WINDNODE

A Fresh Breeze for Cellars and Grids

For the energy system of tomorrow our daily electricity not only must come from renewable sources, it must also be used smart: Both for customers and the grid. In WindNODE, WEMAG shows in an exemplary manner how wind power can contribute to warm houses and stable electricity grids.

WEMAG NETZ GmbH

A great step in a small cellar

Within a WindNODE research project, WEMAG Netz GmbH in Schwerin analyses the opportunity to offer flexible electricity tariffs to its customers for heat pumps and night storage heatings that are based on the renewable energy surplus in combination with congestion management within WEMAG's distribution grid. What is starting here in the cellar of the managing director may be rolled out over Germany in the future by the municipal utility association Thüga.

'Hold on,' says Andreas Haak in the middle of the interview. His cellphone is ringing. 'It's my wife. She only calls if it's urgent.' He picks up.

'Yes,' he answers. This is followed by a worried 'No?', after which he talks about 'heating' and 'workmen' and seems sobered.

Haak is the managing director of WEMAG Netz GmbH, which supplies 165,000 households and commercial customers with electricity through power lines with a total length of 15,500 kilometres in Mecklenburg-Western Pomerania as well as parts of Brandenburg and Lower Saxony. 'They didn't show up? Hm. Yes. Okay. Not good. I'm worried.'

Haak looks around worriedly: 'The heating installers haven't finished their work. It'll be a cold weekend.' The heat pump will definitely not be connected this Friday. And the weather report announced the first frost for the North-German lowlands.

Even if he was discussing about his own home, Haak's conversation with his wife was official business. The managing director has made the cellar of his house near Schwerin available for an experiment in the scope of WindNODE: the 30-year-old oil-fired boiler has being substituted by a heat pump which will be complemented with the already existing boiler. This installation will serve as a research object for WEMAG's technicians and IT experts. It is equipped with the latest control technology standard, so that it can be controlled from the system operator's centre to facilitate the grid.

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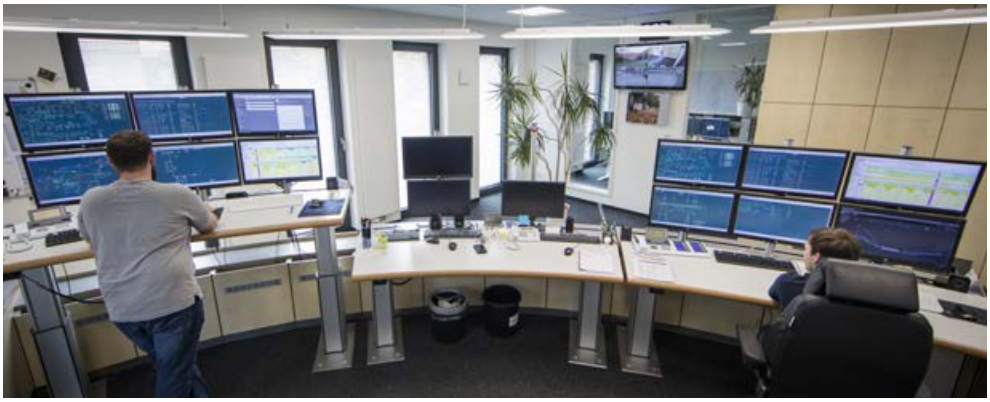
In the future, the installation's compressor should mainly be started when a lot of renewable electricity is being generated in WEMAG's grid area of 8,000 square kilometres. 'For the pilot project, we needed a friendly user who guides the technicians into the cellar at any given time. Our house seemed like the perfect place, as a normal customer would not appreciate it when the workmen arrive unannounced', Haak explains. But no good deed goes unpunished: Haak's family is looking to spend a weekend in the cold.

Renewables instead of coal

In the WEMAG control centre, Haak is surrounded by about a dozen monitors. Two employees are not only supervising the lines of the 110-kilovolt (kV) grid and the 20-kV grid, but also the 3,000 transformers, grid nodes as well as the wind turbines, solar systems and biogas plants. From here, the wind farms are curtailed when there is too much electricity on the grid.

Haak explains that in the past, the only large electricity generator in the region was basically the Rostock coal-fired power station. Since 1994, this power plant has been feeding-in 500 megawatts of electricity into the high-voltage grid at the Bentwisch grid node and also into the medium- and low-voltage grids of WEMAG through the grid connection points Schwering-Görries, Parchim-Süd, Perleberg and Güstrow. Additionally, the northernmost power plant was also responsible for keeping the voltage stable (see further on: "Active control of reactive power").

