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Smart Energy made in Germany

Interim results of the E-Energy pilot projects towards the Internet of Energy

This booklet was prepared as part of action research for the E-Energy Programme. It compiles examples of results from the six pilot projects and initial research findings of general application.

The E-Energy pilot projects and the action research are promoted as part of the E-Energy research priority by the Federal Ministry of Economics and Technology (BMWi) in interministerial partnership with the Federal Ministry of the Environment, Nature Conservation and Reactor Safety (BMU). The interim results presented here and the conclusions drawn have been agreed with the pilot projects but do not reflect in every case the opinion or position of the sponsors.

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FOREWORD

Affordable and reliable energy supply is essential for our industrial growth. Climate change, growing energy demand and depleting raw materials pose great challenges for Germany, as also reflected in the energy and climate policy decisions of the last two years: First, greenhouse gas emissions will be substantially curtailed by 2050. Second, renewable energies will provide the bulk of our power supply in future and third we are looking to curb energy demand by a large margin while raising energy efficiency. In implementing these decisions, the Federal Ministry of Economics and Technology, as the lead ministry in energy policy, will keep a constant eye on economic efficiency and supply security.

In the course of the basic energy reform, the structure of the supply system will undergo far-reaching changes in the coming decades. For example, the number of small and decentralised producers with highly volatile, weather-dependent power generation will increase. These developments pose a great challenge for grid operators. Information and communication technologies (ICT) can make a decisive contribution here. With their help we can better balance the growing power supply from renewable and decentralised energy sources with demand. Communications technology plays a major role both in grid expansion and the conversion of the whole power supply system.

Whether we call it smart, active or intelligent grid, we are talking about systematically maximising the efficiency of electric power supply. This ranges from power generation to storage, transport, distribution up to efficient use. In Germany, this is being pilot tested under the auspices of the funding initiative of the Federal Government, E-Energy: ICT-based Energy System of the Future. E-Energy means Smart Energy made in Germany. We have some enterprising partners on board. Together, we want to find out what is technically feasible and what makes economic sense. In different scenarios in six model regions, industrial and scientific syndicates are investigating and testing the essential elements of intelligent energy supply. We are hoping for major contributions from the model regions to realigning our energy supply. This is why the experts from the model regions are closely involved in the working groups of the platform, Future Energy Grids. This way, E-Energy can help to bring German industry and commerce to the forefront in a decisive field for global competition.

The present booklet affords an initial insight into the results of the six E-Energy model regions and related action research. We can look forward to some more interesting results when they complete their work in 2012. I wish the participants in the model regions all the best in their efforts.

Yours

Dr Philipp Rösler
Federal Minister of Economics and Technology

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SMART ENERGY MADE IN GERMANY

Triple goals of the energy policy shift

From the outset, German energy policy has pursued three major goals: economic efficiency, supply security and compliance with environmental standards. Achieving these in times of growing demand, raw-materials shortage and climate change poses great challenges for us all. With its energy policy, the Federal Ministry of Economics and Technology as the lead ministry seeks to ensure reliable supply at reasonable cost.

As a society, Germany has taken the basic decision to meet its future power supply needs from renewable sources. In autumn 2010, the Federal Government laid the cornerstone in its energy strategy for the advent of the new era. Nuclear energy and fossil fuels will act as a bridge only until renewable energies can perform their role reliably and the necessary power infrastructure has been put into place. The share of renewable power generation in gross energy demand will be raised from 17 % today to 35 % by 2020. Speeding up grid expansion and conversion, improving market and system integration and making greater use of storage facilities will enable renewable energies to increasingly provide enough power to meet needs. The target for 2050 is a ratio of 80 % of power demand. Recent studies indicate that a 40 % share is already attainable in 10 years time.

Above all, the basic conversion of our energy supply will afford an opportunity for future generations. As the first great industrial nation, Germany can chart a new course towards a highly efficient renewable energy system. To do this, however, we shall also need to adopt a very realistic and rational approach and a keep a sense of proportion. Innovation and progressive technologies play as important a role here as a suitable market and competition policy framework. The Federal Government paved the way for this with an extensive package of legislation in the summer of 2011. The so-called energy package contains seven laws and a regulation (including the Energy Industry Act and Renewable Energies Act amendments and changes to the Energy and Climate Fund Act).

With the demands it places on all of us, the energy policy reform can only succeed with the broadest possible support of society. Central government, federal states and municipalities, business, industry and trade unions, environmental and consumer associations and citizens share a common obligation. To promote the necessary dialogue, the Federal Ministry of Economics and Technology has brought together representatives of all these groups in a new networking platform. The exchange of views here will help to ensure that all measures towards a different way of supplying and using energy find a large measure of social acceptance.

Innovation and deregulation as guarantor for economic success

Germany is one of the most efficient and economically successful countries in the world. Competitive energy supply in general and for enterprises in particular is essential for the successful development of our economy. We need to plan and implement the energy policy reform so that it can give an impetus to innovation and economic growth.

Smart grid as a major export

Germany does not just play a spearheading role in policy decisions but also as a lead market in developing technologies for the energy system of the future. The energy policy shift affords new technological and economic opportunities for Germany's competitiveness as an export nation. In the best tradition of German engineering, it will generate new technologies and products, new export opportunities and, with that, employment and growth. With competitive energy prices, power supply security and a high standard of living, speedy progress towards the renewables era will make Germany one of the most progressive and energy-efficient economies in the world.

Keeping ahead in future power supply

Europe-wide market deregulation for electricity and gas is essential to raise competition in the industry. This will break up monopolies and make room for enterprising companies in renewable energies and energy services. It will set off a momentum that will primarily benefit private and industrial consumers through competitive prices. Business start-ups and increased research activity will also help the German economy to gain a leading global role and improve its competitiveness.

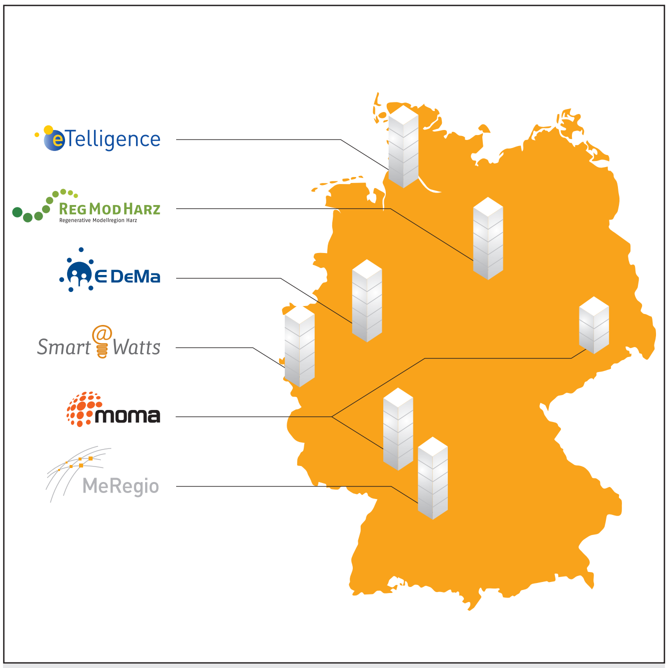
Supply security in the future power grid

Instead of being dependent on electricity imports, we in Germany want to be able to meet our grid needs on our own as far as possible. This is why renewable energies are becoming increasingly important. Yet converting to these volatile energies from wind and sun, for example, will place new demands on secure supply for the population and businesses. The ongoing supply of electric power from nuclear or coal power stations will be supplemented with and finally replaced by a diverse energy source mix. The Federal Economics Ministry is also working towards achieving supply security by reducing energy demand, because more economical and efficient use of energy is the simplest and most cost-effective way to ensure an adequate power supply. This is why the energy strategy is aiming for a 10 per cent reduction in power consumption by 2020.

Six lighthouses for the Internet of Energy

With its research priority, "E-Energy – ICT-based energy system of the future", the Federal Ministry of Economics and Technology (BMWi) in interministerial partnership with the Federal Ministry of the Environment, Nature Conservation and Reactor Safety (BMU), is investigating and testing new ways to reduce electricity consumption and use energy more efficiently. The focus is on integrating renewable energies in the future grids with the help of newly developed information and communication technology (ICT) systems. As a flagship programme of the Federal Government, E-Energy also forms part of the action plan, Germany: Green IT Pioneer.

From 2008 to 2013, industrial and scientific syndicates are investigating and testing the application of ICT in the energy sector in six Smart-Energy Regions. With support from specially commissioned ancillary research team, they also address multi-project, cross-sectoral themes, such as effective global architectures, business models, legal frameworks, data protection and security or standardisation. Overall finance for these projects amounts to approximately EUR 140 million, with the Federal Economics Ministry contributing EUR 40 million and



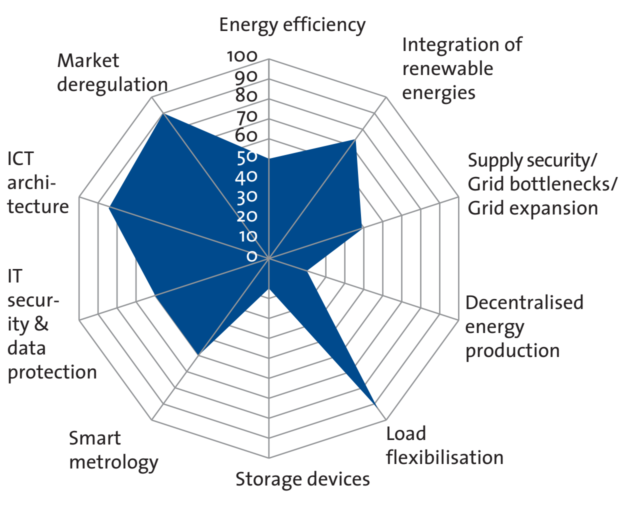
The six model regions are developing solutions for the ICT-based energy system of the future.

the Federal Environment Ministry EUR 20 million. The remainder is borne by the model syndicates themselves.

From consumer to prosumer

The E-DeMa project investigates intelligent consumption management and the near-time capture and provision of consumption data. The regional E-DeMa energy marketplace functions as a central data hub both for consumption and contract data. Together, the project partners develop practical solutions for production and consumption management of household, grid and market applications. The focus is placed on the cost-based application of decentralised small producers, such as power and heat co-generators and electric home appliances. E-DeMa has so far also been able to improve business operations in classic energy supply, for example, switching suppliers now carried out automatically via the marketplace has been shortened from several weeks to two days. Electricity products provided by the marketplace can shift ten per cent of consumption to off-peak times and reduce peak loads. This consumer flexibility can be put to use for the internal adjustment of balancing groups at distribution grid level.

Priorities of E-DeMa



In E-DeMa, 14 micro block-type thermal power stations (µKWK) were installed for the field trial, which can be connected when needed as decentralised small producers and aggregated via the marketplace to tradeable outputs. In addition, over 1,500 households and commercial enterprises were equipped with ICT gateways that enable consumers to take active part in the E-DeMa marketplace. Besides outputs, shiftable loads can also be aggregated as flexibilities and sold on the marketplace. The classic roles of energy consumer and producer in the Rhine Ruhr region have thus been merged into the 'prosumer', who does not just consume energy but also participates on the market as a producer and provider of flexibilities.

Freezing the wind

In the Cuxhaven region, the project, eTelligence, is testing a complex control system to balance out fluctuating windpower that intelligently integrates electricity into the grids and a regional market. The core component of eTelligence is a regional electricity marketplace that brings together producers, consumers with shiftable loads, energy service providers and grid operators. As well as improving supply security from renewable energies, this also enhances economic efficiency.

A particular challenge here is to integrate the marketplace tested in the course of a one-year field trial into the ongoing business operations of the overall power supply system. During the field trial, the participant actors were exposed both to marketing and price risk as well as forecast risk. The market participants are two cold-storage depots, a windpark, the Cuxhaven municipal swimming pool, a treatment plant and a block-type thermal power station. These can be flexibly connected either individually or as a virtual power station and together can be managed and predicted in a similar way to a conventional power station. Here, controllable units in particular (e.g. producers with power/heat cogeneration or switchable loads) can provide power generation flexibilities for the market.

eTelligence was able to demonstrate that especially thermal electrical energy systems, such as cold-storage depots and block-type thermal power stations can be used very effectively as energy storage facilities: When a lot of wind is available, the Cuxhaven cold-storage depot lowers its temperature and creates a cold buffer for itself. When electricity prices are high, the refrigeration systems are switched off. Using the cold buffer previously built up, the cold-storage depot can then run for some days with much lower power demand. This substantially reduces electricity supply costs over the year.

RESEARCH FIELDS OF E-ENERGY (AXIS LABELS IN THE OVERVIEW CHARTS)

There are many facets to E-Energy. The pilot projects investigate how the technical operation and the market mechanisms of the energy industry can be effectively and efficiently managed with ICT. They set different priorities, as can be seen from the project description charts. The axes of the charts indicate:

1. Energy efficiency
Research measures that can help improve the efficient use of available resources, e.g. dynamic rates, price signals for controlling appliances, home-automation technologies, etc.

2. Integration of renewable energies
Research measures for the integration of renewable energies into the electricity mix

3. Decentralised energy generation
Developing solutions to integrate smaller, decentralised producers (e.g. private PV modules, block-type thermal power stations, etc.) and/or bundling several producers into virtual power stations/systems

4. Supply security/Grid bottlenecks/Grid expansion
Research measures aimed at securing future power supply with the inclusion of renewable producers at different voltage levels as well as measures for future investments to prevent grid bottlenecks and/or enlarge grids

5. Market deregulation
Research measures and studies to simulate or test a future free energy market, also accounting for energy imports/exports and innovative market platforms

6. Storage devices
Approaches for integrating energy storage devices in virtual systems

7. Load flexibilisation
Studies on ways to shift loads and/or even out load profiles through (intelligent) consumer management

8. IT security and data protection
Devising measures for the protection of collected (measured) data against alteration, loss and theft

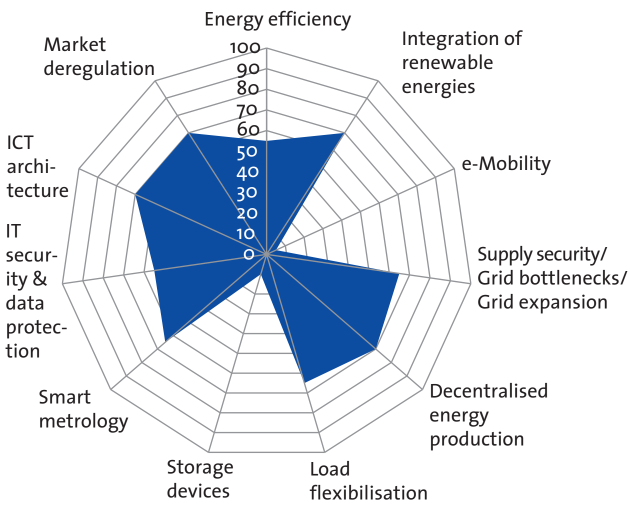
9. ICT architecture
Studies on models and basic technological issues of infrastructure, management and interfaces as well as the interaction of functions in the future smart grid (particularly smart meters, ICT gateways, energy managers, interfaces with marketplaces, protocols, etc.)

