The Smart Grids Debate in Europe

Essential for the transformation of the European energy system, deserving more attention and transparency

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Executive Summary

New information and control technologies (ICT) are about to fundamentally transform the electricity sector after having profoundly changed so many other industries. The introduction of "smart grids" challenges the traditional top-down control logic. It stands for real-time transparency, flexible management of resources, control through market mechanisms, and multiple interactions of a wide range of users throughout the system. Evidently, this raises fundamental new questions about management levels, responsibilities, control rights, data access, markets and market roles, as well as regulation.

Originally understood as a merely technical upgrade of limited impact, the idea of "smart grids" has been developed from different sides since about three decades:

- automation of the interface between the grid and the customer – smart metering and demand side management
- distribution automation – more intelligence in the traditionally dumb distribution grids for improving failure detection and blackout prevention
- dealing with increasing shares of distributed and fluctuating renewable power, requiring to actively manage bidirectional flows and increased flexibility of demand
- e-mobility – managing a new kind of high-power mobile demand and storage

Making grids smarter therefore needs to be considered as a key element of any transition strategy towards renewable electricity. For the interested public, however, and even for many energy policy actors involved, the issues at stake are not very clear and much less the arenas where they are discussed. Against this background the Smart Energy for Europe Platform SEFEP has decided to have a closer look at the smart grid discussion at the EU level.

The development of smart grids has not been as smooth as hoped for three years ago. The development of standards is behind schedule, investments are behind expectations. Involved actors say that fundamental decisions concerning future structures are needed for going ahead. The problem is not a technical one and is not the cost. Roles and responsibilities and the mechanisms for attributing costs and revenues need to be revised. However, there is not yet a shared vision, since all suggested reforms lead to considerable shifts in technological, commercial and political power. Moreover, due to the growing complexity of the issue, positions and strategies are often not yet clear.

In the last two decades the EU has increasingly set the framework for the development of the European energy sector pushing for liberalisation and renewable energies. A range of motivations have been at the origin of EU smart grid activities: competitive energy markets, efficient use of energy, integration of fluctuating renewables, consumer protection and data safety, industry development, research. The key ongoing activities initiated by the EU commission are: The Smart Grid Task Force SGTF, the definition of obligations for the roll-out of intelligent metering systems, the development of network codes, the energy efficiency di-

rective, as well as coordinated research activities (including the SmartGrids European Technology Platform and the European Electricity Grid Initiative).

Also for experienced insiders it is not easy to understand what is happening and where. The organisations of the traditional electricity sector are well represented. The equipment manufacturers are also well established – with the exception of the weakly represented renewable energy industries. The IT and telecom industries are visibly gaining influence while consumer and environmental organisations are not very present. There is a strong risk that the definition of standards in technical committees may have far-reaching consequences for the overall future architecture of the electricity system without an adequate public debate.

A look at the smart grid discussions in different EU countries shows that priorities of the member states involved in the EU debate differ considerably – corresponding to the different structures of the electricity sector and public awareness for the challenges of the transformation ahead. For example Denmark has developed most advanced technologies and visions, calling explicitly for the establishment of local/regional electricity markets with new roles, while others follow a somewhat more centralised vision. The big push for smart grids, however, may come from outside Europe: Both the US and China are determined to play a leading role in the global smart grid industry.

Overall, there are three areas in which the resolution of – often covert – conflicts of interest is essential for further progress of the transformation:

- the shift of responsibilities from the transmission to the distribution level and the redefinition of roles
- the definition of the interface between the public grid and the consumer/prosumer
- the role of regulation at the EU level

Moreover, an important overarching question is how the need for rapid decision and action can be reconciled with the need for openness and transparency of the decision process in a rapidly changing environment.

Conclusions

The importance of the smart grid debate is being heavily underestimated. Important issues concerning the future European energy system and the associated commercial and political power structures are being pre-configured in small, seemingly technical circles dominated by large industrial interest groups. A broader debate is needed. This requires to improve transparency, to explain the issues at stake, to translate between technological, political and business cultures.

Different groups of stakeholders have different, although mostly not explicit, visions of the future system. Making these basic ideas more explicit could help to clarify the debate. While many are still thinking in terms of patches to the old top-down system, new flexible structures are growing bottom-up. Formulating a publicly understandable vision for a multilayered system in Europe, conceived in the spirit of bottom-up subsidiarity, could provide a useful new framework for understanding suggestions and positions.

1 Introduction

The Smart Energy for Europe Platform SEFEP is a "*European non-profit organisation committed to the goal of a fully de-carbonised, reliable and predominantly renewable power supply in Europe before 2050*"[1] funded by large European and American foundations acting with a long-term perspective. In recent years renewable electricity generation technologies harvesting sunshine and wind have made such progress that their potential to generate sufficient power at reasonable cost is no fundamental problem anymore. [2] The big challenge is the "integration" of fluctuating and to a large extent distributed electricity generation with high upfront and no marginal costs into a reliable energy system and energy markets – made even more difficult by the accelerated shift of the transport sector to electricity (e-mobility). It has meanwhile become evident that this "integration" will require a thorough transformation of technical systems and markets.

In this context, the electrical grids and the coordinating functions associated with them are gaining more and more attention. "Smart grids", initially understood as a merely technical infrastructure, are increasingly considered to be a complex concept involving not only hardware and some local control software, but also system-wide control logics, system concepts, market platforms, and even the role of market actors and regulators. While over the last decades the transmission grids and the coordination of large power plants have already become "smart" with the help of modern information and communication technologies, distributed generation with fluctuating renewable energy now requires to allow for a more active management also at the lower levels of the system where "distribution" grids had an essentially passive role.

While the term smart grids is often appearing in the energy discussion and in the media, it has become increasingly difficult to understand what happens, who is proposing what, and where decisions are being taken. On this background, SEFEP has decided to have a look at the complex landscape of discussions in Europe. The present paper aims at giving an overview on the issues, the different policy threads and forums as well as the active stakeholders in the discussion on smart grids at the EU level, and to show how this level relates to national debates. A complete mapping of the landscape would have been beyond the scope of this initial project.

I am thankful to all the interview and conversation partners who have helped to come to the insights summarised in this paper.[3]

[1] www.sefep.eu
[2] E.g. (Schleicher-Tappeser, 2010, 2012)
[3] See Annex

2 Framing the issue: Why smart grids are important for the transformation of the system

"Smart grids" – a complex, evolving concept standing for a paradigm change

The "Smart Grid" is not just an infrastructure we could discuss, plan, agree upon and implement, such as, for example, a high speed railway network. It is a complex, evolving concept which stands for the increasing use of new electronic information, communication and control technologies in the rather traditional electricity business. There is a growing consensus that the use of these new technologies – in one form or the other – is essential for meeting the challenges to which energy and especially electricity systems are confronted. On the background of climate change, growing energy demand, globalisation, increasing fossil fuel costs and a new awareness for the risks of nuclear power, the use of renewable energies has been supported by a growing range of stakeholders and is now gaining such a momentum that it requires a rethinking of the architecture of the whole energy system and of energy markets, especially in the field of electricity. As will be shown below, the concept of "smart grid" has a range of different roots. Different stakeholders in different countries with different structures of the energy sector emphasise different aspects and priorities – and all are involved in a complex learning process concerning their options, their interests, their vision for a future system and their role in it. In discussing the issue with different persons, organisations and institutions, it is therefore difficult to disentangle the different vested interests, the different backgrounds and the different awareness of the coming challenges.

ICT to deeply transform the energy system, as other sectors before

Dealing on one hand with high shares of fluctuating and to a large extent distributed electricity generation and on the other hand with the introduction of new heavy load mobile users (electric vehicles), both within a time period which is shorter than the lifetime of conventional energy infrastructure investments, will require considerable and timely efforts. It requires ensuring a rapid transition towards a highly flexible multidimensional and multilevel coordination and compensation, without compromising the reliability of the system. The technical concept of the European electricity system is essentially based on technologies conceived in the first half of the last century: centralised generation in large units, top-down distribution to the consumers over an essentially dumb distribution grid with unidirectional flows, adaptation of essentially fuel-based generation to rather well predictable load curves of stationary consumers. As in other industries before, the demand for more complex coordination and flexibility can be most economically achieved through an extensive use of information and communication technologies. And as in other industries this does not only imply the introduction of some new devices, but also a fundamental rethinking of the overall system design. This leads to new conflicts: While the incumbent powers of the electricity sector try to keep stability and their own roles by maintaining as far as possible the system logic of the steam engine era, the ICT industry is much more accustomed to conceive highly flexible multi-layered systems with a multitude of feed-backs and distributed responsibilities, allowing for different organisational configurations.