This has changed: coal-fired electricity generation is in decline, and no one knows whether the power plant in Rostock will last until the agreed coal exit in 2038 or will already be shut down before that time. At the same time, electricity generation from renewable sources is on the rise. In the WEMAG area, wind farms with a capacity of 1,000 mega-



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watts (MW), solar installations up to 500 MW and biogas plants up to 120 MW are now supplying electricity. Already in 2015, more renewable electricity was being generated than being consumed in the WEMAG grid area. For 2018, the annual surplus for the entire grid area amounted to 39 percent. By 2030, the capacity from renewable energy sources as wind turbines should be doubled to at least 3,000 MW.

Customers should benefit from fluctuations

'Our customers should help us and facilitate the power grid. This means: maximum consumption in times of high feed-in from renewable sources and vice versa. We want to demonstrate how our customers can also participate and benefit from this in turn, in particular as a result of clearly favourable grid fees and surcharges. This should enable optimal use of electricity and minimise congestion management in the long run,' says Haak.

In the scope of the WindNODE project, it is therefore being tested how WEMAG Netz GmbH can integrate small distributed systems: heat pumps, night storage heatings, and in the future also the growing number of electric vehicles. The goal of the WindNODE project is to use renewable energy instead of curtailing it.

Already before the installation of the heat pump in Haak's cellar, a WEMAG night storage heater was connected in test mode as a pilot device. 'Our customers have night storage heatings from the last four decades,' says Moritz Koch, engineer within the WindNODE project. WEMAG's current electricity tariff is typical for these heatings: they draw their current between ten pm and five am. These used to be the periods during which the old, central energy world with fossil fuel had electricity to spare. WEMAG traditionally offers a fixed electricity tariff of about 21 cents per kilowatt-hour at today's rate, which is around 15 percent less than the normal electricity tariff for household customers. The night storage heatings are controlled by a timer switch, which signals starting and ending point of the charging period.

This old system is, however, not flexible and does not react on the real situation of power generation by wind turbines and solar installations. As system operator, WEMAG of course knows the actual feed-in values of the individual installations; employees of WEMAG's grid control center are ongoing monitoring them. They can also make a reasonably good prediction for the grid situation of the upcoming days.

Storing electricity in the form of heat

In the scope of WindNODE, the test devices were equipped with a smart meter. The digital electricity meter not only measures the consumption of electricity, but can also forward switching signals. 'Behind the smart meter, there is a control box that makes intelligent and clever user behaviour possible, in combination with a new type of control software,' Koch explains. Via the GSM standard for mobile communications, the WEMAG control centre transmits signals to the control relays. For the night storage heatings or the heat pumps a flexible charging period results throughout this process. Just like how the charging time signal was sent via the timer switch. The night storage heater buffers the energy in its refractory bricks. The heat pump heats the boiler, which can additionally be equipped with a heating element to increase the flexible load potential in case of an electricity surplus.

'We're even taking it one step further: we are already saying whether the installation can work at full capacity or only a part of it,' says Koch. This way, the system can react with even greater precision to the actual ratio of feed-in from renewable energy sources and consumption.

To incentivise a large number customers to participate, WEMAG is also testing how favourable grid fees and surcharges can help reward their customers for their 'grid-supporting behaviour' in the scope of the project. The goal is clear: the tariffs for the heat from excess power should drop below the current tariffs for night storage heatings, so that a price incentive is created for this type of sector coupling. This way, everyone benefits: the customers save money, grid operation is facilitated, the investments in grid expansion are reduced and fewer electricity from renewable energy sources is curtailed.

Via WEMAG customers to Thüga

In order to test the technical interaction between the control software for the Controllable Local System (CLS) in the control centre, in the gateways as well as the smart meters and in the control box, only a few heating units are needed on the consumers' side. 'For now, the heat pumps in the CEO's cellar, with an electrical output of 3 kilowatts, and the 1.2 kilowatt night storage unit, are enough for our purposes,' says Koch. Once the pilot system is running, additional installations are planned. And as soon as the software from the WindNODE workstream has been integrated in the operating

Screens in the grid control centre

system of the WEMAG control centre, the process can be scaled up as needed and rolled out for the customers in the WEMAG grid area.

The vision: Regional municipalities are WEMAG's major shareholders with a total stake of ca. 75% whereas the Thüga group is the minor shareholder with the remaining stake of ca. 25%. Within the Thüga group are almost 100 municipals pooled which face the same software standards. Within this pool, WEMAG can publish its research insights to develop commonly new technical devices.

Flexible heat pump replaces oil-fired heating

Back to Schwerin: Managing director Andreas Haak currently estimates the potential of switchable loads (i.e. heat pumps and night storage heatings) in the grid area up to 30 MW. Compared to 1,500 MW feed-in from renewable energy, the flexibility potential is rather limited. However, that is the situation of 2019 with the old or existing installations.

