Internet of Energy
ICT for Energy Markets of the Future

The Energy Industry
on the Way to the Internet Age

Contents

Executive Summary

At present, we can identify three major factors that have an impact on the energy sector. They underpin why this entire sector needs to be restructured and turned into an intelligent and efficient supply system. New integral system solutions are called for, in which information and communication technology (ICT) will play a key role in providing the necessary information networks and intelligence systems.

The first factor is the depletion of global fossil fuel resources: Fossil fuel supplies are finite and are already experiencing major price increases today. In addition, the atmosphere cannot absorb any more CO_2 without facing the threat of a climate disaster, and hence, concerted efforts must be undertaken in terms of active climate protection. In the face of impending strains on and shortcomings of the energy system coupled with the concurrently growing global demand for energy, we urgently need to make significant improvements to achieve greater efficiency in energy usage.

The second factor is the fact that the changed regulatory environment is placing greater demands on the energy system's data networks. Following the decoupling of power generation, transmission, and distribution, different players along the value chain must now communicate and interact using shared interfaces. Furthermore, new rules on standardization, metering, and consumer transparency generate large amounts of data, which require intelligent, automated processes.

The third factor is that as a result of technical developments and rising energy prices, more power from renewable energy sources will have to be fed into the power grid in the future, both from an increasingly decentralized supply structure and from a central supply structure that will continue to exist in tandem. This calls for a much greater degree of flexibility in the areas of voltage maintenance and efficient load flow control than the present system is designed to handle.

These three driving factors are occurring at a time when investments into the German and European energy supply system are urgently needed. Almost half of the installed power plant capacity in Germany must be replaced or modernized in the upcoming years, along with a massive expansion of the energy grids. At the same time, a significant number of residential households will require renovations. Due to rising energy prices, new energy-saving technology and communication end devices will be increasingly used during the necessary overhaul.

In light of this investment potential, we have a unique opportunity to promote a transition from the current energy system to an **Internet of Energy**, which will generate optimal energy efficiency from scarce energy resources through intelligent coordination from generation to consumption. Most of the necessary technologies for the intelligent and efficient renewal of the energy system are already available today.
However, we are still a long way off from harnessing the full potential offered by combining and integrating the available systems to optimize energy systems. It is therefore crucial for the industries involved and for the government to work together and provide the direction and support needed to make this a reality. They need to agree on actions as well as on technical standards in order to actively and systematically devise the necessary transformation processes.

Information and communication technologies will play a key role in the development of a future-oriented energy supply. They form the basis for realizing a future **Internet of Energy**, i.e., the intelligent electronic networking of all components of an energy system. Thanks to this increased networking, generator plants, network components, usage devices, and energy system users will be able to exchange information among each other and align and optimize their processes on their own. Thus, the current energy grid with its passive, uninformative components and predominantly unidirectional communication will evolve into a market-oriented, service-based, and decentralized integrated system providing potential for interactive optimization and the creation of new energy services. Increased usage of power supply systems that are optimized through home automation and smart metering will give residential customers, public agencies, as well as small and medium-sized enterprises the chance to reduce their energy consumption or avoid using energy during peak load times, thus preventing bottleneck situations from arising.
Improved energy management systems on the transmission and distribution levels will enable the optimal use of decentralized generation and renewable energy sources on a large scale, without affecting the stability and quality of the system. Yet, the biggest challenge will be to create a level of integration between management applications and the physical grid that will enable complex IT components distributed across heterogeneous grids and company borders to communicate with each other.

The transition from the current energy system to an **Internet of Energy** will present a good opportunity for a multitude of new business models to be created. In the future, power grid operators will be able to increasingly evolve into information service providers; new services, such as energy management at the customer's premises, will emerge. New players will enter the market, such as operators of virtual power plants for balancing energy. By integrating (hybrid) electric vehicles adapted to the energy supply, it will also be possible for the transportation sector to be actively involved in optimizing the energy networks.

As far as concrete recommendations for developing new business areas and realizing a future-oriented intelligent energy system are concerned, we suggest taking measures on several levels. On the technical level, there must be a strong focus on coordinating standardization in the information, communication, and energy technologies. This standardization is, in particular, designed to support continuous bi-directional communication between energy generation and end users. In addition to promoting basic research as well as education and training in the relevant technical and business management disciplines, initiatives for applied research and piloting of the **Internet of Energy** are also particularly necessary in order to test concepts and introduce lessons learned from research into the ongoing transformation process of the energy business. If we want to ensure that innovative concepts of an intelligent and efficient energy supply will actually be used, we must create long-term innovation incentives especially for the network providers. In this area, appropriate regulations must be passed. Finally, suitable public relations work is required in order to let all relevant players know how they can contribute to transforming the **Internet of Energy** concept into reality.

Acting on the recommendations we have identified can make a major contribution to transforming the current energy system into a more efficient, future-oriented energy supply infrastructure. This will simultaneously have the added advantage of consolidating and extending the global market leadership of German companies and research institutions in the area of intelligent and integrated energy technologies.

1 Introduction

The long-term safeguarding of our energy supply and the reduction of greenhouse gas emissions have become key issues in our times, as evidenced by discussions held across all sections of society about energy efficiency, sustainability, and climate change in the wake of the publication of the latest UN World Climate Report and the measures passed in response.

The pressure to act does not only stem from the problems regarding the climate, but also from highly volatile resource prices and limited resources of fossil fuels. As far as Germany is concerned, the 20/20/20 energy targets of the EU (Hope and Stevenson 2008) passed under German leadership in April 2007 as well as the 14-point energy and climate program of the German government approved in December 2007 are particularly important.

However, the measures taken to date by government and business to reduce energy consumption are inadequate. While fossil fuels continue to become increasingly scarce, demand for these resources shows no sign of let-up. To illustrate this point: In 2005, approx. 18,235 TWh of electricity were consumed worldwide. According to various estimates, this demand is expected to double (The Economist 2008) to quadruple (EU 2007) by 2050. According to a rough calculation using a power plant's currently standard output of approx. 850 MW as a basis, by 2050, approx. 3,500 additional power plants of the same size would have to be built worldwide. In addition, those plants that reach the end of their technical lifetimes during this period will have to be replaced by new power plant output.

These figures demonstrate that we need to develop more efficient generation technologies and that these new, alternative forms of electricity and heat generation systems must be integrated into the market rapidly. Furthermore, the energy at our disposal will have to be used much more economically and intelligently in the future, since ultimately, conserving energy is the largest available source of energy.

In Germany, there is currently a historically unique opportunity to move swiftly and decisively to meet these major challenges. Integral components of the current energy infrastructure will soon have to be replaced with new generation, transmission, and user components. Within the next ten years, power plants generating almost 50 percent of the output installed in Germany will reach the end of their technical lifetimes. During the same period, extensive renovations will have to be undertaken in almost one third of German households (StatBA 2006).

One of the major challenges faced by future energy transmission grids is the issue of how to integrate volatile renewable energy generation. In addition, the current infrastructure for electricity, gas, and water meters must be almost completely replaced by a new generation of meters within the next few years. In order to be able to comply with the requirements for monthly energy bills for residential households – which will be legally mandated in the future – in an economically feasible way, the mechanical meters will have to be replaced by meters that can be read remotely.

The goal is to make the best possible use of this investment potential and to develop and implement an integrated overall concept that is coordinated on the political, technical, and economic levels. On the one hand, a future-oriented energy system is a prerequisite for the economy to flourish in Germany; on the other hand, it is imperative to consolidating and extending the global market leadership of German companies and research institutions in the area of intelligent energy technologies.

One critical factor for the success of the future-oriented energy system will be an integrated information and communication infrastructure modeled and based on the Internet. This will allow simple, standardized, cost-efficient, and near-real-time access to energy information, since both centralized and decentralized energy providers need up-to-date, accurate information at all times regarding the expected energy demands in order to be able to ensure optimal operation. Consumers will also benefit from such an infrastructure, since it is the pre-condition for the development of intelligent end device technologies, which will enable customers to observe their actual energy consumption in real time and operate their devices in a way that minimizes consumption, thereby reducing costs. Only by combining intelligent users, providers, and intermediaries in an **Internet of Energy** will we be able to achieve maximum gains in efficiency in future dealings with energy, while simultaneously adhering to climate protection goals.

The working group "BDI initiative Internet of Energy" has made it one of its goals to devise concepts for Germany in close cooperation between business and science that provide a roadmap for the transition from our current energy landscape to an **Internet of Energy**. In addition, one can deduce concrete recommendations directed at the government, policy makers, and business leaders in Germany which can lead to rapid changes that are socially, economically, and ecologically feasible and technically realizable.

What the **Internet of Energy** might look like in practice has been tested in six German model regions since the end of 2008 in the context of the beacon project "E-Energy: ICT-based Energy System of the Future". E-Energy is a technology support program of the Federal Ministry of Economics and Technology (BMWi). In inter-departmental cooperation with the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), BMWi is providing EUR 60 million in funding for R&D activities of the technology partnerships. The partners will invest another EUR 80 million on their part, so that a total of approx. EUR 140 million will be available for the E-Energy model projects. In addition, BMWi and BMU are jointly creating a new R&D support focus "ICT for Electromobility", which will closely tie into E-Energy.

More information about E-Energy and the six model regions can be found in the article "E-Energy: Germany working towards an **Internet of Energy**", page 34 ff.

2 Radical Changes in Energy Supply
Inevitability and Historic Opportunity

Climate change, depleting global fossil fuel resources, dependency on imports, changes to the regulatory environment, economic and technological pressures, and lack of investment are all factors that will have a significant impact on our energy landscape and lead to major changes. However, when taken together, these factors also offer a historically unique opportunity to rapidly implement far-reaching measures.

2.1 Climate Change, Energy Consumption, and Natural Resources

Some of the most pressing and most widely discussed problems and challenges of our times are those related to long-term energy supply. The IEA World Energy Outlook (IEA 2008) and the current Climate Report of IPCC (IPCC 2007) clearly illustrate the enormous challenges faced by future energy and climate policies. The world population is forecast to grow by 30 percent to more than eight billion people by 2030. Assuming that the global economy will continue to evolve and be structured as expected, primary energy consumption will increase by more than 50 percent worldwide by 2030, while global electricity consumption might even quadruple by 2050, according to estimates published by the EU (EU 2007). The concentration of CO_2 in the atmosphere has risen by almost 40 percent since the start of the industrial revolution; a temperature increase of 3-6° C by the year 2100 seems probable (Cox, Betts et al. 2000). If we are serious about avoiding the prospect of even greater climate changes, we must limit man-made CO_2 emissions as rapidly and comprehensively as possible.

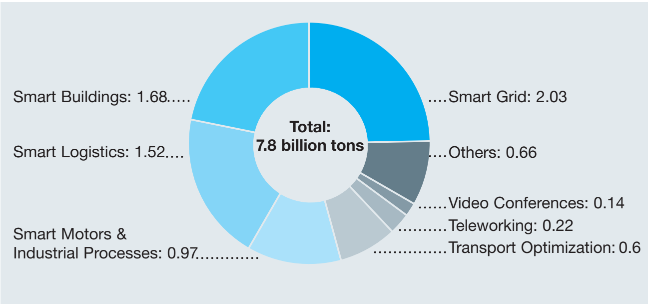
One way of reducing CO_2 emissions is to introduce sequestration processes (Carbon Capture and Storage – CCS). In fossil fuel-fired power plants and in industrial processes, this technology is used to separate the CO_2 from the volume flow and to store it long-term in suitable storage repositories. Currently, CCS technology along with the required infrastructure is still in the testing phase; in fact, individual pilot facilities and geological test areas for CO_2 repositories already exist. With 10-12 major pilot plants, the EU technology platform for CCS is paving the way for commercialization from around 2020. Currently ongoing research projects are mainly aimed at minimizing the loss of efficiency caused by separation and deep injection. At the same time, issues regarding large-scale shipment of CO_2 for permanent storage as well as transportation issues have yet to be fully resolved (Martinsen, Linssen et al. 2006; Schlissel, Johnston et al. 2008). Following Germany's nuclear power phase-out, which will be concluded by 2021, the capacity of the remaining power plants will not be sufficient to deliver all necessary base loads. However, CCS technology will not be sufficiently mature at that time to close the supply gap.

In order to be able to adhere to German and European climate protection goals nonetheless, the main focus should therefore be on reducing energy consumption and increasing energy efficiency. According to the BMWi (2006), the near-real-time display of electricity consumption alone will result in a savings potential of approx. 9.5 TWh per year for residential households. In its energy efficiency action plan, the European Commission estimates the Europe-wide energy-saving potential in industry, commerce, and trade to be 20 percent, and even significantly higher in residential households and in transportation. Figure 1 shows a potential assessment carried out by the Global-e-Sustainability Initiative, according to which up to 3.71 billion tons of CO_2 or almost 15 percent of the total emissions can be saved worldwide by the year 2020 simply by using ICT in the areas of Smart Grids and Smart Buildings[1].

However, change is not only driven by CO_2 emissions from burning fossil fuels, but also by the future availability of natural resources and the development of natural resource prices. There has been a strong increase in crude oil prices in recent years. This is due not only to high consumption and an ever-increasing demand (especially in Asia), but also to a lack of capacity reserves, the weak US dollar, low outputs (e.g., supply interruptions in Nigeria, Venezuela, Norway, Iraq, and Texas) as well as speculative investments on the natural resource markets (IEA 2008).

[1] On the other hand, 830 million tons of CO_2 were emitted due to the operation of ICT in the year 2007. This corresponds to approx. 2 percent of the total amount of CO_2 emitted in 2007.

Figure 1: Annual global CO_2 savings potential through the use of ICT (in billion tons)

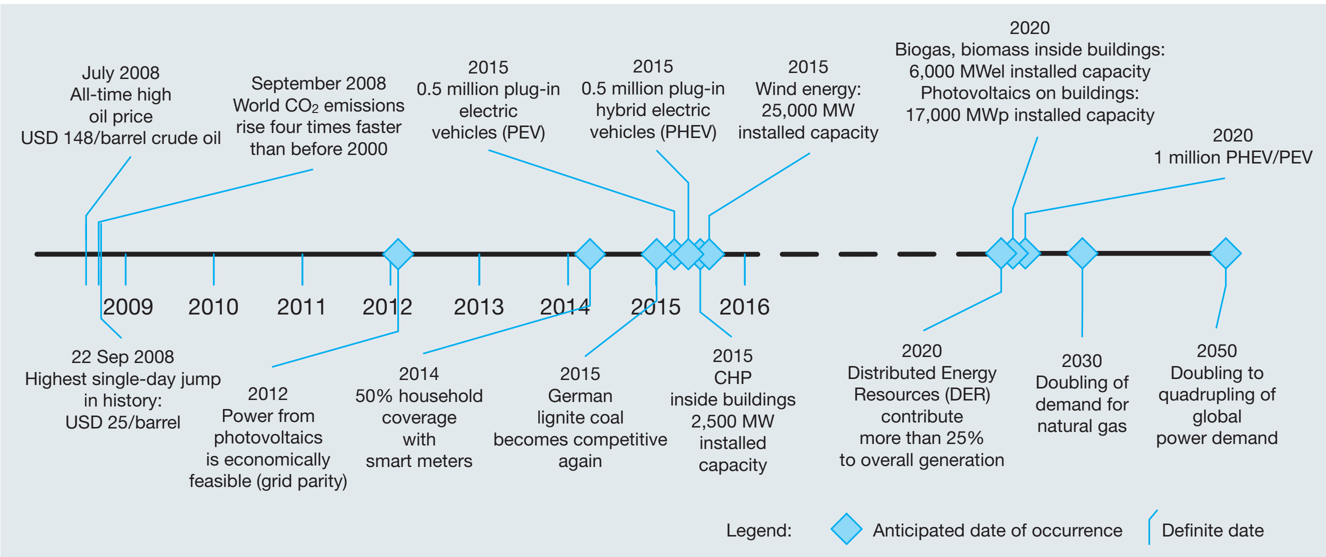


Source: The Climate Group (2008)

Due to political constraints and a lack of investment, current and future projects aimed at exploiting further oil deposits and expanding output capacity are unlikely to be sufficient to cover the expected increase in demand of approx. 1 percent per year (Jesse and van der Linde 2008; Stevens 2008). Thus, peak oil output will inevitably be achieved during the next few years. In addition, "the potential for political conflict" is inherent in *"the concentration of conventional crude oil reserves as well as natural gas reserves within the so-called 'Strategic Ellipse', which extends from the Middle East via the Caspian region all the way into Russia's Far North"* (BGR 2008).

Overall there ought to be enough fossil fuels available in the next few decades to cover the world's growing demand for energy. However, the costs associated with exploiting, transporting, and converting these reserves and resources are set to increase, inevitably along with energy end-use prices. This trend will increase the need to research and develop alternative methods for electricity and heat generation, and to investigate ways to efficiently integrate producers and consumers. It will also make these areas more economically attractive. Figure 2 illustrates these developments on a timeline.

