

Journal 2016

RESPONSIBILITY

NEW START

DIALOGUE

AMPRION – A BRIEF PROFILE

Amprion GmbH is one of four transmission system operators in Germany.

The company can draw on many years of experience in planning, constructing and operating the extra-high-voltage grid. Amprion employs a workforce of around 1,250.

~63 GW

the total installed generation capacity in the Amprion grid area.

79,200 KM²

the area covered by the Amprion grid, stretching from Lower Saxony down to the Alps.

11,000 KM

the total length of power lines that make up the Amprion transmission system; it is Germany's longest EHV grid.

~29 M

the number of people supplied with electricity via the Amprion grid.

~170

the number of substations that connect the Amprion grid to the downstream distribution systems.

THE AMPRION GRID



GRID EXPANSION AT AMPRION

2,000 KM

the total length of upgraded and new extra-high-voltage lines Amprion intends to build by 2026.

€ 5.6 BILLION

the amount Amprion will invest in grid expansion by 2026.

510

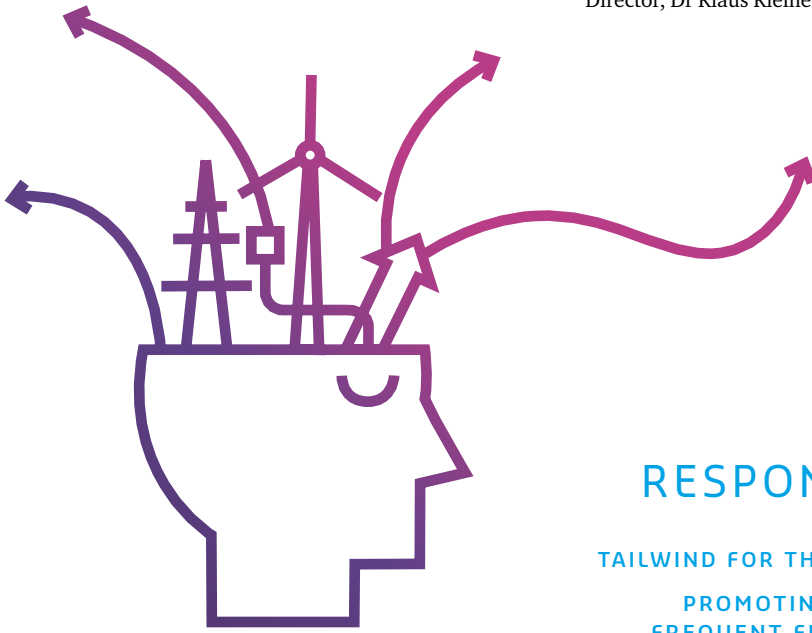
the number of dialogue events Amprion held in 2016 on the topic of grid expansion.

As a transmission system operator active in Germany and Europe, we're helping to shape the NEW START *[page 10]* into the energy world of the future. Our power lines are the lifelines of the national economy. By operating and expanding our network, we're assuming our share of RESPONSIBILITY *[page 28]* for guaranteeing a reliable power supply in the era of the energy transition. To enable us to overcome the challenges of this transition, we're developing innovative solutions and actively engaging in direct DIALOGUE *[page 42]* with citizens, politics and business.

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POWER TO THE FUTURE

The energy transition poses a massive challenge to system operators, grid component manufacturers and scientists alike. It depends on how ingenious and innovative they are, say Prof. Armin Schnettler and Amprion's Managing Director, Dr Klaus Kleinekorte.



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FRESH THINKING

Innovations are crucial to Amprion. Employees are busy developing new concepts, integrating innovative technologies and finding solutions for the energy world of the future.

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TAILWIND FOR THE REGION *_pages 30–35*

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DIGITALISATION IS
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TAILWIND FOR THE REGION

Amprion is investing more than 500 million euros in grid expansion every year. This is guaranteeing jobs in small and medium-sized businesses – such as in the construction industry.

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PROMOTING FLEDGLING FREQUENT FLYERS

Is that a nest on that pylon? Amprion’s bird protection experts are helping birds of prey, such as Eurasian hobbies and peregrine falcons, to nest at dizzy heights.



DIALOGUE

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AGREED!

Getting public approval for a grid expansion project – is that possible? Yes, if citizens, town and parish councils and grid operators work together in a spirit of mutual trust. Here’s an example of how it’s done.



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THE DIALOGUE FACILITATORS

People like Jonas Knoop are the “face” of Amprion – in contact with local residents, authorities, clients, service providers and potential new employees.



PROF. ARMIN SCHNETTLER AND DR KLAUS KLEINEKORTE

spend a great deal of their time imagining and predicting how the energy world is going to look in 20 years' time. To ensure we're properly equipped for this future energy world, we need to initiate innovations right now.

POWER TO THE FUTURE

The energy transition poses a massive challenge to system operators, grid component manufacturers and scientists alike. The success of this transformation depends on how ingenious and innovative they are, say Prof. Armin Schnettler, Head of Research in Energy & Electronics at Siemens Corporate Technology, and Dr Klaus Kleinekorte, Managing Director and Chief Technical Officer at Amprion.

PHOTOS · MARCUS PIETREK INTERVIEWER · VOLKER GÖTTSCHE

INNOVATION IS AN IMPORTANT ENTREPRENEURIAL CONCEPT. BUT WHAT PRECISELY ARE INNOVATIONS?

DR KLAUS KLEINEKORTE For Amprion, innovations are new and sustainable solutions that we require for the energy transition. They are hugely important from a strategic point of view, because they help us to fulfil our duty as a transmission system operator.

PROF. ARMIN SCHNETTLER For us at Siemens, innovations are characterised by the transfer of new know-how to products that prove their value in the field. Without them, we, as a technology provider, would not survive. We systematically analyse technical developments and market trends in order to then invest strategically in those that are of most relevance to us, including ones that are disruptive.

KLEINEKORTE Take this example: we are innovative when we transfer successful technologies from one field to another field – with fascinating results. If someone had said to me 20 years ago that Amprion would be involved in the development of a tunnel boring machine, then I would have said, “I’m an electrical engineer. What has my job got to do with these moles?” Today, we need the technology that was used, for instance, to drill the new Gotthard Base Tunnel for installing underground cables – just a much smaller version, of course.

THE ECONOMIST JOSEPH SCHUMPETER LINKS INNOVATIONS WITH THE “CREATIVE DESTRUCTION” OF THE OLD. IS THAT WHAT IS CURRENTLY HAPPENING IN THE ENERGY INDUSTRY?

SCHNETTLER We are indeed experiencing more disruption in the energy supply industry than evolution. “Decarbonisation” is perhaps the biggest challenge currently faced by mankind – the switch from fossil and nuclear to renewable energy sources. We need to completely rethink our energy supply – technically, structurally and commercially.

» We cannot say, 'Let's wipe the slate clean and start all over again.' We are in the process of making a paradigm shift to renewables, but we have to be able to continue to operate our grid safely and reliably.«



DR KLAUS KLEINEKORTE

KLEINEKORTE That is not possible in the real world. We cannot say, "Let's wipe the slate clean and start all over again." We are in the process of making a paradigm shift to renewables, but we have to be able to continue to operate our grid safely and reliably. This is one of our duties as a transmission system operator. There are days we ask ourselves whether it is actually possible to combine the two, but so far we have always managed it. I have complete confidence in the engineering skills we have here at Amprion.

SCHNETTLER We have to achieve disruption without making the energy supply system vulnerable. And we have already travelled quite a long way down this road. Twenty years ago, we believed the system would be capable of integrating no more than ten per cent of its total capacity in the form of volatile photovoltaic and wind energy. Today, we are studying how we can operate the system with more than 80 per cent renewable energy sources.

WHAT TECHNICAL INNOVATIONS NOW AVAILABLE WOULD YOU HAVE NEVER THOUGHT POSSIBLE BACK THEN?

SCHNETTLER One example is lying right there on the table: my smartphone. It is incredible what has gone on in the field of information and communication technology. Or take photovoltaic installations that are today generating outputs in the gigawatt range. I would never have thought such rapid development possible. The massive expansion of renewables has led to falling costs for green electricity. In the Middle East you can now purchase a kilowatt-hour of power generated by photovoltaic plants for less than it costs us in Germany to even run a conventional power station. The more PV installations and wind turbine generators are connected to the grid, the more complex it becomes to control them. The only way to do so is to use power electronics. Speaking of which, I would never have expected their performance and price levels to have developed so quickly, either. The power grid is increasingly turning into a digitally controlled, electronic network.

KLEINEKORTE Extra-high-voltage direct-current transmission (HVDC) is a good example of that. Twenty years ago, one would have said there was no point in building a power link between Belgium and Germany because absolutely no electricity would flow through it owing to the existing links to the Netherlands and France. The power electronics of HVDC technology make it possible to force this flow of electricity. That is why we are now building this link – and enhancing the security of supply in the entire region. Such technical solutions never used to exist. However, the more power electronics we install, the greater the interdependencies become – and so, too, the demands made on the manufacturers to guarantee the reliability of these new technologies.

SCHNETTLER Siemens is facing up to these demands. We know how important security of supply and a dependable energy supply system are. The eyes of the whole world are on Germany, observing how we are handling the energy transition. We are working on the assumption that all markets around the globe will be developing and switching over to renewables. If we want to be successful in other markets, the solutions we find and implement in Germany will have to prove their worth.

*» We are experiencing more disruption than evolution.
We need to completely rethink our energy supply –
technically, structurally and commercially.«*

PROF. ARMIN SCHNETTLER



WHAT INNOVATION SURGES WILL THE ENERGY TRANSITION GIVE RISE TO OVER THE NEXT 20 YEARS?

KLEINEKORTE That depends on how our future society will deal with the energy issue. It is an issue we at Amprion are devoting a great deal of attention to. I will dare to make a prediction: in just five years from now, consumers will be buying their electricity over the Internet, chopping and changing every two weeks and each time through a different provider. This will be a huge challenge for transmission system operators because transactions that are completed with the aid of digital communication still have to be processed physically.

SCHNETTLER Siemens and RWTH Aachen University are currently working on a “digital twin” of future energy system structures. We are creating digital representations of the present energy system and, with the aid of mainframes, acting out scenarios aimed at depicting how structures, technologies and markets could potentially develop over the coming years. We, too, are working on the assumption that the energy trade will become more fragmented and the degree of digitalisation will continue to grow. At some point, the battery of my electric car will communicate with the photovoltaic system and other electrical consumers, informing them how much energy it requires – or makes available – and when. We expect all sectors to undergo electrification – this is essential if we are to achieve our climate protection goals and, moreover, will lead to the decoupling of renewable power generation from consumption. The chemical and transport industries will generate hydrocarbons from solar and wind power, in conjunction with CO₂ and water.

KLEINEKORTE All this will lead to further growth in the demand for power, demand we will only be able to satisfy by installing more photovoltaic systems and wind turbines. The burning question is: how are we going to orchestrate millions of these systems in a meaningful way? RWTH Aachen University and Amprion are exploring fundamental questions around this issue in a project dubbed the “SwarmGrid”. The idea is to group the systems into swarms. To illustrate what I mean by that: we would no longer control the individual bees, but rather the bee colonies.

