JRC REFERENCE REPORTS

Smart Grid projects in Europe:
lessons learned and current developments

Vincenzo Giordano, Flavia Gangale, Gianluca Fulli (JRC-IE)
Manuel Sánchez Jiménez (DG ENER)

Other JRC-IE contributors:
Ijeoma Onyeji, Alexandru Colta, Ioulia Papaioannou, Anna Mengolini,
Corina Alecu, Tauno Ojala, Isabella Maschio

EUROPEAN COMMISSION

Institute for Energy

EUR 24856 EN

The mission of the JRC-IE is to provide support to Community policies related to both nuclear and non-nuclear energy in order to ensure sustainable, secure and efficient energy production, distribution and use.

European Commission
JOINT RESEARCH CENTRE
Institute for Energy

Contact information
Gianluca Fulli
EC, DG JRC, Institute for Energy
PO Box 2, NL-1755 ZG Petten, The Netherlands
gianluca.fulli@ec.europa.eu

http://ie.jrc.ec.europa.eu/
http://www.jrc.ec.europa.eu/

This publication is a Reference Report by the Joint Research Centre
of the European Commission.

The Smart Electricity Systems (SES) Action of the Energy Security Unit performs independent scientific research and acts as in-house scientific consultant for EU policy-making actors with particular focus on the on-going transformations of smart electricity systems. The SES Action also develops dedicated power system models and hardware / software simulation tools, as well as an energy security Geographic Information System for EU energy infrastructures.
For more information on this report and our activities visit:
http://ses.jrc.ec.europa.eu
or scan this QR (Quick Response) code using a QR reader app on your phone (no typing required)

JRC 65215

EUR 24856 EN
ISBN 978-92-79-20487-6
ISSN 1831-9424
doi:10.2790/32946

Luxembourg: Publications Office of the European Union

Printed in The Netherlands

Contents

ACKNOWLEDGEMENTS

We would like to thank Marcelo Masera (JRC-IE), Patrick Van Hove (DGRTD), Patricia Arsene (DG INFSO), Michal Spiechowicz (DGENTR), Daniel Hanekuyk (DGENTR) and Steven Eisenreich (JRC) for their comments and suggestions regarding this report. We would also like to express our gratitude to Ivan Pearson (JRC-IE), Peter Zeniewski (JRC-IE) and Angelo L'Abbate (RSE) for scrutinising the text. Our thanks also go to all the stakeholders of the Smart Grid Task Force, the European Electricity Grid Initiative and the Florence Regulatory Forum for Electricity who commented on and provided feedback contributing to the improvement of intermediate versions of this report.

EXECUTIVE SUMMARY

Introduction

Meeting the EU's climate change and energy policy objectives for 2020 and beyond will require a major transformation of our electricity infrastructure. Strengthening and upgrading existing networks is of paramount importance to integrating an increasing amount of renewable energy generation, enhancing grid security, developing the internal energy market and realising energy saving and efficiency. To achieve these goals it is not only necessary to build new lines and substations, but it is essential to make the overall electricity system smarter through the integration of Information and Communication Technologies (ICT).

Smart Grids can be described as an upgraded electricity network enabling two-way information and power exchange between suppliers and consumers, thanks to the pervasive incorporation of intelligent communication monitoring and management systems. For Smart Grids to deliver their envisaged benefits however, the realisation of physical infrastructures alone will not be sufficient and must be complemented by the emergence of new business models and practices, new regulations, as well as more intangible elements such as changes to consumer behaviour and social acceptance. Many different stakeholders are involved in this process and different forms of cooperation are already arising.

In the last few years, initiatives on Smart Grids, with different aims and results, have been growing in number and scope throughout Europe. Substantial public and private investments have been made in research and development (R&D), demonstration and deployment activities. At this stage, there is a clear need to survey the implemented projects in order to monitor the direction Europe is taking, to benchmark investments, and to tackle challenges and possible distortions from an early stage. Sharing the results of these projects can also contribute in increasing the stock of knowledge and accelerate the innovation process.

In this perspective, the main goal of this study is to prepare a comprehensive inventory of Smart Grid projects in Europe and use project data to support the analysis of trends and developments. The report looks into several aspects of the Smart Grids landscape to describe the state of the art of their implementation, the emerging hallmarks of the new electricity system and some foreseeable developments.

This report results from a request from Directorate-General for Energy (DG ENER) to start a data collection effort to develop a catalogue of Smart Grids projects in Europe and to carry out a qualitative analysis of their results. The analysis we carried out contributed to the drafting of the Commission Communication "Smart Grids: from innovation to deployment", adopted in April 2011 [24].

This survey of Smart Grid projects in Europe brings together input and feedback from a variety of stakeholders through a cooperative and transparent process. The interim version of this study has been presented on many occasions at expert meetings, including the EU Task Force on Smart Grids[1] and the European Electricity Grid Initiative[2]. Their comments and observations have been carefully taken into consideration and, where possible, integrated into the analysis.

This work is intended to be the first of a series of snapshots that the JRC will periodically prepare on the development status of Smart Grids in Europe to offer a basis for discussion among Smart Grid stakeholders and promote the sharing of knowledge, experiences and best practices.

Methodology

To ensure that all projects could be compared on a fair basis and to support subsequent analysis, a data collection format was distributed to hundreds of stakeholders at the end of November 2010. Within five months, more than 300 project respondents replied to our survey. The responses were then passed through a filtering process to screen out projects, which did not fall into the scope of our study or that did not provide enough information for the analysis. Presently, the final catalogue includes 219 projects and represents the most updated and comprehensive inventory of Smart Grid projects in Europe to date.

1 http://ec.europa.eu/energy/gas_electricity/smartgrids/taskforce_en.htm

2 http://setis.ec.europa.eu/activities/implementationplans/Grid_EII_Implementation_plan_final.pdf/view

Data collected from the project respondents were double-checked to ensure their consistency. All projects' web sites, where in place, and the web site of the leading organisation were examined to support the information we received. In the case of discrepancies or of missing data, the leading organisation was contacted either via email or telephone.

This data collection and analysis was complemented by a further investigation of a restricted number of projects (around 30), shortlisted in such a way as to ensure a fair representation of different project sizes, categories, development stages and geographical areas. The availability of data was also a main criterion for their selection. The aim of this further analysis was to get a closer insight into the projects in order to highlight the main opportunities and obstacles in the development of Smart Grids. To carry out this analysis, we have interacted with project coordinators, retrieved information from project websites and gone through related reports, papers and presentations.

Key messages

The analysis of the collected projects highlighted several key observations and learning points.

Project investments and scale The total budget of the collected projects (over €5 billion) shows that significant efforts have already been undertaken, but that we are just at the beginning of the Smart Grid transition. To put the investments in our catalogue into context, conservative estimates quantify Smart Grid investments by 2020 [47] at €56 billion.

Deployment projects (mainly smart meter roll-outs) cover the lion's share of investment commitments- about 56% of the total- while R&D and demonstration projects account for a much smaller share of the total budget. Most R&D and demonstration projects are small to medium size (€4.4 million for R&D projects and about €12 million for demonstration projects), suggesting the need to invest in larger scale demonstration projects to gain a better knowledge of the functioning and impacts of some innovative solutions and to validate results to a broader extent.

Geographical distribution Smart Grid projects are not uniformly distributed across Europe. Most of the projects and investments are located in EU15 countries, while EU12 Member States still lag behind. The uneven distribution of projects and the different pace, at which Smart Grids are being deployed across Europe, could make trade and cooperation across national borders more difficult and jeopardize the timely achievement of the EU energy policy goals.