Figure 2: Prognoses and trends – availability of fossil energy sources and renewables



Source: BDI initiative Internet of Energy (2008)

2.2 Current Regulatory Environment

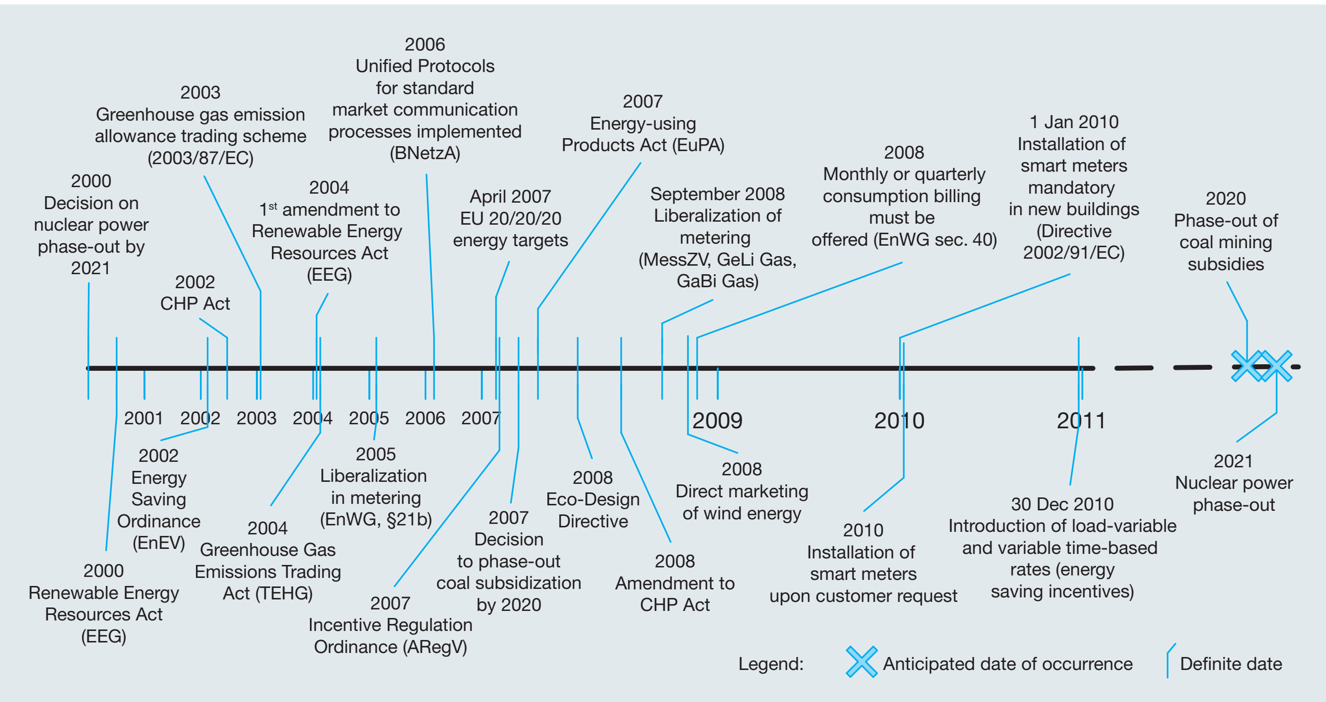
The future development of the European and national energy supply will be determined to a large extent by the regulatory environment. The liberalization of the electricity and gas industry, for example, is based on EU guidelines for the European domestic electricity and gas markets. Their implementation entails major structural, organizational, and contractual changes. The business divisions along the value chain must be unbundled. As a consequence, new market rules continue to be formulated in the form of laws, guidelines, and regulations to ensure the interaction of new and established market players. Figure 3 illustrates the timeline of these regulatory measures. The diagram also shows that the liberalization process is far from complete, but continues to be promoted and driven forward.

The German government already passed an amendment to the Energy Industry Act (EnWG) as far back as July 2005 to establish new meter technologies. Sec. 21b describes the liberalization of metering for the installation, operation, and maintenance of metering devices for the electricity and gas supplied via cable and pipeline. In addition, in July 2008 the *Bundesrat* (the upper house of the German parliament) resolved to completely liberalize metering activities in the electricity and gas industries by amending the EnWG. When the change came into effect on 9 September 2008, metering itself was also liberalized, in addition to the operation of metering points. As of 1 January 2010, all metering point operators will be obliged to install metering devices in new buildings and fully renovated old buildings that display real-time energy consumption as well as usage time (Bundestag 2008). Furthermore, existing metering devices must also be reconfigured at the customer's request.

End customers will have the right to receive a monthly, quarterly, or semi-annual electricity bill from their provider upon demand (sec. 40 EnWG). Providing greater consumption transparency is intended to result in increased energy awareness and ultimately in more economical energy consumption by the end customer. Concurrently, energy supply companies will be obligated to offer customers more flexible electricity rates that provide an incentive for conserving energy or controlling energy consumption the latest by 30 December 2010 (EU 2006; Bundesrat 2007).

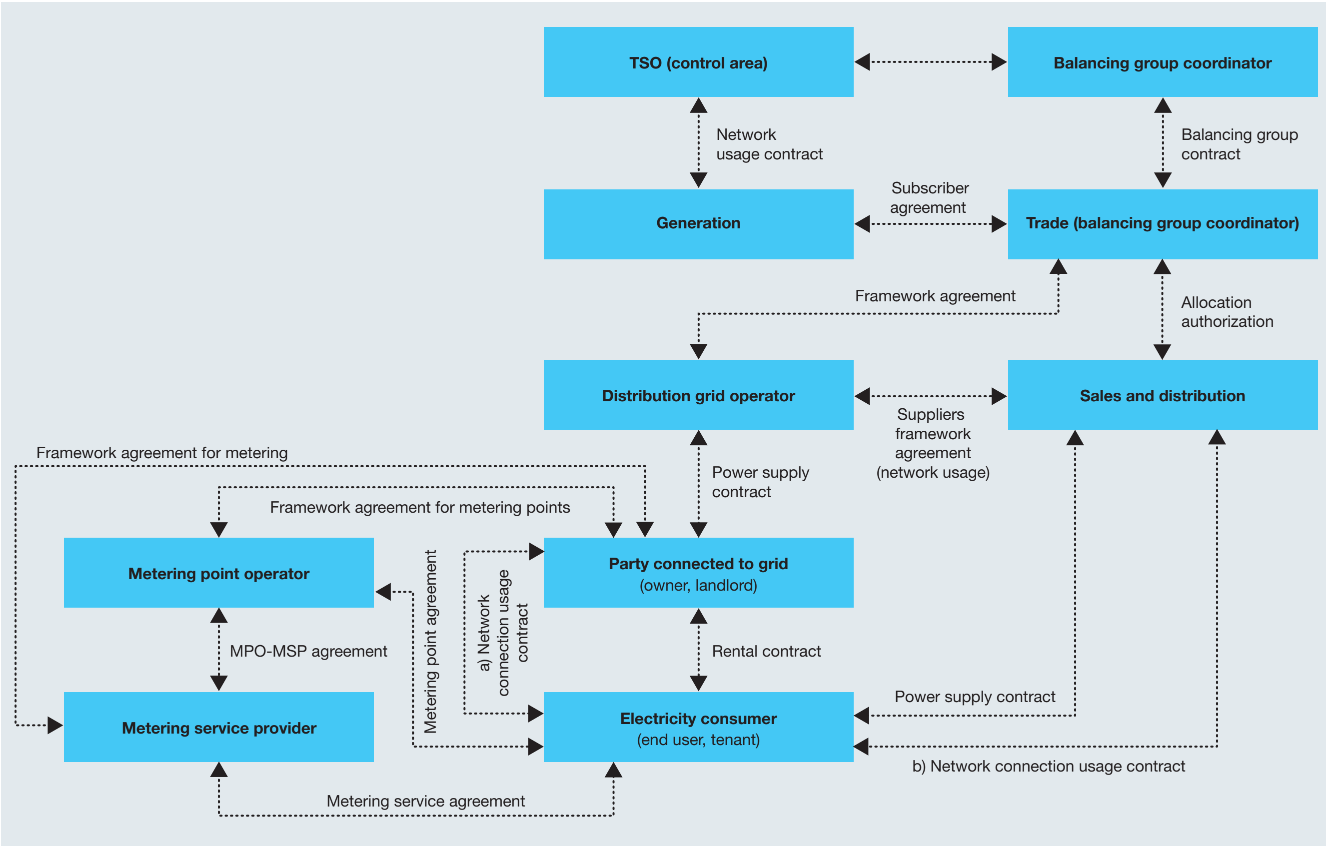
The liberalization of metering enables customers to freely choose not only their energy provider, but also their metering point operator and their metering service provider.

Figure 3: Regulatory and political environment – regulatory measures in the energy sector



Source: BDI initiative Internet of Energy (2008)

Figure 4: Multitude of players and contractual relationships on the liberalized electricity and metering market



Source: BDI initiative Internet of Energy (2008)

However, this unbundling will result in a very complex market structure, as depicted in Figure 4. To ensure that new and established market players interact smoothly in such a liberalized energy and metering market, there must be guarantees that the business and ICT processes to be supported are automated. This requires unambiguous definitions of the minimum technical standards, communication processes, and data formats. This has only been partially realized to date.

For example, in the past, the manual processing time and expense for customer transfer processes and the lack of binding specifications for the process management made it very difficult for new competitors to enter the market. The Federal Network Agency has attempted to solve this problem by laying down uniform rules and standards for handling market communication processes (BNetzA 2006). These form the basis for communication between the providers and the network operators involved in a customer transfer.

However, the goal of a fully automated communication system between the market partners in the context of customer transfer and network usage management processes as well as in metering has not been achieved yet. Loopholes in definitions and incomplete standardization of the process chains mean that all market players continue to incur high costs. These costs mainly result from manual rework and additional coordination communication. They can only be reduced if, in addition to automated market communication, the processes in the core applications can also be handled automatically in the medium term. This includes, in particular, the process of electronic billing.

2.3 Economic and Technological Pressure to Change

The “traditional” integrated planning of electricity generation and transmission has become obsolete as a result of liberalization and the unbundling of the electricity generation and electricity distribution structure stipulated by it. New providers with generation capacities of their own continue to enter the market, resulting in increased competition. However, since new power plants – as far as can be determined – are not all being built in the same locations as existing power plants, the topology of the power grid is changing. In addition, the BDEW estimates that by the year 2020, smaller decentralized facilities and power plants based on renewable energy (below 20 MW) with a total capacity of 12,000 MW will commence operating. Approximately half of the large power plant projects – i.e., generation capacities of approx. 15,000 MW – are planned by market players who are currently not or only barely active in power production (e.g., Allianz 2006).

Due to the fundamental changes in constraints, it is thus essential to maintain the functionality of the power grids. This will require, for example, that the transmission grids have a much higher degree of flexibility in the area of voltage maintenance and efficient load flow control than has been the case to date. The fact that the – partly contradictory – requirements are becoming increasingly and ever more complex means that we must strive for integrated, system-wide innovations to the power supply system. Since mutual effects need to be considered in the context of the system, system research and development work must be coordinated. Optimizing single components alone in terms of their individual economic and technical innovation potential is no longer beneficial. However, the current market regulation (incentive regulation) in the energy sector in Germany does not yet provide enough incentives for investments, which is why further development is necessary in this area.

A well-developed power grid plays a key role in a liberalized energy economy. Through increased power trading and the use of renewable energies, the requirements, especially in relation to supergrids, have already changed considerably today. Whereas these were formerly operated using interconnections spaced far apart, mainly to increase system stability, they now increasingly serve to transport loads across long distances. If wind energy continues to be developed further in the north of Germany and if conventional power plants are erected in new locations far away from actual consumption, this trend will continue to gather force. Major restructuring measures and new operating concepts will thus become indispensible (dena 2005). Considering that it takes an average of twelve years to plan, approve, and build a new high-voltage line, it is clear that immediate action is needed.

New requirements are also emerging on the level of lower-voltage networks. Medium- and low-voltage networks, in which network automation has so far been eschewed to a large extent, can no longer cope with the requirements posed by the increased integration of decentralized generation facilities. In addition, the continual increase in the demand for power will push the well-developed distribution networks to the limit of their load capacity. Although the networks can undoubtedly absorb additional loads in the medium term, those peak loads that depend on the time of day are creating problems not only for the power generation companies. Optimizing the daily load flow can help to avoid expensive investments that are needed only for a few hours each day. Therefore, in the future we should implement more measures that make it possible to shift demand in accordance with economical grid operation criteria. In the future, efficient load management of the power grid will thus also have to take into account the requirements of the distribution networks and involve all market players, down to private customers.

The same applies to decentralized generation. Today, the medium- and low-voltage distribution networks are usually still capable of absorbing decentrally generated power without any quality problems. The strong increase in decentralized energy feed-in we are witnessing has been promoted on a massive scale by the Renewable Energy Resources Act (EEG). In order to achieve further growth, the grid operators must, however, make major investments in order to safeguard supply reliability and power quality in the future. Within a few years, distribution networks will no longer be able to absorb at all times power produced from the fluctuating energy sources (specifically sun and wind).

This complexity is further increased if current heating systems are replaced on a large scale with devices that generate power in addition to heat. Small cogeneration (combined heat and power, CHP or µ-CHP) units are already available on the market, operating with various techniques such as gas diesel engines, stirling engines, or fuel cells. The concurrent use of primary energy for heating purposes and power generation makes such CHP units particularly interesting from the perspective of energy conservation, which is the reason why their use ought to be promoted further (BMU 2008). However, for the distribution network operators, this represents a paradigm shift from pure power distribution to an actively controlled energy grid. The accompanying changes to the electricity grids as well as in the gas networks can only be met by using actively controlled so-called "Smart Grids".

Intelligent load management on the basis of variable time-based price rates is thus becoming an important option for optimizing generation and consumption and thus allowing more economical energy management. In the future, customers will be alerted to price signals which will enable them to shift their consumption of energy to low load times and thus enjoy the lower rates.

2.4 Backlog of Investments

The energy sector in Germany has undergone major changes in recent years and has experienced a slump in investment for a variety of reasons. Companies in this sector gave top priority to consolidating their finances and providing high yields to their shareholders. As a consequence, existing facilities were used as intensively and for as long as possible. This was exacerbated by the fact that, due to the partial or complete lack of framework conditions, the government also failed to create a climate that would have promoted investment in the energy sector on the necessary scale. For these reasons, the existing facilities were sometimes operated until the very limit of their lifespans. An investment boost in future supply infrastructures is thus expected within the next few years.

In Germany alone it is estimated that a total of approx. 50 GW of power plant output – i.e., almost half of the total amount – will have to be replaced by 2020. This is mainly due to the age of the facilities, the targets of climate protection, and the expectations regarding the development of emissions trading along with the concurrent nuclear power phase-out. The use of energy sources and generation technologies with less CO_2 is a decisive competitive edge in this respect (Brinker 2007).

Similar developments are also expected as regards residential households, where new framework conditions have been created ever since energy efficiency became an important issue. This should lead to major investment activities in the future. Examples include the regulations on the replacement of older boilers or the introduction of the energy performance certificate for buildings, which will trigger corresponding investments into new solutions for greater energy efficiency. In addition, approx. one third of all German households will need to undergo renovations within the next few years (StatBA 2006). In light of the sharp increase in energy prices, we can expect that new energy-saving technologies will be used for this scheduled overhaul work, by both producers and consumers alike.

In the area of electric energy, smart energy end user devices and appliances that are capable of reacting to price signals automatically, for example, are becoming more and more common. The introduction of mandatory labeling for durable appliances according to energy efficiency classes alone has not yet resulted in these appliances being used in a cost- and consumption-optimized manner. A significant improvement in terms of conscious energy conservation can only be expected to occur once all major points of power consumption are able to communicate their consumption profiles via standardized interfaces, which are then aggregated, packaged, and displayed in a technical center located at the consumer's premises. New controlling options for energy producers and consumers will only be created on the basis of this real-time energy consumption information accurately displayed by devices, which will ultimately lead to optimizing the load profile and to minimizing consumption and reducing costs.