10. Smart metrology
Research measures on the application of smart metrology systems (e.g. smart meters)

11. e-Mobility
Research measures/simulations that take account of the integration of electric vehicles into the future smart grid (Research not cited here where carried out solely in a sister project of the programme, ICT for Electromobility)

In addition, over 650 households have tested smart meters for everyday use. With different feedback systems (iPod app, portal, monthly printouts), the participants were able keep track of their own electricity consumption and assess the cost of electricity, CO_2 emissions and their consumption pattern.

Priorities of eTelligence



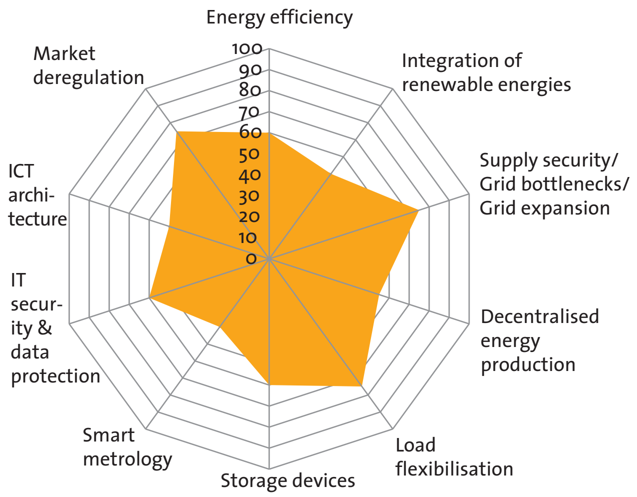
Minimising emissions together

In the MeRegio project, 1.000 electricity customers from Freiamt in the Black Forest and Göppingen are testing the smart home. Here, energy production and consumption are matched up to make the most efficient use of the available energy with the help of local load shifting. Smart deep freezers and dishwashers but also stationary batteries and micro heat/power cogenerators were connected and optimised. The consumers' own production was included in this optimisation process to obtain the best outcome for the customer.

For visualisation purposes, applications are tested for the consumer to provide him with specific support in energy management. An example is the 'Stromradar' (energy radar) as an iPhone app: It indicates current energy consumption second-by-second to give the consumer a clear picture, particularly when no PC is at hand. To communicate the success of the region to the citizens, the project is also working on a general certification method for a 'minimum emission region'.

A way of rectifying critical grid states that can be caused by volatile energy in-feed but also by new market signals is automated demand-side management. This has been demonstrated by a field trial in Freiamt, where so-called control boxes were installed in households. Depending on grid parameters, these receive price, efficiency or priority signals and can control the smart household appliances accordingly. Electricity-intensive activities can then be brought forward or postponed. This way, market mechanisms can improve supply security and curb grid loads.

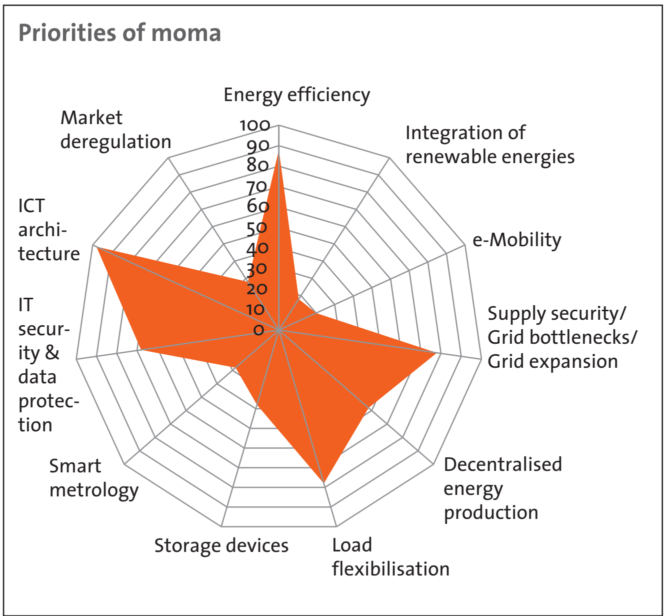
Priorities of MeRegio



Cells for security

To make effective use of smart home appliances, it is important to provide them with the essential information and signals in keeping with the grid parameters. In a field trial, new control devices have so far been installed in 200 households, so-called energy butlers. This energy management system helps electricity customers to bring their consumption into line with the variable prices on the energy market. The energy manager can control appliances and decide independently when to turn them on or off. The most important variable for this is the current price of electricity. The manager only switches on the appliances if this is of monetary benefit to the consumer but optimisation can also take grid requirements into account. Particularly appliances with variable usage times, such as washing machines or deep freezers, can be operated to save costs.

Transparency is the prime concern for consumers. The energy butler keeps them permanently informed about their current electricity consumption. Environmental aspects, however, such as the reduction of CO_2 emissions or the development of renewable energies, also play a major role in decisions to install an energy management system in the home.

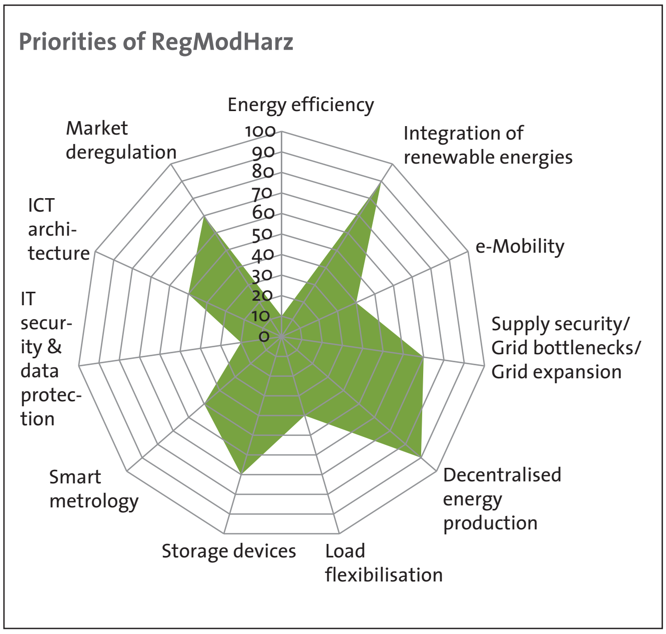


In the E-Energy project with Mannheim as a model city, a complete system architecture was set up for the first time to link up households and commercial enterprises with units that use and generate power. This can provide information for the future on how far this kind of service-oriented approach is feasible in normal operation in terms of real-time capability and scalability. Another focus was placed on developing the system architecture for 'security by design'. This has come up with a cellular energy system, where the outage of a cell does not necessarily impair the whole system, thus improving supply security.

A region as a virtual power station

REGMODHARZ Regenerative Modellregion Harz

The model Harz region is mainly concerned with the joint marketing of regionally available renewable producers and flexibilities grouped into a virtual power station on different markets. For this, the IEC-61850 standard was extended to enable the simple and secure connection of systems to a joint control station. This newly developed generic data model enables the automated assimilation of systems in energy management.



With the innovative 'regional renewable energy rate' created as part of the project and now being tested in the field trial, consumers in the Harz region can obtain regional electricity from renewable energy sources, such as wind, sun or biogas. The rate is geared to minimising the residual load within the region so that the customers can make an active contribution to balancing out production and consumption. It is processed in part automatically through an energy management system and smart household applications. Regional electricity in the Harz region is also a means of retaining customers and fostering identification with the local energy supply infrastructure. This also raises the acceptance of decentralised production units, such as windparks. Visitors to an online platform at RegModHarz can analyse and obtain information on the rate and the present, previous and future production of renewable electricity.

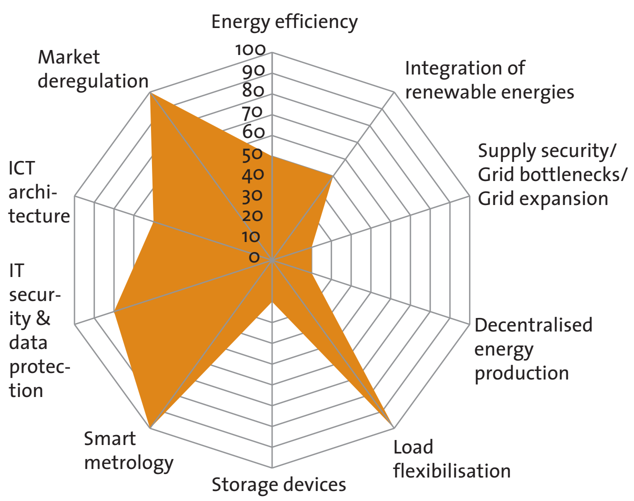
The Harz region project also demonstrated that the storage requirements for energy could be reduced through short-term wind forecasts. Load shifts on the consumer side help to improve voltage regulation in the distribution grid and compensate for forecast errors. The newly developed pool coordinator to bundle and market the decentrally generated electricity is coming to play a central role on the new markets.

Smart kilowatt hour

Smart@Watts

In keeping with the unbundling approach, the aim of the Smart Watts system is to provide an information and control model for the energy system, providing market players with near-time, actual production and consumption data. This enables the overall control and optimisation of the energy portfolio via smart supply management (so-called end-to-end optimisation). Besides the conventional methods of portfolio management, balancing is also effected by directly influencing production and consumption. This way, the best use can be made of availability but also of fluctuations in the renewable power generation. In-feed and consumption and supply and demand can be specifically adjusted through the incentive-based system. Production and consumption are priced dynamically in keeping with set rules and the prices sent to the respective terminals. Via the reference variable price in the smart home, the smart kilowatt hour provides an incentive to the consumer to shift his energy consumption (manually or automatically) to cheaper periods with no loss of comfort. The consumption data captured by smart meters provide the basis for variable rates that are invoiced and clearly recorded with a flexible billing and reporting system, so that supply can be managed to encourage energy savings.

Priorities of Smart Watts



The requisite networking of the household with the information and control systems is done by means of the open standard, EEBus. The information thus provided can be processed automatically by smart power sockets and home appliances in compliance with user settings. Via a modern visualisation tool, the iPad, the customers receive detailed information on their electricity consumption. By way of the Smart Watts app, they can adjust their usage and contribute to raising efficiency in the energy system.

The interaction of the various Smart Watts components is being tested in a field trial in Aachen.

E-Energy was represented at the IEC General Meeting in Seattle as part of the attendance of the German Commission for Electrical, Electronic & Information Technologies (DKE).

ICT: Key to the conversion of energy supply

The conceptual phases have been completed in the model regions. Many components of an Internet of Energy have now already been implemented and are being tested in extensive field trials. Over 5,000 private households and enterprises have been solicited for this trial phase, which will last until the end of 2012. Based on initial evaluations, it is already clear today that E-Energy and smart grid technologies can make a central contribution to meeting the challenges of future power supply. In particular, matching the use times of electric power in households and enterprises with electricity supply can contribute to integrating renewables into the distribution grids. The initial trials with new electronic market platforms have made promising progress.

Using available technologies and preparing the way for new ones

With today's technologies and new approaches for their application, all E-Energy pilot projects examine how renewable energy volatility can be transformed from a disadvantage to an advantage. The prime concern is with the ICT-optimised operation of distribution grids, networking consumers and producers and new marketplaces and business scenarios. These new information and communication technologies will pave the way for an Internet of Energy, where decentralised producers communicate with the power grids and the consumers technically and as market participants. In preparation for this, they are also investigating the market-conform provision of data and services in an IT-secure environment under current and future legal frameworks.

Smart meters for more transparent power supply

In future, ICT will help bring about an active 'intelligent' distribution grid. Electronic meters will provide information on the major parameters in the grid. This equipment will measure data at a substation, for example, or at carefully selected points in the supply line. With this information, controllable substations, for instance, can then optimally adjust electricity quality in line with the measured values. Smart meters installed at private and corporate consumers can provide valuable help. In future, their task will no longer just consist in measuring electricity consumption and the amount of in-fed electricity to prepare an invoice. A dense network of these meters can provide precise information on power demand, mains voltage and frequency. This near-time and localised information will afford the basis for the largely automated intelligent matching of production, grid load and consumption. Besides smart meters, this requires appropriate controllers and terminals in households and enterprises that can be induced to temporarily reduce or increase their consumption, through price incentives for example. ICT will enable the paradigm shift from previous consumption-based electricity generation to production-optimised consumption.

Architectural features of the Internet of Energy

So that renewable energies can advance to become the main energy source, the whole system of power production, storage, distribution and consumption must become more intelligent. The Internet of Energy networks the many actors of the energy system. Every unit connected to the power grid is integrated into the control system through plug & play. They are connected to the overall system through equipment called energy managers, communication managers, control boxes or ICT gateways. They are provided with the necessary information and help to match up production, grid load and consumption largely automatically. This will give rise to an integrated data and energy network with completely new structures and functionalities.