Multidisciplinary cooperation The increased complexity of the electricity system requires multidisciplinary consortia to share competencies and reduce risks. Collected projects highlight the trend towards a fruitful cooperation between different organisations, which brings together network operators, academia, research centres, manufacturers and IT companies. The implementation of Smart Grids is also a significant opportunity for European industry to research, market and export new technologies, to create new jobs and to maintain global technological leadership.

System integration Most Smart Grid benefits are systemic in nature as they arise from the combination of technological, regulatory, economic and behavioural changes. The survey indicates that in almost all countries, a significant amount of investments has been devoted to projects, which address the integration of different Smart Grid technologies and applications. Most technologies are known, but the new challenge that these projects are now confronting is their integration.

Role of regulation Data in the catalogue confirm the leading role that Distribution System Operators (DSOs) play in coordinating Smart Grid deployment across Europe. DSO-led projects represent about 27% of all projects and about 67% of investment. Current regulation in EU Member States generally provides network owners/operators with the incentive to improve cost efficiency by reducing operation costs rather than by upgrading grids towards a smarter system. The regulatory incentive model should be revised in order to accelerate the investment potential of network owners/operators and to encourage them to move to a more service-based business model. Regulation should also ensure a fair sharing of costs and benefits in the set-up of service-based market platforms. Network owners/operators are expected to sustain the majority of upfront investments whereas several players might get benefits when market platforms become operational.

Consumer awareness and participation Consumers' awareness and participation is crucial for the success of Smart Grid projects. Most projects highlight the need to involve consumers at the early stages of project development, to give consumers the freedom to choose their level of involvement and to ensure data privacy and protection. It is imperative to ensure that consumers have trust in and understanding of the whole Smart Grid process and receive clear tangible benefits. To differing extents, consumers will be able to reap numerous potential benefits: energy savings, the reduction of outages, more transparent and frequent billing information, participation in the electricity market via aggregators, and a better business case for the purchase of electric vehicles, heat pumps and smart appliances.

Contribution to energy policy goals The results of collected projects illustrate the numerous contributions that Smart Grids can make to the achievement of EU energy policy goals. A Smart Grid can contribute to sustainability by facilitating the reduction of CO_2 emissions, enabling the integration of large-scale renewables and increasing energy efficiency in the power sector. It supports competitiveness and open and efficient markets by increasing market participation through the aggregation of distributed prosumers (consumers also able to produce power) and through the strengthening of interregional markets. It contributes to security and quality of supply by integrating technologies/mechanisms to balance flexible generation and by increasing the observability and controllability of the grid in order to reduce outage times. All these potential benefits need to be monitored and verified to adjust the framework for better results.

The role of ICT An open and secure ICT infrastructure is at the core of the successful implementation of the Smart Grid. Addressing interoperability, data privacy and security is a priority requirement for making the ICT infrastructure truly open and secure and reducing transaction costs among Smart Grid users. A scan of collected projects highlights the convergence towards proven standards and industry best practices used for IT systems (e.g. Internet Protocol communication). However further coordinated efforts are needed to fully tap European potential in this field and move to the deployment phase. Standardization developments are a step in the right direction. Also, new projects focusing on data handling would be useful to assess how data handling principles from other industries (e.g. the banking industry) could be applied to Smart Grids.

Data collection and knowledge sharing Finally, effective knowledge sharing and the dissemination of best practices among Smart Grid stakeholders are crucial for the success of the European Smart Grid programme. The difficulties encountered during the data collection process of this study suggest the need for improvements in data collection/exchange, such as through a common structure for data collection in terms of definitions, terminology, categories, and benchmarks, etc. and coordinated project repositories at the national and European levels.

1 INTRODUCTION

A shift in energy policy goals is at the heart of current transformations in the electricity sector. The smooth integration of renewable energy sources, a more efficient and secure electricity supply, and an internal energy market with full inclusion of consumers are key priorities for the European Union [21, 22, 23].

To this end, it is necessary to strengthen the electricity system that we have today by building new lines, substations and power plants. In parallel, it is also necessary to make the electricity system smarter through the integration of ICT solutions. A smart electricity grid in place opens the door to new applications with far reaching impacts: the adaptation of electricity demand to grid and market conditions, automatic grid reconfiguration to prevent or restore outages, and the safe integration of distributed generators, electric vehicles and large scale renewables [7, 19, 20, 55, 56, 62].

Smart Grids are electricity networks that can efficiently integrate the behaviour and actions of all users connected to it — generators, consumers and those that do both — in order to ensure an economically efficient, sustainable power system with low losses and high quality and security of supply and safety [24]. In this perspective, a Smart Grid can be considered as a Smart Electricity System, which encompasses both the grid and the users connected to it, and includes both technical and non-technical building blocks.

Building a Smart Grid is therefore not only a matter of modernisation of the electricity grid or of deploying physical assets and technologies. A key role is played by new business models and practices, new regulations, as well as more intangible elements like consumers' behavioural changes and social acceptance [29, 57, 58, 59,]. Steering this transition is a challenging, long-term task. It requires coupling a policy-led vision with a market-driven deployment, balancing energy policy goals and market profitability.

In the last few years, initiatives on Smart Grids have been growing in number and scope [37, 63]. A variety of projects have been deployed throughout Europe with different aims and results. Substantial public and private investments have been made in research and development (R&D), demonstration and deployment activities. At this stage, there is a need to evaluate the outcome of Smart Grid projects in order to monitor the direction Europe is taking, to benchmark investments, and to tackle challenges and possible distortions from an early stage. Particularly, there is the need to unlock the investment potential of the market. A clear business case for investment is presently among the biggest challenges in Smart Grid implementation.

Following a request from DG ENER, the Joint Research Centre Institute for Energy started a data collection to assemble a catalogue of Smart Grids projects in Europe and to carry out a qualitative analysis of project results. In this study, building on the work of the European Smart Grid Task Force [18, 19, 20], we have collected and analyzed around 300 projects. On the basis of feedbacks from the field, this report addresses the following specific questions:

- In which direction is Europe moving in the field of Smart Grids? Who is investing? What are the motivations?
- How can system integration create business value? What is in it for consumers?
- How do Smart Grid projects contribute to the EU's main policy goals?

1.1 Definitions and Assumptions

1.1.1 Aim of the study

The aim of this study is to collect lessons learned and assess current developments on Smart Grids in Europe. In order to support our analysis, we will use data and information collected from Smart Grid projects throughout Europe. To the best of our knowledge, the collected Smart Grid projects represent the most comprehensive and up-to-date inventory in Europe at present. An exhaustive mapping of Smart Grid projects in the different Member States is not the primary scope of this report. Rather, this is an ongoing task. Further collected projects will be included in subsequent updates of this study.

1.1.2 Boundaries of the Smart Grid catalogue

In line with the definition of Smart Grids reported above, we have followed three main screening rules in assembling our catalogue:

1. We have included projects focusing on individual new energy technologies and resources (e.g. new storage devices, Electric vehicles, distributed renewable generators), only if their integration in the grid was also part of the project.
2. We have included projects aiming at making the grid smarter (through new technologies and new ICT capabilities).
3. We have not included projects aiming at making the grid stronger (e.g. through new lines, substations and power plants) using conventional design approaches.

Around 80 projects (out of the 300 we have received) have been screened out from the catalogue because either they did not comply with the screening rules or because insufficient data had been provided to be fairly evaluated. At this stage, these projects have not been taken into consideration in the analysis but they will be included in an update of this study as soon as more detailed information becomes available. The final catalogue includes 219 projects (see ANNEX IV).

It is worth stressing that projects intended to reinforce the transmission grid, as much as they are crucial to modernizing the European power system (see e.g. [13]), have not been included in our catalogue. In fact, transmission operators are mainly and heavily investing in what can be defined as strengthening rather than smartening the transmission grid, as the transmission system is already a partly smart system capable of managing and balancing the resources (currently) connected to it.