Big challenges for a sector that has not yet digested liberalisation

The situation is complicated by the fact that the energy sector has already embarked in a still incomplete organisational transformation process which was initiated before the challenges of fluctuating renewable energy and e-mobility became evident to the key players involved: the liberalisation of electricity markets with the unbundling of different roles, reduced reach of the traditional monopolies and an increasingly differentiated regulation. Introducing competitive markets has increased innovation in the sector. The new roles and markets, however, have been conceived on the basis of the old technical energy system. In their present form they do not meet the new challenges: investments into "smart grids" – whatever might specifically be meant by this – are far below expectations, investments into appropriate capacities for balancing fluctuating renewable generation (demand response, storage, highly flexible CHP plants) risk to be too low for coming needs. At the same time, "smart" technologies are increasingly used for ensuring the appropriate communication between the different actors and for coupling the increasingly differentiated markets with the technical energy system. In order to speed up the transformation, key regulatory questions have to be solved.

More organisational and regulatory than technical challenges

Some years ago the discussion about "smart grids" may have seemed to be an issue for specialised technicians. Today, since the focus of the debate on the energy transition has shifted from the availability and cost of renewable energy sources to the systemic questions of how to deal with their characteristics, the discussion about "smart grids" is at the core of the energy debate. It concerns technical, organisational, and political issues. The cost of renewables, the future share of different technologies, the architecture of markets, the role of the different actors, the speed of transformation of the system – all are intrinsically linked with the question of how, in addition to copper wires, the different elements and actors of the system will be linked by "smart" controls and communication. For many actors in the energy debate this comprehensive system perspective and the necessary fundamental change in the system logic are rather new. The transition towards a much more "smart" system can be considered as a vast learning, discovery and negotiation process in which the answers to many questions have still to be found.

The next big issue in the energy and climate debate

Not only in an abstract academic conceptual debate, but also in a real hands-on technological, commercial and political power-game, the "smart grid" design and implementation process is about developing a fundamentally new system logic in the energy sector, a new assignment of roles, powers and revenues. Introducing "smart grids" means that software-controlled new technologies are substituting hardwired top-down control mechanisms, allowing for a much more complex, flexible and efficient management. In principle, this opens opportunities for new and new kinds of actors at all levels of the system. However, the new technologies allow for a wide variety of system configurations – including much more sophisticated centralised control. Smart grids are the key for a rapid and least cost transition towards energy supply with large shares of fluctuating renewable power generation. A key issue of the energy and climate debate will be to ensure that the chance of a fundamental reconfiguration of the energy system through smart grids supports this transition as effectively as possible and is not hindered or misled by particular interests or lack of understanding.

3 The debate has reached a new stage – the evolution of the smart grid concept

For understanding the difficulties and the incoherencies of the present discussion on smart grids, a short look at the history of this concept is useful.

3.1 Different roots of the Smart Grid idea

Long before the discussion on the integration of fluctuating renewables into the electricity systems, first "smart grid" concepts emerged from the efforts of solving specific problems by substituting traditional electromechanical devices by more intelligent electronic ones.

Smart Metering

After the hopes had vanished that electricity would become "too cheap to meter"[4], further automation of metering had mainly the following motives: to avoid the need of regular visual data collection by utility personnel, to gain a better short-term control over electricity losses (including theft prevention), to support customers in saving energy, to facilitate the use of peak and off-peak tariffs, and to manage loads, mainly of larger consumers. Already in 1977, the first fully automated, commercially available remote meter reading and load management system was launched[5]. Since the nineties large customers with differentiated tariffs have to a large extent been equipped with one or another kind of smart meters. For residential use, smart meters have increasingly been considered as a support for raising awareness about energy consumption behaviour leading to energy conservation – however the resulting energy consumption reductions in pilot projects vary widely and have often been disappointing. The option of managing the time of use of appliances has only gained interest in the last years with the increasing share of renewable electricity generation. The up to date largest deployment of smart meters for 30 million customers has been undertaken in Italy between 2000 and 2005. Although the meters show advanced features, important motives seem to have been direct control over peak power and theft prevention.[6]

[4] Lewis Strauss, chairman of the US Atomic Energy Commission, 1954
[5] http://en.wikipedia.org/wiki/Automatic_meter_reading
[6] See case study and http://www.businessweek.com/globalbiz/content/nov2009/gb20091116_319929.htm

Distribution automation / Active distribution networks

While electricity flows on transmission grids are being intensely controlled and their capacity is efficiently managed, distribution grids at the medium and low voltage level traditionally have not been equipped with control technologies. However, in Europe they are generously dimensioned, and in large parts redundant and meshed, so that traditionally their operation has been highly reliable. In the United States, where grids are weaker and more extended, reliability has been much more of a problem and has led earlier to considering new technologies. American texts on the smart grid often start with the big blackouts in 2003.[7] Automatic disconnection/ reconnection of parts of the distribution grid can more effectively prevent local breakdowns to spread into larger parts of the system. Close surveillance of frequency, voltage and reactive power in combination with new means to compensate variations (solid state power electronics) can considerably increase the capacity of existing dumb distribution grids.

This has become particularly important with the increase of distributed power generation which may cause inversions of the electricity flow and requires a more sophisticated management of grid capacity.[8] If distributed power generation is explicitly involved, an increasingly used term is “active distribution grids”. The smart combination of different distributed generation sources (wind, sun, CHP) in so-called virtual power plants, as well as the real-time management of demand response and storage are becoming important in this context. So-called microgrids can temporarily operate independently from the main grid and increase overall stability - interest for them has grown especially in the United States.[9] Many smart grid pilot projects in the EU involve active distribution grids. Some of them also have tested smart pricing concepts allowing for an effective management of grid capacities.[10]

Energy management in buildings and facilities

Within buildings and factories, smart energy management technologies have been evolving since decades. Often their main focus is heating and cooling, and they are capable of managing complex demand systems. Since electricity generation by the consumers themselves is emerging, their tasks have become more complex. With increasingly cheaper captive PV power generation the incentive for shifting consumption into sunshine hours increases, and may lead to a boost of investments in these technologies independently from public grid regulations. This will increase the flexibility of the demand side and will require flexible adaptation of public grid tariffs (with the help of smart grid technologies) in order to make sure that this flexibility contributes to the reliability of the main grid and does not undermine it.[11]

[7] E.g. the introduction of (Sioshansi, 2012)
[8] See also (Klose et al., 2010)
[9] See e.g. (Chowdhury et al., 2009; Driesen and Katiraei, 2008; Lasseter, 2002; Platt et al., 2012)
[10] See e.g. (Brandstätt et al., 2012)
[11] See (Schleicher-Tappeser, 2012)

E-Mobility

The last strand of smart grid developments is the establishment of a charging infrastructure for electric vehicles that allows for interconnectivity and roaming. The mobility of these new loads, the high currents required for relatively short and unpredictable periods as well as the need for ensuring appropriate accounting and payment, poses unprecedented challenges to existing grids that can only be met with smart grid technologies.

3.2 Conceiving an integrated technical system of a new kind

As the technologies and the application fields of these different strands leading to smart grids overlap, they have gradually been integrated into more comprehensive technical concepts which represent a real paradigm shift compared to the traditional power system. Implementing these new concepts in reality is expected to create huge business opportunities. Market reports forecast hundreds of billions of turnover. Traditional power sector suppliers have developed a series of proprietary solutions; IT companies have made considerable efforts to enter the markets. Large players have spent huge sums to buy more specialised companies. Different consortia are struggling for technical standards that would ensure interoperability. The different approaches put the focus on different aspects. And it is increasingly acknowledged that there cannot be a standard approach for all situations and countries, since different existing structures require different priorities.

Definitions of the smart grid have become rather comprehensive. The definition used for the technology oriented German standardisation roadmap, for example, says:

> *„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 centralised and distributed power generation and storage facilities reaching tight up to consumers, so as to achieve better networking and control of the system as a whole*"(DKE, 2010)

Pilot projects across Europe corresponding to such a broad approach have shown the technical feasibility of a wide variety of systems and configurations.