Intelligent power generation

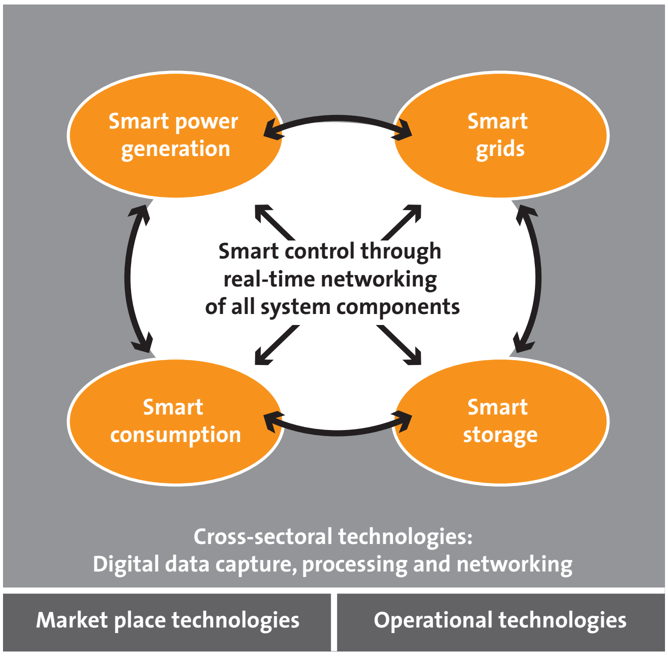
With the rapid growth in the number of decentralised and volatile power producers, we need to rethink in-feeding into the grid. A specific challenge in some places already today are the photovoltaic modules connected to the low-voltage grid. If the sun emerges from behind the clouds, many systems start to feed into the grid at high output at the same time. This raises the frequency and in response to pre-settings some generation systems connected to the low-voltage grid would have to switch off automatically when they reach a mains frequency of 50.2 Hz. As many installations register this and switch off simultaneously, they can seriously disrupt system stability. New technical provisions have now been made in response to this problem, but it will be exacerbated in future and can be solved more elegantly through options created by the Internet of Energy. The necessary smart inverters for this have already been developed. They now need to be connected with the other participants in the overall system and the corresponding control systems through appropriate communication modules. Of great importance also is the ability of decentralised producers, such as micro block-type thermal power stations, to switch in at the right time. If they are connected with the whole system via communication units, they can, for example, be switched on, if the sun disappears again behind the clouds.

Smart grid operation

The system of transmission and distribution grids developed to date is very reliable. Decentralised generating units on the one hand and new types of consumer, such as charging stations for Electromobility, on the other, pose challenges that exceed the present grid operation resources. To make the best use of grids and prevent uncontrollable states, grid operators need much more information at the right time and from many points in the grid. This will be supplied in future by meters placed at suitable points in the grid. In part, these can be the smart meters in households and enterprises and in part specially developed measuring instruments to continuously gauge the main grid parameters along the supply lines of the distribution grids and transmit these to the control centres. From there, intelligent substations can then be controlled and price and other control signals can also be sent to the production and consumption units. To be able to plan efficient and cost-effective control measures, the Internet of Energy needs forecasting systems that can provide reliable information on production and consumption.

Smart consumers

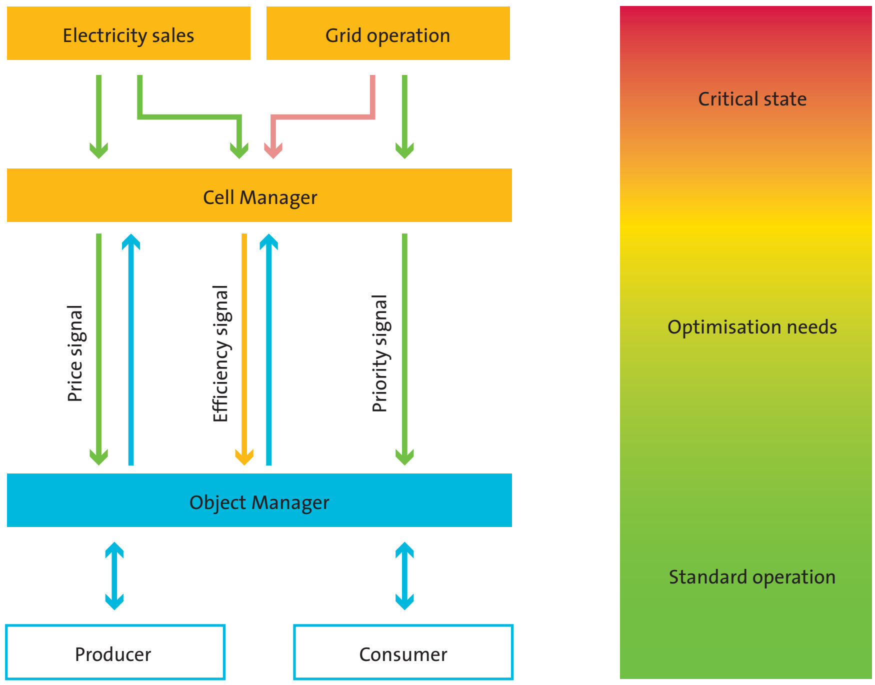
Consumers are called smart or intelligent when they can adapt in the best way to the present supply in the grid. They are connected with the overall system via intelligent communication facilities. These, aptly called energy butlers in the E-Energy project moma, control boxes (MeRegio) or ICT gateways (E-DeMa), receive information on current prices, the production mix or grid states and can switch consumption appliances on or off in response to this. They must be intelligent enough so that they only actuate appliances if they are in a suitable operating state. In the Internet of Energy, therefore, hard control signals will only be issued for extreme critical states. Otherwise, the controllers will receive offers as it were that they can accept but also reject. This so-called demand-side management is thus subject to market rules as depicted through the electronic platforms that were also developed as part of E-Energy. As the pilot projects show, not all appliances are equally suitable to adapt their consumption over time at all or in a cost-effective way. Installations in companies afford great potential in general, e.g. large cold-storage depots, treatment plants or block-type thermal power stations. In the private sector, these are primarily heat pumps, refrigerators and air conditioners of a certain scale and in future charging stations for electric vehicles (and/or batteries in general) that can shift their consumption within hours or days.



Integration of electric mobility

With its new ICT solutions, E-Energy has also laid the foundation for the intelligent integration of electromobility in the whole energy supply system. Via the Internet of Energy, vehicles can report their current position, their battery charge and when it will need to have a certain state of charge. The owner can preset for recharging at minimum cost, for example, or generally only with ‘green electricity’. If the owner of the battery allows, the E-Energy systems can even arrange for the electricity from the battery to be fed back into the grid to meet peak loads.

Control signals for power producers and consumers



Some functions developed in E-Energy can be generically defined by the terms 'cell management' and 'object management'. Together, they make up smart energy management. The electricity seller provides cell management with, for example, current electricity prices (for production and consumption) and the grid operator supplies it with information on the grid state (usually with the aim of stabilisation). Cell management collates this (possibly contradictory) information into suitable signals and transmits them to suitable objects. As long as the overall system is in the green zone, price signals are sent to (all) objects and a decision taken via negotiation (e.g. first-come first-serve) on who accepts the supply on offer or meets requests.

If the system is in the yellow zone, i.e. there is need for optimisation, special control signals can be transmitted to suitable objects. If the device control has the technical capability under a pre-agreed and pre-set regime at the present time, the respective producers and consumers are connected so as to help stabilise the grid. One goal of E-Energy is to ascertain whether it needs these control signals or whether everything can be communicated via price signals.

If the system is in the red zone, the grid transmits special requirements to the energy management. Without additional optimisation algorithms but via the same communication channels as the other signals, these are passed on as a priority signal to interruptible and/or startable producers and consumers.

Smart storage

With stationary or electric-vehicle batteries, peak loads, such as from PV modules, can be reduced. The future power supply system will not, however, only need to balance production and consumption in the short term, as can be done with these decentralised storage devices or the methods of demand-side management. To be able to bridge intervals without wind and days without sunshine over a longer term, energy from renewable sources must also be stored for longer. The capacity of home pump storage devices is too small for these purposes.

Experiments are already being conducted with additional technologies, such as the production and storage of hydrogen or methane (Power2Gas & Gas2Power). This increasingly raises the question of not just when electricity is consumed but also where and how it is stored and when it must be fed back into the grid. Information and communication technology will therefore also help in future to intelligently integrate storage devices in the overall system with maximum efficiency.

Interview with Ute Urban, participant in the RegModHarz field trial

Ms Urban, why are you taking part in the e-Mobility field trial?
At the University of Harz, I was jointly responsible for the sustainability assessment of the RegModHarz project. That is how I came into contact with the sister project, e-Mobility, which researches aspects of electromobility in the region. In addition, I would like to help introduce and upgrade electric vehicles so that they will be interesting for a broad market. I think that we must all try to reform our energy supply so as to be more independent of fossil fuels. Our 95 % dependence on petroleum cannot be a viable strategy for the future.

What have you done exactly in the field trial?
In the field trial, we attempted to shift the load times of electric vehicles to off-peak times of renewable energies. I was not only able to charge up my car at the charging station at home but also at my workplace. So this enabled me for the first time to adapt my charging times to load times. If charging stations are installed everywhere, electric vehicles could also be used as mobile storage batteries and provide electricity from renewable energies, whenever there is an acute power demand.

How do you know when so-called off-peak times are?
Every day at 11 o'clock, the prices are set on the electricity market for the next day. We were informed of this by SMS. The most important indicator here was price. Unfortunately, the whole thing still only functions in theory, as the necessary daily rates are not available. The price information even appeared automatically at one of the charging stations.

When plugging into this station, I could set the charging time and it started automatically at the cheapest point. So you can decide to recharge the car today or not until the next day. This gives you the individual choice of matching your charging behaviour to the various prices and selecting the most favourable day rate. It is also generally possible to simply set the time when the recharged car is needed and the charging station takes this over.

New marketplaces, new market functions, new products

More than today, producers and consumers in the Internet of Energy will be able to align their behaviour closer with the market. Whoever generates electricity in his company or home will therefore no longer just be a consumer but also a producer, in short: a 'prosumer'. The future energy marketplaces will not only provide electricity at conventional rates. There may be new business models, such as least-cost or prepaid electricity supply. Some open questions need to be settled outside of E-Energy, though. There are certain to be dynamic rates in future, where people will be rewarded for their flexible power consumption. Probably not every single household will be able to trade electricity from his production units and storage devices, but there will be a number of new participants on the electronic marketplaces that represent their customers as agents or flexibility operators. Additional services can be offered on these marketplaces, for example, necessary forecasts for promoting economical behaviour or programmes to raise efficiency in households and enterprises through smart maintenance and control of energy-producing and energy-consuming systems. This is where the smart grid solutions converge with the rapidly developing ICT-based controls in smart homes and smart factories.

Data protection in the Internet of Energy

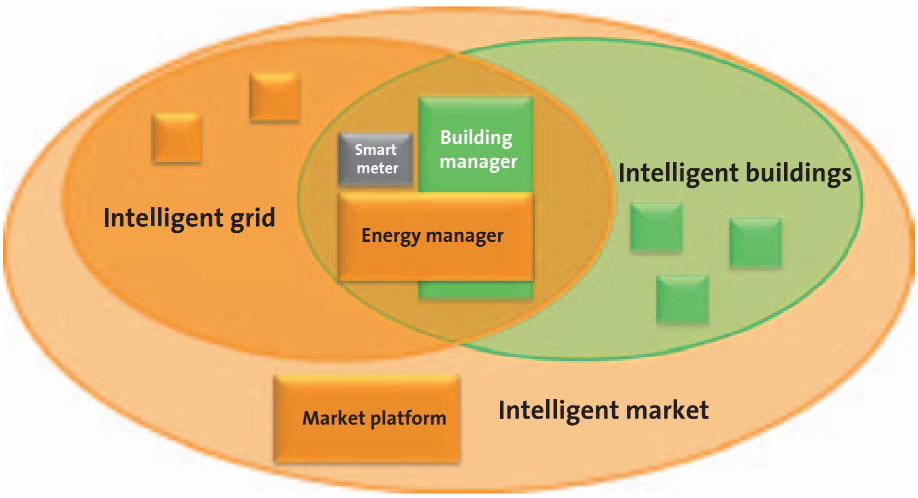
Communication and transparency are vital for the Internet of Energy. Ensuring that for all the transparency the consumer does not have to reveal too much of himself and the emerging infrastructure is protected against harmful access also poses a problem that is being addressed by the E-Energy pilot projects and action research. The E-Energy legal working group has drafted recommendations for data protection in smart grids, which have in part already been channelled into the amendment of the Energy Industry Act.

The protection of personal data from unauthorised access is rightfully seen as a major prerequisite for the acceptance of smart grid solutions. Certainly, the main measures for data protection are the purpose limitation, the economical use and the transparency of data. Only data needed to optimise energy efficiency and the management of the overall system should be stored. For most application scenarios, no personal data are required. 'Privacy by design' denotes ICT methods and architectures where data is only saved in aggregated form and only when it is actually needed. In the few cases where specific data is required, it must be anonymised or pseudonymised beforehand. Finally, it is important for the user to know what data on him is stored and passed on. The individual providers must disclose what information is finally saved, to whom it is transferred and in what format.

Secure and self-healing systems

While the rights of private persons can be safeguarded through these measures, there is a need to look more closely at the security of the overall system. Data and control systems must be protected against unauthorised, illegal access. With its initiative to develop a protection profile for smart household meters, the Federal Ministry of Economics and Technology has taken an important initial step in the direction of security in the smart grid. Others will follow. Many of these have to do with the architecture of the whole system, because not every undesirable state is attributable to a criminal act. ICT equipment can break down and any software can contain errors. Error conditions need to be encapsulated through the intelligent design of the overall system and individual areas of the whole system must be able to operate independently for a while and re-assimilated into in the overall system step by step. The present and future goal must be to ensure that power consumers can rely on secure supply at all times.

Interfaces of smart grid and smart home



Smart meters and energy managers combine the intelligent grid and the electronic marketplace with automated private and commercial properties.

E-ENERGY: INITIAL FINDINGS AND RESULTS

Energy efficiency and renewable energies

When customers have detailed information about their electricity consumption, they can take specific measures to reduce it. In the first pilot field trials of E-Energy, savings of up to 5 % were made in the private sector. In the large-scale eTelligence field trial, savings have even been made of as much as 10 %. Individual enterprises in different E-Energy projects were able to save up to 20 % of their energy.

