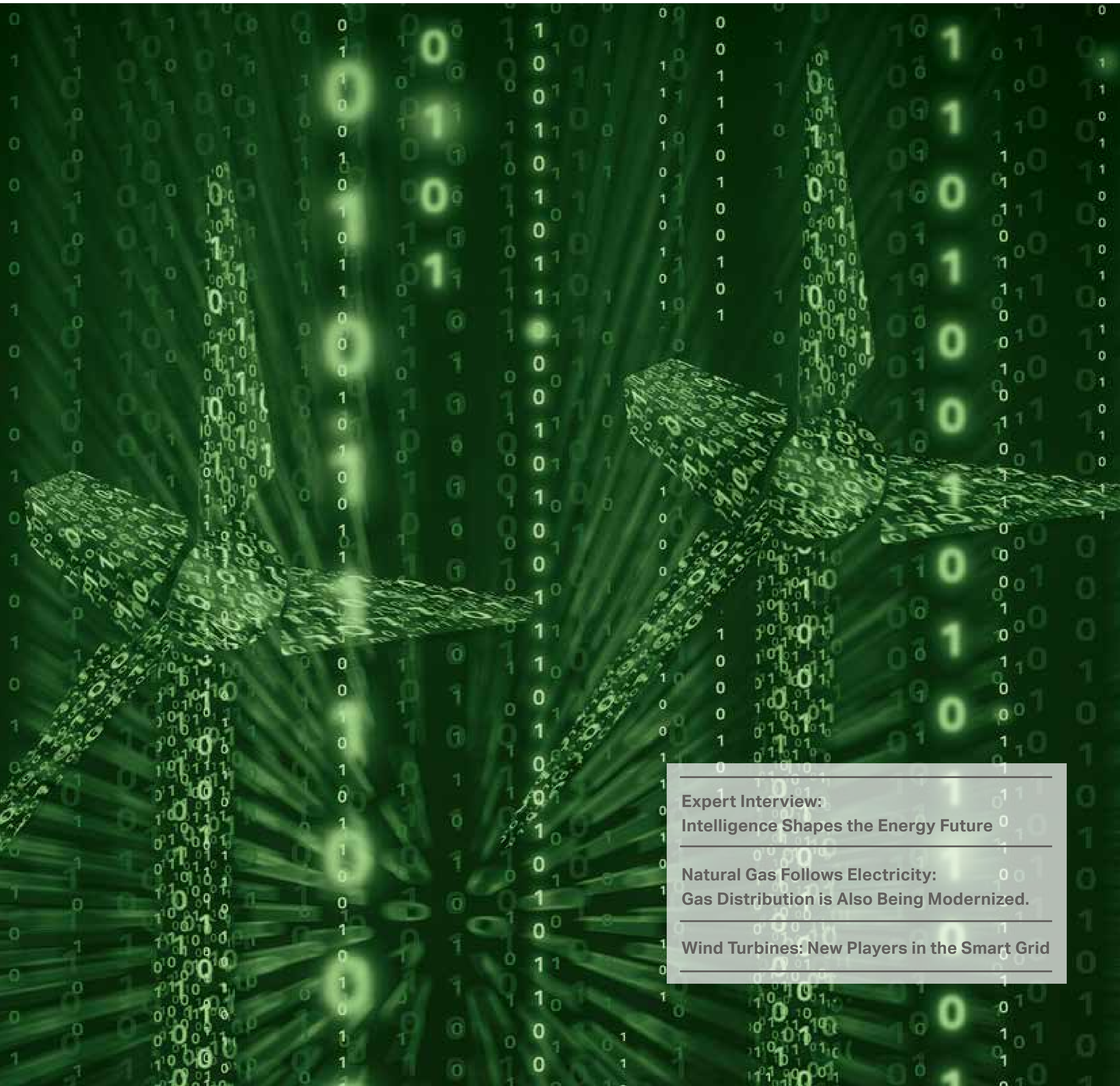
DIRECTENERGY

The Energy Transition Goes Digital

High Tech Controllers and IT Direct the Renewable Symphony



Expert Interview:
Intelligence Shapes the Energy Future

Natural Gas Follows Electricity:
Gas Distribution is Also Being Modernized.

Wind Turbines: New Players in the Smart Grid

REMOTE ACCESS VIA GPRS AND SMS

The PFC200 with Integrated 3G Modem

- High-performance controller with integrated 3G modem and standard mini-SIM card
- Wireless data transmission over great distances
- GPRS Internet connectivity and bidirectional SMS communication
- Highest security standards via IPsec and OpenVPN

EDITORIAL
TIME FOR GREATER INTELLIGENCE AND HIGHER PERFORMANCE

Dear Readers.

Imagine the following: You're watching television during the evening, and suddenly an advertisement for a less expensive electricity rate appears on your screen. Unrealistic? By no means! Digitalization has gained entry into all areas of life and ensures that services will meld together. In the future, electricity and heat will not be exclusively marketed, but provided as a flat rate, for example, in conjunction with communications and entertainment. Multifunctional smart meters for electricity, heat, and telephone make this possible. These types of intelligent meters are already in use in China – and will appear in Europe soon. At that point, classic energy providers will become modern service managers. Or DSL and mobile telephone companies will additionally offer energy services.

One driver for the digitalization in the energy sector is the decentralization of the energy system, caused by the expansion into renewables. Solar parks and wind turbines only produce volatile electricity, as a function of weather, and therefore have to be coupled to batteries and flexible energy consumers in order to balance out the fluctuations. This is forcing energy suppliers to rethink things: instead of merely selling green energy, they also need to organize and market the flexibility that is required for maintaining stability in the electrical network. This means that the energy system with its analog network needs to be controllable using intelligent communication networks from production to consumption – a mammoth undertaking.

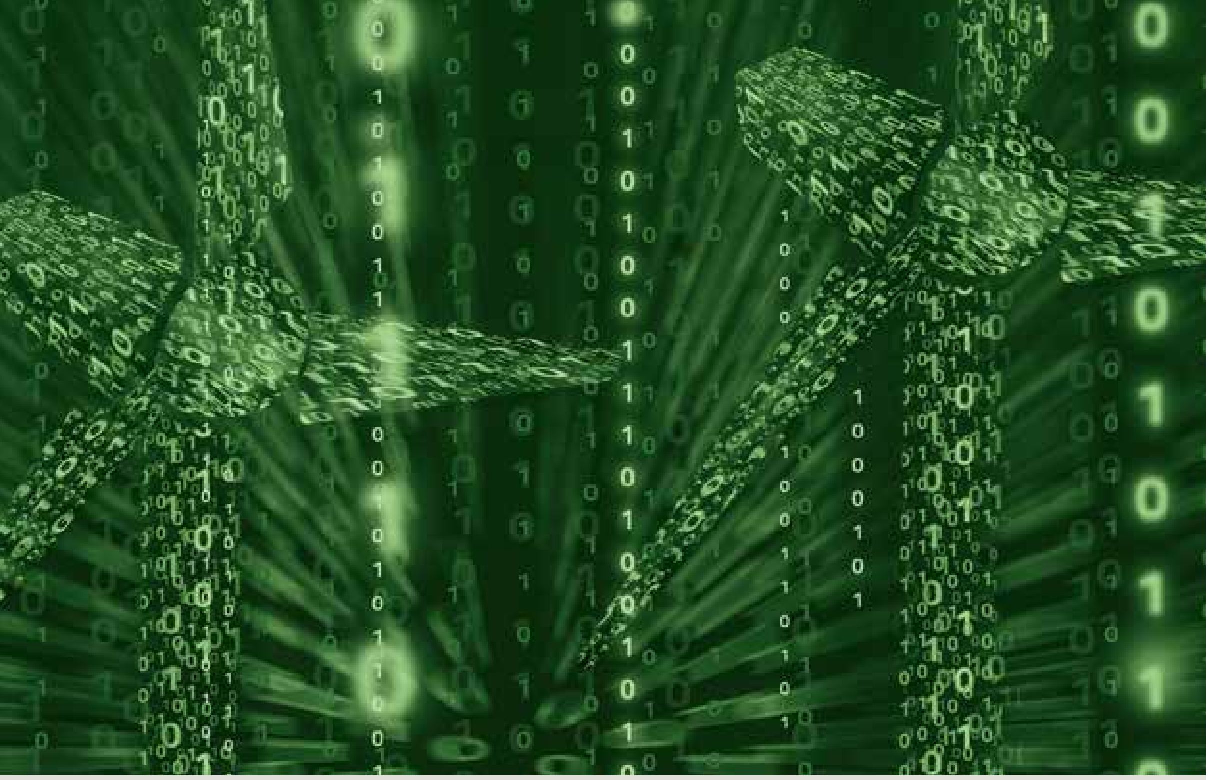
That this can be solved is demonstrated by the first virtual power plants: they combine solar arrays and wind turbines with batteries or industrial consumers to form a flexibly-controllable consortium. Another approach can be seen in intelligent local network stations. They record important network data and transmit them to the network operator so that the humans can quickly counteract any interruptions. Even wind power has become suitable for incorporation into the smart grid, in that the facilities and transformer stations are equipped with modern control and measuring technologies. If a fault does occur, the control room is immediately looped in and can react accordingly. Cloud applications are also on the horizon. The most recent software packages provide data for network monitoring and control, calculate the projected amount of power generated, based on the system outputs and weather reports, and provide forecasts of future network states.

WAGO provides the key technology for almost all currently available smart grid applications: Our controllers measure, control, and monitor in virtual power plants, intelligent local network stations, and in wind farms. Thanks to the encryption of the data, specially secured connections, and the new VHPready standard, this is both uncomplicated and absolutely secure.

The current issue of **WAGO DIRECT**ENERGY provides you with various exemplary applications that demonstrate what WAGO Automation is already accomplishing in the energy sector. If you would like to learn more about our technology, please contact us.

Best regards,

Heiko Tautor



COVER STORY

The energy transition is going digital.

The conversion of the energy system is steaming ahead: solar arrays and wind farms are increasingly forcing the previously-dominant, large, centralized power plants out of the market. Yet, how does one organize the interplay of renewable energy with flexible energy consumers and batteries that are required to compensate for the fluctuating production of green energy? Powerful controllers and digital technologies can create remedies: they can convert the analog electrical network into a communicative smart grid and smooth the path for virtual power plants, which network producers and consumers with one another.

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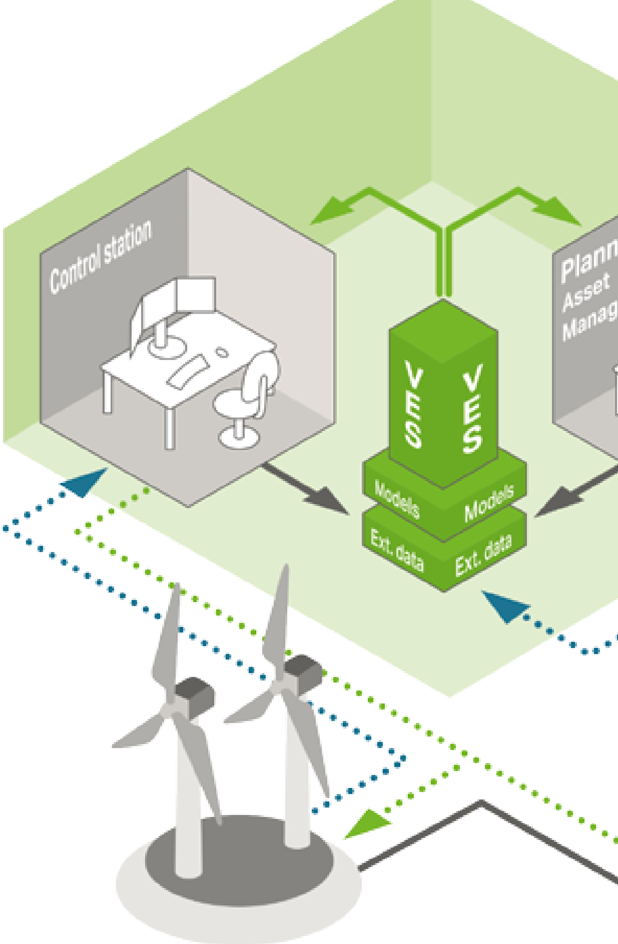


The distribution network becomes transparent.