However, in many policy initiatives and public debates the focus is still lying on the deployment of smart meters which an increasing number of experts are considering not to be the first priority.[12] Also the approach of the Smart Grid Task Force of the European Commission following the Third Energy Package seems to be much more restricted and focuses on "services and functionalities" to be delivered by smart grids. However, the approach is quickly evolving. Especially the report of Expert Group 3 of the Smart Grid Task Force 2009-2011 has shown that the discussion cannot easily be confined to technical issues and more fundamental questions need to be tackled.[13]

[12] Result of most interviews. See also (Schwartz, 2010; Schwartz and Sheaffer, 2010, 2011)

[13] See http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/expert_group3.pdf and the section on the SGTF below

3.3 A new phase of the debate – it's more than technology

Compared to the expectations of three years ago, many actors say to be deceived by the effective progress in smart grids. The development of standards is behind schedule, investments are behind expectations, and enthusiasm for the envisaged smart-meter rollout is fading[14]. Equipment vendors, distribution grid operators and electricity retailers are complaining that business cases for smart grid investments are still difficult to be identified and that missing standards make technical choices risky. Increasingly they are calling for a clarification or revision of the regulatory framework. Although smaller investments which lead into the direction of smarter grids are happening everywhere, it seems that more fundamental decisions would need to be taken for going ahead.

The problem is not a technical one and is not even the cost. Tradeshows present a wide variety of functioning technical solutions. Even new high-end solid-state power electronic devices, which would drastically boost the capacity of existing copper wires, could quickly come down to much lower cost if they were mass-produced. It also does not seem that the problem lies in finding technical and procedural compromises between different interest groups which take their time.

Across all stakeholders there seems to be a growing acknowledgement that the present definition of roles and responsibilities and the mechanisms for attributing costs and revenues are being fundamentally challenged by the need to change the logic of the system. The attempts to reorganise revenue flows which would help to fund smart grid investments, to define or restructure responsibilities for data handling, customer contact or local congestion management, easily lead to considerable shifts in technological, commercial and political power between the players involved. There is not yet a shared vision which would coordinate the endeavours of the large range of actors in deregulated markets.

Old and new groups of actors in the energy arena are trying to understand the upcoming challenges and opportunities and to secure themselves an important role in the emerging new configuration. However, because of the growing complexity of the issue, the high innovation speed of new energy technologies and the large numbers of new entrants in the debate, positions, strategies and possible conflict lines among different interest groups are not yet clear.

[14] Although market research reports forecasted a strong growth in deployments last year (http://www.fiercesmartgrid.com/press-releases/smart-grid-become-%E2%82%AC68-billion-industry-europe-2016-according-gtm-research) on the basis of the EU requirements for an accelerated roll-out. The cost/benefit analyses required by the EU are progressing slowly. See also http://www.oracle.com/us/industries/utilities/emeasmartgridreadinessstudy-182804.pdf, http://www.frost.com/sublib/display-market-insight-top.do?id=241350409, http://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/EPNG/PDFs/McK%20on%20smart%20grids/MoSG_Europe_VF.ashx

4 The EU policy arena

4.1 Why the EU level matters in this context

For several reasons the discussion on smart grids at the EU level is of particular interest for the development of the energy sector worldwide.

From a global perspective, the EU has still a leading role in the transition towards a predominantly renewable energy supply. Its endeavour to integrate very high shares of fluctuating and to a large extent distributed renewable electricity generation into a highly reliable and affordable power system is being observed with high interest. And smart grids are playing a key role in this effort.

From the perspective of EU member countries, an EU-wide approach is becoming increasingly important:

- for many European countries EU initiatives have been a key driver for starting to overcome unsustainable and risky energy supply patterns
- an intensified European electricity exchange can help to balance the fluctuations of renewable power production
- new technologies need large markets for bringing the costs down
- a joint learning process helps to keep up with the challenges of an accelerating transformation
- and a joint approach helps European industries to play an important role in the game.

Nevertheless the conditions in European member countries are rather diverse, and diversity also helps in a creative joint learning process.

Due to their short history and given their wide range of motives and origins, the discussions concerning smart grids at the EU level are scattered across a landscape of different and not always well-coordinated bodies. To understand what is happening seems to be a challenge also for experienced insiders.

4.2 Main activities promoted by the European Commission

Corresponding to the complexity of the evolving smart grid concept, the initiatives of the EU Commission and of EU-related bodies are being pushed from different sides. The endeavours are originating from different motives and Commission services: competitive energy markets, efficient use of energy, integration of fluctuating renewables[15], consumer protection and data safety,[16] industry development (mainly ICT, electrical equipment, appliances),[17]

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[15] All three in DG Energy, see more below.

[16] Task Force Smart Grids, http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/expert_group2.pdf, DG Connect, ENISA: http://ec.europa.eu/dgs/connect/mission/index_en.htm#DirH , http://europa.eu/rapid/press-release_SPEECH-12-732_en.pdf, https://www.thegrandconference.org, http://www.enisa.europa.eu/

[17] DG Enterprise & Industry: http://ec.europa.eu/enterprise/sectors/electrical/competitiveness/electra/index_en.htm, http://ec.europa.eu/enterprise/magazine/articles/industrial-policy/article_11038_en.htm,

research[18]. Important activities can be found in three Directorates-General: DG Energy (Grid activities), DG Information and Society (SmartGrid Activities), DG Research and Innovation. Many other DGs are involved in specific aspects of Smart Grids (e.g. Transport, Regional Policy, Enterprise and Industry, JRC etc.). In the last two years, however, there have been considerable efforts for improving coordination. The most important ongoing activities of regulatory relevance are shortly presented in the following sections.

SGTF Smart Grid Task Force

Under the provision of the Third Energy Package DG Energy has created the "Task Force for the implementation of the smart grid into the European internal market" in 2009[19]. Under the guidance of a Steering Committee composed by representatives from Commission services, the regulators, a wide range of industries and the consumers, four Expert Groups have delivered reports in 2011. While the mission started from a rather narrow focus on metering and directly grid-related services and functions, especially Expert group 3 on "Roles and responsibilities of actors involved in the Smart Grids deployment" has emphasised the necessity of rethinking the whole architecture of electricity markets and roles[20]. This may be exemplified by two passages in the report:

> *The DSOs' responsibility in the future electricity market with massive DG[21] and micro DG is multi-fold and resembles that of the TSOs in the transmission grid of today. These include (i) keeping operational security and quality of supply, (ii) enabling the new operations at the distribution level (including non-discriminatory and effective real-time grid capacity monitoring and management of injections / withdrawals), (iii) market based congestion management, (iv) support energy efficiency and integration of renewables at the producer side by setting harmonized and non-discriminatory rules and codes.(p.11)*

> *With the increase in distributed generation, new energy market places will have to be promoted, contributing to a further optimization of the system. These market places might require additional rules than the ones which are in place today in the wholesale market. The structures in the markets will start to reflect more and more the increasing decentralized character of the power system and balancing, clearing and settlement will have to react to this development by opening to smaller participants. It can be expected that an increasingly flexible formation of energy prices and ancillary services (both on the time scale and in the spatial extension) as well as increasingly flexible grid tariffs will ultimately be required to deliver the full potential of Smart Grids.(p.30).*

The work of the Task Force has contributed to the key document of the Commission's Smart Grid activities published in May 2011: "Smart Grids: from innovation to deployment"[22], which focuses on five objectives: (1) developing technical standards; (2) ensuring data protection for consumers; (3) establishing a regulatory framework to provide incentives for Smart Grid deployment; (4) guaranteeing an open and competitive retail market in the in-

[18] DG Research in different programmes: Energy, ERA, Infrastructure, ICT, Social Sciences…
[19] First mission: http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/mission.pdf. SGTF website http://ec.europa.eu/energy/gas_electricity/smartgrids/taskforce_en.htm
[20] http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/expert_group3.pdf
[21] DG = distributed generation
[22] COM/2011/0202 final

terest of consumers; (5) providing continued support to innovation for technology and systems.

An important outcome of the first mandate of the SGTF are ongoing negotiations on standards framed by three standardisation mandates of the Commission to the European Standard Organisations[23] based on the work of expert group 1.[24]

In 2012 a new Steering Committee (with twice as much members and a stronger representation of the telecom industry) has been appointed by DG Energy.[25] The updated mandate puts a stronger emphasis on regulatory issues as well as on communication and data handling. The challenges of distributed and fluctuating renewable energy play a stronger role. Overall, the second mandate seems to acknowledge more than the first one that the development of smart grids and increased distributed generation involve a fundamental rethinking of actor's roles, the logic of the technical system and market architectures.