Transparency through smart meters and submeters

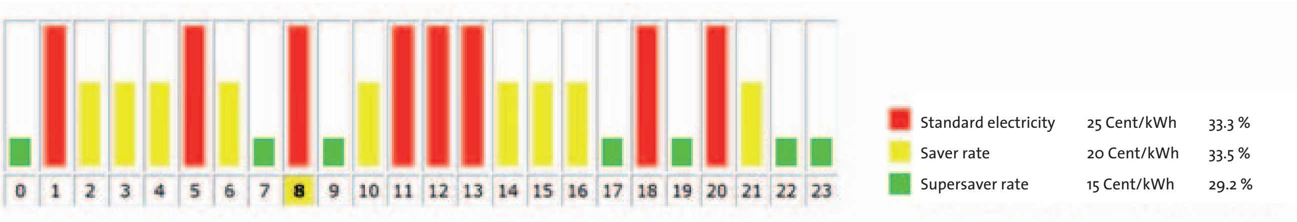
First of all, electricity consumption needs to be transparent. This is ensured through so-called feedback instruments that can indicate current consumption as well as the course over several days or weeks. They obtain their information from a smart meter either directly or from a metering point service provider which has already aggregated or processed the data accordingly. For private households, the provision of consumption curves in the monthly account can sometimes function as a feedback instrument. To specifically locate reduction potential, a more precisely scheduled record of consumption is sometimes necessary in households but certainly in companies. MeRegio, for example, applies the Powersubmeter®, which is especially useful to gain a better understanding of the enterprise monitored and identify the potential for load shifting and energy efficiency. It can also give the customer a more detailed picture of his consumption pattern.

Information plus options

Transparent electricity consumption patterns alone are not enough to save on energy. Power consumers must be able to assess the relevant information and decide on the possible options. In the pilot projects, households usually receive specific advice from the electric utility company. Relevant and also government-sponsored (here: KfW) advisory measures are conducted in enterprises. Where feedback is provided for households via the Internet, automated efficiency indicators are given. By means of ICT, consumption curves can be analysed in detail as a basis for specific adjustment proposals or replacements for power consumers. Data protection regulations apply here, however, which only permit this consumption curve assessment after a relevant agreement has been reached.

Interview with Jürgen Mayer, participant in the MeRegio field trial

MeRegio traffic light/smart meter
30. Jan. 2012



Why are you taking part in the MeRegio field trial?

I am a trained electrician and have studied computer science. MeRegio was a good opportunity for me to gain experience in dealing with smart grids and anticipate the future a bit, because what is presently being researched at MeRegio will probably come to be part of real life everywhere in ten years.

What has been your involvement in the field trial?

I have changed my consumption: I switch on my home 'appliances, if the MeRegio electricity traffic light is on green. This means that current is available at a particularly cheap rate because general demand is low. Smart home appliances are one step ahead here and switch themselves on at the relevant times.

How many days in advance can you foresee the price level with the electricity traffic light?

I generally always get up-to-date daily data. They show me in which phase I am at the moment and how it will look in the next few hours. Towards evening, I can then already request the rates profile for the next day. So I can, for example, see that as of 10 p.m. the following day the supersaver electricity rate applies, where a kilowatt hour costs 15 cents, instead of the usual 25 cents. However, I can also see which rate is on offer at the moment. The traffic light can, for instance, be green, but the display reveals that the rate will be more expensive in 35 minutes and the traffic light will switch to red. So I could turn on my appliances now but would, however, have to trade off against a more expensive rate after 35 minutes. On the Stromampel.com website that I programmed, you can read on the Internet what the participants in the MeRegio field trial are seeing on their electricity traffic light.

What advantages and disadvantages have you discovered for yourself through participation in the MeRegio field trial?

The advantage is that I can now take a close look at and analyse my electricity consumption. This enables me to refrain from various activities, consistently remove electrical appliances from the grid and identify power guzzlers. Through MeRegio, I save money simply by shifting the consumption of household appliances that do not necessarily have to be running at particular times. On balance, this can make for savings of some EUR 43 a month. In annual terms, this amounts to a saving of some EUR 160 a year through participation in MeRegio. Thanks to MeRegio, rates are now available that are no longer rigidly tied to times. In the past, rates only went down between 6 p.m. and 8 a.m. Through constantly changing rates, the consumer pays more attention and is more aware of the use of power guzzlers in the household. If I still had smart devices now, I could, for example, automatically integrate my deep freezer or the charging station for my electric vehicle in the system and certainly achieve even larger economies. The disadvantage is that electricity in the green zone is often not available until 10 p.m. When you are not at home or already in bed, it is course difficult to switch on the appliances. That is why it is important to work on expanding a smart home appliance infrastructure so that the equipment can then switch on automatically.

Saving energy with consumption information

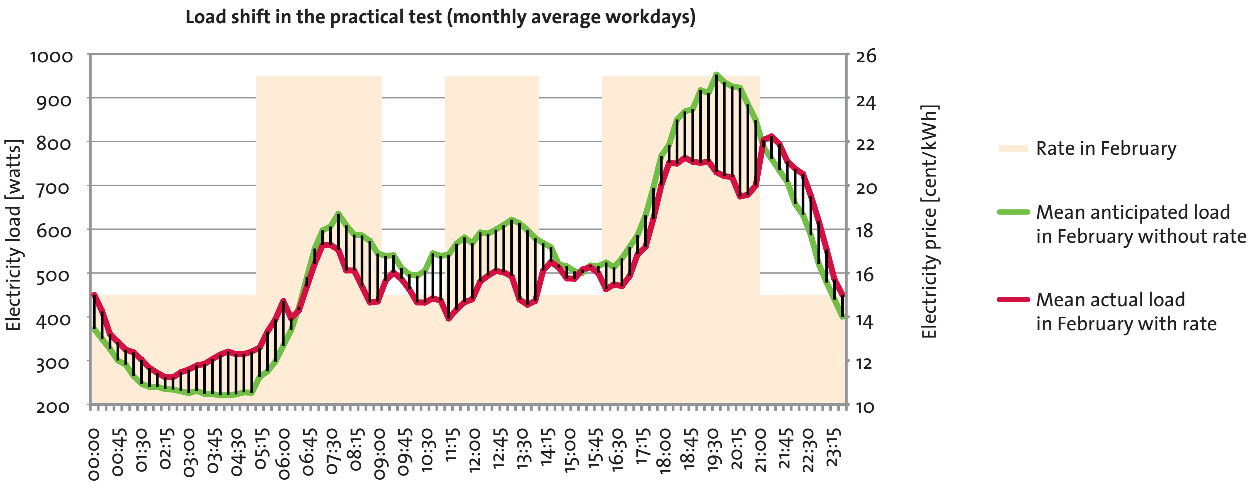
It is Friday afternoon in a single-family house with an additional flat in Burtscheid, Aachen. Barbara Blum and her companion, Yorck Abicht, give an account of what has changed for them since they started to take part in the pilot trial. Shifting their power consumption to the evening hours and the weekend has been worth-while: From 9 p.m. to 6 a.m. as well as at the weekend, they pay four cents less for their electricity than on week days.

"I have been trying since to wash the laundry whenever possible in the cheap hours," says Barbara Blum, "which is also easy to do as a rule." The dishwasher now runs more often in the evening and at the weekend. This saves money: Monthly costs of electricity have declined. The invoice is now easier to read as well: "I can now make much more sense of the monthly statement than the previous annual bill. You can easily remember four weeks and then know why the consumption was a bit higher or lower than usual," she explains.

In an initial pilot trial, the customers were supplied with two individually selectable modern products to determine their readiness and the potential for reducing and shifting energy. An attractively designed and user-friendly, individually protected online portal functioned as the feedback medium. For this, electronically read meter data of up to a quarter of an hour were transmitted via data interface and GPRS to the STAWAG energy utility database. The pilot customers could then request their data on the Internet optionally as daily, weekly, monthly or annual statements and in different formats. They were closely supported by the customer advisers. It was found that the impact of rate incentives depended on duration of membership in the field trial. The trial was therefore able to verify a learning effect.

In the second pilot phase, the customers were given the Smart Watts system for the iPad. In a simple and attractive format, the issue of energy is integrated into the everyday life of customers without loss of comfort. With the Smart Watts app., the customers receive detailed information on their electricity consumption and can use modern applications, for example, individually adjusting a price threshold per kilowatt hour in the dynamic pricing scheme. Here, with the support of smart power sockets large home appliances only switch on if the current price of electricity is below the pre-selected price threshold. The price signals sent are calculated with artificial intelligence based on neural networks.

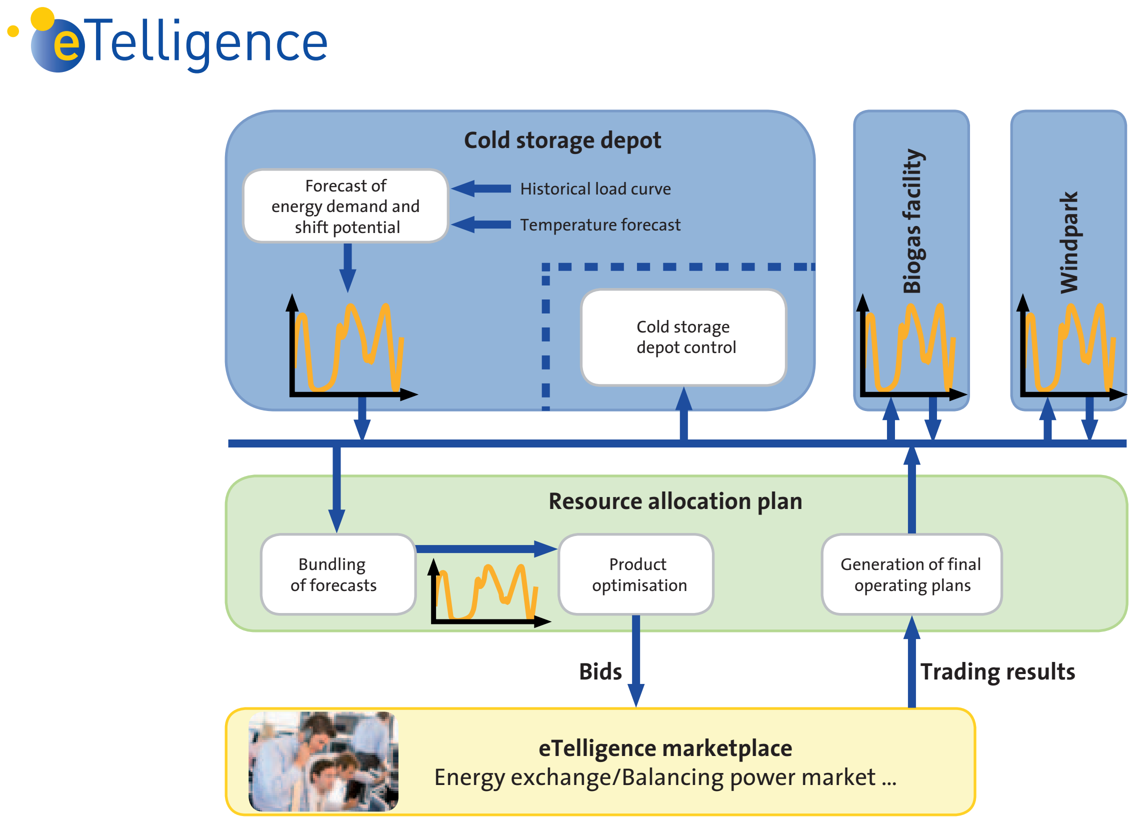
Load shifting through variable rates



The second field trial in the model city of Mannheim showed that the consumers on average shift the electricity consumption of appliances connected to load management to low-rate periods. The evaluation chart reveals that the real consumption (red line) in high-rate periods – above all at the peak period in the early evening – keeps below forecast consumption (green line) and usually above in low-rate periods.

More efficient electricity use is not the only way of progressing towards a power supply system largely based on renewable energies. The better consumers adjust to production volatility the easier it is to integrate renewables into the supply system. To stabilise distribution grids, this can sometimes also require that more electricity is consumed in the short term, for example, if more solar power is produced than forecast. In E-Energy, the related flexibilities of more than 5,000 households and numerous enterprises are examined. As has already been determined, 5 to 10 per cent of electricity consumption in households can be influenced over time. This figure may seem small, especially as the test households are predominantly interested single-family home owners and do not thus correspond to the average household. Nevertheless, this can make a major contribution to enabling distributor grid operators to reduce a local critical power load. Considerable efforts need to be made to raise this potential. Special scaled rates and marketing instruments were developed in the pilot projects to motivate consumers to ease the burden on the grid via market signals (on this, see p. 17).