ANALYSIS INSTEAD OF EXPANSION

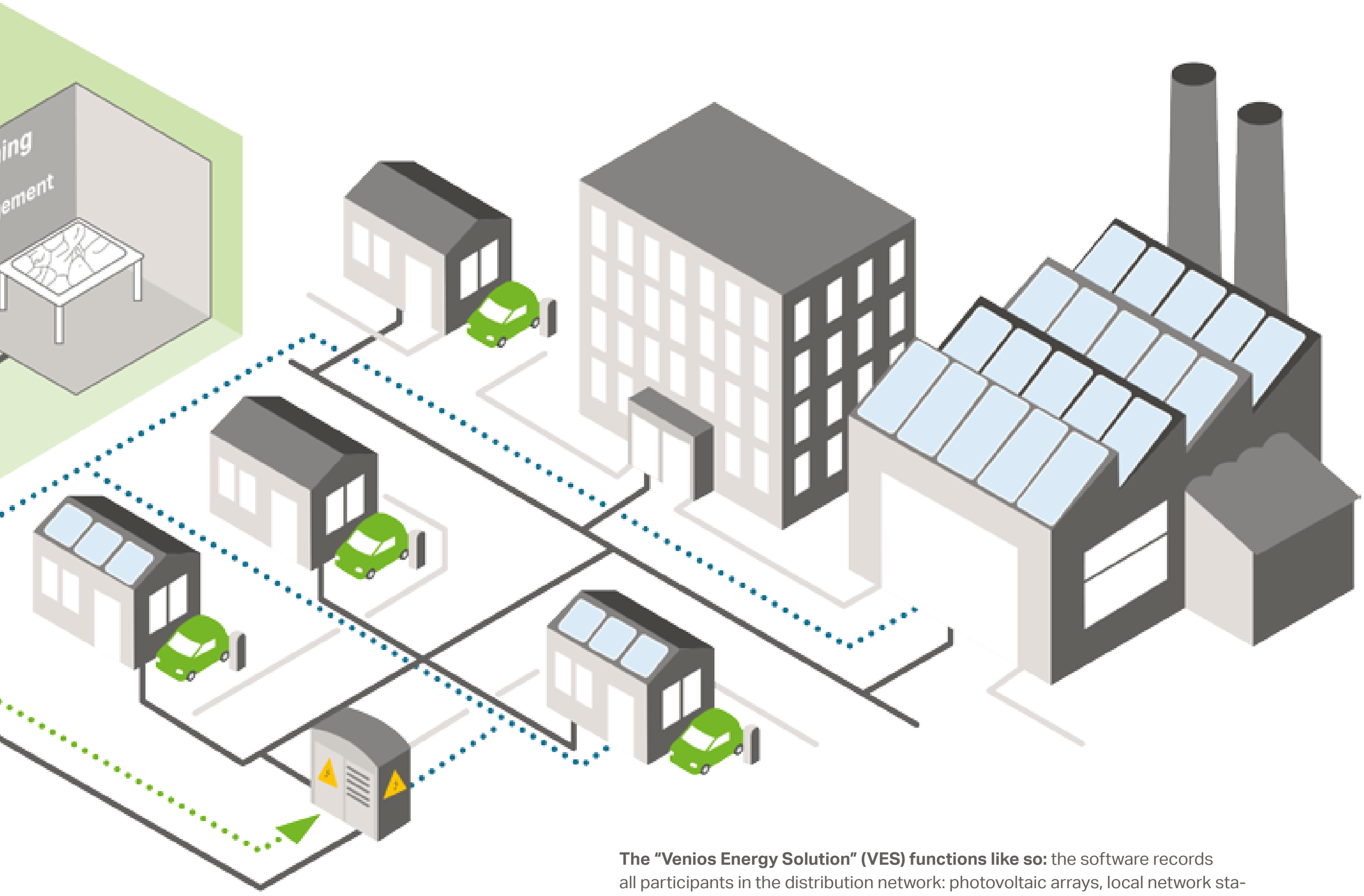
The "Venios Energy Solution" (VES), cloud-based software, provides data for network monitoring and control, and helps to prevent bottlenecks.

Volatile amounts of current, network bottlenecks, fluctuating voltage quality – the energy transition has produced a number of challenges. "One of the largest is providing transparency at the level of the medium- and low-voltage networks. The suppliers here might as well be blind," states Jonas Danzeisen, CEO and co-founder of Venios .

The company has received attention, starting in 2012, for its software; their developers are driven by a vision of tomorrow's energy distribution. As there are already numerous decentralized electrical producers, whose output fluctuates with the weather, new ways to manage the distribution networks are needed. "One path would be to lay new and more powerful cables that can handle any demand. However, it is more economical and sustainable to create transparency in the network. Our software provides this first step, and also assists in the second, which is optimizing the network states," explains Danzeisen.

A Hybrid Approach using Models and Real-Time Data

The software is called "Venios Energy Solution" or VES. It records all assets, from electrical conductors through local network stations to transformer stations, that make up a distribution network. Here is the trick: in order to provide



The "Venios Energy Solution" (VES) functions like so: the software records all participants in the distribution network: photovoltaic arrays, local network stations, electrical lines, and transformer stations, and represents the network state using a combination of calculated models and real-time data. In addition, VES calculates the projected amount of energy generated based on the output of the systems and weather data, and generates forecasts about future network states.

the desired transparency, the tool uses a hybrid approach made from calculated models and real-time data, insofar as the later are available from the network. The software can map every interim step, from the purely model-based to those redundantly described with measured values. With every piece of new measurement technology, the supplier gains a deeper insight into the state of the network and his components. Changes, for example, a new decentralized electrical producer, like a solar array, can be flexibly incorporated. As soon as they are virtually connected to the network, the software algorithms consider the data, like the output of each facility, calculate the projected amount of electricity generated based on weather data, and produce forecasts of future network states.

"No one expects that the German suppliers will equip all of the 800,000 local network stations and other network components with intelligent measurement and telecontrol technology," states Danzeisen. The more interesting question is where intelligent technology is required to optimally use the assets, and where a supplier can rely on models. "If, for example, a transformer runs at 150% for a short time, that is not a problem. However, this should not happen for longer periods. Yet, most suppliers cannot determine when high loads occur and how long they last. This type of information is enormously important for optimized management of the network," according to Danzeisen. Potential is also found in the optimization of maintenance.

Where do you go with the endless data that arise in digitalized energy systems? The cloud provides the requisite computational ability. Modern software helps to transmit information securely from the field level and to manage it.

High Innovation Speed

Some German providers are already using the Venios software. Loads can be made visible, and then distributed, in order to reduce costs for network expansion. There is also demand for this software abroad. Stedin, a network operator in the Netherlands, relies on the tool as the central component their current project to determine how to flexibly counteract network bottlenecks. The Venios experts recently conceived of an additional module for the project, which can be used to link electric vehicles and battery units as electrical buffers, and any free capacity can be sold. "In this way, an entire series of innovations can be generated, and ultimately the Venios customers will profit. The speed at which we are continuing to develop the software is incredibly high," says Danzeisen.

The software is functionally up to date, as well as technologically. It is cloud-based, and can be operated using the Web browser, which is the physical basis for Microsoft's cloud-based platform, Azure. Azure is now hosted on telecom servers in Magdeburg and Frankfurt. Microsoft reacted to the requirements of German companies, who did not want their data arriving at third parties via foreign servers. The Venios software is highly scalable, as it is a cloud-based solution.

The Next Evolutionary Steps are Already Integrated

In the future, suppliers in Germany will acquire increasing amounts of measurement data due to smart meters; this is true on the consumer side as well. Even though there will always be sectors in which excavators are required, "it is more economical to rely on measurement, monitoring, and control technology, in connection with software, in many sectors."

TEXT DANIEL WIESE | WAGO

GRAFICS VENIOS , WAGO

RETHINKING TELECONTROL TECHNOLOGY – THE WTG PROTOCOL CONVERTER FROM WAGO

With the Telecontrol Gateway, WAGO offers a manufacturer-independent connection of up to 16 telecontrol substations to the control system.

Regardless of whether they supply water, electricity, heat, or gas, the importance of decentralized participants and the complexities of the control systems are constantly increasing. Often, a network arises through aggregation, combining interfaces from different manufacturers. Operators are forced to involve the control system manufacturers with every system adjustment, programming change, or parameterization. Intelligent, flexible telecontrol solutions are thus more necessary than ever. WAGO's new, compact Telecontrol Gateways (WTGs) enable connection of up to 16 substations in an open structure at the control level. This provides suppliers with a new degree of freedom, transparency, and cost efficiency. The new, compact Telecontrol Gateway is especially suited for decentralized use due to its narrow design, and as a precursor to data concentrators/ front-end communications channel and the control system.

Connectivity and Security

WAGO's WTG introduces, for the first time, an open transmission level between participants at the field and the control levels. A PFC200 with WAGO telecontrol software connects the telecontrol substations (according to IEC 60870-5-101/104) and the protective devices (according to IEC 60870-5-103) to the control level (according to IEC 60870-5-101/104). Up to four RS-232/485 modules can be connected to the PFC200 for serial communication in the field. The WTG can be used everywhere that telecommunication substations are supposed to be powered up, independent of the manufacturer, or where limitations in control technology – with regard to the number of possible connections – need to be alleviated. Connections to the field level are provided via standard wiring, dial-up connections, or transparent TCP/IP connection (DSL or GPRS router), and to the control level via ETHERNET or serial communication. Data are communicated reliably and securely to the control center, such that no additional parameterization is necessary. An optional redundant structure is also possible via a TCP/IP connection of two WTGs to a control system. This ensures increased security, particularly in areas of critical infrastructure. In addition, for example, the PFC200 can be hardened according to the BDEW White Paper and is designed to implement the current highest security requirements according to ISO 27002.

Maximum Scalability and Cost Efficiency

The WTG enables comprehensive data collection from all telecontrol substations, regardless of manufacturer, and centralized transmission to the control level. In addition to data transfer bundling, it also supports coordination of incoming and outgoing analog, GSM or ISDN dial-up connections to substations. No special parameterization software is required for operation. Using Web-Based Management (WBM), operators can, within the parameters of their license agreement, add participants and carry out system adjustments. This simplifies the installation of telecontrol substations and reduces integration costs. Costs arising from external servicing are eliminated as unnecessary. The improved data transparency allows operators to recognize potential errors in the field at the transmission level, and thus these errors can often be independently alleviated.

Flexible and Complete Solutions

With its detailed modular design, the WTG meets the high requirements for telecontrol technology in the energy, environmental and process sectors.

Interface management at EV charging stations

SOLAR FUEL – EVEN AT NIGHT

The brakes have been placed on E-mobility in Germany, in part due to a lack of charging infrastructure. Ingenieurbüro Fehringer (IBF), an engineering consulting firm from Dortmund, might be able to advance the expansion with an innovative solution. They have developed a solar EV charging station which can provide green energy around the clock due to a combination of photovoltaics and batteries. WAGO technology manages the interfaces and ensures secure data communication.

How will the federal government's goal of one million electric vehicles on the roads in Germany be achieved by 2020? Many experts have already

Open 24 hours:
Thanks to a battery storage unit, e-vehicles can also charge up at night at the Fehringer charging station.

labeled the proposal as unrealistic; there is both a lack of affordable e-vehicles with acceptable driving ranges and also an insufficient number of charging stations for the e-vehicles currently on the road. To drive, for example, from Dortmund to Minden and back, an e-vehicle with a range of 200 kilometers would have to charge somewhere along the return trip. But where? Fear of insufficient range has put the brakes on potential buyers.

Therefore, the German car manufacturers are working proactively to solve this. BMW, Daimler, Ford, and Volkswagen and its subsidiaries Audi and Porsche plan to jointly construct quick charging stations across all of Europe. In the first stage, a total of 400 EV charging stations shall be created along the largest European traffic arteries by 2017. By 2020, a dense network of charging stations should cover Europe, providing impetus to electric mobility.

Innovative companies are driving parallel developments in new fueling station technologies with great dedication. An EV charging station, where e-vehicles can charge using green electricity around the clock, is among these recent projects. The approach: a photovoltaic array on the roof of the station supplies the charging columns with solar electricity. If the solar modules produce more on a sunny day than is required for charging e-vehicles, or which can be accommodated by the electrical grid, the the excess is fed into lithium-ion batteries. These supply the charging units at times when the modules do not provide energy – at night – so drivers can use the charging station at any time.

Blunting Midday Peaks

The concept was developed by Ingenieurbüro Fehringer (IBF) from Dortmund. "Electric mobility is the future. In the next few years, the federal government plans to invest 300 million euros in expanding the charging infrastructure," explains CEO Nicolaj Fehringer. In order that his company's EV charging stations might also be considered during this process, IBF has already constructed a demonstration system with a 36 kilowatt hour storage capacity in Dortmund at the corporate headquarters. "The interplay of electrical generation, storage, and charging functions problem-free in this project," states Fehringer. In addition, the solar battery provides relief for the electrical grid by capping dangerous midday peaks on sunny days – an important contribution to an energy system that must incorporate increasing numbers of renewable energy producers.

Admittedly, the IBF engineers initially faced several challenging questions during the design of the electric fueling station: How to efficiently connect the individual systems – solar modules, lithium-ion batteries, charging columns, and inverters – to the control technology. How to implement a secure data exchange between the individual components? Which controller is compact enough, despite the high technical demands, to be accommodated in the switch cabinet in a space saving and inconspicuous way? During collaborative projects, in which different technologies have to integrated in limited space, compactness is an essential requirement.

During their search for suitable solutions, IBF came upon WAGO. The Telecontrol PLC (750-8207/025-001) takes on all communication and interface management in the EV charging station. Communication with the control center is carried out using the TCP/IP-Protocol IEC 60870-5-104 via a VPN tunnel. "This allows us to satisfy the requirements on the part of the network operators and the highest security standards, like the BDEW White Paper," explains Fehringer. Another advantage of the Telecontrol PLC: it can securely transmit SMS and email via the mobile phone network due to an integrated GSM module within the context of operations management. In addition to telecontrol functions, the controller also offers visualization. An integrated Webserver provides the engineers with configuration options and status information. "Normally, we would have to purchase this feature separately," states Fehringer. Due to expansion potentials with serial interfaces, communication with additional systems within the charging station in not a problem. For example, one component communicates using Modbus RTU, another via a proprietary serial protocol. The controller offers the necessary flexibility and capabilities to satisfy all requirements, both in the present and the future.

100 percent emission-free: The electric charging station designed by Fehringer from Dortmund is supplied exclusively by solar modules on the roof.