'Here in the country, many new oil-fired heating systems were installed in the 1990s, after the reunification, which are slowly reaching the point where they need to be replaced,' says Haak. And because as of 2025, no new oil-fired heating systems can be installed, alternatives such as gas- or wood-fired heating systems are being considered. That or heat pumps, a technically simple and clean affair by comparison. They become even more interesting if the customers can be granted lower heat pump tariffs. As a result of the switch to greater use of green electricity for heating, the current capacity potential will grow significantly.

Outlook

Furthermore, Haak is also looking towards the expected switch to electric vehicles and the expansion of industrial electrolysers, which could in the future make use of excess power in regions with a lot of wind power.

Haak is convinced that if one adds up all possibilities in private households and the industry, several hundreds of megawatts in flexible load would be accrued. 'We, as system operators, are the enablers. We have to provide the impulses. Then, minor and major installations on site can independently decide whether they want to use this cheap electricity or not.' What is missing is the legal framework, says Haak, in view of the high taxes on electricity on the one hand and continued subsidies for oil and gas on the other hand, even if the first attempts can already be found in the climate package of the German federal government. 'Our current energy legislation dates back to the 80s. In this field, many hurdles still need to be taken to reach the new world.' Major changes often begin in a small cellar.

The invisible power of the energy supply

Not only do the large fossil power plants feed electricity into the grid, they have also guaranteed the secure operation of the grids for a hundred years: among other things, by providing 'reactive power'. In the scope of WindNODE, WEMAG and other partners have demonstrated that wind farms can undertake some of these tasks in the future, when conventional power plants are gradually being decommissioned.

On 9 January 2019, shortly before nine am, WEMAG's experts were observing the large monitors in the Schwerin control centre with bated breath. Outside there was a gentle breeze, and the generation and consumption of electricity matched the targets. The colleagues in the 50Hertz transmission control centre in Neuenhagen near Berlin were also glued to their screens. It is a good day for experiments on the power grid.

The area south of Parchim is one of the main wind power areas of WEMAG Netz GmbH. That Wednesday, the installations fed-in a capacity of some 150 megawatts from the 110-kilovolt (kV) distribution grid into the 220-kV high-voltage line through the Parchim Süd substation. From here, the electricity is transported to southwestern Germany over Magdeburg.

System operators such as WEMAG or 50Hertz are always keeping an eye on different target values from their control centres. This includes the grid frequency, which in Germany can only vary between 49.8 and 50.2 hertz. When the

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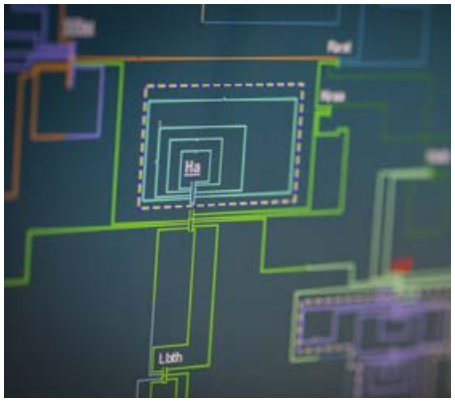

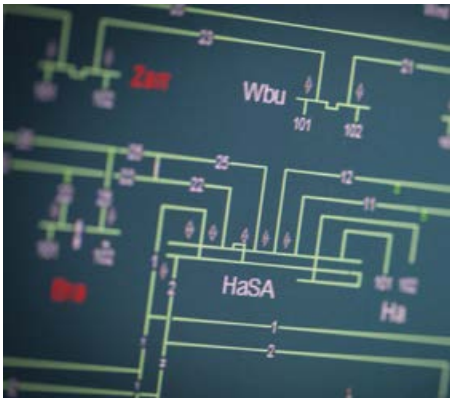

Digital diagram of the WEMAG distribution system in the control centre.
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frequency drops, a few gas-fired power stations are ramped up until the electricity feed-in once more matches the consumption.

'The second important value is the voltage,' says Philipp Kertscher, head of the Asset Management Department at WEMAG Netz GmbH and leader of the WindNODE subproject "Dynamic reactive power in the 110-kV grid". The distribution grid covers different voltage levels, from the low-voltage grid level (through which the final customers can be provided with 400 volts) to the high-voltage grid level with a nominal voltage of 110,000, through which local transports are possible up to a line length of around 100 kilometres.

The target voltage for the final customers can only deviate up to 10 percent upwards or downwards during normal operation. This ensures that all customers always receive the same power quality and that household appliances or equipment in the commercial areas can be operated as usual.

