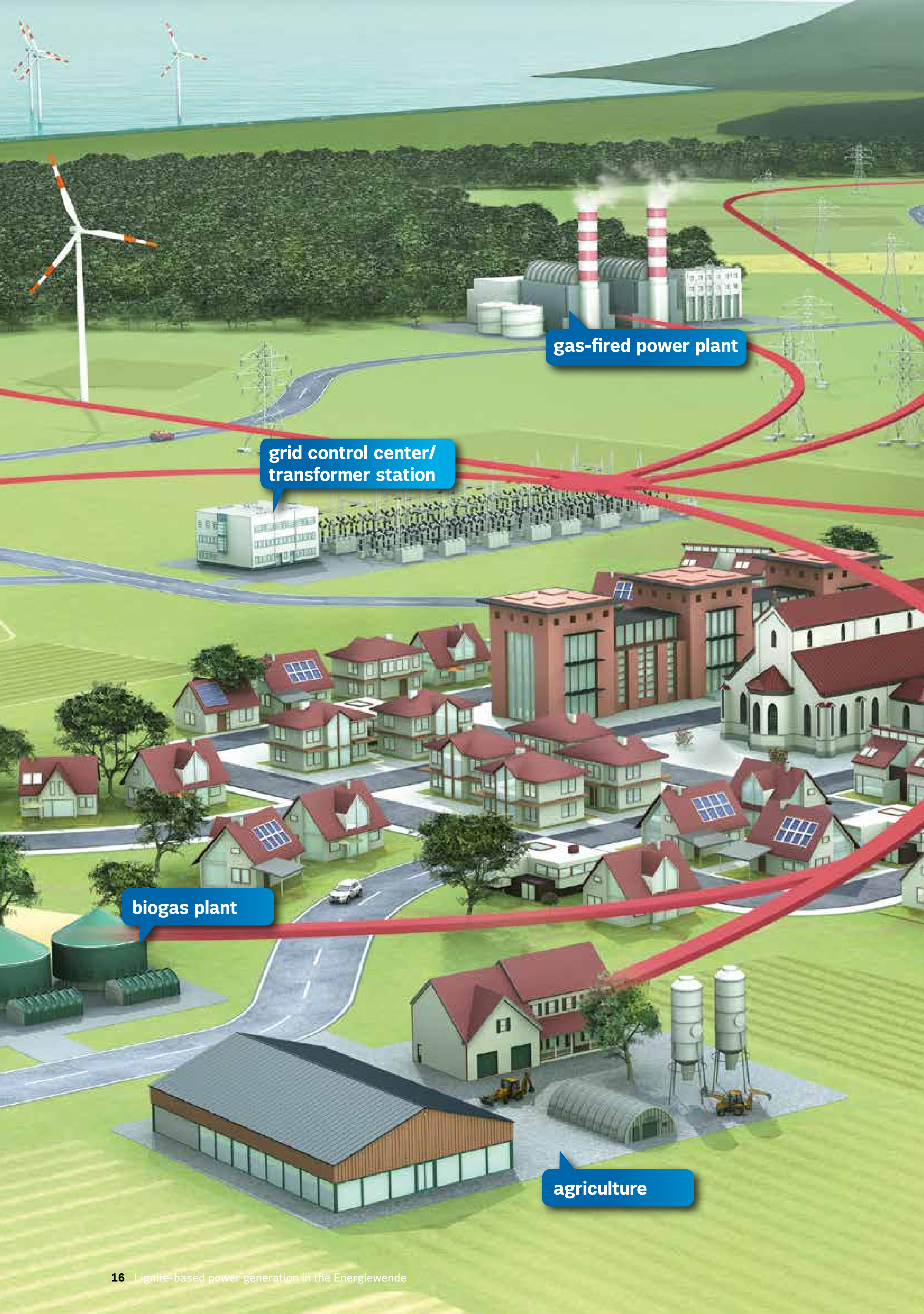


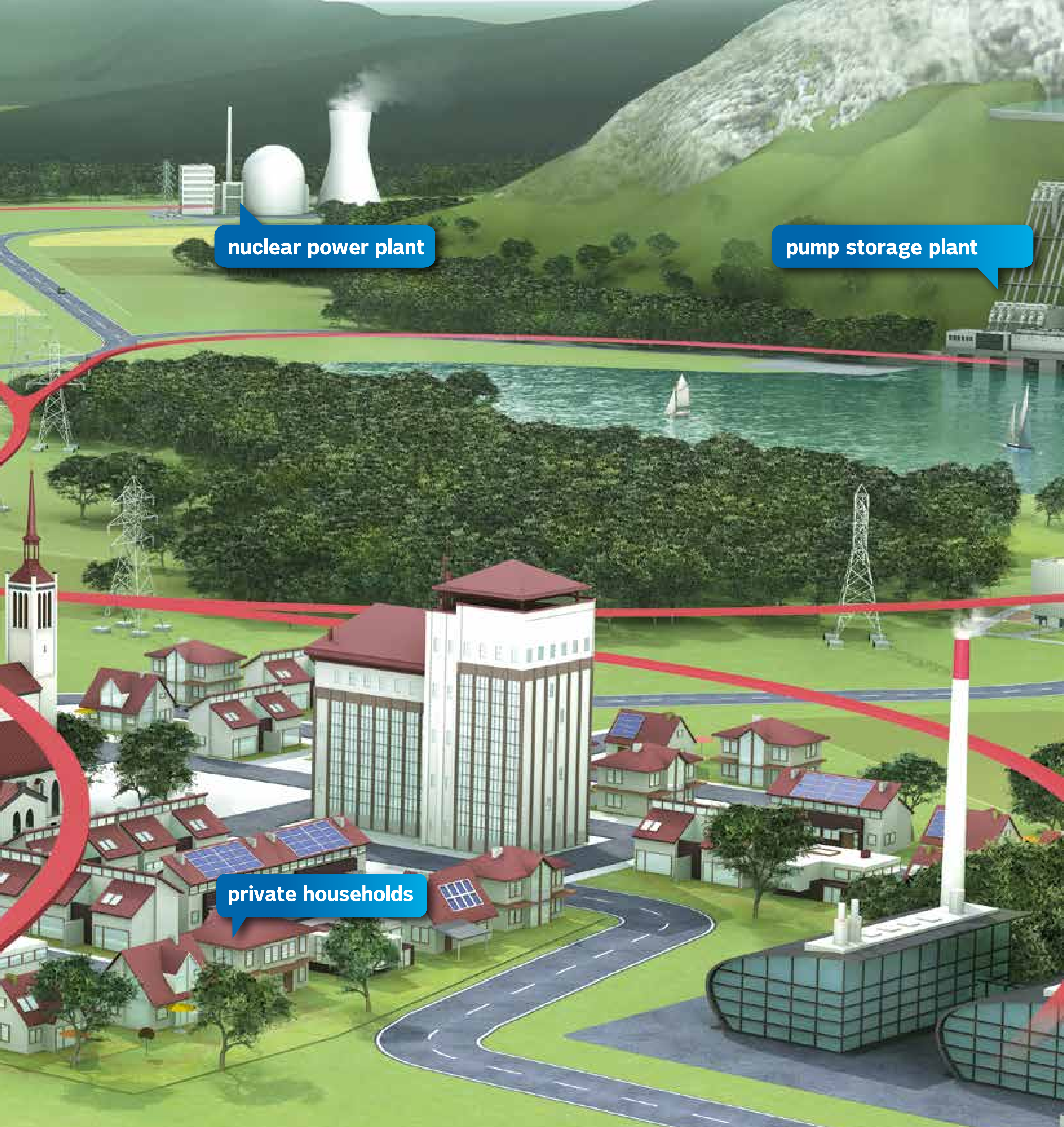
System services

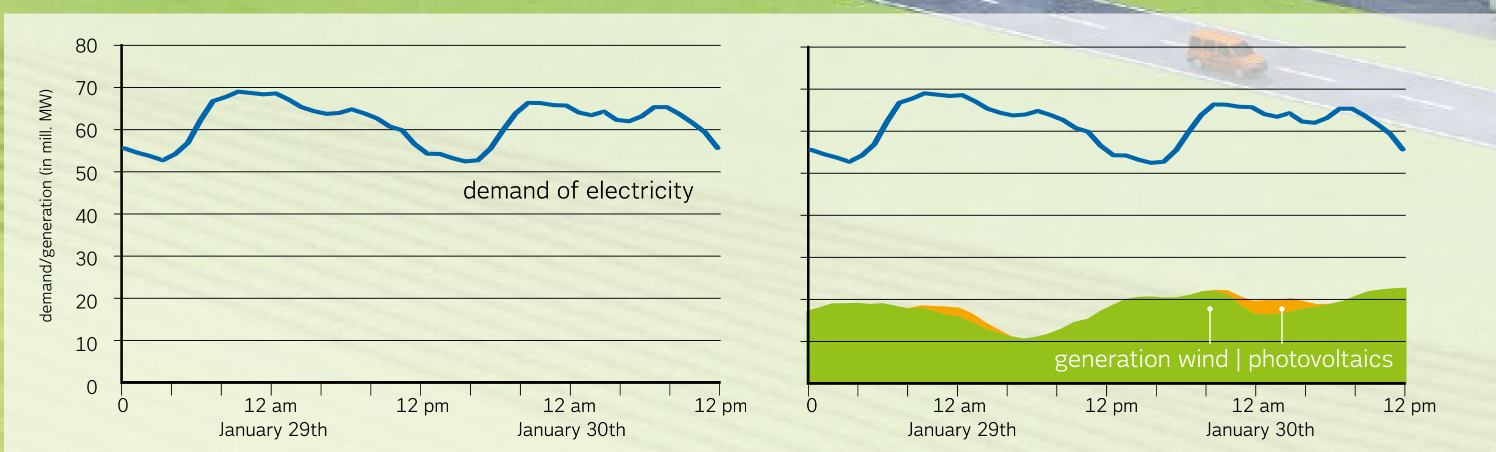
It is not only due to their high flexibility that lignite-fired power plants are an important enabler in a regenerative era.
For security of supply more is needed than just supplying electricity according to demand. There are also other “system services” which are essential for the stability of the grid and therefore for a secure electricity supply. One of these is the voltage and frequency of the electricity must always be kept constant; otherwise there can be local power outages and even extensive blackouts.
To be able to keep within the very tight limits of secure system operation alone, according to transmission system operators, there have to be between 8,000 and 25,000 MW of conventional generation capacities in operation and in the grid. Together with plants from heat-operated electricity generation (mainly CHP plants), these capacities are called “must-run capacities”. To date, photovoltaics and wind have only been able to make a limited contribution to voltage stability. Supporting the frequency, which must be kept in a tolerance range of 49.8 to 50.2 Hertz, is currently exclusively carried out by conventional power plants.