High Technology and Eye Catching

In addition to the technical advantages, the EV charging station is also visually engaging, with colored LED lighting that creates a welcoming ambiance at the charging columns after dark. "We placed a lot of value on the entire design, because people spend time where they feel comfortable," explains Fehringer. The combination of high technology and style has already generated interest among well-known companies. "There have been high-profile contacts." Opportunities could develop that combine shopping or leisure activities with charging in the future: the e-vehicle could charge while the owner dined or shopped. Operating companies could use excess power to cover their own energy requirements. For these types of applications, Fehringer plans to offer batteries with a capacity of 400 kilowatt hours.

Another business model would combine multiple 400 kilowatt hour batteries into a single, larger unit, and operate it as a pool. This would allow operators to sell their output to the large network operators to help compensate for short-term fluctuations in the transmission network. According to Fehringer, the priority for a system like this would be to provide so-called primary reserve power, which must be available to the network within 30 seconds, unlike the five or 15 minutes required for secondary and minute reserves respectively. The primary reserve places extreme demands on telecontrol technology, because it requires high measurement and control functionalities. This is not a problem for WAGO: diverse projects have already proven that they have the right automation solutions on hand.

TEXT DANIEL WIESE | WAGO

PHOTO IBF

Secure communication in the municipal network

TRANSLATOR FOR THE CENTRAL NERVOUS SYSTEM

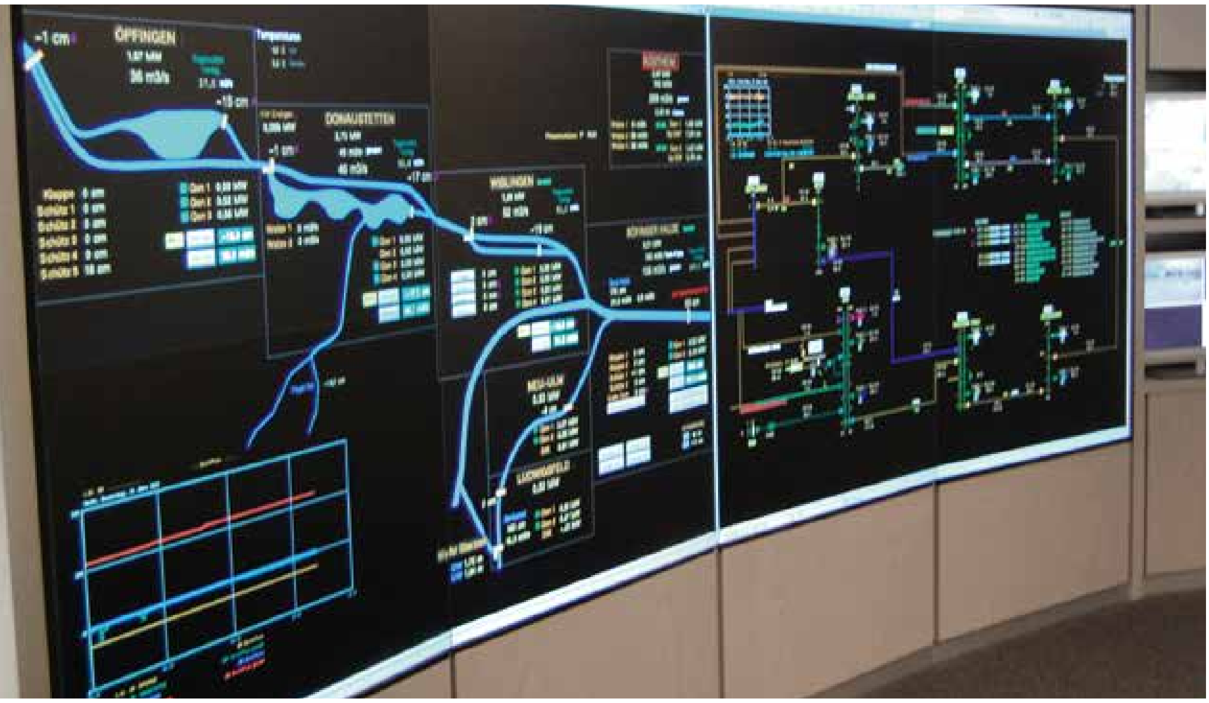
The Ulm/Neu Ulm municipal utility has converted their telecontrol technology to a sustainable network structure. A protocol converter from WAGO ensures problem-free communication during this process.

For more than 160 years, the Ulm/Neu Ulm municipal utility and its predecessors have borne the responsibility for essential parts of the infrastructure in the two communities on the left and right banks of the Danube. It began with the gas supply; shortly after, drinking water was added; responsibility for the electrical supply was gained at the end of the 19th century. In the meantime, the municipal utility also provides district heating, together with a partner. To guarantee a reliable and also cost-efficient supply, the utility relies on a carefully balanced mixture of proven technology and new, innovative solutions.

They are now applying this strategy to the challenges of the energy transition. Due to the expansion into renewable energy, the power grid is consistently supplied by smaller providers, generation has become more volatile, and control expenses have risen. The demands for security in critical infrastructure – including power, water, gas, and heat – have also increased at the same time.

These provide excellent reasons for suppliers to revamp the structure of their telecontrol technology In this context, the municipal utility has replaced the traditional star structure – in which the control center is at the center, and the substations are directly connected using RS-232 lines – with an IP-based network. This enables control of every point within the network through multiple paths. The risk of individual component failure is significantly reduced by the structural redundancy. "Our telecontrol system is the central

Newly connected: In Ulm and Neu Ulm, all substations in the supply network are linked to the control center via an IP-based network. The WAGO Telecontrol Gateway provides problem-free communication.



In the control center: due to the increased use of renewables, electrical flows are more complex and controlling the network has become more expensive. Therefore, the utility in Ulm/Neu Ulm invested in telecontrol technology.

nervous system for supplying Ulm and Neu Ulm. Therefore, the conversion was an important step for us," explains Sebastian Grenzner from his position at the network control center for Ulm/Neu Ulm's municipal utility.

Communication Sustainable into the Future

Whereas communication in the star structure was carried out via IEC protocol 60870-5-101, the network demands another language. The change to the IP-based technology forced the municipal utility to convert the entire data exchange between the control center and the substations – transformer stations, CHPs, and gas transfer stations – to the IEC 104 protocol. The question was how to achieve this in light of the multiplicity of interfaces and systems. According to Grenzner, there was no way to do this conventionally. "If we had had to convert everything manually, the expenses would have been enormous. We would have had to add each system by hand," he explains.

Therefore, Grenzner began searching for a solution that would accomplish this task automatically. This led him to WAGO, whose telecontrol gateways (WTGs) already include an automated data concentrator for telecontrol protocols. In the first test, there were limitations in serial communication. "WAGO was immediately ready to adapt their product to our needs, and ensured open configurability for serial communication," reports Grenzner. Like a translator, the compact WTG ensures that all data are automatically translated from the IEC 101 standard into the IEC 104 protocol, without requiring additional parameterization. The protocol converter is thus flexible enough to deal with the latitude that the IEC 101 standard offered to manufacturers. There are small deviations in the data outputs for each system – dialects of this language, so to speak – which WAGO's WTG easily understands.

"Using the WAGO solution saved us time and money," summarizes Grenzner. In addition, the protocol converter ensures that the municipal utility can continue to operate all 110 substations, that are currently linked to the network, in their traditional way. Many of the systems have been running for twenty years or more; these are reliable, proven technologies on which the suppliers rely. Some of them have been in operation long enough that their documentation is only available in handwritten form. A manual conversion to the IEC 104 protocol would only have been possible with an enormous expenditure of effort. By incorporating the WAGO solution, the municipal utility avoided the need to invest in network-capable systems; the present technology already functions as needed.

Fast Implementation, Easy Operation

The automated conversion also ensures lower costs, greater efficiency, and higher security at other points within the network. According to Grenzner, the municipal utility has been able to reduce their modems to a single ETHERNET type.

“WAGO was immediately ready to adapt their product to our needs, and ensured open configurability for serial communication.”

Newly connected: The WAGO Telecontrol Gateway ensures that all components, that are connected to the telecontrol network in Ulm and Neu Ulm, can continue to operate in their proven manner.

This alone led to 30% savings in this area. The utility also profits during maintenance and repair work. "Our colleagues only have to be familiar with one modem type." In addition, the protocol converter allows the control technology to switch a limited number of inputs and outputs in the substations – to pass fault messages through or acknowledge messages – without requiring updates to the substation control technologies. "It functions perfectly," extols Grenzner. "We can freely set up the inputs and outputs at little to no expense."

The municipal utility required a mere three weeks to bring all 35 protocol converters on line. "There were no problems. We had scheduled more time for this," explains Grenzner. The set up was carried out using Web Based Management. "We had all the information we needed immediately at our fingertips using the Web interface. In addition, we could see the protocol in detail, down to the hexadecimal level."

Redundancy Creates Security

With the new telecontrol structure, the municipal utility for Ulm/Neu Ulm has created a sustainable, economical, and efficient control system that satisfies the highest demands for quality and security. In addition, the utility was able to use the ring network to establish a second, remote telecontrol station to function as a back up with the same functions in the case of emergencies. This redundancy provides the utility with flexibility in spatial expansions, as the central control center will have to be extended in the foreseeable future. The WAGO protocol converter as a central component has provided an important contribution to the security of the utilities for the double city on the Danube.

TEXT KAY MILLER | WAGO

PHOTO RALPH DIERMANN, KAY MILLER | WAGO

POWERFUL MODULES FOR CLEAN ENERGY

A new line of PCB terminal blocks gives WAGO a comprehensive product portfolio that perfectly meets the needs of today's power electronics.

Power electronics have a central importance during the conversion of the energy supply. Inverters and DC/DC converters, for example, are essential components for preparing electrical energy obtained from photovoltaic (PV) systems or wind farms. However, the increasingly compact design of the devices means that the components must be more densely populated on the PCBs, while the power rating remains the same, or even increases. This influences circuit board design and thus connection technology.

WAGO's new power electronics portfolio includes six terminal block families. The new PCB terminal blocks accommodate 4 mm² (12 AWG), 6 mm² (10 AWG) and 16 mm² (4 AWG) conductors, are rated up to 1000 V/76 A IEC, and can be operated via operating tool or lever. They are equipped with Push-in CAGE CLAMP® technology for all conductor types, allowing solid and ferruled conductors to be simply pushed into the unit. Conductors can be terminated both horizontally and vertically to the PCB using the new modules. In addition, testing can be performed both parallel and perpendicular to conductor entry.

Save Space on the PCB

The new blocks also offer a unique space-saving feature: the PCB terminal blocks may connect solid and fine-stranded conductors up one size larger in cross-section than their nominal cross-section dimension.

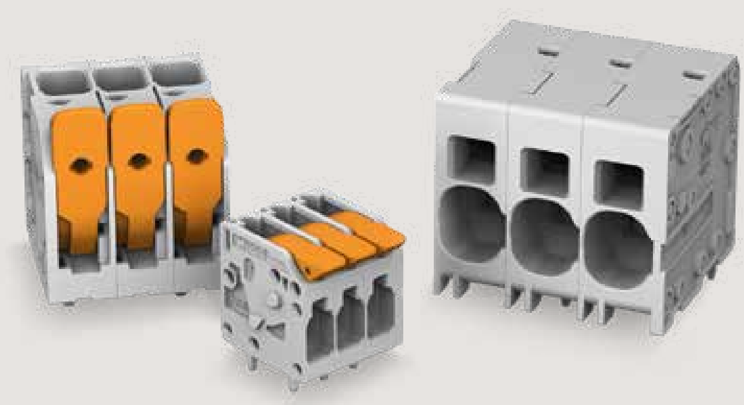
WAGO's 2624, 2626 and 2636 Series PCB Terminal Blocks are ideal for space-restricted applications. Tool operation is performed parallel to conductor entry so that the clamping points can be easily operated – even if individual components are tightly packaged on the PCB.

Easy-to-Use Lever

If individual components are wired in the field during the installation of the systems, then highly accessible and simple-to-operate connection points are essential. To meet these requirements, WAGO developed the 2604, 2606 and 2616 Series PCB Terminal Blocks that enable intuitive and tool-free operation via a lever.

WAGO's compact and high-performance PCB terminal blocks are both easy to use and also offer maximum wiring flexibility. Based on their impressive features, there are multiple potential uses for them in power electronics.

For additional information:
www.wago.com/powerelectronics



The new PCB terminal blocks from WAGO unite compact dimensions, high current carrying capacity, and ease of wiring with a particularly high degree of design freedom.

"THE ENERGY MARKET IS STILL IN THE STONE AGE!"

Tobias Kurth from the consulting firm Energy Brainpool and WAGO energy expert Heiko Tautor see the energy sector as standing on the cusp of change. In the future, decentralized and digital technologies gain ground, classic power suppliers convert to service providers, new business models unify generation and consumption.

The proportion of renewable energies in electrical consumption is supposed to increase from the current level of around 30% to 100%. However, the capacities of the networks are already bumping against their limits. Can the energy transition succeed?

» **Tobias Kurth:** Large demands have arisen for infrastructure, networks, controllers, and flexibilities, which were previously provided by controllable power plants. Biomass as the single, controllable renewable energy appears to be limited; instead, solar and wind energy have dominated the field. The problem is that electrical production in the decentralized systems fluctuates with the weather. Therefore, in addition to new networks, technologies that provide flexibility, like batteries, are necessary both to store excess current and supply it as needed. In addition, the demand for electricity must become more flexible. Up until now, supply has followed demand. This becomes more difficult at increasing levels of fluctuating supplies. «

What will the core features of the future energy market look like?

