Final Report

Smart Grids and the Energy Transformation

Mapping Smart Grid Activities in Germany

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Content

1 Scope of the study

1.1 Approach

The analysis and results in this report are based on literature research, stakeholder interviews, conversations with experts and participation at workshops, fairs, symposiums and informational meetings. The main goal was to identify relevant positions and developments within the amorphous and highly complex smart grid debate that will foster the energy transition.

1.2 Key Findings

1) ICT is a Major Precondition for the “Energy Transition”

The integration of information and communication technologies (ICT) in the power sector can serve many functions in a variety of contexts. In Germany, such smart grid technologies must play an essential part in the "energy transition" towards an electricity supply system based on high energy efficiency and changing renewable energy supplies.

a) Smart grid technologies provide infrastructure to enable the technical integration of a large number of distributed energy resources.

b) Smart grid technologies also provide infrastructure to form new market mechanisms based on flexibility and corresponding market roles.

The integration of ICT has already been tested in the ground-breaking “E-Energy” pilot project. It demonstrated how net demand can be managed technically and economically through the introduction of ICT for balancing group levels.

2) “Energy Transition Supporters” Tend to Underestimate the Role of Smart Grids

In spite of their prominent role, smart grids are not a high priority for “energy transition supporters,” i.e. those with a "green" mindset who have been the driving force towards the energy transition. There is a general reluctance to recognize the importance of smart grids for the energy transition; or, their emergence is mostly taken for granted. Besides that smart metering triggers fears of remotely-controlled home devices and “big brother” intrusions into privacy. Smart metering is in fact overrated, and is only a minor part of the overall smart grid system.

3) Upgrading the Grid is the Most Urgent Task, but Restructuring it Has to Follow Suit

Considering the significant increase of intermittent power production units that feed electricity into the distribution grid, implementation of advanced instrumentation and communication technology is needed right now, especially on the medium voltage level. A full scale smart meter roll out, however, is not immediately necessary to manage grid stability.

In the long run, the energy transition will require a shift to a new cellular structure of the electricity grid that will be able to handle increasing complexity. The job of distribution grid operators will change from simply distributing power to actively coordinating with all market participants.

A standardized plug and play ICT integration will be necessary in order to smoothly transition to automated control mechanisms that regulate production, consumption and storage as well as grid use. Plug and play execution of the smart grid design is also key to new (regional) market structures.

4) Through ICT Deployment, a New Infrastructure Level is Created: The Energy Information System

The ICT infrastructure serves grid operation as well as market functions and will provide a new level of infrastructure. Whereas the regulator, Bundesnetzagentur "BNetzA" erroneously tries to separate grid operation and market services by distinguishing between "Smart Grid" and "Smart Market," in the future, both the grid and the market will have to rely on the energy information system. In particular, the energy information system will manage the intersection of grid operations and market services.

5) The Future Energy Information System Will Not be Financed by Current Market Mechanisms and Existing Regulatory Rules

From the perspective of the German regulator, BNetzA, it is up to the distribution grid operators (DSOs), whose role is to serve all market participants, to upgrade grids with automation technology. However, the regulator insists on maintaining the current investment framework for DSOs, so there is only a limited financial scope for advancement. In addition, DSOs are not entitled to reap any additional benefits generated by updating the network. As a result, DSOs are unwilling to make the substantial investments required for the successful, full-scale introduction of smart grids.

BNetzA clearly considers that balancing fluctuating power supply or demand response services are issues that should be handled by the market rather than the grid operator. This approach, however, will not work under the current system for two reasons: 1) For a smart energy market, ICT infrastructure needs to be in place. This infrastructure refers not only to grid automation components but also to gateways, communication networks, platforms and middle ware. At the moment, nobody is willing to invest in "market" infrastructure, as investments would be beneficial to those who funded development as well as competitors. 2) Under the current market design, business models based on flexible tariffs that reflect scarcities are not feasible. Without a new market design that values flexibilities and without clear rules on how to manage the interface between grid operation and the market, there will be no viable business models suited for future progress even if an appropriate ICT infrastructure is established.

Apparently there is a chicken-and-egg conundrum resulting from the fact that there will be no smart market without an ICT infrastructure, but politics and regulation place their faith on the market to provide the infrastructure. **The process to advance to a smart grid system would be driven by market forces, but only if the market were able to actually impact the grid operators.** Unlike other market driven revolutions like that of the iPhone, the market will not be a driving force for updates in the smart grid infrastructure that will help achieve the energy transition. Instead, these advancements would be more like the origins of the Internet, whose first developmental phases were initiated and funded by the U.S. Government.

6) The Regulator's Main Goals Need to Be Redefined

BNetzA's approach neither takes into account nor meets the requirements of the energy transition because it is motivated by the desire to safeguard existing rules in the liberalized power market regulations. Under this paradigm, the implementation of smart grid technologies is expected to be a slow and evolving process of modernizing within the existing electricity infrastructure. This serves the interests of the current power sector utilities as it slows integration of distributed power generation.

In contrast, E-Energy project results show that balancing demand and supply and overseeing a large number of participants will only be possible if the energy system implements ICT to create a new kind of infrastructure that is open to a wide range of new market participants. The establishment of such a smart energy system, however, requires new regulations that reflect the infrastructural role data management is going to play.

7) "Energy Transition Supporters" Should Participate in the Plug and Play Standard Setting Process

Future business and operation processes need to be defined and standardized in order to function in a "plug and play" style. This raises the question of how and by whom the plug and play standards will be developed. Existing workflow definitions are tailored to the requirements of a fossil fuel based system characterized by bulk generation and unidirectional power flows. Future definitions will have to reflect a mixture of decentralized and centralized power supplies that are fluctuating and flow in many directions. In order for distributed generation units to participate in the market, it is necessary to determine how various units will be combined. How will the interaction of these aggregates, virtual power plants, DSOs and data hub operators be conceptualized? And how will these concepts be translated into standards?

Committees of technical experts are responsible for defining industry standards and shaping future workflows. Because these experts represent competing interests and because there is little cooperation between various industries, progress is slow. At the same time, the sectors participating in this evolution will be able to outline policies that serve their own best interests. If "green-minded" energy transition supporters do not contribute to the on-going discussions in these committees (and with the E-Energy project due to end next year), the current power sector will be able to unilaterally shape workflow definitions.

8) Large Data Volumes and Data Protection are Still an Issue

The challenge of handling large volumes of data and associated data protection issues are another impediment to the implementation of smart grid technology. Workflows in the power sector are not accustomed to processing large volumes of data. In addition, the issue of data protection has yet to receive the attention it warrants. A skilled workforce that can coordinate and manage the interface of electricity and data management is not currently in place. Finally, there is a generational issue at the CEO level: companies with younger CEOs tend to be more open for new business challenges, while older CEOs are less willing to change.

9) Knowledge and Information Gap Needs to Be Closed

There is a knowledge gap concerning smart grid/smart energy system requirements between power sector insiders and ICT specialists and supporters of the energy transition. Those who work in the power sector have the advantage of already being familiar with the "known unknowns" of the new technology. For supporters of the energy transition, smart grids are still mysteries that generate misinformation, ungrounded fears and overly simplified or unrealistic assumptions. It is time to develop expertise on smart energy systems among supporters of the energy transition.

10) Political Leadership is Lacking

The implementation of a smart energy system that enables the energy transition has yet to be set as a clear political goal by the federal government. BMWI's Energy Directorate's preoccupation with smart metering is a focus on the wrong issue. Ever since 2010, the Energy Directorate has been fixated on smart meter related questions, for example considering the BSI protection profile. However, when it comes to solutions for how to balance a fluctuating power supply, smart metering on the household level plays no significant role at the moment.

To make matters worse, there are currently no major projects in place to follow up on and further develop the findings of the E-Energy pilot project, which will end in early 2013. E-Energy was initiated by the IT-Directorate of the Federal Ministry of Economics and Technology and co-financed by The Federal Ministry for the Environment. It has never fully been embraced by the Energy Directorate of the Federal Ministry of Economics and Technology. If this work does not continue, there is a serious risk that Germany might lose the edge in smart grid know-how that it acquired through this pioneering project. Such a loss would be unfortunate not only for industrial policy, but also because of the importance of smart grids for the energy transition.

1.3 Introduction

2011 marks an important turning point in the evolution of the German power system. Under the heading of "Energiewende" (energy transition), the centre-right government lead by Angela Merkel decided to take eight nuclear power plants off the grid immediately and phase out the remaining ones by 2022. The plan is to switch German power supply to at least 80 % renewable sources by 2050.