This also applies to Vattenfalls flexible lignite-fired power plants, which for decades have been reliably and smoothly carrying out this work. Due to the inexpensive fuel costs, they are considerably more economical than gas utilities in this area. And: only if the provision of system services is carried out by existing and, above all, economical plants will there be no additional costs of further required power plants.

This means that ultimately lignite will help to increase the population´s acceptance of the Energiewende, as these additional costs would ultimately have to be paid by the consumers.


gas-fired power plant
grid control center/
transformer station
biogas plant
agriculture


nuclear power plant
pump storage plant
private households


demand/generation (in mill. MW)
80
70
60
50
40
30
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10
0
demand of electricity
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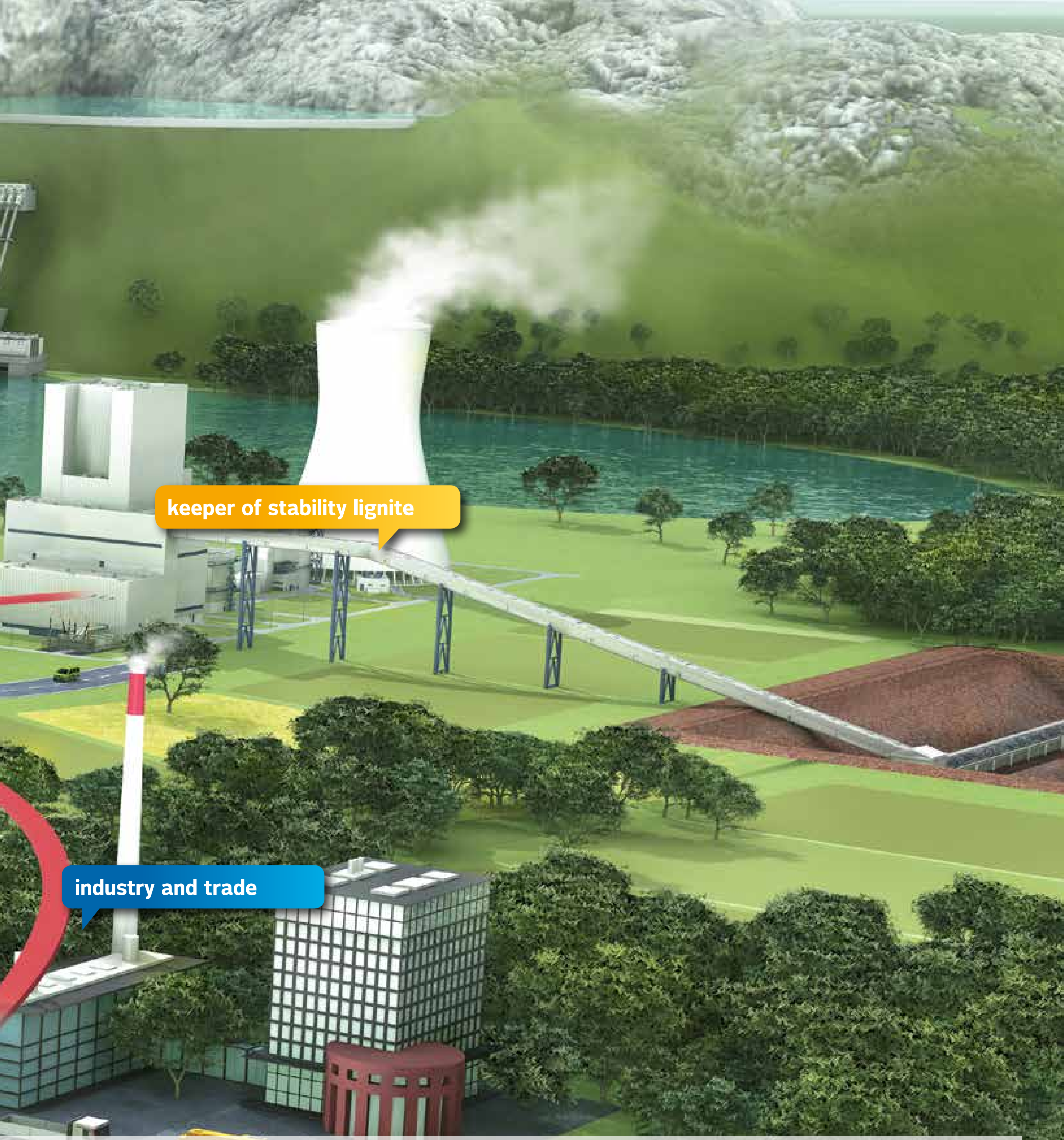
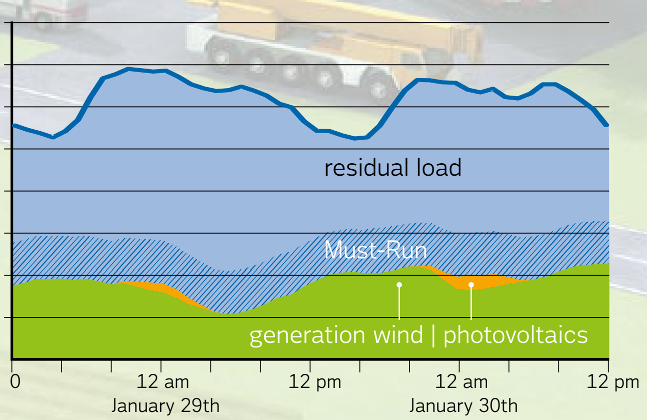
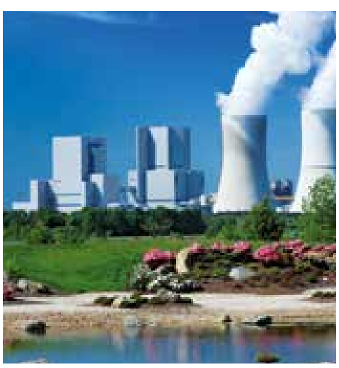




The German consumers can use electricity freely according to their demand. The difference (residual load) between the electricity needed and the priority feed of wind and solar energy, which is not based on need, must be balanced out quickly and flexibly at any time by other generation utilities in order to guarantee grid stability. In this case at least 8,000 MW conventional generation capacities must be permanently available in order to perform necessary system services (must-run).

