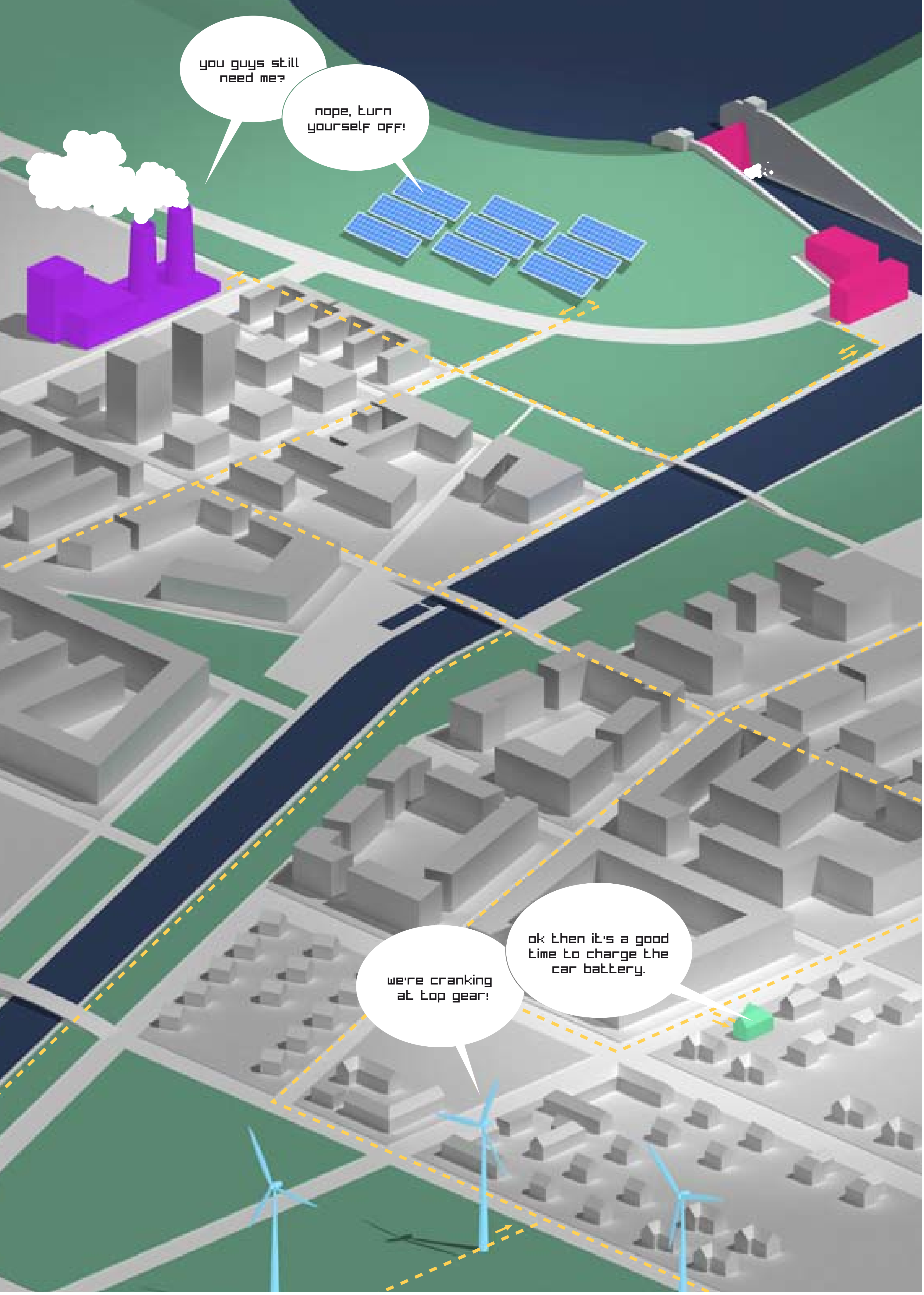

you guys still need me?
nope, turn yourself off!
we're cranking at top gear!
ok then it's a good time to charge the car battery.

Smart supergrid

Gigantic transmission lines could connect North Sea wind farms and African solar farms to European consumption centers. Linking them with smart grids would produce a "supergrid."

By Nicole Weinhold, **charts by** Dirk Rittberger

It was some years ago that Eddie O'Connor first formulated his vision of an enormous system of transmission lines connecting offshore wind farms with neighboring states. Formerly head of Airtricity and now CEO of Mainstream Renewable Power, he's been tirelessly canvassing for this idea ever since (new energy 2/2009).