The energy transition means much more than just a switch to renewable sources: it is a comprehensive technical, economic and socio-cultural paradigm shift of the entire energy system. Not only will primary energy carriers will be replaced, but the entire system of production, transport, distribution and use will undergo a fundamental transformation over a short period of time. In the future, electricity will no longer be transported in a single direction – from several large fossil or nuclear power plants to consumers – but rather, as renewables come to represent an ever increasing share of the total power supply, a **multi-directional flow will develop and connect an untold number of new market players**.

Information and communications technology (ICT) will be essential to manage the resulting complexity.

In the last twenty years, ICT has transformed all industry sectors. In the power sector, which is characterised by long investments cycles, information technologies has taken a long time to significantly take hold. It is only in the last seven years that Europe has seen noticeable progress towards a "smart grid" – a power grid that **consistently and systematically integrates ICT**.

But it would be misleading to understand the term "smart grid" only in the context of the energy transition. All over the world, including in Germany, outdated power infrastructures are being upgraded and new ones being built – not always happening under the auspices of a transition to renewables. Quite to the contrary, the major international drivers for increased ICT deployment in the power system include demand for more grid stability (such as in the US) and the prevention of electricity theft (such as in India). Particular emphasis is placed on "smart metering", the near-to-real-time measuring and billing of power consumption. The power industry expects the promise of "more consumer transparency" to open up a profitable business segment.

In light of such heterogeneous value propositions, numerous concepts for the precise definition of the term "smart grid" are used at the international, European and German levels. This confusion reflects the competition for spheres of influence and market shares in a growing industry. As a consequence, a definitive formulation that incorporates all stakeholder interests and possible applications would have to be too broadly conceived and become meaningless.

A particular perspective was thus chosen for this study, which focuses on the implementation of the energy transition. The integration of ICT technologies in the existing power system ("smart grid") is essential to the execution of the energy transition. While a large number of stakeholders wrestle to get influence on the configuration of an intelligent power system, it is not difficult to conceive of future smart grid scenarios that are detrimental to the achievement of energy transition goals either because they produce additional costs, the public does not accept them, implementations are delayed or unnecessary barriers emerge. This study therefore looks into potential drivers and obstacles for the evolution of a smart energy system that will be a key enabling element of the energy transition.

1.4 Germany: A Front Runner in Smart Energy Systems

Germany is of particular international interest in two aspects. First, it is the most major industrial country that is embarking to use fluctuating renewables from wind and sun as the basis for its power system. And second, Germany has financed an internationally renowned model project called "E-Energy", that can be considered to have anticipated the current "megatrend" towards integrating smart grid technologies into a seamless architecture as early as 2007. As a result, pioneering experience and extensive insights into how a systemic smart grid driven energy system could function both technically and economically have been gained.[1]

[1] Asmus (2012).

E-Energy's origins date back to the early years of the 2000s, when e-commerce and e-government were taking off. Initiated by the Federal Ministry of Economics and Technology's IT department, six regions in Germany were chosen to research (1) smart grid marketplace functions, (2) system administration and maintenance functions and (3) options for the realisation of integrated economic and technical aspects of the technology, especially with respect to demand response and demand side management/ demand side integration.[2]

Whereas the main focus of the project has been to establish an "Internet of Energy", the integration of fluctuating renewable energy sources (RES) and supply generated through distributed systems into the national grid have been core issues. Additional research efforts cover energy efficiency, security of supply, load management, storage devices, grid congestion and expansion. With the advent of the German energy transition in 2011, the E-Energy project positioned itself as a solution provider for this endeavour.

Of course, E-Energy is not the only project in this arena. However, an overall budget of 120 million Euros from government and industry does mean that it is the biggest and most comprehensive program of its kind. Numerous other activities - from large corporations running research projects at the European level down to small scale investments in substation automation or smart metering - can be found all over Germany. But E-Energy's comprehensive approach has generated ground-breaking results with relevance far beyond Germany.

2 Smart Grids: Definition is Power

There is no generally accepted definition of the term „Smart Grid“. Different stakeholders interpret it according to their specific viewpoint. On a very general level, it just means that ICT meets the power sector. But these two sectors come with very different perspectives:

(1) A component perspective, which focuses on modernizing the electricity grid or parts of it (smart meters). This is predominantly the perspective of the power sector, but also of the Energy Directorate of the Federal Ministry of Economics and Technology (BMWI) and the German regulator, the Federal Network Agency (Bundesnetzagentur "BNetzA").

(2) An integrated systemic perspective, which starts from the idea of a smart future energy system ("Internet of Energy"). This is mainly the ICT perspective, which understands that the parts of a system that adopt information and communication technologies always will converge towards common interfaces.

So far, the groups whose main interest is the acceleration of the energy transition have not entered this debate with their own perspective but have largely been bystanders. It is argued here that a smart grid tailored to the requirements of an electricity system based on a large share of renewables will be key to the success of the energy transition.

[2] See for the concept of demand side integration chapter 4.2.2. and ETG-Task Force Demand Side Management (2012).

2.1 “Modernized Grid”: The Component Perspective

Characteristic for the component perspective is a strong focus on modernizing single elements of the national grid, most notably meters and distribution girds. Driven by European energy efficiency goals, a focus on smart metering can be traced back to policies[34] from Brussels. In Germany the Energy Directorate of the Federal Ministry of Economics and Technology (BMWI) has reacted to European and German climate policies since 2008 by trying to trigger a market-driven roll out of smart meters. Accordingly, the BMWI defines smart grids[5] with an elaborated reference to smart meters as the basis for variable tariffs and new business opportunities. Up to now, however, the desired markets could not be developed, as will be shown in chapter 5.1.

Another important strand of the “component” debate takes place within the German power sector and is backed by the Energy Directorate of the Federal Ministry of Economics and Technology. The issue is a very practical one: How can smart grid technologies solve the problems caused by a rising share of renewables? The main concern is to find solutions for trouble-shooting on distribution and transport grids in order to safeguard the security of power supply[6].

At the beginning of 2012, the German regulator “BNetzA” provided important input to the debate, which can also be characterized as focusing on smart grid components. By distinguishing between “smart grids” and “smart markets,” BNetzA introduces the key concept of grid capacity versus energy volumes.[7] Here, grid capacity is the grid’s load-carrying capacity and is considered to be a regulated asset. In contrast, “energy volume” is the flow of electricity sold in Euro per kilowatt-hour on the market. In order to enhance grid capacity, BNetzA considers a smart update on the distribution level necessary. Embedded in the regulator’s concept is the concern to safeguard the liberalization of the power sector.[8]

In the component perspective, stakeholders emphasize single smart grid technologies that serve specific functions and interests while largely remaining within the existing limits of the power system.

2.2 “Smart Energy System”: A Systemic Convergence Innovation

The German Association for Electrical, Electronic & Information Technologies (VDE), who closely cooperates with E-Energy, defines smart grids as follows:

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[3] See Schleicher-Tappeser (2012): “Based on a provision in the Electricity directive (2009/72/EC) which requires Member States to massively roll out positively assessed intelligent metering systems, in April 2012 the Commission has adopted a recommendation, defining assessment procedures and criteria as well as minimum required functionalities for smart meters. Member States have to conclude their assessments by September 3, 2012, and to roll out 80% of the positively assessed systems by 2020.”

[4] Commission recommendation on preparations for the roll-out of smart metering systems [C(2012)1342], http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/20120309_smart_grids_recommendation_en.pdf

[5] http://www.bmwi.de/DE/Themen/Energie/Stromnetze/intelligente-netze-und-intelligente-zaehler,did=354138.html

[6] “For the purposes of this grid expansion study, the conventional electricity grid becomes a smart grid when it is upgraded with communications, measurement, control and automation technologies by means of IT components. In effect, ‘smart’ means that, to the extent necessary, grid conditions can be monitored, controlled and adjusted in ‘real time’.” BMWI 15.06.2012.

[7] Bundesnetzagentur (2012).

[8] As will be shown in chapter 5.3.4., the distinction between the grid and market does not work because of the convergence effects of smart grid technologies.