Cost-benefit analysis and roll-out of intelligent metering systems

On a somehow separate track, 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.[26] Member States have to conclude their assessments by September 3, 2012, and to roll out 80% of the positively assessed systems by 2020. The coordination of this activity is with DG Energy, Assessment criteria and required functionalities have been developed in cooperation with DG INFSO and DG JRC. The corresponding JRC report[27] does not mention an involvement of the SGTF.

Development of Network Codes

Another most important activity concerning Smart Grids following the Third Energy Package[28] is the development of Network Codes[29]. On request of the Commission the Agency for Cooperation of Energy Regulators ACER elaborates Framework Guidelines. Subsequently the European Network of Transmission System Operators for Electricity ENTSO-E (for gas ENTSOG) elaborates the network codes.[30] The whole process is supervised by the commission and involves public consultation. The current 3-year work programme envisages the finalisa-

[23] CEN, CENELEC and ETSI, see mandates on http://ec.europa.eu/energy/gas_electricity/smartgrids/taskforce_en.htm
[24] See also the regulation guidelines for member countries issued by ERGEG (ERGEG, 2011)
[25] (European Commission, 2012)
[26] 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
[27] http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/2011_10_smart_meter_funtionalities_report_full.pdf
[28] http://ec.europa.eu/energy/gas_electricity/legislation/third_legislative_package_en.htm
[29] http://ec.europa.eu/energy/gas_electricity/codes/codes_en.htm, based on Regulation (EC) No 714/2009 on conditions for access to the network for cross-border exchanges in electricity, 32009R0714.
[30] https://www.entsoe.eu/resources/network-codes

tion of framework guidelines on "capacity allocation and congestion management" (Q2/2011), on "grid connection" (Q2/2011), on "system operation" (Q4/2011), on "balancing" (Q3/2012) and on "Third Party access" (Q2/2013). Corresponding network codes are supposed to be ready about two years later.

This means that highly complex rules concerning the future functioning of smart grids are going to be finalised in a very short period of time. Most, but no all, interlocutors assume that these codes will be most important for the whole architecture of future grids. While these codes are originally intended to facilitate cross-border exchanges, they effectively tend to make detailed prescriptions for the distribution level. Anecdotal accounts report attempts to introduce very detailed requirements for appliances that would serve specific interests and would not be based on a widespread consensus. As ENTSO-E represents the transmission system operators, transmission grid operators interests are much more strongly represented in this process than the view of actors at the distribution level.

There seems to be no systematic coordination between this development of codes and the earlier mentioned development of smart grid standards on the basis of the SGTF recommendations.

Energy Efficiency Directive

A different source of legislation for the development of smart grid functionalities will be the Energy Efficiency Directive on which the EP, the Commission and the Council have reached an agreement in June 2012.[31] The directive due for final vote in the EP in September 2012, after having been watered down in most respects during negotiations, contains two key provisions for demand response: member states have to ensure that (1) demand response be allowed to participate alongside supply in electricity markets and that (2) grid operators treat demand response providers in a non-discriminatory manner when providing balancing and reserve services. This is a considerable step forward, since a series of hurdles have prevented demand response measures from competing with the electricity generation.[32]

Research activities

Another important forum of discussion between a wide range of stakeholders is the **Smart Grids European Technology Platform (SmartGrids ETP)** initiated by DG Research.[33] It describes itself as the "key European forum for the crystallisation of policy and technology research and development of pathways for the smart grids sector, as well as the linking glue between EU-level related initiatives". It recently released its "SmartGrids Strategic Research Agenda 2035" emphasizing that such a long perspective is needed for envisaging the deep transformations required by high shares of renewables, highly efficient buildings and a

[31] Commission Proposal COM/2011/0370 final - COD 2011/0172, 52011PC0370. The negotiation agreement: http://static.euractiv.com/sites/all/euractiv/files/EED.en12.doc
[32] http://sedc-coalition.eu/2012/07/13/press-release-energy-efficiency-directive-a-positive-step-for-demand-response/
[33] http://www.smartgrids.eu

strong role of storage (European Technology Platform SmartGrids, 2012). Members of the SmartGrids ETP represent a wide range of stakeholders.[34] Its mission, however, includes ensuring that the Platform's strategy remains consistent with EU policy.

The SmartGrid ETP is linked to the overarching European **Strategic Energy Technology Plan** (**SET Plan**).[35]

Under this umbrella The SmartGrids ETP has initiated the **European Electricity Grid Initiative (EEGI)**, coordinated by ENTSO-E (TSOs) and EDSO4SG (DSOs)(ENTSO-E and EDSO-SG, 2010). The EEGI is a nine-year RD&D programme 2010-2018 focusing on smart grid system issues. The estimated cost amounts to 2 billion EUR. The GRID+ project supports the networking of the EEGI 2012-2014.[36] The **European Energy Research Alliance**, which involves also activities and funds of the member states, is supporting the endeavours of the SET Plan with an own programme on smart grids.[37] A more general initiative of the SET Plan is the information system **SETIS** which has an interesting section on electricity grids.[38]

The **JRC** (Joint Research Centre) of the EU Commission has produced a catalogue of research, demonstration and implementation projects on Smart grids in Europe, listing 219 projects (Giordano et al., 2011). It reports 23 projects in the **EU research programme FP7**, some more are funded by other programmes such as the ERDF or the EU Recovery plan. The DG Information Society (INFSO) programme "ICT for Sustainable Growth" coordinates the technical SG research projects of the Commission, currently it lists 11 projects.[39] Moreover, DG INFSO regularly organises EC-Telecom-Utility workshops.

4.3 Main Stakeholders present in the debates at EU level

In the different boards and committees of the activities discussed in the previous section a wide range of stakeholders are represented. The most important ones are the following.

Organisations of the electricity sector

EURELECTRIC , the Union of the Electricity Industry**,** is the sector association representing the common interests of the electricity industry at pan-European level.[40] Its members are the national associations of the electricity industry. EURELECTRIC is a large organisation, fac-

[34] representatives from: TSOs, DSOs, Regulators, Generation, Renewables, Users, Electrotechnology equipment manufacturers, Telecommunications, Metering manufacturers, Research and development within the electricity companies, Research institutes

[35] http://ec.europa.eu/energy/technology/set_plan/set_plan_en.htm

[36] http://www.gridplus.eu

[37] http://www.eera-set.eu/index.php?index=21

[38] http://setis.ec.europa.eu/technologies/Smart-grids

[39] http://ec.europa.eu/information_society/activities/sustainable_growth/funding/prj_grids/index_en.htm

[40] http://www2.eurelectric.org, Secretary General: Hans ten Berge

ing increasing internal discussions following the growing importance of DSOs and Distribution companies in the transition of the electricity sector.[41]

Transmission System operators are represented by the European Network of Transmission System Operators for Electricity **ENTSO-E**.[42] Members are 41 TSOs from 34 countries covering their complete territories. The organisation also carries out semi-official tasks for the EU, such as the development of grid codes or the semi-official Ten Year Network Development Plan TYNDP.

Distribution grids and distribution companies are represented by three somewhat overlapping organisations:

- **CEDEC,** European Federation of Local Energy Companies[43], founded in 1992, represents predominantly public local energy companies resp. their national organisations in Germany (VKU), France, Italy (Federutility), Belgium, The Netherlands…
- **EDSO4SG,** European Distribution System Operators for Smart Grids, a relatively new organisation, consisting mainly of the distribution branches of the large incumbent electricity companies, but also some smaller private companies.[44] EDSO4SG is strongly involved in the EEGI and considers that balancing at the local level will become necessary (Granström, 2012).
- **GEODE**, European independent distribution companies of gas and electricity[45], founded in 1991, representing more than 600 companies in 12 countries. Strong focus on legal issues.

SEDC, Smart energy demand coalition, represents a wide variety of industries dedicated to promoting the requirements of demand side programs in the European electricity markets.[46] It is an active organisations specifically addressing SG issues.

Independent energy providers without own grids do not have a separate representation such as the BNE in Germany. For Renewables and Cogeneration see below.