1.2 Data collection template

To ensure that all projects could be compared on a fair basis and to support later analysis, a data collection template was prepared and distributed on the 5th of November 2010. The template had to be returned by the 25th of November. The data collection exercise was originally intended to collect pilot projects but was then extended to Smart Grid projects across the innovation chain (from R&D to demonstration/deployment), by further interacting with national contact points, project coordinators and other relevant stakeholders. Due to the large number of requests by project coordinators for an extension of the deadline, projects were accepted through March 2011. In total, more than 300 responses were received.

The data collection template has been structured in two parts: one for qualitative assessment and one for quantitative assessment (see ANNEX I).

1.2.1 Qualitative assessment

The qualitative assessment section of the template included a brief description of the project and a summary of goals and outcomes. Other information requested included the location and duration of the project, the budget, the participating organisations and their budget share and the EU contribution (where applicable).

The qualitative assessment section of the template also included a specific request for information on how the project addressed data protection and security issues.

In addition, we have asked project coordinators to classify their project according to the following categories:

1. Smart Meter and Advanced Metering Infrastructure
2. Grid Automation Transmission
3. Grid Automation Distribution
4. Integrated System
5. Home application Customer Behaviour
6. Specific Storage Technology Demonstration
7. Other

This classification is in line with the mapping exercise of Smart Grid projects that is currently ongoing in the US (Virginia Tech Clearinghouse)[3] and is intended to facilitate international sharing of Smart Grid experiences. In the context of the EUUS council, the JRC is collaborating with the US Department of Energy on common assessment methodologies of Smart Grids.

The first category "Smart Meter and Advanced Metering Infrastructure" includes projects which specifically address smart meter implementation. The second and third categories "Grid Automation Transmission" and "Grid Automation Distribution" refer to projects dealing with automation upgrades of the electricity grid (e.g. feeder automation, wide area monitoring etc.), at the transmission and distribution level respectively.

The fourth category "Integrated System" focuses on the integration of different Smart Grid technologies and applications (e.g. Smart meter, Demand Response, grid automation, distributed storage, renewables, etc.).

The fifth category "Home application - Customer Behaviour" includes projects which address new applications at home or directly involve consumers. Finally, the sixth category "Specific Storage Technology Demonstration" includes projects which address the potentialities of storage technologies both new and more conventional ones (e.g. hydro, chemical, and mechanical).

A single project can span over different categories. In that case, project coordinators have expressed the relevance of the applicable categories with a number between 0 and 1.

1.2.2 Quantitative assessment

The quantitative assessment part of the template has been divided in three sections.

In the first section, we have asked participants who had already performed a cost-benefit analysis to share their results.

The second section provided guidelines for the collection of cost-benefit quantitative data from those participants who had not performed a study themselves. The respondents have been asked to choose among the list of benefits and KPIs (Key Performance Indicators) defined by the Smart Grid Task Force (see Annex III).

In the third section project coordinators were asked to fill in the service/benefit merit deployment matrix developed by the Smart Grid Task Force [20].

1.3 Reliability and completeness of data

Data collected from the project respondents were double-checked to ensure their consistency through different means. For all projects we checked the project web site - where in place - and the web site of the leading organisation to corroborate the information we received. In case of discrepancies or in case the template was not clear enough we also contacted the leading organisation either via email or phone.

For the most relevant information there seems to be fairly reliable data. The level of reliability of some data particularly those concerning the budget, the project duration and results is higher for projects which have already been completed: 33% of the projects in the catalogue were completed by April 2011, while the remaining projects have different closing dates spanning up to 2020. 34% of collected projects are expected to be completed by the end of 2012.

The catalogue includes a relatively small number of projects which started in 2011. This circumstance is strictly related to the deadline set for filling in the questionnaire and not to a decrease in the number of projects over time.

Shortlisted projects The data collection and analysis was complemented by a further investigation of a restricted number of projects (about 30), shortlisted in a way to ensure a fair representation of different project size, categories, stages of development and geographical areas. The availability of data was also a main criterion for their selection. The aim of this further analysis was to get a closer insight into the projects in order to highlight the main opportunities and obstacles in the development of Smart Grids. This supplementary scrutiny also allowed us to survey and to compare the projects' expected results and their contribution to the EU policy goals. To carry out this deeper analysis we have contacted project coordinators either via phone or email, retrieved information from project websites and gone through reports, papers and presentations.

[3] http://www.sgiclearinghouse.org/

1.4 Overview of the Smart Grid landscape in Europe and beyond

Worldwide, the Smart Grid landscape is highly dynamic and rapidly changing with emerging economies as major players in Smart Grid investments. The information presented in this section aims at giving an overview of the main estimates of overall investments in the electrical system and a snapshot of the investments already committed for Smart Grid development (see table I). Where available, we also reported the plans concerning smart meter roll-outs.

European Union A recent report by Pike Research [47] forecasts that during the period from 2010 to 2020, cumulative European investment in Smart Grid technologies will reach €56.5 billion, with transmission counting for 37% of the total amount. The report also suggests that by 2020 almost 240 million smart meters will have been deployed in Europe.

According to the International Energy Agency (IEA), Europe requires investments of €1.5 trillion over 2007-2030 to renew the electrical system from generation to transmission and distribution [30]. This figure includes investments for Smart Grid implementation and for maintaining and expanding the current electricity system.

United States According to [16], full implementation of Smart Grids in the United States will require investments between $338 and $476 billion over the next 20 years. Costs allocated for transmission and substations are between 19 and 24 % of total costs, while costs allocated for distribution are between 69 and 71 % and costs for consumer systems are between 7 and 10 %. These costs are in addition to investments needed to maintain the existing system and meet electric load growth.

According to [5], $1.5 (€1.06) trillion is necessary to update the grid by 2030 (under current trends and policies) of which $560 (€395) billion is needed for new and replacement generating plants and $900 (€635) billion for transmission and distribution together; the report adds that benefits from Smart Grids could amount to $227 (€160) billion over the next 40 years [5].

In 2009, The Recovery Act provided additional funding for $4 (€2.8) billion in cost-shared Smart Grid projects. In total, the funding will enable more than $7 (€4.9) billion worth of pilot projects deployment. At the end of 2009, the number of Smart Grid projects in the US exceeded 130, spread across 44 States and two territories [42].

According to recent estimates, more than eight million smart meters have been deployed by United States' electric utilities with 60 million expected to be in use by 2020 [50].

China The State Grid Corporation of China (SGCC) is the driving force behind China's effort to build a nationwide Smart Grid. SGCC plans to invest in the period 2009-2020 a total of $601 (€423) billion into a nationwide transmission network with $101 (€71) billion of these funds to be dedicated to developing Smart Grid technology [65]. In 2010 China granted Smart Grid Stimulus investments of more than $7,3 (€5.1) billion [49].

Presently, Chinese Smart Grid efforts are focusing on the creation of a large capacity interconnected transmission backbone to transfer bulk power and to accommodate fast growing electricity demand.

The distribution grid in China is less mature than in most developed countries and the penetration of small-scale renewables is limited at the moment. However, according to a report by Innovation Observatory [31], China is set to roll-out 360 million smart meters by 2030 and is investing heavily in more efficient distribution transformers.

South Korea The South Korean Government has laid out plans to establish a national Smart Grid. According to [39], South Korea plans to spend $24 (€16.8) billion over the next two decades on Smart Grids to make electricity distribution more efficient, cut greenhouse gas emissions and save $26 (€18.2) billion in energy imports. In 2010 South Korea invested $824 (€580) million in stimulus funding for Smart Grids [49].