2.5 Historic Opportunity

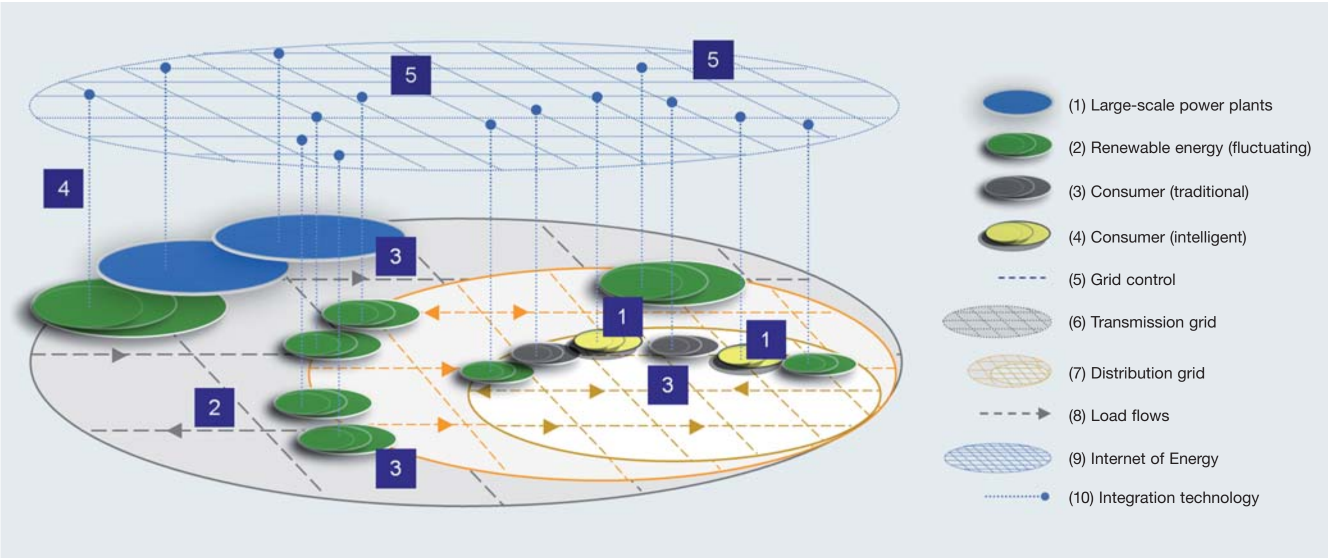
In this chapter, a multitude of factors have been addressed that highlight the need for modernizing the current energy infrastructure. They will also accelerate modernization. Climate protection, air pollution control, and resource conservation are major ecological drivers of this change on the energy markets. The development of a European domestic energy market, the legal separation of power generation and distribution, rising prices for natural resources and energy, as well as new regulatory requirements are placing increased economic pressure on the energy providers. These factors, along with the fact that there are a growing number of co-competitors that increasingly come from other sectors, are the major economic drivers of this change on the energy markets. An ever-growing number of decentralized power generation companies with volatile generation profiles, high-volume energy transmissions via transmission points, transnational integrated networks, and bi-directional energy flows in distribution networks are major challenges that, from the technological point of view, call for modernizing the energy grids.

In Germany, these key factors are at play at a time when almost 50 percent of the power plant capacities will have to be replaced or modernized within the next few years, and when almost one third of the German households are in need of renovation. This convergence of factors provides a historically unique opportunity to devise a well thought-out transformation process. Information and communication technology plays a key role in a well-planned overall concept in terms of a more intelligent and energy-efficient energy supply system. Maximum synergy effects can only be achieved if all economic, regulatory, and (IT) technical innovations are well coordinated. We should strategically exploit this unparalleled opportunity!

3 Networked Components and Integrated ICT
Building Blocks for the "Internet of Energy"

Many of the building blocks for a future Internet of Energy have already been developed and are available today. However, these components and technologies have hardly been networked with each other to date. Maximum gains in efficiency can only be achieved if information and communication technology is integrated intelligently with energy systems.

Figure 5: Internet of Energy



Source: BDI initiative Internet of Energy (2008)

At first glance, the technical energy grid of the future will not appear to be very different from today's infrastructure. Figure 5 shows this schematically – just like today, there will be large-scale power plants (1) that transport energy to the consumers (3) via transmission grids (6) and distribution grids (7). In order to make greater use of regenerative energy sources, an even larger number of decentralized generators (2) will be installed than currently exist today, which – just like the large-scale power plants – will contribute to meeting the demand for energy. Since energy feed-in will be increasingly decentralized and consumers will react more flexibly and intelligently (4), more situations will occur in which load flows (8) in sub-grids will be reversed. If this dynamic infrastructure is to be operated and coordinated efficiently, all individual components must be integrated (10) into a uniform communication infrastructure – the **Internet of Energy** (9) –, which will serve to map all producers and consumers of the energy grid onto one virtual level. This is the only way to enable near-real-time communication, thereby ensuring efficient coordination of the grid despite the continually increasing number of dynamic consumers and decentralized, fluctuating generators.

Parts of the infrastructure for an **Internet of Energy** already exist today, whereas other technologies are available in principle, but are not being extensively used yet:

1 Technologies for home automation and decentralized energy generation
2 Intelligent grid management systems on the transmission and distribution levels
3 Installed smart metering technology
4 ICT as a link between the **Internet of Energy** and the technical infrastructure
5 Applications and services implementing the coordination of the energy grid on the economic level

These are described in greater detail in the sections below, and the current state-of-the-practice technology is explored for each item. In addition, the issue of where further action is required in the respective areas on the way to the **Internet of Energy** of the future is also addressed.

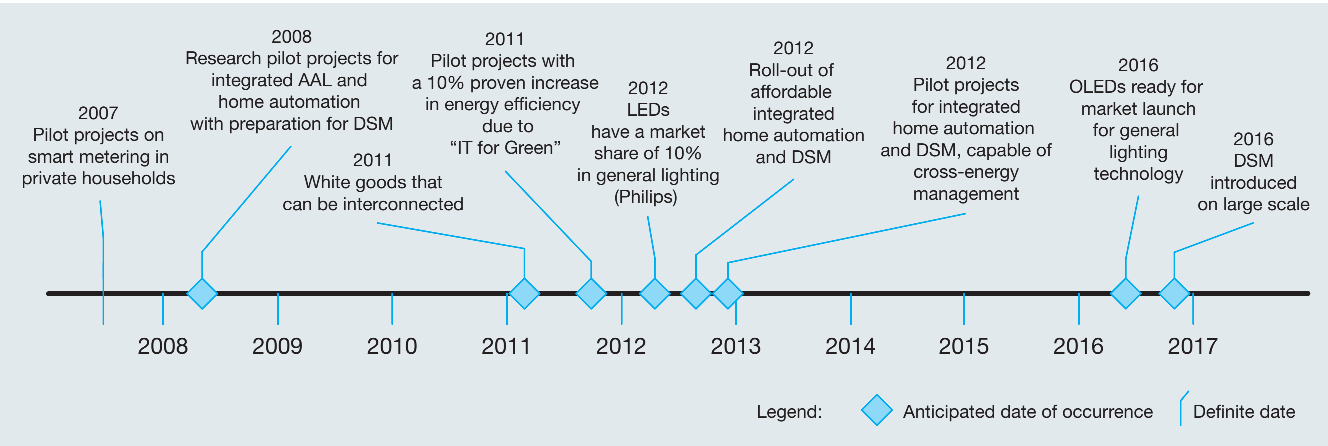
3.1 Building Automation and Smart Homes

In contrast to commercial buildings, the automation of residential buildings is still largely in its infancy today. In general, residential households are neither equipped with networked devices nor with control equipment. In addition to energy consuming devices such as refrigerators, washers, dryers, home entertainment devices, and lighting, these buildings usually only have one heating system, which generates heat for heating both rooms and water. Most of the available appliances and devices are controlled manually or semi-automatically. Some do have built-in automatic controls (e.g., washer, heating system), but this merely allows them to optimize their own performance in accordance with the requisite manufacturer-specific target parameters.

In principle, it is already possible today to equip residential buildings with networked building utilities and building automation. However, this mainly applies to newly constructed buildings where the main focus is on prestige and convenience rather than on cost or energy optimization. Well-established applications include those for controlling individual components such as heating, ventilation, and air conditioning, electricity distribution facilities, lighting, shading, or telephone and security systems. Yet, there is no integrated control of these areas, particularly in terms of energy optimization.

The vision of an intelligent residential building ultimately geared at maximizing convenience will become less important. Instead, intelligence in residential buildings will increasingly be found in decentralized energy management systems (DEMS), which will be installed with the objective

Figure 6: Smart Home – use of ICT for energy optimization in residential households



Source: BDI initiative Internet of Energy (2008)

of reducing energy consumption. However, at the same time, they will also be capable of providing other services, such as “Ambient Assisted Living” (AAL). Thus, the introduction of these technologies will not only be driven by an expected increase in the value of comfort and convenience, but also by a reduction in energy consumption in light of rising energy prices. In Germany, for example, heat consumption in residential households accounts for almost 22 percent of the total end-user energy consumption. A graphical illustration in Figure 6 shows the predicted availability of the Smart Home technologies required for the introduction of DEMS.

Operating future building automation systems optimally and energy-efficiently while keeping costs down will be just as challenging for residential households as it will be for the energy providers. In addition to providing a control system inside a building, DEMS can also serve as an integration point for the energy provider’s central grid control (cf. also Sections 3.2 and 3.3). So far, the energy sector’s communications infrastructure has been organized mainly in a hierarchical fashion. This hierarchy must be replaced by a system that is able to communicate with a large number of decentralized generators, storage units, and loads. This calls for an integrative concept that enables bi-directional exchange of data with the grid control and grid management based on the basic data of the generator and the storage units as well as the loads. To date, however, a multitude of different standards and protocols have made it difficult to establish such a system. On the grid side alone, more than 360 different technical standards exist. In terms of the building itself, there are even more systems and communication protocols, such as ZigBee, LON, EIB/KNX, or BACnet – which also means greater complexity. However, in order to optimally manage the energy inside a building, all available sensors and actuators need to be integrated in a uniform building information chain: air conditioning and ventilation control, lighting and shading facilities, building security systems, energy measurement devices, as well as energy generation and consumption devices. The first pilot projects for such kinds of integrated systems are slated to be realized by approx. 2012. Wide-scale introduction of these technologies to the market is expected within the next ten years (cf. Figure 6).

Current plug&play solutions for home automation cannot fulfill these requirements, since they are all based on proprietary protocols and thus cannot be used in heterogeneous environments with devices and components from different manufacturers, or can only be integrated at considerable cost and effort. Section 3.4 describes a technical integration platform intended to bridge these communication gaps using an integrated approach from the individual end device all the way to the producer.

The benefits of this kind of home automation and the advantages offered by seamless integration of decentralized energy generators are obvious. For the first time, end users will be able to observe almost in real time (e.g., via home displays or from anywhere via the Internet) how certain appliances/devices and consumption habits influence their use of energy and thus their energy costs. As mentioned above, estimates by the BMWi put the resulting energy savings potential at more than 9.5 TWh per year. Currently, when consumers buy energy-efficient technology, they can only see how much they save when they receive their final bill at the end of the year. Once they can actually look at their energy consumption and the ensuing costs in near-real time, less time will elapse between such purchases and the resulting savings. Since the cost-benefit relationship will become transparent, consumers will find it easier to make an investment such as buying LED or OLED technology if these additional expenses can be directly linked to the resulting daily energy savings (Darby 2006).

3.2 Centralized and Decentralized Energy and Grid Management

The intelligence of the future power supply infrastructure will be characterized to a large extent by the use of electronics as well as communication and control components and systems. Figure 7 shows the fundamental shift in paradigms that is required for the development of a Smart Grid. Today's static infrastructure design and its usage "as built" will turn into a dynamically adapting, "living" infrastructure with proactive operation.

3.2.1 Energy Management Systems on the Transfer Level (High Voltage and Maximum Voltage)

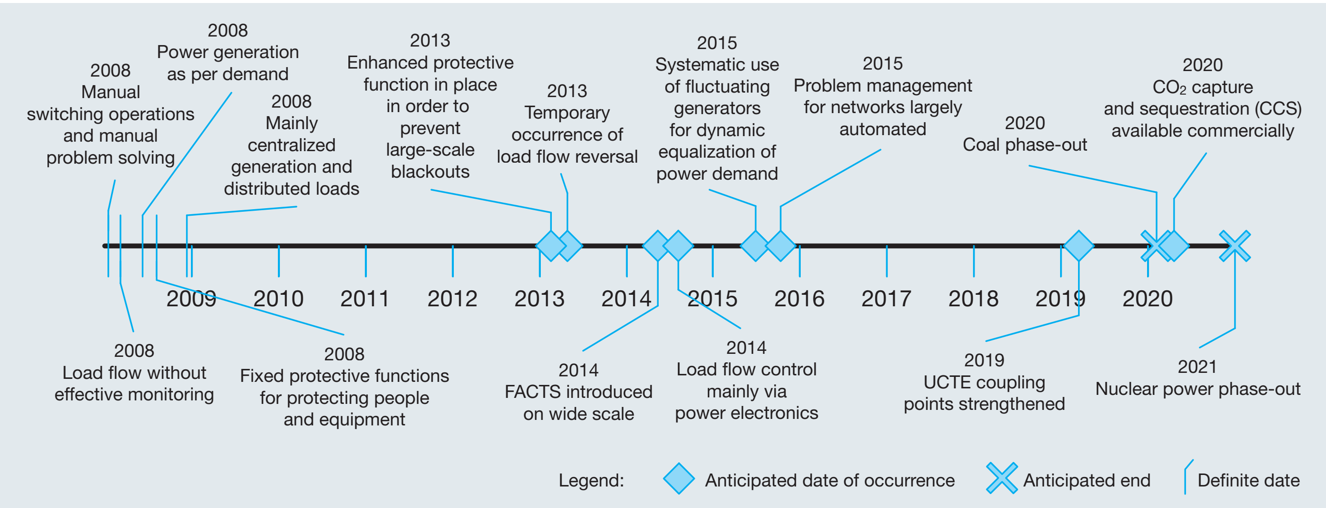
The increase in cross-border power trading and feed-in from wind energy plants (WEP) – especially in low-consumption regions – is causing a significant increase in the number of bottlenecks in the German and European transmission grids. In addition, there is also a growing risk of potential oscillation and voltage problems due to concentrated wind power feed-in in the grids' border regions. In combination with the high basic load of the transmission lines, the demand for quickly adjustable elements that can be used to control the active and reactive power flows is also growing rapidly.

These special strains on the grid ensuing from incalculable shifts of the load flows, such as those that can be caused by WEP feed-in or power trading, for example, become controllable if flexible alternating current transmission systems or high-voltage direct current transmission (HVDC) are used. The combined use of intelligent inverters (IGBT technology) with technologies such as HVDC and FACTS (Flexible Alternating Current Transmission System), which are based on power electronic components, offers great advantages in terms of system technology compared to conventional three-phase technology.

In many cases it is advantageous if direct current transmission and flexible alternating current transmission systems (FACTS) complement each other. Whereas HVDC connections serve to transport power across larger distances or to couple asynchronous grids via HVDC close coupling, FACTS regulate the voltage and the load flow in the grid.

In the future, modern network control technology will have to capture more information and package it for the operators for fast processing, unlike in the systems of the past, which were planned "top down". The goal is to make relevant operating data available in real time in order to avoid critical operating conditions. This information must be accessible system-wide, even in a supply system with several system operators. So-called wide area monitoring systems (protection and control technology) for safely and efficiently operating grids and managing large integrated grids are thus becoming increasingly important (both nationally and Europe-wide).
Wide area monitoring serves to establish an early warning system regarding grid instabilities through dynamic monitoring on the basis of online information. In the event of a of system fault, such a system is able to provide faster and more accurate information than is presently the case, thereby ensuring stable system operation even in case of

Figure 7: Large-scale generation, distribution and storage of energy – paradigm shift in grid technology



Source: BDI initiative Internet of Energy (2008)

malfunctions or bottleneck situations. Early detection of possible instabilities due to voltage or frequency deviations, or thermal overload, can help to avoid far-reaching secondary damage caused by large-scale power failures.

Today, the regional responsibility structure for the operation of the grids and the economic allocation of the follow-up costs of large-scale grid malfunctions still remain a barrier to investment in such innovative solutions. The best way to prove that the expected functionality will actually work would be to implement a complex German or European model project.

3.2.2 Decentralized Energy Management in Distribution Grids (Medium and Low Voltage)

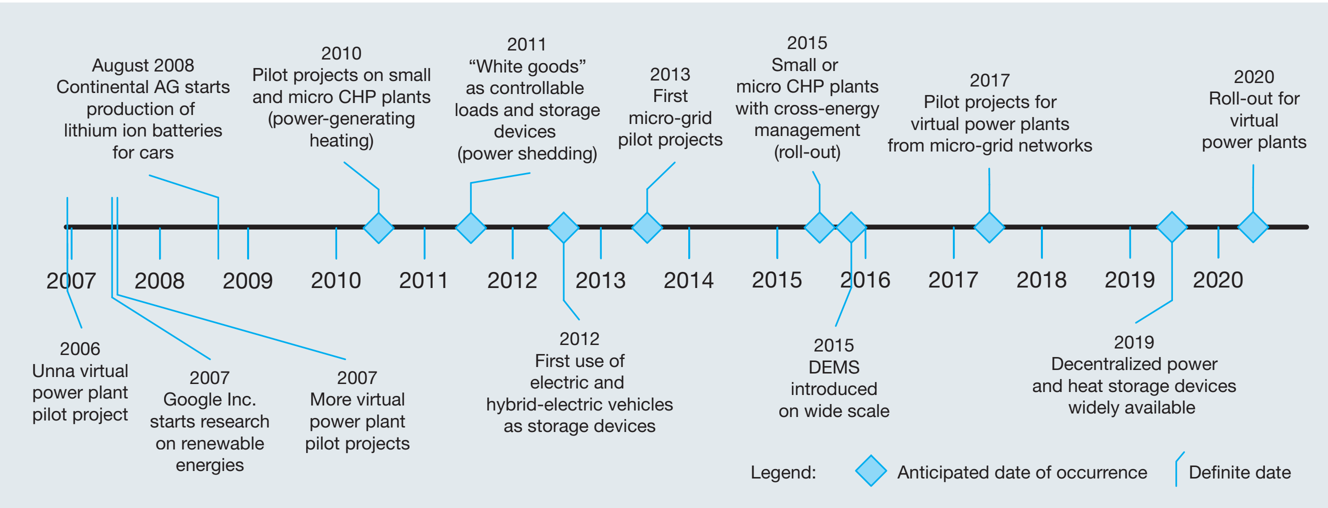
For the distribution grid operators, providing a reliable power supply and adhering to the relevant voltage quality criteria (voltage band, flicker, harmonics) means that they have to fulfill stringent requirements. The changed constraints have made it necessary to automate the distribution grid processes. If automation is available, then even defective equipment can be turned off quickly and automatically, and medium voltage rings can be reconfigured remotely. Thus, it is possible, for instance, to resume the supply within minutes after a cable or an overhead line fails, whereas the repairs will only be done at a later time.