He's obviously succeeding, for many politicians and scientists are now persuaded that a 100 percent renewable supply for Europe is possible only in combination with electricity highways. These would connect generating areas and consumption centers, balancing out production and demand across country frontiers. The idea has backing from the industry. A group of companies joined forces in March to form "Friends of the Supergrid" (FOSG), urging that the requisite political decisions be taken. Firms like Hochtief, Areva, Mainstream and Siemens are on board. They already possess some supergrid technology and say they could lay it at sea and on land.

But how are we to picture such a megagrid for Europe and its neighbors? What technology do we need? What political barriers have to be overcome? In a roadmap published in mid-March, Price Waterhouse Coopers (PWC) discusses how the European and later the global energy sector need to be reshaped to enable a 100 percent supply from renewables by 2050. Infrastructure plays a crucial role here.

Present-day transmission lines are too weak and poorly interconnected to handle this demanding task. Europe has five grids side by side, interconnected with a few high-voltage, direct-current (HVDC) coupling points: the Scandinavian and the British grid, with an annual electricity consumption of 400 terawatt-hours (TWh/a), the Baltic and the Irish grids, each of 30 TWh/a, and the largest grid covering the whole European mainland for 2,600 TWh/a.

Each European state in fact operates its own grid, and only rudimentary lines connect them to each other because the original structure was designed for central power stations. Now, however, the rising contribution of renewables and the increase in electricity trading within Europe make cross-border grid planning necessary.

The PWC scenario envisages transmission lines extending from North Africa to Europe by 2050, linked so well that 100 percent renewable energy can flow without difficulty to safeguard supplies. Strengthened high-voltage, alternating-current (HVAC) transmission lines are to be used, as is a supergrid routed by a high-voltage, direct-current (HVDC) cable over the Mediterranean. Further developments call for the introduction of smart grids and a SuperSmart Grid.

Competing plans

As defined by PWC, a supergrid is an extensive HVDC grid to transport large amounts of electricity. The SuperSmart Grid links this level with the widely used smart grid. Gus Schellekens, PWC's sustainability director, explains the difference. Unlike a supergrid, the SuperSmart Grid would integrate both distributed and central systems. He worries that competing ideas for supergrids could delay development.

Joe Corbett, Mainstream's head of technical services, doesn't see any such competition. "It wouldn't make sense to use such an expensive grid just to transport wind power," he says, and the FOSG also want to link the distribution network with the transport level.

The challenge for everyone is that the alternating current transmission lines used today are unable to carry anywhere near as much electricity as direct current cables. The underdeveloped connection between the EU states further complicates the transport of large amounts of electricity. The aim is therefore to build an HVDC grid through the North Sea, Europe and the Mediterranean to North Africa, obtain solar power from there as required, and speed up the distribution of fluctuating renewable electricity from, for example, offshore wind farms in the North Sea. Electricity will then have to be transported in two di- ▶

On an international level, the SuperSmart Grid could one day be what a smart home is on a small scale and the smart region on a medium scale. Enormous amounts of electrical energy could then be transported to consumption centers from central generating sources, such as offshore wind farms in the North Sea, hydroelectric power stations in Norway and solar fields in North Africa, over high-voltage, direct-current (HVDC) cables. The supergrid would in turn be connected at a large number of coupling points to smart networks in the regions. This way, a system consisting of powerful grids would deliver both central and distributed energy to consumers in line with demand determined by digital communications.

Brave smart world

Hardly a day goes by without some company vaunting its new software or hardware for supporting "smart grids." A field test is launched here, a politician points out the tremendous opportunities opened up by intelligent networks there. But what is a smart grid? What does it look like, and how does it work? We've seen the term "smart" used for all sorts of things – from the mere introduction of different daytime and night-time power tariffs to fully automated regional energy-control tailored to the load curve. And anyway, hardly anyone knows how the whole thing's meant to work.

We went to Baden-Württemberg to find out more about the model Mannheim project, a consortium led by energy supplier MVV Energie. Called "Moma," the project is one of the six winners of a competition jointly organized by the German Economics and Environmental Ministries. Named "E-Energy – information and communications technology (ICT)-based energy system of the future," the model projects investigate various questions about intelligent networks.

The key concern is always "the optimal coordination of generation, storage, distribution and consumption by means of ICT." That's how Ludwig Karg defines the smart grid. "You can extend the grid, or you can use it better. Aided by communications technology, E-Energy's objective is to make better use in future of the whole power supply system," says the head of research of Munich-based Baum Consult, with is involved in E-Energy. But how?