> "The term 'Smart Grid' (an intelligent energy supply system) comprises the networking and control of intelligent generators, storage facilities, loads and network operating equipment in power transmission and distribution networks with the aid of Information and Communication Technologies (ICT). The objective is to ensure sustainable and environmentally sound power supply by means of transparent, energy- and cost-efficient, safe and reliable system operation."[9]

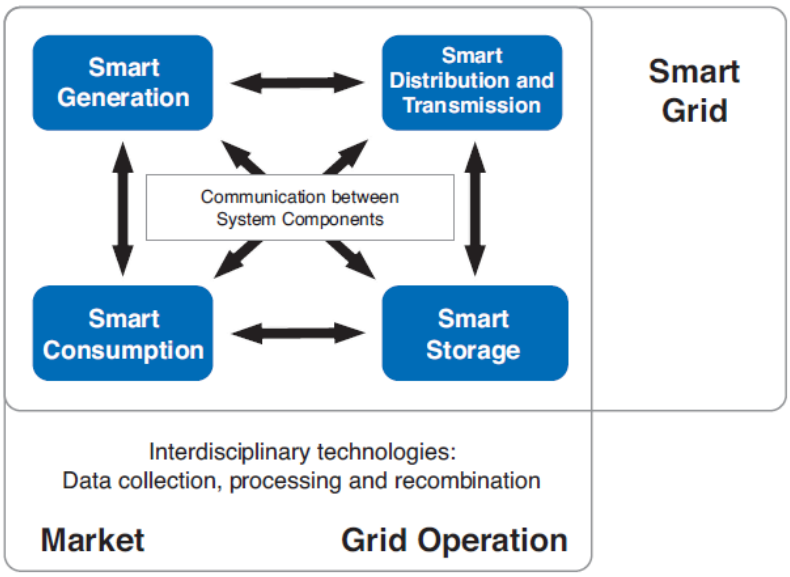
The VDE continues:

> "A smart grid is a holistic, intelligent energy supply system, not just an 'intelligent network'. It comprises the operation of active power distribution and power transmission networks with new, ICT-based technologies for network automation, and the incorporation of central and distributed power generation and storage facilities reaching right up to consumers, so as to achieve better networking and control of the system as a whole."[10]

The main emphasis of this definition lies on "communication between system components." Here, the full value proposition of a smart grid can only be delivered by a high degree of connectivity within the system.

In contrast to the component perspective, the systemic innovation perspective stresses the convergent aspects that will be come about when smart grid technologies are deployed; something completely new is going to develop. As with the ICT revolution in many other sectors, the power sector will also change considerably if the components of the electricity grid and the power market merge into a smart energy system. This means that new roles, actors and responsibilities will emerge along with new workflows and new forms of added value.[11] In its essence, the systemic perspective sees the smart energy system as a radical breakthrough. In the component perspective, a smart gird is a mere incremental, continuous innovation – an update. The difference hinges on the converging role communication is playing between system components.

Real-time Communication between System Components



Source: DKE[12]

[9] DKE (2010).
[10] Ibid.
[11] See chapter 5.
[12] Ibid.

With this systemic definition, the idea of an Internet of Things is applied to the electricity system, transforming it into a “smart energy system.” The control and connectivity of system components are at its centre, while the installation of smart meters and distribution grid automation play an indispensable part. The VDE’s definition is supported by the E-Energy project and the ICT industry.

2.3 Energy and ICT: A Culture Clash

Within the ICT industry, “smartness” is a term that refers to a strategic dimension of connectivity and convergence. Within the power sector it just means upgrading the existing grid system in order to be able to exert control over devices, equipment and installations. From the ICT point of view, the energy industry’s approach might easily run into a complexity trap if too many single initiatives overlap.[13] On the other hand, the power sector fears that the systemic approach might lead to an incessant increase in data volume, to unforeseeable changes, and to unwelcome new competitors. A quick fix of current problems and a bet on evolutionary development is preferred over planning for radical changes in the future.

This tension between these two sectors of industry can be partly attributed to a culture clash between the former’s extremely quick and the latter’s extremely slow reaction time to changes. The power sector is currently under particular pressure to change rapidly, and some players will be left behind. The fear of losing out provokes strong defensive stances.

Setting definitions on what a smart grid is supposed to deliver is a strategic way to defend and expand one’s own position in the energy transition. Future political key decisions for the introduction of specific configurations of smart grid technologies will therefore reflect the power of those who were able to impose their very specific ideas.

2.4 ICT as a Major Requirement for a Successful Energy Transition

No smart grid definition is tailored to the requirements of the energy transition. On the contrary, for the “green” crowd behind the energy transition, smart grids and smart metering very often have a bad reputation, mainly because smart metering and smart grids are thrown into the same pot. Due to the overpromising European concept of reaching energy efficiency targets via smart meters, a full rollout has widely been considered the ideal solution to change customer behavior, but this approach has evoked fears of remotely controlled home devices and "big brother" intrusions into privacy. In the meantime, it has become clear that the push for a full-scale smart meter rollout can be traced back to business lobbies eager to sell meters and smart household appliances.

Beyond the smart metering cause, a smart grid – and, even more so, a breakthrough smart energy system – has a totally different and much wider scope than counting kilowatt-hours of household power consumption. For the energy transition, smart grids will have to perform a crucial balancing task in a system with fluctuating supply.

[13] Appelrath et al. 2012.

By mid-2012, the renewable share of the overall power supply was 25% in Germany. On a technical level, this growth puts more and more pressure on distribution grids. Upgrading technical units, such as substations, is indeed a main requirement.[14] But much more has to be done.

By balancing demand and supply in real time, ICT technologies will also be key to creating new value out of capability resources, such as CHP plants, cold storage, etc.[15] Research results from the E-Energy project show a first variety of options.[16]

Still, implementing a smart energy system will require a radical overhaul of existing commercial structures, new sets of regulation and market mechanisms and a shift in power usage especially among above-average electricity customers.[17]

In conclusion, a smart grid definition that suits the energy transition could be guided by the following question: "What does a smart grid have to deliver when the energy mix is changing to accommodate a rising share of renewables?"

3 Upgrading the Grid

The reasons to introduce smart technologies into grids and meters are said to be:

- The need to adapt the system to the increasing amount of intermittent renewable energy sources, both central (offshore wind parks) and distributed (solar)
- The need to reduce energy consumption and increase energy efficiency
- The need to integrate new applications, such as electric cars
- The growing sophistication of information and communication tools
- The desire to promote competition in the energy market to benefit small and large consumers

If one takes a closer look, not all of these reasons hold true. From the perspective of the energy transition, updating the distribution grid is the more important task.

3.1 Who Needs Smart Metering?

First, from an energy transition perspective, no large-scale roll out of smart meters is needed.[18] To provide the necessary data for grids to run safely even with high amounts of distributed renewables, only a few metering points are necessary. The big push for a smart meter rollout comes from the smart home industry sector, which has eagerly been using the energy efficiency argument to their benefit.

Furthermore, E-Energy findings show that smart metering does not lead to the desired savings in households under the current market design.[19] A recent study conducted by European Consumer Organization BEUC confirms these findings.[20] In addition, on the

[14] See chapter 3.2.
[15] See chapter 4.2.2.
[16] B.A.U.M. Consult GmbH (2012).
[17] "Above average" means more than 6,000 kWh/year; see footnote 67 for respective legislation.
[18] This important point has even been confirmed by BNetzA (2012).
[19] BAUM Consult (2012).
[20] Klopfert, Frédéric; Wallenborn, Grégoire (2011).

English market, where a far-reaching smart meter rollout has already begun, experience shows small consumers may not benefit from variable tariffs at all.

A more structural argument is presented by business consultancy Arthur D. Little.[21] The consultancy points out that smart metering does not make sense without an integrated plug & play interoperability in the backend. As a stand-alone technology, smart meters will not enable variable-tariff business models in any fashion. Nor is today's "old-fashioned" electricity market design able to generate profit with smart meters.[22], [23]

The Acatech[24] study "Future Energy Grid" diagnoses the same problem. We are putting the cart before the horse if the BMWI's Energy Directorate pushes for a smart meter rollout without making sure that systemic connectivity with the backend grid structure will be available. An automated distribution grid first has to be set up for smart metering to be useful.[25]

Instead of rolling out smart meters to a huge number of small household consumers (which would be the third step), it is advisable to stick with the current ruling that obliges electricity consumption above the average – more than 6,000 kWh/year per household – to be smartly metered.[26] Above-average electricity consumers in trade, industry and big buildings should be convinced to identify energy-saving and load-shifting potentials that benefit their businesses so that participation in demand management programs and/or virtual power plants will appeal to them.[27], [28] From the energy transition perspective, it is important to identify the potential for demand management that is promising in terms of the energy volumes involved.[29] Starting with mid-sized trade and industry would also help overcome anxieties about data protection and privacy on the household level.

3.2 An Indispensible Task Ahead: Automated Distribution Grid Control

In Germany 97% of renewable power is fed into the distribution grid. In particular, solar power production has increased tremendously over the last three years. The problem is that distribution grids were initially designed to facilitate a passive top-town throughput of power from fossil and nuclear plants connected to the transport grid. With PV pushing the other way, the traditional DSO has no monitoring techniques to observe these load flows and to react. As a result, with ever more PV coming in, distribution grids are suffering from voltage problems: dips, transient overvoltage, asymmetries etc.