» **Kurth:** It will have to be more decentralized, more complex, and digitally controllable. Large changes are coming: the expansion of renewables has led to a reduction in marginal costs in energy production, and thus to reduced electrical prices. Therefore, electricity will replace other primary energy sources in heating and transportation. Urbanization also raises questions: since increasing numbers of people live in cities, how do we link the increasing energy requirements of urban centers with decentralized power generation? Do we move generating units into the metropolis? or do they remain outside? If the latter, we desperately need new electrical lines. In any case, intelligent systems will be required to control the increas-

Tobias Kurth studied industrial engineering with a focus on environmental technology at the Cologne University of Applied Sciences. He has worked at Energy Brainpool GmbH & Co. KG since 2013, and has served as CEO since April 2015. His focus is on the market transformation with renewable energies and on electrical price forecasting as a basis for investment and financing decisions.

Heiko Tautor is Head of Market Management Energy at WAGO Kontakttechnik GmbH & Co. KG and specializes in renewable energies, smart grids, and battery technologies. The expert in energy technology has worked at WAGO for 13 years. In addition to renewable energies, he has focused on automating distribution networks.

ingly complex power flows. We will also need business modules that fit the new decentralized and digitized world. «

» **Heiko Tautor:** An additional complication to the conversion of the energy system: the demands of various regions differ extensively. In the north, the priority lies in expanding the network in order to transport the wind energy from the coastal regions to the centers of consumption. Cities, in contrast, are turning to photovoltaics, and CHPs are also gaining as heat generation units. On cold, clear days, the CHPs produce both the requisite heat and also electricity in conjunction with the PV systems. Where does one store all this power? Batteries offer one solution. «

What options for flexibility do you see in addition to batteries?

» **Tautor:** Power-to-heat, power-to-gas, and power-to-mobility are gaining importance. The proposal: excess electrical energy is converted into heat, gas, or synthetic fuel. This linking of sectors offers the advantage of alleviating the load on the power grid, and is also a way to link heating and transportation into the energy transition: until now, these sectors have played a subordinate role in climate protection. «

» **Kurth:** The demand for flexibility will provide other important options, primarily in the industrial and commercial sectors. Many processes are already automated and controlled using measured values. It would not be a problem to consider electrical costs as an additional control variable. If a green energy flow comes on line and electricity is offered at a correspondingly inexpensive price, the company could produce; when power is expensive, the processes could idle. Control and measuring technologies are required to enable such an approach. And it would also require an energy supplier who operates in the background to handle all of the processes for customers. «

However, production companies could also offer negative reserve power to compensate for short-term peak loads.

» **Kurth:** Not all companies will be willing to participate. During balancing power operations, they would be handing over the majority of their processes to large network operators, who would be able to intervene whenever they needed power. If, however, the companies manage their production based on electrical prices, then they remain in control of their own processes. This business model could be quite lucrative for industry. «

Is the digitalization of the energy economy already so advanced that these types of models are possible?

» **Tautor:** Actually, digitalization is only in its infancy. The potential for efficiencies in industry and commerce are enormous; however, the problem remains that these consumers scarcely communicate with the network operators. The missing pieces are the interfaces, which enable the exchange of relevant measured values between the individual actors: how much power is produced? how much is consumed? and when does it make sense to shut off consumers? «

» **Kurth:** At the moment, the energy market remains is the stone age with regard to communication technology. Measurements and calculations are carried out in 15 minute intervals in the energy economy – there is no trace of real-time activity. However, there is even less communication in the private sector. The mechanical meters, for example, which record private energy consumption, are usually read once annually. The different formations need to be much more closely interconnected in the future in order to react autonomously. «

What technologies do we specifically need?

» **Kurth:** Technologies that precisely measure, control, and monitor, and can simultaneously incorporate prognoses about power generation. And they need to function in real time. We are talking about enormous quantities of data: previously, there was one data point per consumer and one per power plant. With a total of around 400 centralized, controllable power plants, which were operating in Germany, the data were manageable. This changed with renewables. There are currently 10,000 systems in the network, and the energy transition is still relatively young. «

» **Tautor:** There are already technologies that can measure, control, and monitor, with limitations. However, for the final expansion phase starting in 2030, we need systems that are smart and extremely powerful. For example: smart meters are intelligent electrical meters that do nothing but record and forward data. They neither control nor monitor. An additional box would be required to regulate and monitor suppliers and consumers. Today's controllers are too small and not powerful enough. We desperately need technical innovations for future applications.«

What does the transition mean for electrical suppliers?

» **Kurth:** They need to quickly begin to convert their business models, because they will no longer be able to earn enough if they only provide electricity. Customers will no longer want to buy kilowatt hours; instead, they will need energy services. They will be divided into two categories: so-called flat rate and pay-per-use customers. You can already purchase communications and entertainment as a flat rate from suppliers. Why not supplement this with an electrical supply contract.

In China, they already have smart meters for everything: electricity, water, and telephones. This trend will soon appear in Germany. The opportunity for energy suppliers lies in how well they manage services in the background. And how successful they are in linking up additional revenues. For example, they might be able to identify from the load curve how old a refrigerator is. Based on this, they could offer the consumer a leasing option for a new appliance. Customers pay in part through access to their data. Anyone who does not agree, can probably set up a less transparent model. In the pay-per-use principle, customers only pay for the electricity that they actually use. Each kilowatt hour is probably more expensive in this case, but the customer can provide less data, because less data are sufficient for this model. Industrial customers could virtually make themselves invisible to outsiders: by using their own generating systems and batteries, they can supply themselves and prevent access to their own energy data. Energy services could sell or rent the systems, and thus offer industrial customers a real added value. The digitalization thus offers a real opportunity to energy providers who are capable of change. «

Mr. Kurth and Mr. Tautor, thank you for the conversation.

THE ENERGY TRANSI-TION GOES DIGITAL

High Tech Controllers and IT Direct the Renewable Symphony

The expansion of renewable energies will only succeed when the fluctuating supplies from solar and wind arrays are compensated by flexible electrical consumers and batteries. Digital technology can help to solve this problem: intelligent systems convert the analog electrical network into a communicative smart grid and smooth the path for linking virtual power plants, generators, and consumers with one another.

A new team: the sun shines, or not; the wind blows, or not. Solar arrays and wind turbines do not always produce electricity when needed. Generation and consumption thus need to be better synchronized.

There are troubles ahead for wind energy. Although wind turbines are supposed to carry the lion's share of electrical supply over the long term, the federal government is putting significant brakes on new construction in northern Germany. Beginning in 2017, Bremen, Hamburg, Schleswig-Holstein, Mecklenburg-Western Pomerania, and the northern parts of Lower Saxony are only permitted a maximum new wind output of 902 megawatts – this is not even 60% of the output that is currently available. This is because the electrical lines in the stormy coastal regions have reached their capacitive limits. Wind turbines are increasingly switched off within the context of the so-called supply management, because the numerous green energy flows would damage network stability.

The difficult problem becomes how to release the brakes on the energy transition. New electrical lines are supposed to transport the wind power from the coast of the North Sea to the south; however, the network expansion has been held up because laying the ground cables has taken

longer than planned. Another challenge is gaining control over the weather-dependent, fluctuating green energy production. Solar arrays and wind farms already provide one-third of the electricity required in Germany – a proportion which is supposed to increase to 100 percent by 2050. According to experts, technical adaptations and new business models for marketing renewable energy are desperately needed. "We are relying on a type of generation that fluctuates, is decentrally distributed, and involves small producers. This engenders new challenges for the infrastructure, the electrical grid, and the management and flexibility, which were previously available through controllable power plants," explains Tobias Kurth from Energy Brainpool, energy marketing experts from Berlin.

The industry faces a mammoth task: they must develop solutions that retain stability in the electrical grid at a frequency of 50 Hz, even with increasing green energy production. Battery storage units, among others, are required, as they can quickly accommodate excess current and discharge again as needed. If they were installed, for example, at the base of large wind farms, then the stored energy could be used as balancing power to compensate for short-term fluctuations in the electrical grid. This would also avoid the mandatory switching off of wind turbines. The combination of batteries with photovoltaics is also logical. If solar batteries are coupled to charging stations, then EV charging stations can operate around the clock, providing solar energy to electric vehicles, or the batteries could also be used in the residential sector as energy stores. These could increase personal consumption, and simultaneously cap the midday peaks from solar production that endanger the electrical grid.

Heat and Fuel from Electricity

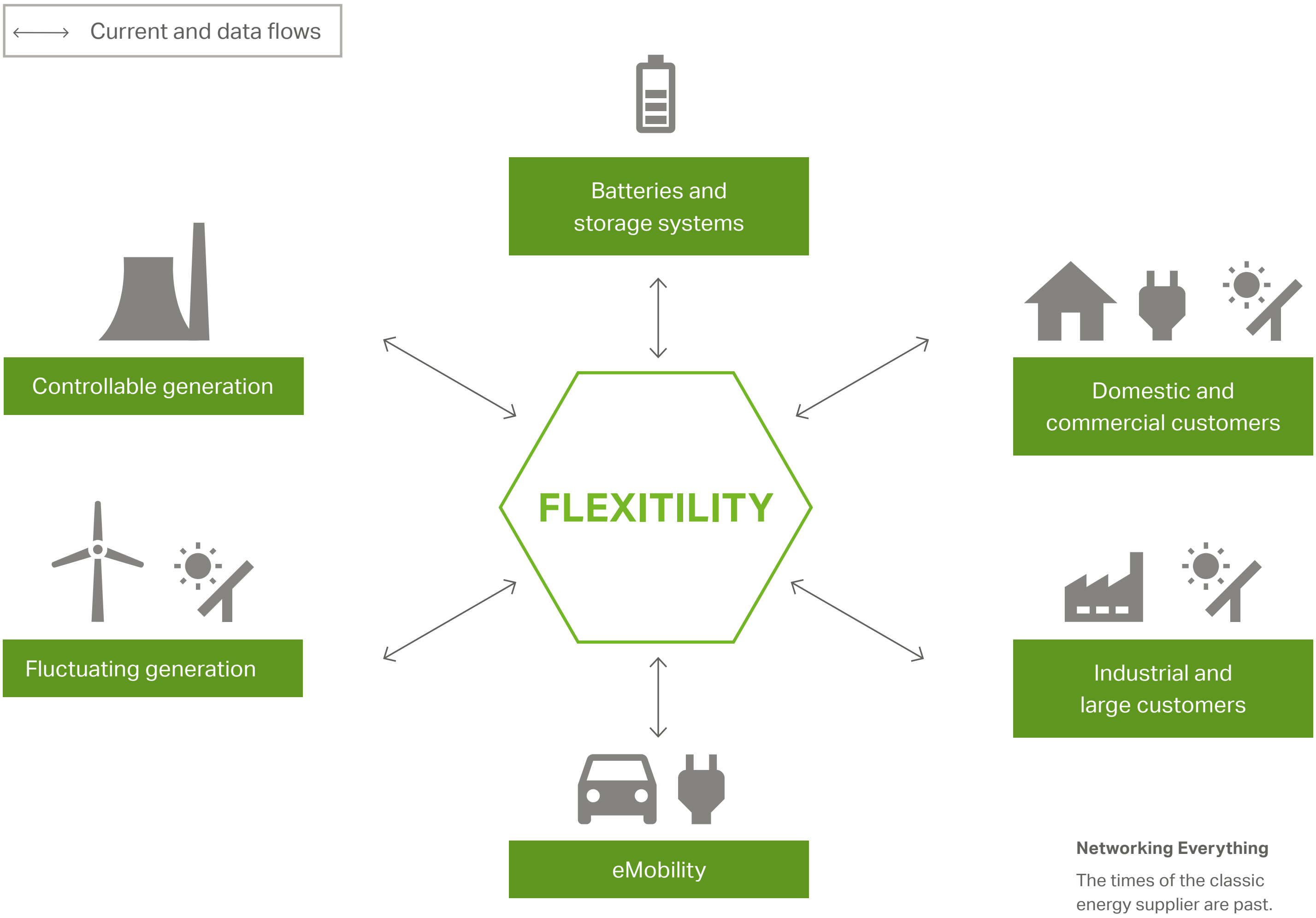
Power-to-heat and power-to-gas systems offer additional options for flexibility. They convert green energy into heat, using electric boilers, or into hydrogen and then methane through electrolysis. The heat can be supplied into a local district heating network, the gas can be stored for longer periods in existing natural gas networks, which supply residential areas, power plants, and fuel stations. Thus, power-to-heat and power-to-gas both reduce the load on the electrical grid and also link in the heat and mobility sectors, which have previously played a subordinate role in the energy transition. “We could use northern Germany as a gigantic test lab for sector linkages. A few possibilities include: gas or heat generation using excess wind energy, supply local programs for heat pumps or e-vehicles, establish test routes for electric trucks or buses using overhead lines. This would also enable the quick expansion of the wind energy sector,” explains Volker Quaschning, Professor in renewable energy technologies at the University of Applied Sciences Berlin.

However, the development of potential flexibilities, like batteries, is not the only challenge. Batteries must also be networked with the decentralized generators and consumers. The energy originates in a system built from thousands of producers, dominated by solar arrays and wind turbines, and flows in many combinations in several directions: it is comparable to data in the Internet. Therefore, intelligent, digital systems are necessary to mea-

Herculean task in the energy transition: According to Tobias Kurth from the energy market experts, Energy Brainpool, the energy market stands at a turning point.

FROM SUPPLIER TO "FLEXITILITY"

In the future, energy must be managed, not just distributed.