Virtual power station in Cuxhaven



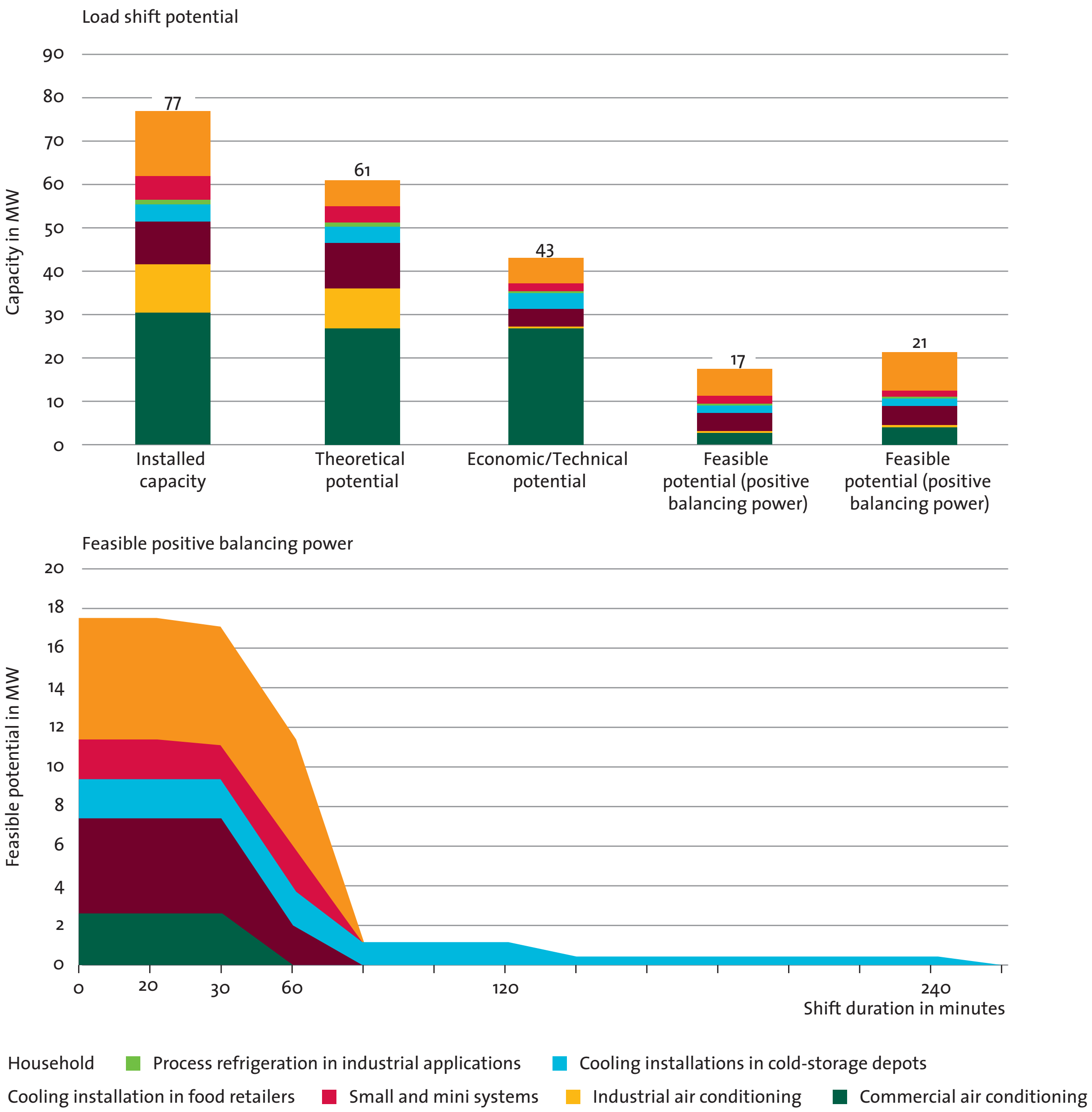
eTelligence aims at the local balance of windpower generation and consumption in large refrigeration installations. Modules are used here to connect commercial and industrial power consumers to a virtual power station. This optimises the supply and consumption of the connected plants and enables purchase and sale on the eTelligence marketplace.

In enterprises and large municipal energy consumers, load management today is in many cases technically and commercially feasible. The best example is provided by the model region of Cuxhaven, where in the eTelligence project the refrigeration assemblies of large cold-storage depots adapt automatically to the windpower generated in the region. Here, the large cold storage capacities of cold-storage depots are used in a power balancing group to cope with the fluctuating off-forecast production of windpower. In addition to eTelligence, moma and MeRegio also looked into the buffering scope and the resultant capacities of cooling systems to provide balancing energy. They depend on the type of refrigeration plant and the area of application. Currently, an average 25 % of installed refrigeration capacities can be expected to provide positive or negative balancing energy, only a maximum of 10 % of which for buffering over several hours or days, however. An exception are the large cold-storage depots, where the eTelligence field trial revealed a much higher shift potential.

In interaction with the transmission grids and the related mechanisms for providing balancing power, most distribution grids can deal in the short term with the current additional decentralised power capacity, but there are already indications of bottlenecks in some regions so that considerable expansion and conversion needs in the distribution grids can be expected in the medium and long term. What exactly will be required depends heavily on the existing grid topology, the anticipated in-feed and the flexibility of the production and consumer systems.

Refrigerators and freezer cabinets as buffers

moma



The moma pilot project has sounded out the potential of cooling installations in the private and commercial sector. The outcome: Unlike with the other facilities, in home appliances and small and mini units almost the entire theoretical capacity can actually be shifted forwards or backwards. As the figure below indicates, for about 30 minutes almost 20% of installed capacity can be used as positive balancing power through switch-off or delayed switch-on. Larger refrigeration plants can shift their consumption over longer periods (in this case up to 4 hours).

Flexible, controllable storage devices

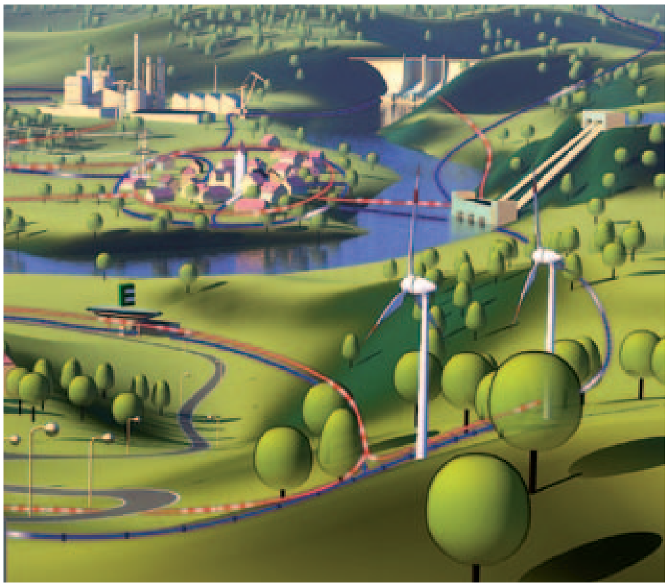
The tests with the cold-storage depots have led to a major finding: Despite good forecasts and influence on loads in real time, a 100-per cent spatial and temporal balance of production and consumption is not possible. The future energy system will therefore need more storage capacity than today. One technology alone will not be enough, as it must perform buffering functions between a few seconds and many days or even weeks. Even though a small addition to capacity can be expected in pump storage and also intelligent charging management in electric mobility, the expansion of these storage systems will not be able to keep up with the rapidly growing balancing needs for renewable energies. The storage technologies to be developed and particularly their costs will play a large role here. In the ICT-controlled combined energy networks, heating grids that use waste heat from power/heat cogeneration and gas grids (Power2Gas) could increasingly contribute their flexibilities in future.

Good forecasting for smart grids

The more we know about when and how much electricity is generated from renewable sources, the better it can be integrated into the grid. This is why forecasting systems play an important role in the smart supply system. They enable the timely provision of generating capacities (e. g. biogas facilities) or the early initiation of consumption adjustment (e. g. more cooling on reserve). With a suitable mix and use of all technologies already available today both on the production and the consumption side and in terms of hardware and software, short-term adjustment would seem feasible, at least within a region. This would relieve the distribution grids, reduce expansion needs and increase regional value added. This calls for considerable efforts in energy technology and above all in information and communications technology, but as the results of the simulations in the RegModHarz project indicate, the effort will be worthwhile.

Simulating 2020 in a village in Allgäu

Associated to E-Energy, the project Integration of Renewable Energy and Electric Vehicles (IRENE) follows up on findings to date and with support from the Federal Economics Ministry examines how many and which storage facilities are needed and what role electric vehicles play. By means of innovative ICT at many points in the grid, the relevant parameters are measured and a decision taken based on this whether mobile storage devices or a stationary device should be charged or discharged or whether it would be better to switch decentralised producers on or off. The pilot municipality of Wildpoldsried was therefore selected because the production mix of renewable energies and the stock of electric vehicles there already correspond today to the current forecasts for the whole of Germany for 2020.



In many cases, using electricity near where it is produced can raise the efficiency of the whole system. The ICT solutions developed in E-Energy can help to ensure that decentrally produced power is also increasingly consumed locally, which will ease the burden on the grid.

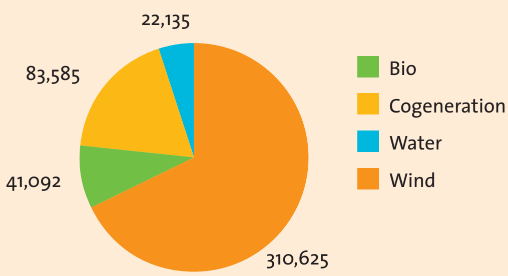
Finally, the question remains of whether the ICT applied in the Internet of Energy does not incur more losses through its own power consumption than it helps to save. This was also examined in the E-Energy Programme. While in its field trial moma ascertained low additional consumption, especially in small households, MeRegio and Smart Watts could not identify any significant additional consumption since installation of ICT.

A whole region as a virtual power station

REGMODHARZ
Regenerative Modellregion Harz

The administrative district of Harz has a high potential for renewable energy use. Thirty per cent of the requisite energy in Harz is already now in-fed there, with windpower the dominant form of generation: About 2/3 of the energy generated today is from windparks. Windpower also affords the largest potential in future but photovoltaic installations can be expanded as well. Federal state and local authorities play a pivotal role in expanding renewables, particularly windpower.

Annual energy generated in 2008 (MWh)
Renewable energy facilities in Harz administrative district



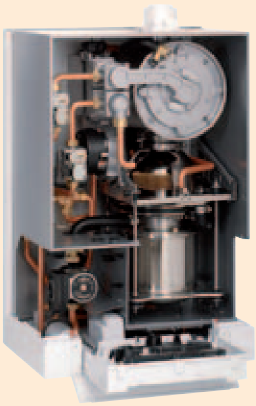
In future energy supply with a very high percentage of renewables, rural regions such as the Harz administrative district will play a special role. Due to the high potential available for renewable energy use and simultaneous low local consumption, surpluses are produced that are then transported via the power grid to conurbations, for example. Electricity surpluses are already exported today from the administrative district. To be able to plan this energy management, all components are matched up with the help of precise forecasts.

E-ENERGY FINDINGS:

- Savings potential is available in the commercial sector of up to 20 %, in the private sector, of 5 % to max. 10 %.
- In the private sector, a load shifting potential of up to 10 % is available (above all with heat pumps and air conditioners, on a smaller scale dishwashers, dryers, washing machines). Considerable educational work is needed to raise this potential.
- The load shifting potential is very high in the commercial sector and in part already economically attractive today. Due to the necessary adjustments in the production process, it can, however, frequently only be raised with intensive advisory services.
- ICT control of flexible generation plants (controllable inverters, current-regulated use of cogeneration stations) and localised purchase of reactive power can support grid stabilisation.
- The intelligent use of conventional storage devices (pump storage, batteries) affords scope for short-term load balancing in a balancing pool. For long-term buffering, other storage technologies need to be used (e.g. production of hydrogen or methane and storage in the gas grid).

Prosumers as an integral part of future supply

E DeMa



Block-type thermal power stations and ICT Gateway II

As part of E-DeMa in Mülheim and Krefeld, 14 micro CHPs (combined heat and power) are being intelligently integrated into the distribution grid. Power consumers thus function as producers at the same time. The term used at E-DeMa is 'prosumers'. To control prosumer units, it uses the so-called ICT Gateway II.

The E-DeMa marketplace enables prosumers to assess their consumption and costs at any time and switch to a cheaper rate. It also facilitates the best placement of electric power from these CHP stations on the market. This gives rise to completely new business models. Now, the electricity customer – represented by an agent or aggregator, as he cannot participate on the market himself as a rule – can offer his own generated electricity or his flexible consumption on the marketplace

Secure and adaptable supply system

Before the expansion of decentralised renewable energies, there was hardly any need for control mechanisms in the low-voltage range and little need for digital telemetrics and remote-controllers. With few exceptions (e.g. load monitors in industrial plants), electric loads were hardly included at all in controlling the overall system in the low-voltage range. 80% of largely decentrally generated electricity will be in-fed in future into the distribution grids, so that voltage maintenance and load matching for bottlenecks must be forecastable, localisable and controllable at grid nodes. This task can also become more difficult, if a large number of new power consumers enter the system, such as electric vehicles or heat pumps.

Smart measurement and control technology in the grid and at the grid margin

A major goal of E-Energy and all pilot projects is to help maintain supply security with increasing decentralised in-feed using intelligent measurement and control technology. The E-Energy model regions are developing and testing the necessary sensors (e.g. phasor-measurement units or smart meters) and analytical and forecasting tools for this. They also deploy actors (energy managers, control boxes, gateways, etc.) for production and consumption management. With these, they can intervene as soon as voltage range deviations occur or there is a danger of grid congestion. As far as possible, these interventions are made via timed and localised market incentives. Contractually pre-agreed switch-off and switch-on commands are only sent via special signals if there is urgent need for action (see page 14). This kind of smart grid control can reduce or delay distribution grid expansion, whose scale has not yet been quantified in detail.

ICT applications enable better control of the increasingly complex energy grid. Extreme situations, such as grid bottlenecks, can be better foreseen and dealt with in future. The risks entailed in using ICT should not, however, be underestimated. Computers can fail and must be protected against unauthorised access. This is why security aspects were also considered in all model regions and appropriate solutions developed and implemented in the field trials, at least in part (see p. 34). It was found that improving spatial and temporal forecasting accuracy for production and consumption contributes greatly to long-term supply security.

Increasing ratios of volatile power generation from renewables place heavier flexibility demands on the other components in the energy system. These fluctuations must be offset by means of controllable production and consumption, distribution and storage and their interaction and reliable power supply has to be maintained. The principle of subsidiary adjustment is essential for grid load reduction and the related scope for savings in the transport infrastructure. The load reduction measure for this must be carried out by controlling smart prosumers at the actual critical grid point. This requires grid node-based forecasting and localisation and localised intervention in the corresponding subgrid. Caution is needed where autonomous grid agents act separately. Their interventions via control signals can have countervailing effects or lead to so-called rebound effects. In MeRegio, these states were simulated and suitable control mechanisms examined more closely.

Cellular system instead of central grid management

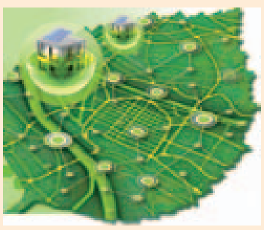
In keeping with the principle of security by design, the model regions, such as moma, consistently design their system architecture decentrally, modelled on nature, imitating the structures of trees, branches, leaves and their cells. The strategy of a cellular system as a substitute for central grid management and control gives precedence to self-controlling structures that are still connected via a transmission grid and a central grid management. Physical energy exchange between the grid and the cells is kept to a minimum. As the cells act autonomously as far as possible, transmission losses are also accordingly lower. These systems are less vulnerable to errors spreading in the overall system (so-called resilience). In this strategy, individual cells can be fully decoupled when needed and operated autonomously until all elements of the whole system are fully functional again. A special feature is the cold start-up ability. This is needed if a part of the power supply system fails because control computers are out of operation, e. g. due to an electromagnetic pulse. These in turn cannot be re-started without power. The pilot projects have in part shown how this kind of situation can be avoided and rectified through redundant power supply and emergency power systems. Other architecture considerations tend towards a distributed intelligence, where the (small) ICT units in the overall system, such as energy butlers or grid agents in the case of moma, can jointly restabilise the system. Other approaches take advantage of the ability of smart inverters to obtain electricity themselves from their generators if the power grid cannot provide sufficient voltage.