Intelligent housekeeping

The Wirth family lives in northern Mannheim. Mother Antje, father Harry and daughter Kim are among the first test subjects in the Moma project. Control boxes have been connected to some electrical appliances in their home – the refrigerator and dishwasher in the kitchen, washing machine and drier in the cellar. Each day, the Wirths are sent a curve showing the times when next day's electricity prices will be higher or lower. Their old power meter has been replaced with a digital smart meter. An energy butler stands between the shooting club trophies in the attic. This little white box looks after energy management based on domestic consumption and generation data (if any) and information about next day's electricity prices. Customers can program it to start specific electrical appliances just when electricity is especially cheap. When widely used, energy butlers can help reduce consumption peaks, cut energy costs and increase energy efficiency.

"It took us a few days at first to figure out the electricity price curve," says Harry Wirth, but then they programmed some of their appliances appropriately. The drier in the cellar now automatically runs overnight. The family starts some of its domestic appliances manually when rates are low – the washing machine, for example. "I was initially surprised," recalls Antje Wirth. When she opened the refrigerator door, no light went on. "I thought it was out of order." But now she knows that it switches off at peak load times for as much as four hours, a temperature sensor ensuring that it doesn't get too warm.

What's the point of all this effort? Friedrich von Dungen, head of grid control operations, welcomed us to the control room of 24/7 Netze GmbH, which is in charge of grid control in Mannheim. The city of Mannheim's electricity grid is depicted here on computer screens and large displays. You can't see the Moma project because only the medium and high-voltage (110 kilovolt) levels are shown in the control room, while the test is running at low voltage (0.4 kilovolt) level.

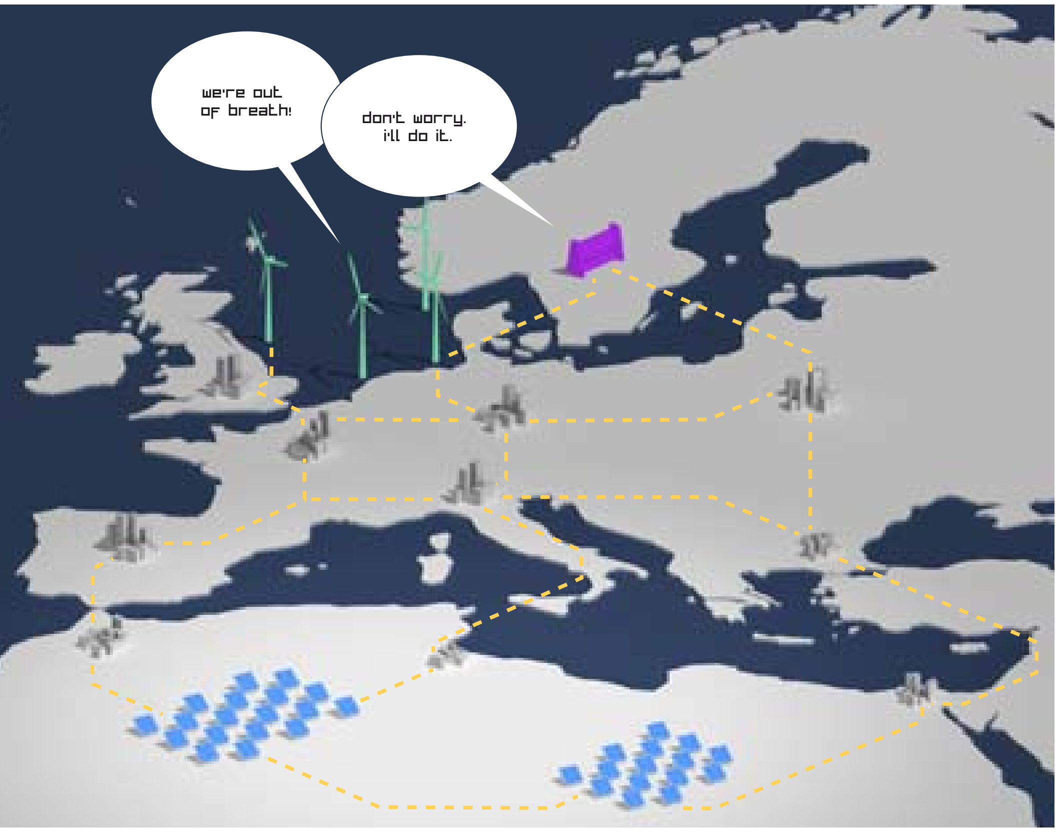
Von Dungen's staff ensure that sufficient electricity is always available to supply the city. He points to a yellow dot on the display. "That's a transformer. In the future, we'll be able to zoom in and see how much bioenergy, for example, is coming in." He says this transparency is important to keep generation and consumption optimally balanced. So far, only medium and high voltage levels are being watched, but the low voltage level will take on importance as well as distributed renewable sources are increasingly used. "Here in the control room, we want to identify how much electricity is being fed in from renewable sources," says von Dungen. The next step will be to network all these sources with communications software.