State-run electricity monopoly Korea Electric Power Corp (KEPCO) plans to install 500,000 smart meters in 2010, 750,000 in 2011 and complete roll-out by 2020 with a total of 24 million smart meters installed. The company is expected to cover all metering costs and retrieve them through regular power bills [51].

Australia In 2010 Australia invested US$360 (€253) million in stimulus funding for Smart Grids [49]. Australian utilities have a mandate for the installation of smart meters. Under the Smart Grid, Smart City initiative the Australian Government has committed AUS$74.6 (€52.5) million to develop, in partnership with the energy sector, a Smart Grid demonstration project which will provide cost-benefit analysis of Smart Grid technology [2]. The State of Victoria has planned a State-wide roll-out of 2.4 million smart meters by 2013.

India According to the Ministry of Power, India's transmission and distribution losses are among the highest in the world, averaging 26% of total electricity production, with some States as high as 62%. When nontechnical losses such as energy theft are included in the total, average losses are as high as 50%. The need to decrease losses and energy theft, together with the new trend towards increasing energy efficiency and the share of renewables in electricity generation, are all important drivers for the development of a smarter grid [64]. A recent report by Innovation Observatory [31] ranks India third among the top ten countries for Smart Grid investment and reports that India has announced massive smart meter roll-out projects with a plan for more than 130 million smart meters by 2020.

Brazil In 2010 Brazil invested $240 (€143.6) million in stimulus funding for Smart Grids [49]. While Brazil has moved slowly to set guidelines for its smart meter mandates, it could see some mass deployments as early as 2012, and could become one of the biggest smart meter markets of the world by the second half of the decade. Brazil has announced massive smart meter roll-out projects and is planning to replace 63 million electricity meters with smart meters by 2021. As one of the first South American countries to plan nationwide smart metering, Brazil could also be an important testing ground for deployments in the rest of the continent. As with emerging economies, such as India, stopping power theft and fixing too-frequent power outages are key functions that Latin American utilities want out of their smart meter networks.

Japan In 2010 Japan invested $849 (€143.6) million in stimulus funding for Smart Grids [49]. According to recent news, Japan is planning to increase renewable energy sources in its new energy plan and is considering the use of Smart Grid technologies in establishing a new energy system following the nuclear crisis of Fukushima [48].

Table I Smart Grid investments in Europe and beyond

Country / Region	Forecast Smart Grid investments (€/$)	Funding for Smart Grid development (€/$)	Number of smart meters deployed and/or planned
European Union	€56 billion by 2020 [47]* *(estimated Smart Grid investments)*	€184 million (FP6 and FP7 European funding for projects in the JRC catalogue) About €200 million from European Recovery Fund, ERDF, EERA. National funding: n/a	45 million already installed (JRC catalogue,2011) 240 million by 2020 [47]
USA	$338 (€238) to 476 (€334) billion by 2030 [16] *(estimated investments for implementation of fully functional Smart Grid)*	$7 (€4.9) billion in 2009 [49]	8 million in 2011 [50] 60 million by 2020 [50]
China	$101 (€71) billion [65] *(Smart Grid technology development)*	$7.3 billion in 2009 (€5.1) [49]	360 million by 2030 [31]
South Korea	$24 (€16.8) billion by 2030 [40]] (estimated Smart Grid investments)	$824 (€580) million in 2009 [49]	500,000 in 2010, 750,000 in 2011 and 24 million by 2020
Australia	n/a	$360 (€253) million in 2009 [49]	2.4 million by 2013 in State of Victoria
India	n/a	n/a	130 million by 2020 [31]
Brazil	n/a	$204 (€143.6) million in 2009 [49]	63 million by 2020 [31]
Japan	n/a	$849 (€143.6) millions in 2009 [49]	n/a

* Other estimates (http://setis.ec.europa.eu/newsroom-items-folder/electricity-grids, June 2011), referring to the upgrade of transmission and distribution grids (not only Smart Grids) forecast a required investment of €500 billion by 2030, where distribution accounts for 75% and transmission for 25%.

2. INVENTORY OF COLLECTED PROJECTS – IN WHICH DIRECTION IS EUROPE MOVING IN THE FIELD OF SMART GRIDS?

The main goal of our study is to collect a wide inventory of Smart Grid projects in Europe and use project data to support analysis of trends and developments. In this chapter we will use the results of our analysis to describe what is happening in the field of Smart Grids in Europe from different perspectives. In the first paragraph we will look at the projects to examine their distribution across countries and project categories and survey the budget allocated by each country to Smart Grid development. In the second paragraph we will have a closer look at the projects to determine how they distribute along the stages of the innovation process and how this distribution has changed with time. In the third paragraph we will get an insight on selected Smart Grid applications, namely the integration of distributed energy resources (DER), Demand Response (DR) and the safe integration of large-scale renewables (RES). We will survey the development trend of these applications and their level of maturity. Finally, in the fourth paragraph we will focus on the actors involved in the innovation process to see where they are investing and why.

2.1 Projects and budget distribution across countries and project categories

Geographical distribution of projects and investments Projects are not uniformly distributed across Europe. The majority of them are located in EU15 Member States, while most of the EU12 still lag behind. Figure 1 shows the location of projects and their distribution between the EU15 and EU12. For demonstration and deployment projects, the project was assigned to the country where the demonstration or roll-out actually took place, while in the case of R&D projects, the project was counted towards all the participating countries. Most of the projects are concentrated in a few countries; Denmark, Germany, Spain and the UK together account for about half of the total number of projects.

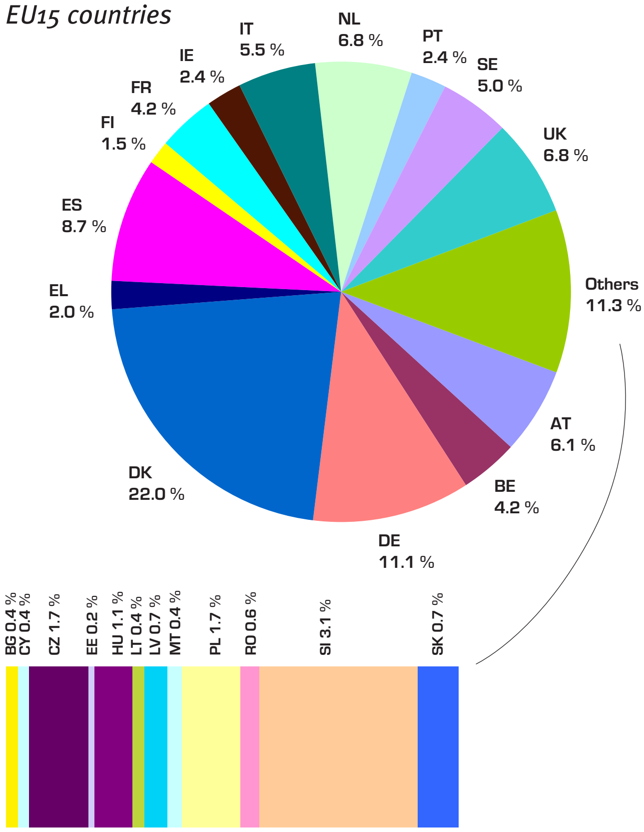


Figure 1. Distribution of projects between EU15 and EU12 Countries

As for investments, Figure 2 shows the allocation of budget across different countries and project categories. In the case of demonstration and deployment projects, the budget was allocated to the country or countries where the project had at least one implementation site. When a project had several implementation sites located in different countries, the project budget was shared evenly among them. In case of R&D projects, when budget shares were not available, the budget was evenly spread across the participating organizations.