Networking Everything

The times of the classic energy supplier are past. Instead of merely distributing energy, the interplay between decentralized producers and consumers must be intelligently coordinated. This requires sophisticated digitalization strategies and business models.

sure the complex energy flows and to control and monitor the production systems according to the network situation. In addition, the systems must enable absolutely secure communication between the production level and the control technology; hacker attacks on power plants and the electrical grid are common and can endanger the supply network. "The digitalization of the energy transition is the prerequisite for managing a decentralized energy market," states Kurth.

The good news: according to the study, "Germany's Energy Suppliers are Going Digital", conducted by pwc consulting, more than two-thirds of the energy production companies assign consider decentralized energy solutions to be highly relevant and view digitalization as a lever for increasing their process efficiency. Digitalization potentials arise along the entire energy added-value chain. Flexible electricity pricing, which follows the availability of green energy, is an approach that is especially appealing to commercial and industrial consumers: when solar arrays and wind turbines produce a lot of energy, then suppliers offer electricity at reduced prices. This encourages consumers to adjust their use to the fluctuating generation. This is merely a first step: "Increasing numbers of households produce their own electricity with small CHPs and solar modules. They are no longer consumers, but have become prosumers, who both consume and provide excess power to the grid," explains Kurth. If these households are networked together, they can balance supply and demand among themselves.

2017

33% of the electricity consumed in Germany will be produced from renewable sources; by 2035, this should reach 55 to 60%. (Source: BMWi)

520 billion

represents the total costs for expanding renewable energy up to 2025. (Source: DICE)

76%

of energy suppliers want to use digital technology to optimize their business processes and network economics. (Source: pwc)

64%

of energy suppliers have already noticed changes in customer demands, like digital contact channels, higher servicing expectations, and increased price sensitivity. (Source: pwc)

91%

of companies and universities consider IT security to be a critical topic for the success of digitalization. (Source: VDE)

2025

one fourth of the energy producers will fail, due to demands for digitalization, and they will vanish from the market. (Source: pwc)

Virtual power plants are a move in the same direction. The combine decentralized producers, like biogas, solar arrays, wind turbines, CHPs, heat pumps, emergency generators, and batteries, with intelligent control technology to form a flexibly controllable group. Network operators supply balancing energy from registered suppliers to compensate for fluctuations in the higher level transmission networks. Some companies are already using virtual power plants to offer this service. Trianel, a municipal cooperative, bundles generating and storage technologies into a balancing pool with more than 700 megawatts of total output. In practice, the biogas systems, storage facilities, etc. in the Trianel power plant are operated as usual. If the network operator calls for balancing power, then an algorithm in the control system selects the suitable systems and controls them from the control center. The advantage of the Trianel power plant is that it is composed of 400 individual systems and thus offers a high level of flexibility. It can thus cushion short-term fluctuations quite well.

Safely Managing Complex Energy Flows

Intelligent local network stations (iLNS) can also play an important role during the digitalization. Earlier transformers were passive elements that reduced the electrical voltage from the medium-voltage network to the lower voltage used by the local supply network using a fixed ratio. An iLNS, in contrast, records various measurement data in the medium-voltage network and offers the potential for reading these values remotely. This allows the network operators to adjust the voltage levels at any time. If, on a sunny day, a lot of solar power is supplied, which increases the voltage, an iLNS can quickly compensate for this. This increases the accommodation capacity of the network and prevents bottlenecks, which can ultimately put the brakes on the expansion of renewables.

WAGO's development can help promote the digitalization of the energy supply. In order to retrofit conventional local network stations into intelligent ones, it is essential to synchronize the primary and secondary components in a reliable way that conforms to standards. In conjunction with their project partners, WAGO has already created a corresponding system and completely equipped it with automation technology. The station uses a **PFC200 XTR Controller** for the medium voltage, a **PFC200 Controller** for low voltage, an ***e!****DISPLAY* panel for visualizing the measurement and control data directly at the LNS, and completely automated connection technology.

The WAGO Controllers, which are freely programmable via CODESYS, collect all data from the substation's various systems via digital and analog signals (e.g., via Modbus RTU). These controllers then translate the data into supplier-required communication protocols (IEC 60870-5-101/-104 or IEC 61850) and transmit the data to the control center via data lines. In the opposite direction, the control center can access the substation's systems (e.g., medium-voltage switch cabinet, protective devices, measurement systems from different manufacturers) via the WAGO Controllers. The WAGO Controllers protect the data flow by encrypting the data using TLS1.2 and also by transmitting the data via specially secured connections, like IPsec or OpenVPN, according to the BDEW White Paper.

The WAGO technology provides secure communication and control for virtual power plants as well. The generators and consumers combined into this type of power plant speak different languages and can thus barely communicate. The new open-source communication standard, VHPready (Virtual Heat and Power Ready) can change this. It functions like a translator so that control centers and distributed systems understand one another. Instead of a system-specific set of variables, which was previously the case, VHPready communicates via predefined profiles using uniform data point systems. In addition to communication, domain-specific definitions, like the specifications for operating behavior and reaction times, are also defined. This provides the ability to control systems using timetables. Thus, the power plant control center can transmit control parameters for a time period of 24 hours. Without digitalization, the energy transition will not succeed – intelligent control systems are thus becoming the key technology on the energy market.

TEXT HEIKO TAUTOR | WAGO
PHOTO MANFRED H. VOGEL | vor-ort-foto.de, iStockphoto.com
GRAPHIC ENERGY BRAINPOOL

More Expensive Network Expansion

The discussion has already been completed: the energy transition demands new networks. Yet how and where should the targeted expansions take place? In Germany, electricity flows through a total of four networks. If it has to travel great distances, the transmission network comes into play. Three distribution levels bring electricity to the consumers. To ensure energy transport from fluctuating renewable sources over the long term, the four transmission network operators, Tennet, Amprion, 50 Hertz, and TransnetBW, who are responsible for the network expansion, want to construct three new high-voltage routes with a total length of around 3000 km. The high-voltage, direct-current transmission lines of the planned electrical highway are supposed to transport up to eight gigawatts of electricity to southern German in the near future – which also provides relief for the wind generating areas in northern German. In addition, a similar length of the existing network is supposed to be optimized. Estimated total costs: 22 to 25 billion euros. In some regions, additional costs may accrue. The German Energy Agency estimates the investment requirements in the distribution networks, which are supplied by 90% of the renewable sources, to amount to 25 billion Euros by 2030.

Modern supplier: RheinEnergie has begun to breathe intelligent life into the local network stations in contract to the Rheinischen NETZGesellschaft (RNG). WAGO technology is an important component in intelligent LNSs

Clever, fast, and secure – new measuring technology for intelligent local network stations

DIGITAL MAKEOVER

RheinEnergie, electrical suppliers based in Cologne, have created insights into the distribution network using robust I/O systems based on the WAGO 750 XTR. Their goal is to further reduce down times.

Christopher Brunn skillfully wields an X-acto knife to free a recently delivered switchgear unit from multiple layers of protective film. "We currently have two of these new switchgears in the hall," Brunn is the coordinator for primary technology at RheinEnergie. "Both will soon replace the older technology in local network stations around Cologne," explains Markus-Oliver Maitz, a system planner in technical network services at RheinEnergie.

These two switchgears are not the end. RheinEnergie regularly modernizes their local network stations (LNS), exchanging old technology for new, as part of their contract with the network operator, Rheinisch NETZGesellschaft (RNG). This now involves more: instead of mere modernizing, the distribution network is supposed to become more intelligent as well. "Our supply area is quite enormous. If a fault occurs in Lindlar requiring a maintenance team, during rush-hour, for example, then it takes a good bit of time before they are on site." Maitz explains the background for the intelligent upgrades. The maintenance team then has to localize the problem on site. If the control center can narrow the fault down to a single LNS, then alleviating the problem can be carried out faster.

Basis for Optimizations

There are approximately 8000 LNSs in the region supplied by RheinEnergie, including private stations. The majority are located in and around Cologne. "Our stations are modernized per the requirements of the strategic asset management of the network operator," explains Thomas Otto, expert in design and controllers at RheinEnergie. In order to reduce down times, as desired, it is sufficient if three or four LNSs from one supply ring transmit the error direction, according to Otto. In these intelligent LNSs, "clever" measurement technology is not only the prerequisite for fast error location, but it also forms the base for the next step. "The installed telecontrol technology allows our colleagues in the cross-connected control center to carry out switching operations remotely. In the optimal case, at least half of the customers affected by down times are reconnected in a short time," explains Otto.

The new Switchgear I/O controllers from WAGO's 750 XTR series ensure that everything functions as planned. "We wanted a compact control system that could maintain an overview of all necessary information, and still be accommodated in a small switch cabinet," Maitz, the systems designer, summarizes the challenges. It should also be inexpensive. High dielectric strength posed an additional challenge. The 750 XTR Series satisfies all this – and more. Despite its compact design, the robust controller can address up to 16 channels

per control panel using different communication protocols, and forward the data. At RheinEnergie, this is carried out via Modbus TCP/IP. Short circuit indicators, ground connection indicators, circuit breakers, or SF6 pressure loss – in all, the WAGO controllers manage around 50 messages and commands in the switchgear units for RheinEnergie.

One Single LAN Cable Instead of a Cable Snarl

"If you wanted to implement something like this earlier, you had to lay an individual cable to the telecontrol unit for each command," explains Otto. The resulting cable snarl even confused maintenance experts of long standing. Now, one single LAN cable suffices to connect the controller and the telecontrol system. Information arrives at the control center from the telecontrol device. RheinEnergie does not use public communications, but relies on their own data network to transmit data from the LNS to the control center.

The switchgear units, including all primary and secondary technology, were delivered in so-called turnkey condition to RheinEnergie. Basic equipment for each switchgear unit includes a fieldbus coupler, a mains filter, and an end module – everything else depends on the individual demands placed on the local network station at the respective location. Each switchgear unit additionally has an uninterrupted power supply, which is supplied by two battery packs from WAGO. "The battery packs were configured exactly to our specifications by the WAGO experts. The system should operate for four additional hours during a power failure and each field should be able to be switched three times" explains Maitz.

Simply connect it: RheinEnergie receives its switchgear units as turnkey devices, including primary and secondary technology. Each system includes a fieldbus coupler, a mains filter, and an end module as basic equipment. This facilitates installation.

Following the installation of the first system prototype in Spring 2016, the technicians at RheinEnergie continue to install successive systems. “The WAGO controller provides us with all necessary data, it is compact, especially suited to the environmental conditions, easy to parameterize, flexibly expandable, and above all, inexpensive – all of our requirements have been optimally satisfied,” concludes Maitz.

It takes only one week to makeover the average LNS with three to four digital control panels. The smart technology has been a fixed component of the station retrofitting program and is constantly being integrated into the LNSs. Gradually, over the coming months and years, additional iLNSs will be incorporated into the control center at RheinEnergie, including all of the data that the WAGO controllers monitor on site. It can be said as a side effect, that the network also functions better with decentralized and volatile energy sources, like photovoltaic systems or wind turbines. Because if the systems push too much power into the network to the point of failure and the power flows reverse, then the WAGO controller reports this and the control center can react. “Our average down time, is currently less than eight minutes,” states Maitz. “This important parameter will soon be reduced again.”

TEXT DANIEL WIESE | WAGO

PHOTO NIKI ROMCZYK | ALPHADIALOG

Everything firmly in hand: Tino Tietze is the primary expert in process technology and IT project planning at DREWAG NETZ , and is thus responsible for the technology in the gas and district heating sectors.

Intelligent networking technology in the natural gas sector

CONTROLLED BY PRESSURE

It is said that the energy transition is currently limited to the electrical sector. DREWAG NETZ GmbH is going a step further, and modernizing its gas distribution stations to bring intelligence to its gas division. The company thereby relies on automation solutions from WAGO.

When smart grids are discussed, the focus is commonly on the electrical sector. The same occurs during public discussions about the energy transition. The gas and district heating sectors are experiencing, in contrast, a shadow life, at least as far as perception goes. Yet adding intelligence is no less lucrative here. Recently, energy suppliers like DREWAG NETZ from Saxony employed smart technology at the regional level in gas distribution systems. The I/O technology from WAGO's 750 Series is used in an increasing number of gas pressure regulating stations in Dresden.

Data Transmission in the Connectionless Network

Tino Tietze, primary expert in process technology and IT project organization, is responsible for the technology in the gas and district heating sectors. Under his leadership, DREWAG NETZ began expanding a proprietary process-IP network based on MPLS (Multiprotocol Label Switching) in 2007. MPLS enables connection-oriented data transmission in an otherwise connectionless network. While the gas is distributed connectionless, that means, without transmission in the opposite direction, a message connection between transmitter and receiver can be established in both directions for data exchange. This forms the foundation for a distributed system that has many advantages: controlling and accessing all data of the connected system is possible from any linked in location. This increases security against down time. The entire system can be more easily scaled, so that output can be adjusted to demand at all times. Additional systems can subsequently be more easily connected, which could become even more important with greater decentralization.

Increased Functionality through Process Control Systems

Against this background, DREWAG NETZ began introducing a process control system across all pipe media in all control and dispatching centers starting in 2011. The pipe media include gas, water, and district heat, as distinguished from from electricity. The project was completed in 2016 and enabled an entire series of additional functionalities. For example, objects from different data recording systems can be represented and updated in a single image. Event protocols from all systems can be displayed in one window. System images can be called up everywhere, alarms from all systems can be displayed and acknowledged. In this context, reliable communication is consistently established using the IEC-60870 telecontrol protocol.