Source:European Energy Exchange (EEX), state 02/2013 / reduced for presentation purposes)



Flexible and indispensable

On a closer view, lignite-fired power plants repeatedly prove themselves to be the "emergency service" within the grid. In order to be able to immediately balance out the feed peaks on the one hand and the deficits from renewable energies on the other hand, they now have to be able to increase or reduce their output within a very short time and round the clock.
As part of the Energiewende, this is already a daily occurrence because without this capacity for adjustment, the current dynamic growth of renewables would hardly be conceivable while keeping the security of supply.

The four lignite-fired power plants operated by Vattenfall with an installed total capacity of 9,000 MW already provide an adjustment potential of around 5,900 MW thanks to flexible ramping up and down down. This means that, from a purely mathematical perspective, they were in the position to balance out 90 per cent of the wind power installed in Brandenburg and Saxony in 2014 in a secure, reliable and cost-effective manner.

In 2014 Vattenfall´s power plants Jänschwalde, Schwarze Pumpe, Boxberg and Lippendorf provided 56 billion kWh electric power in overall.

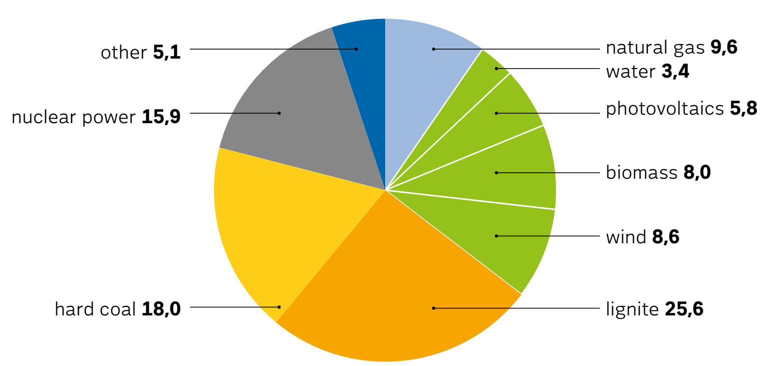
What is the electricity mix like?

More than 610 billion kWh of electricity was generated in Germany in 2014. Wind and hydro power, photovoltaic, biomass and biogenic household waste contributed 26 per cent. This is around 136 billion kWh. This means that electricity generation from renewable energies has tripled over the last ten years.

The proportion of nuclear power has reduced further, by more than six per cent since 2010, with the decision to phase it out. It will contribute zero per cent in 2022.

Last year, lignite-fired power plants generated 159 billion kWh of electricity. This means that every fourth kWh consumed in Germany comes from this domestic energy resource. The share of hard coal, at 18 per cent, has declined slightly as well as natural gas recorded a slight decrease.

gross power generation in Germany 2014



all figures in percent

source: German federal association of energy and water industry (12/2014)

The energy system of the future

A cross border electricity grid, which accepts every kilowatt hour of electricity generated and transports it throughout Europe – from Poland to Spain, from Norway to Italy.
Gigantic reservoirs where surplus energy is stored and only released when needed.
Smart household devices such as fridges, washing machines and dishwashers which switch on when electricity is cheap. Millions of electric cars, which are vehicles and storage mediums at the same time. Citizens who generate electricity and heat in their own mini power plants, but use as little as possible themselves...

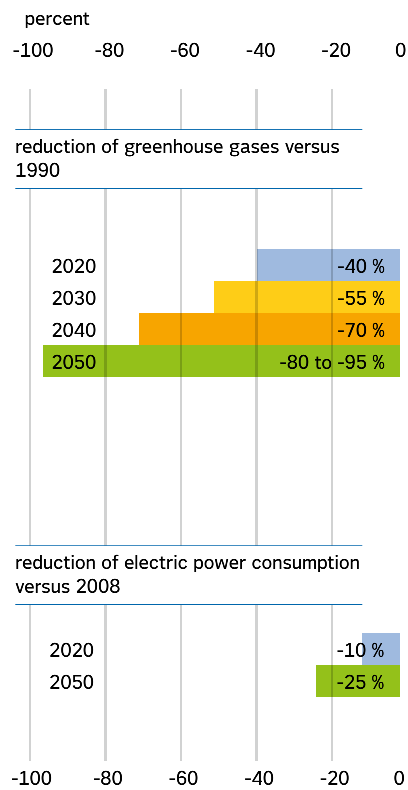
Many things are conceivable for the energy system of the future. Today experts are already designing exciting visions for tomorrow's electricity landscape. However, they all agree in one thing: We have a long way ahead of us before we reach this future.

The Energiewende is proving to be a highly complex project from a social, technical and economic perspective. To date, the German energy system has been based on energy resources with a high energy density such as uranium, coal, natural gas and oil. They can be used when they are needed. The challenge for the Energiewende is to integrate renewable energies, with their volatile electricity generation, into the system intelligently. This requires the expansion of the grid infrastructure, the development of new storage technologies and the introduction of an intelligent load and generation management. The latter includes, for example, the intelligent electricity meter ("smart meter"), which records and demonstrates visually electricity consumption in real time. This transparency can show the consumer potentials for energy saving and also visualize the success of energy saving measures that have already been implemented.

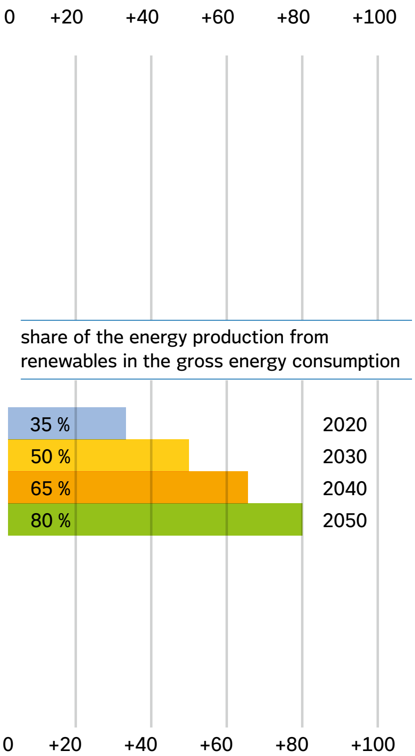
However, the energy system will continue to be determined by the premises of security of supply, economy and environmental protection in the future. Therefore it is not only the economy that is demanding a reorganization of the energy sector to keep Germany as an industrial nation internationally competitive. This also means keeping electricity prices at a reasonable level. Cost-efficient and stably-priced raw materials, such as lignite play an important role in this.