The three-phase current system as a show stopper

Finally, the voltage determines the amount of power that can be distributed from the source to the consumers' end. In case of direct current power (P) is simply the product of voltage (U) and intensity of current (I).
In the three-phase current system, things are a bit more complicated: here, voltage and current intensity constantly alternate from positive to negative values and the temporary relation between the three systems (phase position) is different. The total power on the grid is the so-called apparent power, the product of the usable active power and the reactive power in the system. The reactive power undertakes essential tasks to put the grid into operation (e.g. capacity load of the lines) and serves as the actuating variable to control the grid voltage.

For optimal use of the power lines, power plants can either provide reactive power to the grid or draw it from the grid.

During traditional operation, fossil power plants based on coal and gas firing as well as conventional grid operation resources such as transformers and reactive power compensation modules provide the reactive power as an ancillary service to the power supply grid. Reactive power compensation modules are usually coils that can supply the grid with reactive power in a targeted manner as the situation requires. In the WEMAG grid region, the conventional main control units for the voltage structure are the Rostock coal-fired power station, distributed compensation modules in the transmission system as well as the transformers between the extra-high and high-voltage level.

Wind power assumes the tasks of coal power

In the future, the provision of reactive power can essentially be supported by renewables. The first step towards this goal: in the scope of WindNODE, WEMAG developed the IBMS package ("Intelligentes Blindleistungsmanagementsystem", smart reactive power management system) together with the software provider of the control centre. The software package monitors the grid, determines the reactive power needed at any given time, and subsequently calculates how much reactive power the wind turbines in the area can provide. 'Today, wind turbines are equipped with smart control systems and can modify the ratio between active and reactive power in the same manner as a modern power plant,' Kertscher explains. Nevertheless, this potential is hardly ever used, because the installations usually run on a fixed active-to-reactive-power ratio. Here, the new approaches should lead to an on-demand provision. The objective is to optimise grid operation and lay the groundwork for the secure grid operation of the future.

In January 2019, the wind farms around Parchim had to demonstrate their flexibility. During the field test of the new reactive power management system, the colleagues of WEMAG's control centre controlled individual wind farms and gave targeted specifications for reactive power to the installations.

With success: the reactive power could be controlled as planned within a range of about 60 megavolt-amperes (MVar) and therefore modified the voltage in the grid accordingly. 'We were able to lower the voltage in the 220-kV grid by 1.8 percent and increase it by 2.3 percent,' Kertscher reports.

In WEMAG's 110-kV grid, it was even possible to lower the voltage by 5.2 percent and to increase it by an impressive 7.2 percent.

'This shows us the practical usecase for the theoretical potential of controlling reactive power with wind turbines and solar installations,' says Kertscher. Everyone benefits: the operators of the wind farm can harvest more wind power from their installations. The existing power supply grid can be exploited better, so that investments in conventional grid operating facilities can be avoided to a considerable extent. The optimisation of the entire system therefore offers advantages for the final customers as well.

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3 QUESTIONS FOR...

Andreas Haak, CEO of WEMAG Netz GmbH

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3 QUESTIONS FOR...

Andreas Haak, CEO of WEMAG Netz GmbH

What does WindNODE have to offer?
In the scope of WindNODE, we are driving a specific project forward in which we and the customers, installation manufacturers as well as software developers are learning what is needed to enter the new world of grid control together. The exchange with the partners and the network within the WindNODE consortium (over 70 consortium partners as well as other participants from the energy industry, research and development, IT and installation manufactures, and many others) is decisive. Furthermore, it is important to show the state of the art by using the smart metering systems, and to learn together how we can drive a good solution forward that is acceptable for all our customers as well as the energy supplier. Not least, we want to formulate impulses for the very important profitability of such solutions towards the political world. We have for instance agreed with heating system manufacturer Viessmann that we will continue collaborating on this subject, exchanging data and aligning improvements as much as possible during the next ten years.

Were there any unexpected successes during the project?
The BTC company for example developed the very useful Controllable Load System Management (CLS), and Viessmann developed the useful SG-Ready interface. CLS Management can also be used as a smart replacement for the old radio ripple control and can be integrated via the control centre. As a customer, I look forward to having more room in the cellar and clean energy from the earth and green electricity. I no longer have dirty muck from diesel soot in the heating room (super clean!) and no longer have to send for a chimney sweep. According to the first estimate for three months of heating, the operating costs decrease as well. The total amount of possible savings, is still being worked out in the project.

Where can you see this in action?
In the biosphere reserve of Schaalsee in Zarrentin, a visitor site is being created for this specific purpose. A pavilion is being built underneath the so-called solar pyramid to provide visitors with information about the project “Wind Heating instead of Night Storage”.

Andreas Haak, CEO of WEMAG Netz GmbH

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