Equipment manufacturers

T&D Europe, the European Association of the Electricity Transmission and Distribution Equipment and Services Industry, has national associations as its members, representing companies with a turnover of 35 bn €. It is very active in the EU Smart Grid debate emphasis-

[41] See e.g. http://www.eurelectric.org/Download/News/WN.asp?DocID=32479 and http://www2.eurelectric.org/docsharenoframe/Common/GetFile.asp?PortalSource=4294&DocID=31910&Stype=SaveAS&mfd=off&pdoc=1
[42] https://www.entsoe.eu, Sectretary General: Konstantin Staschus
[43] http://www.cedec.com Secretary General: Gerd De Block
[44] http://www.edsoforsmartgrids.eu, Secretary General: Per-Olof Granström
[45] http://www.geode-eu.org/
[46] http://sedc-coalition.eu , Secretary General: Jessica Stromback

ing the necessity of investments in smart grids and transmission. Its positions are prudent and open for all kinds of developments.[47]

ESMIG, the European Smart Metering Industry Group, representing 37 companies, aims at "the pan-European introduction and roll out of Smart Metering through harmonisation and interoperability", (http://www.esmig.eu).

EREC, the European Renewable Energy Council, represents the renewable energy industry: equipment producers, operators, fuels, research (http://www.erec.org/). It has a low profile on smart grids, more active are the member associations EPIA (PV) and EWEA (wind). Overall the presence of the renewable energy industry in the SG discussion is remarkably small.[48]

COGEN Europe, the European Association for the Promotion of Cogeneration, whose membership consists of a wide range of associations and industry companies keeps a rather low profile on SG (http://www.cogeneurope.eu).

EU.BAC, European Building Automation Controls Association, has an astonishingly low profile and interest on smart grid issues (http://eubac.org). Some member companies are much more actively promoting building automation or smart buildings as a part of integrated smart grid systems.

CECED, European Committee of Domestic Equipment Manufacturers, is an active participant in discussions (http://www.ceced.eu). Implementing demand response would require new equipment functionalities and open new prospects for the sector. CECED seems to prefer a high degree of local intelligence protecting autonomous decision making and privacy of customers.

ORGALIME, European Engineering Industries Association, cooperates with T&D, ESMIG, CECED on this issue.[49]

ESIA, European Semiconductor Industry Association, http://www.eeca.eu/esia/

AIE, European Association of Electrical Contractors, Association Européenne de l'Installation Electique, http://www.aie.eu/

IT and Telecom industry

With "smart grids" the energy sector opens for the logic and the influence of information and communication technologies (ICT). This is a huge growth opportunity for the corresponding industries offering hardware, software, data handling and communication. Different smart grid strategies open different opportunities for the various subsectors of the wide range of ICT industries.

[47] http://www.tdeurope.eu, position paper on infrastructure http://www.tdeurope.eu/data/TD%20Europe%20position%20paper%20on%20Infrastructures%20and%20Smart%20Grids%20010212.pdf
[48] This is also the case in member states, e.g. in Germany
[49] http://www.orgalime.org , (ORGALIME, 2009)

DIGITALEUROPE, represents the digital technology industry in Europe having as members national associations and large companies. DIGITALEUROPE is an active member of the TFSG. Strong interest in smart meters and standardization of the "last mile to consumers" [50]

ETNO, European Telecom Networks Operators Association, represents 41 operators in 35 countries (http://www.etno.eu).

ECTA, European Competitive Telecommunications Association, represents "the regulatory and commercial interests of 'challenger' electronic communication service providers and their suppliers" (http://www.ectaportal.com).

EUTC, European Utilities Telecom Council, represents the telecommunications and information technology interests of Europe's electric, gas and water utilities and other critical infrastructure organisations (http://www.eutc.org).

GSMA, represents the interests of mobile operators worldwide (http://www.gsma.com).

Consumer and environmental organisations

BEUC, the European Consumers Organisation, does not seem to be very active on this issue, but is represented in the SGTF (http://www.beuc.org).

Environmental Organisations – which play a strong role in the energy debate – are not represented in the analysed forums on smart grids and have not yet developed strong own activities on this issue.

Cities and Regions

While cities and regions have developed intensive energy and climate policy activities and also interesting initiatives on smart grids[51], they are not represented in the main forums and discussions listed in the last section.

This overview on the major stakeholders involved shows that overall, the directly interested industry is very well represented – with the exception of the renewable energy industry, both manufacturers and new independent operators. Business at large, also including the industry as energy consumer, is not represented separately. Organisations representing public interests, e.g. focusing on environmental issues, privacy concerns, consumer interests or territorial communities are heavily under-represented considering the issues at stake.

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[50] http://www.digitaleurope.org/ . White paper on SG: http://www.digitaleurope.org/Portals/0/Documents/TRPG/DIGITALEUROPE_White_Paper_on_Smart_Grids_2011-09-21.pdf , Recommendations http://www.digitaleurope.org/Portals/0/Documents/TRPG/DIGITALEUROPE_Recommendations_on_Smart_Grids_2011-09-21.pdf

[51] See e.g. http://energy-cities.eu/What-are-Smart-Cities-really-all , http://www.local-renewables-conference.org/freiburg2012/, http://setis.ec.europa.eu/about-setis/technology-roadmap/european-initiative-on-smart-cities, http://www.deenet.org/100-EE-Regionen.1023.0.html

5 The discussion in EU member states

5.1 Large differences in structures and awareness, creative diversity

The starting conditions and the efforts for developing smart grids vary considerably between European countries.[52] This is illustrated by the number of smart grid projects (R&D as well as deployment): More than half of the 219 projects listed in the already mentioned JRC project catalogue (Giordano et al., 2011) are located in Denmark, Germany, Spain and the UK. While Denmark counts 22% of all projects, Poland contributes only 1,7% and Bulgaria 0,4%. The same holds for the investments: While Italy invested € 2150 million (mostly smart meters), Germany 228 (mainly integrated systems), France 195 (mainly smart meters), investments in Eastern Europe were mostly negligible, with € 3,7 million in Poland and 0,7 million in Bulgaria. The UK has established a unique 500 million low-carbon network fund for innovative pilot projects.[53] Forecasts estimate the cumulative European smart grid technology market to reach €3.1 billion in 2012, and €6.8 billion in 2016.[54]

These important differences in interest and in efforts essentially reflect the different capacities for innovation in the respective energy sectors. They cannot be explained by the differences in the existing grid structure, since weak grids may even open opportunities for leapfrogging heavy wiring efforts by expanding capacities with smart approaches, such as the examples of the US or India show (see below). Powerful incumbent (ex-)monopoly utilities linked to heavy base-load generation (coal and nuclear) and defying the growth of distributed generation with renewables, seem to be the most important hindrance to more flexible approaches. Countries with a strong growth in renewables, such as Germany, Italy, Denmark, Spain or Austria show a strong interest in smart grids, as well as those with innovative regulators looking for an intensifications of competition, such as in the UK, in the Netherlands, or in Finland. Evidently, also the existence of an innovative industry is playing an important role.

Given the strong differences in the structures of the electricity sector in EU member countries (concerning the generation mix; the ownership structure in generation, transmission and distribution; the existence of a strategically oriented public regulator and/or public transmission grid operator…), also the priorities in smart grid strategies inevitably differ.

While France has a strong emphasis on a conventional centralised approach (dominating nuclear, very little distributed generation) and a traditional interest in load shedding (important electric heating programmes for adjusting to the large share of base-load nuclear generation), there is a strong push for e-mobility coming from the car industry combined with important electric network equipment and ICT industries looking for global markets.

[52] Interesting overviews on the endeavours in different European countries are given by (Hübner and Prüggler, 2011), (Renner et al., 2011), (SEDC, 2011) and (Appelrath et al., 2012).
[53] http://www.ofgem.gov.uk/Networks/ElecDist/lcnf/Pages/lcnf.aspx
[54] http://www.fiercesmartgrid.com/press-releases/smart-grid-become-%E2%82%AC68-billion-industry-europe-2016-according-gtm-research

Spain, on the other side, is making considerable efforts to integrate its important wind capacities. In Germany, a strong motivation is not only coming from the strongly increasing share of renewables, but also from the efforts for e-moblitiy (important car industry), from the increasingly powerful municipal utilities as well as from the important electric network equipment and ICT industries.

Such differences have to be respected when designing European policies in this regard. As in all European policies, it is a challenging task to find a balance between trend accelerating and cost-reducing joint endeavours and innovation-friendly diversity, between different cultures and industry interests, between technologically advanced members and those fearing to be left behind.