In its "Action Plan for Energy Efficiency", the EU Commission has quantified the annual costs for not tapping the full energy savings potentials in Europe at EUR 100 billion (EU Commission 2006). In order to tap this potential, one of the key priorities of the EU action plan is to intensify the expansion of decentralized capacities for trigeneration below the 20-MW threshold. Today, only 13 percent of the total power consumed is produced in a cogeneration process. Promoting local generation, in particular, based on these technologies can lead to an increase in overall energy efficiency and a reduction of transmission losses within the power grid.

In the context of a "virtual balancing group", decentralized energy management not only includes typical decentralized generation plants such as cogeneration plants (on the basis of renewable and conventional resources) in the basic load operation, but also fluctuating generation technologies (wind, photovoltaics). Power is acquired and delivered beyond the boundaries of the balancing group. If all parameters are assessed – including those loads that can be influenced and those that cannot – a transfer profile to the surrounding grid can be developed. The "intelligence" of the decentralized energy management system is manifested in mastering the complex technical requirements due to the facts that generation plants can be influenced in various ways and that power consumption is optimized.

The objective is to avoid inefficient load and generation peaks. This means that appropriate reserve loads must be maintained in the supply system, which can be achieved through internal balancing within the virtual balancing groups. Initial field trials such as the Unna Virtual Power Plant (Henning 2006) primarily refer to "smoothing" the

Figure 8: Decentralized energy generation and storage



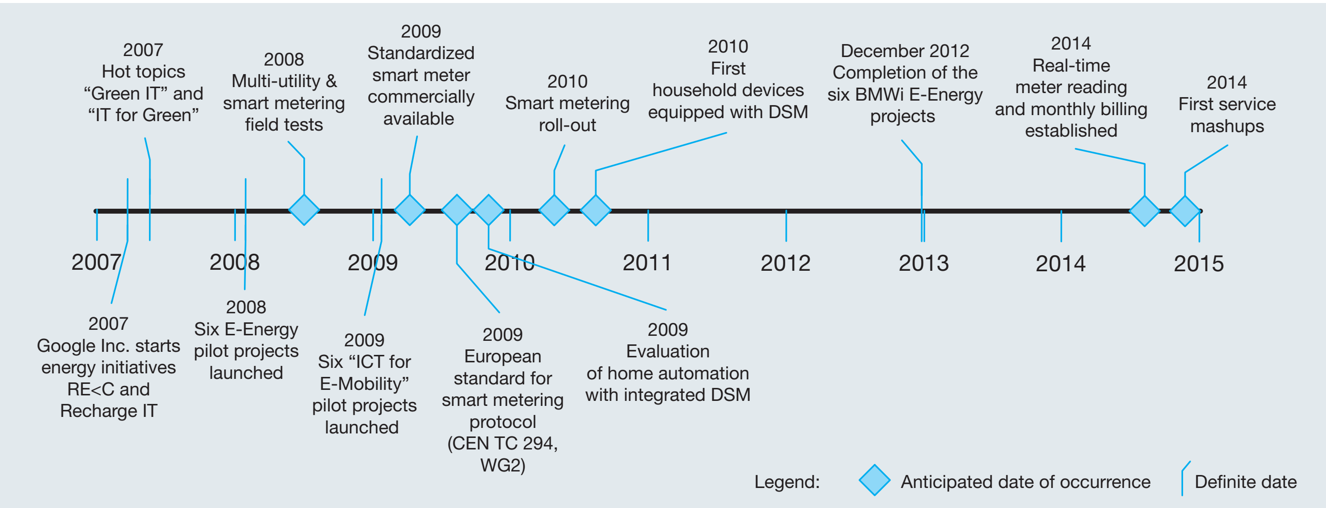
Source: BDI initiative Internet of Energy (2008)

demand lines through additional feed-in at peak load times. There are virtually no reports of consumers smoothing the demand curve, for example as a result of dynamic price incentives during the course of a day.

Individual pilot projects with this objective will be realized in the course of a four-year field trial of the project "E-Energy: ICT-based Energy System of the Future", which is set to run until the end of 2012. The project is supported and funded by the Federal Ministry of Economics and Technology (BMWi) in an inter-departmental partnership with the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). Six model regions are testing the everyday usability of a wide variety of elements of an Internet of Energy. E-Energy, which aims at harnessing the potential for optimization of communication technologies to complement power grids, has huge economic potential for the producers of electricity, for the network operators, and for both residential and commercial consumers. All E-Energy consortia are pursuing an integral system approach at all levels of the value chain. This approach includes energy-relevant activities on the technical operation level as well as on the level of innovative markets. E-Energy is a basis for future-oriented, new, cross-sector areas of activity and growth impulses, and underscores the need for greater liberalization and decentralization of the energy supply system, and, last but not least, for the development of electromobility.
E-Energy is a complex innovation program and encompasses far more than mere technical progress. Important goals of this program include the build-up of transferable knowledge, the formation of networks enabling rapid exchange of the new E-Energy know-how, and the establishment of effective, integrated cooperation structures for resolving important cross-sectional issues. For this purpose, BMWi has commissioned "ancillary research". A consortium that is continually evaluating the progress made in the model regions ensures that the solutions are interoperable, and organizes the exchange of knowledge.

However, it will be necessary to quickly realize additional large pilot projects that provide evidence of the potential and reliability of virtual balancing groups in order to roll out this technology on a wide scale by 2021 – that is, by the time the planned nuclear power phase-out is scheduled to be concluded. As alluded to in the recommendations for action in Section 5, this requires systematic funding and support. Research in this area must be ongoing and must include ancillary research activities beyond such research conduction in the initiated projects.

Figure 9: ICT infrastructure with smart metering



Source: BDI initiative Internet of Energy (2008)

3.3 Smart Metering

The metering technology in use in Germany today can be divided into two categories. For residential customers, mechanical or electromechanical metering technology is mainly used for measurement. For commercial and industrial customers over the load profile threshold[2], electronic meters with a communication component are in use. The two recording systems are described in greater detail below.

3.3.1 Consumption Measurement: Residential Customers

To record how much electricity and water is supplied to the approx. 36 million German residential households, approx. 44 million electricity meters, 13 million gas meters, 18 million water meters, and 0.3 million heat meters are used. What is being measured is not the individual demand over time, but rather just the total consumption during the billing period. Since the existing meters are not equipped for communication, they are read once a year by the operator of the metering point or by the metering service provider (electricity and gas), as well as by the utility company (water and heat), or even by the customer.

3.3.2 Consumption Measurement: Commercial and Industrial Customers

Large commercial and industrial customers whose annual energy consumption is above the load profile limit are entitled to time-based measurement of their energy consumption. In accordance with the German Electricity Network Access Ordinance (Strom NZV) and Gas Network Access Ordinance (GasNZV), the energy consumption of this customer group must be recorded by means of "registering load profile measurement". This means that the amount of electricity consumed is recorded every quarter of an hour, while gas consumption is recorded hourly. The meter data are read via remote meter reading systems and must be made available to the supplier on a daily basis. In the categories water and heat, measurement devices not equipped with communication technology are normally used. Here, the consumption data are read on a monthly basis without any correlation to time.

3.3.3 Necessary Changes in Metering

In contrast to the commercial and industrial customers segment, where all requirements for individual, time-based metering have already been fulfilled to date, further action is still needed as regards the household customer segment. The mechanical meters used there have become outdated and have no future in a digital age. The replacement of the entire meter infrastructure will thus have to be initiated within the next two years. Due to the high investment costs, it is not possible to directly transfer industrial metering technology to the residential customer segment; rather, special tailor-made residential customer meters will have to be designed and developed for this purpose. First large-scale trials with such devices are currently underway in several European countries. In addition to remote meter reading, other functions such as remote connection and disconnection of consumers, power limitation, rate registers, and failure detection are also being tested.

Bi-directional communication between metering point operators and connected electronic residential meters, in particular, will gain special importance in the future. By using smart metering, valuable information about the condition of the distribution grid can be obtained and adherence to the permissible voltage levels can be monitored. In addition, smart metering can also be used as a gateway to gain direct influence on decentralized power generators or loads. This communication thus constitutes the basis for actively managing generation and consumption in distribution grids.

Different communication channels can be used for data transmission. The E-Energy scenario envisages the use of radio modules, the use of cell phone networks, or information transmission via the power line itself. Critical issues that have yet to be resolved in this context include the question of how to design smart metering in such a way that it meets privacy requirements. In addition, clear rules have yet to be formulated regarding read and control rights to smart meters by grid operators, metering point operators, power companies, and other potential service providers.

Currently available reading systems are either category-specific or manufacturer-specific, and only have a short lifespan on the market. Smart metering, however, is only feasible economically– especially for multi-utility companies – if a standardized device technology is used that spans all categories and manufacturers. In other words, the technology for remote reading and control of both commercial and industrial customers and residential customers is available in principle. However, the basic uniform standards for ensuring mutual interoperability of the devices do not exist yet.

[2] The load profile limit is 100,000 kWh/a (StromNVZ), respectively 1,500,000 kWh/a (GasNVZ).

The development of a German smart metering standard is currently being pursued jointly by the two working groups Figawa[3] and ZVEI[4], comprising the German meter and device manufacturers. Completion of this standard is expected at the beginning of 2009. However, additional follow-up activities will be needed to achieve a European standard for smart metering systems.
Therefore, concurrent efforts regarding the development of a Europe-wide metering standard are also underway on the European level: by KEMA[5] on behalf of the Dutch regulators and by ESMIG[6] as the association of European meter manufacturers. These parallel and uncoordinated activities are proving to be ineffective. Therefore, these activities should be pooled as rapidly as possible – as also described in greater detail in Section 5.1 – in order to achieve a uniform European standard. The EU Commission is planning to award a respective mandate to a task force consisting of Cenelec[7], WELMEC[8], and ETSI[9]. Under the leadership of Cenelec, a European standard for smart metering is to be defined. This standardization approach ought to be supported by the German Federal Government.

[3] http://www.figawa.de/
[4] http://www.zvei.de/
[5] http://www.kema.com/
[6] http://www.esmig.ei/
[7] http://www.cenelec.eu/
[8] http://www.welmec.org/
[9] http://www.etsi.org/

3.4 Integration Technology

In addition to the energy technology layer for the generation, transmission, distribution, and usage of energy, the future **Internet of Energy** will also contain a communication layer, which will enable the flow of information along the value chain and will map the corresponding business processes. In order to achieve greater overall energy efficiency, improving this flow of information from the producer to the end user will be of vital importance.

As far as implementing this in ICT solutions with IT components is concerned, an integration level must be created between economic applications and the physical grid. Such an ICT platform must enable “end-to-end” integration of all components, beyond heterogeneous grids and company boundaries: from data-supplying end devices and smart meters via different communication channels right up to data provision for a multitude of different users, and from the end customer via the grid operator to the energy supplier.

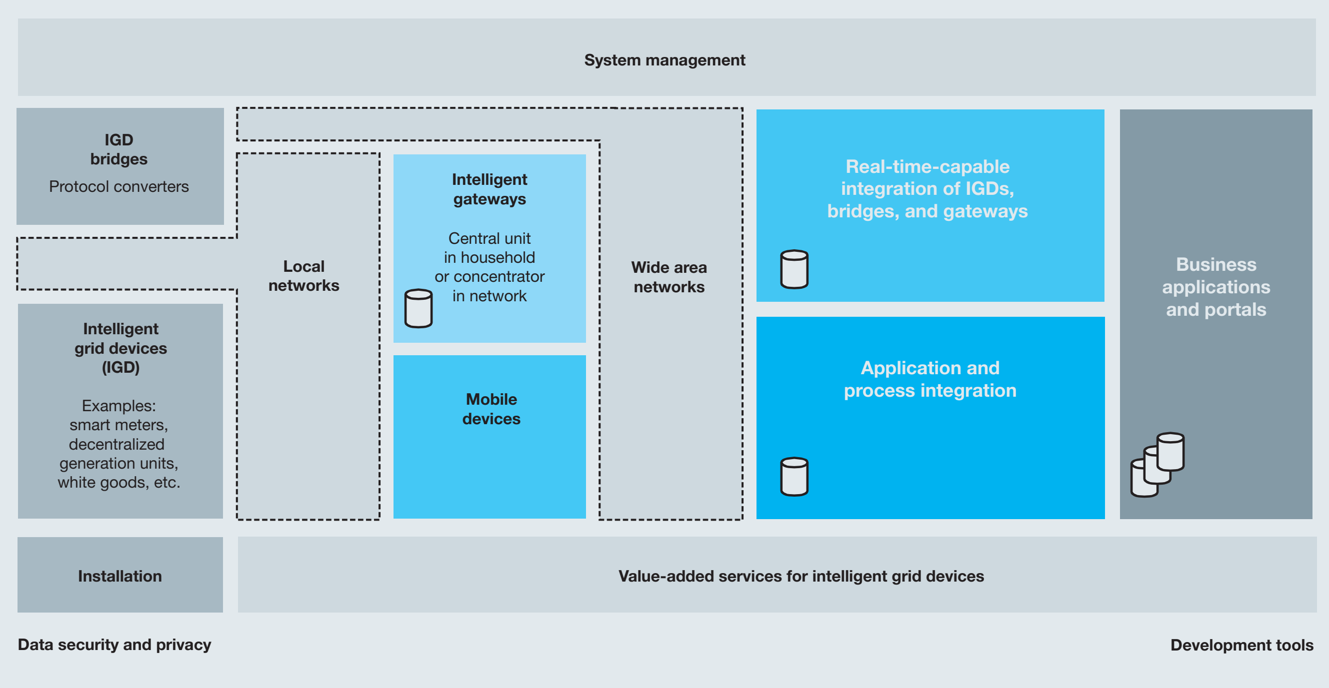
Integration infrastructure and communication lines pose the biggest challenge in realizing such an integration platform. Conceptually, a precise, albeit application-neutral technical definition of the core functionality of such a platform is necessary. It will form the basis on which both new and existing components can be integrated according to a uniform scheme, independent of the respective implementation.

In terms of technology, concepts from the area of service-oriented architectures (SOA) are particularly suitable for achieving flexible coupling and decoupling of individual components. Figure 10 shows an overview of sectors that must be integrated into an **Internet of Energy** platform. It must be possible to make the core functionalities of each of these sectors available via open standard interfaces, independent of the concrete implementation, and to integrate them into a joint, cross-domain Enterprise Service Bus (ESB). In this context, stringent message exchange protocols, standardized data formats, and secure data storage, usage, and transfer are very important.

One important benefit of a uniform SOA architecture is that point-to-point interfaces between single applications are avoided. Instead, each application only needs to implement one single interface to the integration platform, which can subsequently be used to address and dynamically use all other applications.

The unique feature of the approach described here is the extension of the service-oriented integration of individual components to intelligent end devices (Intelligent Grid

Figure 10: Requirements domains for the Internet of Energy



Source: BDI initiative Internet of Energy (2008)

Devices – IGD), which makes the overall system highly flexible and scalable. This approach is often referred to as "Extended SOA" (Keen, Chin et al. 2006).

Two areas of the interface architecture of such a platform are particularly critical: (i) the integration point for local grids in the IGD bridge or in smart meters and (ii) the intelligent gateways in the apartment, in the building, or in transformer stations. Only real-time integration at these points makes the information provided by the IGD, the independent remote reading systems, and the intelligent gateways directly available on the overall platform. Although realizing such fast data availability requires a lot of effort, it is necessary, especially if a large number of heterogeneous systems must be integrated while keeping the overall platform controllable at the same time.

One important element of such an integration platform is setting up central directory and search services listing the respective available functions (applications and devices) and making them accessible. This is the prerequisite for flexible usage. The necessary technical basis for setting up such services already exists today. In addition, many providers of economic software have integrated SOA interfaces into their own applications, so that, in principle, numerous applications would already be available today on such a platform.

The situation is similar with regard to the integration of electronic meters, which have undergone intensive development over the last few years (cf. Section 3.3), making the SOA-based integration of these devices technically possible even on a large scale in the context of so-called Advanced Metering Infrastructures (AMI) (Heimann 2008). New business models and services such as those described in Section 3.5 not only require fast availability of consumption information from smart metering devices, but increasingly also demand possibilities for active intervention and control. Thus, the integration of complex energy management solutions will constitute a major part of the integration work, beyond mere smart metering. Not only consumption information from the intelligent end devices (generally aggregated by smart meters) will be transmitted to the components in the network (such as residential meters, decentralized generation facilities, consumption devices, cooling units), but so will price signals, rate information, and similar things. This data will also be provided to the service suppliers for dynamic usage.