Even if the development of renewable energies continues, conventional power plants will still be indispensable for decades to come. This is because they can do something that the majority of regenerative electricity generation is currently not able to do: provide electricity reliably when it is needed.

targets of the German Government towards energy



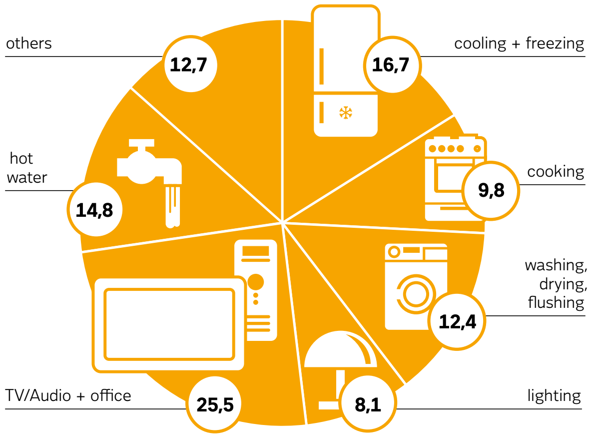
politics



Consumer

One of the greatest potentials for the development of the future energy supply lies in the hands of the consumers. An increase in energy efficiency can lead to a reduction in electricity consumption. This can be achieved using energy-saving appliances, but also by being more aware when using electricity. In this case there are not only energy saving potentials for private consumers, but also for trade and industry. One widely discussed approach is "demand side management", i.e. controlling the electricity demand on the consumer side according to the generation situation.
However, consumers can not only use electricity more efficiently, they can also generate it themselves. For houses and blocks of flats this is mainly possible by using roof solar panels and micro CHP plants (CHP = combined heat and power) for parallel production of electricity and heat. The compatibility of individual energy solutions and a socially acceptable overall system will also be one of the challenges for the future.

home appliances



all figures in percent

Sources: BDEW; EEFA 2014

Grid

A comprehensive expansion and adjustment of the grids will be essential for the energy system of the future. It is the only way to ensure that the electricity gets from where it is generated to where it is needed in this way. Transmission losses can be minimised by optimising the transmission lines. At present, up to six per cent of the electricity generated is still being lost during transport through the grid in Germany.

In addition, the grid needs to be adjusted for the increasingly decentralised electricity production. This will primarily have to be carried out using a considerable expansion of capacity. There is also an ongoing discussion about the idea of intelligent electricity grids. The "smart grid" could use the potential for active control (e.g. energy storage, shut downs and start up of plants).

Renewables

Renewables are supposed to make up the lion's share of electricity generation in the energy system of the future. The German Federal Government´s declared target is that by 2050 at least 80 per cent of electricity should come from renewable sources. Additionally, electricity consumption must be decreased by roughly a quarter compared to today, and the expansion of renewables must continue to be actively promoted.

With this, generating facilities will be predominantly built where the greatest energy yield can be expected: wind power plants onshore and offshore, and photovoltaic plants in the sunny south of Germany. There will also be further expansion of other regenerative energy sources such as biomass, geothermal and hydro power, although not to the same extent. Howeve, simultaneously securing the necessary expansion of the electricity grids and finding sustainable solutions for the future market participation of renewables is essential.

Fossil fuel power plants

Fossil fuel power plants secure a stable energy supply and will still be needed for this in the future. The competitive lignite-fired power plants in particular will continue to be a reliable partner for renewables and an important stable anchor

In times of lower electricity demand pump power storage plants, such as Hohenwarte II in Thuringia, store power by pumping water from their lower reservoir to their upper reservoir. Therefore, the upper reservoir itself becomes a kind of „electricity reservoir" which can be „tapped" as required: If there is a demand for electricity, the water stored in the upper reservoir is released and flows back to the lower reservoir through pipelines over the turbine driving the generator to produce electricity.

in the German future energy system to come due to a further increase in their flexibility and continual optimization of the lignite power generation process.

A technological change is required to be able to integrate fossil power plants into the future energy supply system in an environmentally compatible way. To meet the constantly growing demands due to an integration of fluctuating renewable energies the new generation of lignite fired power plants have to be operated in a highly flexible way with significantly less CO_2 emissions.

Innovative technologies such as the predried lignite supplementary firing at Jänschwalde power plant are a good basis to optimize existing plants.

Power storage

Power storages in the system are becoming increasingly important with the growing share of renewable energies. They are needed to help balance out the fluctuating generation of wind and photovoltaic electricity and bridge slack periods also on the long-term.
Pump storage plants are currently the only option for storing larger amounts of power for a comparatively short amount of time. Other storage technologies are currently still in their infancy. Compressed air reservoirs, power-to-gas plants or large-scale technical battery solutions are still research years away from being ready for use in the market. However this research is needed in order to be able to cover the greatest possible share of the electricity requirement with renewables in a reliable and cost-effective manner.

With a fleet of 45 vehicles, as part of the e-SolCar project, Vattenfall and the project partners are researching if electric cars could contribute to the stabilization of the electricity grid using their batteries as mobile electricity storage units. The results were fed into the ongoing E-Mobility project Smart Capital Region.

E-mobility

Electromobility will play a special role in the energy system of the future. For example, in the future electric cars will not only make emission-free travelling possible, they will also be included in load management as mobile storage units. Thanks to innovative batteries, energy will be able to be transferred both from the electricity grid into the vehicle battery and vice versa from the battery back into the grid. Using this technology, as storage units, electric cars will be able to help balance out fluctuations in the electricity grid.

What is Vattenfall working on?

With numerous activities in all of these areas, Vattenfall has been for many years already committed to an innovative, pioneering energy system. For example, with more than 1,000 wind power plants and an installed capacity of around 1,825 MWMW onshore and offshore, Vattenfall is already one of the biggest wind farm operators in Europe. The company has the largest electricity storage capacities available in Germany; there is a total of almost 3,000 MW if all its pump storage plants are put together.

Vattenfall´s plant park also includes different models of highly-efficient combined heat and power (CHP). In Hamburg, Berlin and Lusatia Vattenfall operates CHP plants, in which electricity and heat are generated in an environmentally friendly manner.

Furthermore, the energy provider is committed to various efficiency projects such as smart meter, smart grid and smart home. By using intelligent power grids and meters as well as home networks energy supply will become more efficient and reliable in the future.

The company is also working on other topics for the future of the energy industry, such as the virtual power plant. This combines decentralized energy generation plants into a linked, flexibly adjustable and centrally controllable plant system. It can thus provide power plant capacity that can be used flexibly, and therefore contribute to balancing out temporary fluctuations in the electricity grid.

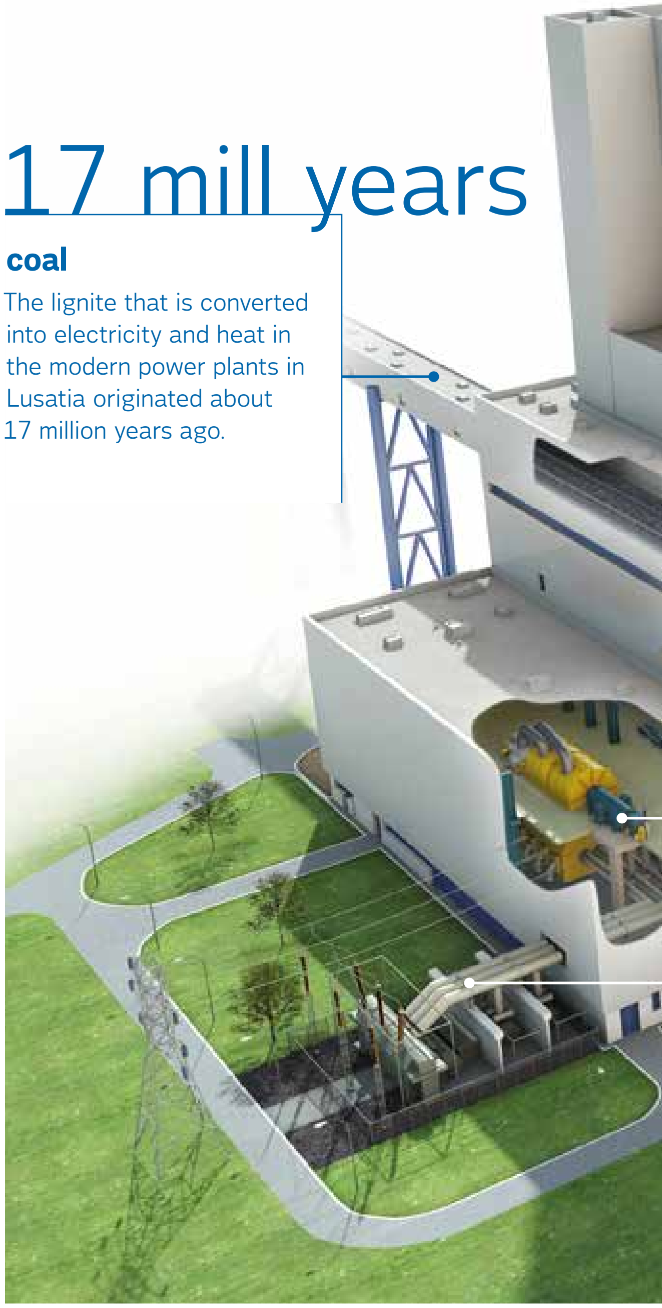
Modern lignite-based energy generation

A clap of thunder, then the last chimney collapses. When the clouds of dust have settled, the modern skyline of Boxberg power plant becomes visible against the clear October sky: light cooling towers with curved lines and shiny silver turbine halls set the tone.
They are a visible symbol of a generational change which has taken place at Vattenfall´s power plant sites since the German reunification.