However, fifteen remote control technology components for middle and low voltage substations are already available on the market, as the Federal Association of Energy and Water Management (BDEW) pointed out in a recent ground-breaking study.[30] The BDEW

[21] Arthur D. Little (2011).
[22] Quote Arthur D. Little (2011).
[23] See chapter 5.2.
[24] See chapter 5.2. and Appelrath, Hans-Jürgen; Kagermann, Henning; Mayer Christoph (ed.) (2012).
[25] See chapter 4.2.3.
[26] Legislation package June 2011, see footnote 67.
[27] See chapter 3.3.1. for more details.
[28] See B.A.U.M. consult (2012): As E-Energy findings show, customers need an above-average amount of information in order to agree to load-shifting programs.
[29] See chapter 4.2.2.
[30] BDEW; ZVEI (2012).

estimates that one third of all DSOs are interested in deploying the new equipment, especially those with a high share of PV in their grids. Deployment would ensure that the grid remains stable – a very significant step for the success of the energy transition.

But the costs are significant. The German Association of Local Utilities (VKU) has published a study prepared by KEMA consulting that presents a figure of seven billion Euros annually for upgrading the distribution grid with automation equipment until 2030. [31]

3.3 Who is Going to Pay for Smart Metering and Smart Grids?[32]

The Metrology Liberalization Act of 2008 constituted an essential amendment to the provisions on metering in the Energy Industry Act and aimed at a smart meter rollout by 2014.[33] On the basis of a study conducted in 2009/2010, BNetzA decided that the rollout of smart metering should be business-driven.[34], [35] Ever since, the German regulator, DSOs and metering service operators have been arguing about who is going to pay for a rollout. DSOs say there is no business model. Even if an entrepreneur were to take all the risks mentioned in chapter 5.1., capital investments in the installation of smart meters would benefit all market participants. Investors would thus finance the businesses of the complete value chain and the profits of their competitors. As a result, DSOs are far from eager to install smart meters.

DSOs are also under strain regarding investments in smart grids. The German regulator says that DSOs should finance the smart update of their grids on the basis of existing revenue streams determined by a calculation of operational and capital expenditures, limited interest rates and regulated profitability.[36] DSOs point out that the deployment of new technology needs room for experiment and even failure, which is not covered by existing budgets. Even more so, in parallel with smart metering, any additional capital investment would benefit all market participants who use grids.

As a result, only the most progressive and financially sound DSOs confronted with a rising share of PV are investing in grid automation. There is also a generational issue; companies with younger CEOs tend to be much more open to new business challenges. Others, especially those reluctant to accept the challenges of integrating IT into their businesses, hide behind the German regulator and postpone action. Thus, BNetzA’s position to minimize costs and stimulate cooperation between DSOs leads to a delay of the smart grid technology deployment.

Still, upgrading the distribution grid with automation equipment is not enough. It helps to securely integrate distributed RES into the system at the moment, but this will probably not be sufficient in the long run. With the share of renewables rising, the question of how to guarantee affordable security of supply in a system-wide fashion is gaining momentum.

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[31] KEMA Consulting GmBH (2012).
[32] See Chapter 5.1.
[33] Ecofys (2009).
[34] Bundesnetzagentur (2010).
[35] Bundesnetzagentur (2010).
[36] As grids are natural monopolies, since the liberalization of the European energy market energy service providers have been obligated to follow the rules of their national regulator. In Germany, regulation comes from the Bundesnetzagentur (BNetzA), which has already featured prominently in the current debate on the future of energy supply in Germany.

4 Restructuring the Grid: Security of Supply in a Distributed World

As Acatech's study "Future Energy Grid" shows, an ICT infrastructure that enables the convergent interplay of production, consumption, storage, transport and distribution of electricity is the technical basis for a successful energy transition. A smart grid can do much more than even out voltage dips. Towards a power supply that is much more distributed than today, a cellular grid structure and regional markets can replace today's central structure.[37]

4.1 Copper or What? Security of Supply in Need of a Smart Answer

In today's energy grid infrastructure, large power plants generate the bulk of our power, but this is changing due to the energy transition. Patterns of supply and demand are moving away from the current system of "supply follows demand" towards a system of "demand follows supply." Instead of relatively few steady supply sources serving variable consumption needs, a high number of distributed generation units will produce fluctuating amounts of power. So the most important question is how the intermittent generation of renewables should be managed in order to ensure that supply securely meets demand at any given time? What structures need to be put in place in order to achieve this in a cost efficient manner?

Security of supply implies that there is a sufficient volume of power available (resource adequacy) and an exact balance between generation and consumption at any given millisecond in time (system quality).[38], [39] Renewables produce considerable spikes in over and under production; these spikes are the benchmark upon the basis of which security of supply has to be guaranteed. Traditionally, net demand is satisfied through the use of

- power from fossil fuel plants
- balancing power from fossil fuel plants and domestic hydropower storage
- grid connections to Europa
- management of renewable resources
- load management with very big industry clients to reduce generation spikes. [40]

Today, the market has to provide power volumes; TSOs must keep the grid at 50 Hz. At the same time, TSOs and DSOs have to expand the grid whenever necessary to securely transmit peak voltage levels, for example from wind parks.[41] Grid extensions, however, take a very long time, are very costly, and usually unpopular with residents near proposed sites. The number of new lines required is thus an extremely contested issue.[42]

Beyond the necessity to build transport lines for excess power from north to south, advocates of the smart grid claim that the deployment of new hardware and software

[37] See chapter 4.2.2.
[38] See Hogan; Gottstein (2012)
[39] See Ibid.
[40] Deutscher Bundestag (2012).
[41] Such as building copper lines.
[42] See www.forum-netzintegration.de for documentation of the debate.

could considerably reduce the need to build physical infrastructure, especially on the distribution grid. From the perspective of such a smart energy system, the static system of supply following demand would be replaced by a dynamic and systemic interplay of generation from resources that are both central and distributed with consumption, storage and grid infrastructure. Thus, security of supply would come from the negotiation of smart elements according to a dynamic mechanism of orchestration based on economic and grid operation criteria within a cellular system.

Such "a stronger integration (convergence) between players [who] used to operate in more or less distinct markets" based on a smart grid as technical facilitator promises to meet two challenges:[43]

1) Control of the complexity that arises from coordinating the high number of distributed participants,
2) Control of both the physical infrastructure and the commodity system that make up power supply.[44]

4.2 The Architecture of a New Smart Energy System

4.2.1 Cellular Grid Structure

Controllability of power flows on the TSO level will reach its limit with an ever growing number of distributed generation units. The EU Commission Task Force for Smart Grids for example points out that "the number of system components actively involved in the coordination task will be huge. Central control of such a complex system will reach the limits of scalability, computational complexity and communication overhead."[45], [46]Therefore, the E-Energy's Moma project developed and tested a cellular system architecture that provides a framework within which each cell can act in a subsidiary fashion.[47] As a micro-grid, each cell is equipped with the necessary ICT hardware and software so that energy generated from distributed renewables is automatically connected to storage and consumption devices. Grid control and marketplace software enable the cells to coordinate physical flows and economic transactions, thus forming a balancing circle that also provides reserve power and ancillary services.[48] The ability to act completely autonomously is, however, limited to emergency cases. In normal, non-emergency circumstances, each cell is connected to the transport grid. Responsibility for maintaining security of supply will thus be shared between the cellular structure made up of low and medium voltage micro-grids and the high voltage transport grid.

The German regulator has already approved of this concept in principle. But it will take further pilot projects to test the interaction between single cells and the transport grid,

[43] EU Commission Task Force for Smart Grids (2011).
[44] K.Kok et alii (2011) As a flow commodity, energy "follows the path of least resistance, possibly using a number of parallel trajectories." This transport path is not at all congruent with the contract path of commodity transactions. The challenge for overall system stability then lies in the fact that trading acitivites have to result in a perfect balance of electricity consumption and production whilst avoiding grid congestion and overstressing.
[45] K.Kok et alii (2011).
[46] See also Bundesnetzagentur (2011).
[47] Kießling et al. (2011).
[48] See chapters 3.1. and 3.2.

especially in a larger scope in order to guarantee the smooth implementation of a cellular grid architecture.[49]

4.2.2 Regional Market Places, the New Playing Fields in Micro-Grid Style

A cell can be conceived of as one balancing group. Power flows have to be maintained at 50 Hz all the time within this group.[50] As a consequence, a cell consists of at least one regional marketplace where power supplies are traded and net demand is satisfied through flexible resources.[51] One can conceive of a variety of flexible resources; some of them are already available on the market, while others exist only on a conceptual level: (a) storage, (b) demand side integration and (c) virtual power plants.