SCHNETTLER Perhaps the era of artificial intelligence will soon be upon us, aiding us to determine and control complex systems. There are some highly promising approaches around in this regard, but only if we have the necessary powerful computers and superfast communication networks will we be able to work with such smart systems in real time.

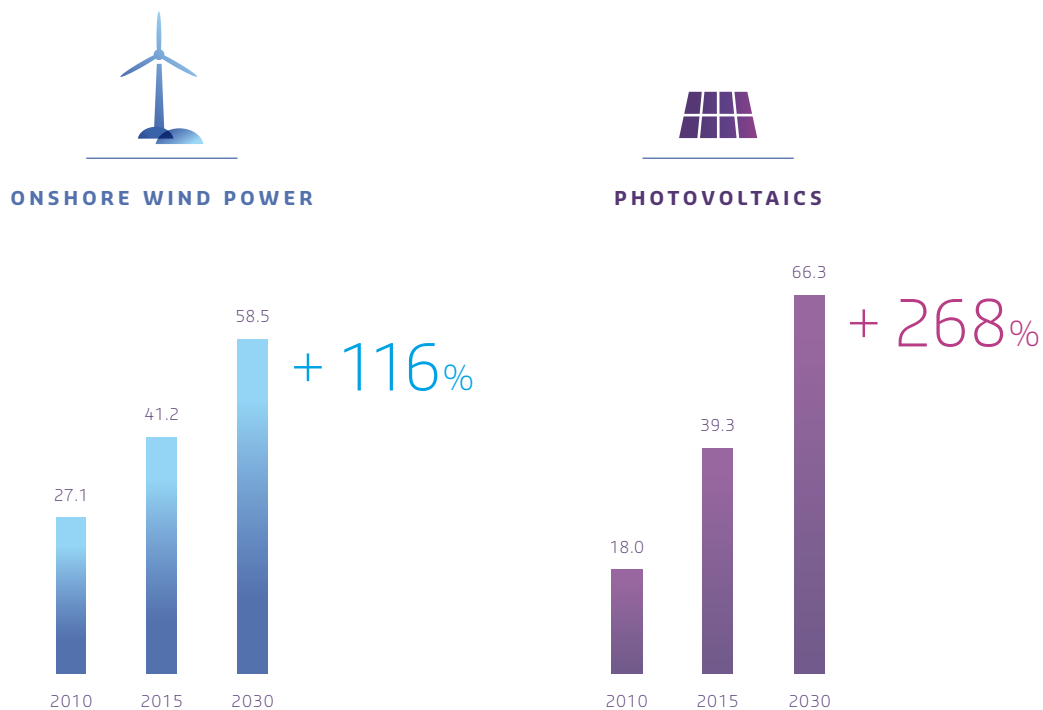
IF YOU HAVE ANY, WHAT ARE THE INNOVATIONS OF YOUR DREAMS?

KLEINEKORTE Whoever discovers how to store electrical energy with a high density deserves a Nobel Prize. If, for example, a mobile phone could go three months without having to be recharged, that would be fantastic. Perhaps we will have to store energy in some other form – such as technologically generated gas. We must not stop looking for such solutions. To my mind, it is important that we do not impose any kind of ban on free-thinking – nothing must be declared off-limits. And we also need to throw ideas back and forth with the research universities. Students’ minds are not weighed down by “mental baggage” they bring with them from previous experience. They challenge existing solutions. This can lead to totally new approaches.

SCHNETTLER The issue of storage is the biggest challenge facing us and that we have to address tenaciously. If we succeed, we can then go about implementing decarbonisation globally. We can only overcome this challenge by working hand in hand with research institutes and industrial partners on mass-storage technologies. What we are really looking for from these partnerships are unconventional ideas – the marketplace will show us what makes sense and what not.

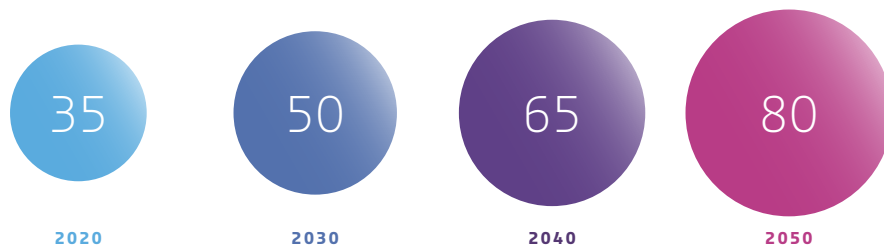
WIND POWER AND PHOTOVOLTAIC SYSTEMS ARE BOOMING

Installed capacity in gigawatts



TARGETS OF THE ENERGY TRANSITION

Increase in the share of renewable energy sources as a percentage of gross power generation



Source: NEP 2022, BNetzA Monitoringbericht 2016, Entwurf NEP 2030 Szenario B 2030



New start

Amprion promotes FRESH THINKING *[page 12]*. To make the grid fit for the challenges of the future, we're combining our concepts with innovative technologies. Together with strong partners, we're creating a COSMOS OF INNOVATIONS *[page 22]* and facing the challenges of the digital transformation: THE DIGITALISATION IS CHANGING THE GRID *[page 24]*. It is getting smarter – and we're also learning new things every day.



FRESH THINKING



Innovations are crucial to Amprion. To make the grid fit for the challenges of the future, employees are busily developing concepts, integrating new technologies and, together with research partners, finding solutions for the energy world of the future.

PHOTOS · MATTHIAS HASLAUER TEXT · VOLKER GÖTTSCHE

It all began with an idea. Stephen Gray knew that friction generates electricity. Could this electricity be transported over short distances? On 14 July 1729, the British physicist and a friend ran a 200-metre-long rope made of damp hemp fibres across a field. They propped it up with beanpoles. And yes, the rope did indeed transmit an electric charge – and the world’s very first overhead power line had worked.

Today, Gray’s heirs no longer work with hemp fibres and beanpoles. They develop conductor ropes made of steel and aluminium that transmit a hundred thousand times the amount of power Gray had been handling. They test control systems and have software programmed that can better forecast the amount of wind and solar power that will be fed into the grid. They work in the laboratories

of universities and research institutes, in the development departments of component manufacturers – and in the offices of Amprion.

One of Gray’s heirs is Martin Finkelmann (48), who heads Amprion’s department for Long-term Grid Planning. The common link between Martin Finkelmann and Stephen Gray is their passion for everything that has to do with electricity. “We too want to try out new things,” says the engineer, “in order to develop innovative solutions for our grid.” These solutions are sometimes the fruit of many long years of intense research. They also arise from Finkelmann and his colleagues working on and further advancing existing inventions, technologies and processes, so that challenges that arise when operating and expanding Amprion’s power grid can be mastered.

» With the aid of innovations, we want to actively shape the transition underway in our energy system.«

DR HANS-JÜRGEN BRICK,
MANAGING DIRECTOR AT AMPRION

Like everywhere else, every innovation at Amprion begins with an idea. Such as the idea to control cross-border electricity flows in a totally new way. Finkelmann and his team came up with this idea around eight years ago. “Back then, the question arose as to how renewable energies could best be used across borders,” he remembers. The growing supply of wind and photovoltaic energy and the increasing amount of trade in electricity within Europe would make it essential to expand the continent’s power grid – and in a way that would give it even greater capacity and flexibility. One important component of this is a direct, controllable power line between Germany and Belgium.

SYSTEM RELIABILITY IN EUROPE’S NORTH-WEST

Together with engineers from Amprion’s Belgian partner ELIA, Martin Finkelmann and his team started looking for a technical solution. Their approach was innovative in two respects: an underground cable that carries a direct current. It will allow the power flows to and from Belgium to be controlled extremely precisely. The short name for this technology is HVDC-cable: an underground cable for the transmission of extra-high-voltage direct current. The link is scheduled to be commissioned in 2020. “Through this project, we’re helping to ensure system reliability not only in the Aachen-Cologne region, but also in Europe’s north-west,” says Finkelmann. At the

same time, the link will help to better integrate Belgium into the European electricity network and market if the country pulls out of nuclear energy by 2025 as planned. A development that many people in North Rhine-Westphalia also welcome.

The new DC link is known as the “Aachen Liège Electricity Grid Overlay” – or ALEGrO for short. “Innovations like this one help us to overcome the energy transition,” explains Dr Hans-Jürgen Brick, Managing Director at Amprion. “More than that, they enable us to actively shape the transition underway in our energy system.”

This transition is far-reaching: by 2030, renewables are to supply half of our total electricity supply. New, large-scale wind and PV farms as well as more and more micro installations are to come on stream. Wind power will mainly be fed into the grid in northern Germany, while the major share of solar energy will be fed in southern Germany. In both cases, the infeed will fluctuate massively owing to their dependence on the weather conditions. Add to these the producers and consumers in neighbouring countries, who influence what goes on in Germany’s grid – and vice versa. The complexity of all the processes involved in the European grid is consequently growing. That’s why the grid has to become smarter and even more flexible. ▶