17 mill years

coal

The lignite that is converted into electricity and heat in the modern power plants in Lusatia originated about 17 million years ago.

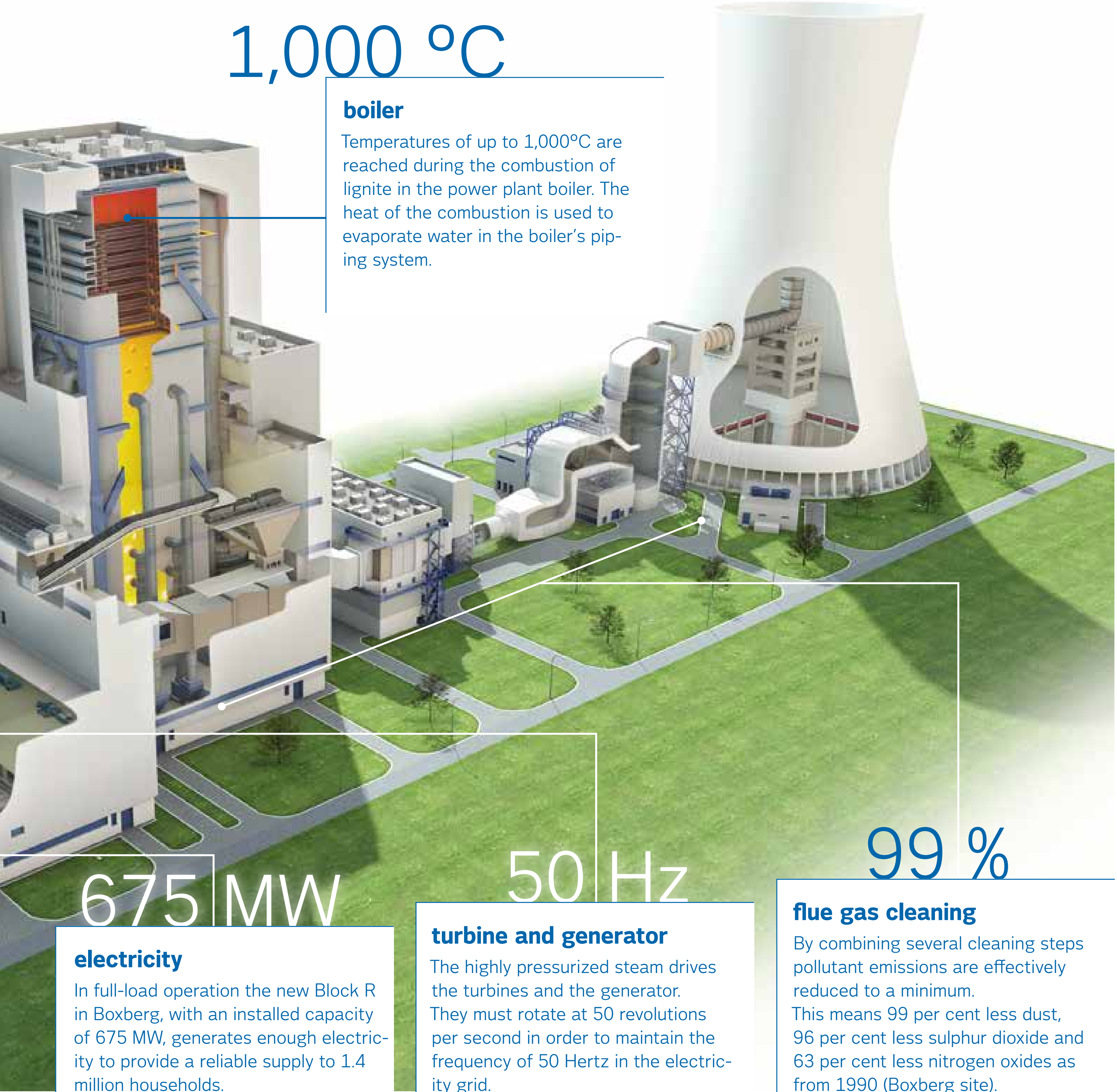


Billions of Euros were invested in existing power plant units which have been retrofitted and equipped with modern combustion and environmental protection technology. New efficient power plants have emerged. Boxberg included.

A few days after the demolition of the last chimney, BoxR, the latest and most state-of-the-art power plant unit in Vattenfall's portfolio, was inaugurated here on 11 October 2012. It combines all the features which make up a state-of-the-art power plant: efficiency, sustainability and flexibility.

With an net efficiency of almost 44 per cent, BoxR sets new standards. It is therefore clearly above the international average. For this reason the new unit is an active contribution to climate protection: The higher the fuel utilisation, the lower the CO_2 emissions per generated kilowatt hour of electricity. Overall, BoxR emits around 20 per cent less carbon dioxide than older power plant generations. Engineers estimate that efficiency levels can be increased further –from today´s view approx. 50 per cent is possible.

The flexibility of the unit, for example, reacting to fluctuations by the feed in of renewable energies cannot be underestimated for a secure current and future energy supply in Germany. Vattenfall´s other lignite-fired power plants also meet these high requirements. Their output can be varied by between 100 and 50 per cent within 20 minutes. The stereotype slow lignite-fired power plant has long gone and has been replaced by the highly flexible operation mode of the Vattenfall power plants.



1,000 °C

boiler

Temperatures of up to 1,000°C are reached during the combustion of lignite in the power plant boiler. The heat of the combustion is used to evaporate water in the boiler's piping system.

675 MW

electricity

In full-load operation the new Block R in Boxberg, with an installed capacity of 675 MW, generates enough electricity to provide a reliable supply to 1.4 million households.

50 Hz

turbine and generator

The highly pressurized steam drives the turbines and the generator. They must rotate at 50 revolutions per second in order to maintain the frequency of 50 Hertz in the electricity grid.

99 %

flue gas cleaning

By combining several cleaning steps pollutant emissions are effectively reduced to a minimum.
This means 99 per cent less dust, 96 per cent less sulphur dioxide and 63 per cent less nitrogen oxides as from 1990 (Boxberg site).

Regulation as the norm?

Adjusting to the changes in demand for electricity has become the norm rather than the exception for the lignite-fired power plant for some time now. The adjustment can be realized by precisely dosing coal and steam quantities. So for example when electricity consumption decreases then less lignite is fed into the boiler. This also reduces the amount of steam which reaches the turbines. If the electricity consumption increases then the quantity of coal and therefore the steam generated is increased accordingly. This way lignite fired power plants help to regulate and maintain the balance between electricity generation and use, thus keeping the grid frequency of 50 Hertz stable.

How electricity is produced from coal

Lignite – a domestic resource
Lignite is Germany's most important energy resource. Nearly 40 per cent of the German primary energy production comes from it. More than 178 million tonnes of lignite were mined in Germany in 2014, and about 90 per cent of that was for electricity and heating production.