(a) In the debate on energy transition, the topic of storage is important and widely covered.[52] Storage serves several functions:

- Balancing seasonal fluctuations and longer periods of time without wind and sun
- Balancing short-term fluctuations (interday and intraday)
- Balancing forecasting errors
- Providing reserve power to maintain grid stability[53]

Existing hydro power storage capacities will not be sufficient, and it is currently not possible to estimate how much storage will be necessary in the future. It is also impossible to foresee which technologies will be utilized for greater storage capacity.[54] As batteries are very costly, hybrid storage options like integration with heating systems (CHP) or demand side integration seem to be attractive.

(b) According the German “Association for Electrical, Electronic & Information Technologies” (VDE) demand side integration is defined as follows:

> “The integration of renewables requires a paradigm shift in load management by means of demand side integration (…). Flexibilisation of the load enables load transfer (demand side management), an interesting way to shift the load from periods of undercoverage to periods with an excess capacity, thereby reducing peak loads and furthermore optimising the resource utilisation. In addition, shutdown of generating facilities is prevented by consumption during periods of high feed in. These possibilities go beyond demand side management and will subsequently be consolidated into the term demand side integration (DSI).”[55]

In its study, VDE has identified a high theoretical potential of 46 gigawatts for load management in trade and households by 2030, while only 9 gigawatts are technically feasible. The technically feasible potential in industry is 4.5 gigawatts.[56] Overall, these numbers should only be taken as a very rough indication of supply potential, as they are heavily reliant upon certain assumptions about future developments. It is, for example, far from clear whether electrical cars will be rolled out as projected. Many demand concepts

[49] Bundesnetzagentur (2011).
[50] Resch, C; Pier, C. (2012).
[51] For the concept of marketplace, see also chapter 5.3.2.
[52] i.e. Deutscher Bundestag Drucksache 17/10579.
[53] BAUM Consult (2012).
[54] Deutscher Bundestag Drucksache 17/10579.
[55] ETG-Task Force Demand Side Management 2012.
[56] See idem. The difference between theoretically and technically feasible potential is determined by factors like convenience.

rely on electrical vehicles as battery resource that can be shifted over time, but no one knows whether this is realistic.

Furthermore, it is contested whether the theoretical potential for demand side integration in small households is feasible within the next few years.[57] In contrast, E-Energy findings show that processes in building automation (hybrid heat pumps, micro CHP, air conditioning and lighting) have the biggest potential for practical realization along with heating and cooling processes in commerce and small industry.

Already big industry is participating in load shifting programs, which are possible because power consumers with a usage of more than 100,000 kWh/year always have smart meters and can be remotely controlled dependent on their specific contract.

(c) Storage and consumer flexibility can be used by component and collected by an aggregator to satisfy net demand; but they can also be considered new sources for power supply.[58] If so, they need to be integrated into a flexible concept of power generation: the Virtual Power Plant (VPP). The idea of a VPP is to use ICT to automatically collect and operate small-scale supply units, most notably consisting of biogas units.[59] In the context of the energy transition, one would typically choose a combination of RES (including biogas), micro-combined heat and power (micro-CHP) and new sources such as DSI. The result will be a balanced power band that can be physically adapted to changing weather conditions and TSO requirements. Economically, a VPP is a virtual balancing area that can participate in the marketplace. In addition to power supply, which is traded on the (regional) spot market according to schedule management, a virtual power plant can provide ancillary services such as balancing and reserve power, losses, re-dispatch, refinement of renewable power, reactive power, and black start capacity.

Of course, storage, demand side integration, Virtual Power Plants and provision of ancillary services don't necessarily need to be integrated in a cellular structure. Already, some frontrunner VPPs – RWE's and such start-up companies like as Next Kraftwerk – participate at the power exchange EEX as stand-alone enterprises.[60] Nevertheless, the Acatech study "Future Energy Grid" warns that developing a myriad of isolated projects to market renewables on a smart basis will result in a complexity trap and will get very expensive.

4.2.3 No Cost Effective Future Energy System without Plug & Play

"Future Energy Grid" presents two possible development scenarios: a "complexity trap scenario" and an "economically sustainable scenario."[61]

One of the major differences between both scenarios confers to the availability of ICT connectivity:

> "The information technology communication links of all ICT related system components of intelligent power supply systems will be characterized by ICT connectivity. These communication links range from the connection of sensors and actuators with power grids to

[57] See Klopfert, Frédéric; Wallenborn, Grégoire (2011).
[58] See chapter 5.3.1. for the concept of aggregator
[59] In fossil systems, a VPP can, of course, also consist of coal-fired power plants.
[60] http://www.rwe.com/web/cms/de/237450/rwe/innovation/projekte-technologien/energieanwendung/dezentrale-erzeugung/virtuelles-kraftwerk/
[61] Appelrath, Hans-Jürgen; Kagermann, Henning; Mayer Christoph (ed.) (2012)

> the monitoring and control systems within market communication. The communication links ensure information exchange and control functions between the various applications – from power generation to distribution to storage to transport and, finally, to consumption."[62]

In the complexity trap scenario, ICT connectivity of the components of the power system could not been achieved and isolated initiatives exist in parallel; in the "sustainable" scenario, standardized interfaces and a middleware platform across all grid levels are available from a very early stage. Acatech found that a well build ICT infrastructure layer allows for far-reaching automated interaction between authorized authors. Being cost effective and accessible, it would be the basis for the development of a broad spectrum of energy services. Smart control of RES could allow both grid operation and power demand requirements to be negotiated and met by automated processes. In a complexity trap world, however, the low voltage grid would be completely or partly left without middleware providing connectivity.[63]

Beyond the issue of connectivity, "Future Energy Grid" identifies eight key factors and nineteen technology fields that need to be developed by 2030 to guarantee a full, cost-effective convergence of power generation, storage, transport & distribution and consumption.

A necessary precondition for implementation is the availability of standardized plug & play interfaces. Standardization activities mainly occur on a European level. In a use-case approach, the German Commission for Electrical, Electronic & Information Technologies of DIN and VDE (Deutsche Kommission Elektrotechnik Elektronik Informationstechnik im DIN und VDE "DKE") worked with the European standardization organizations CEN, CENELEC and ETSI within the framework of the EU Smart Grid Mandate M/490. The resulting set of recommendations is to be adopted nationally. In Germany, BMWI's grid platform "Intelligent Grids and Meters" is already working on a complex national process of use-case identification, which is further elaborated in chapter six. Despite these activities, the development of standards is a slow process.

5 The Missing Business Model: A Chicken-And-Egg Conundrum

There are numerous reasons why it is hard for a smart market to emerge on its own. They add up to a chicken-and-egg conundrum: There will be no smart market without an ICT infrastructure, but politics and regulation place their faith in the market to provide the infrastructure.

It is shown below that a smart grid infrastructure necessary for the energy transition will not be driven by market forces in the same way as the oft-quoted iPhone revolution. On the contrary, the example of the iPhone is misleading. A suitable model for comparison would rather be the very origins of the Internet, in which the first developmental phases were initiated and funded by the U.S. Government.

[62] Appelrath et al. (2012)
[63] Appelrath et al. (2012).

5.1 Obstacles to the Deployment of Smart Metering/Smart Grids

Not even massive stakeholder interests from politics and various industry sectors (especially from the smart home industry) have considerably prepared for the smart meter rollout in Germany up to now. Notably, DSOs show little interest in the technology. The reasons include:

a) The risk of stranded investments because meters compliant with new laws are not yet available.[64]

To speed up smart metering, the Energy Directorate tightened laws in 2011.[65] Part of the package is dedicated to data protection; as a consequence, a protection profile for smart meters (BSI-Schutzprofil) has been commissioned in Germany for development by the end of 2012. The BSI protection profile" is said[66] to become the world's best data protection regulation. At the same time, it has caused a lot of delay and uncertainty, as everyone is hesitant to build and install new meters until the profile specifications are out. For this reason, the overdue and obligatory cost-benefit analysis (CBA) for the roll out of smart meters will not be ready before the end of the year. Without the CBA, there is no clarity as to how many smart meters will have to be installed.[67]

b) Missing communication standards

Despite numerous standardization activities, systemic plug and play interoperability is not available. Even more so, smart meters cannot yet facilitate the integration of consumer appliances with smart grid controls and interfaces to enable demand management as integration technologies are either not available or are proprietary.

c) Customers are not interested

Economically, smart metering would only make sense as a mass market under the current market design. Device manufacturers, metering point operators and data hub operators (like Deutsche Telekom) depend on high numbers of standardized devices and equally standardized routines to reap profits. To the mass market customer, however, smart metering is not attractive at the moment. There are practically no interesting variable tariffs, and those that exist amount to nothing more than the ability to pay back the expensive meter rent.

d) Enormous amounts of data

Smart metering will be generating enormous amounts of data. Smaller DSOs, metering point operators and suppliers, who already face problems with minor tasks like switching suppliers quickly, will not be able to cope. These companies are afraid of the ICT challenge, especially when headed by a CEO close to retirement.

e) Who is going to invest into the smart infrastructure?