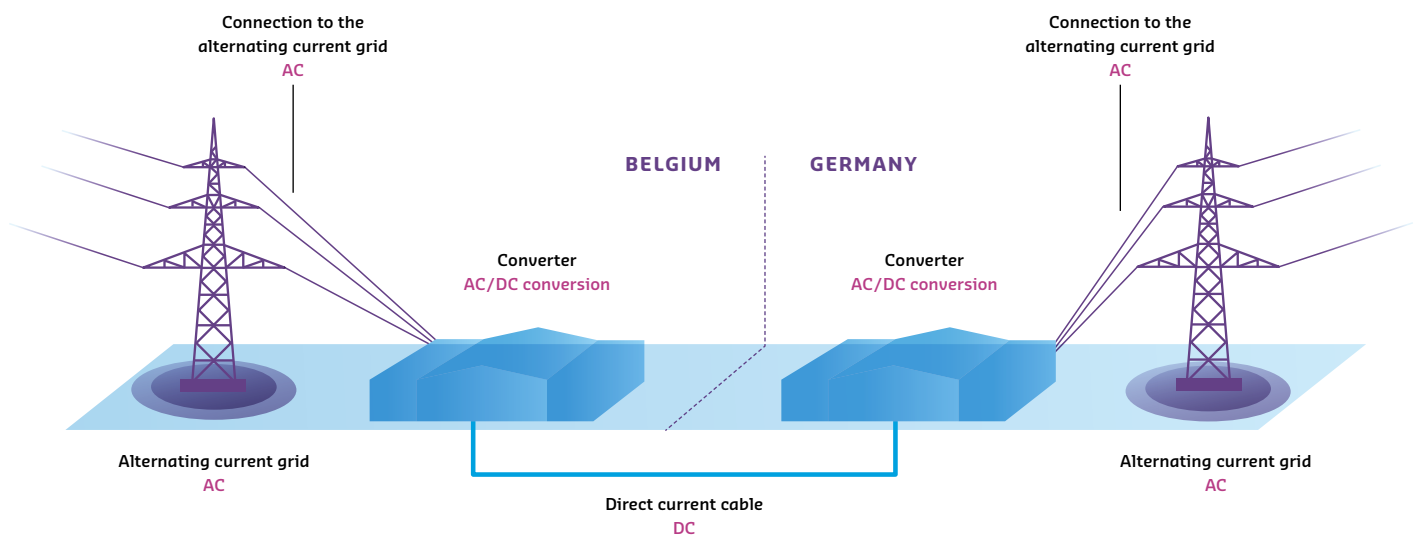
PIONEER WORK FOR SYSTEM RELIABILITY

"ALEGRO" DC LINK



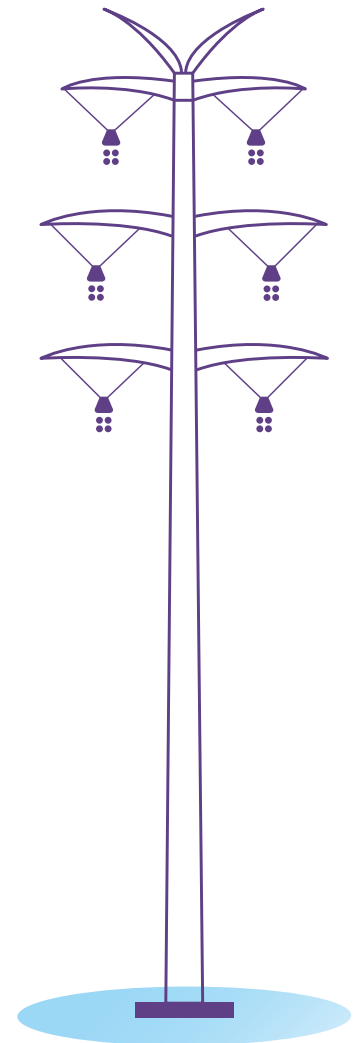
Martin Finkelmann, Head of Long-term Grid Planning at Amprion.

The "Aachen Liège Electricity Grid Overlay" – or ALEGrO for short – sees Amprion combine two innovative technologies to control the flow of electricity to and from Belgium right down to the megawatt-hour. It will go into trial service in 2020. "ALEGrO is one of the first fully controllable DC links in Europe's meshed AC transmission network," says Martin Finkelmann, the head of long-term grid planning at Amprion. The 90-kilometre-long section is being built as an underground direct-current cable with a transmission capacity of 1,000 megawatts and a rated voltage of 320,000 volts. At either end, converters will transform alternating current into direct current and vice versa. In total Amprion is investing more than 400 million euros in ALEGrO.





Dr Christoph Gehlen is responsible for power line construction at Amprion.



PILOT POWER LINE CONSTRUCTION PROJECT

NEW DESIGN OF SOLID PANEL PYLON

By adopting a new type of pylon, Amprion wants to expand its toolkit for power line construction. "We are investigating whether the solid panel pylon offers us benefits in respect of construction, operation, cost-effectiveness and public acceptance compared with the lattice pylon," says Dr Christoph Gehlen, Head of Power Lines at Amprion. This new design of pylon is around 60 metres high and

made of steel plates that are rolled and then welded together. This gives the pylon its round shape. The pylons have three levels of curved cross-arms with a projection of 7.5 metres. Solid panel pylons will start to be erected from 2017 as part of a pilot project along a section of the new AC link between Wesel/Lower Rhine and Doetinchem in the Netherlands.

» Innovation is more than just a successful experiment. It encompasses the entire process from the idea through to guaranteed application.«

DR BARTOSZ RUSEK,
HEAD OF TECHNOLOGY MANAGEMENT AT AMPRION

TRANSMISSION FROM ZERO TO 1,000 MEGAWATTS

ALEGrO meets these requirements. When Martin Finkelmann explains how the new HVDC link actually works, the electrical engineer's eyes light up. "We're planning one of the first fully controllable DC links in Europe's meshed transmission network," he continues. To be able to control the transmission of power via the ALEGrO cable between zero and 1,000 megawatts, converters are being built at either end of the link. These high-tech installations convert the alternating current used in the conventional transmission network to direct current and vice versa. According to Finkelmann, the advantage of DC is that "it is controllable and suffers only low levels of loss." This is why the decision has been made to install HVDC lines to transmit, for example, wind power generated in the north of Germany over great distances to the conurbations and industrial centres of southern Germany.

Whereas other links are still at the planning stage, ALEGrO will from 2020 give Amprion plenty of opportunity to collect valuable field experience, allowing the grid operator to work out how HVDC technology can be best put to use in Europe's close-mesh transmission grid. "In a technology-driven industry like ours, innovations are an important success factor," explains Dr Hans-Jürgen Brick, Managing Director at Amprion. Accordingly, the company has begun to develop and implement innovation projects in all areas. The ALEGrO project falls under the area of Transmission Technology. Further projects are

being conducted under the headers of System Operation and Control, Systems Engineering and the "Energy System of the Future" (see pages 22–23).

WORK ON THE INNOVATION PORTFOLIO

"Even the craziest idea requires a degree of order if it's to become reality," says Dr Bartosz Rusek, Head of Technology Management at Amprion. The 39-year-old engineer studied in Poland and obtained his doctorate in Germany. Together with colleagues from other departments, he puts structure into the company's innovation projects. Above all, two questions need to be answered: Which new solutions does the energy world of the future need? How can Amprion meet future challenges that arise from the energy transition?

Rusek and his colleagues go about this task systematically: they set priorities for how the multitude of ideas are to be handled. They do this by organising the projects according to their technological maturity. "In the initial phase, we collect and evaluate what we think are clever-looking ideas," Rusek explains. If the evaluation is positive, Amprion then gets stuck into researching and developing a prototype. "The fact that you've got a prototype that works doesn't necessarily mean it's going to be a simple path straight to regular operation," clarifies Rusek, before turning his attention to the absolute top priority at Amprion when it comes to innovation: every new technology is put through its paces – many, many times. "The transmission grid is the backbone of the ▶

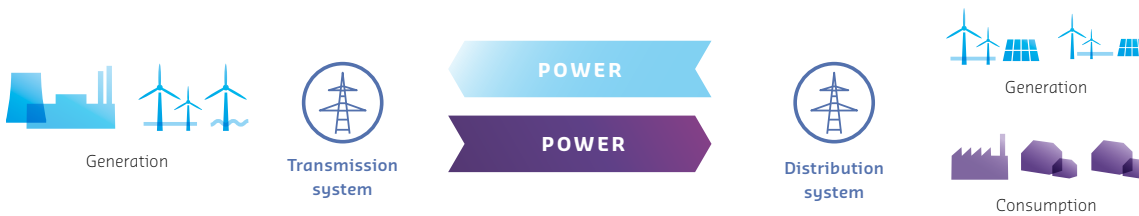


Dr Frank Reyer, Head of Grid Management at Amprion.

PREVIOUSLY



TODAY



SOLUTION FOR THE FUTURE

GRID RESTORATION IN THE ENERGY WORLD OF THE FUTURE

The energy world is undergoing a transformation. New structures require new concepts. For this reason, Amprion is working with research partners on a new strategy for “Grid Restoration with a High Proportion of Renewable Power Generators”, as the innovation project has been dubbed. The starting point for this is the growing number of fragmented wind and solar installations. These are connected not only to the transmission system but also to the distri-

bution systems (see diagram above). “We need new concepts for restoring the grid that take the changing infeed situation into account,” says Dr Frank Reyer, Head of Grid Management at Amprion. “From these, we can then derive strategies that we can implement flexibly, in line with the prevailing infeed levels from wind and PV installations, following a major disruption.” Among our project partners in this field is the Technical University of Kaiserslautern.

» We're developing new solutions in order to meet the requirements of the grid expansion.«

DR CHRISTOPH GEHLEN,
HEAD OF POWER LINES AT AMPRION

German economy. That's why it must always operate safely and reliably," says Rusek. Innovation is therefore more than just a successful experiment. "It encompasses the entire process from the idea through to guaranteed application in the grid." For a new technology, this means it must first prove itself within the framework of pilot projects before it can find its way into the grid as "standard equipment".

PRACTICAL TRIALS UNDER REAL-WORLD CONDITIONS

Take the innovation project "Solid panel pylon" that is now entering the pilot phase: this type of pylon is to be tested along a six-kilometre route in the Lower Rhine region. It belongs to a new AC link connecting Germany and the Netherlands. "We're developing new solutions in order to meet the requirements of the grid expansion," explains Dr Christoph Gehlen. The 48-year-old graduated in electrical engineering and is Amprion's man for power line construction. And he knows: no two grid expansion projects are alike. For instance, the landscape, ground composition and housing and population density differ from region to region. "This is why we are expanding our toolkit for power line construction – so that we can implement each project as best as we can," Gehlen explains. To this end, he and his team have joined forces with pylon constructors to develop these new solid panel pylons. The next step is to gain experience with regard to construction procedures, operation, cost-effectiveness and acceptance by the general public. The overhead power

line is scheduled for completion in 2018. The pylons will then undergo practical trials under real-world conditions, after which this new type of pylon will be assessed to determine whether it is fit for use in other grid expansion projects.

PREPARING FOR THE WORST-CASE SCENARIO

Change of location – to Amprion's System Operation and Control Centre in Brauweiler. This is where Dr Frank Reyer and his team ensure that the power grid functions reliably. And they also investigate how this stability can be maintained in the energy world of the future. At Amprion, such questions are not discussed in abstract terms. "Our staff are far too focused to waste time doing that," says Reyer, who is Head of Grid Management. "If there are signs of a problem arising, our specialists follow it up until they have found a solution." This also applies to the people at the System Operation and Control Centre, who, with our domestic and international partners, regularly train how to restore the grid to full functionality. "This is a situation we never want to experience," Reyer emphasises. "But it's part of our remit to prepare a professional response to the worst-case scenario, should it ever arise."

Until now, the team has followed a rigid procedure whenever training for grid restoration following a crisis: the system controllers would have used conventional power stations with stable infeed into the transmission system to restore grid operation, and then gradually reconnected

consumers back to the distribution system. As a result of the energy transition, the system will change fundamentally, Reyer's team believes. The more power we generate from renewable sources, the more likely we are to face a commingling of generation and consumption in the distribution system. "We need a concept that enables us to respond flexibly to the prevailing infeed situation from wind and PV installations." Amprion is already carrying out research to this end, together with the Technical University of Kaiserslautern and the Fraunhofer Institute for Wind Energy and Energy System Technology. Their objective is to complete this new concept as quickly as possible – long before the majority of conventional power stations have been taken offline.

Collaborations with universities and research institutes are nothing unusual in the world of technology. Amprion, too, fosters an international network that includes some notable universities. "Maintaining a close relationship and exchanging ideas and data with the scientific world are a matter of course for us," says Managing Director Hans-Jürgen Brick. "Given the challenges of the recon-

struction of the energy system, this will no doubt intensify." Amprion doesn't just talk about innovations, but proactively drives them forward – with the declared intention of integrating the R&D results obtained into the grid.