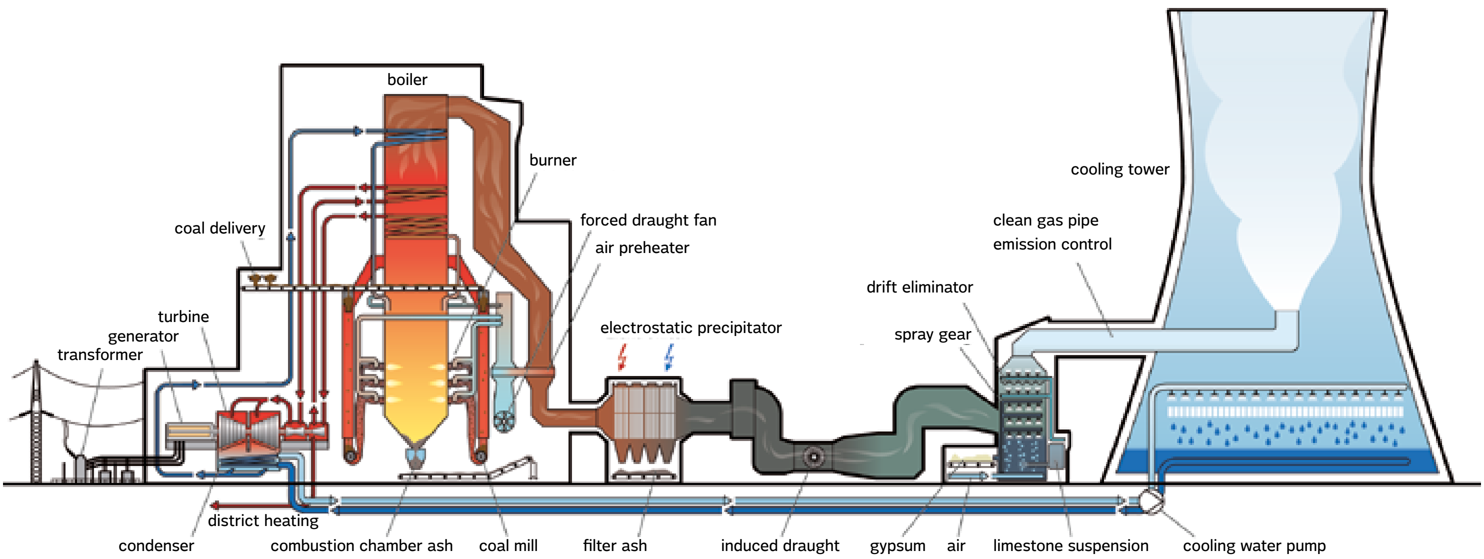
62 million tonnes of this amount was mined by Vattenfall's pitmen in Lusatia . Due to the close proximity of the open-cast mines to the lignite-fired power plants, the security of supply is reinforced.

From raw material to electrical energy
In the power plant, lignite from the coal bunker is transported to the power plant unit via conveyor belts. There it is milled to dust and it is then blown into the combustion chamber of the boiler. It is fired at a high temperature here, thereby heats water to generate steam. The steam is led across the individual blades of the turbine and makes the turbine spin at high revolutions. At one end of the turbine shaft, electricity is produced by a generator. The kinetic energy of the turbine shaft is transferred to the generator which converts it into electricity like the dynamo of a bicycle. After passing the turbine, the steam is condensed and returned to the steam boiler to be reheated again. The electrical energy is fed at a voltage of 380 kilovolts via overhead lines to switchgears and from there it is fed into the extra-high voltage grid.

Water ensures the right temperature
To generate steam and for cooling purposes, the power plant needs water which mainly comes from dewatering the opencast mine. It is thoroughly purified and processed before it is reused. Process water is used a number of times in order to keep the power plant water requirements low. Technological waste-water is cleaned and fed back into the general water circuit without compromising the quality.

What about the environment?
The combustion of fossil fuels produces flue gases, which mainly include nitrogen, steam and oxygen, but also dust, sulphur dioxide, nitrogen oxides and carbon dioxide. Through a combination of highly effective measures, such as low nitrogen oxide combustion, flue gas particulate removal using electro filters and flue gas desulphurisation, pollutant emissions are considerably and effectively reduced. With the increased efficiency, the CO_2 emissions per kilowatt hour of generated electricity decrease.
Limestone is needed for flue gas desulphurisation. It is mixed with water and used as a reactant, binding the sulphur dioxide contained in the flue gas desulphurisation plant (FGD plant). The resulting gypsum, a product of the reaction, is processed further in the construction materials industry.

A bonus in the form of heat
Part of the waste heat created in the energy conversion is removed from the process and used for supplying district heat. This way fuel utilisation is increased and there is no need for additional generation at another location – a contribution to the good of the environment.



Flexibility and efficiency lead to success

An interview with Hubertus Altmann, power plant board member of the Business Unit Lignite Mining & Generation at Vattenfall, about the Lusatian lignite-fired power plants and their future

With the Energiewende, Germany is planning to secure the electricity supply to a large extent from renewables. What role will conventional energy sources, lignite in particular, play in the future?
The trend is moving towards renewables. But I am certain that lignite will also play a role in the energy mix of the future. It has an undisputed advantage over other energy resources: The fuel costs are calculable on the long-term. This “price guarantee” is a key point in the cost analysis.

„Todays technical development is a good basis to bring the Energiewende to success – with flexible and efficient power plants.“

The question is: What proportion of the German energy mix will it make up in the future?
Renowned economic research institutes such as Prognos say that in the future Germany we will need capacities of between 20.000 and 50.000 MW for base load generation. Nuclear power plants will be decommissioned in a few years. This means that only lignite and hard coal fired power plants will be left for base load generation. In Germany we currently have around 20.000 MW installed capacity in lignite-fired power plants. I am convinced that we have to retain this capacity on the long-term. This would be in line with the forecasts of the minimum operation scenario. Lignite will continue to play a considerable part in the future energy mix in the next four to five decades.

What will the power plant of the future look like?
Highly flexible and efficient. Some lignite power plant´s control capabilities are now only slightly behind gas power plants. There is further potential of flexibility in current tried and tested technology such as ignition and supplementary firing with pre-dried lignite. The highly refined fuel is also the key to higher efficiency. For power plants fired with pre-dried lignite an increase of five percentage points can be expected which is equivalent to a net efficiency of around 50 percent. This means: reduced fuel input, lower operating costs, less CO_2.

It has already been possible to reduce CO_2 emissions significantly in existing plants by increasing efficiency. Todays technical development is a good basis to bring the ‘Energiewende’ to success– with flexible and efficient power plants. At this point I see there is still a lot of work for the coming years.

„I am certain that lignite will play a role in the energy mix of the future.“

Into the future with energy

In order to continue to guarantee the high level of service reliability we are used to in partnership with a growing proportion of renewable generation, lignite-fired power plants will need to react even quicker, more consistent and more variable then they already are today.

A few years ago, there was a clearly defined task for the lignite-fired power plants in Lusatia: They consistently helped to secure the base load for the electricity supply. In the process, the resource lignite was used increasingly efficiently, and the emissions levels were constantly reduced. This is how German power plant engineers became world leaders in the industry.

Today they are faced with another technical challenge. An increasing amount of renewable energy being fed into the grid calls for a high degree of flexibility from the power plants.

While the power plants were previously shut down once a year for maintenance work, now the power plant technicians have to expect that the future individual units will have to switch between the minimum capacity and maximum capacity modes up to 100 times per year – so roughly every third day.

It becomes particularly problematic if the output has to be lowered far below 50 per cent of the installed capacity. So far some units need to be shut down when this is the case, which has consequences for power plants and grid operators: Each restart takes time and increases the maintenance work.

Increase consistency

Therefore the aim is to upgrade power plants so that their minimum load can be reduced as far as possible. The power plants will remain running “in idle mode”; they will stay warm and then will be able to be started up quickly.

Supported by national universities and colleges, various investigations are currently underway at the power plant sites Jänschwalde, Schwarze Pumpe, Boxberg and Lippendorf with the aim of increasing the flexibility of the power plants.

Initial results show that sites that are made up of several small units have an advantage. They react even more flexibly than those whose capacity is generated in just a few large units. Amongst the modern single unit Boxberg R, the Jänschwalde power plant site with its twelve boilers and six units is now already comparable with hard coal power plants and gas utilities in terms of flexibility. The duo construction (two boilers to one turbine) allows the load of individual power plant units to be reduced to 33 per cent of the installed capacity.

Increase speed

In addition to the so-called controlling power range, i.e. the range than can be controlled between the maximum and minimum load, in which the boiler can still be operated, the control speed (known as load change speed) is a decisive factor in flexibility. Engineers believe there is also scope for improvements here. By adjusting the mode of operation they can reduce reaction times further.