[64] Arthur D. Little (2011).
[65] Sect12 para 4 Energy Industry Act; Sect13 para 4a Energy Industry Act; Sect 14a Energy Industry Act; Sects 21b-i Energy Industry Act; Sect40 para. 5 Energy Industry Act; Update of Metrology Act 2008.
[66] F.e. Peter Heuell, CEO of metering company Landis & Gyr says: „Dieser Ansatz ist der weltweit konsequenteste im Bezug auf Sicherheitsanforderungen für Smart Metering.
[67] See footnote 3.

As shown in chapter 3.3, however, the German regulator says smart meters belong to the market sphere and should be financed via market mechanisms. At the same time, customers are not interested, so there is hardly any market. Finally, investing means paying for an infrastructure where competitors can free ride on.

What can be said about smart meters also holds true for a smart energy system as such. Attractive business models are lacking as only small margins are possible for market-based services like demand response. With regard to the regulated parts of the grid, up to now[68] BNetzA has ruled that there will be no additional financial scope for DSOs to invest in smart grid technologies. These are demanding prospects for the development of a smart energy infrastructure as investment costs are significant.[69]

5.2 No Market without Appropriate Mechanisms

> "The E-Energy Market is the place in a future energy system that integrates the markets for energy and Information/Communication Technologies (ICT). From the economic perspective of electricity, business models and business cases can already be developed for sub-markets and sub-areas of network load management, wholesale marketing and energy-market regulations, which as core elements manage consumer load in the mass customer area. As it turns out, the expected surplus value for all business cases is still tightly assessed and the E-Energy Market is therefore not an automatic process. "[70]

E-Energy findings show that within existing economic coordination mechanisms the price spread for flexibilities beyond the industry scale is not sufficient to incentivize load shifting. Courageous startup companies like Next Kraftwerke GmbH, which bundles flexibilities in a VPP, face the same challenge and the same underlying structural problem: tailored to the requirements of large central fossil and nuclear power plants, the existing market structure reflects the traditional supply-follows-demand logic with its concepts of merit order and base load/middle load/peak load generation.[71] In Germany, power from renewables has been pushed into this pre-existing system via the preferential grid access set forth in the legislation for renewables (EEG).

As a result of the growing share of renewables, there is no more demand for the most expensive power plants, which has initiated a heated debate over a future power market design. An interesting voice in this debate is the Regulatory Assistance Project (RAP). In papers published this year, RAP points out that a fossil energy system hinges on the cost of coal, oil and gas, whereas a renewable system needs flexibilities and better predictabilities. Flexibilities in energy consumption and the ability to offer "load-following demand" in energy generation can thus be considered new scarce commodities, whose hidden value is not yet reflected in present market coordination mechanisms. RAP-principal Meg Gottstein points out that "the value of flexibility must, therefore, be readily accessible to potential providers of demand response."[72]

A future smart energy system requires a market design that values flexibility much more than today. Accordingly, trade rules for renewable power and flexible sources need to be adapted.

[68] There is an ongoing debate to grant research budgets for DSOs.
[69] See chapter 6.3.1.
[70] Leprich et alii (2010).
[71] Skilling; Gottstein (2012).
[72] Ibid (2012).

1) As a first step, E-Energy's Moma project therefore suggests a set of new rules that foster the realization of new flexibility options:
   - "Farewell to standard load profiles for households and small trade and industry, as these profiles do not incentivize flexible tariffs
   - Power labels in order to qualify green and ecological power products
   - Incentives for distributed renewables producers, suppliers and consumers to participate in forecast programs
   - Introduction of flexible grid tariffs."[73]

2) Intraday trading platforms relying on more sophisticated, flow-based capacity allocation methods have to be installed to cope with increasingly variable generation patterns. Aggregators, traders and suppliers of flexibilities, ancillary services, real-time information and weather forecasts will be the actors that make use of intraday trading platforms.

3) Renewables support needs to be reformed. Instead of trying to integrate RES into a market it is not tailored for (cf. above discussion), it is time to incentivize a better overall technical integration of wind and solar power. RES could be incentivized according to their contribution to ancillary services stabilizing the grid and their connectivity (both in ICT and in geographic terms) to the grid.

5.3 No Business Models without a Clear Allocation of Market Roles

Business models are driven by actors who incorporate roles. Market forces will thrive solely if there are market actors in place with a business model in mind and willingness to invest. Generation from distributed RES and the deployment of a well connected smart grid will result in a considerable shifting of existing roles in the electricity sector. Partly, this is already happening; to some extent, the emergence of new roles has been tested in the e-energy model project, while some of these new roles are only projections on paper.

5.3.1 Aggregators/Flexibility Operators

As small scale distributed energy resources (DER) cannot interact directly with the market or with TSOs to contribute to system stability, the new role of aggregator/flexibility operator is needed. It may be defined as follows: "The flexibility operator is a general role that pools small flexibilities of customers/network users in order to make use of them in the grid or energy market."[74]

Whereas the aggregator's role includes pooling small flexibilities to market them on the national stock exchange, the flexibility operator is also active on a grid operation level. The difference derives from the evolution of a convergence area, where grid operation and energy market interface. A flexibility operator would be active in both arenas; however, this dual role is difficult from the existing regulatory point of view.[75]

[73] Modellstadt Mannheim (2011)
[74] Ibid.
[75] Resch, C; Pier, C (2012)

5.3.2 Operation of the Regional Market Places and the Data Hub

A future energy system based on a smart grid with a large share of renewables will not only produce the new role of aggregator, but also new (local) market places that help optimize power supply.[76] New marketplaces will be convergence areas realized by data hubs that, in turn, enable the introduction of a variety of business models to suit local conditions. The use of hub technology will allow for the transparent display and exchange of data, a balancing of power supply, demand and customer response through incentives and price signals, and the trading of ancillary services. **Thus, the provision of the marketplace platform and the management of these data hubs will be a task of considerable infrastructural significance.** It is, however, far from clear who is going to play this role.

5.3.3 Distribution System Operators at Many Crossroads

Today, DSOs still passively continue the distribution of power on a top-down basis though many of them already handle bidirectional power flows. A new active role is waiting for them, as the EU Commission Task Force for Smart Grid points out:

> “Connection of distributed and micro generation will provide more options for the DSOs to balance their grid areas on the medium and low voltage level, thereby reducing stress on TSO level. At the same time, this will place new requirements on TSOs and DSOs in terms of operational security.”[77]

The latter also implies increased power injections at the boundaries between the TSO and DSO grids. Hence, new communication interfaces between grid operators must be introduced. As the system responsibility of DSOs grows, a fierce debate is taking place at the EU level regarding grid codes.[78] TSOs are trying to overtake DSO tasks. The question is how TSOs and DSOs will redefine their mutual levels of influence.

But there are more tasks coming up for DSOs. Research findings show that DSOs might play the role of marketplace and/or data hub operators ensuring provision of infrastructure for everybody without discrimination.[79] DSOs themselves would prefer to operate the data hub to control grid stability, leaving operation of the market place to someone else.[80] However, DSOs are very often part of a non-unbundled municipal unit, so independent suppliers fear that DSO parent companies could gain competitive advantage from the DSO’s data knowledge.[81] An alternative route of development might see DSOs in the role of mere market participants buying flexible loads and ancillary services from flexibility operators. The data hub could then be operated by the metering point operator.