ON THE ROAD TO THE ENERGY WORLD OF THE FUTURE

As such, Amprion is continuing down the same road Stephen Gray went down almost 300 years ago. It's the road along which electrification first took off in Germany in around 1880. Fifty years later, the first extra-high-voltage power line went into service between Brauweiler and the Alps – the starting gun for Germany's transmission system. Once again, 100 years later, in 2030, Germany's energy system is set to complete another fundamental restructuring process, which will make it primarily dependent on renewable sources. In the meantime, the experts at Amprion will continue to work on innovative solutions to bring about a safe and reliable power supply system, demonstrating both their thirst for knowledge and smart ideas – like Stephen Gray.

» If there are signs of a problem arising, our specialists follow it up until they have found a solution.«

DR FRANK REYER,
HEAD OF GRID MANAGEMENT AT AMPRION

INNOVATION - A SUCCESS FACTOR

Amprion aims to continuously strengthen its innovation capacity in all departments.



DR HANS-JÜRGEN BRICK

is Chief Commercial and Chief Financial Officer (CCO/CFO) at Amprion. He is responsible for finance, the economic grid management and communication, among other areas.

HOW IMPORTANT IS INNOVATION TO AMPRION?

It is of huge importance from a strategic point of view. As a transmission system operator, it is our duty but also a genuine desire of ours to actively shape the transition underway in our energy system. To achieve this, we have to develop and implement new concepts, processes and technologies. This will also be to our commercial benefit, because in a technology-driven industry like ours, innovations are an important success factor.

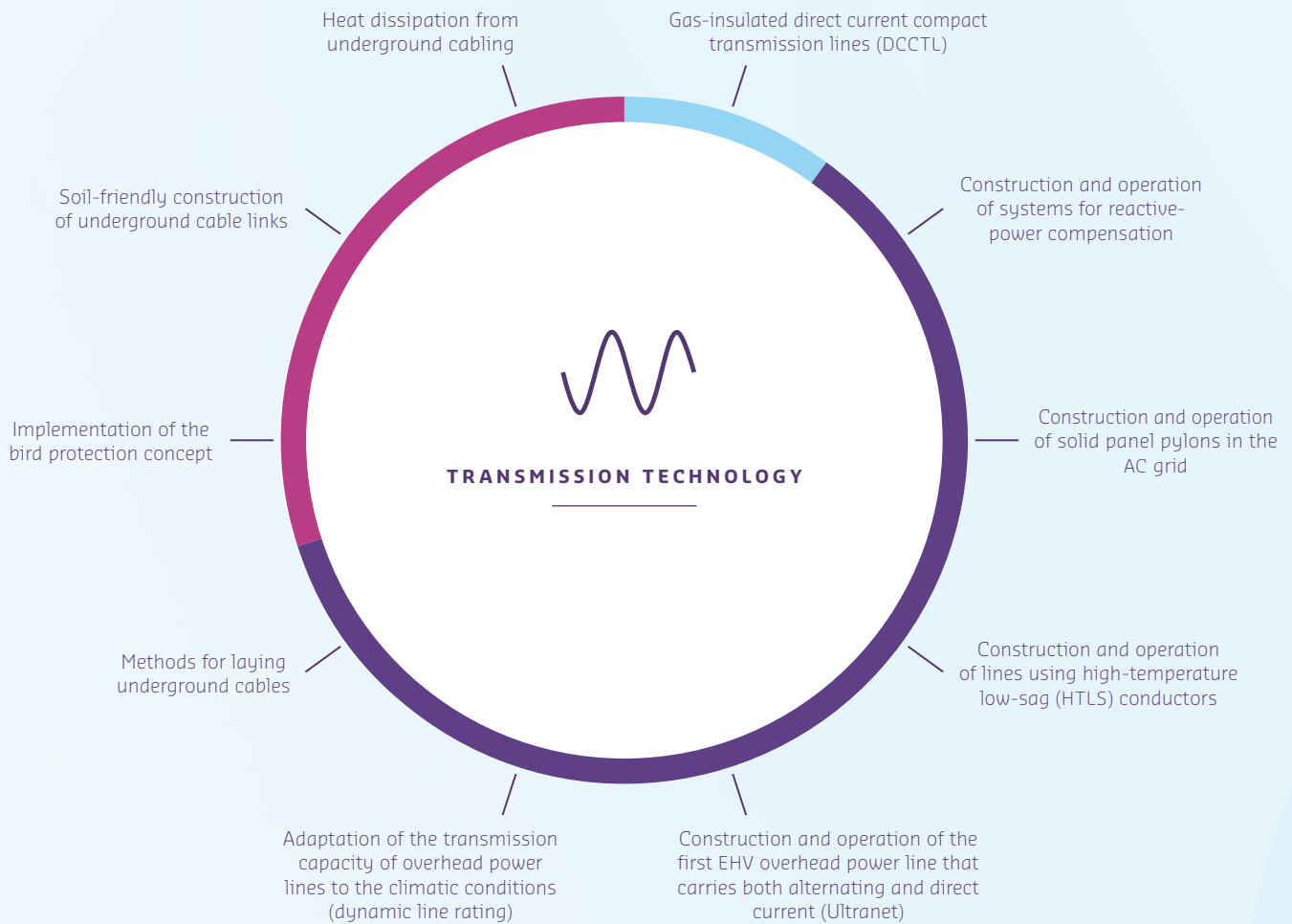
DOES INNOVATION GO BEYOND MERE TECHNICAL PROGRESS?

Absolutely. We also see ourselves as a driving force in the economic grid management, for instance. How will the electricity market function in future? How can the costs associated with the energy transition be apportioned fairly? In project communication, we are using new event formats to expand the dialogue with local residents and other community groups. We need such innovations in order to actively shape the transition underway in our energy system. Therefore, as part of Strategy 2020, we have taken it upon ourselves to strengthen our innovation capacity in all departments.

HOW DO YOU PROMOTE THE INNOVATION CULTURE IN A COMPANY?

To begin with, we have taken a good look at the innovation projects at Amprion. In which areas are we working together with partners? What level of maturity have the projects reached? The information collated will flow into a company-wide portfolio that we want to use to align our long-term innovation activities. The innovation capacity of a company essentially depends on the people who work there. Amprion employs many very good people who are experts in their respective field and who – as is apparent almost every day – identify deeply with the firm and its goals. That's something we can and will build on.

COSMOS OF INNOVATIONS



TECHNOLOGICAL MATURITY



Amprion is working with universities, research institutes and other companies to discover and develop sustainable solutions for the transmission system. The various projects are differentiated according to their technological maturity. Basic groundwork needs to be conducted to lay the foundations required for us to shape the energy system of the future. For instance, within the scope of the MIGRATE project, Amprion and 24 global partners are currently investigating how a high level of stability and quality in the European power grid can

be reconciled with the increasing infeed levels from renewable energy sources. Other innovations in transmission technology have already progressed to the stage that they are currently undergoing trials in pilot projects. This includes a tunnelling method for underground cables. Already approved for regular operation are methods for reactive-power compensation. It's with such technologies that Amprion is helping to shape the new start into the energy world of the future.

First bilateral European Security Service Centre (SSC) and pan-European TSO (transmission system operators) Security Cooperation (TSC)

Improved forecasts as to how much renewable energy will be fed into the grid the next day

Efficient coordination of the transmission capacities in the cross-border electricity trade (flow-based market coupling – FMC)

Concept for better visualization of the system status in the grid control room

Combined operation of underground cable and overhead power line routes in one system

New grid control system and station control technology to meet the challenges of the future (HSL 2020/NBF-NG)

Construction and operation of converters to connect DC links (Ultranet, ALEGRO, A North)

Systematic control of current flows thanks to HVDC technology in Europe's meshed AC grid (ALEGR0)

Solutions for grid stability with increased infeed of renewables (MIGRATE)

Grid restoration with renewable energy sources following a large-scale disruption

SwarmGrid – safe operation of electricity grids with swarm-enabled system services

Technology for smart grids with a high proportion of renewables (Designetz)

Modular development plan of the Pan-European Transmission System 2050 (e-Highway2050)



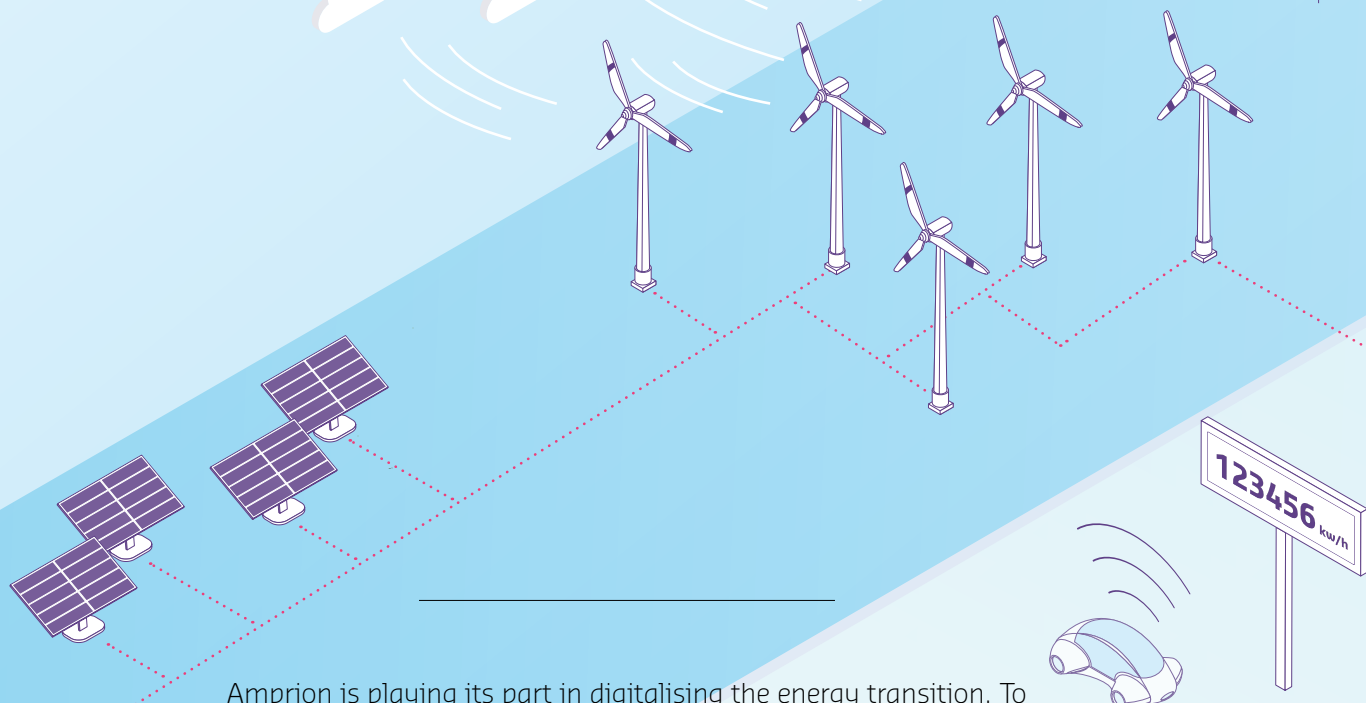
SYSTEM OPERATION AND CONTROL & GRID OPERATION



ENERGY SYSTEM OF THE FUTURE

DIGITALISATION IS CHANGING THE GRID





Amprion is playing its part in digitalising the energy transition. To continue to operate the grid safely and flexibly in the future, the company is processing ever greater volumes of data. The future lies with powerful grid control systems and smart electricity meters.