One unresolved problem relates to the semantics of the data exchange. The SOA interfaces of meter infrastructures and information systems normally only provide a syntactic structure, and the content of the messages exchanged via these interfaces must still be specified in more detail. An **Internet of Energy** can only be realized if, in addition to open interface definitions, the semantic structures of the messages to be exchanged have also been standardized. Here, legislation must be enacted to support the efforts of the German industry regarding the introduction of such standards and especially to support and promote these efforts on the European level as well.

The regulatory measures already mentioned in Section 2.2 have resulted in profound changes to the ICT landscape of the German energy sector during the past 12 months. The processes, for example, were fundamentally changed when ownership unbundling of grid operation and distribution became a requirement. For instance, originally, the transmission of a provider's meter data to its grid units was mapped as an internal process. The same was true for new lines or customer cancellations. In the future, however, these processes will have to be mapped across companies, which will lead to a more complex market structure (cf. Figure 4).

With the increasing liberalization of the energy markets, the requirements will continue to increase as regards ensuring greater flexibility of ICT infrastructures. Overall, the existing (individual) applications must therefore be further developed in order to merge them together into one large common platform – analogous to the Internet. On this aggregation level and with defined open interfaces and data exchange formats, it will become interesting to create new combinations of the functionalities offered by producers, transmission operators, and consumers, to develop innovative business models, and to thus realize further potentials for efficiency in a liberalized energy market.

3.5 Economic Applications and New Business Models

In addition to the energy technology infrastructures for the production, distribution, and usage of energy flows, there is another level, namely that of economic programs and applications. A multitude of applications is used to manage master data (e.g., data about business partners and their facilities), organize customer relationships (e.g., contracts, bills, and complaints), operate plants and equipment, organize manpower planning for employees, or process economically relevant energy data. In addition to these industry-specific functions, standard applications such as financial accounting, personnel management, or supply procurement naturally also play an important role.

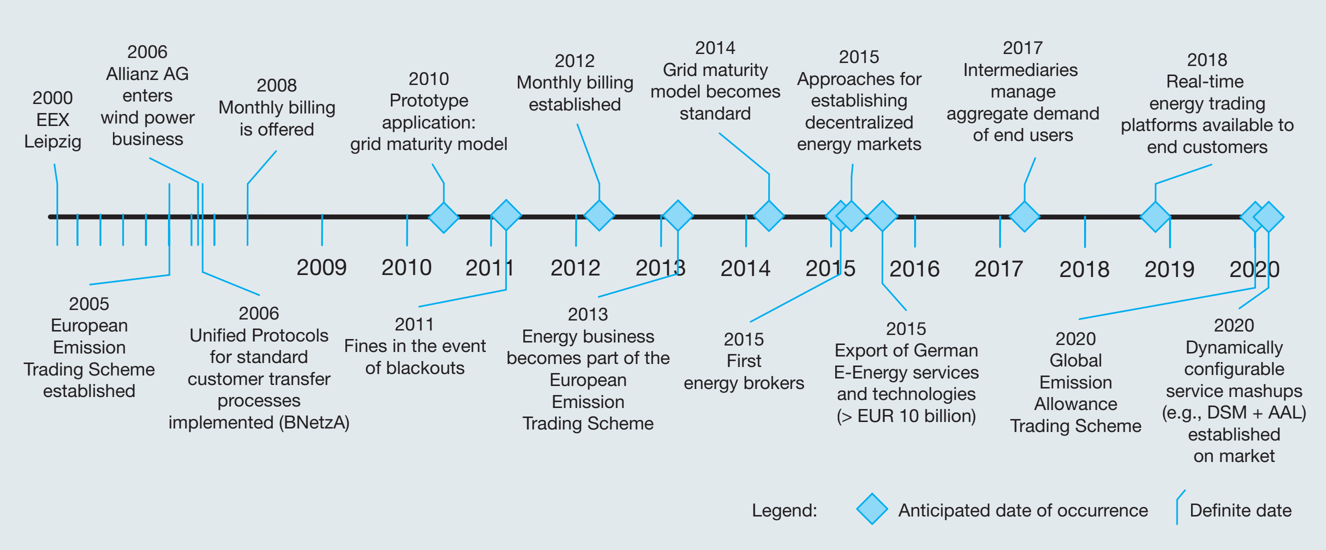
The ICT solutions commonly used today are primarily intended to support "traditional" business models of the energy industry. A business model describes the respective value added, the performance architecture needed to achieve it, and the revenue model (Stähler 2001). In the traditional model, a vertically integrated utility company supplies energy to a large number of customers and bills this energy periodically – for private end consumers, this is typically done on an annual basis. Its sales revenues are mainly generated from selling energy to customers. As comprehensively illustrated in Chapter 2, this traditional business model will be increasingly rendered moot in the future. The implementation of energy conservation measures as well as increased competition are leading to a decrease in the revenues obtained from electricity sales. Thus, in order to meet future challenges, it will be of decisive importance for a company's competitiveness to find new business models that take into account the changing framework conditions. New technologies such as smart metering and bi-directionally communicating end devices will create a totally new kind of market transparency as well as new opportunities. These will make a significant contribution to the development of such innovative business models, which can then be realized both by companies established in the sector and by new players alike.

With regard to the components of the **Internet of Energy**, appropriate business applications that are capable of mapping new business models quickly and flexibly also need to be made available and further developed. Defined open interfaces will be needed in this respect that make these applications interoperable in the **Internet of Energy**, thereby ensuring that the new possibilities can be implemented in an economically viable and efficient manner. Figure 11 shows an approximate timeframe for the different business models briefly described in the following sections.

3.5.1 New Business Models for Energy Producers

Lewiner (2002) describes a scenario in which energy producers, driven by massive political efforts to dissolve vertically integrated utility companies, will increasingly reclaim their original core business, namely, the generation of energy. However, in parallel to this, new technologies and thus new business areas such as biogas feed-in or electromobility are also on the verge of their large-scale launch into the market and offer enormous potential. The increasing decentralization of energy generation also leads to new business areas. Contracting, for instance, might become even more attractive for energy producers in the future. In this business model, an energy utility company installs and operates, among other things, cogeneration plants, micro gas turbines, or fuel cell heating systems at a customer's premises. Such models are attractive from an energy supplier's perspective, since (i) operating numerous smaller plants entails lower investment risks than operating one large plant, (ii) controlled decentralized generation

Figure 11: Trade and services – developments on the liberalized energy market



Source: BDI initiative Internet of Energy (2008)

enables better control of the grid load in transmission and distribution grids, (iii) a new form of providing balancing energy might become possible under certain conditions if these technologies are used on a large scale, and (iv) by operating the facilities on site, it is possible to achieve long-term contractual customer retention. From the perspective of the customer and the economy in general, the benefits of such a business model include (i) the elimination of initial investments, (ii) better energy recovery of the resources used, and (iii) a resultant reduction in energy costs. There are already suppliers that offer large-scale heat and CHP contracting for small and medium-size enterprises. As a result of increased funding for small CHP plants that has been approved in the meantime, this business model will also become attractive for residential customers in the future.

3.5.2 New Business Models for Grid Owners and Grid Operators

The impact of liberalization is currently most evident in the area of grid infrastructure. Transmission and distribution grids will, by and large, continue to be operated by natural monopolists in the future, who will continue to generate their revenues primarily from billing the actual energy consumption. The issue of ownership of these natural monopolists is currently being intensively debated. A Europe-wide consensus seems to be in the offing, according to which energy utility companies will have to spin off their grid-operating companies and run these as economically independent enterprises, which will provide both their parent company and other energy providers with non-discriminatory access to their sub-grid, albeit subject to a fee. In the future, this separation as well as the new communication requirements in the **Internet of Energy** will increasingly turn grid operators into information service providers that can supply the market not only with energy transmission services, but also with generation and sales data. It is conceivable that a grid operator will offer individually customized information packages and will charge for these according to expenditure and complexity.

3.5.3 Business Models resulting from Energy Trade and Marketplaces

Existing marketplace operators such as the European Energy Exchange (EEX) in Leipzig, the Amsterdam Power Exchange (APX), or Powernext in Paris, will certainly continue to be a force on the market in the future with their current business models. The trend of the last few years is expected to continue and the trade volumes and revenues of such marketplaces are set to continue to increase. In the future, institutionalized energy trading, which is currently still limited to a small number of market players, is likely to be gradually made accessible all the way to the end users. Operators of the trading platforms required for this purpose might be companies from outside the sector (e.g., stock exchanges). However, the established energy providers have experience with energy trading in its current form and are most familiar with sector-specific characteristics that have to be taken into account. Thus, based on these fundamentals, they would also be suitable as marketplace operators.

On the demand side, it might become attractive in the future for wholesale traders to use the newly emerging markets as (multi-utility) distributors in order to buy different energy resources and then resell customized products to retailers or large end customers (e.g., municipal utility companies). It would thus become very easy for customers to obtain the precise mix of energy that they require, without having to deal with the complexity of market-based procurement needed for this purpose. Furthermore, the development of a market for secondary products, such as insurance against failure/outage risks, price fluctuations, uncertain prognoses, or weather influences, is to be expected. Here, appropriate specialized providers from other sectors could also become active.

3.5.4 New Business Models for Service Providers and Retailers

This is the segment that is expected to undergo the biggest changes in the future. Pioneers in this area are spin-offs of existing companies (e.g., the electricity and gas provider Yello Strom GmbH as a subsidiary of EnBW AG, E wie Einfach of E.ON AG), which will soon be joined by service providers from outside the energy sector (e.g., TelDaFax AG, Allianz AG, Google Inc.) and by start-ups. In addition to the classical supply of energy, products individually customized to specific customer groups will also appear on the market (e.g., electricity, gas, and water from a single source), and a portfolio of third-party products (e.g., credit cards, cross-sector bonus programs) might round off the service offer.

Additionally, this might provide an opportunity to tap into completely new market segments with new services, such as optimization of a customer's energy consumption. It would also be conceivable for customers to enter into master agreements with specialized service providers, which would enable the latter to access and control decentralized generation capacities (e.g., cogeneration plants, parked electric vehicles) at short notice. This would thus enable a service provider to set up a virtual power plant for balancing energy, whose output could once again be offered in wholesale energy trading. Such a business model could also be combined with the contracting model.

Another important area is the dynamization of trade itself. Whereas static rate contracts are still standard for residential customers, this may fundamentally change following projects such as “Price Signal at the Power Outlet” (Frey 2007) as well as the introduction of price-variable rates, which were enacted into law by the *Bundesrat* (upper house of the Germany parliament) in July 2008. In the aforementioned project, customers receive real-time information about the development of energy prices over the next few hours and can then – initially manually, but later with the aid of home automation technology – optimize their energy consumption profile in terms of price. Several studies have shown that this makes it possible to reduce peak loads by approx. 6-20 percent (Lieberman and Tholin 2004; Valocchi, Schurr et al. 2007).

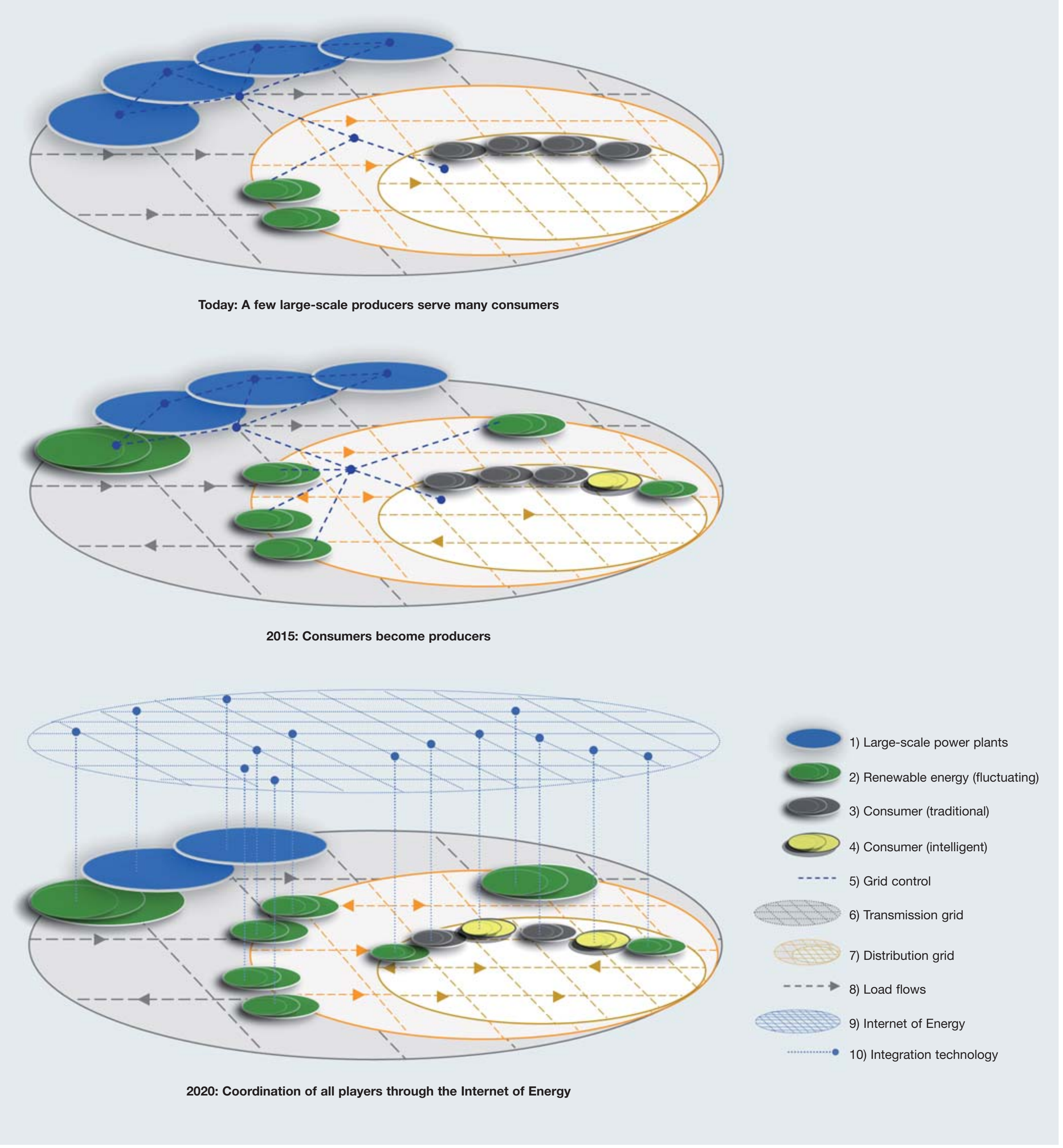
All new business models described here can only be realized with the use of modern ICT and consistent standardization of the communication protocols. In addition to the applications available today, it will become necessary to develop novel applications that complement existing software solutions or possibly replace them, and that can be integrated into an overall platform – as described in Section 3.4.

3.6 Transition Process to the Internet of Energy

A schematic drawing in Figure 12 shows the transition from the conventional energy grid to the **Internet of Energy**.
Basically, more customers will also assume the role of energy producers. The distribution grids and the central producers must be adapted to the resulting requirements in order to continue to ensure the stability of the grid and the quality of power. This will only succeed if an ICT network that can be used in real time is established in parallel to supply all stakeholders with data on offers and consumption and to transmit control and price signals.

It is obvious that the majority of the participants in this network (from residential households to commercial producers) can only interact effectively and efficiently if standardized interfaces and data exchange formats as well as highly automated business processes are available. In terms of the resulting transparency, and in light of the susceptibility of this infrastructure to new security attacks, security and user privacy must head the list of priorities that have to be realized. Access authorization and privacy regulations are thus core elements of the **Internet of Energy**, which are just as important as interfaces and data formats.

Figure 12: Transition process to the Internet of Energy



Source: BDI initiative Internet of Energy (2008)

4 Scenarios for the "Internet of Energy"

Developments and Opportunities in a Networked Energy Economy

The drive towards realizing an Internet of Energy contains complex interrelationships and mutually dependent milestones. Based on the three scenarios "Electromobility", "Decentralized Generation", and "Energy Trade and New Services", the interrelationships between possible developments together with their mutual dependencies, possible timeframes, and potentials can be understood.

4.1 Scenario I
Electromobility

The climate debate is one of the reasons why the issue of electromobility, i.e., the use of hybrid or purely electrically operated vehicles, has achieved widespread publicity. The German government is currently in the process of developing a "National Electromobility Development Plan", which is intended to make Germany the market leader in this area within the next decade. According to this plan, by the year 2020, at least 1 million vehicles that can be charged from the electric grid (so-called plug-in electric and hybrid vehicles) are expected to be in use throughout Germany. As soon as the proportion of plug-in (hybrid) electric vehicles (PHEVs) available in the future fleet of vehicles reaches a significant level, their storage devices will be able to be used systematically as buffers for capturing surplus supplies and for optimizing the load profiles. A significantly higher performance density of batteries and super-capacitors than today would give this development a significant boost. From a technical perspective, the pilot operation is not expected to start until 2013 at the earliest, the commencement date being subject to further development of the energy management systems inside the vehicle linked to a communication infrastructure between vehicle and provider. A further prerequisite is the making of concrete offers by utility companies that provide sufficient incentives for owners of plug-in electric vehicles to make the buffer service available to the providers and to guarantee purchase. Making electricity produced by photovoltaics cheaper until grid parity is achieved would provide further impetus to this trend, since this would lead to decentralized private producers investing more in photovoltaics. As a result, these private producers could either feed their surplus supply of energy into the grid or store it in their own vehicles.