1,000 open questions

Project manager Andreas Kiessling says no one can tell yet what will emerge later from the Mannheim project. "We're getting significant findings and experience with it." He estimates it will take a good ten to 15 years before the technology is deployed nation-wide.

Why does it all take so long? "Where metering technology is concerned, we're still at the donkey-driver stage," says Andreas Bolder, data supply manager for regional supplier Rheinenergie. There aren't more than a handful of pilot projects. Aside from Bulgaria, he says, Germany is the only country in Europe that was still installing mechanical electricity meters in new buildings in late 2009. Since early 2010, only smart meters can now be installed. The long overdue regulations that prepared the ground for the introduction of the new technology are just one reason for the sluggish development. Bolder says the main problem is a lack of uniform standards, which are important if equipment of differing manufacture and type is to be used in combination with the current technologies of the energy suppliers. "We need a standard at European level, if possible." The EU Commission is at least working on the case.

Another problem is data protection. At present, it's in the hands of the data protection officials in Germany's individual states, making business particularly difficult for the developers of smart meters, because they have to cope with too many different regulations. The question of how much data is wanted also remains open. Will consumers want to see their consumption every month or every minute? Cost is another unanswered question. These are just some of the matters that have to be settled. But the load curve can only be optimized when the technology is used nationwide. Around 45 million meters will have to be replaced in Germany alone. One thing is certain – the Wirth family won't be among those who have to wait for their digital meter.



In a smart region, renewable and initially also fossil energy sources are connected to consumers and each other, not only via the grid but also via a communications network. They share information to ensure the better use of the fluctuating production of energy, say from wind turbines. The turbines pass the information on to large computing centers. Electricity generation components, energy use, meters and resources are controlled there, as is communication with all consumers and generators. Electric car batteries can be charged when the wind blows strongly. Pumped storage hydroelectric stations are also used as energy storage devices where a big supply of wind and solar power is available. Fossil power stations can be switched off when renewables cover demand. The fluctuating supply of solar power can be optimally exploited this way. Smart homes moreover reduce peak loads, because domestic appliances only run during off-peak times.

rections on both the transport and distribution level. The optimal distribution of African sun and North Sea wind on a global level parallels the regional supply of households with electricity from distributed generators in the direct vicinity, say, from rooftop solar arrays.

The technology required is demanding. ABB has just laid the first HVDC submarine cable to connect the Borwin 1 offshore wind farm. “The cable is eleven centimeters thick and has been designed for up to 1,000 megawatts,” says ABB expert Günther Stark. Although overhead cables can carry more, he says, they have little chance of implementation because of popular resistance. Converter stations are also limited to one gigawatt at present. “But we'll soon be technically capable of setting up stations to handle two or three gigawatts,” says Stark, who reckons it's much more important to agree on uniform standards so that products from different manufacturers can all be used. Work is being done on such standards.

Barriers popping up

Grids are already overloaded in some European regions, while planning and licensing new cross-border connections takes far too long – seven years on average at the moment. Furthermore, grid extensions are planned nationally, and costs are calculated for the mid-term. Direct-current cables, on the other hand, only pay for themselves in the long term and need to be at least 800 kilometers long.

Two new organizations now hope to overcome these problems. The Agency for the Cooperation of Energy Regulators (Acer) is responsible for developing standards and rules for interstate trading in electricity, and the European Network of Transmission System Operators for Electricity (Entso-E) is tasked with guaranteeing the safe operation and optimal management of the European grid system. It published a ten year plan for grid development in early March with recommendations for infrastructure investments in 34 European states.

Price Waterhouse Cooper says the planning of new extra-high-voltage transmission lines coordinated by Entso-E could begin in 2012. The first new HVDC cable between Europe and North Africa would then be laid in 2015. The supergrid through Europe is to be completed in ten years. Connections to the regional grids will then be established so that the transmission lines can be supported by the increasing use of intelligent systems. These connections between regional smart grids and the supergrid are to mature into a European SuperSmart Grid by 2050. ◀