TEXT · ALEXANDRA BRANDT

From huge wind farms in the North Sea and Baltic through large numbers of micro-photovoltaic installations on the roofs of houses in southern Germany to electric mobility – our energy system is transforming rapidly. A transformation that presents all players with a whole series of daunting challenges. Among them are Joachim Vanzetta and his colleagues at Amprion’s System Operation and Control Centre. When he looks out of his office window in Brauweiler, just outside Cologne, he so far sees very few electric cars at the parking area. But that will change – and that’s something Vanzetta is absolutely sure about. But when will their owners “fill up” their batteries? “Preferably when electricity is especially cheap,” says the System Operation and Control Manager at Amprion. This will be the case when wind turbines or PV systems are feeding a lot of energy into the power grid. “But there’s one thing in particular that’s required for all of this to work: communication,” the engineer says. “Digital communication between the power utilities, grid operators, power providers and grid users, such as car drivers.” And as far as possible in real time.

Joachim Vanzetta could rattle off a whole host of similar examples: examples from a future energy world that can’t

do without communication and digitalisation because everyone is networked with everyone else – and in which gigantic volumes of data flow. Grid operators such as Amprion have to process all of this data if they want to fulfil their core task: to ensure their grid operates safely and reliably at all times. The stability of the grid depends on Amprion and its counterparts obtaining and processing all such relevant data in order to maintain a constant balance between power generation on the one hand and electricity consumption on the other. At the same time, our engineers have to make sure that none of our transmission lines are overloaded or fail. For this digital data is indispensable. “This is why digitalisation is such an important field of innovation for us, one that is tightly interwoven with our core business,” explains Vanzetta.

THE ENERGY SYSTEM IS BECOMING MORE FRAGMENTED

A few steps away from his office, in Amprion’s System Operation and Control Centre a new grid control system is currently being built. His assignment: to collect and process all data of importance for the safe and reliable operation of



the grid. Even if the future with digitally communicating electric cars has not yet begun, the computers already installed still have to put in a full shift. Among other things, the system has to process data relating to the degree of utilisation and the status of overhead lines, underground cables and substations, weather data, the schedules of power stations and information from Europe's electricity exchanges. The new control system will collate and evaluate all of this information almost instantaneously and inform the control engineers in good time where potential bottlenecks in the grid could arise. "As the expansion of wind turbines and photovoltaic installations advances, our system of power generation is becoming ever more fragmented and management of the electricity flows ever more complex and demanding," Vanzetta stresses. "To enable us to continue to overcome these challenges in future, we are developing new IT concepts. Algorithms from the realm of artificial intelligence are also being employed to make the necessary forecasts even better – for example, to predict the power output of PV installations in Germany."

SMART ELECTRICITY METERS FOR CONSUMERS AND UTILITIES

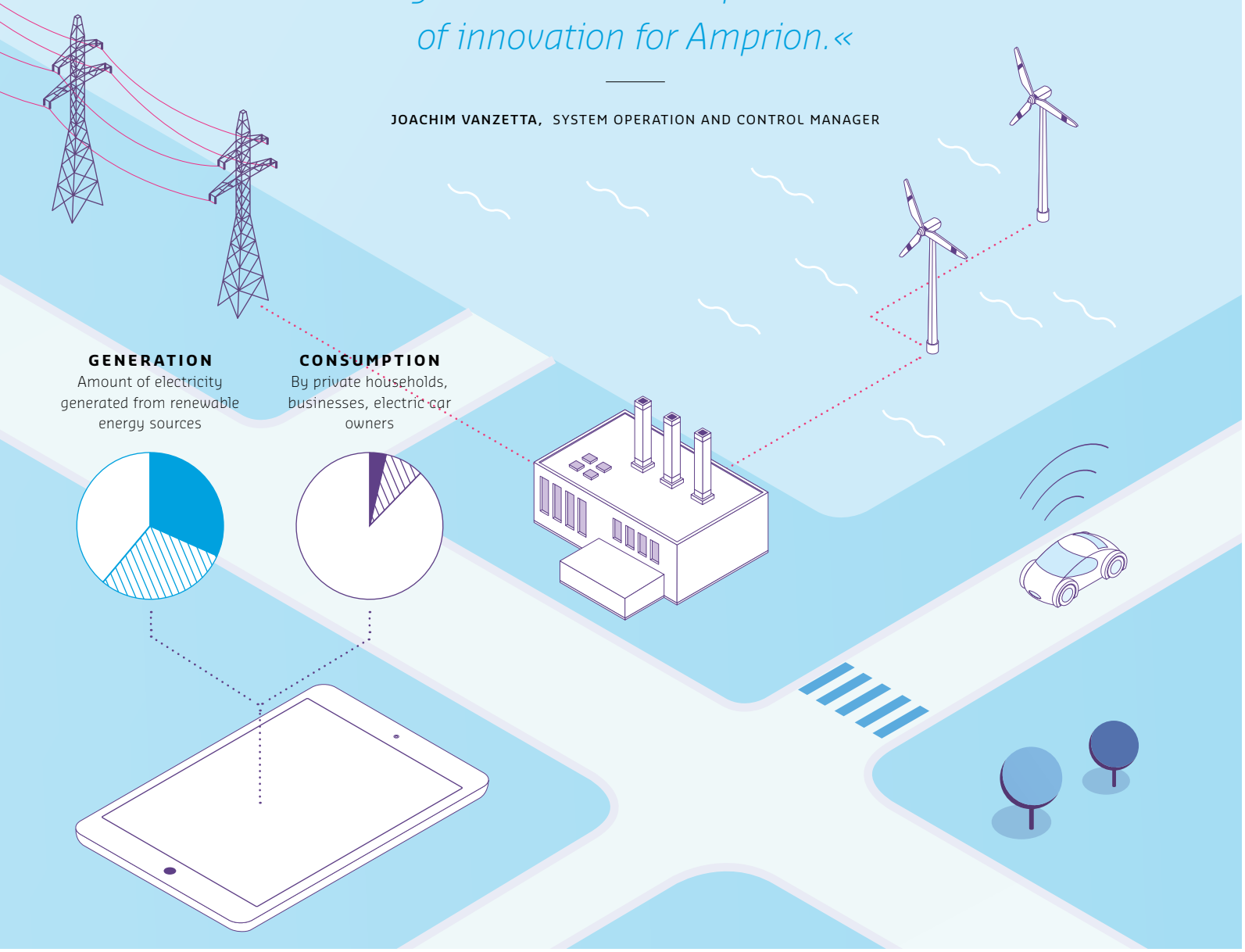
In parallel with construction of the new grid control system, colleagues at Amprion's headquarters in Dortmund are working on ways to manage the new data flows. "In future, it'll all be about measuring and forecasting consumption and infeed levels more accurately than today," says Henner Schmidt, Head of Balancing Group Management at Amprion. The digital smart meter will play a crucial role in this. Whereas conventional meters have supplied merely the total amount of electricity consumed over a long period, smart meters measure consumption at least every 15 minutes. This gives customers a more precise insight into their personal consumption habits. In future, Amprion will also be recording and processing the data from the smart meters installed throughout its entire grid. Around half a million microgeneration plants and some 1.5 million electricity consumers will be kitted out with these new meters. This throws up new questions with respect to legal issues, security and data protection. The law regulating digitalisation in respect of

the energy transition stipulates particular caution when handling the data gathered: the data must be encrypted and sent via specially secured channels. All market operators have until 2020 to install and get this new technology up and running. Amprion will be launching the first phase of this project as early as October 2017. The company will also be using this time to research further into the interaction between data flows and electricity flows. Together with scientists at RWTH Aachen University, company experts working on the “SwarmGrid” project are investigating the potential opportunities in controlling lots of microgeneration units of renewable energy in “swarms” along the lines of “Together we are stronger”. One thing is for sure: the number of fragmented, microwind and photovoltaic installations will continue to

grow. The problem is this: unlike the conventional, large-scale power stations – which are going to be shut down over time – they don’t feed energy into the transmission grid, but rather into the distribution grids of municipal utilities and regional grid operators. In order to still be able to control the flows of electricity in the transmission grids precisely, their operators need to know not only what’s going on across Germany and the whole of Europe at EHV level, but also how the situation in the distribution grids looks like. And the same applies at the other end: the distribution system operators need more information about EHV grids. Yet again, this means data has to be exchanged – and we need powerful computers and some great minds. Another example of Amprion moving a step closer to the energy world of the future.

» Digitalisation is an important field of innovation for Amprion.«

JOACHIM VANZETTA, SYSTEM OPERATION AND CONTROL MANAGER





Responsibility

Amprion bears responsibility for ensuring that the transmission grid is safe, reliable and sustainable. To this end, we are investing more than 500 million euros every year in grid expansion. This opens up opportunities for small and medium-sized enterprises and provides a TAILWIND FOR THE REGION *[page 30]*. We're operating the grid and upgrading it so that nature and the environment are affected as little as possible. That's why we're also PROMOTING FLEDGLING FREQUENT FLYERS *[page 36]*.



Partners on the construction site: Heckmann site foreman Ferdinand Langenkämper (left) and Amprion site manager Olaf Tietz have been working together in Essen-Eiberg since October 2014.



TAILWIND FOR THE REGION

Amprion is investing more than 500 million euros in grid expansion every year. This is boosting the power grid. In addition, these investments are safeguarding jobs and regional value creation.

PHOTOS · MATTHIAS HASLAUER · MARCUS PIETREK TEXT · VOLKER GÖTTSCHE



Planning meeting in the site container: the substation at Essen-Eiberg is being modernised and expanded. Ferdinand Langenkämper and Olaf Tietz discuss the next steps.



Ferdinand Langenkämper trudges through the construction site mud. The loamy soil prevents the rainwater caught between the concrete foundations on which the new switchgear and measuring instruments of the Essen-Eiberg substation are built on. It's been drizzling for hours. Droplets of rain drip from the helmet of the 51-year-old foreman. But he couldn't care less about the wet conditions. "After 35 years on construction sites, I'm used to it," he says. "It's part of the job."

