E-Energy – Paving the Way for an Internet of Energy

Auf dem Weg zum Internet der Energie

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E-Energy: Just another one of these short-lived e-buzzwords? It doesn’t look so! The adequate supply with various forms of energy is turning into one of the deepest challenges for mankind: How can we satisfy the growing world-wide demand for energy while reducing simultaneously the emission of greenhouse gases? The European Union has set up an ambitious strategic plan for developing low carbon technologies (see [1]) in order to support the 20-20-20 targets, which ask for reducing the EU’s greenhouse gas emissions by 20% and increasing its proportion of final energy consumption from renewable sources to 20%, both to be achieved by 2020. The German beacon project "E-Energy” addresses these challenges by providing strong financial support to six so-called model regions where project consortia from academia and industry cooperate over a period of four years to develop and test new concepts for enhancing the efficiency of the (electrical) energy system by the intelligent use of market mechanisms and of information and communication technologies (ICT). The objective of the Federal Ministry of Economics and Technology (BMWi) in cooperation with the Federal Environment Ministry (BMU) is to develop a future highly efficient energy system which guarantees the security of power supply and achieves an increased environmental compatibility (Fig. 1). E-Energy is meant to be Germany’s major contribution to the vivid global development efforts for Smart Grids.

One of the major challenges of an increased share of power generation from renewable sources is the inevitable uncertainty with respect to the performance of these sources (which is particularly true for the volatility in distributed photo-voltaic and wind power generation). Since traditional energy management is more or less based on the assumptions that power demand cannot be controlled and that electrical power cannot be stored effectively, the existing energy system has to provide a sufficient amount of power generation capacity which can satisfy the peak demand even if the unreliable renewable sources for power generation are not available.

Therefore, the approach of the E-Energy program is to introduce new degrees of leeway for managing the energy system by increasing the flexibility of power demand, supporting decentralized power generation, collecting real-time information about the current state of all the components of the energy system – from power generation over power distribution and storage to power consumption – and by creating new concepts for power storage (Fig. 2). The energy system will be transformed into an Internet of Energy: all its components are equipped with intelligent modules with unique addresses, standardized protocols may be used for communication in a completely decentralized system, and there will be a range of services supporting an energy management system.
which is no longer demand-oriented only but based on the new paradigm of “supply-oriented demand”.

The availability of information on the current status of the entire energy network combined with knowledge about the demand profiles of single appliances will allow balancing power consumption and supply by appropriate shifting of power demand. Furthermore, there will be a range of decentralized real or virtual storage facilities: Real storage facilities will emerge due to the anticipated increasing use of (plug-in hybrid) electric vehicles, since their batteries will be used in a bi-directional way as power consumers whenever there is sufficient power supply and as power suppliers whenever there is a need for additional supply.

Virtual storage refers to the capability of shifting power consumption back and forth with respect to available supply. There is a broad range of possible approaches to such a new “smart” energy management – from centralized control based on large amounts of data to decentralized approaches using some mixture of local information and global parameters (like price signals or information on network bottlenecks). Strategies range from optimized power supply and demand schedules for a long time range over day-ahead planning to intraday market and self-organized adaptation strategies in the time range of seconds. Hence, there is a strong need to evaluate these different approaches and to determine the most effective selection and combination of market mechanisms and system architectures. E-Energy consortia are in search for methods and technologies which have the highest potential to guarantee the necessary reliability and cost-efficiency of power supply while meeting ICT performance, data security, and data privacy demands.