To analyse the different conditions, interests, and positions in EU member states is beyond the scope of this report. The discussion in Germany has a strong influence on the EU discussion, the e-Energy programme of the Ministry for Economy [55] has produced a series of pilot projects which have attracted international interest. However, the intense German discussion on future energy grids[56] does not yet seem sufficiently connected to the discussions at the EU level. A parallel report for SEFEP deals with the Smart Grid discussion in Germany. Of particular interest may be the examples of Denmark and Italy which give some insight in different advanced discussions in EU member states.

5.2 Example 1: Denmark

Ambitious targets for a deep transformation

Because of the early development and high share of wind energy, and because of an overall ambitious climate policy, smart grid operation has been an issue early on. In 2008 the Danish government installed a Commission on Climate Change Policy with the task of showing how Denmark can phase out fossil fuels by 2050 (Danish Commission on Climate Change Policy, 2010). The new government, in office since October 2011, has formulated ambitious milestones for its energy policy: 2020: 50% of electricity consumption covered by wind, 2035: electricity and heat supply covered by renewable energy, 2050: all energy needs covered by renewable energy (The Danish government, 2011). An energy agreement voted in Parliament with a vast majority has confirmed these goals, provided financing, announced a smart grid strategy for 2012 and stipulated a thorough revision of electricity market regulation.[57]

[55] http://www.e-energy.de/en/

[56] See e.g.: (Appelrath et al., 2012) an influential study with scenarios for the migration toward a smart grid; (Bundesnetzagentur, 2011), the regulator outlining a possible definition of roles at the distribution level (controversial reactions);(Köhler-Schute, 2012) giving a good overview, especially on role discussions; (Energietechnische Gesellschaft im VDE (ETG), 2008), proposing a framework for smart distribution and virtual power plants; (Energietechnische Gesellschaft im VDE (ETG), 2007) on decentralized supply; (BNE, 2011) independent electricity suppliers on new market roles;

[57] http://www.ens.dk/da-DK/Politik/Dansk-klima-og-energi-politik/politiskeaftaler/Documents/Accelerating%20green%20energy%20towards%202020.pdf

The Danish state is in a good position to organise a smooth transition since it owns the national TSO.

The Danish Energy Association, representing the energy companies (net companies, traders, producers), says that DSOs need to actively manage their network and will have a similar role as TSOs today. It envisages a "dynamic pricing system and a market for 'using' the network at DSO-level", where the "DSO will set the framework, standards and rules for the market", while service providers will ensure the contact to customers (Stouge, 2012).

Using the heat market as buffer

Coupling the electricity market with the heat market plays a central role in the agreed transition strategy. The Danish Commission on Climate Change Policy envisaged that electricity would grow from 20% to 40-70% of total energy use. This strategy is facilitated by the fact that in the last three decades small, often cooperative, district heating systems on the basis of CHP have been installed all over the country and cover a large share of the heat supply. Increasingly, heat pumps shall now provide heat to these systems and represent a highly flexible load able to compensate fluctuating wind power generation.[58] This transition is also facilitated by the fact that large parts of the wind energy producers are directly acting on the electricity markets and have to provide or contract their own balancing (Energinet DK, 2007).

Expected heavy investment requires new definition of roles

All this will only be possible with heavy investments in smartening the grids. The Danish energy association estimates that active management of distribution networks can increase the amount of distributed generation that can be connected to existing distribution grids by a factor of three to five without requiring network reinforcement. According to a study of the Association together with the Danish TSO, instead of investing DKK 7,7 billion into traditional grid expansion, it is much more interesting investing DKK 9,8 billion in smart grids while reaping benefits of DKK 8,2 billion (savings in regulating power and reserves, electricity generation, costs for energy-saving initiatives) leading to residual costs of DKK 1,6 billion (Stouge, 2012). How to organise that these benefits contribute to the return on the initial investment is still an open challenge. The discussion on the future role of DSOs as market facilitators is still under way.

Important research and demonstration projects

An outstanding number of research and demonstration projects in Denmark have contributed to this vision (Giordano et al., 2011). This has been facilitated by the fact that the state-owned TSO, funded by its customers, is directly in charge of research in this field. Important orientation was given by the ecogrid project (Lind, 2009; Trong et al., 2009). New approaches show potential for considerable simplifications: e.g. controlling demand response at the

[58] See also http://www.europeanenergyreview.eu/site/pagina.php?id=3417&toegang=cfcd208495d565ef66e7dff9f98764da

consumer's premises, simply on the basis of the frequency in the grid, may save expensive communication and maintain privacy and autonomy of consumers[59] .

5.3 Example 2: Italy

The situation in Italy is characterised by

- a dominant role in generation, distribution and sales of the former national monopoly ENEL with 30 million customers in Italy and 30 million abroad, mainly in Spain (Endesa)
- an independent national TSO, Terna Spa., the largest grid operator in Europe.
- a dense and relatively reliable grid
- an important and rapidly growing role of distributed generation with wind and recently also solar (2nd largest PV market globally in 2011)
- a relatively flexible mix of conventional centralised generation with an important role of hydroelectricity, a dominant role of natural gas and the absence of nuclear power
- high electricity prices

The general conditions are therefore rather favourable to a sustained growth of renewables and smart grid projects. Effectively, Italy is one of the leading countries concerning smart grid investments.

Smart meters

Italy has been a pioneer in smartening its grids and especially in installing smart meters.[60] Between 2001 and 2006, Enel deployed smart meters (bi-directional communication, power measurement and management capabilities, software-controllable switch) to all its 30 million customers. Obtaining considerable cost savings, Enel achieved the return on investments (EUR 2,1 billion) in just four years. Also consumers may save considerably, adjusting their consumption to the different tariffs in three time bands.[61] Smart meters are managed by a centralised system "Telegestore" evolving continuously and considered to be one of the largest worldwide.[62] Enel has partnered with Telecom Italia and Electrolux for a communications platform for a home area network that will allow for value-added services.

An important motivation for Enel to start the early introduction of smart meters during the period of its privatisation,[63] seems to have been the effort to better control peak power consumption after necessary power cuts culminating in a blackout in 2003. The electronic meter used by Enel allows for precise control of the peak power used. Power limitations have always existed; maximum power for most private households is traditionally limited to 3 kW.

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59 http://www.ea-energianalyse.dk/projects-english/927_electricity_demand_as_frequency_controlled_reserve.html , (Xu et al., 2011), (Douglass et al. 2012)
60 http://www.businessweek.com/globalbiz/content/nov2009/gb20091116_319929.htm
61 http://aretusa.ice.it/SchemaSite/images/UserImageDir/177/EN/Presentations/CFT_Smart%20grids.pdf
62 http://www.enel.com/it-IT/innovation/smart_grids/smart_metering/telegestore/
63 For the privatisation story see (Di Nucci, 2004)

While the tolerance of the old systems seems to have been considerable (up to 4,5 kW), the new meters allow to limit maximum power efficiently.[64] While Enel voluntarily started to introduce smart meters when it was still in a monopoly role, the national regulatory Authority ordered the mandatory introduction of smart meters in 2006[65] in view of the liberalisation of the market for private households in mid 2007.

Distribution automation

Supported by funds from the European structural funds, Enel is currently upgrading the medium voltage grid in southern Italy, including pilot projects for active grid management in four regions. An important goal is the improvement of the integration of distributed renewable electricity generation.

Smart grid pilot projects

Enel is involved in a series of pilot projects concerning more advanced smart grid features. E-mobility is considered to be an important element of future systems. Enel distribuzione coordinates one of the most important smart grid EU project: ADDRESS[66], with 25 partners. Enel distribuzione seems to be more open for decentralised solutions than its French counterpart. However its vision is much more centralised than the Danish one. In the model proposed by ADDRESS, the DSO has a commercial and a technical role (Lombardi, 2011).

6 The discussion in other parts of the globe

While Europe can still claim to be leading in renewable energy development, concerning smart grid activities, the leadership is much less clear. Independently from climate-change driven policies aiming at growing shares of renewables, a smart grid approach with new technologies promises to save costs where massive investments in grid infrastructure and generation are necessary. Therefore, the United States – where decades of low investment into the grid system have led to a relatively low system reliability compared to Europe – as well as China, India and South Korea – where grid development has difficulties to keep up with high growth rates of the economies – have started to look at smart grid technologies before they were concerned about the transition towards high shares of renewables. Forecasts concerning smart grid investments vary widely but show the dimensions: while Europe is expected to invest € 56 billion by 2020 (Woods and Gohn, 2011), equipping all grids globally with smart girds technologies would require some $ 2 trillion by 2030[67].