He's been working in Essen-Eiberg since October 2014. Amprion is modernising and expanding the substation, upgrading it and making it ready for its future energy transmission duties. As the site foreman, Ferdinand Langenkämper is responsible for organising the construction works and assigning jobs to skilled construction workers, machine operators and craftsmen. He does so in the typical Westphalian manner – straight-talking, with a dry humour. That's something he has in common with his boss: Werner Schmidt is Managing Director of the construction company Bernhard Heckmann GmbH, headquartered some 80 kilometres away in Hamm. "Our word is

our bond," is the 58-year-old developer's maxim. "We are an archetypal example of a German SME – the 'Mittelstand'," he says proudly. The company employs a workforce of around 430 and has an annual turnover of 85 million euros. "We're the largest construction company in Hamm, and our order situation is currently quite positive," Schmidt emphasises. "Amprion is one of our long-standing customers."

INVOLVING SMES IN CALLS FOR TENDERS

Amprion is investing more than 500 million euros in grid expansion every year – among other things in the construction of stations and transmission lines. One in every four euros flows into civil engineering, with the other 75 per cent being spent mostly on components, such as transformers, structural steel elements, control technology and their installation. The economy profits twofold: the power grid continues to remain stable – and businesses receive orders. Amprion also invites capable, regional companies to bid for contracts. This has a variety of benefits. "It enables us to complete projects on schedule," says Managing Director Dr Hans-Jürgen Brick. "At the same



» We're the largest construction company in Hamm, and our order situation is currently quite positive. Amprion is one of our long-standing customers.«

WERNER SCHMIDT, MANAGING DIRECTOR AT HECKMANN

time, we see that this approach safeguards employment in the region." Another positive aspect in the eyes of the transmission system operator is that SMEs from the region can often respond more flexibly to requirements – an important factor that helps keep the grid expansion process moving along.

"On average, we have around 50 plant engineering and construction sites running in parallel at any one time," summarises Dirk Bannach, Plant Construction Manager at Amprion. The figure for power line construction is slightly higher. For each project, Amprion seeks and commissions construction service providers. One priority of the grid operator in this respect is that these services are put out to tender not just as turnkey projects but in separate contract sections for each trade. "This allows us to realise the projects cost-effectively. We have the requisite technical expertise in-house – people who can define the technological requirements or assure compliance with quality standards."

50

Medium-sized construction companies for whom turnkey projects would be a little too ambitious also submit tenders. "Collaboration with partners from the local region has frequently proven to be highly beneficial for us," says Olaf Tietz, Amprion's site manager at the Essen-Eiberg substation. Such as when unexpected problems have arisen on-site. "Fast response times are crucial to us in such

construction sites are currently running in parallel at Amprion simply in connection with switchgear and substations.

situations. And firms from the region are often particularly good at this." Companies such as Heckmann from Hamm. Heckmann CEO Schmidt estimates that almost ten per cent of his staff are working on an Amprion construction site.

GRID EXPANSION WITH THE SUPPORT OF THE "MITTELSTAND"

Nevertheless, his workers don't perform all construction works required. If a new building is to be roofed, the company hires tradespeople from the local area. "In the case of a project like that in Essen-Eiberg, a good 60 to 80 tradesmen will be involved over the years", Werner Schmidt estimates. In this way, then, Amprion's



» *Amprion is our main customer in the extra-high-voltage segment.*«

SVEN BEHREND, MANAGING DIRECTOR OF SAG GROUP

investments in grid expansion support not only medium-sized developers, but also small, local tradesmen's workshops. What's more, Heckmann purchases the building materials required for Essen-Eiberg from regional suppliers. For instance, prefabricated concrete elements come from the Münsterland region. This, too, helps support the regional economy there.

And it's not only substation upgrade projects where collaboration between construction companies, subcontractors and suppliers has established itself: it's a common modus operandi in power line construction, too. In this particular field, Amprion cooperates with the SAG Group, among others. "Our qualified personnel are up to and up for the demands of grid expansion," says SAG Managing Director, Sven Behrend. The company, headquartered in Langen near Frankfurt/Main, is one of Germany's leading service providers for energy infrastructure. A total of 6,000 employees working at more than 100 locations around the country generate an annual revenue in excess of 1 billion euros. "Amprion is our main customer in the extra-high-voltage segment," says the

90

51-year-old engineer. 800 people are employed in this SAG business unit, some 300 of them in the area covered by the Amprion grid.

INVESTMENT FACILITATES LONG-TERM PLANNING

For companies like SAG and Heckmann, Amprion's investment in grid expansion is more than just an important figure in their order

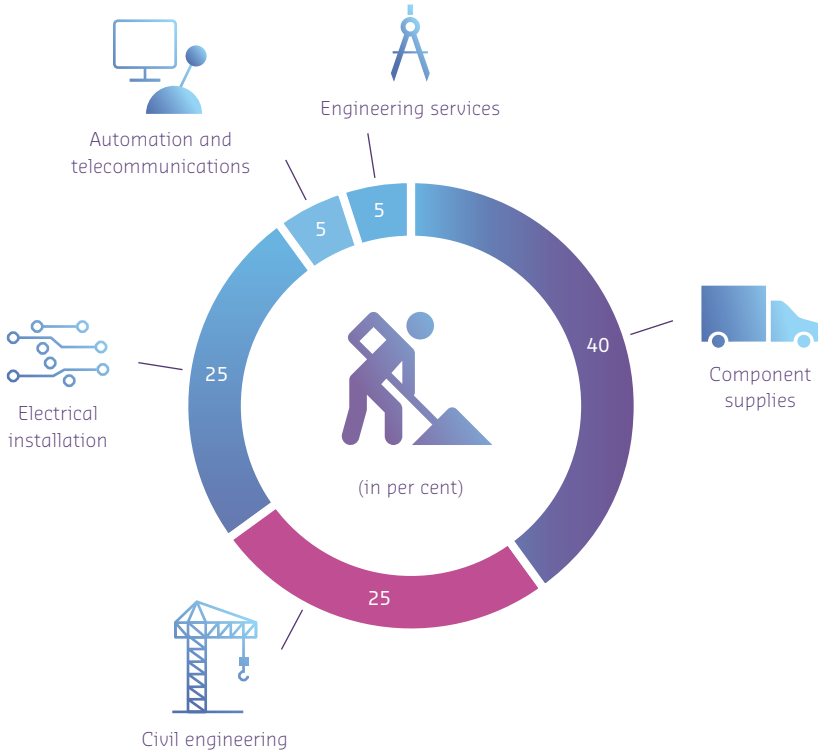
books. Thanks to their long-standing relationships with Amprion, many firms have been able to specialise and build up valuable know-how. The quality and efficiency of their services have improved continuously. "It's enabled us to develop as a company and business," says the SAG manager. "Today, we are a genuine partner to the transmission system operators."

Equally as important to Amprion's service providers is the knowledge that the grid operator will be investing more than 5 billion euros in the expansion of its energy infrastructure over the next ten years. "There aren't that many clients with whom we can plan over such a long period," enthuses Heckmann CEO Werner Schmidt.

is the number of companies Amprion has contracted to perform civil engineering services to run concurrently.

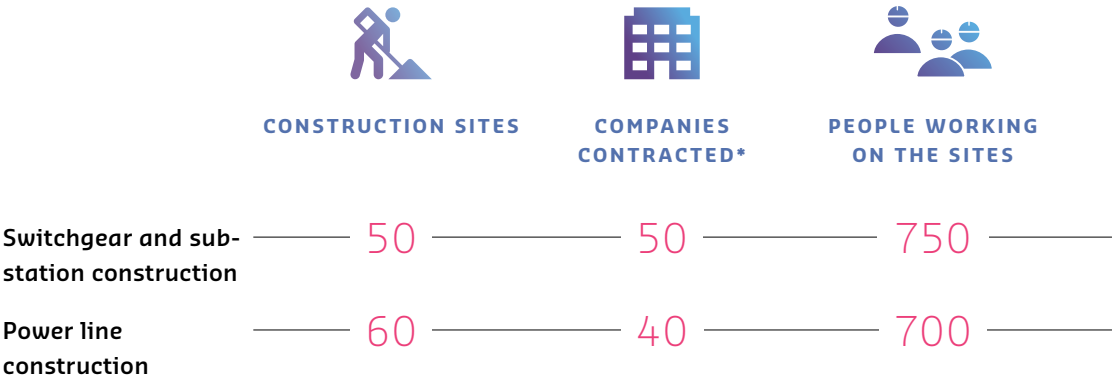
VALUE CREATION IN THE REGION

One-quarter of the sums invested in plant engineering and line construction benefit construction companies.



AMPRION PROTECTS JOBS

The impact of investments



* Excluding subcontractors/tradespeople



Out and about for Amprion in the name of bird protection:
Elmar Pieper observes "air traffic" in the Hellwegbörde.

PROMOTING FLEDGLING FREQUENT FLYERS

Birds of prey such as Eurasian hobbies and peregrine falcons like to nest in abandoned crows' nests perched on power line pylons. Amprion adapts to the situation, protects the old eyries and secures nesting aids at dizzy heights – just one of the many activities of its wide-ranging bird protection programme.

PHOTOS · MARCUS PIETREK · DOMINIK PIETSCH · ALFRED LIMBRUNNER TEXT · ALEXANDRA BRANDT





Up we go! A nesting aid is secured to Amprion pylon 133.

A cold but dry December day at the bird sanctuary Hellwegbörde, near Hamm. This open landscape, characterised by fields and meadows, is home to some rare bird species, such as the corncrake, peewit and Montagu's harrier. Skylarks, hobbies and common buzzards also reside here. Along the edge of the sanctuary, one of Amprion's power lines runs from Dortmund-Kruckel to Hamm-Uentrop. While carrying out preparations for upcoming construction work on pylon 133, workers have noticed an old crow's nest. Today, Claudia Jaehrling, a bird protection expert employed by Amprion, meets up with two colleagues on-site. They remove a dark-brown rattan basket, roughly a metre in diameter, from the boot of the car. "Eurasian hobbies can raise their offspring in this next spring," Jaehrling explains.

Overhead linesmen Sebastian Skoruppa and Tino Herrmann want to install this nesting aid on the pylon's second cross-arm, at a height of 34 metres. That's what people in the trade call the booms or crossbeams of pylons, from which the conductor ropes are hung. "Bird conservation is very

important to Amprion," says Jaehrling. Over the past years, the transmission system operator has put in place a comprehensive bird protection programme for its entire extra-high-voltage grid. Part of this programme is to prepare route sections for the coming breeding season by installing nesting baskets.

PYLONS ARE IDEAL BREEDING SITES

Working at dizzy heights is just part of the linesmen's daily routine. Skoruppa and Herrmann expertly climb the pylon and secure the wicker basket to the cross-arm. Electricity pylons are popular with birds of prey as breeding places: "They offer the animals an excellent view of the landscape," explains landscape architect and qualified ecologist Elmar Pieper, who monitors the bird protection measures as an external expert. The nesting aid on pylon 133 is primarily targeted at hobbies, but peregrines can also breed in it. In the best-case scenario, it'll be used over a period of many years, says Pieper. Many species are faithful to this habitat and like to breed in the same spots year in, year out.



The wicker basket at a dizzy height is an ideal breeding site for birds of prey.