A few countries stand out in terms of spending. With a budget of over €2 billion, Italy accounts for almost half of the total spending in our catalogue. The great majority of this budget is however attributable to only one project, the *Telegestore* project, which consisted in the national roll-out of smart meters in Italy. Due to graphical constraints, the corresponding bar in Figure 2 had to be cut down to allow its representation without overshadowing the other countries. In general, EU12 countries show a much lower level of investments compared to EU15 countries (see Figure 3), circumstance which is mainly explicable with the lower number of projects and generally to a later start in Smart Grid development. A remarkable exception is Malta, which is investing over €80 million for the deployment of smart meters and the implementation of a remote management system.

The different pace at which Smart Grids are deployed across Europe could make trade and cooperation across national borders more difficult and jeopardize the achievement of the EU energy policy goals. Knowledge sharing and the dissemination of lessons learned in other countries can help to bridge the gap in the future.

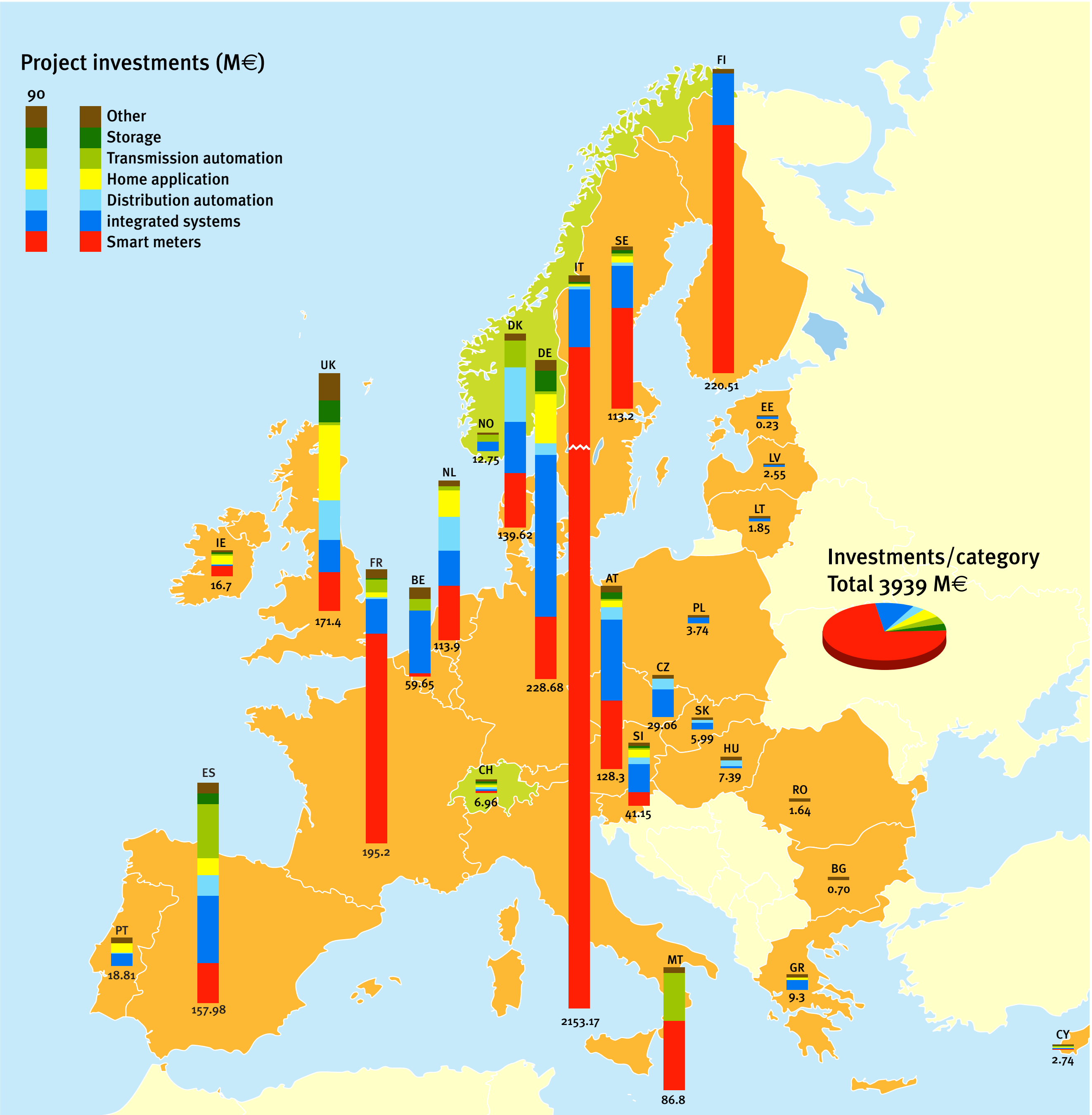


Figure 2. Geographical distribution of investments and project categories[4]

[4] This figure does not include the total budget of the Swedish smart meter programme (estimated budget €1.5 billion), as not enough details were made available at this stage.

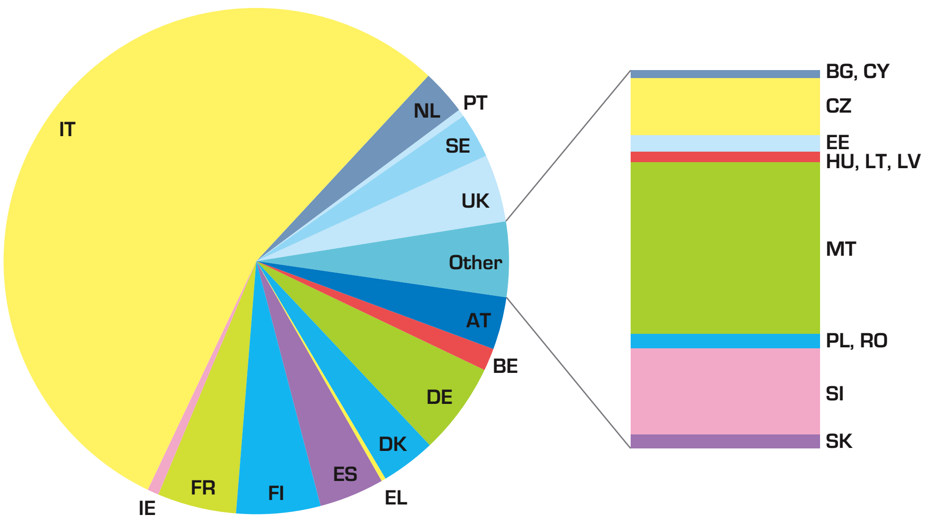


Figure 3. Distribution of investments between EU15 and EU12 countries

Project distribution across project categories Figure 2 shows remarkable differences in the distribution of project categories in Europe. Generally speaking, the investment pattern and project categories coverage in different countries is strongly influenced by different starting points in the adoption of the various Smart Grid solutions and by national circumstances. Investments depend crucially on regulation, generation and consumption structures in each country. For example, countries with large penetration of RES may favour developments that increase hosting capacity (i.e. Transmission Automation, Integrated System, Storage), whereas countries with a high share of flexible electricity use (e.g. space and water heating) may favour investments that promote Demand Response (i.e. Distribution Automation, Integrated System, Home Application, Smart Meters).

In our catalogue, the most represented project categories, which also attract the highest level of investments, are Smart Meters and Integrated Systems (Figure 2).

About 27% of the projects collected in the catalogue fall in the Smart Meters category; as we will see better later (see Box.1) these projects involve the installation of about 40 million devices for a total investment of around €3 billion. These figures are quite significant, but a lot more of investments are needed in this field, as smart meters are a key enabler for many Smart Grid applications. Estimates forecast about 240 million smart meters to be installed by 2020 [47].