[64] http://www.asmpomigliano.it/news/attenti-ai-consumi-di-energia-elettrica.aspx, http://www.energia360.org/Contatore_Enel.html, http://www.dreamsworld.it/emanuele/2007-07-01/hacking-contatore-enel-come-aumentarne-la-potenza/ ; http://it.answers.yahoo.com/question/index?qid=20110420052340AACT417;

[65] delibera 292/06

[66] http://www.addressfp7.org, (Valtorta et al., 2011)

[67] http://memoori.com/smart-grid-2012

Global forums for discussing smart grid policies are less important than European or US-American ones since there is no explicit global policy making. However, there are some influential poles:

(1) The International Energy Agency IEA has issued a Smart Grid Technology roadmap[68] and supports two Implementing Agreements dealing with smart grids:
   - IEA-ISGAN International Smart Grid Action Network (http://www.iea-isgan.org)
   - IEA-ENARD Electricity Networks Analysis, Research and Development (http://www.iea-enard.org)

(2) International companies, international trade fares and conferences are most important for international knowledge and experience transfer

(3) Strongly linked to industry but also involving a range of other stakeholders is the Global Smart Grid Federation[69]

(4) Not to be underestimated are the international standardisation organisations[70]:
   - IEC, International Electrotechnical Commission, Geneva, composed by national committees [71]
   - IEEE, Institute of Electrical and Electronics Engineers, New York, composed by individual members in 150 countries, strong focus on the US [72]

6.1 United States

The regulatory landscape in the United States is as least as varied as in the EU. Important competencies are with the single states. Liberalised markets, state monopolies, different kinds of market systems co-exist. The federal jurisdiction only concerns interstate exchange but is gaining importance. Overall, in 2011, coal made up for 42%, natural gas for 25%, nuclear for 19% and hydro for 8% of electricity generation. Problems with fluctuating renewables are much less urging than in Europe. California showing the highest contribution of renewables still has a much lower percentage (2010: solar 0,4%, wind 3%)[73] than e.g. Germany (2010: solar 2%, wind 6%), but is planning to catch up quickly.

Given the problems with grid reliability and capacity, since many years distribution system automation, peak shaving with demand side management, rapid detection and isolation of grid failures, as well as energy conservation have been key concerns driving the interest in smart grid technologies. Meanwhile, the prospect of growing distributed power generation and e-mobility are strongly contributing to this interest. Smart Grid development in the US

[68] http://www.iea.org/publications/freepublications/publication/smartgrids_roadmap-1.pdf
[69] http://www.globalsmartgridfederation.org/
[70] A good overview on international standardisation activities is given by (ITU Telecommunication Standardization Bureau, 2011) See also (Appelrath et al., 2012) and http://www.smartgridnews.com/artman/publish/Key_Players_Associations/Standards_Organizations-892.html
[71] http://www.iec.ch/smartgrid/
[72] http://smartgrid.ieee.org/
[73] http://energyalmanac.ca.gov/electricity/total_system_power.html

has been boosted by the allocation of USD 4,5 billion to grid modernisation under the American Recovery and Reinvestment Act in 2009.

As a simultaneous answer to grid problems and distributed generation, microgrids, which can – but must not – operate separately from the main grid, are encountering more interest in the US than in Europe (Carson, 2012; Chowdhury et al., 2009; Lasseter, 2002; Marnay, 2011; Platt et al., 2012). Especially a new IEEE standard (IEEE Standards Organisation, 2011) has led to a strong increase in microgrid projects (Asmus and Lauderbaugh, 2012). If not completely independent in remote areas, microgrids constitute a subsystem of the utility grid which can operate autonomously, balancing generation and consumption in its own circuit and can exchange electricity with the main grid as desired, depending on regulatory conditions and time-dependent tariffs. Technically, this approach reduces the complexity of the management of a large grid with distributed generation. From a regulatory point of view, microgrids are no problem if they are fully owned by one consumer, but unbundled market roles, as defined today, raise problems for the establishment of microgrids within a public grid.

Smart meters have been intensely discussed in the US. An increasing number of utilities see advantages in deploying them, and deployment programs are quickly progressing. Nearly one third of US households are now equipped with smart meters.[74]

The US are estimated to invest between € 240 and 330 billion into smart grids by 2030 (Giordano et al., 2011). Market forecasts for 2012 estimate that the US market will be three times as large ($ 9,2 billion) as the European one ($ 3,1 billion). Large American companies aiming at this market and pushing for its development include traditional equipment manufacturers, ICT companies as well as specialised start-ups. According to GTM research more than ¾ of the top 150 vendors on the US and European smart grid markets are based in the US.[75]

A large number of market research companies and newsletters provide detailed information about developments of the US market and US policies in thies field. Among the specialised organisations, the GRIDWISE Alliance is the most important one.[76]

6.2 China

China is set to play a leading role in the global smart grid industry.[77] China's State Grid Corporation has decided to invest $ 250 billion in electric power infrastructure upgrades over the next five years; another 240 billion will be spent between 2016 and 2020. In each period 45 billion are earmarked to for smart grid technologies (Hart, 2011). According to GTM fore-

[74] http://www.smartgridnews.com/artman/publish/Technologies_Metering/Nearly-a-third-of-U-S-households-have-smart-meters-already-new-study-reveals-4799.html/?fpm
[75] http://www.greentechmedia.com/research/report/the-networked-grid-150/
[76] http://www.gridwise.org
[77] http://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/EPNG/PDFs/McK%20on%20smart%20grids/MoSG_China_VF.ashx

casts for 2016[78], the smart meter market will account for § 8 billion and the distribution automation market for $ 6 billion. With this plan the State Grid Corporation pursues a double objective: strengthening the own grid and empowering a corresponding Chinese equipment industry.

The Chinese grid needs upgrading and smartening for two reasons: The first one is that electricity consumption is expected to double over the next decade, while supply is already grappling to meet demand, also due to coal shortages. The dimension is huge; in 2010 annual utility revenues exceeded $ 300 billion.[79] The second reason is that fluctuating renewables and electric vehicles are going to play an important role. Total wind generating capacity is expected to reach 100 GW in 2016. Moreover, energy supplies (coal, gas, hydropower, wind farms) are more abundant in the west, thousands of kilometres apart from the large consumption centres.

Smart grid development is being considered as a strategic national priority (Hart, 2011). In order to grow an own industry, the State Grid Corporation, which controls transmission and distribution and has important subsidiaries in the equipment industry, has issued proprietary standards in 2010. However, also in China, there are critics of the overwhelming power of State Grid Corp., calling for more competition. In this context, the relatively slow development of international standards seems to favour Chinese companies aiming at conquering international markets starting from a strong and large home base.

Compared to European and American endeavours, the Chinese efforts seem to be more straightforward. On the backdrop of the success of Chinese equipment vendors in the telecom and the renewable energy industry, large European, American and Japanese corporations who acknowledge the strategic role of smart grid technologies, start to take the Chinese competition seriously. A number of important recent mergers and acquisitions show the efforts to concentrate forces.

At the present point in time, however, the main emphasis of the Chinese “smart and strong grid” efforts lie on transmission and storage while efforts in the distribution grid have still to grow.[80]

7 Key issues of the debate at the EU level

Looking at the debate across the different forums, there seem to be three areas in which the resolution of – often covert – conflicts of interest is essential for further progress of the transformation: (1) the shift of responsibilities from the transmission to the distribution level (2) defining the interface to the increasingly responsible consumer (3) the role of regulation

78 http://www.greentechmedia.com/research/report/smart-grid-in-asia-2012-2016/,
79 http://www.greentechmedia.com/research/report/smart-grid-in-asia-2012-2016/
80 http://www.smartgridnews.com/artman/publish/Business_Global/China-and-the-smart-grid-Missing-pieces-5079.html#.UJdnK2fn-Cx; http://www.greentechmedia.com/articles/read/enter-the-dragon-china-and-the-worlds-greatest-smart-grid-opportunity

at the EU level. A fourth important issue is how to organise the process of overcoming the obstacles caused by these open question.

7.1 Role and management of the distribution grid

In the conventional top-down electricity system, large electricity producers and the owners of the transmission systems had control of the system and were responsible for its reliability. This power structure has only to a certain extent been changed by unbundling the roles in a regulated market. The emerging new paradigm, however, seems to call for a much more distributed responsibility at different levels of the system. Transmission grids and large power units – the top level of the old system – are already managed and optimised with sophisticated ICT. The concept of smart grid consists in introducing similar control and communication structures also at lower levels of the system, down to the interface with consumers and even in their own premises, and to intelligently link all these levels. This opens the door for a wide range of possible configurations which might involve more competencies, responsibility and autonomy for public and private distribution system operators at the local and regional level as well as for different kinds of service providers organising the commercial link between supply and demand at different echelons.