» Bird conservation is very important to Amprion.«

CLAUDIA JAEHRLING, EXPERT
FOR ENVIRONMENTAL PROTECTION AT AMPRION

Nesting aids are mostly installed at spots where birds of prey have at some time already used a nest to breed in. “If the eyries are in the way of construction work lined up along the route, we have to step in. In this case, we transfer the eyrie to a nesting basket, which we then secure at the same height but at a more suitable position on the pylon. We hope that the falcons accept the nest in its new location when they return the next spring,” Claudia Jaehrling explains. If construction work needs to be done on pylons on which protected animals are already breeding, her colleagues usually put off this work to a later date. If that’s not possible, the young affected are entrusted to the care of experienced bird carers. In 2016, while conducting a particular construction measure, Amprion took a number of young hobbies to a bird rescue centre. The animals were successfully reared there and then released to the wild in September.

MARKERS IMPROVE VISIBILITY

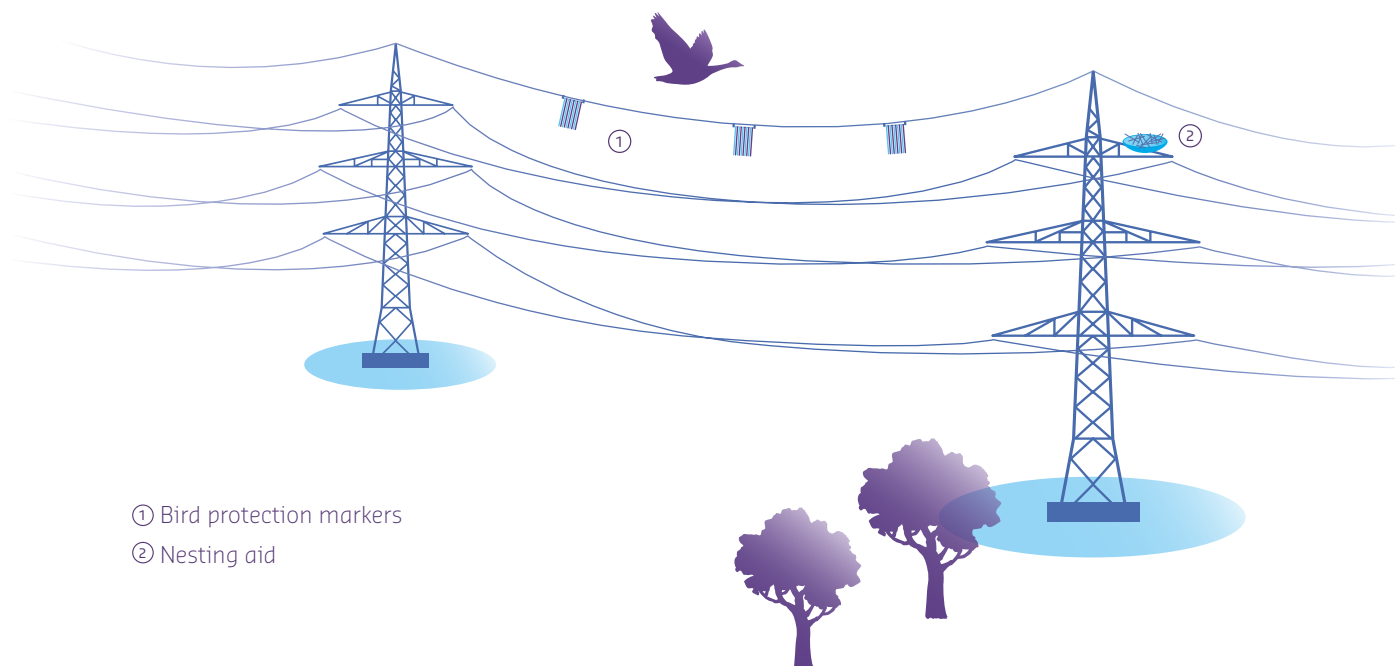
Safeguarding old nests and equipping route sections with nesting aids is just one facet of Amprion’s comprehensive bird protection programme. The grid operator also pays special attention to those species that, unlike the agile hobby, have difficulty identifying and evading horizontal obstructions such as single conductor ropes. “In the case of the thin overhead earth wires that are strung right at the very top of

the pylons, there is a danger of less nimble birds colliding with them,” explains Claudia Jaehrling. In order to better assess how high the risk of this happening is along various sections of its grid, Amprion had a team of ornithologists systematically study its entire network more than 20 years ago and has conducted follow-up studies regularly ever since. “We particularly keep an eagle eye on popular migration routes, as well as lowland and coastal areas and stretches of water,” Jaehrling continues. Along the 410 or so kilometres of power line that experts have identified as especially relevant to bird conservation, Amprion has attached special bird protection markers to the uppermost wires. These small, black-and-white plastic tubes that flap about and rotate in the wind are easily visible to the birds and help them to better pick out the thin overhead earth wires. “Through this measure, we’ve been able to cut the collision risk by up to 90 per cent.” Some sections of Amprion’s lines at the bird sanctuary Hellwegbörde have also been marked in this way.

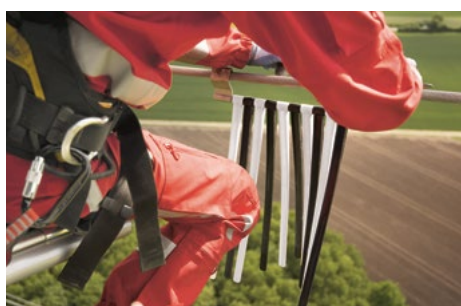
At the base of pylon 133, Sebastian Skoruppa and Tino Herrmann are gathering up their equipment. The nesting basket carrying the old eyrie sits up high on the second cross-arm at its designated position. Perfect for future residents: they can move in as soon as they return from their winter quarters.

BIRD PROTECTION ON OVERHEAD POWER LINES

Amprion's bird protection programme covers all overhead power lines in the area covered by its grid. In addition to special markers attached to the conductors, selected pylons are fitted with nesting aids.



- ① Bird protection markers
- ② Nesting aid



Using a helicopter to help install bird protection measures: the black-and-white markers help the birds better see the conductors.



Dialogue

Amprion wants to expand its grid in a manner that is as acceptable to local residents as possible. Our goal: to get the stakeholders to say “AGREED!” *[page 44]*. It’s important to us to engage in open discussion with them. QUESTION TIME *[page 48]*: one issue on everyone’s lips is underground cables. Our experts give you answers. They belong to the many members of staff who actively campaign as THE DIALOGUE FACILITATORS *[page 52]* for grid expansion.



Zwiefalten, located in the district of Reutlingen: a fantastic example of successful dialogue with citizens.

AGREED!

Getting public approval for a grid expansion project – is that possible? Yes, if citizens, town and parish councils and grid operators work together in a spirit of mutual trust. A great example of where it led to a positive result for all sides is the municipality of Zwiefalten at the foot of the Swabian Jura mountain range.

PHOTOS · BERTHOLD STEINHILBER TEXT · ALEXANDRA BRANDT

Ulrich Mußmann and Jörg Weber are travelling light. It's mid-November 2016 and the two Amprion employees take the early train from Dortmund to Tübingen in the south-west of the country. Their destination is the regional administrative authority, where they want to submit an application for planning approval for a new construction to replace the old Amprion power line between Reutlingen and Herberlingen. The necessary documentation has already been sent by parcel service – 13 folders would have been a bit too much for the overhead luggage compartment.

Mußmann has been working for four years to get to this stage: together with his team, he's drafted plans, performed calculations and obtained expert opinions; he and project spokesman Jörg Weber have provided the local citizens with all the details of the expansion work planned for the almost 61-kilometre-long power line. All in all, the team has held more than 60 dialogue events, and listened, explained and discussed the potential variants proposed for the route. Amprion wants to upgrade the route across the Swabian Jura in order to prepare for the energy transition. Instead of a 380-kilovolt and a 220-kilovolt line, the route is in future to carry two 380-kilovolt lines capable of transmitting much more electricity. This will enable it to transport more wind power from the North to the centres of consumption in Germany's south-west. The volume of the investment: 85 million euros.

On their arrival at the regional administrative authority, Department President Dr Tobias Schneider greets the two men from

Amprion. It is his authority that will be examining the documents submitted and will decide on whether to give the go-ahead for the planning approval procedure. During the course of this procedure, citizens, authorities and associations will be able to review the plans and voice their feelings and reservations, as well as make suggestions. Schneider is full of praise for the preparatory work carried out by Amprion: "You have done a great deal on the public relations side over the past two years. Your team has done some good work."

PLANNING LINES WITH CITIZENS

Project spokesman Weber is delighted to receive such recognition: "We view the dialogue with citizens, associations and local politicians as part of our core business." Mußmann adds, "We want to plan the lines with the citizens, not against them."

The two have seen how well this works in the municipality of Zwiefalten in the district of Reutlingen, a good 50 miles south of Stuttgart, that they want to visit again. They hire a car and set off. Weber and Mußmann have an appointment with the local mayor, Matthias Henne. The two Amprion representatives had first presented the company's plans for the new 380-kilovolt overhead power line to Henne in September 2014: a stretch of just under seven kilometres that is to run through the neighbourhoods of Sonderbuch and Attenhöfen. Back then, at citizens' consultation meetings and in Amprion's infomobile, it quickly became clear that the locals wanted the new line to be built further away from their homes. At a consultation meeting held in the former primary school in Sonderbuch –



Field visit: Jörg Weber and Ulrich Mußmann from Amprion talking with Mayor Matthias Henne (top photo, centre) and Dr Tobias Schneider, Department President at the regional administrative authority in Tübingen (photo bottom left, centre).



*» Amprion's staff were
always very informative.«*

GERHARD REICHELT, CHAIRMAN OF
THE CITIZENS' ACTION GROUP IN RIEDLINGEN

which the current Minister President of the state of Baden-Württemberg, Winfried Kretschmann, once attended – the local residents plotted their own route proposal in Amprion's plans that would circumvent the residential areas. In addition to the basic technical feasibility, the only real condition on Amprion's part for accepting this relocation was that the owners of the land along this new route would have to agree to it.

Great credit in this case goes to Mayor Henne for his mediation work: in the end, it was down to his powers of persuasion that everyone showed willing to compromise and facilitate relocation of the overhead extra-high-voltage power line. He backed the plans, "because they allowed us to achieve something positive for the community. If we succeed in communicating our own responsibility for future generations, too, people who are affected are more likely to be ready to waive their own personal interests in favour of the common good." The result of the extraordinary meeting of the landowners held in the village hall: 100 per cent approval for relocation.

BYPASS FOR RIEDLINGEN

But it's not everywhere that the local residents all pull in the same direction. A half-hour drive away from Zwiefalten lies the town of Riedlingen. This is where the two Amprion men meet up with Gerhard Reichelt, the former manager of the local savings bank and

chairman of the citizens' action group in Riedlingen. He has lived for many years right next to the existing power line – it straddles the garden behind his house. "The residents of the housing estate would like a bypass," says Reichelt. However, unlike in Zwiefalten, the owners of the land potentially affected are not willing to agree. They're afraid of their properties falling in value.