The six model regions of the E-Energy program have been the winners in a highly competitive selection process. Every consortium forms a technology alliance of several partners from academia, major utility companies, and IT industry. Equipped with an overall budget of about 140 Mio € (including 60 Mio € from the BMWi and the BMU), their 4-year projects started in late 2008. They will design and analyze different approaches which might be major components of the anticipated future smart energy system. The analysis and evaluation will be based on physical model regions, where private households and small and medium enterprises will be equipped with devices for intelligent power metering and control and where innovative energy products and services will be traded on specialized market platforms combined with flexible price and control systems. The real life implementations will be complemented by simulation studies. The R&D work of these projects is aligned and supported by an ancillary research consortium which comprises energy, computer, communication, and market experts. This group initiated and organizes task forces on topics of joint interest like market structures and mechanisms, system architectures, interoperability and standardization and – last but not least – legal issues. Details on the six model regions and the ancillary research consortium are available from the E-Energy website [2].

This special issue consists of contributions from each of these model regions presenting first results and conceptual approaches on different aspects of the future smart energy system.

The paper by Sebastian Beer et al. from the model region “eTelligence” describes their approach “Towards a Reference Architecture for Regional Electricity Markets”. Besides a description of the general market design, a more detailed view of selected market players is provided. The goal is to get a reference model capturing the essential roles and relationships between the market players which are essential and characteristic for electricity markets.

This is followed by an outline of an approach to the design of a generic process model for companies in the energy industry. In their paper “Reference process modelling for utility companies” the authors Matthias Deindl and Eric Naß from the “Smart Watts” consortium particularly focus on modeling processes for municipal utilities that deal with end customers such as change of electricity supplier, customer’s settlement etc.

E-Energy solutions will allow private or business subscribers to act as a producer and consumer as well. In the model region “E-DeMa” they call this a prosuser and in their paper “Development and demonstration of decentralized power systems culminating in a future E-energy-marketplace” Michael Laskowski et al. investigate the potential to develop such a new active market player, whose abilities to exploit his energy demand and supply opportunities might help to increase efficiency in the overall system.

David Nestle and his coauthors from the “Model city of Mannheim” describe their concept of an “Open energy gateway architecture for customers in the distribution grid” which is supposed to provide a single gateway between the customer and the grid on top of which a variety of applications shall be executable, e.g., accessing customer devices, user displays, smart meters, measuring data, or dynamic tariffs.
The special focus of the “Regenerative model region of Harz – RegModHarz” is the effect of the increase of decentralized and renewable generation on reliability of power supply. In their paper “Renewable Generation and Reliability in the Electric Power Network” Zbigniew Styczynski and his coauthors describe a model for analyzing power system reliability with special consideration of distributed intermittent generation from renewable sources and they discuss potential measures to keep on the high reliability standards of the current power system.

Since the size of physical model regions will be rather constrained, and since there might be potential events in future power grids which should not be tested on real customers, an essential part of the “Minimum emission Region MeRegio” is the use of “Simulations in the Smart Grid Field Study”. Christian Hirsch et al. describe their specific approach of controlling power generation and consumption and highlight the roles of offline and online simulations which are essential for analyzing the scalability of the E-Energy concepts and for testing potential effects of special events like power outages or extreme weather conditions.

Finally, an aspect is addressed which may be most essential for the chances to transfer the concepts of the E-Energy model regions into large scale real energy systems: Oliver Raabe and Mieke Lorenz (MeRegio) and Knut Schmelzer (eTelligence) are concerned with “Generic Legal Aspects of E-Energy”. They analyze legal use cases and practical problems regarding the Internet of Energy and discuss various scenarios in terms of their reconcilability with the prevailing law. Subsequently, the regulatory framework is interpreted and the need for legal adjustments is demonstrated.

Since the six model regions are just in their second year of operation, the contributions in this special issue can only highlight their major concepts and approaches to shaping the future energy system. Due to its integrated and holistic approach, the E-Energy program definitely has the potential to provide the foundation for a leading role of German industry with respect to building and managing sustainable, reliable, and flexible energy systems, hopefully at a significantly reduced level of greenhouse gas emissions. A major insight of this and of related programs is the fact that this urgently needed re-engineering of the energy system inherently depends on an intelligent design and exploitation of information and communication technologies. The broad technological and business approach will make sure that E-Energy is not just a passing phase but the future of sustainable energy supply.

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References


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