The country leading investments in smart meters is Italy, where a national roll-out (Telegestore project) has already been achieved. In two other countries, France and Finland, the great majority of the budget is also attributable to smart meter projects. In France the demonstration project *Pilot Linky* accounts for about 75% of the total spending, while in Finland the *Smart Meters roll-out* project by Fortum accounts for over 80% of the whole budget. It is worth stressing that the Swedish smart meter roll-out is largely underrepresented in our catalogue at the moment. We have received communication from the Swedish regulator that the full smart meter roll-out program consisted of 150 projects for a total estimated amount of 1.5 billion. However, so far we have received and included in our analysis data from only three projects, involving the deployment of about 1.2 million smart meters.

As for the Integrated System category, Figure 2 shows that in almost all countries, a significant amount of investments has been devoted to projects, which address the integration of different Smart Grid technologies and applications. Integrated System projects represent about 34% of the projects and about 15% of the total budget. Most of the technologies are known, but their integration is the new challenge. This result highlights the need to consider the Smart Grid as a system rather than simply a collection of different technologies and applications. For a more detailed discussion, refer to Chapter 3.

***

Combining the overall investment from the catalogue (around €4 billion) with the investment costs of the Swedish smart meter roll-out (around €1.5 billion), we can estimate the investments in Smart Grid projects in Europe to be about €5.5 billion so far.

These figures show that important efforts have already been undertaken, but we are just at the beginning of the Smart Grid transition. To put the investments in our catalogue into context, conservative estimates quantify Smart Grid investments by 2020 [47] at €56 billion (see Chapter 1).

BOX 1. SMART METERING

The introduction of smart metering systems in Europe has received an important regulatory push by the European Union's Third Energy Package provisions and especially Annex I.2 of the Electricity Directive . The Annex explicitly asks Member States to assess the roll-out of intelligent metering systems as a key step towards the implementation of Smart Grids and to roll out 80% of those that have been positively assessed.

Many Member States have already started implementing provisions in their legislation, while some others are still lagging behind.

Independently of the legislative and regulatory framework, in some Member States utilities have started to introduce smart meters as a means to modernise the grids and to bring about operational changes, i.e. reduce nontechnical losses, introduce remote reading and switching or simplify the billing procedures.

In our catalogue, a set of Member States is leading the investments in the deployment of smart meters.

ITALY started a national roll-out already in 2001 (*Telegestore* project). By the end of 2006 about 30 million meters had already been installed. Pursuant to Regulatory Order No. 292/06 of 18 December 2006, automatic metering infrastructure is now mandatory. The focus of the Italian metering system is on reduction of nontechnical losses more than on energy savings [1].

SWEDEN Already in 2003, Sweden mandated monthly automatic meter reading for all electricity meters by July 2009. Within the given timeframe DSOs were free to decide the pace of implementation. Thanks to the new legislation, investments in Smart Metering developed fast and the roll-out at national level was achieved in time. Given the high number of DSOs in the country, since 2003 there has been a correspondingly high number of smart meter roll-outs. Overall, the national deployment of smart meters was carried out by means of about 150 projects, amounting to around €1.5 billion and involving the installation of approximately 5 million smart meters. In our analysis we have included three of these projects, accounting for the installation of about 1.2 million smart meters.

FRANCE The demonstration project *Pilot Linky* started in 2007 and involved the installation of 300,000 smart meters. Building on the results of the pilot phase, a national roll-out is in preparation. The roll-out phase envisages the deployment of 35 million smart meters, with an expected investment of about €4 billion. The goal is from January 2012 to install only electronic meters and to have 95% coverage by the end of 2016. The regulator defined some guidelines and minimum functional requirements for electricity meters. A cost-benefit analysis with a positive result was presented in 2007.

MALTA The deployment of smart meters started in Malta in 2008 with a 5 year pilot phase which provides for the installation of 250,000 meters. The pilot project uses the Enel technology and it is aimed at identifying any problems ahead of the planned replacement of all electricity and water meters. In 2010 Enemalta launched a roll-out plan to replace all electricity and water meters by the end of 2012.

FINLAND The smart meter roll-out is well on its way in Finland. The new electricity market act (66/2009 Act on electricity supply reporting and metering) required all connection points over 63 Ampere to have remotely readable hourly metering by 2011. By 2014 the Act demands for full smart meter penetration with no more than 20% exception. The Ministry of Employment and Economy has estimated roughly that the cost of a full roll-out is €565–940 million (for 2.2 million customers who do not yet have AMR – Automated Meter Reading).

UK The Smart Meter National Roll-out Program in the UK is planned to start in 2012 and be completed in 2020, with an estimated investment of more than €11 billion.

Highlights from collected projects Most of the smart metering projects are demonstration projects (59%), followed by deployment (32%) and R&D projects (9%). All the smart metering projects together account for about 75% of the catalogue's total budget, but a considerable share of this figure (71%) is attributable to a single project, the smart meter roll-out in Italy. Although a substantial amount of money has already been invested in this field, there is still need for considerable investments.

Estimates forecast €51 billion investments in smart meters by 2020 [27]. The projects in the catalogue will result in the installation of more than 40 million smart meters, of which 32 million in Italy.

Business case for investments Investment in smart meters is currently mainly justified on the basis of the expected reduction of DSO's operational expenditures, typically resulting from the elimination of meter reading costs, reduction of power theft, remote activation and deactivation of service, faster detection of power outages, and improved management of bad-payers. This investment is also likely to yield additional benefits arising from the provision of dynamic pricing for consumers. These benefits are usually not considered in the business case for deployment of smart meters, as they depend on the development of future functionalities and applications (i.e. in-home displays, smart appliances).

Examples of operational benefits recorded by DSO from smart meter deployment

- With the Telegestore project, Enel has gained approximately €500 million in yearly savings, with a 5 year payback period, and a 16% internal rate of return.

- The period for settlement of balance power was reduced from 13 to 2 months after the delivery month (*Storstad Smart Metering project*).

- Contribution to a decrease in the SAIDI index (System Average Interruption Duration Index) from 128 min to 49 min, and a consequent decrease of cash cost/customer from €80 to €48 from 2001 to 2009 (*Telegestore*).

- With the Telegestore Project, Enel managed 3,027,000 bad payers in 2008 (Telegestore).

- Lead time for exporting meter readings to suppliers was shortened from 30 days to 5 days (Project AMR).

- Over a two year period, the number of calls for both meter-reading and invoice related issues dropped by 56% (*Storstad Smart Metering project*).

2.2 Project maturity and scale

Projects were classified according to their stage in the innovation chain. To identify R&D projects we used the definition laid out in the Frascati Manual, according to which R&D projects comprise *creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications* [43]. The term R&D covers three activities: basic research, applied research and experimental development.

For demonstration projects we referred to the conceptualisation largely used in the literature, which defines a demonstration project as a finite initiative to test a technology according to the project objectives. A technology could be everything from a base technology to a complete system concept [33]. The project starts with a conceptual design and ends when the technology is implemented and the results are evaluated and communicated [11]. Demonstration projects can therefore be seen as a 'preview' phase when the interaction between users and support systems and emergent products is tested. The concept includes projects designed to test the performance of the technology in different operational environments, through to full market trials in which the technology is used in customer installations [3]. These projects aim at exposing the technology to realistic user environments to test its suitability for more extensive diffusion.

Finally, deployment projects refer to the implementation of a technology, application or system as a default solution within the project geographical boundaries. Some deployment projects are nationwide; some others are limited to a more restricted geographical area.

Some projects in the catalogue include two different stages, typically R&D and demonstration. In these cases, for the sake of simplicity, we have assigned the project to the stage that seemed to best characterize the project and to which most of the time and budget were allocated.