Increasing attention for an efficient management of lower tiers of the system does not only raise the question of the relation between TSOs and DSOs but also questions concerning the future role of different (unbundled) actors at the lower levels: How will the communication between energy vendors and grid operators be organised? Who will have access to real-time consumption data of the customers? Will there be distribution-level markets for optimally managing capacities, including the capacities of distribution grids? Where to draw the line between regulated and competitive areas when real-time management of grid capacities blurs present distinctions between grid managers and grid users?

It is evident that the emerging new logic of the system threatens the influence of the incumbent large electricity companies which until now have dominated the debate in Brussels. They try to adapt while new actors are emerging. But also the new players, which are stronger in some countries than in others, have different interests and a variety of options which are not yet fully understood.

7.2 The interface to the consumer/prosumer

At the bottom of the system, consumers might become more actively involved in a market-based management of the system. However, not all stakeholders share this vision. When consumers start to produce their own electricity and start to shift their loads so as to maximise their economic advantage, they create an urgent need for the public grid to adapt frame conditions and tariffs so as to use this new flexibility for a stabilisation of the whole system.[81]

[81] See (Schleicher-Tappeser, 2012)

A market-based approach would be to find ways to offer locally adapted time-dependent tariffs that would incentivise a system-supporting behaviour of consumers and prosumers alike. Those preferring to maintain a central control of the system are advocating technical and regulatory solutions which would allow grid operators or retailers (see previous section) to directly intervene in the operation of the consumer's appliances. Especially when applied to private households, the two alternatives would have very different legal and technical consequences. A centralised approach would require much more efforts for data gathering, data handling, data security and discussions on data privacy. On the other hand it might, as advocates sustain, allow for more demand response reliability and shorter reaction times.

The two alternatives might converge in a compromise offering consumers attractive automation options while preserving the freedom of choice – however, this would not avoid the need for differentiated tariffs. Across the large range of different stakeholders different models are being proposed and discussed. One of the hottest issues is who will handle and have access to detailed consumer data.

Moreover, in a perspective where consumption and production of energy cannot be clearly separated anymore since increasing numbers of (industrial, commercial and private) prosumers manage their own combination of consumption, production and storage of energy, the smart grid debate merges with the debate on renewable energy support systems.

7.3 Room to manoeuvre for the member states

A further basic issue in all these debates is how far the EU level should go in setting binding rules for member states. Considering the novelty of emerging problems, the wide range of possible solutions and the structural differences between member states, there are good arguments for limiting binding rules to essential issues, and leaving room for further experimentation with different approaches. On the other hand, there might be considerable economic advantages, and also important particular economic interests, in adopting a rather uniform approach. Considering the global context, industrial policy aspects of the smart grid discussion cannot be neglected: Europe has to face strong international competition. Joining forces, creating large markets and speeding up the setting of standards might be important for maintaining an influence not only of European industries but also of European political decision making concerning future energy supply.

Setting the right priorities in the European decision making process therefore seems to be essential. Good decisions in such a complex context require broad discussions and therefore time. Decisions scheduled to be taken in the next months might risk having far-reaching consequences for the structure of the energy industry and for millions of consumers, without having been adequately discussed by an informed public.

Despite the existence of different roadmaps[82] there seems to be no coherent vision concerning the appropriate levels and time scales of regulation. Just as for the management of the energy system, a coherent multi-level governance approach would be needed concerning regulation.[83]

7.4 Speed and transparency of the process

Even the stakeholders more directly involved only have started to acknowledge the profound transformation of the energy sector required by the transition to renewable energies, and the key role of smart grid technologies and policies in this transformation process. Also among specialists at the EU level, the discussion is to a disturbing degree at the same time an open learning process concerning a new range of issues, and a result-oriented negotiation process setting rules and standards for many years to come. This combined process seems to be characterised by:

- the difficulty of fully understanding the issues at stake for the own interest group or for society as a whole, by the broad public and also for many of the stakeholders involved
- cultural gaps between policy and market specialists on one side and technicians on the other, between the top-down approach of the conventional energy industry and the more systemic thinking of the IT industry set out to conquer new markets in this sector
- efforts, but also difficulties to ensure communication and coordination between different discussion forums and policy processes
- a lack of transparency concerning the different initiatives and discussions, of the stakeholders involved and, most important, their positions
- a difficulty to understand the importance and the implications of the standards and codes being developed in a range of procedures as well as for many stakeholders the cultural reluctance and the lack of resources to be more involved in these detailed issues

Not all stakeholders are unhappy with this lack of transparency. And the high speed of setting standards and rules may in some cases help the incumbent well-equipped interest groups to maintain their influence and to slow down change.

At difference to many environmental problems in the past, climate change has the uncomfortable characteristic that it requires not a slowing down of change but an acceleration of deep transformations at a speed which might jeopardize a broad discussion and democratic control. In the case of smart grids, also most proponents of renewables have underestimated the speed at which these will raise important challenges for the energy system and societal questions associated to it. Considerably slowing down the decision making process is therefore no option.

[82] COM/2011/0202 , SET-Plan, SG-ETP, EEGI, Standardisation mandates following SGTF, ENTSO-E grid code development, as well as national roadmaps such as the German standardisation roadmap.
[83] Multi-level governance approaches have been widely discussed in a wide range of policy fields since more than a decade. See e.g. (Schleicher-Tappeser, 2000), (OECD, 2010), (OECD, 2011)

The difficult solution for this dilemma lies in speeding up the learning process by increasing transparency of the processes and of the viewpoints of the different stakeholders involved, raising awareness for the issues and interests at stake, facilitating discussions between the different professional, sectoral and national perspectives and cultures, improving the understanding for the paradigm shift under way.

8 Conclusions and recommendations

The main result of this overview is that the importance of the smart grid debate is being heavily underestimated by political actors, the large public and also the renewable energy community. Most important issues concerning the future European energy system and the associated commercial and political power structures are being debated and pre-configured in small, seemingly technical circles dominated by large industrial interest groups. This needs not to remain so. For example the standardisation procedures offer public consultation opportunities.

Wrongly, smart grids are seen as a mainly technical issue.[84] Smart grids are not a given technology that may have impacts that can be analysed. Rather, there is a set of available new technologies that open a wide range of opportunities for transforming the old unsustainable energy supply system into a new more sustainable socio-technical system involving much more actors. For making best use of these opportunities for society we need a broader debate. This requires efforts: for improving the transparency, for explaining the issues at stake, for translating between technological, political and business cultures.

This paper has tried to make a contribution in this direction. A next step, deemed to be useful by a series of interlocutors, could be a more detailed mapping of activities, stakeholders, positions and suggestions. A key difficulty is the accessibility of technical debates for non-technicians. Especially the ongoing standardisation procedures would require a detailed analysis in view of their potential to predetermine future decisions concerning the key questions identified above. Among the wide range of organisations involved in promoting a sustainable transformation of the energy system, there seems to be none engaged in a systematic observation of smart grid issues in Europe. This may be partly due to the lack of a shared framework for discussing these issues.

An important contribution to the European debate could also be a comparative analysis of the approaches in the single member states. Such an overview would also shed light on the present difficulties to organise revenue streams for financing smart grid developments: due to European and specifically national rules and role definitions potential benefits of smart grids are not accessible to those who might invest.

[84] This is also true if one adheres to a narrow definition of smart grids such as the one used by the German regulator who distinguishes between smart grids and smart markets: the functioning logic of the technical infrastructure is intrinsically linked to associated commercial and institutional structures.

Different groups of stakeholders have different, although mostly not explicit, ideas of the functioning logic of the future system. Making these basic ideas more explicit could help to clarify the debate. While many are still thinking in terms of patches to the old top-down system, on the other side of the spectrum new flexible structures are growing bottom-up with private energy management or even microgrids making use of cheap captive power generation with photovoltaics. Formulating a publicly understandable vision for a multi-layered system in Europe, conceived in the spirit of bottom-up subsidiarity, could provide a useful new framework for understanding suggestions and positions. It should explain guiding principles as well as leeways for different solutions and transition paths, and could thereby also help to clarify the role of regulation at the EU level.

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