For this scenario, see:
Figure 2: Prognoses and trends – availability of fossil energy sources and renewables;
Figure 8: Decentralized energy generation and storage.

4.2 Scenario II
Decentralized Energy Generation

Decentralized energy generation is one of the keys to reducing CO_2 emissions. The generation of heat and electricity in close proximity to where the load occurs reduces the primary energy demand by 60 percent compared to the centralized generation structure currently in use. In addition, decentralized energy generators in a network could help to make balancing energy available and to reduce the further extension of centralized supply. Overall, the introduction of small-scale cogeneration is still largely in its infancy today, despite the German CHP Act (KWKG, 2002, amended in 2008). On the distribution grid level and on the medium voltage level, several pilot projects are already under way, operated mainly by smaller energy providers (Stadtwerke Unna, Stadtwerke Karlsruhe), as are the first individual commercial projects that attempt to provide balancing energy by combining different decentralized cogeneration plants (e.g., Evonik 400 MW). All ongoing projects and applications are individual solutions that cannot be extended without substantial investment in technology and manpower. The first scalable solutions permitting the establishment and extension of a micro-grid are not expected until 2013 or later, because integrated ICT solutions are needed that can be used to combine and control different generation plants in one area, and because the local heat networks that transport the heat output of these plants to the end customers still need to be re-structured.

Furthermore, it will be necessary to also install micro generation facilities in residential buildings. Power-generating heating systems will be the main focus here initially and will establish themselves independent of the developments on the distribution grid level. Major pilot projects are slated to commence in 2010. In the long term, the demand for heat in the residential sector will become secondary due to improved heat insulation, while the demand for electricity is set to increase. Concurrent to this development, the focus will shift to power-operated micro cogeneration plants, fuel cells, and small combined heat and power plants.

As of 2010, the networking of power generation inside buildings with the loads and the energy supplied by the grid will be driven to a large extent by variable rates for energy procurement and feed-in. The introduction of smart meters is a basic prerequisite for this, since this is the only way in which consumption- and rate-dependent billing is possible. Complex energy management calls for interconnecting all major producers and consumers by means of load and generation control. The introduction of white goods that can be connected (as of 2011) as well as that of a consumer-side load management system (Demand Side Management – DSM, as of 2012) are major steps in this direction. Coupling the loads with the decentralized generators – if possible, one's own generators – will only become possible as of 2015 with the introduction of Decentralized Energy Management Systems (DEMS). These will permit automatic optimization of the energy consumption on the basis of set parameters such as CO_2 emission or price. Stationary and mobile storage devices (electromobility as of 2015 and, on a larger scale, as of 2020) can make a significant contribution to achieving these goals.

For this scenario, see:
Figure 3: Regulatory and political environment – regulatory measures in the energy sector;
Figure 8: Decentralized energy generation and storage;
Figure 6: Smart Home – use of ICT for energy optimization in residential households.

4.3 Scenario III
Energy Trade and New Services

As already partially laid down by sec. 40 of the German Energy Industry Act (EnWG), load-based and variable time-based rates for end customers will gradually replace the fixed electricity and gas consumption rates and prices charged today. Instead of fixed prices, an increasingly dynamic, market-based energy trade will be established, whose pricing mechanisms will promote more efficient use of energy. On the consumer side, this will become possible through the introduction of home automation technologies enabling transparent, intelligent, and (semi-)automated consumption control and thus dynamic response to variable energy prices. On the producer side, the installation of remotely controllable decentralized generator and storage technologies (incl. electric vehicles) as well as their dynamic combination into virtual power plants will enable rapid reaction to price changes on the market. These technologies will allow ever smaller generation and consumption units to directly participate in the on-exchange energy trading if they wish.

Customers who shy away from the resulting complexity of this trade can use specialized energy brokers to assume this task. For such intermediaries, it will become even more interesting to take on trading activities if customers grant them the right (against payment) to remotely control certain parts of their consumption or generation devices. The resulting balancing energy potential can then also be offered on the market. In the **Internet of Energy**, each producer and each consumer will be able to decide for him-/herself whether, for whom, and to what extent he/she will provide access to his/her devices. On this technological basis, new services will become possible, such as real-time consumption analyses or, for example, mergers into virtual consumption and generation communities.

For this scenario, see:
Figure 3: Regulatory and political environment – regulatory measures in the energy sector;
Figure 6: Smart Home – use of ICT for energy optimization in residential households;
Figure 8: Decentralized energy generation and storage;
Figure 11: Trade and services – developments on the liberalized energy market.

5 Designing the Transition Process
Concrete Recommendations

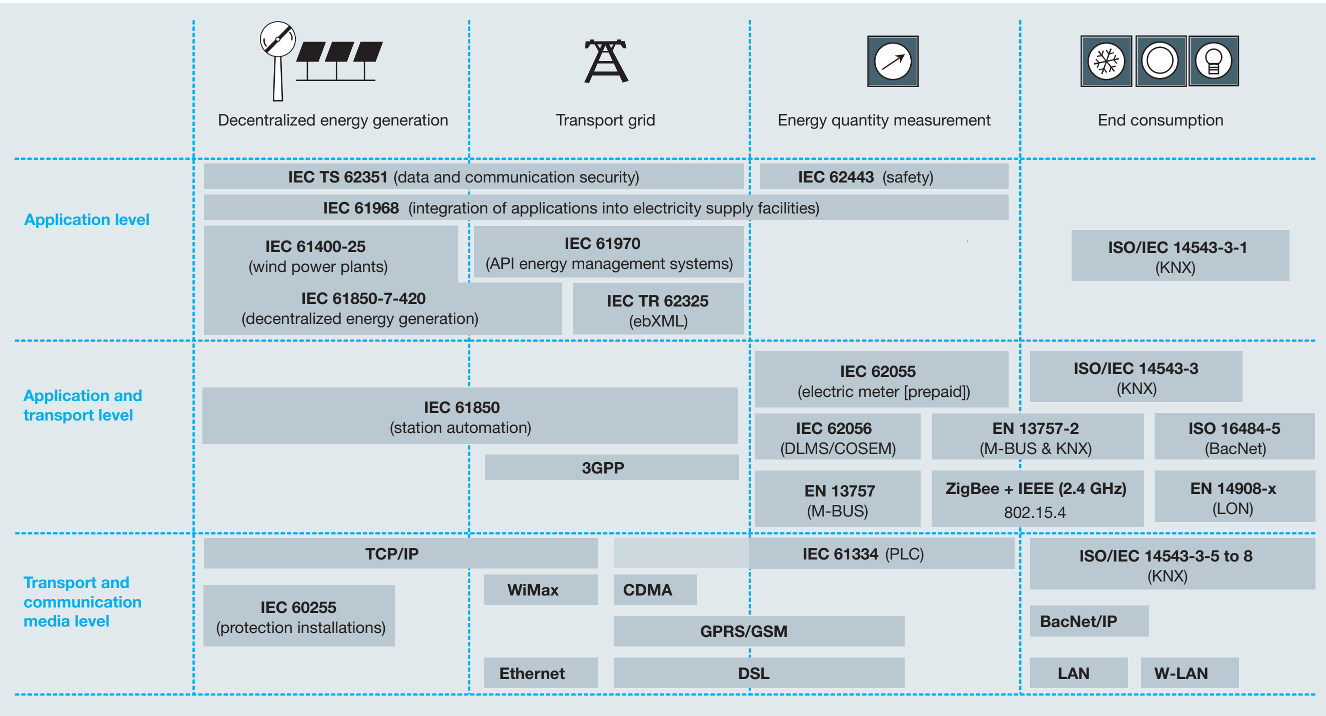
The major upcoming changes to the energy sector pose significant challenges. They will affect not only the traditional energy industry, but also many other sectors and players. If we want to realize the vision of a future Internet of Energy soon, and make sure that the developments will actually result in more efficient processes, we need to take targeted measures in the areas of standardization, research funding, and regulation.

5.1 Standardization

5.1.1 Harmonization and Integration of Existing Standards and Protocols

In the areas of generation, transport, and distribution of energy, up-to-date measurement and status values are an important issue when it comes to operating power plants and ensuring the secure and reliable supply of energy. Optimization of energy consumption is based on integrated and near-real-time electronic communication between producers and loads on all levels of the grid. For the individual sections of this integrated communication, communication protocols already exist worldwide and EU-wide (see Figure 13). These protocols are mainly limited to one section, meaning that an integrated communication system is still a long way off. As regards the introduction of Smart Grids, a key task in the near future in relation to the drive towards realizing the **Internet of Energy** will be the need to establish an integrated, bi-directional communication system from generation to the end consumer. Furthermore, the importance of virtual power plants will continue to grow, and these will be dependent on up-to-date energy data in the same way as the **Internet of Energy**. Thus, a comprehensive communication chain is a basic prerequisite.

Figure 13: Various standards in building automation, smart metering and energy technology



Source: BDI initiative Internet of Energy (2008)

5.1.2 Extending the Standardization Efforts to Gas, Heat, and Water

To achieve improved energy usage, all energy sectors will need to be integrated into the **Internet of Energy**; in other words, not only electricity, but also gas, heat, and water. The standardization framework presented above must therefore be expanded to all energy sectors – where this has not yet taken place. Only the intelligent and combined usage of different energy sources will make it possible to realize maximum gains in efficiency.

5.1.3 Coordinated Promotion of Interoperability

Currently, different groups and organizations across Europe are working on defining communication standards. However, it makes no sense if several institutions make parallel attempts to define standards. If we really want to achieve a global or at least a uniform European solution, then this must be done under the leadership of an independent institution, for example the IEC, CEN, Cenelec, ESMIG, or ERGEG. At the moment, the EU Commission is examining the possibility of giving a mandate to a task force consisting of Cenelec, WELMEC, and ETSI, see Section 3.3.3. This task force will be entrusted with bundling, orchestrating, and continuing to push ahead with all standardization efforts made so far.
The result of these standardization efforts must be a standard applicable throughout the EU, such as an IEC, EN, etc. The German government must support the establishment of such a task force and the speedy drafting of a standard.

5.1.4 Open Communication Standards for New Technologies

If an integrated communication system exists, new products and services can be developed. The communication system must also be available for these new products. The communication standards to be created must therefore be open to enable other applications to be integrated.

5.2 Incentives, Regulatory and Legal Framework

5.2.1 Creation of an Unambiguous Legal Framework

A new uniform and unambiguous legal framework will promote the development of an integrated communication system. Together with the development of a standard, the new legal framework will ensure the interoperability needed by the market players (customers, energy producers, technology companies, etc.) and provide sufficient legal stability and investment security.

5.2.2 Data Protection Compliance from the Outset

When the **Internet of Energy** is introduced, large amounts of different energy data on different levels of aggregation will be generated and transmitted. Thus, high priority should be accorded to data protection in particular during the design and implementation of the **Internet of Energy**, not least because of the high degree of awareness among consumers and the media regarding this issue. The legislature must actively promote the development of the **Internet of Energy** and, if necessary, make appropriate amendments to the existing legal framework in order to regulate data protection in this new environment. Only if clear and transparent legal regulations exist regarding access rights and restrictions for both read-only access to measurement and consumption units and control access to producers and consumers will the new technologies be embraced and achieve the necessary acceptance.

5.2.3 Providing Incentives to Grid Operators to Enable Sustainable Innovation

The operators of transmission and distribution grids are key players when it comes to realizing an energy industry networked via IT. Since the operation of a grid constitutes a natural monopoly, the economic constraints for cost-efficient electricity and gas grid operation are mainly established by the government. Policy makers should use this scope for action to pave the way for the drive towards greater efficiency and environmental friendliness. The current incentive regulations in Germany are aimed at strengthening the market and thus increasing competitiveness. The resultant risk is focusing too much on short-term cost reduction. Considering the upcoming fundamental changes in energy supply, this goal contradicts the development of a structure that is optimal in the long term. In the case of cost-based regulation as well as in the case of incentive regulation, the grid operator will try to avoid incurring expenses that will not be recouped by higher revenues resulting from grid usage fees. Entry into the **Internet of Energy**, however, calls for financial commitments in the areas of research and development and the pilot operation of new systems and investments in the grid infrastructure. The German Federal Network Agency (Bundesnetzagentur) should therefore ensure that grid operators are provided with sufficient incentives to make these investments. For example, such expenses could be considered and reimbursed separately when grid usage fees are regulated. It would also be desirable to promote better access to funding innovative solutions that consider the chances and risks in a suitable manner. This would be made possible by introducing a supplementary innovation component into the incentive regulation, similar to the Innovation Funding Incentive (IFI) in the United Kingdom, or through specific funding for energy-efficient solutions, as stipulated, for example, by the Californian incentive regulation. Denmark is also leading the way in setting itself targets that go beyond those of the EU, namely, generating 50 percent of its electricity from wind power by 2025, which can be promoted effectively if suitable regulations are in place.

5.2.4 Targeted Financial Incentives for Energy-Efficient Companies

On the part of the commercial energy consumers, the general electricity and energy tax discounts common in many sectors today should be conditional upon a company's use of an efficient energy management system. Companies that actively participate in measures designed to reduce energy consumption and implement an intelligent and efficient energy system should receive preferential funding. Such monetary incentives accelerate the use of such technologies and their networking, reward energy-efficient companies, and strengthen their competitiveness against less efficient companies. This would result in the quicker realization of the vision of a future-oriented energy system.

5.2.5 Promoting the Use of Innovative Networked Devices and Appliances among End Users

In the area of private end consumers, government programs can make a major contribution to speeding up the use of new technologies and to rewarding efficient energy consumption behavior. Consumers should be encouraged to allow temporal load shifts when operating their electrical appliances and to use smart meters in order to be more alert and conscious of their personal consumption and to recognize savings potentials. If we provide information about the new possibilities for people to intelligently and efficiently control their own energy consumption, then it will be easier to encourage them to start using the necessary technologies (also see Public Relations Work, Section 5.6). Targeted subsidies can further reduce the costs for residential households.

5.2.6 Promotion of Electromobility

In the future, the use of (hybrid) electric vehicles will also play an important role in climate protection. The batteries that these cars use to store electric energy could constitute an important buffer in the power grid, capable of absorbing power from the grid during times of increased energy availability (e.g., if during times of high winds, grids with a high wind-generation power capacity can store power) and feeding power back into the grid in bottleneck situations. Both research and development in this area as well as the practical usage of these concepts should be actively promoted by the government, for example by continuing to provide tax incentives for electric vehicles even after these have been rolled out in mass. Electrically operated vehicles are one of the most promising options for reducing emissions in the area of traffic and transportation and thus contribute to climate protection, provided they mainly use regenerative energies.

5.3 Research Promotion

5.3.1 Funding for “Multi-Utility” Projects Covering Several Sectors

Too often, “energy research” is still equated with “research in the area of electricity supply”. However, maximum synergies for higher overall efficiency can only be achieved if we take an integrated approach to electricity, heat, water, and possibly refrigeration. Initial activities such as the E-Energy projects[10] and the project DEUS 21[11] must be intensified in the future. On the one hand, this will require funding for projects to develop and pilot multi-utility smart metering that test the communication connection as well as the protocols and interface formats to be employed. On the other hand, appropriate standards must be further developed and tested as regards integrating smart generation, so that combined heat and power plants, controllable generators, and consumers with on/off switches (e.g., refrigerators) can be integrated and used without any problems. Integrated approaches, such as those in the E-Energy projects, which take into account the integration of generation, distribution, and consumption, should be given priority.

5.3.2 Funded Projects for the Realization of Virtual Power Plants

In the coming years, one task will be to combine different decentralized generation capacities with the possibilities of load control (process-controlled load shedding, e.g., in industrial production or through incentive-controlled behavior of residential consumers) in large-scale model projects and thus to achieve optimized energy efficiency of the supply infrastructure under consideration. In the context of the European technology platform Smart Grids (EC 2006), existing regional model projects should be expanded across national borders, so that by approx. 2021 – i.e., by the time of the planned nuclear power phase-out in Germany – virtual power plants will have been realized throughout Germany.

5.3.3 Funding of FACTS Pilot Projects in the German and European UCTE Grids

For regulating the energy flows between the balancing groups, technologies such as FACTS and HVDC must be established area-wide on the network side. Although these are not being used yet in Germany, they can make a decisive contribution to the improved usage of transmission grid capacities. By realizing large-scale pilot projects in the German and European UCTE grids, we should create the possibility to study and demonstrate the potentials of these technologies systemically and in real operation, thus minimizing technology risks, removing reservations held regarding these technologies, and demonstrating their practical benefit for the management of high-voltage lines.

5.3.4 Basic Research on Energy Storage and Transfer

In the more technology-oriented areas of basic research, there should be a separate research focus on the storage and (long-distance) transmission of electricity, since the demand for sustainable solutions will grow with the increasingly decentralized and geographically distributed generation of power and the increased usage of electric vehicles. The funding initiative “Lithium-based Energy Storage Devices” of the German Federal Ministry of Education and Research BMBF is a good starting point for this, but it is not comprehensive enough. Technologies worth funding in this area also include, for example, large chemical energy storage devices in the form of redox flow systems[12] for stationary use and electric double layer capacitors (supercaps) as a promising successor technology for battery storage devices in electric vehicles.