***

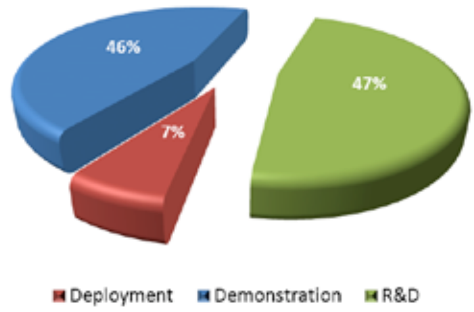


Figure 4. Distribution of projects along the stages of the innovation chain

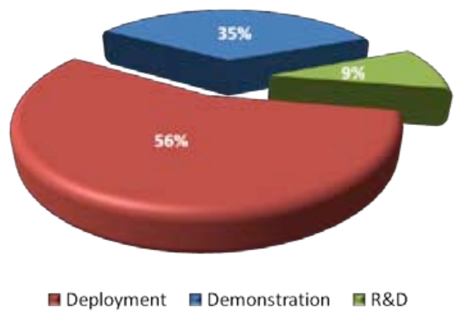


Figure 5. Distribution of investments along the stages of the innovation chain

The collected projects span across all the stages of the innovation process, but the majority of them are concentrated in the R&D and demonstration phases (Figure 4). Only 7% of the projects are in the deployment phase.

When we move our attention from the number of projects to the corresponding investments, the picture changes considerably (Figure 5). As expected, deployment covers the lion's share of investment commitments; 7% of the projects account for almost 60% of the investments. An important share of these investments however is attributable to only one project, the massive roll-out of smart meters in Italy (Telegestore project, €2,106 million). R&D and demonstration projects account for a much smaller portion of the total budget. Most of these projects are small to medium size, with an average budget of €4.4 million for R&D projects and about €12 million for demonstration projects. In the future there might be the need for larger scale demonstration projects to improve our knowledge of the functioning and impacts of some innovative solutions at a realistic scale and to validate results to a wider extent.

R&D and demonstration projects can be found in almost all the countries in the catalogue (Figure 6), while deployment projects are concentrated only in a few countries. Given that almost all of them are smart metering projects, the main reason for their concentration might lie in the favourable legislative and regulatory environment.

Denmark stands out in terms of the number of R&D and demonstration projects.. This is partly explained by the fact that Denmark has already achieved a very high penetration of renewables and distributed generation and therefore needs to update its electricity system. Moreover, the Danish TSO is charged with supporting R&D and demonstration activities in the electricity sector, activities which are then financed through a Public Service Obligation (PSO) tariff[5]. This system also implies the traceability of the projects which can then be easily monitored and communicated, favouring the assessment of their results and knowledge sharing. This is not the case for many other countries, where retrieving information about Smart Grid projects proved to be a more difficult task.

Figure 6 shows a very high number of R&D projects, which might give the impression of a higher share than presented in Figure 4. In reality, this is explained by the fact that about 25% of R&D projects in our catalogue involve the participation of several countries, and they have therefore been counted towards each one of them. All of these projects have been co-funded by the European Union, mainly through the FP6 and FP7 programmes and they represent an important means of enhancing international cooperation, knowledge sharing and the dissemination of lessons learned.

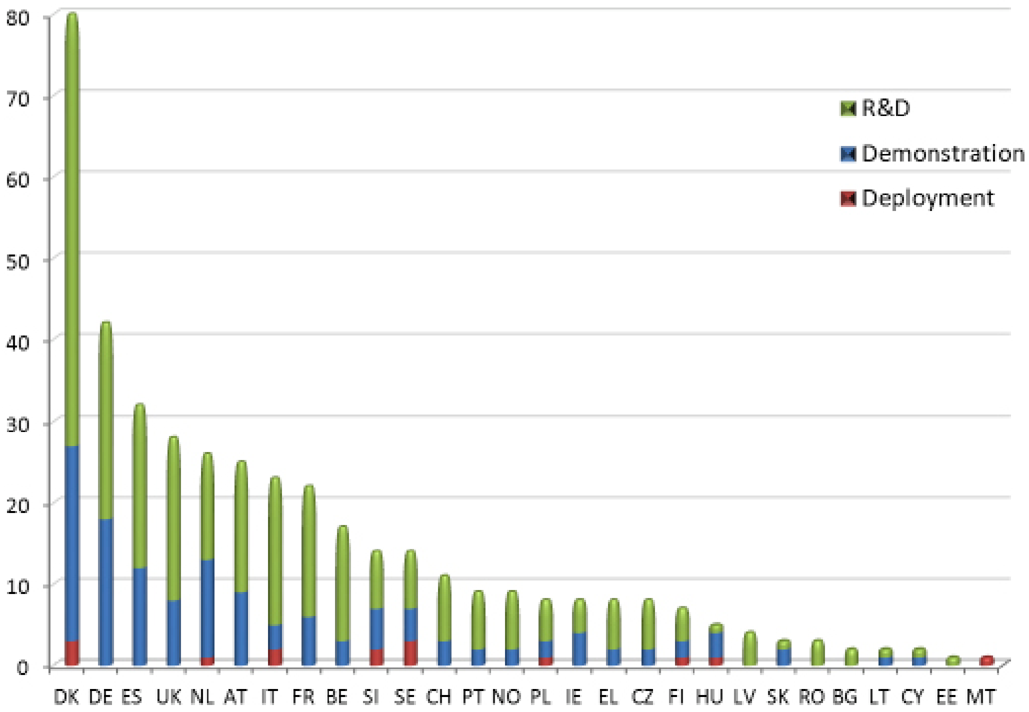


Figure 6. Stages of development and participating countries across collected projects

5 Under the PSO Programme ForskEL, the Danish TSO administers PSO funding of 130 million DKK a year which, through a call process, is granted to research, development and demonstration projects within selected and prioritized focus areas. The ForskEL program has run since 1998.

As for the investments, Figure 7 focuses on R&D activities, grouping countries according to their level of investments in R&D projects. Relevant differences can be noted between countries; as stated in § 1.1.2 however, the investments we reported in our catalogue are only those which fall into the scope of our analysis. R&D projects in our catalogue range from network assessment and planning tools to the investigation of new market solutions and consumers' behaviour.

Figure 7. Investments in collected Smart Grids (SG) R&D projects per country

Finally, Figures 8 and 9 show the trend of the different maturity stages over time. The number of R&D and demonstration projects grows constantly while the number of deployment projects has not increased dramatically since the first project in 2001. The constant growth of demonstration projects is particularly important as it shows an increasing confidence in the viability of Smart Grid projects.