5.3.4 Encounter of the Third Kind: When Smart Grids and Smart Markets Collide

Beyond data protection issues, the problem with the operation of the data hub arises from the poorly defined intersection of grid operation and energy market requirements. When local consumption and generation have to be balanced, technical and commercial

[76] Final report of the CEN/CENELEC/ETSI Joint Working Group on Standards for Smart Grids ftp://ftp.cencenelec.eu/CENELEC/Smartgrid/SmartGridFinalReport.pdf
[77] EU Commission Task Force for Smart Grids (2011)
[78] Resch, C; Pier, C. (2012)
[79] Müller, Schweinsberg (2012)
[80] KEMA Consulting GmBH 2012
[81] Bundesnetzagentur (2011)

flexibility are not necessarily congruent. BNetzA's report discussing these matters does not satisfactorily answer how a clash between grid operation functions (optimization and safety) and energy trading interests should be managed. Currently, industry and the regulator are discussing a "traffic light concept" with clear supplier responsibilities in times of "green" non-critical network states and DSO responsibilities in times of "red" network emergency states. Notably, "yellow" "in-between"-states presently remain a contested arena of turf wars.[82]

How will direct control be exerted on customers in "yellow" and "red" states? This is one of the most burning questions because those in charge will wield a considerable amount of power (and business opportunity). As plug & play interoperability is the precondition to any business model, it is in the standardization committees where – beyond technical specifications – use case definitions are agreed upon that will describe the scope of roles in the smart energy world of the future. Workflows in the energy market and respective business models will depend on those decisions.

But no matter which roles will be attributed to the actors in the smart grid arena, the ICT infrastructure serves grid operation and market functions. As such, it will be a new infrastructural layer. BNetzA's distinction between load capacity and energy volumes (i.e. smart grids and smart markets) does not make sense because it fails to acknowledge data infrastructure as a new emergent part of the system. When the regulator compares the smart market to the emergence of the iPhone, it misses the point that the iPhone relies on an infrastructure initially funded by the U.S. government.[83]

5.4 Who Will Drive the Development of the ICT Infrastructure and How?

It is far from clear who will organize the market place/data hub and how the principles guiding the power market design will look like, and the regulator's position doesn't help either. BNetzA not only refuses to consider necessary investments in smart grid infrastructure, but also misses the point that existing guidelines distinguishing regulated and non-regulated roles and actors have to be adapted when infrastructure as such is changing.

ICT infrastructure not yet available needs to be in place to start up a smart energy market. This finding implies the following questions:

1) What new regulatory necessities take into account the infrastructural role data management will play?
2) Who will pay for ICT infrastructure?
3) Who is going to drive ICT deployment beyond current smart metering rollout initiatives? Who is going to decide on the design of the marketplace itself?
4) How will new market places and new business models be designed in order to:
   - provide sound profit and investment incentives for extant and emerging market roles
   - maintain power quality and grid stability,
   - offer equal access to a well maintained grid infrastructure, and

[82] See Chapter 5
[83] As he did during the E-Energy congress in February 2012.

- adhere to market liberalization principles?

6 Smart Grid Roll Out and Policy Process: Actors & Activities

It is far beyond the scope of this study to name all the political and societal actors and activities contributing to the development of smart grid technologies in Germany. Therefore a selection has been chosen that represents the actors and activities with the deepest impact and biggest scope.

6.1 Ministries and their Activities

The ministries active in the smart grid cause are the Federal Ministry of Economics (BMWI) with its IT and Energy Directorates, the Federal Ministry for the Environment and the Federal Ministry of Education and Research. Mostly, the funding of major activities such as pilot projects or discussion platforms comes from more than one ministry.

6.1.1 The Directorate for ICT Convergence at BMWI, BMU and the E-Energy Model Project

The earliest political steps towards the deployment of smart grid technologies in Germany were started within the Directorate for ICT Convergence of the Federal Ministry of Economics in 2004/2005. Following e-commerce and e-government, E-Energy was considered to be the next step of the IT revolution. Consequently, the E-Energy model project consisting of six model regions started in the wake of Germany’s High-Tech Initiative in 2008. Two of the six projects were financed by the Federal Ministry for the Environment. In 2009, E-Energy was supplemented by the ICT for Electro Mobility project, which was funded with 45 million Euros from BMWI and 45 million from business partners.

Originally, the Energy Directorate of the Federal Ministry of Economics and Technology cooperated in alignment with the IT Directorate on the E-Energy model project. Their teamwork changed in 2010, when the Energy Directorate started to pursue its own ambitions by concentrating on the installation of smart meters. Since then, support for the E-Energy model project from the Energy Directorate has lessened. A follow-up research after the project’s end in spring 2013 has been postponed until further notice. The sister project ICT for Electro Mobility, however, has been funded for a second round, which is scheduled to end in 2015.

6.1.2 BMWI: The Energy Directorate

In 2008, the Metrology Liberalization Act was passed; it constituted an essential amendment of the provisions on metering in the Energy Industry Act and aimed at a smart meter rollout by 2014.[84] Ever since, the German regulator, DSOs and metering service

[84] Ecofys (2009).

operators have been arguing about who is going to pay for the rollout. Whereas the regulator is pleading for a market-driven rollout, DSOs say there is no business model.[85]

In order to speed up the smart metering cause, the Energy Directorate tightened laws in 2011[86]. Part of this package is dedicated to data protection; as a consequence, the protection profile for smart meters ("BSI-Schutzprofil") has been developed and an accompanying technical guideline has been commissioned for specification until the end of 2012.For this reason, the overdue but obligatory cost-benefit analysis for the roll out of smart meters[87] will not be ready before the end of 2012 either.

The Energy Directorate's preoccupation with smart meters has been called "putting the cart in front of the horse."[88] Critics say that without a smart grid infrastructure in place, the full benefit of smart meters can't be exploited. In order to have a basis for an assessment, the Energy Directorate has commissioned a study with the aim of quantifying and evaluating a smart grid update in comparison to physical grid extension based on copper lines. As a first of its kind, this extensive study is due next spring.

6.1.3 BMWI & BMU: Grid Platform

The Grid Platform was launched in June 2010 by BMWI and BMU; it aims to support the energy transition by fast-tracking the extension of the national grid. After the Fukushima disaster, it turned into an active dialogue forum, enlarged by an additional working group on Smart Grids and Smart Meters headed by the Energy Directorate of BMWI. It addresses a broad mix of societal associations ranging from the power sector, environmental, consumer and business lobbies to TSOs and DSOs, Ministries, the regulator, etc.The task of the working group is to provide a framework for the introduction of a smart grid. In BMWI's own words, it says:

"The grid platform's aim is to identify where there is specific need for action and to lay down details in a matrix. Thus, step by step the complex interplay of grid control, generation, consumption and power supply shall be mastered through the means of high-performance and safe information and communications technologies."[89]

In order to fulfill its goal, the working group is collecting use cases and collating data on an excel sheet.[90] Use cases are the basis to develop standards that guarantee plug & play usability in a smart energy system; they depict future workflows upon which future business models can be build. For example, a use case describes the way direct control can be exerted on electricity customers. Accordingly stakeholders are fighting to get their specific interests represented in the layout of these use cases. As a result, progress in the Grid Platform's Smart Grids and Smart Metering group is very slow.

[85] Bundesnetzagentur (2010).
[86] See footnote 56.
[87] See footnote 3.
[88] Acatech (2012).
[89] BMWI 2012 German original: „Die Netzplattform hat sich zum Ziel gesetzt, den konkreten Handlungsbedarf zur Entwicklung intelligenter Netze systematisch in einer Matrix darzustellen. So soll Schritt für Schritt das komplexe Zusammenspiel von Netzen bzw. Netzsteuerung, Erzeugern, Verbrauchern und Stromhandel unter Nutzung hochleistungsfähiger und sicherer Informations-und Kommunikationstechnologien gemeistert werden.“
[90] See chapter 4.2.3. and 5.3.4.

6.1.4 BMWI, BMU and BMBF: Storage Beacon Projects

July 2012 saw the kickoff for the “Storage Beacon Project.” The three ministries for the economy, the environment and research & education are funding sixty storage projects. They aim at technological breakthroughs to reduce costs and allow a rapid market launch. The program has two focus points: batteries and hydrogen production from wind energy.

6.2 The Federal Network Agency (BNetzA)

The most important authority dealing with smart grid questions in Germany is the regulator, the Federal Network Agency (Bundesnetzagentur “BNetzA”). As a regulated asset, grid operators must act within a framework approved by the regulator. Therefore, the regulator plays a major part in the smart grid debate. In parallel with the Energy Directorate of BMWI, BNetzA has paid a lot of attention to smart metering. In 2009, it launched an investigation into development perspectives of metrology that ended with the conclusion that the rollout of smart metering should be business-driven.