Decentralised systems for the provision of system services

Of increasing importance is not just the question of the quantity but also the quality of the renewable electricity generated. In interaction with and in the transition from conventional to renewable power generation, the new energy systems must not just contribute to power supply security but also participate in the provision of so-called system

Cellular system in Mannheim

moma



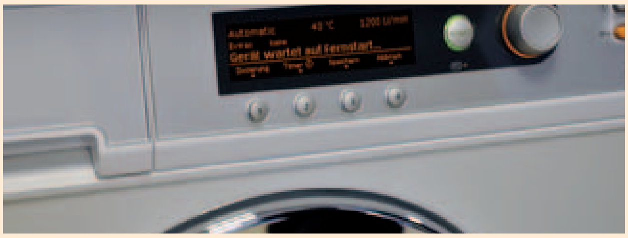
In moma, every building with a main connection constitutes an object cell. Approx. 200 object cells are grouped into a distribution grid cell, which comprises agents for grid and market support.

The approx. 300 distribution grid cells of the pilot city of Mannheim make up the components of a system cell. For overall grid management, a CORE platform for integration connects the grid cells with the grid control station and with the transmission grid. The CORE platform also connects the local market mechanisms via the energy market in the system cell with the primary energy markets. Communication in and between the cells is IP-based via broadband powerline.

The system is modelled on nature. The idea is to divide up the components of the energy system in autonomous cells so that the outage of one cell or component does not immediately affect the overall system.

Houses as autonomous cells

MeRegio



In their field trials, MeRegio and the sister project, MeregioMobil, show how all the elements of a smart, low-energy home can be interconnected - from the PV module on the roof and the micro block-type thermal power station in the cellar to the controlled household appliances and the electric vehicle whose battery can be used as a buffer for electricity. This way, a house can supply itself completely with power for a certain time when necessary.

A pilot house at the Karlsruhe Institute for Technology (KIT) is actually occupied. The prefabricated house with an area of about 80 square metres is a prototype for the future energy-efficient household that incorporates electric vehicles as storage batteries and home appliances in the smart household control. Equipped with the typical elements, producers, consumers and energy storage devices, the residents of the smart home can test the model for the low-energy household of tomorrow.

In interaction with various meters and display systems, a control box is responsible for the overall management of the house and connection to the grid.

services. Modern inverters permit of very diverse methods of in-feeding into the grid to accurately target the requisite phases of alternating current. They do not just generate active power but can also compensate reactive power as a major condition for stable overall operation of a supply system with a large number of highly volatile producers and consumers. Some model regions (e.g. moma) are still looking into whether this can provide an economic solution. At present, the costs for this kind of solution are 45 % higher than the conventional method of reactive-power compensation. The picture is different, for example, if compensation is demanded exactly at the time of maximum inverter output. These modern inverters can only be used to full effect if they are interconnected in the Internet of Energy and are instructed accordingly to provide power at exactly the right place and time.

By pooling different power producers, storers and flexible consumers in virtual power systems, some model regions have effectively reduced the so-called residual load, that is, the remaining energy demand beyond the power generated by renewables. The simulations in RegModHarz have shown that this is possible above all if controllable renewable energies, such as biogas facilities, feed in as needed. Supply must, however, be secured at all times, which poses new challenges for the balancing energy system with a growing number of small producers and incalculable consumers (such as charging stations for electric vehicles).

Balancing energy on electronic marketplaces

The model regions have implemented the basic technology for virtual marketplaces to make increasing future demand for flexible energy services transparent (active and reactive power, regulated production and adaptable consumption) and where they can be traded locally and among regions. Day-ahead trade has been largely tested or simulated so far. The provision of short-term balancing inputs presently ranges in the minute reserve segment. The marketing of primary and secondary balancing energy is presently (still) hampered technically by missing real-time interaction capability in controlling decentralised systems and lack of experience in the reliability of rate-based demand-side management. More

E-ENERGY FINDINGS:

- The integration of decentralised, small producers will be feasible in future with ICT without endangering grid stability and with less extensive grid expansion.
- Sensors are needed both in the grid and at the grid margin (that is, for producers and consumers). Actors are needed both to control production and also regulate consumption.
- Improved production and consumption forecasting is possible and will enhance supply security.
- To a certain extent, renewable energy systems can deliver system services (balancing power, reactive current compensation, etc.). The legal framework, however, affords little scope for efficiency.
- Cellular approaches can support high supply security.
- Supply and demand can be balanced with more ICT at balancing group level. The transportation of high windpower surpluses remains a problem at transmission grid level. Depending on local grid state, the most cost-effective variant (smart grid ICT in the grid or at the grid margin, storage or transport) needs to be optimised.

barriers are the existing market regulations, the prequalification requirements for the balancing power market and accounting guidelines, and the costs of maintaining capacity, so that the requirements for providing highly flexible balancing energy for the time being will still have to be increasingly met by conventional power station capacity. In the E-Energy regions, the feasible flexibilities at distribution grid level are therefore mainly used for balancing within the respective balancing groups and not transferred up to the transmission grid level.

New products, marketplaces and market participants

Electricity cannot change colour, but the times are now past when one kilowatt hour was the same as another. If there is a power surplus, the kilowatt hour will be cheaper than in periods of shortage. If, however, all consumers switch on their equipment or even charge their storage devices during cheap supply, this would overload the grids. A surcharge would then have to be added to the kilowatt hour for the grid load. This means that pricing must be geared to several factors and above all must respond quickly to changes. This will only be possible, if the adjustment is based on largely automated, electronic market platforms as developed and tested by the E-Energy pilot projects.

Incentives through rate scales

Future power supply will require innovative scaled rates, not just because this is required by law but above all because it can create incentives to adjust consumption to production. The E-Energy model regions are experimenting with various rating schemes. As Table 1 shows, four types of rates can be distinguished. Common to all of them is that electricity costs more or less during certain intervals than in others. While in the time-variable rate both the intervals and also the various prices charged are fixed and communicated long in advance, in the dynamic rate, both the time intervals and also the price per kilowatt hour can change depending on availability of electricity or grid load. This is why the term real time pricing (RTP) is used for the latter. As a rule, the intervals and the price scales in the dynamic rate are set and communicated one day in advance. The consumption-based rate is also made up of different price scales. The higher

Table 1: E-Energy rates

	Structure	Objective	Getestet bei
Time-variable rate	Energy price for individual rate phases determined by day, week and month and set for a specific interval (monthly, weekly, etc.). Rate phase spreads in E-Energy between 10 and 60 cent/kWh	Time shift of load can result in: ❱ Avoidance of load peaks or consumption troughs ❱ Possible improvement of basic load	*E-DeMa* *eTelligence* *MeRegio* *moma* *Smart Watts*
Consumption-based rate	Depending on amount, power consumption is invoiced at different rate scales: The higher the energy consumption in a month, for example, the more expensive the kilowatt hour.	❱ Energy savings ❱ Load reduction	*E-DeMa* *eTelligence*
Dynamic rate	The energy price is based on external variables (exchange price, forecasts, residual load, grid load, etc.). Time intervals and the prices charged are set a day in advance, for example.	Near-time and flexible load shifts in response to specific situations can balance production and consumption.	*E-DeMa* *MeRegio* *moma* *RegModHarz* *Smart Watts*
Event rate	Extension of the time-variable rate: For the pre-notified time interval, extremely high or low prices per kilowatt hour are charged in response to external events	Avoidance of load peaks and troughs at critical times	*E-DeMa* *eTelligence* *MeRegio*

the total consumption, e.g. in a month, the more expensive is each kilowatt hour consumed in that month.

While time-variable, dynamic and event rates are suitable above all for influencing the load curve (e.g. cutting peak loads), a consumption-based rate can itself encourage energy savings. However, consumption based rates were difficult to convey to the customer and Smart Watts had to abandon this trial. An appraisal of the eTelligence field trials, however, showed that these rates in particular provide an incentive for saving. The final results on this from the ongoing field trials in E-DeMa and eTelligence are therefore being awaited with keen anticipation.

All pilot projects first experimented with simple time-variable rates. In the ongoing large-scale field trials, complex dynamic rate constructions have been added. The two differ distinctly in terms of handling and their ICT requirements.

- In a time-variable rate, there is continuity in rate scales and their distribution. They are very similar to the already familiar high/low rates and consumers only need to remember a few times for switching between the rate scales. With relatively simple feedback systems (see Table 2), the customers obtain transparent information about their current consumption and therefore gain control over costs. As the (few) high-price and low-price intervals are easy to remember, appliances can be switched on manually at the right time to cut costs.

- The complexity of most rates precludes a manual response to price incentives. This task is performed by energy management systems, e.g. energy butlers (moma), control boxes (MeRegio), ICT gateways (E DeMa), bidirectional energy management interfaces – BEMI (RegModHarz), multiboxes (eTelligence.) and/or smart power sockets and terminals (Smart Watts). They all receive price signals or can request the current price before switching on an appliance via standardised interfaces.

They can be programmed to take account of the requirements of the supply system depicted through prices but also of the needs of the consumers in private households and enterprises.

In E-DeMa and eTelligence there are bonus and penalty events. In certain exceptional situations, the price for defined periods is lowered or raised to an extreme. This relies on the market-conform behaviour of consumers to help rectify the imbalance by shifting their consumption. In its field trial in the Freiamt supply area, MeRegio was able to impressively demonstrate that these market mechanisms provide an effective means of optimising grid operation.

The pilot projects were able to demonstrate the technical feasibility of innovative pricing schemes. There are, however, still limits to the scope for setting attractive rates. Fixed grid charges in particular pose a constraint. The MeRegio and Smart Watts pilot projects have, though, been able to show that a significant number of end consumers already changed their behaviour at low spreads of only 6.5 cents (MeRegio) and/or 4.2 cents (Smart Watts) between high-price and low-price periods and with attractive, user-friendly feedback through electricity traffic lights. In the two pre-pilot phases, clear load shifts into the low-price zones were recorded. Interaction with the system also raised awareness among customers and energy savings could be made of between 3 and 5 per cent.

New market functions

Due to the changed legal position, two new market roles have already emerged: the metering point operator and the metering service provider. Whether the Internet of Energy will also engender other market roles remains to be seen. The incorporation of renewable energies or the trade-off between market and grid interests will, however, probably require other (new) market functions with the business goal of optimisation for the benefit of the overall system. The electronic marketplaces of the Internet of Energy will not just trade electricity. Flexibility in scheduling consumption represents a good in itself and will increasingly come to be treated as a commodity. There may be a need for a separate function to manage and reward flexibility on the consumption side. The smart grid could also require ICT infrastructure operators.

New services

Also completely new services, such as managing and servicing an overall household energy system for taking full advantage of rates differentials, will be provided on the energy marketplace of the future. Households that not only have consumers but also flexible production systems (e.g. micro block-type thermal power stations) and possibly also storage devices will benefit most. A popular service among consumers is efficiency advice based on (voluntarily) disclosed consumption data or the identification of power guzzlers in households. Also successful has been the application of the co2online advisory tool in eTelligence and the online consultations for households and commercial enterprises in moma and MeRegio. The new marketplaces will also be able to provide specific regional or ecological electricity products for which there has so far been no market or means of labelling. Above all, Smart Watts has set itself the task of explaining the smart kilowatt hour to the consumer with precise information, for example, on composition and origin. Other model regions also attach importance to providing consumers with detailed information in future, so that they can take more informed decisions and act more independently.

Table 2: E-Energy feedback mechanisms

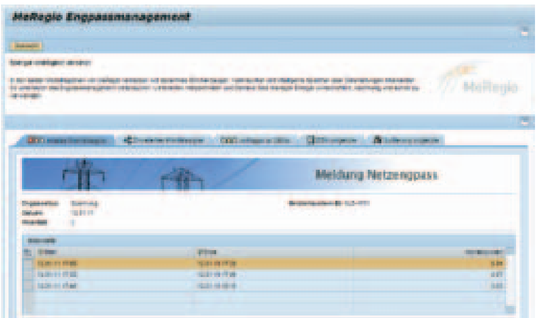
	E-DeMa	eTelligence	MeRegio	moma	RegModHarz	Smart Watts
Online portal	X	X	X	X	X	
iPod/iPad/Smart phone	X	X	X			X
Hard copy		X	X	X		X
Own display (e.g. electricity traffic light)	X		X			
Gateway/Energy manager display, etc.				X	X	(X)

Grid stability through automated negotiation with consumers

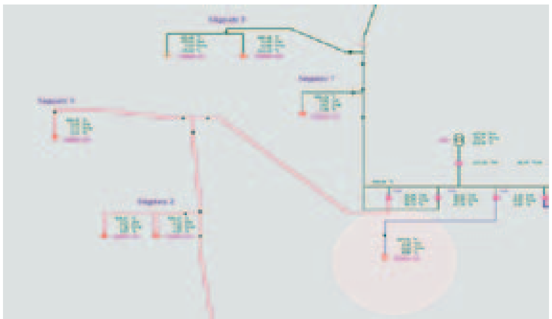
1. Voltage problem has been identified

2. Negotiating process starts

3. Offers are solicited and accepted



4. Voltage problem is rectified



The field trial successfully demonstrated that production fluctuations can be offset by automated, market-based demand-side management.

New market participants

The deregulation of the energy sector is well advanced. Monopolistic supply structures are a thing of the past. The more than 900 grid operators and power producers in Germany already make for a diverse landscape in energy supply, but there are now about 300,000 small and mini power generators in private hands. As these facilities become economically viable, the number of market participants will continue to increase substantially. All this will lead to changes on the energy market and above all in energy services.