5.3.5 Study of End Consumer Behavior, Incentive Schemes, and Technology Acceptance

The largest energy optimization potential lies in each individual’s conscious change in behavior. However, individual incentives provided with the intent of changing people’s behavioral patterns are currently insufficient. Although every citizen is by now aware of how important it is to save energy, only a small minority are adapting their lifestyle and consumer behavior accordingly. Increased funding for economic and sociological projects should start from here. Such projects should study incentive schemes and group effects aimed at raising public awareness about energy efficiency, which will contribute to long-term changes in attitude and behavior. Another factor for the delayed introduction of innovative energy savings technologies may be their lack of user acceptance. In studies and research projects on this topic, we should therefore thoroughly check which expectations, needs, and fears end consumers have in dealing with intelligent end devices, so that the lessons learned can be taken into account when designing and implementing the **Internet of Energy**.

[10] http://www.e-energie.info
[11] http://www.isi.fhg.de/n/Projekte/deus.htm
[12] cf. http://www.vrbpower.com

5.4 Funding Methodology and Reorganization

5.4.1 Better Coordination of Funding Activities

German research funding in the area of energy remains very disparate. In specific research and innovation policy initiatives conducted between 2006 and 2009, six different federal ministries were named as responsible coordinators – and coordination with EU initiatives is not under discussion. Thus, the first recommendation is to bundle all activities for funding energy research across ministerial boundaries into the hands of one national coordinator. This coordination agency should possess the requisite expertise and be entrusted with the task of better coordinating individual activities in order to achieve the goal of more target-oriented research.

5.4.2 Stronger Focus on Systemic Research

The current focus on some technologies considered especially worthy of funding is unidirectional and too short-sighted. Therefore, a systemic approach is advocated including sub-areas of energy research from the engineering sciences, computer science, as well as from the economic and social sciences. All these areas should be placed into a comprehensive context. A good example of this is the newly founded "KIT Centre Energy" of the Karlsruhe Institute of Technology.[13]

5.4.3 Certify and Reward Pioneers in Intelligent Energy Usage

In addition to providing direct financial subsidies for projects, funding instruments that provide companies with the opportunity to make a name for themselves as pioneers in a certain area such as climate protection have also proved to be successful. Certifications, awards for the most energy-efficient company, participation in innovative and highly visible pilot projects, as well as prizes (analogous, e.g., to the X-Prize for the first private space flight) can provide a strong incentive for a company to make a sustainable commitment.

5.4.4 Integration of the Public Sector into the Internet of Energy

The emergence of the **Internet of Energy** can be actively promoted by integrating the public sector at an early stage. Public buildings such as schools, universities, administrative agencies, and city halls can be used to demonstrate best practices in a manner that is highly visible to the public. At the same time, the associated contracts and investments will directly promote the pertinent business areas and thus drive the development and installation of the necessary technologies. The public sector would thus actively contribute to saving energy, and would then be in a position to demand more forcefully that citizens also follow suit. In addition, the processes of the public sector themselves should become compatible with the standards of the **Internet of Energy**.

[13] http://www.forschung.kit.edu/147.php

5.5 Continuing Education and Training

5.5.1 Interdisciplinary Courses of Study

With the emergence of the **Internet of Energy**, the demand for skilled personnel, especially from the areas of electrical engineering and computer science, but also from the economic sciences, will continue to grow. In particular, graduates with dual qualification will be needed. In order to be ready to meet this increased demand, German universities should introduce appropriate courses to the course curriculum.

5.5.2 Extension of the Continuing Education and Training Programs

In addition to university education, the national continuing education and training program must also be adapted. Electricians, mechatronic engineers, and plumbers will have to install and maintain very complex components such as electronic meters or home automation solutions in the **Internet of Energy**. These will require not only electrotechnical skills, but also ICT skills. Furthermore, there will be a large demand for IT specialists with good knowledge of the energy sector. Although there is a high demand for intelligent components such as smart meters, DEMS, etc., there is a dearth of appropriately qualified IT specialists. In order to meet these new demands, new apprenticed trades must be created and the existing apprenticed trade regulations must be adapted and extended.

5.6 Public Relations Work

5.6.1 Communicating the Potentials and Benefits to the General Public

The **Internet of Energy** has the potential to revolutionize many areas of our lives. If this is to happen, though, customers must be willing to accept certain changes in existing lifestyles in the future, something that cannot be taken for granted. For example, in the future, a user will not directly turn on the washer when it is filled, but only give it permission to run. The system will then optimize the time when the washer will actually run from the perspective of overall energy efficiency, but still in accordance with user preferences. In order to accept something like this, the general public must be comprehensively informed about the system, its applications, and especially about the associated benefits in terms of improved efficiency and climate compatibility. We must therefore present the respective technical and energy industry-related backgrounds and contexts to different target groups in a clear and comprehensible way.

5.6.2. Confidence-Building Measures

The necessary resources must be made available to trustworthy sources, in particular, to present and communicate the issue of the **Internet of Energy** to the general public, and to answer and resolve related questions. A good way to heighten public awareness of the impending changes would be to disseminate brochures, hold expert conferences, or take out advertisements in daily newspapers. These measures must go hand in hand with the active design of the legal framework and the precautionary data protection regulations. The measures taken for implementing data protection must be made transparent at an early stage of the process.

E-Energy: Germany Working towards an "Internet of Energy"

Increasing demand for energy, depleting fossil-based resources, and climate change are emerging as a huge challenge to the electric power supply industry. New solutions are called for, which will provide maximum economic viability and security of supply and ensure that the highly complex power supply system remains environmentally compatible. The aim is to create a system that minimizes energy losses and better handles the fluctuating generation of renewable energy sources such as wind power and solar energy by integrating them into an energy system that will also enable the integration of electric vehicles into the power supply system of the future. Despite advances in technology, today's electric power systems are unable to perform complex tasks such as feeding energy into a power network; energy that is, for example, generated by solar collectors which transform houses into mini power plants.

E-energy: ICT-based energy system of the future

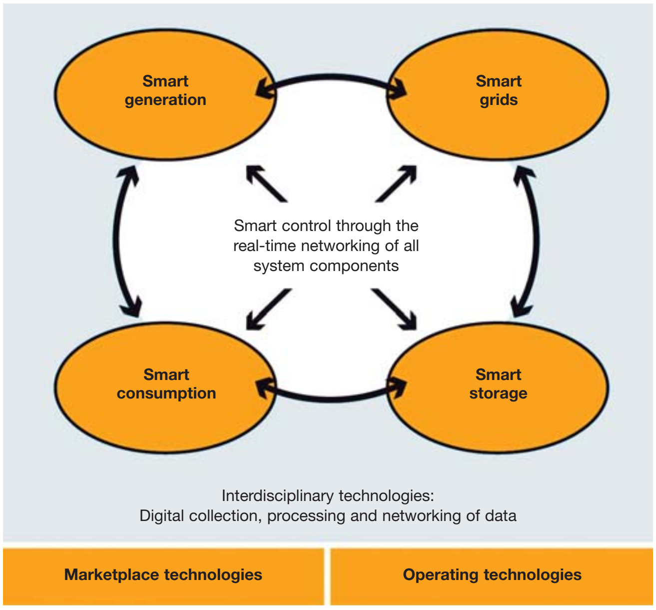
Current analyses and expert assessments have made it clear that, in order to solve the problems, not only further progress in the field of energy technology is necessary but, above all, comprehensive digital networking and a far greater use of computer intelligence. The aim is to create an intelligent electricity system that is practically self-regulating, in which all the elements in the commercial energy supply chain are digitally interconnected and optimally coordinated. Information and communication technologies (ICT) will play a key role in the modernization of the electricity industry.

The German Federal Government has been quick to recognize the need to find innovative energy solutions and has launched the "E-Energy" technology support program with a budget of approximately EUR 140 million in order to boost and intensify necessary research and development activities (R&D). The funding program was initiated in April 2007 by the Federal Ministry of Economics and Technology (BMWi) and is now being conducted in conjunction with the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

As part of the E-Energy project, six model regions were selected to develop and test the core technical components of E-Energy solutions, which will intelligently monitor, control, and regulate the entire electricity supply system all along the chain from power generation and distribution to storage and energy consumption. E-Energy has been declared a beacon project that aims to motivate businesses and regions to contribute to the development of a highly efficient, ICT-based energy system. In addition to making project funding available, the BMWi will also encourage ancillary research aimed at addressing strategic problems and working together to develop the solutions. This research will focus on cross-cutting issues such as software architecture, the standardization of open interfaces, acceptance, and legal conformity. In addition, the ancillary research will work towards creating a national and international network to ensure the rapid communication of results and the development of potential synergies.

E-Energy will contribute to a greener environment, present a good opportunity for the creation of new future-oriented jobs, and open up new multi-billion markets. One of the key functions of the E-Energy beacon project is to create highly efficient solutions to promote the expansion of decentralized and renewable energy sources through system integration and to provide a launch pad for an optimum integration of electric vehicles into the power network so that electromobility can make an important contribution to increasing energy efficiency, as a means of energy storage and by utilizing its potential as control energy. The aim is to create an integrated data and energy network with innovative structures and functions. Digital measuring devices (smart meters) will replace today's electricity meters, providing the basis for innovative control and monitoring systems that will guarantee the equilibrium between power generation and power consumption. These control and monitoring systems will ensure that power generation, network load, and power consumption are synchronized at all times and that this interaction functions largely automatically. This will help reduce peak load times and minimize expensive control energy as well as reduce the load on the power network and increase the security of energy supply. ICT gateways can be preset to coordinate the activation of power consumption facilities, to switch on small cogeneration plants, or to feed power into the network from storage units. The E-Energy initiative will also create a new, electronic "energy marketplace" where all types of service providers can showcase new products and services that go far beyond the mere selling of power. Examples of possible services are specific energy-saving programs, the monitoring and remote control of electrical devices, and charging the batteries of electric vehicles using low-cost "green" power as it becomes available (e.g., in strong winds). End consumers can also play an active role in this marketplace; for example, they can sell small amounts of home-generated power (e.g., from their solar power system or mini cogeneration unit).

Figure a: The Internet of Energy integrates all the elements in the energy supply chain to create an interactive system



Source: E-Energy, Federal Ministry of Economics and Technology

E-Energy links processes within the energy industry to create an interactive system

Up to now, the prevailing paradigm of power supply has been "consumption-oriented power generation". In the future, it will be practically impossible to maintain this one-way system, for the new power supply systems of tomorrow will be based to a far greater extent on weather-dependent energy sources such as sun and wind. For this reason, innovative ICT solutions are to be created within the six E-Energy model regions (see below), which will, for the first time, enable a "generation-oriented power consumption" system to be implemented alongside conventional "consumption-oriented power generation". Within the framework of the E-Energy model regions, our electricity system, which has been unidirectional up to now, will be developed into a highly complex, intelligent, interactive real-time system that will digitally link all the elements in the energy supply chain.

One of the functions of the Internet of Energy will be to link central and decentralized power generation units and integrate them to form a harmoniously-operating network. It will be able to create a dynamic equilibrium between volatile renewable energy sources and fluctuating power consumption and guarantee precise regulation and optimum utilization of the power network. A self-regulating network controlled by central and decentralized computers can activate power-consuming devices on demand, for example, when low-cost surplus energy is available from strong winds. At the same time, the interaction between electrical devices and power networks ensures that the grid is not overloaded. Refrigerators and heat-pump units, for example, or washers and dishwashers could be regulated by an ICT-based, generation-oriented load management system and be supplied with volatile renewable energy.

E-Energy as a launching pad for electromobility

A prime example for the effectiveness of the E-Energy system is the safe, cost-efficient integration of electromobility into the power supply chain while maintaining overall network stability. With electric vehicles, the precise time at which the battery is charged is irrelevant. The important thing is that it has been charged by the time the vehicle is next used. In the Internet of Energy, electric vehicles will be able to register their current position, the energy level of the battery, and the time at which it must be recharged to a specific level via the "Internet of Energy". The owner of the vehicle can, for example, preset the system so that the battery will be charged at lowest-possible cost, or so that the battery should generally only be charged with "green power". If the owner of the battery so desires, the E-Energy systems can even ensure that any power remaining in the battery is fed back into the network in order to cover peak period demand. In this way, electric vehicles are transformed into storage and control elements as part of the intelligent power network of the future. The National Electromobility Development Plan is paving the way for the spread of electromobility across Germany. The development, infrastructure, and market launch of the electric vehicles will be subsidized in a 10-year program. With the E-Energy project as a "launching pad", the Federal Ministry of Economics and Technology is supporting new application-oriented research focusing on "ICT for electromobility".

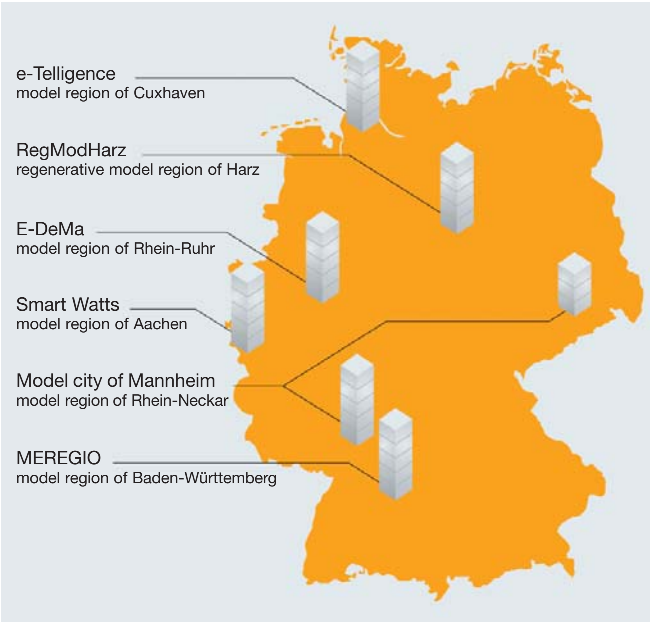
E-Energy creates new jobs and growth markets

E-Energy unites the major marketplaces in the fields of energy and ICT. This creates cross-sector areas of employment with enormous potential and marketplaces that require totally new forms of technical and business cooperation. The E-Energy project also bolsters growth prospects in the form of innovative services and new business models and by providing a variety of innovative technical products that need to be installed and serviced. A number of small and medium-sized businesses – first and foremost energy utility companies – stand to benefit from E-Energy as will engineering firms, producers of hardware and software, and globally active companies involved in energy facility construction projects.

The Six E-Energy Model Regions at a Glance

Within the framework of the E-Energy beacon project, six model regions are being supported by the Federal Ministry of Economics and Technology (BMWi) in an interdepartmental partnership with the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

Figure b: Model regions of the E-Energy beacon project:
The six model regions in the E-Energy technology competition are developing solutions for the ICT-based energy system of the future.



Source: E-Energy, Federal Ministry of Economics and Technology

Further information can be found at www.e-energy.de.

eTelligence – model region of Cuxhaven
The aim of the eTelligence program in the Cuxhaven model region is to implement concepts for the energy supply network of the future. The region is perfectly suited for this project because a large proportion of its energy needs are covered by renewable energy sources. The crux of the Cuxhaven eTelligence project is to create a regional energy marketplace that brings all market participants together online, i.e., power generators, power consumers, energy service providers, and power network operators. In addition, the project team is also incorporating consumers into the project, such as the fishing industry with its refrigerated warehouses and swimming pools, thereby creating new, controllable energy storage that assists in compensating for the variations in wind power production.

The partners in the project are linked via state-of-the-art information and communication technologies (ICT). In the long term, standardized plug and play interfaces will facilitate the entry of new power generators and power consumers into the system. In addition, consumers will be able to identify “energy guzzlers” in their own homes via an online platform and adapt their consumption behavior. In order to establish what the market participators expect from an E-Energy marketplace, the eTelligence project will examine the extent to which users approve the new system and will present the ideas and concepts of the Internet of Energy to locals as well as visitors to the Cuxhaven vacation region.

The participants in the eTelligence project are:
EWE AG,
BTC AG,
OFFIS e.V.,
energy & meteo systems GmbH,
Fraunhofer-Verbund Energie,
Öko-Institut e.V.

Further information: www.etelligence.de

E-DeMa – The development and demonstration of decentralized linked energy systems to create the E-Energy marketplace of the future

A large private energy service provider is working together with a medium-sized municipal energy service provider in the Rhine Ruhr area model region to develop an E-Energy marketplace by the year 2020. One important feature of the E-DeMa project is that it includes both representative rural areas and urban areas. Smart household devices also play an important role, as does communication via smart ICT gateways.

The aim of the project is to develop an integrated data and energy network that intelligently controls power consumption. An open electronic marketplace will connect private power consumers with energy distributors, grid network operators, and suppliers of other energy services. The concept of a customer does not exist. The customers are both producers and consumers of energy, commonly referred to as "prosumers". The aim of the E-DeMa project is to pool small amounts of generated energy in order to provide Germany with a more flexible and more decentralized energy supply.

One key element of this project is a system comprising "smart gateways" that allow for constant bidirectional monitoring of power supply and demand. The new smart electricity meters allow customers greater flexibility in that they are able to enjoy lower rates by adapting power consumption in their homes to a variable electricity price. Customers are equipped with smart household devices, meaning that they are actively integrated in the energy system, which thus becomes more transparent. Information and communication technology will enable the power supply network to be optimized into decentralized distribution grids.