When it comes to upgrading grid components by DSOs, BNetzA has made its position abundantly clear with the publication of the white paper “Smart Grid and Smart Market” at the end of 2011.The main thrust of the argument presented in the paper concerns the clarification of responsibilities with respect to the emergence of smart grid technologies. From the perspective of BNetzA, it is up to the distribution grid operators (DSOs) to upgrade grids with automation technology, as their role is to serve all market participants. This approach has raised a lot of criticism (reasons elaborated in chapter 5) and praise, for example by independent suppliers, as BNetzA is upholding liberalization goals. Meanwhile, some concessions are on the horizon. For distribution grids at the 110kV level, bigger financial scope is underway.

Nevertheless, BNetzA’s main goal to liberalize and deregulate the power sector is not tailored to the requirements of the energy transition; liberalization aimed to destroy monopolies in the power sector to guarantee a free market.[91] It will be the task of government to provide an appropriate legislation for current problems to adjust BNetzA’s course.

6.3 Industry Associations

BNetzA’s white paper **Smart Grid und Smart Market** provoked quite a reaction from industry associations.[92] Whereas **Bitkom**, the association of the IT industry, has stayed out the debate, **BDEW, VKU, bne, VDE** and **BDI-IdE** have commented.

6.3.1 VKU: Who is Going to Pay? – Not Us.[93]

The Association of Municipal Companies (Verband Kommunaler Unternehmen or VKU) founded in 1949 represents the interests of the local public utility sector in Germany (more

[91] See the regulator’s website for an extensive task description . http://www.bundesnetzagentur.de/cln_1912/DE/DieBundesnetzagentur/UeberDieAgentur/UeberDieAgentur_node.html;jsessionid=F0A6CF5F92C108B423B04ADBE10876CB
[92] Bundesnetzagentur (2011).
[93] Stock Juni (2012).

than 700 distribution grid companies). Many of the municipal companies are not unbundled because of their small size. Municipal companies are an important pillar of the energy transition as they provide regional added value. They will also be important players on future regional marketplaces.

The conflict between DSOs and BNetzA has been a distinct topic in this report. Standing at the crossroads to a new and active role, DSOs want appropriate regulation, including an investment framework for grid upgrades so that distributed RES generation can be safely integrated into the grid. To determine how much an ICT upgrade would cost, VKU conducted a major study along with KEMA, which found that 7 billion Euros would be needed for operation and 24 billion as capital expenditure up to 2030.[94] Up to now, no real solution for the conflict with BNetzA is in sight, but that might change when results of BMWI's distribution grid study are made available next year.

6.3.2 bne: Full Support for BNetzA's Position[95]

Founded in 2002, the Federal Association of New Energy Suppliers (Bundesverband neuer Energieanbieter or bne) represents energy suppliers that, without owing a grid, seized the opportunity of an unbundled power sector to foster competition. bne's position stands in stark contrast to the DSO perspective as both are fierce competitors. As a consequence, BNetzA's strict distinction between smart grids and smart markets is strongly welcomed by bne. bne opposes the inefficiency of too many DSOs and the redundancy of their grids.

6.3.3 BDEW: Strong Position in Favor of a Systemic View and Security of Supply[96]

The German Association of Energy and Water Industries (Bundesverband der Energie- und Wasserwirtschaft - BDEW) is one of Germany's most important industry associations and represents 1,800 companies. In addition to water, the BDEW covers the sectors of electricity, natural gas and district heat. The spectrum of the Association's members ranges from local and municipal utilities to regional and inter-regional suppliers.

BDEW is a very outspoken organization. It has always actively participated in debates concerning E-Energy; it presented an influential paper outlining available smart grid technologies and took a clear position regarding BNetzA's White Paper.[97]

With respect to the latter, BDEW identifies two main concerns: (1) the need to safeguard security of supply, with a strong emphasis on a systemic view of the whole system. There will be a growing number of problems at the intersection of grid operation and energy trading[98] On top of unbundled role conceptions, a communication mechanism needs to be established that allows appropriate actions in any situations. Variable grid fees are favored as scarcity signals towards the market. (2) Like the VKU, the BDEW points to the lack of money for investments in grids.

[94] KEMA Consulting GmBH (2012).
[95] bne (2012).
[96] BDEW 26.03.2012.
[97] See chapter 3.2.
[98] The "yellow" state of the capacity traffic light; see chapter 5.3.4.

BDEW's supported the deployment of smart grids actively by publishing its White Paper "Smart Grids in Germany."[99] The industry association also plays a very active role in standardization activities, favoring DSOs in the role of data hub operators.

6.3.4 VDE

The VDE, the Association for Electrical, Electronic & Information Technologies, is one of the largest technical and scientific associations in Europe with more than 34,000 members. VDE members include not only engineers but also scientists, students, technicians, all important businesses in the electrical, electronic and information technology industry, the electrical utilities, federal authorities and institutions.

The VDE excels in the publication of many studies and position papers, such as on smart grids with demand side integration, storage and business models.

One of VDE's most important tasks, standardization in Europe, is done by its subcommittee DKE (German Commission for Electrical, Electronic & Information Technologies of DIN and VDE). For E-Energy, the DKE developed a smart grid standardization roadmap, whose second edition is soon to appear.[100]

Even more so than BDEW, the VDE is strongly advocating for a systemic view on smart grid technologies. Whereas the BDEW is more oriented towards daily business, the VDE conducts scientific research to identify and solve tomorrow's technical issues.[101] At the moment, the VDE strongly pushes for a clear definition of the new role for DSOs. As is also pointed out in this report, VDE identifies the poorly defined intersection between grid operation and power markets as an important stumbling block to new business models.

6.3.5 BDI-IdE

The BDI's Internet of Energy working group (BDI-IdE) has a special role as it is not an industry association, but a think tank. Founded as a project group within the Federation of German Industry in 2007 to accompany the "High Tech Strategy" of the German government, it soon began working with E-Energy BDI-IdE shared E-Energy's principle of integrating all smart grid components into one communication based structure called the "Internet of Energy." After its official end in 2009, BDI-IdE continued working as an expert body on voluntary basis. It is interdisciplinary and independent.

6.3.6 Environmental NGO's and Lobby Organizations Representing the Solar and Wind Energy Business

Whereas environmental NGO's and lobby organizations representing the solar and wind energy business are heavily fighting for maintaining the German Renewable Energy Act (EEG), they are rather absent in the smart-grid debate. In the grid platform of BMWI and BMU, only two environmental organizations are represented: DUH (Deutsche Umwelthilfe - German Environmental Relief) and bee (Bundesverband Erneuerbare Energien - Association for Renewable Energies).

[99] BDEW; ZVEI (2012); see also chap. 3.2.
[100] DKE (2010).
[101] Some of VDE's recent smart grid related publications are ETG-Task Force Demand Side Management (2012); VDE |. ITG-Arbeitskreis Verteilungsnetzautomatisierung (2012).

In 2009 Umweltbundesamt (UBA - German Federal Environmental Agency), Wuppertal-Institute and Friends of the Earth Germany did not reply when BNetzA held an "inquiry on competitive developments and perspectives with regard to smart metering and variable tariffs."

Interestingly, different groups of stakeholders, especially environmental minded ones who advocate the energy transition, talk about the necessity to synchronize demand and supply for future power market design. However, up to now, this debate has not taken into account the need to pay for the deployment and maintenance of a smart energy infrastructure, nor does it include the rather tricky question of how regional market place considerations can be integrated into a new power market design. Rather, the discussion focuses on solving current affairs problems, not the search for a strategic approach to smart grids. One of the reasons for this reluctance to dealing with smart grid technologies is the uncertainty about how future scientific developments will turn out.

6.4 Scientific Institutions and Studies

In February 2012, a significant scientific contribution to the smart grid debate was delivered by Akademie der Technikwissenschaften (Acatech - the Academy of Technical Sciences). Their study "Future Energy Grid" was conducted in cooperation with the Offis Institute of Oldenburg and the Munich Institute of Technology (TU Munic) along with a number of company representatives.[102] Within the framework of E-Energy, this study shows that smart grids are needed for the energy transition to be successful. There, Acatech stresses the necessity of an "overall strategy aligned with political, economical and technical issues, more intense research and a strong involvement of economics and society to strengthen consumer acceptance and trust." [103]

Whereas Acatech's comprehensive oversight shows how, over time, all facets of smart grid technologies can be integrated smoothly into the electricity system, recent studies have concentrated on how the hybrid technical integration of electricity, heating, cooling and gas technologies can be achieved. The institutions involved include Fraunhofer ISE and IWES, the IZES Institution, EcoFys, and ENCT.

ICT will unite the different parts of the energy sector into one interacting conglomerate. In the long run, this hybrid, highly complex system will probably be the shape the energy transition is going to take.

[102] Appelrath et al. 2012
[103] Ibid.

7 Annex

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