> "By applying smart meters for smart home solutions combined with creating storage facilities, e.g. through transformation into other forms of energy and the time-variable or load-based rate products and energy advisory services, the small-scale energy user can also monitor his energy consumption more transparently and shift it."
>
> FROM THE BDEW DISCUSSION PAPER: SMART GRIDS – AUF DEM WEG ZU EINEM ZUKUNFTSFÄHIGEN MARKT- UND REGULIERUNGSDESIGN (SMART GRIDS – TOWARDS VIABLE FUTURE MARKET AND REGULATION DESIGN)

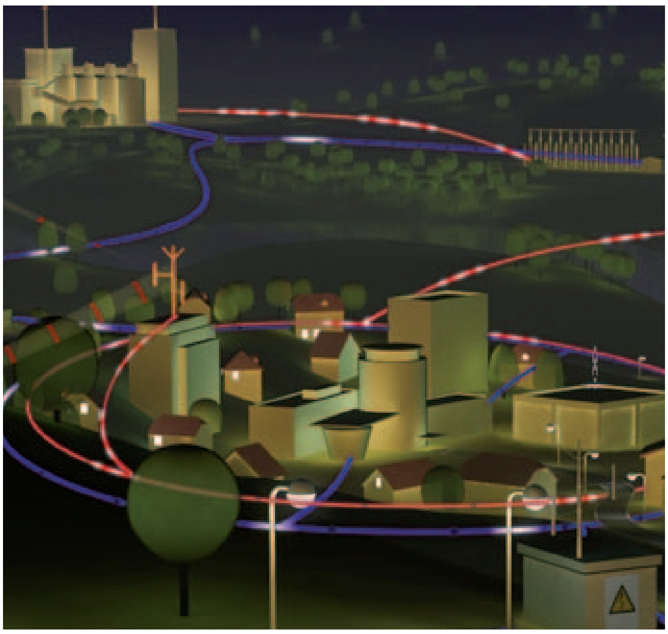
Most of the E-Energy model regions do not expect that all consumers and producers will engage on the future electronic marketplaces themselves. Instead, a new market function will come into play with bundling and optimisation tasks to be performed by different market players. These aggregators, demand-side managers or pool managers will enter into contracts with a (larger) number of small producers and flexible consumers, bundle their output and offer it as an optimum product to grid operators, electricity traders or power exchanges. These activities will need to be supported by ICT platforms to ensure that the requisite data and services are provided in secure form in keeping with market roles.

Optimising existing business operations

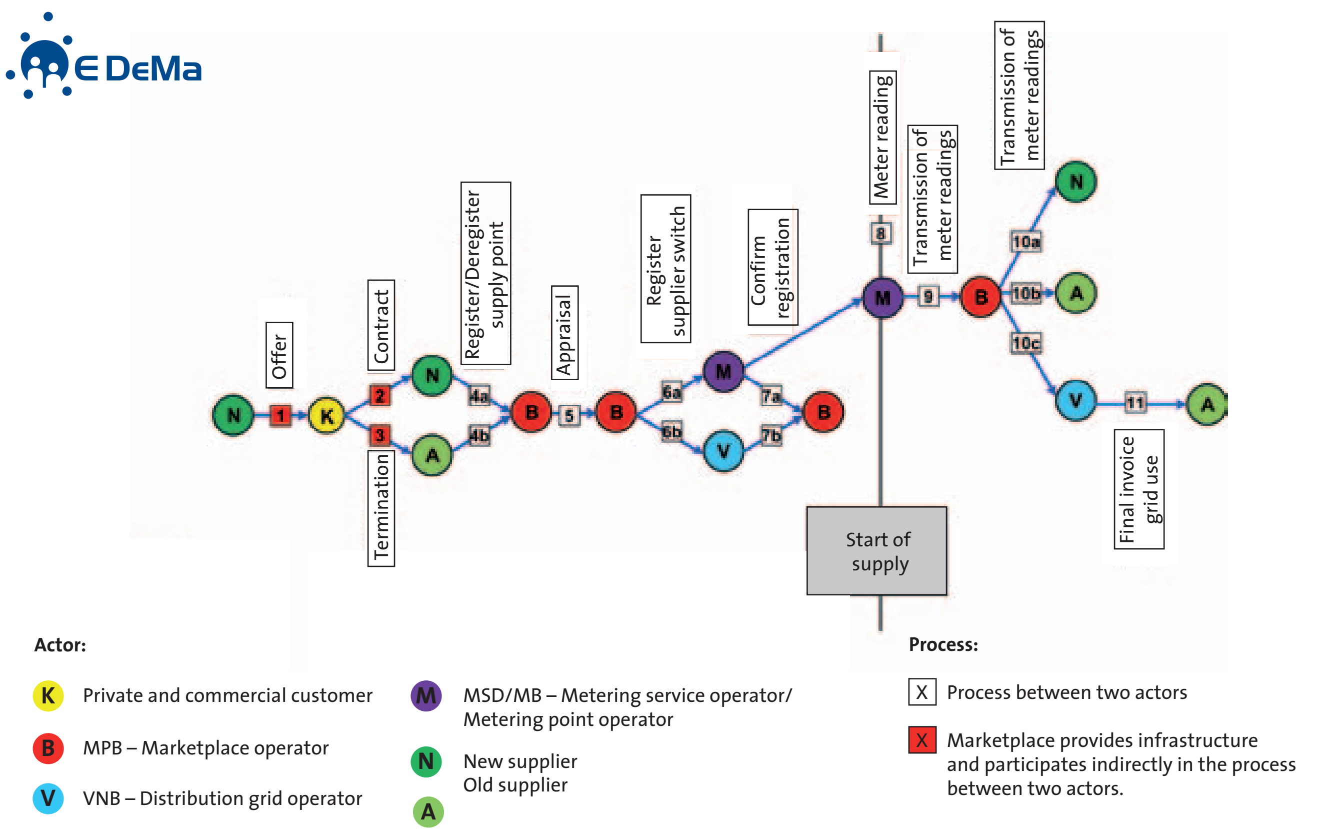
For all this, we must not forget that established market processes and participants will also remain in place. In part, today's power suppliers and grid operators will take on new tasks and in part they will optimise their business operations for greater cost-effectiveness. Depending on the regulatory framework, grid operators can meet their own needs in an active role or remain in a serving position. Their role so far would propose that they will engage in regional capacity management and participate with localisable market signals, which will then be combined with aggregators' signals via a market process.

Education for smart energy

To be able to meet the new requirements, changes in the educational facilities are also needed. More than in the past, ICT system developers will have to address the rapidly changing energy market. Their greatest challenges will be secure data management systems and service platforms in compliance with data protection provisions. New occupational profiles will also emerge at the interface between energy and information technologies. Of particular importance here is therefore mainstreaming the issue in the scientific and training community. In the project promoted by the Federal Economics Ministry, Media-based Learning and Collaboration Services for Electromobility (MEMO), experts develop material for multi-media basic and advanced training of craftsmen based on the grid integration of electric vehicles. The experience gained can be transferred to other fields in energy supply. Guided by action research and actively supported by the model regions, young scientists at the Centre for Digital Technology & Management (CDTM) of the Ludwig-Maximilian and Munich Technical Universities have developed far-reaching scenarios and business models. A separate E-Energy research priority has now been established there.



Rapid change of suppliers



The electronic E-DeMa marketplace enables the full switch of supplier in a few days, usually before the start of delivery by the new supplier at the beginning of the month. The previous procedures in contrast lasted several weeks.

E-ENERGY FINDINGS:

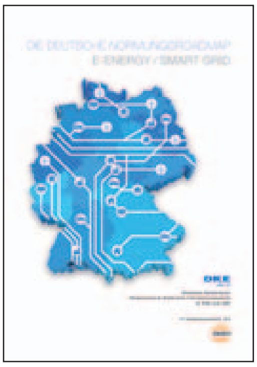
- Through E-Energy technologies established market participants can optimise their previous business operations.
- Time-variable, dynamic rates could be implemented in the pilot projects and brought about changes in consumer behaviour.
- Clear behavioural changes are recorded in the initial phase; sustainable changes are usually only possible with automated systems.
- Through automated, market-based negotiating systems, grid stability can be maintained, also with highly volatile in-feed.
- Marketing flexibilities in primary and secondary reserves is not (yet) possible, but E-Energy controlled systems can deliver near-time balancing energy (to compensate forecasting errors).
- E-Energy controlled systems can deliver system services (voltage maintenance, frequency maintenance, reactive current compensation) for grid management, particularly in the distribution grid.
- Besides dynamic electricity prices to reward load transfers, other services can also be provided on the electronic market-places, such as managing energy systems or continuous efficiency advice.
- There will be at least one new market function on the energy marketplace: Flexibility Operators will ensure non-discriminatory market access for small suppliers as well and bundle their energy outputs and flexibilities into marketable units for grid operation or electricity trading.
- E-Energy can integrate electrical and thermal storage devices for up to 1-2 days. The focus is on shift duration of a few hours.

TOWARDS THE INTERNET OF ENERGY

Standardisation

Anyone intending to play a decisive role on the world markets must set standards or at least actively contribute to standardisation. From the outset, one of the requirements of the state aid donor for the model regions in the promoted research and development tasks was to take account of the status of international standardisation and then to develop new or upgrade existing solutions. Accordingly, E-Energy pilot projects cooperate closely and exchange information regularly on solutions of general application in a working group.

E-Energy Expertise Centre to bundle strengths



An E-Energy Expertise Centre has been established in the German Commission for Electrical, Electronic & Information Technologies (DKE) that combines the E-Energy pilot projects with other approaches in Germany, Europe and worldwide. DKE has thus also underscored its role in the smart grids sector as a modern, public-benefit service organisation for the secure and efficient production, distribution and use of electricity in the public interest. The tasks the DKE Expertise Centre has set itself and the approaches to solving them are described in the booklet, German Standardisation Roadmap E-Energy/Smart Grid. The role of E-Energy is not merely stressed in the choice of title, but also in its many substantive influences for charting the course and the milestones towards smart energy supply – to the Smart Grid made in Germany. Currently, DKE and the members involved in the E-Energy Expertise Centre have taken on leading roles in developing a pan-European position for the smart grid and cooperate with other experts from all over Europe under the M/490 mandate of the EU Commission.

Data privacy and security

To operate, the Internet of Energy requires a good database. At all times, it needs to know how much and at what points in the grid energy is being produced and consumed and where possible combine this with a forecast for the next hours and days. The gigantic dataset generated requires the adequate technical management capacity and also legal regulations.

Sensitive handling of personal data

Smart meters can continuously deliver data on the consumption of private households and enterprises. The future smart grid will also need other sensors and measuring instruments (e.g. phasor-measurement units – PMU) that provide information on the grid state and overload risks. Data of private persons measured by smart meters is especially sensitive. To prevent any inferences being made on personal lifestyles, this data in the Internet of Energy is anonymised and aggregated, provided it is not needed for invoicing purposes with detailed itemisation. No more data is collected than is actually needed for billing and for monitoring the grid state. If it must be gathered, it is not stored for longer than necessary.

The E-Energy expert group on legal questions has thoroughly evaluated the relevant data protection issues. This group has published their comments and proposals on technical and legal data protection aspects in book form. Some of the suggestions have already been adopted in the amended German Energy Industry Act.

The Internet of Energy must not only protect people and their rightful interests. The whole system must be protected from intentional and unintentional harm. Only by assuring the high operational security of all systems and the integrity of data in the smart grid can the customary high standard of supply security be guaranteed. The relevant issues are generally summarised under the term data security. The E-Energy pilot projects are carrying out initial investigations on this. They have identified above all which research and development requirements still need to be met. Under no circumstances can unauthorised access be allowed to data and programmes in the smart grid and the meters and energy managers in households and enterprises, neither due to negligence and human error nor intentionally outside an agreed or legal framework. Conversely, the necessary protective mechanisms must not be allowed to hamper the development of useful applications and business models.

An operating system for the smart grid

OGEMA

moma

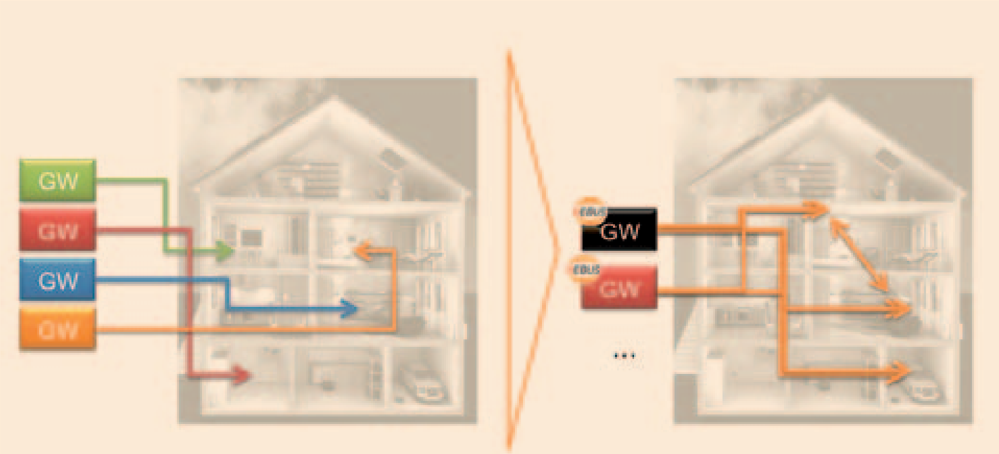
RegModHarz
Regenerative Modellregion Harz

The Open Gateway Energy Management Alliance (OGEMA) is developing an open software platform, sometimes called an operating system for energy management. OGEMA enables the integration of the most diverse communication systems (e.g. the EEBus for communication with household appliances). The OGEMA framework was developed by the Fraunhofer Institute IWES in Kassel. It is applied in the moma energy butler as well as in the BEMI of RegModHarz, where it has already laid the foundation now and in future to develop numerous applications for optimising power and heat supply.

Clear language from generation to consumption

Smart@Watts

EEBUS



Developed in Smart Watts, the EEBus is used for the non-proprietary control of home appliances as part of load management. It describes the use of existing communication standards to enable energy suppliers and households to exchange applications and services for greater comfort and efficiency.