Amprion has submitted an application in Riedlingen for this bypass. "The majority of citizens are for it, and overall it also makes more sense for operational reasons. Expert reports show that the old pylons are simply not suitable for the transmission loads required today," Mußmann explains. All we can do now is wait and see how the regional administrative authority assesses possible objections during the course of the planning approval procedure.

Despite initial conflicting interests, the citizens' action group did not see Amprion as an adversary. As Reichelt describes, "Amprion's staff were always willing to talk to us and were always very informative. They willingly and quickly made all documents and plans available to us." Mußmann and Weber set off on their journey back to Dortmund. They leave the region with a good feeling. "We've done our job and submitted plans that have been very well thought through," says Mußmann, satisfied. "Now it's time for the regional authority to do its job."

QUESTION TIME

Amprion is facing up to the challenge of building new underground cable links as cost-effectively and in as “soil-friendly” a way as possible. Experts from our specialist departments explain what it’s all about.

ILLUSTRATIONS · IRENE SACKMANN



1

WHAT IS THE LEGAL FRAMEWORK GOVERNING UNDERGROUND CABLING?

In December 2015, Germany's legislators reshaped the legal framework for installing underground cables. A clear distinction is now made between direct current and alternating current power lines. From now on, priority is to be given to using underground cable to construct new, major direct current links, which are so essential to securing the nation's power supply. In Amprion's case, this affects the ALEGrO and A North projects. Our Ultrahigh DC power line is an exception to this rule, because for most of the route we can use the existing pylons, which means there's practically no need to build new – neither above nor underground. The AC overhead power line will remain unchanged. However, under certain conditions, subsections of 11 pilot projects are to be laid underground. Amprion is involved in four of these projects: we have already completed one cable section, near Raesfeld in North Rhine-Westphalia, and another is currently under construction. Amprion is presently examining the technical and legal requirements with respect to partial cabling for three more pilot projects.

DR LARS RÖSSING IS RESPONSIBLE FOR LEGAL ISSUES IN RELATION TO LINE CONSTRUCTION.



2

WHY CAN'T ALL NEW AC POWER LINES BE UNDERGROUND?

The crucial factor determining the use of underground cable for AC links are the laws of physics. And these mean that cables behave differently underground compared with conductive ropes in the air. One key aspect is the right level of reactive power: too low a reactive power level results in impermissibly low voltages, while too high a level leads to excessive voltage levels. Compared with overhead power lines, underground cables generate so much reactive power that elaborate correction measures are required. In turn, these measures lead to complicated reciprocal effects. As a result, the maximum length of underground AC cables is limited. We devote a huge amount of our time to such issues, conducting studies and recording the data and knowledge we gain from our pilot projects with 380-kilovolt AC power lines. That's how we find out how overhead power lines and underground cables can best be combined in the transmission grid. For one thing is absolutely crucial to us: there must be no negative effects on the high levels of availability and reliability of our grid.

MARTIN LÖSING IS IN CHARGE OF GRID AND SYSTEMS ANALYSIS IN ASSET MANAGEMENT.



3

WHAT EXPERIENCES HAVE YOU ALREADY GAINED WHILE CABLING AC LINKS?

With its pilot project in Raesfeld/Münsterland, Amprion has done some pioneering work in the densely interconnected grid. Our colleagues have laid a stretch covering a good three kilometres; trial service has been underway since mid-2016 and running very smoothly indeed. We're already integrating the know-how gained into the plans and construction of our cable sections in Borken and Legden. Like Raesfeld, these sections are part of the Diele-Lower Rhine power line, EnLAG Project No. 5. In particular, it's routes that combine sections of overhead power line and underground cable that are posing new technical challenges, because both technologies have their own peculiar and very different electro-technical characteristics. But there's one thing that can't be denied: AC cable links are only suitable for short stretches and are much more expensive than an overhead power line.

DR JAN BRÜGGMANN IS AMPRION'S MAN FOR CABLE TECHNOLOGY AND CONSTRUCTION.



4

HOW WELL IS AMPRION PROGRESSING WITH UNDERGROUND DC LINKS?

Amprion is responsible for two DC links for which underground cabling has been prioritised since 2015. ALEGrO is a cross-border line that is to connect Oberzier in Germany and Lixhe in Belgium from 2020. We have completed the technical planning work and the official approval process has commenced in April 2017. Our second DC project is A North. It is being planned primarily as an underground cable connection and is to be used to transmit wind power from northern Lower Saxony to North Rhine-Westphalia. The experience and know-how we have gained while planning ALEGrO are now being incorporated into the A North project. This also applies to our public relations work: we are informing everyone along the route from a very early stage and will take on board any proposals and information offered regarding potential cable routes even before we trigger the approval process. By doing so, we aim to get A North built as quickly as possible.

PROJECT MANAGER INGO SANDER IS RESPONSIBLE FOR THE ALEGR0 UNDERGROUND DC LINE PROJECT.



5

WHAT'S THE DIFFERENCE BETWEEN THE UNDERGROUND CABLES ON LAND AND SUBMARINE CABLES?

The biggest difference between land and submarine cables is the length of the individual cable sections and the number and manufacturing process of the junction sleeves.

Submarine cables are preassembled with junction sleeves in the factory and are loaded on to special cable-laying ships immediately following their manufacture. These ships can lay cables that are many nautical miles long. Consequently, very few connection sleeves are required. By contrast, around 40 times as many sleeves are required per phase for a comparable distance on land. Trucks transport the cables on reels from the factory to the construction site. A heavy-duty truck can carry one reel with a maximum of 1.3 kilometres of cable wrapped around it. On the construction site, the individual cable sections are laid, the connecting sleeves fitted and the sections connected up to form a cable system. This makes laying cables on land much more time-consuming – and also increases the number of potential sources of trouble.

TOBIAS WINKEL PLANS NEW EHV CABLE SYSTEMS FOR AMPRION.



6

WHAT IMPACT DO UNDERGROUND CABLES HAVE ON THE ENVIRONMENT?

Whenever we lay underground cables in open trenches, we make sure that we go easy on the ground, the soil and its hydrology. Independent experts conduct comprehensive environmental surveys for each of our underground cable projects. We have gained valuable information in this respect while working on the Raesfeld project. From the very beginning of our pilot projects with underground cables, we have cooperated closely with the local farmers and followed up the effects of our construction work on the ground. Even before we started laying, experts investigated whether the heat generated in the cables can have a negative impact on harvest yields. These studies have revealed no evidence of this. After the cables have been laid, no buildings, deep-rooting trees or shrubs are allowed to stand on a defined protective strip above and to either side of the underground cable trench. There are no restrictions on animals grazing and fields being tilled.

CHRISTIAN TRIMPE CONCERNS HIMSELF WITH ENVIRONMENTAL PROTECTION ALONG AMPRION'S OVERHEAD AND UNDERGROUND CABLE ROUTES.



»A lot of questions arise when dealing with new power line construction projects. As a communicator, I have to provide people with answers. If we can communicate to our stakeholders why the decision to change course and bring about the energy transition means we have to expand and upgrade our grid, we've done our job well.«

Jonas Knoop is a project spokesman in the Corporate Communications department and joined Amprion at the beginning of 2016.



THE DIALOGUE FACILITATORS

They are the “face” of Amprion in contact with local residents, authorities, clients, service providers and potential talents in the labour market. They go out there and get involved, so that the energy transition will be a success.

PHOTOS · MATTHIAS HASLAUER



» Our relationship with our grid clients gives rise to many fascinating questions. Providing them regularly with information on technical and regulatory issues and with good advice is very important to me. After all, stable customer relationships are always founded on trust.«

Sigrid Hanebutt is a consultant in the field of grid customer management and has been with the company since March 1999.

»As a project coordinator, I get to hear and read a great many pieces of information that I share with our external grid partners. My job also covers coordinating scheduled construction measures with authorities, municipal bodies and citizens. Clearly defined responsibilities and interfaces are the basis for mutual success.«

Markus Mochalski is a consultant for the management of grid projects and has been with Amprion since 1995.





» Identifying talented people and persuading them to join Amprion is one of the best parts of my job. It means I come into contact with different personalities almost every day. But working closely with the various specialist departments in the company is also crucial to successful recruiting.«

Dr Meike Wenzel is a personnel officer and joined Amprion back in March 2011.

» Whenever we build new or make modifications to existing substations, we work hand in hand with some highly capable business partners. This guarantees high-quality standards and helps us meet the ambitious project deadlines.«

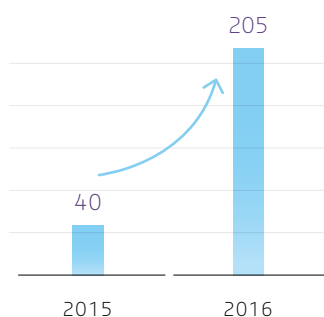
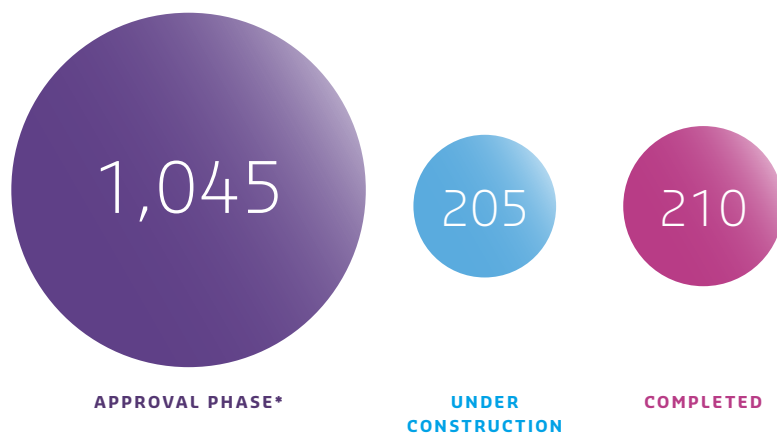
Berthold Pilz is Head of the Plant Engineering Projects department and a employee since 1992.



STATUS QUO 2016

GRID EXPANSION AT AMPRION

(km)



+ 165 KM

that entered the construction phase in 2016. Grid expansion has taken a great step forwards.

As the energy transition progresses, Amprion will continue to upgrade and expand its grid over the coming decade as required. 2016 saw us take a great step forward. We have advanced many of our projects from the preparatory phase to the official approval process. Furthermore, last year we received approval notices for more than 200 kilometres of power line, the majority of which are now already under construction. These include important projects such as the line from the Lower Rhine to the municipality of Doetinchem in the Netherlands and the section of underground cable between Borken and Nordvelen. So far, we have completed 210 kilometres of our grid expansion brief. A good two-thirds of the stretches of power line we have been mandated to build are now in the approval phase, under construction or have already been completed. We will get all remaining sections of line in our remit off the ground during the next few years.

* Source: Evaluation of "EnLAG- und BBPIG-Monitoring" dated 31 December 2016

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NOTE

This is a translation of the German version. In cases of uncertainty or conflict, the German version shall prevail.



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