Participants:
RWE Energy AG,
Stadtwerke Krefeld AG,
Siemens AG,
ef.ruhr GmbH,
Miele & Cie. KG,
Prosyst Software GmbH

Further information: www.e-dema.com

MEREGIO - the emergence of "minimum emission regions"

The aim of the MEREGIO Baden Württemberg model region is to fulfill the demand for more efficient, decentralized energy systems. In order to accomplish this, decentralized power generators, smart storage systems, as well as private and commercial power customers are to be linked via data lines. Creating an energy marketplace that will coordinate energy supply and demand together with the complementary power service providers is the centerpiece of the MEREGIO project.

The key objective of the MEREGIO project is to ensure more efficient use of combined heat and power plants and fuel cells. Variable power rates will ensure genuine consumer choice, with the aim of reducing greenhouse gas emissions. The project will incorporate and analyze the input provided by 1000 households and commercial businesses, which have already been equipped with smart metering systems in order to make the system more transparent for consumers.

The smart electricity meters provide data useful for planning, load transfer, and for calculating variable rates, thus creating an active awareness geared towards more efficient energy use. Another important aspect of this project is the fact that the entire system is controlled by one central platform. Price incentives will be used to control power consumption so that energy is consumed when it is cheap and when sufficient energy is available. The success of the region will be documented by the Minimum Emission certificate.

Participants:
EnBW Energie Baden-Württemberg AG,
ABB AG,
IBM Deutschland GmbH,
SAP AG,
Systemplan GmbH,
Universität Karlsruhe (TH)

Further information: www.e-energy.de/de/meregio.php

Mannheim model city in the Rhine-Neckar metropolitan region

In its plans for an energy supply system of the future, the consortium concerned with the model city of Mannheim envisages an intelligent power network connected to numerous decentralized energy producers and power rates, which are calculated according to supply and demand.

The model city of Mannheim is working to transform this vision into reality. The project is concentrated on an urban agglomeration with a high supply density where both renewable and decentralized energy are widely used.

The E-Energy project in Mannheim – which will also be carried out in Dresden in order to demonstrate the transferability of the scheme – will encompass a representative large-scale test using new methods for improving energy efficiency and network quality and will demonstrate the ways in which renewable and decentralized energy can be integrated into the urban distribution grid. The key objective of the project is to develop a multi-disciplinary approach (electricity, heat, gas, water) that creates an open platform equipped with a broadband powerline infrastructure integrating the various components. Customers will be offered electricity from a nearby source at the time of its generation. This will prevent power losses during transport and will include the use of decentralized energy storage. The energy market of the future will empower energy consumers to better manage their power consumption and personal energy generation (as a prosumer) in accordance with variable time-based rates. In addition, real-time information and energy management components will help the customer to make his personal contribution to achieving greater energy efficiency.

Participants:
MVV Energie AG,
DREWAG – Stadtwerke Dresden GmbH,
IBM Deutschland GmbH,
Power PLUS Communications AG,
Papendorf Software Engineering GmbH,
Universität Duisburg-Essen,
ISET – Verein an der Universität Kassel e.V.,
ifeu Heidelberg GmbH,
IZES GmbH

Further information: www.modellstadt-mannheim.de

RegModHarz – Regenerative model region of Harz

The aim of the E-Energy project known as the “Regenerative model region of Harz” (RegModHarz) is the technical and economic development of renewable energy resources and their integration into everyday life. A factor of major importance is to ensure the stability of the power network notwithstanding the highly volatile nature of renewable energy sources. For this reason, the pilot project will connect suppliers and consumers of renewable energy and integrate them into a virtual power plant, making use of electrically-powered vehicles to provide temporary energy storage and thereby optimizing future coordination between power generation and power consumption. This concept, in connection with an electronic marketplace in the form of an online network, guarantees to the participating power suppliers, power distributors, network operators, and consumers an electronic marketplace that ensures them an energy supply conforming to the highest ecological and economic standards.

The Bidirectional Energy Management Interface (BEMI) controls household devices and ensures that household devices such as freezers, refrigerators, and washers can be switched on at times when cheap electricity is available and then turned off again.

In the Regenerative Harz model region, a number of suppliers of renewable energy are cooperating in a comprehensive energy system. One of the participants in the project is the Wendefurth pumped storage hydro power station, for example, which contributes 80 megawatts of turbine power; another is the Druiberg Energy Park in Dardesheim, which comprises numerous wind power plants and photovoltaic energy plants. Electromobility is another integral RegModHarz project concept. Electric vehicles are equipped with a bidirectional interface, which enables them to store power originally supplied from wind energy and subsequently feed this power back into the energy network. In this way, they function as temporary energy storage for volatile wind energy.

Participants:
Cube Engineering GmbH,
envia Mitteldeutsche Energie AG,
envia Verteilnetz GmbH,
E.ON Avacon AG,
Fraunhofer-Institut für Fabrikbetrieb und -automatisierung IFF,
Halberstadtwerke GmbH,
Harz Regenerativ Druiberg e.V.,
HSN Magdeburg GmbH,
Universität Kassel IEE Rationelle Energiewandlung,

in.power GmbH,
ISET – Verein an der Universität Kassel e.V.,
Landkreis Harz,
Otto-von-Guericke-Universität Magdeburg,
RegenerativKraftwerk Harz GmbH & Co KG,
Siemens AG,
Stadtwerke Blankenburg GmbH,
Stadtwerke Wernigerode GmbH,
Stadtwerke Quedlinburg GmbH,
Vattenfall Europe Transmission GmbH

Further information: www.regmodharz.de

Smart W@tts

Smart W@tts has developed the smart kilowatt hour, which will become a major factor in a more decentralized energy market. This "smart" energy system will pave the way for public utility companies, manufacturers of electrical devices, service providers, and consumers towards optimized energy consumption and increased efficiency.

To help achieve this goal, an automated transaction platform is necessary through which the increasing volume of standardizable business transactions between participants in the energy system can be concluded efficiently and at minimum risk. In the course of the pilot project, approximately 500 households will be equipped with Smart W@tts electricity meters and compatible intelligent household devices by the year 2011. In addition, electric vehicles will also be included in the field experiment. The aim of this pilot project is first and foremost to examine the practicability of various solutions for energy suppliers and consumers, and, additionally, to test and document the effects of the concept on the energy industry.

In the future, required smart meter systems will be able not only to process the values that have been read, but also to furnish consumers with real-time information on rates and prices in their homes. One forecasting method makes it possible to predict the way in which changes in the rates will affect consumer behavior so that these price changes can be measured correctly. One specific electronic component makes price information available that relates to specific devices and consumers. This enables consumers, for example, to take advantage of differences in price to optimize household consumption ("Customers are able to plan ahead as regards using their appliances and equipment when cheaper electricity is available!"). Hence, this electronic component functions as an intelligent balance between supply and demand.

Participants:
utilicount GmbH,
Soptim AG,
Forschungsinstitut für Rationalisierung an der RWTH Aachen,
PSI Büsing & Buchwald GmbH,
Kellendonk Elektronik GmbH,
Stadtwerke Aachen AG

Further information: www.smartwatts.de

Appendix
Figures

Abbreviations

µ-CHP	Micro combined heat and power generation (small CHP plants))
AAL	Ambient Assisted Living
APX	Amsterdam Power Exchange
ARegV	Anreizregulierungsverordnung (Incentive Regulation Ordinance)
BACnet	Building Automation and Control Networks (communication standard)
BDEW	Bundesverband der Energie- und Wasserwirtschaft e.V. (German Association of Energy and Water Industries)
BDI	Bundesverband der Deutschen Industrie e.V. (Federation of German Industries)
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe (Federal Institute for Geosciences and Natural Resources)
BMBF	Bundesministerium für Bildung und Forschung (Federal Ministry of Education and Research)
BMWi	Bundesministerium für Wirtschaft und Technologie (Federal Ministry of Economics and Technology)
BNetzA	Bundesnetzagentur (Federal Network Agency)
CCS	Carbon Capture and Storage
Cenelec	Comité Européen de Normalisation Electrotechnique
CHP	Combined heat and power generation
CHP plant	Combined heat and power plant
DEMS	Decentralized Energy Management System
DSM	Demand Side Management
EEG	Erneuerbare Energien Gesetz (Renewable Energy Sources Act)
EEX	European Energy Exchange
EIB/KNX	KNX Association
EnEV	Energieeinsparverordnung (Energy Conservation Ordinance)
EnWG	Energiewirtschaftsgesetz (Energy Industry Act)
ERGEG	European Regulators' Group for Electricity and Gas
ESB	Enterprise Service Bus
ESMIG	European Smart Metering Industry Group
ETSI	European Telecommunications Standards Institute
FACTS	Flexible Alternating Current Transmission System
Figawa	Bundesvereinigung der Firmen im Gas- und Wasserfach e. V. (German Association of Firms in the Gas and Water Industries)
GaBi Gas	Grundmodell der Ausgleichsleistungs- und Bilanzierungsregeln im Gassektor (Basic Model of Balancing Services and Balancing Rules in the Gas Sector)
GasNZV	Gasnetzzugangsverordnung (Gas Network Access Ordinance)
GeLi Gas	Geschäftsprozesse Lieferantenwechsel Gas (Business Processes for a Change in Gas Supplier)
HVDC	High-Voltage Direct Current transmission
ICT	Information and Communication Technologies
IFI	Innovation Funding Incentive
IGBT	Intelligent inverter
IGD	Intelligent Grid Devices
KEMA	Beratungs- und Prüfgesellschaft für die Energiewirtschaft (association for energy consulting and testing & certification)

KWKG	Kraft-Wärme-Kopplungsgesetz (Combined Heat and Power Generation Act)
LED	Light-Emitting Diode
LON	Local Operating Network
MessZV	Messzugangsverordnung (Metering Access Ordinance)
OLED	Organic LED
PEV	Plug-in Electric Vehicle
PHEV	Plug-in Hybrid Electric Vehicle
SOA	Service-oriented Architectures
StromNZV	Stromnetzzugangsverordnung (Electricity Network Access Ordinance)
TEHG	Treibhausgas-Emissionszertifikate-Handelsgesetz (Greenhouse Gas Emissions Trading Act)
TWh	Terawatt hour
UCTE	Union for the Coordination of Transmission of Electricity
VDE	Verband der Elektrotechnik, Elektronik, Informationstechnik e. V. (Association for Electrical, Electronic & Information Technologies)
WEP	Wind energy plants
WELMEC	Western European Legal Metrology Cooperation
ZigBee	Low-power wireless standard of the ZigBee Alliance
ZVEI	Zentralverband Elektrotechnik- und Elektronikindustrie e. V. (German Electrical and Electronic Manufacturers' Association)

Literature Sources

Allianz (2006). "Energie der Zukunft." accessed 15.12.2007, http://www.allianz.com/de/allianz_gruppe/presse/news/finanznews/beteiligungen/news6.html.

BGR (2008). Reserven, Ressourcen und Verfügbarkeit von Energierohstoffen 2007 – Jahresbericht 2007. Hannover, Bundesanstalt für Geowissenschaften und Rohstoffe.

BMU (2008). Klimaschutz-Impulsprogramm zur Förderung von Mini-KWK Anlagen. Berlin, Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit.

BMWi (2006). Potenziale der Informations- und Kommunikations-Technologien zur Optimierung der Energieversorgung und des Energieverbrauchs (eEnergy), Bundesministerium für Wirtschaft und Technologie.

BNetzA (2006). Geschäftsprozesse für den Lieferantenwechsel im Gassektor (GeLi Gas), Bundesnetzagentur. BK7-07-067.

BNetzA (2006). Geschäftsprozesse zur Kundenbelieferung mit Strom (GPKE), Bundesnetzagentur. BK6-06-009.

Brinker, W. (2007). "Stromwirtschaft fördert zukunftsweisende Energieprojekte." http://www.strom.de/vdew.nsf/id/DE_20070522_Rede_Brinker.

Bundesrat (2007). Vorschlag für eine Richtlinie des Europäischen Parlaments und des Rates zur Änderung der Richtlinie 2003/54/EG über gemeinsame Vorschriften für den Elektrizitätsbinnenmarkt KOM(2007), Bundesrat. Ratsdok. 13043/07.

Bundestag (2008). Gesetz zur Öffnung des Messwesens bei Strom und Gas für Wettbewerb, Bundesanzeiger. 1790.

Cox, P. M., Betts, R. A. et al. (2000). "Acceleration of global warming due to carbon cycle feedbacks in a coupled climate model." Nature 408: 184-187.

Darby, S. (2006). The effectiveness of feedback on energy consumption. Environmental Change Institute, University of Oxford.

dena (2005). Energiewirtschaftliche Planung für die Netzintegration von Windenergie in Deutschland an Land und Offshore bis zum Jahr 2020. Köln, Deutsche Energie-Agentur GmbH.

EC (2006). European Technology Platform Smart Grids, Vision and Strategy for Europe's Electricity Networks of the Future, European Communities. RTD Info – EUR 22040. Luxembourg, European Commission.

EU (2006). Richtlinie 2006/32/EG über Endenergieeffizienz und Energiedienstleistungen, Europäisches Parlament und Rat der Europäischen Union.

EU (2007). World Energy Technology Outlook to 2050, MEMO 07/2.

EU Kommission (2006). Aktionsplan für Energieeffizienz: Das Potenzial ausschöpfen, Kommission der Europäischen Gemeinschaften. KOM(2006) 545.

Frey, H. (2007). Preissignal an der Steckdose. dena Energie Forum. Berlin, EnBW Energie Baden Württemberg AG.

Heimann, K. (2008). Energy Supply of the Future – Introduction to the AMI@SAP Project. 2008 IET Seminar on Smart Metering – Gizmo or Revolutionary Technology.

Henning, E. (2006). "Positives Fazit: Betriebserfahrungen mit dem Virtuellen Kraftwerk Unna." BWK. Das Energie-Fachmagazin 58(7): 28-30.

Hope, S. and Stevenson, M., Eds. (2008). Climate Change and Energy: 20 20 20 by 2020. EU Focus, Delegation of the European Commission to the United States.

IEA (2008). World Energy Outlook 2008. Paris, International Energy Agency.

IPCC (2007). Climate Change 2007: Synthesis Report, International Panel on Climate Change.

Jesse, J.-H. and van der Linde, C. (2008). Oil Turbulence in the Next Decade: An Essay of High Oil Prices in a Supply-constrained World. Den Haag, Netherlands, Clingendael International Energy Programme.

Keen, M., H. H. Chin, et al. (2006). Patterns: Extended Enterprise SOA and Web Services, IBM Redbooks.

Lewiner, C. (2002). "Business and Technology Trends in the Global Utility Industries." Power Engineering Review, IEEE 21(12).

Lieberman, B. and K. Tholin (2004). Retail Real-Time Pricing for Mass Market Customers – Experience, Perspectives, and Implications for a Post-2006 Policy Framework, Illinois Commerce Commission.

Martinsen, D., Linssen, J. et al. (2006). "CCS: A future CO_2 mitigation option for Germany? A bottom-up approach." Energy Policy 35(4): 2110-2120.

Schlissel, D., Johnston, L. et al. (2008). Don't Get Burned – The risks of investing in new coal-fired generating facilities. New York, Synapse Energy Economics, Inc.

Stähler, P. (2001). Geschäftsmodelle in der digitalen Ökonomie: Merkmale, Strategien und Auswirkungen. Köln, Josef Eul Verlag.

StatBA (2006). Datenreport 2006: Zahlen und Fakten über die Bundesrepublik Deutschland. Berlin, Statistisches Bundesamt.

Stevens, P. (2008). The Coming Oil Supply Crunch. London, Royal Institute of International Affairs.

The Climate Group (2008). SMART 2020: Enabling the low carbon economy in the information age, Global e-Sustainability Initiative (GeSI).

The Economist (2008). "A special report on the future of energy." Economist 25/2008.

Valocchi, M., Schurr, A. et al. (2007). Plugging in the consumer: Innovating utility business models for the future. IBM Institute for Business Value study.

Catalog of Demands

Standardization

1. Harmonization and integration of existing standards and protocols
2. Extending the standardization efforts to gas, heat and water
3. Coordinated promotion of interoperability
4. Open communication standards for new technologies

Incentives, Regulations and Legal Framework

5. Creation of an unambiguous legal framework
6. Data protection compliance from the outset
7. Creation of sustainable innovation incentives for grid operators
8. Targeted financial incentives for energy-efficient companies
9. Promoting the use of innovative networked devices and appliances among end users
10. Promotion of electromobility

Research Promotion

11. Funding for “multi-utility” projects covering several sectors
12. Funded projects for the realization of virtual power plants
13. Funding of FACTS pilot projects in the German and European UCTE grids
14. Basic research on energy storage and transfer
15. Study of end consumer behavior, incentive schemes and technology acceptance

Funding Methodology and Reorganization

16. Better coordination of funding activities
17. Stronger focus on systemic research
18. Certifying and rewarding pioneers in intelligent energy usage
19. Integration of the public sector into the “Internet of Energy”

Continuing Education and Training

20. Interdisciplinary courses of study
21. Extension of the continuing education and training programs

Public Relations Work

22. Communicating the potentials and benefits to the general public
23. Confidence-building measures

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