EEBus proceeds from existing standards and upgrades them. A registered society has been founded in Germany to advance the further development, marketing and standardisation of the EEBus technology. Supported by the E-Energy Expertise Centre and E-Energy action research, the actors of EEBus and the KNX syndicate, which represents a now widespread standard in home and building systems, have founded an Alliance for Smart Energy Solutions. This joint initiative will set the global standard for connecting the smart home with the smart grid. EEBus is now under discussion in the IEC committees and has a good chance of achieving this objective.

Costs, benefits and acceptance of actors

The energy policy shift will not be for free. Only rough estimates have been made to date on the costs of the transition to secure power supply largely based on renewable energies. Investments in the new generating systems and the expansion and conversion of the transmission and distribution grids are estimated at EUR 500 billion, with the grids accounting for some 10 %. The technologies developed and tested in E-Energy will lay the foundation for the controlled integration of volatile power producers into the grid. All this will only be possible if industry and society are prepared to contribute their share.

Attractive services for commercial consumers

There is both considerable energy saving and load shifting potential in the commercial sector. With the policy requirement to establish energy management systems (DIN/EN 16001 and/or ISO 50001), energy-intensive enterprises are also increasingly focusing on strategic considerations. It will be increasingly interesting for many enterprises to produce power themselves, e.g. in small power and thermal cogeneration stations with controlled in-feed of any surpluses into the grid.

Initial experience gained in integrating commercial customers demonstrates that initial misgivings must be overcome towards interventions in operational procedures. Especially demand-side management for load transfer while marketing the resultant flexibility can be economically attractive for electricity customers, if the shiftable loads are large enough and direct load management in operations is acceptable. This is the case above all for cooling systems in the food retailing and catering trade. However, on appraisal of the actual development scope, the theoretical load shift potential may shrink to a fraction. For example, the moma cold storage study revealed that only about 10 per cent of installed cooling capacity is actually suitable. Based on potentials analysis, besides cold intensive enterprises, MeRegio selected above all plastics and metalworking firms for the field trial. Besides shift potential, the latter afford high potential reductions in power use and the attendant CO_2 emissions.

Unlike in households where a large degree of flexibility is usually afforded by time rates, concepts are also being developed in the commercial sector for the direct control of production and consumer systems. The pilot projects have gained initial findings for raising acceptance here:

- If rates scales are too complicated for the enterprises, transaction costs often become excessive and acceptance diminishes.
- Interventions in functional processes are expensive and lack of personnel capacities hardly allow for managing load transfer. Competent technical support through service packages can help here.
- Especially in cooling systems, control can shorten the storage life of food, give rise to complaints from employees or customers on poor air conditioning or disrupt of production in the industry. Liability issues therefore play a role both for plant operators and energy suppliers. Close cooperation among all stakeholders is essential to reduce these barriers.

In all cases, the implementation of load management schemes requires competent technical advice and the installation of automatic control systems, as developed and tested above all in eTelligence and MeRegio.

Difficulty in soliciting household customers

Private households have very diverse motives for participating in the field trials in the model regions. For most, however, the motivation is the expected cost saving, either through lower electricity consumption or through the intelligent use of time-variable rates. Present potential is distinctly limited here, though. Currently, private customers with average consumption (about 3500 kWh/year) can be expected to make annual economies of EUR 70 through cutting consumption by 2-3 per cent and the use of time-variable rates. If small block-type thermal power stations, electric vehicles and heat pumps are integrated, the economic advantage can be increased to above EUR 100, in ideal cases to EUR 500 a year. The economic effects of grid or purchase incentives for load shifts have not been quantified.

The reason why most households in the pilot projects reacted to the incentives (see p. 18) is also the selection of participants. For many consumers, it was important to make a contribution to environmental and climate protection or to get to know a new technology as a 'pioneer customer'. Altogether, the field trials clearly demonstrate that regional electricity products can allay customer misgivings. For greater acceptance of E-Energy technologies in the private domain, the following aspects are of chief importance:

Smart approach to smart-grid customers

- Long periods of absence from home make it difficult to make manual use of low-price times. After the novelty interest wanes, the readiness for manual switching also diminishes considerably. The installation of intelligent facilities, such as energy managers, to control the terminals autonomously based on price signals and knowledge of their operating states is indispensable.

- With progressive technologisation and automatic regulation of appliances, technically less proficient consumers often fear losing control over their household. Simple and easy use is a basic prerequisite for acceptance in the broad population. Also important is retaining the option of switching the appliances on and off by hand as usual.

- Technology will only find acceptance if it has been developed to an adequate standard of maturity and is secure and responsibilities are clearly regulated in the case of a fault. Here, it is up to manufacturers to develop solutions to improve security and comfort both for specific devices (protection against overheating, warning signals for faulty parts, etc.) and for system integration (smart-home approach).

- The integration of load management into rapidly developing home automation technologies affords good prospects for greater acceptance, as it will be bring benefits in efficiency and comfort as well as security, against burglary and theft, for example.

- Data protection is a very serious issue (on this, see p. 34). A survey of 1,321 residents of Germany as part of the EU Smart-A project shows, however, that an unexpectedly small percentage of customers appear to be concerned about this and that confidence in the respective power supplier is greater than expected. Nevertheless, the customers can and must be clearly informed of what data is encrypted where and who has access to it. In the projects implemented, no complete consumer profile need leave the house.

- Information from the energy industry and profit-seeking manufacturers is often seen as dubious. Customers take a sceptical view of new rates and their apparent benefits. The population should be informed about the functions and advantages of the smart grid as far as possible in collaboration with independent institutes and political agencies and consumer protection organisations. Energy saving tips and impartial consumer information build confidence and arouse interest.

- If customers have the impression that they are helping their town or their region, they are easier to motivate for the new services.

- Strategies for introducing E-Energy technologies must take into account the various needs and attitudes of consumers. Not all customers are the same. Roughly speaking, customers seeking emancipation and self-fulfilment and who are interested in technology can be reached in an initial round. Then, those that are aware of socio-economic issues and are generally interested in change can be targeted in a second phase. Communication and marketing need to be planned to meet the expectations of these groups.

Benefit for grid operators

The pilot projects have already demonstrated that the satisfaction of stochastic control needs in the distribution grid and in individual grid segment nodes is technically feasible through E-Energy technology. Further research is needed to ascertain how far this is possible and is the most cost-effective solution. Using the electronic market platforms developed in E-Energy, however, flexibility operators can provide the requisite services and offer the distribution grid operators guaranteed capacity flexibilities for compensation of decentralised peak in-feeds, for example. The necessary financial scope for these kinds of business model could be provided by flexibilising grid charges, either in the form of variable or separate charges, the latter being favoured by the Federal Network Agency.

One obstacle could prove to be the scheduling requirements for the regulatory system. The volatility of renewable energies must either be forecast very precisely, which is only possible on a limited scale, or producers and consumers must be controlled with high spatial and temporal resolution. As far as possible, this will be done via market signals, which must, however, be transmitted to all possible suppliers of suitable balancing options because of the non-discrimination requirement. The ensuing negotiations could take too long even on electronic marketplaces to take timely countermeasures against grid instability.

Good reasons for early action

For various reasons, innovative grid operators and electricity suppliers are looking at the E-Energy technologies in this context:

- In some regions, decentralised producers already pose grid operators with serious challenges. With the technologies now already available and with the experience gained from the E-Energy model regions, alternatives are available to conventional adjustments of grid infrastructure.
- In some areas, especially in supply to municipal and commercial enterprises, lucrative arrangements can already be made available to suppliers and customers.
- Especially when it comes to a municipal or regional supplier, private customers expect their electric utility to make effective and visible contributions to making the energy policy shift a success.

Considerable changes will occur in energy sector overall. In the unanimous assessment of the industry, the ICT-based smart grid and smart home applications above all will generate a gigantic market. New market roles could emerge and new players are entering the market. It is still unclear here how many of their services will be subject to regulation and which will be offered on the free market without prejudice to non-discriminatory access to smart infrastructure. Current market participants need to gain experience here and get involved in decision-making processes so as not be overtaken by the rapid developments. Besides the advantages for individual actors, there is also the economic issue of the benefit for the overall system: What costs and CO_2 emissions can be saved through smart, decentralised flexibility? Model calculations in eTelligence indicate that these savings will increase substantially in future with a larger ratio of volatile renewable energies.

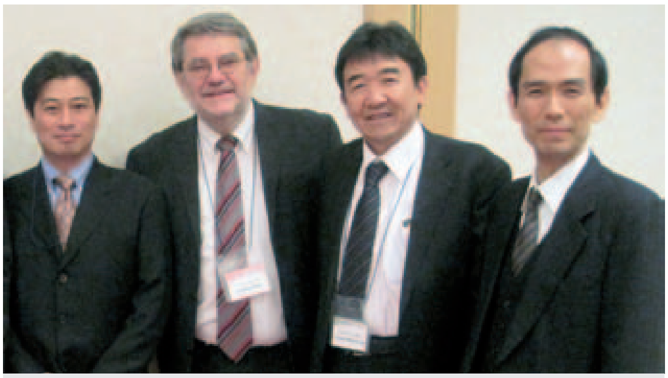
Germany is not alone in developing smart grids. Intensive efforts are being undertaken worldwide to make power supply more efficient and secure. The preconditions and the technologies applied differ greatly by country but many of the models and solutions developed in E-Energy can be transferred to all these cases. The artificial name 'E-Energy' coined in the call to tender of the funding programme has established itself well beyond Germany as a synonym and generic term for the inclusive digital networking and optimisation of the power supply system.

SMART GRIDS: THE INTERNATIONAL ASPECTS

Germany as a pioneer of smart energy

The E-Energy model regions are seen as the avant-garde of German and international development towards the Internet of Energy. Thanks to the lead gained through E-Energy, German enterprises can take a spearheading role worldwide. The experts from the pilot projects and ancillary research are sought-after speakers at many conferences in Europe and overseas. Several cooperation agreements have now been concluded between E-Energy syndicate partners and large international companies.

Smart grid developers cooperate particularly closely in the German-speaking countries. In the so-called D-A-CH cooperation adopted at the E-Energy Congress in November 2009, German, Austrian and Swiss model regions, associations, research institutions as well as the responsible ministries cooperate in developing ICT-based energy systems. Besides the joint development of convergent smart electricity grids, system integration of electromobility has also emerged as a central cooperation interface. Cross-sectoral themes, such as standardisation, data and law and business and market models are prepared and discussed in task forces at joint workshops. Common approaches and findings can then be aligned with the so-called coordinators of D-A-CH and submitted to the Steering Committee, consisting of the competent ministries in all three countries. This pools comprehensive information on research and demonstration activities in the relevant ministries to enable Switzerland, Austria and Germany to effectively coordinate and combine their innovation policies on smart grids.



E-Energy and the results of the development focus of ICT for electromobility were presented to an interested audience at the German-Japanese Environmental Dialogue in Tokyo. Left to right: Eiji Ohira (NEDO), Ludwig Karg (B.A.U.M.), Yutaka Matsumoto (Toyota Motor Corporation), Hiroshi Watanabe (NEDO).

This institutionalised cooperation has already brought about initial specific results. Agreement has been reached on providing all field trial customers in all three countries with the same questionnaire before the start of the trial. Based on this, the individual model regions can be compared across national boundaries. In the data task force, proposals are collected especially for the necessary regulatory measures, developed further and suitable dissemination mechanisms discussed. As part of cooperation, a comparison of legal provisions on calibration is also in preparation. The workshops on standardisation look at innovative use cases and discuss suitable system architectures.

E-Energy is well represented in international groupings. Representatives of pilot projects and ancillary research are

Organisation of D-A-CH cooperation

Steering Committee
- Objectives
- Governance of cooperation

D-A-C-H coordinators
- Coordination of task forces
- Support for the steering committee and instigating new initiatives
- Preparation of work programme in cooperation with task force leaders

Task forces
- Thematic working groups made up of representatives of national working groups
- Alignment of thematic national results and positions
- Preparation and implementation of the Smart Grids D-A-C-H work programme

"We have identified five pillars of the Energy Internet. Pillar one is the production of clean energy from wind, sun and other renewable sources to replace uranium, petroleum and coal. Second, there is already a visible trend towards the decentralisation of energy production. Every building is potentially its own power station; the role of the old large-scale facilities is diminishing. Because, though, renewable energy often depends on the weather and is not regularly available, thirdly we need new energy storage facilities. Hydrogen could be the decisive medium here. Pillar four: the smart power grid which interconnects hundreds of thousands of power producers and consumers to balance energy supply and demand. In Germany, this Internet of Energy is already being tested at eight locations. And fifth: This is where the automobile was invented. Why should not your enterprises also take the lead for the electric vehicles of the future that run without oil. If we look at all five pillars together today, Germany is clearly in the lead.

Jeremy Rifkin, US American sociologist and economist, Chairman of the Foundation on Economic Trends (cited in the the Märkische Allgemeine newspaper of 26 Sept. 2011)

The Chinese delegation of industry and commerce visits Aix-la-Chapelle and is given a demonstration by Lutz Steiner (Technical University Darmstadt, E-Energy action research) and Peter Kellendonk (Elektronics/E-Energy- Smart Watts pilot project) of German E-Energy developments.

Signing of the EEBus cooperation agreement in Korea by representatives of Smart Watts

engaged in the activities of the International Smart Grid Action Networks (ISGAN), the European Energy Grid Initiative (EEGI) and the European Technology Platform for Electricity Networks of the Future (SmartGrids ETP). Via international development projects, such as the Future Internet for Smart Energy (FINSENY), the findings of the E-Energy projects are also communicated to other researchers and developers.

Active participation in international standardisation

The E-Energy Expertise Centre at VDE/DKE provides a good platform for coordination and joint international representation of E-Energy developers. Through the close interlinkage of DKE with international standardisation organisations (particularly CEN, CENELEC, ETSI and IEC) and the participation in the standardisation mandates, M/490, M/441 and M/468, much has been achieved. On the one hand, the (international) standardisation developments in smart grids in E-Energy model regions are well known and can be taken into account. On the other, it will ensure that the proposals developed in Germany as part of E-Energy are channelled into the national and from there the international standardisation bodies.

The already highly successful E-Energy animation shown at numerous trade fairs and conferences and on the Internet has been enlarged at the request of DKE to include the issue of standardisation and presented in this format and in English as a DKE contribution under the heading Smart Grid/E-Energy at the IEC General Meeting in autumn 2010 in Seattle.

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