In principle, the speed is “only” a question of digital control. However, a power plant works with an interaction of hundreds of components. These are designed for a specific mode of operation. If this is to be changed then each individual component will need to be examined for its suitability. These investigations primarily identify weaknesses. In this case the trend is clearly moving towards slim components. Thick-walled materials are more temperamental and slow in their reactions to temperature changes.

Focus on combustion technology

The investigations, with Brandenburg Technical University (BTU) Cottbus among others, are focused on the burners and ignition processes, in order to be able to operate power plants “at a low flame” if possible. This can be demonstrated by the new flame monitor at Block Q in Boxberg. It ensures that even with a low fuel supply, the flame in the boiler remains stable. The use of the automatic monitor provides an additional increase in flexibility of at least 15 to 20 per cent of the installed capacity, or around 160 MW.

There is a potential of more important percentages by equipping the power plants with dried lignite ignition and auxiliary firing. In addition to improved start up and shut down properties, this measure will primarily allow for considerably more stable operation at a low load range. This is because: Large power plants need a "jump start" in order to start up. Previously the boiler was fired up using oil burners. However these burners are not suitable for permanent auxiliary firing, i.e. for the operation of the power plant unit in "idle mode".

Therefore in a pilot project in 2014 the first steam boiler in Jänschwalde will be converted to an electrical dried lignite burner. This way the unit´s minimum load will be reduced from 500 MW to around 100 MW, i.e. to 20 per cent of the installed capacity. Further units in Lusatia will follow.

The dried lignite for the process comes from the Schwarze Pumpe site. Vattenfall tested the procedure of pressurized fluidized bed drying (PFBD) in a pilot plant here from 2008 to 2012 in partnership with universities. The new drying procedure reduces the residual moisture of lignite to around 12 per cent before combusting it in the boiler. In contrast pit-wet lignite has a water content of around 50 per cent. The use of pre-dried lignite can therefore not only increase the flexibility of the power plants, but also increases the efficiency and therefore reduces CO_2 emissions. Vattenfall's PFBD plant has been in commercial operation since February 2013.

Keeping one's eyes on the target

By taking several small steps Vattenfalls engineers have already optimized power plants and will consequently continue. There are ideas for example: when the output of the power plants is reduced, to use the exhaust heat, which now blows out unused, and store it in the boilers to reuse it when starting up the turbines, thus saving both energy and time.

The aim is to make lignite-fired power plants so flexible that they provide a similar control capability as gas utilities. In modern combi power plants (gas and steam turbine operation), the technical minimum load is between 20 and 40 per cent of the installed capacity. Lignite-fired power plants already have a minimum load between 33 to 40 per cent.

This availability for adjustment, and also the reliability and efficiency of Vattenfall's modern lignite-fired power plants will also be required in the future to secure the electricity supply in Germany as a partner for renewables energies.

The controllability of power plants depends on complex basic conditions. These include, among others, the number of units and main components (e.g. steam generators per power plant) and the standby situation to provide system services. There are also contracts with internal or external industrial consumers to supply district heat and or steam. There are also other contracts involving (f.e. co-combustion of secondary fuels and gypsum deliveries to the construction material industry).

Lignite and renewables – partners in the Energiewende!

The past few years have shown that the transition to increasingly flexible lignite-fired power plants is in no way a contradiction to high capacity utilization. In spite of considerable renewable electricity generation, they achieved a high number of usage hours.

With 55 billion kWh, last year Vattenfall's lignite-fired power plants generated more electricity than they have since the start of the 1990s.

At the same time in the 50 Hertz control area, the grid area where the power plants are located, the targeted share of renewable energies for overall Germany for 2020 – more than 40 per cent – had been already reached. Combined with the increasing feed of hardly controllable renewable energies, it is particularly important to keep the lignite units at the minimum load on the grid for the increasingly frequent extreme situations.

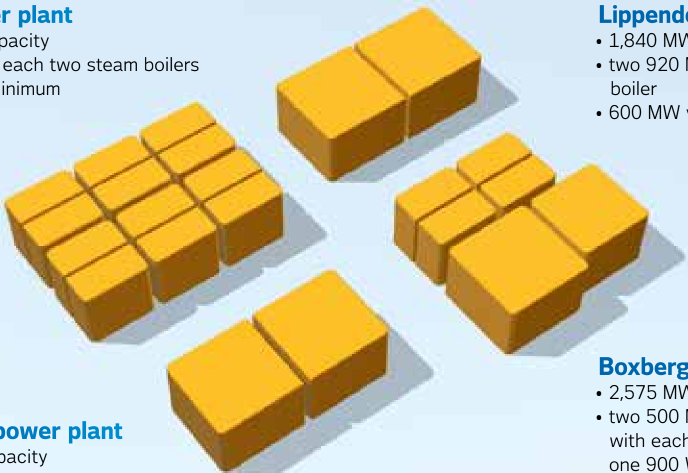
Only this way it will be possible to provide the system services such as frequency and voltage stability which are demanded by the grid operators and are so important for the stability of the energy supply system. In particular the ability to ramp -up again quickly after temporary reductions ensures competitive electricity generation from lignite. If, on the other hand, there were insufficient flexibility then the contribution of lignite to the electricity supply in these periods would have to be supplied by other forms of generation (e.g. natural gas).

With the phasing out of nuclear power, which has previously also contributed to the base load supply and provision of system services, lignite will gain importance in the coming decades. It supports the integration of renewables into the energy system of the future and, as a reliable partner, adds a valuable contribution to stability and the security of supply.

The flexibility of Vattenfall´s lignite-fired power plants

Jänschwalde power plant
- 3,000 MW installed capacity
- six 500 MW units with each two steam boilers
- 1,200 MW valid load minimum

Lippendorf power plant
- 1,840 MW installed capacity
- two 920 MW units with each one steam boiler
- 600 MW valid load minimum



Boxberg power plant
- 2,575 MW installed capacity
- two 500 MW units (plant site III) with each two steam boiler, one 900 WW unit (plant site Q) and one 675 MW unit (plant site R) with each one steam boiler
- 700 MW valid load minimum

Schwarze Pumpe power plant
- 1,600 MW installed capacity
- two 800 MW units with each one steam boiler
- 600 MW valid load minimum

Glossary

Energiewende
The German Federal Government's energy concept from 2010 already included key elements of the "Energiewende" from 2011: a considerable increase of the share of renewable energies in gross electricity consumption to 80 per cent by 2050, a complete phasing out of nuclear power and a reduction of greenhouse gas emissions by 80 per cent by 2050.

Energy mix
This term is understood to mean the supply of electricity generated from various energy sources such as lignite, hard coal, nuclear power, gas and oil, as well as renewable energies such as wind, solar and hydro power to an economy.

Renewables
Renewable energies are natural energy resources where the energy sources are either permanently available or can be regenerated/recreated within reasonable periods of time. Above all, these include solar energy, wind energy, hydro power, energy from biomass and geothermal power.

Renewable Energies Act
The Renewable Energies Act governs the preferred feeding of electricity generated from renewable sources into the electricity grid. The generation of electricity from hydro power, biomass, geothermals, wind energy and solar radiation energy (e.g. photovoltaics) is subsidized. According to the Renewable Energies Act, the nearest public grid operator is obliged to connect appropriate electricity generation facilities for the priority acceptance of the generated electricity and to pay remuneration stipulated by law.

Frequency
The frequency at which the European electricity grid operates is 50 Hertz. It is the duty of the grid operators to keep this frequency stable at all times. This means that the energy provided must be balanced out by an equally high energy demand at any given time. If the equilibrium between the use and provision becomes imbalanced then there are frequency fluctuations and, as a result of this, power outages.

Hertz (Hz)
Hertz is the unit of frequency named after the German physicist Heinrich Hertz (1857-1894). One Hertz corresponds to one complete oscillation per second.

Installed capacity
The installed capacity designates the maximum electrical capacity of the generators in a power plant. It is given in the unit Watts and multiples such as Megawatt (MW, 1 MW = 1,000,000 Watts) or Gigawatt (GW, 1 GW = 1,000,000,000 Watts). It is only possible to use the installed capacity to conclude the actual electricity generation for power plants operating at base load.