Telecontrol Technology from WAGO is Convincing at the Field Level

For process-related components, Tietze trusts the technology from WAGO, particularly where the actual measuring, controlling, and monitoring takes place. Uninterruptible power supplies (UPS), signal conditioning modules, and telecontrol technology from WAGO is found in increasing numbers of switch cabinets at gas pressure regulating stations in the DREWAG NETZ. The telecontrol technology, in particular, was economically convincing, both for various telecontrol systems and in the subsequent field tests. 15 of these controllers are currently active in the supply area, and this trend will only increase. This is because the ICA technology is upgraded in an average of six gas pressure regulating stations per year. The controllers have been supplied by WAGO since 2013. “Ultimately, we were convinced by the reliability of WAGO’s telecontrol technology,” explains Tietze.

Specifically, the ETHERNET Telecontroller from the 880 Series in connection Ex-i modules, the so-called “blue modules” from the modular WAGO-I/O-SYSTEM 750. The ETHERNET PLC can be used as a freely programmable controller in corresponding networks, and is provided for use in industrial applications. In addition to a number of standardized ETHERNET protocols, it also supports IEC 60870, IEC 61850, and Modbus (TCP, UDP, RTU). With two ETHERNET interfaces and an integrated switch, it ensures that no additional elements, like switches or hubs, are needed. “Small, practical, good,” summarizes Tietze.

The I/O systems can be used as process-related components in gas pressure regulating stations in the DREWAG network.

Ex-i Technology Prevents Explosions

The “blue modules” are specifically designed, as part of the WAGO-I/O-SYSTEM 750, for use in hazardous areas and satisfy all specifications and safety standards. They ensure that no risk to the system arises from the electrical equipment used. Therefore, they are linked to the PLC in series, like the standard modules, and communicate with the actuators and sensors from Ex zones 0, 1, and 2. They provide a safe, easy, and cost-effective connection. Thus, if the gas pressure valve is controlled, the gas pressure can be changed through the telecontrol technology, or the gas temperature can be monitored without creating a risk of explosion. The economics are strongly foregrounded, since external Ex-barriers are unnecessary.

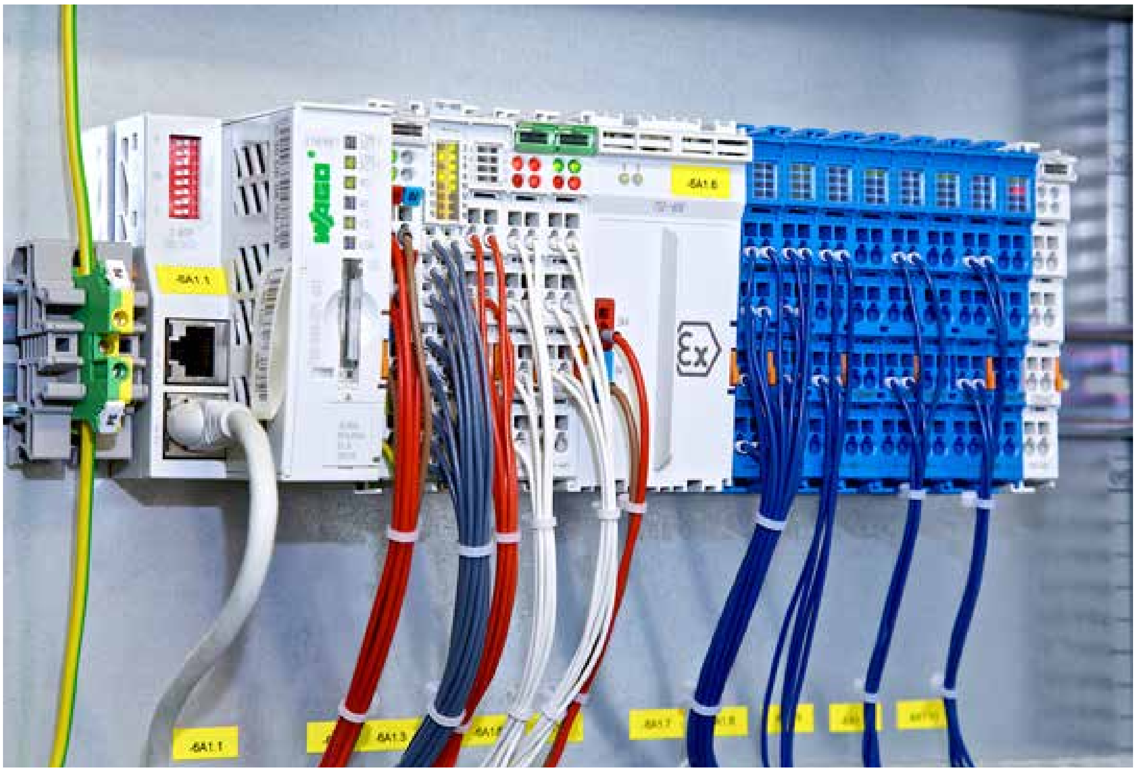
Fit for the Future

Due to the broad application area for the Ex-i modules, from clarifiers to petrochemical plants, WAGO has a specifically-based expertise in the technical equipment required for hazardous areas. This is requested more commonly by gas suppliers. This trend will only increase if technologies like power-to-gas or sector coupling gain in importance.

TEXT DANIEL WIESE | WAGO

PHOTO BILDSCHÖN GMBH

"Ultimately, we were convinced by the reliability of WAGO's telecontrol technology."



DREWAG NETZ relies on ETHERNET telecontrollers from the 880 Series, in connection with Ex-i modules, the so-called "blue modules" from the WAGO-I/O-SYSTEM 750.

With WAGO automation: modern plate heat exchangers in the new transfer stations run by the Flensburg municipal utility ensure that thermal energy arrives at the consumer with almost no losses.

Controlling district heat as needed using automation technology

EFFICIENCY IN THE DISTRICT HEATING CONTROL CENTER

In Flensburg, they make their own electricity – for more than 30 years, this has been linked with a district heating network. When they commissioned a new gas and steam turbine system in the Fall of 2016, the city on the Baltic Sea bid adieu to coal; they now use natural gas for the district power-heat coupling. In parallel, the residents of Schleswig-Holstein also modernized their district heating network. Control technology is used for the decentralized control as well as connections to the remote monitoring.

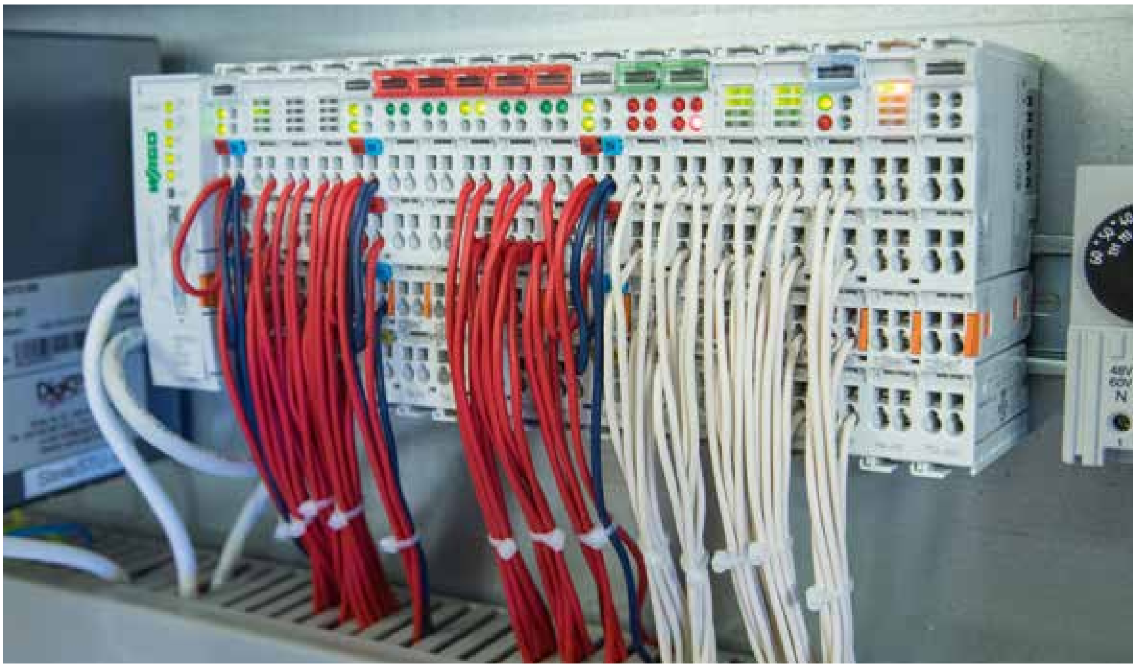
The municipal utility supplies the primary circuit of the district heating network with 110°C of supply temperature – they are able to tap into the thermal energy produced by the power-heat coupling in the city's power plant for heating and hot water. There is broad acceptance of district heating in Flensburg and the surrounding areas. Frank Nicolaisen, Team Leader in telecontrol transmission technology at the municipal utility cites as proof the impressive connection participation of 98%. "District heating is politically popular and is thus easy to support in Flensburg."

The municipal utility currently supplies 60,000 customers in Flensburg, Harrislee, Glücksburg, Tastrup, Wees, and the Danish border city of Padborg.

Using High Temperatures in the Primary Circuit

To achieve this, water heated by the power plant past the boiling point is initially pumped into a primary circuit that extends several hundred kilometers and remains there in a fluid aggregate state at a pressure of up to ten bar. Due to this combination, the water can be conveyed through the conduits at a high energy density, which makes transport through the longer stretches more efficient. In order to prevent burdensome safety issues at the customer end, houses, apartments, and commercial properties are supplied by intermediate heat transfer stations. There are just under 100 distributed across the supply area – and they are currently being modernized with automation technology from WAGO. In the equipment rooms, which appear unimpressive to outsiders, the primary circuit delivers its thermal


Primär



The WAGO PFC200 Controller links the heat transfer station to the control center of the district heating network.

energy to a second network via plate heat exchangers. The heat exchangers reach maximum supply temperatures of 95°C, and thus remain safely below boiling. Only now does the hot water flow into heat exchangers in the residential and commercial units.

Previously, the control center of the power plant, located in Flensburg's harbor area, had no data access to the pumps and valves in these stations. If there was a fault, or a valve shut off due to temperature overages in a water circuit, the shift workers had to be satisfied with an error list signal. This was transmitted from the transfer station to the control center via a telephone connection. "However, we didn't know exactly what it was," explains Nicolaisen, "which meant that a technician had to go trace the problem on site." According to the experiences of the two technicians, Horst Jordt and Vitali Kerner, these were the specific situations that regularly cost time and made their work less efficient. Then, the heat regulators, which had been used for years, were discontinued, which leant urgency to the planned modernization.

One System That Does It All

During the tender phase, WAGO was the most convincing, according to Nicolaisen, "because the system can do everything that we need." The requirements profile initially included TCP/IP communication per the IEC 60870-5-104 telecontrol protocol standard. The municipal utility also pursued the goal of connecting complete sensors and actuators as simply as possible. One example is found in the directly switched Pt100 temperature sensor. "If some of the well-known manufacturers were also able to use the 104 protocol, we would still have needed a signal conditioning module for our thermometers," explains Jordt. "WAGO was the company that can do everything, and they significantly simplified the complete installation for us."

In an already modernized transfer station, the starter motor for the circulation pump is directly controlled by the controller (750-880/025-001); therefore, the municipal utility was able to omit the complex frequency converter needed for speed control. Such functions are now programmed in the standardized language of IEC 61131-3. For telecontrol technology, WAGO offers a specifically-matched telecontrol configurator for its controllers, in which standard functions are largely provided, and thus only need to be configured.

Direct Access Increases Efficiency

By using this equipment within the district heat supply network, the Flensburg municipal utility increases the efficiency of their personnel, because employees can log in on site using the remote maintenance access in the technology. For Nicolaisen, the TCP/IP communication with the 880 Series controller as the terminal functions as the foundation for running the entire district heating supply on an as needed basis; he can thus configure the energy flows more efficiently.

“We now have better opportunities, for example, to measure return temperatures. If we pump 95°C water to Glücksburg and get 60°C water back in the return, then the return temperature is too high,” explains Kerner. It is ultimately the goal of the district heating control to maintain the highest possible temperature change between supply and return. “With the new telecontrol technology, we can now see which actual states prevail, and we can also record them for further analysis. Previously, we were happy when all of the customers were satisfied. Now we are in a position to increase our efficiency,” says Nicolaisen with a look to the future. The WAGO controls are paving the way to completely mapping the stations in the control center of the power plant. There are also plans to replace pure observation with active interventions in a subsequent step. “We are currently working on how to chronologically combine interventions on site with those from the control center. The WAGO controller needs to know which settings are mandatory, so that old vales do not overwrite new specifications.”

In another project, in which Flensburg is truly striking out into uncharted territory, the municipal utility wants to supply a new residential area with the return flow, instead of the supply. “A good 50°C water temperature is still sufficient for heating. To prevent problems with Legionella bacteria, this is planned in combination with small instantaneous water heaters,” the Team Leader reveals the plan for the district heating technology. If everything functions as planned, then Flensburg can increase their efficiency by another factor. The technical prerequisites are already available, due to the modernization of the transfer stations, and the political support is also there.

TEXT DANIEL WIESE | WAGO

PHOTO THORSTEN SIENK

Innovative trio: Horst Jordt, Vitali Kerner, and Team Leader Frank Nicolaisen (from left) plan to use more telecontrol technology in the future.

In the Wittmund wind farm, the WAGO PFC200 functions as a communication hub.

THE MULTILINGUAL TRANSFORMER STATION

Brought up to voltage: The output from the wind farm in Wittmund is transformed up to 110 kV.

The security of the power supply can be easily interrupted. For example, when a backhoe operator damages electrical lines with an energetic excavation. In such cases, a fast and particularly targeted diagnosis of the electrical grid is essential, both along long spans and also in the decentrally located transformer stations. In the transformer station in the Wittmund wind farm, ENERCON relies on the WAGO PFC200 telecontroller for signal processing and data transmission.

ENERCON, headquartered in Aurich in northern Germany, is counted among the technological leaders with more than 26,300 wind turbines. In Wittmund, ENERCON both constructed facility and operates the wind farm and transformer station. "There is increasing demand for turnkey solutions for a wind farm from a single source, from planning through construction to supplying the electrical grid," explains Gerd-Evert Meyer, Project Manager at ENERCON. Consequently, the company is seriously considering how to link wind farms into the smart grid, and primarily how to ensure the availability and monitoring of the systems, including the transformer stations.

Heart of the Communication

With this goal in mind, the WAGO PFC200 Telecontroller assumes a central communication role in the transformer station. First, it establishes the link between the network operator and the wind farm controller. It should be understood that the network operator uses a different language than is used within the wind farm, and between the facility and its operator, that is, ENERCON. The multiple languages are a result of different protocol standards for telecontrol technology. A serial, point-to-point connection, based on IEC 60870-5-101, is established between the network operator and the wind farm regulator. The data to be transmitted are typically requests for active power or reactive power. In return they receive, in addition to the acknowledgement of the setpoints, the actual output, wind strengths, and additional weather data, "to be able to derive the output capability of the wind farm," explains Meyer.

IP communication, using the 'dictionary' of IEC 60870-5-104 is used between the wind farm controller, the ENERCON control center, and the PFC200. "For us, the WAGO controller represents the largest communication node in the transformer station, and it manages everything," explains the Project Manager. A third protocol, using IEC 60870-5-103, connects the technology within the transformer station. 103 communication represents the official standard in Europe for transmitting messages to digital protective equipment in the station control system. The protective devices can be understood here as slaves that transmit data cyclically or at the request of the master. In addition, signals are also received via

"For us, the WAGO controller represents the largest communication node in the transformer station, and it manages everything."

digital inputs. Typical signals in a transformer station include door closed contacts, switch monitors, and filling state or pressure sensors.

Uninterrupted Monitoring Creates Security

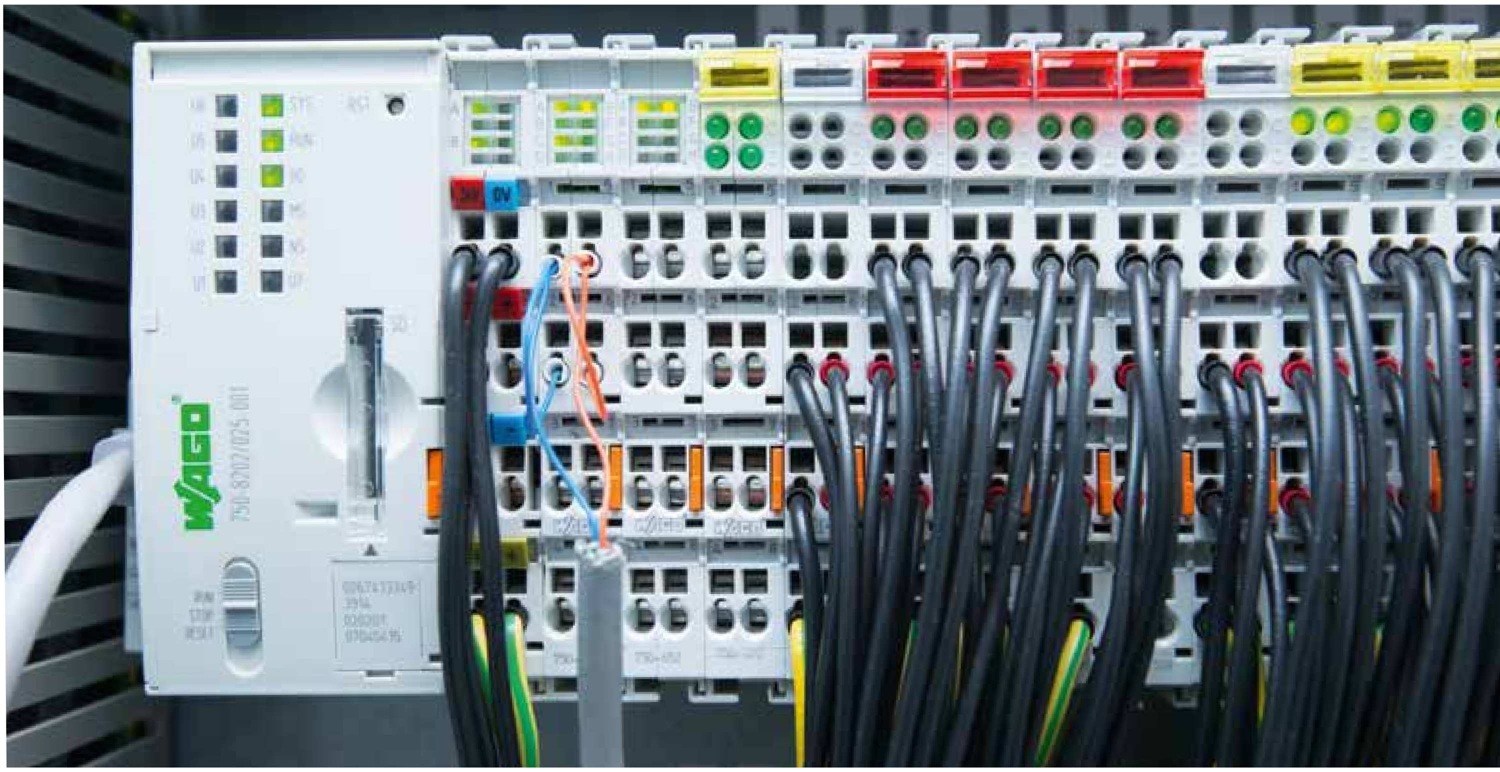
Virtually everything is monitored in a transformer station. Door contacts function as a first line to detect access, and to prevent break ins. Linking the fill state sensors in the transformer foundation increases operating safety and protect both employees and the environment. The foundation must always be available to capture all of the oil from the transformer. If the water level were too high, for example, due to rain water or ground water in the foundation, the oil could no longer be captured, which could damage the environment.

To ensure that signals are transmitted physically error-free, ENERCON uses fiber optic cables within the transformer stations, which collect all connected components using a star coupler, and in turn are connected to the PFC200 using a serial interface module. The switching devices for the medium voltage are isolated using SF6 gas. If this gas escapes through a leak, then the switch is blocked by a lock. This is reported by the protective device, using the IEC-60870-5-103 protocol, to the PFC200, and from there to the ENERCON control center, using IEC 60870-5-104.

Flexible Yet Standardized

To program these functions, ENERCON uses the standardized languages of IEC 61131-3, which are included in the series equipment of the PFC200. Programming via CODESYS offers Meyer the advantage that he can more easily adjust to the specifications of the network operator in the area where his wind farm and transformer station are located. This detail has recently become more important for systems that supply electricity outside of the Central European time zone. It is then used to combine different time stamps with each other. According to Meyer's experiences with the high voltage systems, he can thus "easily program the second time stamp" within the WAGO controller. "I retrieved the variables and added or subtracted the time difference." The PFC200 sends the data with the original time stamp to ENERCON in Germany, and corrects it with the local time for the network operator. Features like this are why Meyer values the PFC200. "We have more opportunities, we can make the programming easier, and still retain individual adaptations using standard communication."

The whole is implemented in that the telecontrol configurator automatically supplies the relevant information and variables for data transmission from the depths of Linux®. "This is our great advantage. We can both freely program and yet also use a certain standardization by using the telecontrol configurator."



The PFC200 Telecontroller plays a central communication role in the transformer station.

Why Three Languages?

One system, three communication protocols. In light of the trends in building technology and automation, which are currently standardizing communication and link everything using ETHERNET, the question is justified: why are three systems linked in this way? ENERCON explains the whole as a result of security requirements. "Communication inside of the station is implemented using the IEC 60870-5-103 protocol for serial data transmission, which is an economical standard in the area of protection technology. The signals are then sent to the ENERCON control center via a VP tunnel using TCP/IP, the IEC 60870-5-104 protocol. The network operator, in contrast, prefers a serial end-to-end connection, which is more difficult to influence than the TCP/IP protocol. We use the IEC-60-870-5-101 protocol here, which is usually converted by the network operator in his own network into IEC 60870-5-104." As a consequence, the three protocols are completely justified.

Meyer and his team also like the fact that WAGO offers visualization in addition to the telecontrol and controller functions of the PFC200. "We would have to buy it for some cases anyway," opines Meyer, and estimates that the visualizations created can be easily transferred to other projects, which ultimately reduces the time required for development. The new device in Aurich has also received positive feedback, because the PFC200 can send SMS or emails within the context of management. "This is unusual for a telecontroller," states Meyer. Because the telecontroller can also process two separate communication networks, service technicians can now send messages over their own channel, while ENERCON operates a VPN tunnel in parallel. WAGO has since equipped the PFC200 with an integrated 3G modem. "Now we have three separate accesses," celebrates Meyer.

TEXT HEIKO TAUTOR | WAGO

PHOTO THORSTEN SIENK

Electrical source of the future: simply building and connecting is yesterday's news. Today, the use of wind turbines must also be focused.

Telecontrol technology monitors and controls wind turbines in Poland

NEW PLAYERS IN THE SMART GRID

Constructing wind turbines is a dynamically growing market, due to the energy transition. The German FWT Group, which constructs turnkey wind turbines in the multi-megawatt class and builds complete wind farms, has concentrated in the last few years in developing markets in central and eastern Europe, and in Asia. In telecontrol technology, differences from the telecontrol protocols conventionally used in western Europe, based on the relevant IEC standards, have to be considered. Therefore, FWT relies on the PFC200 Controller for WAGO for telecontrol technology in these applications.

Within the context of the energy transition, the proportion of energy from renewable sources is constantly increasing. Volatile power suppliers, like wind turbines, present network operators with new challenges. Since the supply is significantly harder to predict, the networks have to be converted into so-called smart grids. One important aspect of this conversion is communication. Modern telecontrol technologies must ensure the linkage of energy generators with the control centers of the network operators. Telecontrol technology is also an important topic for the FWT Group, which constructs turnkey wind turbines and builds entire wind farms. The company arose at the beginning of 2013 from the bankruptcy of the wind energy pioneer Fuhrländer AG, and initially planned to ensure maintenance for Fuhrländer’s existing wind turbines. However, by mid 2013, they had again begun producing their own wind turbines. The company currently offers three different models, with outputs of 2 MW, 2.5 MW, and 3 MW. One of the largest projects for FWT was the production of a wind farm for Expo 2017 in Kazakhstan, which took place in Astana with the motto, “Future Energy”.

Focus on Developing Markets

The mid-sized company, headquartered in Waigandshain, currently employs around 100 people and posted sales revenues of just under 50 million euros.. FWT’s focus lies in developing markets, in which stronger growth is expected in the wind energy market, in comparison with Germany. In addition to the wind farm in Kazakhstan, FWT has constructed systems in Germany and Poland, and additional wind farms are in production in Russia and Belarus. One of the current projects is a wind farm with a planned total output of 90 MW, located in Kranowitz in southern Poland. At the end of 2014, FWT began construction and commissioning of the first of three wind turbines. It is planned as a turnkey project, in which FWT provides the wind turbines, the complete control technology, the wind farm power management up to the network transfer point, and the telecontrol technology. “We had to satisfy specific demands from the Polish network operator for the telecontrol technology,” explains Christian Oppermann, who heads the application engineering division at FWT. The difference

Well Coordinated: wind turbines only function efficiently and usefully if they are communicatively linked to one another.

in Poland is that their telecontrol technology is based on the DNP3 protocol. While this is similar to the conventional telecontrol protocols used in western Europe, based on IEC 60870, it is not identical. To implement the telecontrol technology, FWT relies on the PFC200 Controller. For Oppermann, it has a decisive advantage, "The PFC200 Controller already has a DNP3 interface. Therefore, we don't have to worry about programming the interface." It was not chance that led FWT to the PFC200 when they were searching for suitable telecontrollers. "We have used WAGO controllers for several years for the pitch control in the hub of wind energy systems, and have always had good experience with them."

Integration into the Central Wind Farm Controller

Each wind turbine within a wind farm is equipped with its own controller. The individual turbines are linked to the central controller of the wind farm power management via a fiber optic network, using various TCP/IP protocols, among them, Modbus TCP. The telecontroller is also integrated into this network so that it receives data from the individual turbines. The PFC200 collects the data, prepares them, and forwards them to the network operator via the DNP3 interface. In addition, VPN connections (IPsec) of the wind farm are available for remote monitoring via a Lancom router. "We can intervene in the wind farm at any time from our central control using the VPN based on IPsec," explains Oppermann. The central control in Waigandshain is staffed around the clock. In addition, maintenance personnel are available on call, who can react quickly in case a fault should occur in the wind farm.