Running water power plant
Running water power plants dam a river and guide the water flowing from the upper to the lower reservoir through turbines which drive generators and thereby generate electricity. They therefore generate electricity continuously, but the amount fluctuates with the water level of the river. Their capacity lies in the range of a few kilowatts to a couple of 100 MW. In contrast to barrage dams, running water power plants mostly only dam a river with a low difference in levels, often of less than ten metres, and are also not able to store this dammed water.

Grid usage fee
The grid usage fee is the state-regulated fee for the transport and distribution of the energy by transmission system operators and the local distribution grid operators. Roughly a fifth of the electricity price is based on the price for grid usage. For industrial customers, who are connected to higher voltage levels, the share of the grid usage fees is considerably lower.

Smart grid
The smart grid manages the flow of electricity between producers and consumers using digital data transfer technologies. It enables a better exchange of information about the supply and demand for electricity. In this way it is possible to make better use of the large fluctuations in wind and solar energy generation.

Smart meter
Smart meters record electricity consumption in real time. They offer the end consumer the possibility to see detailed information on their own electricity consumption and quickly recognize possible savings.

Voltage
The electrical voltage specifies the difference in the electrical charges between two poles. If a connection is created between the poles then a discharge occurs and an electrical current flows.

System services
System services are all services which are provided by power plant and grid operators additionally in order to ensure the quality of the electricity supply at all times, in particular guaranteeing a stable voltage and frequency (50 Hertz).

Volatile feed
"Volatile" has Latin origins and means "changing". Accordingly, volatile feed in means that wind and solar electricity is not always available when it is needed, but instead only when the wind blows or the sun shines. The fluctuations in the feed must be balanced out by other power plants. This demands a high level of flexibility from these power plants.

Virtual power plant
The virtual power plant combines decentralised, usually small energy generation assets such as photovoltaic plants or wind farms, block heating plants and heat pumps, into a networked, centrally controlled plant system which can be flexibly adjusted. The aim is to provide flexibly applicable power plant capacity which contributes to balancing out temporary fluctuations in the electricity grid.

Efficiency
Efficiency refers to the ratio of expenditure and achieved benefits. The electrical generation efficiency (Eta) is a measure for the efficiency of energy conversion and describes the ratio of output energy to input energy.

Vattenfall – A European energy company

Vattenfall is one of the largest electricity generators in Europe and the largest generator of heat. The company is 100 per cent owned by the Swedish State.

Vattenfall operates in Sweden, Germany, the Netherlands, Denmark, UK and Finland. Vattenfall's vision is to play a leading role in the development of a sustainable energy supply by having a strong and diverse generation portfolio in place.

The strong backbone of the German generation division is provided by Vattenfall Europe Mining AG (responsible for lignite mining in Lusatia) and Vattenfall Europe Generation AG with its lignite-fired power plants and gas utilities in Brandenburg and Saxony as well as pump storage plants in central Germany.

Vattenfall is not only an important energy supplier it is also one of the largest employers and training organisations in eastern of Germany. The demand for goods and services in turn secures thousands of jobs in other companies. Active promotion of new technologies for a responsible use of raw materials gives momentum to the entire region.

i The Lusatian Lignite Mining Area

All activities for the recovery, refining and conversion of the domestic energy resource into electricity are concentrated in the Lignite Mining & Generation Business Unit (BU). BU Lignite operates five open-cast mines and three power plants in the Lusatian Lignite Mining Region. Vattenfall also operates the Lippendorf power plant near Leipzig and owns one of the two units. At the refining centre in Schwarze Pumpe briquettes, pulverized and fluidized bed lignite is produced from Lusatian lignite.

BU Lignite is managed from Cottbus. It has more than 8,000 employees, including 670 apprentices. In 2014 a total of 61.8 million tonnes of Lusatian lignite was extracted and 55.9 billion kWh of electricity was generated from lignite. This means that every tenth kilowatt hour of electricity used in Germany comes from Vattenfall's Lusatian lignite-fired power plants.

Further links

Vattenfall: www.vattenfall.de
European Energy Exchange: www.eex.de
Energy Strategy of the German Government: www.bundesregierung.de/Webs/Breg/DE/Themen/Energiekonzept/_node.html
German Energy Agency(dena): www.dena.de
German Federal Association of energy and water industry: www.bdew.de
Federal Network Agency: www.bundesnetzagentur.de
Network development plan of the four Transmission System Operators: www.netzentwicklungsplan.de
50Hertz Transmission GmbH: www.50Hertz.de

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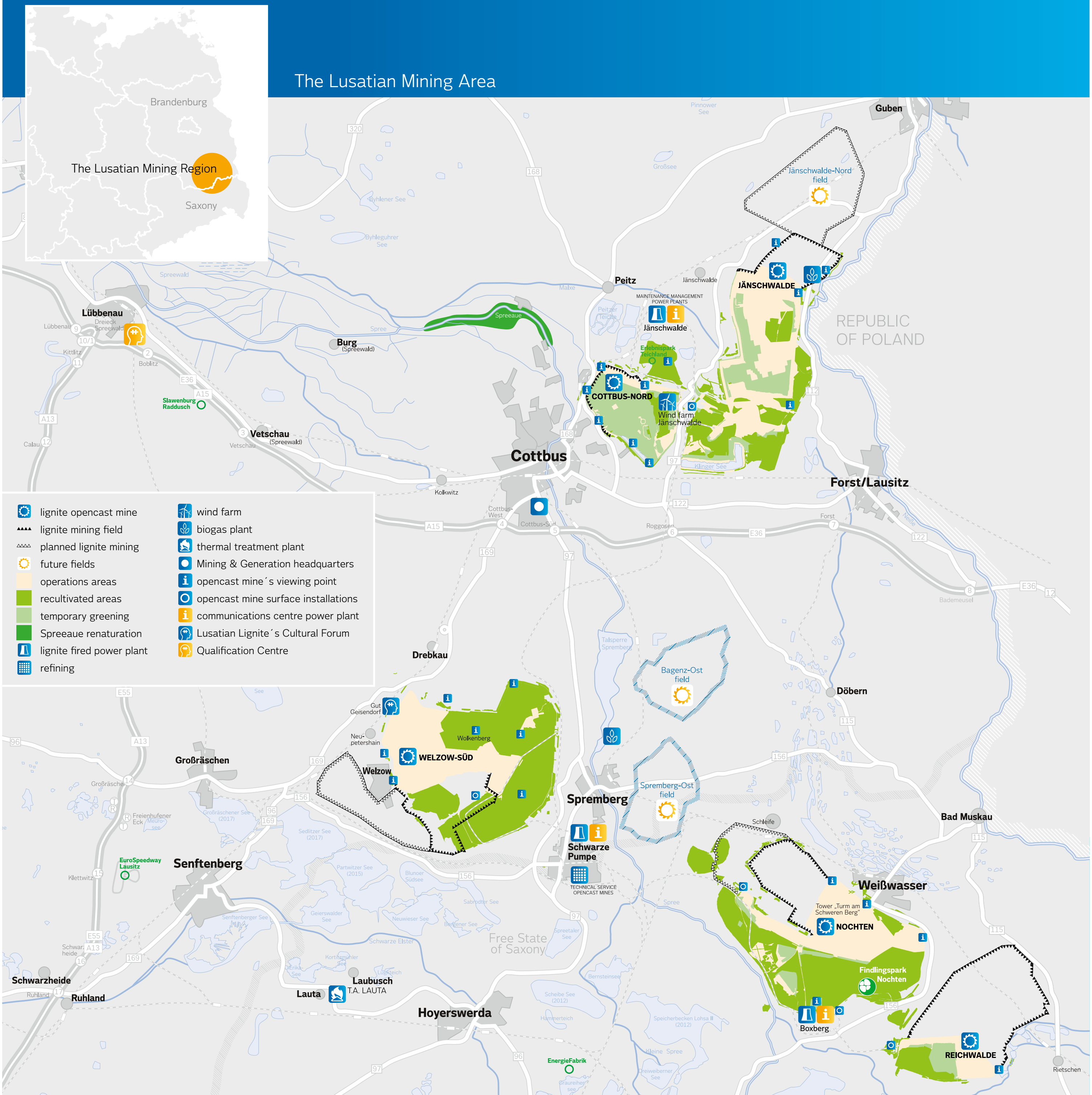
The Lusatian Mining Area



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