Currently 13 data points, for example, voltages, frequency, and output, are collected for each turbine using the PFC200 and provided to the network operator. Active and reactive power at the network transfer point are also recorded using the telecontroller. At the same time, the DNP3 interface provides an input channel, via which the network operator can, for example, adjust the reactive power behavior of the wind farm. Stepless output reduction, down to a complete shut down of the wind farm, is also possible using this interface. By using additional I/O modules, which can be connected in series to the PFC200, the circuit breakers on the medium voltage level can be monitored, and triggered if needed. The operator can thus completely sever the wind farm from the grid. The telecontroller does not merely provide the DNP3 interface; it also functions as a data logger. All data, both regarding the status of the wind farm and also interventions from outside via the DNP3 interface, are recorded on the internal SD card in csv format. The data are available for transmission to the internal FTP server. "We can also implement a push transmission of the data to the wind farm operator," says Oppermann. The complex logging is of particular importance for proving the availability of the wind farm. FWT guarantees, as a rule, availability of 97 percent. If this is underrun, FWT must pay financial penalties. "It is therefore decisive for us," according to Oppermann, "that we can determine when the wind farm has been stopped by the network operator. In this case, the network operator has to pay the down time penalties."

“A simple and fast conversion of the interfaces for telecontrol technology is decisive for us.”

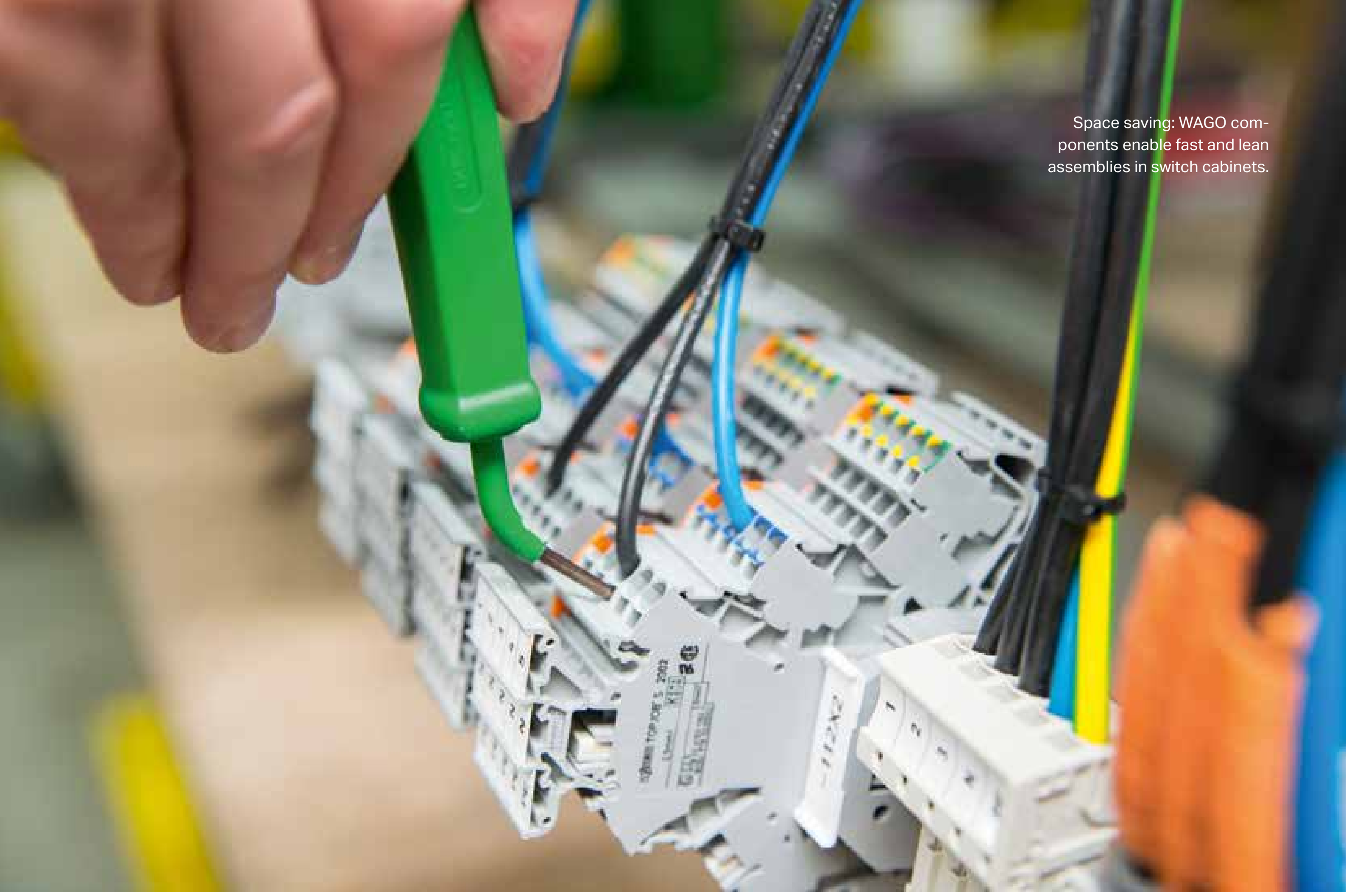
Robust Hardware for Harsh Environmental Conditions

FWT implemented their first telecontrol connections using 750-880 Controllers from WAGO. In the past year, Oppermann has switched to the PFC200. “We have defined the XTR variant of the PFC200 as our standard telecontroller, so that we are always on the side of safety in these difficult environmental conditions.” The entire control technology of the farm power management, including the telecontrol technology, is installed in an unheated building within the wind farm. The temperature fluctuations can thus be quite large. If the wind farm is not connected to the network for several frosty days, then the entire electrical technology must withstand negative temperatures, and subsequently start up again. The XTR variant of the PFC200 is suited for temperatures of -40°C and up to +70°C, and also withstands a temporary thawing of the components.

The primary reason for using the telecontrollers is, according to Oppermann, the open programming feature: “With CODESYS, the PFC200 offers programming in languages according to IEC 61131-3, and also in higher level programming languages. Since interface programming is already taken care of, the system enables a fast and easy implementation of our applications.”

TEXT MICHAEL RADAU | WAGO

PHOTO FWT ENERGY GMBH



Space saving: WAGO components enable fast and lean assemblies in switch cabinets.

Pre-assembled technology facilitates CHP construction.

THE TREND TOWARD COMPACT POWER PLANTS

2G Energy AG exploits a number of application areas for combined-heat-and-power plants with their g-box. The compact systems are tailored to be profitable small power plants, with an electrical output range from 20 to 50 kW, for use in small hotels, industrial operations, or apartment blocks. The CHP specialists from western Münster have designed the quiet turnkey module for coupling power and heat to be particularly lean. Completely assembled DIN rails from WAGO are used for the electronics connections.

Two outputs, high thermal efficiency due to condensing boiler technology, and long runtimes with low maintenance expenses: the turnkey g-box is designed as a compact series model for the broader market. As a consequence, the CHP manufacturer 2G considered more than technological details and design tricks during development of the small power plant. Economic production in large numbers ultimately depends on designing a lean and time-saving assembly process. Therefore, 2G uses pre-assembled DIN rails from WAGO for the electronics in the switch cabinets of their CHP series.

Multi-Facetted and Pre-Assembled

"By purchasing pre-assembled DIN rails from WAGO, we save time and warehousing costs," Stefan Liesner, Business Development International at 2G, comes right to the point. If his company were to assemble the electronics themselves, "we would have to store each, individually-packaged component."

To ensure that 2G still has a DIN rail that exactly matches their requirements, 2G and WAGO collaborated closely to determine which electronic products needed to populate the standard DIN rails. WAGO TOPJOB® S Rail-Mount Terminal Blocks are used in particular. Their advantage: the potential solutions provided by the TOPJOB® S rail-mount terminal block portfolio are practically unlimited, due to the various combinatorics, labeling possibilities, and links to other electronic components, like signal conditioners.

The diversity of components offers 2G the ability to find the optimal configuration for their g-box; however, were 2G to purchase them individually, they would have to stock an extremely high number of individual components, which would include the complete documentation as well as master data management in the ERP system. It is precisely for this reason that 2G decided to purchase complete DIN rail units from WAGO. The pre-assembled DIN rails are designed so that sufficient space is provided at specifically defined points for additional electronics. These additional components are added, depending on demand, by 2G during installation. "With this solution, we gain the ability to adjust output and functions according to customer preferences," explains Liesner.

Producing More Quickly and Flexibly

In addition to the fact that the pre-assembly dramatically reduces stocking expenses and EDP documentation, the company from Münster can also react more quickly to sudden surges in demand on the market. If the sector is booming, they can maintain short ordering deadlines. This pays off for 2G, since the WAGO connection electronics can be ordered using a single item number: "WAGO has gotten to know how we work here. If demand peaks, we inform our suppliers quickly," Design Manager Jörg Schmiemann describes the closely entwined supply chain.

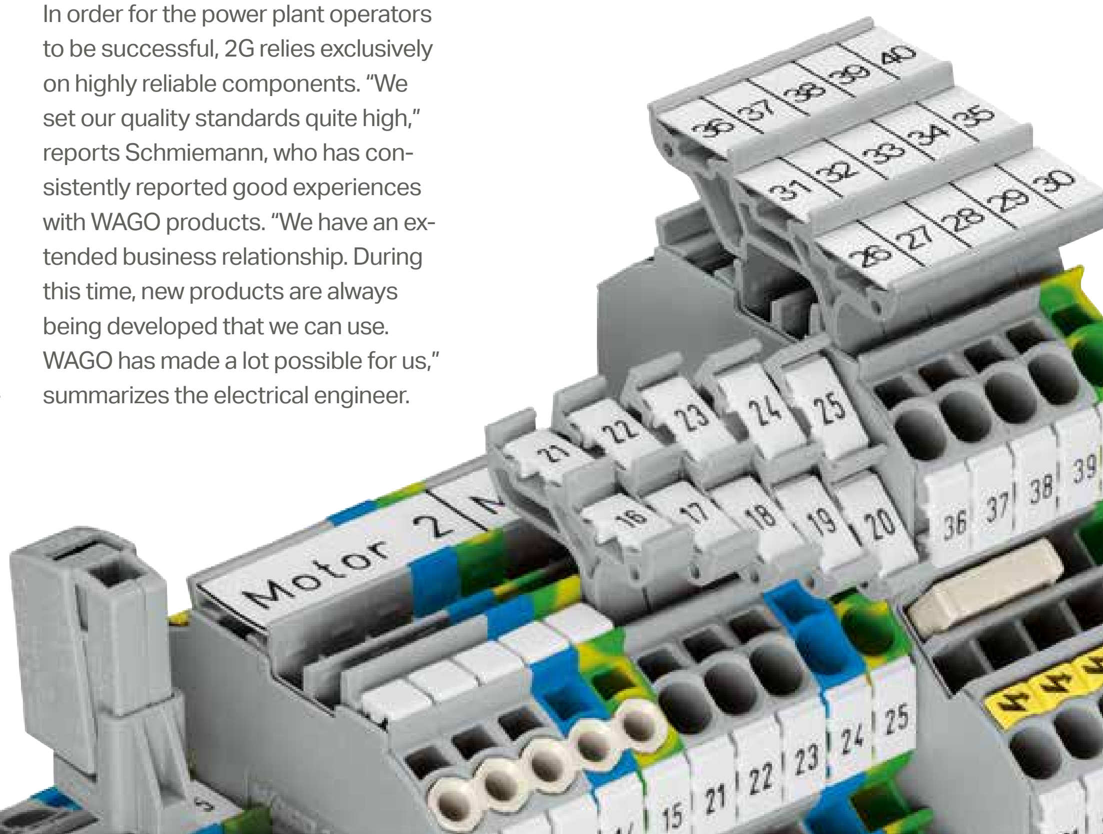
In his view, pre-assembled switch cabinet components offer additional advantages: reduced risk of error, thus higher quality and system availability. "To begin with, our customers want to reduce energy costs, and at the lowest possible expense. Because the systems function efficiently, the amortization period for investing in a CHP is rather short," Schmiemann explains the advantages of the 2G CHP. The systems convert up to 42% of the gas into electrical power due to specialized fine-tuning. "A standard motor achieves 38%." 2G's specialty is optimizing this point, explains Schmiemann. "We optimize our systems depending on the different types of gas, because sludge gas, biogas, and natural gas all have different knock limits," explains Liesner, adding that 2G also develops their own spark plugs and cylinder heads. "We began with an efficiency of 38.7%, and now we are at 42.5%." While it sounds like a modest increase, the cost savings in gas for this motor class amount to several tens of thousands of euros per year – over the system lifecycle of ten or more years, this can recoup the majority of the total investment.

Individual and Reliable Solutions

In order for the power plant operators to be successful, 2G relies exclusively on highly reliable components. "We set our quality standards quite high," reports Schmiemann, who has consistently reported good experiences with WAGO products. "We have an extended business relationship. During this time, new products are always being developed that we can use. WAGO has made a lot possible for us," summarizes the electrical engineer.

For example, in relation to approvals: "Because gas prices in the USA are so low and the electrical grid is less reliable, the US is currently our most important foreign market." To provide the units with a chance on the North American market, WAGO supports all certifications related to the UL safety mark in the USA. WAGO has also been helpful for certification according to the German household appliance standard. "The household appliance standard does not apply to electronics that are used in industry," concedes Liesner, "however, the compact CHPs in the g-box series are also provided for use in residential buildings."

TEXT ANDREAS GRABOSCH | WAGO
PHOTO THORSTEN SIENK



Imprint
WAGO DIRECTENERGY, January 2017
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WAGO DIRECTENERGY appears at irregular intervals.

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0888-0207/0117-6901 – WAGO DIRECT ENERGY 1/17 US – 01/2017 - Printed in Germany