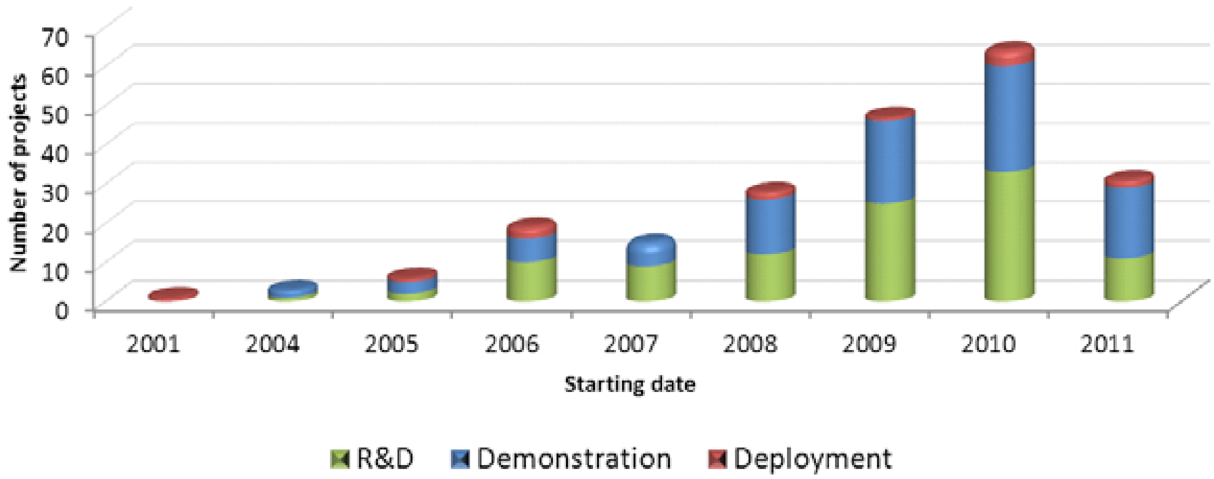


Figure 8. Share of R&D, demonstration and deployment over time

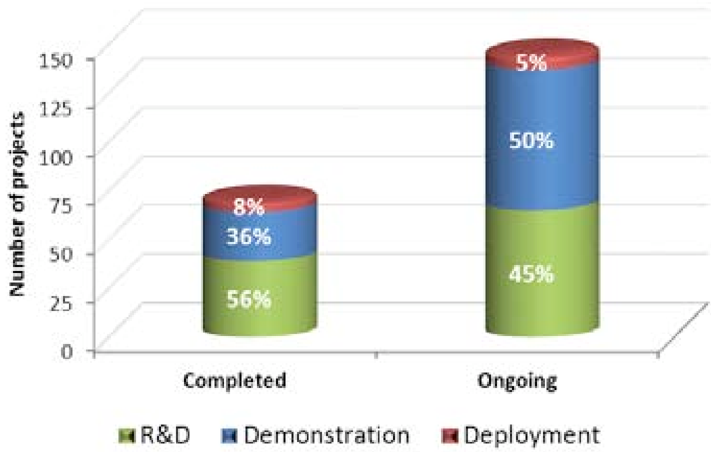


Figure 9. Project status and stage of development

2.3 Insight into some final applications and their level of maturity

As aptly stated by [17], Smart Grids are not an end in itself but a means to an end. The project categories in Figure 2 can be seen as the key technological areas addressed by the projects to achieve Smart Grid solutions. Building on the categorisation effort carried out by project respondents and through an in-depth analysis of the project elements, we identified three main final applications pursued by the projects in the catalogue, namely the safe integration of Distributed Energy Resources (Distributed Generation, Storage, EVs, see Box 2), the possibility for consumers to respond to prices (Demand Response and dynamic pricing, see Box 3), and the safe integration of large-scale renewables (see Box 4).

In this section we will analyse these three applications and their level of maturity in the context of the general results of the survey to gain an insight into the current developments in the Smart Grid landscape. Since smart meters are a key technological enabler for many of these developments, we have included them in the analysis as well.

BOX 2. Integration of Distributed Energy Resources

The deployment of Distributed Energy Resources (DER) is useful to (1) offer alternatives to large centralized plants facing permit problems and construction uncertainties, (2) exploit the potential of dispersed Renewable Energy Sources (RES), and (3) include prosumers in the electricity market. Decentralization supports scalability and robustness, i.e. the capability to integrate new components or cope with component failures. The trend toward decentralization is also encouraged by consumers' push for more control over energy consumption.

The integration of large quantities of DER is extremely challenging both from a physical and market point of view. The goal of projects in this area is the online coordination of electric vehicles, distributed generators and/or storage devices to adjust to grid and market conditions, guaranteeing grid stability, optimization of energy resources, easier access to the electricity market for small players. Different methods are implemented across projects to explore the capabilities of DER units to provide ancillary services through an aggregated DER portfolio.

Scanning through the projects, we observe that, while some make use of the concept of diversification by combining a variety of types of micro-generation units, others focus on just one single type of energy source by compensating for the variability of power flows through means of storage and/or modification of load profiles (instantaneous modification of electricity consumption levels).

BOX 3. Demand Response

Demand Response (DR) is one of the central themes in the catalogue. Its target is to enable active participation of commercial/domestic consumers in the market through the provision of consumption flexibility services to different players in the power system. This is achieved by aggregating consumers' reduced load into larger amounts for participation in market sales (e.g. to sell to network companies, balancing responsible parties, owners of non-controllable generation, etc.). Aggregators are the key players to mediate between consumers and the market.

Particularly challenging is the integration of domestic consumers who, as opposed to DG and large industrial consumers, are less motivated by purely economic concerns (minimal gains). Furthermore domestic consumers are generally unable to make precise predictions on their available load flexibilities; therefore it is difficult for them to 'offer' services in the classical sense. Rather, the idea is for their services to be made available at the market's 'request', i.e. through price and/or volume signal mechanisms, and for the provision of services to be on a voluntary and contractual basis.

BOX 4. Large-scale integration of renewable energy

More and more variable renewable energy generation, for the time being mainly based on wind and in future also expected to include other technologies (e.g. concentrated solar power), is grouped in large-sized plants often installed far from existing power infrastructure (e.g. offshore or in remote areas).

This large-scale renewable generation poses a number of challenges on the power system architecture and operation:

- It requires adequate connection to the existing infrastructure and appropriate internal grid reinforcements in order to wheel the renewable power to the demand centres (often far from the connection point);

- Due to a more marked time-variability and weather-dependence of its energy output (compared to other generation technologies), the balancing task of power system operators becomes harder to carry out; as a matter of fact, since electricity is not stored on a massive scale to date, the power produced must at all times equal the power consumed (and lost).

- As the current power grids do not generally appear adequate to reliably cope with large-scale penetration of such intermittent renewable generating plants, network operators are getting together with research centres, academia and other partners to study and demonstrate how to overcome the barriers of grid access and system integration for large-scale renewables; as a consequence, large investments are being committed to upgrade the existing grids and to demonstrate/implement measures such as reserve capacity increase, balancing area expansion, redesigned market mechanisms, load shifting and storage integration to cope with renewable energy variability.

Figure 10 shows the number and the starting year of projects focusing on the integration of Distributed Energy Resources (DER), on Demand Response (DR) and on the safe integration of large-scale RES. Figure 11 shows the investments associated to these projects. For sake of simplicity, the entire project budget was allocated to the starting year. Figure 12 reports the classification of the projects in these three areas according to R&D, demonstration and deployment stages.

Projects focusing on the integration of distributed energy resources are steadily growing. Most of the work is still focusing on the R&D and demonstration stages to test aggregation concepts (e.g. Virtual Power Plant, Vehicle2Grid). None of the collected projects has moved these concepts to the deployment stage.

Demand Response projects testing dynamic pricing and consumer participation, are growing in number. They are benefiting from the deployment of smart meters, which are key enablers for the increase of Demand Response initiatives. More and more Demand Response projects are moving from R&D applications to demonstrations to test actual consumer engagement. Gaining consumers trust and participation is the main challenge in this field. Potentially, consumers' benefits are significant. They range from energy savings (up to 10-15%, see e.g. GAD project) to a more favourable business case for the purchase of home energy resources (heat pumps, EVs, CHPs etc.) through a direct participation in the electricity market (selling power and/or load flexibility). However, in order to capture most of these benefits the whole system (infrastructure + market) needs to be in place.

There is an increase in the number of projects and budget available for the integration of large-scale RES with time, but at a lower level compared to other applications. However, we remark that the majority of investments in this area are concentrated in grid reinforcement and they do not appear in our analysis as we have only focused on Smart Grid projects.

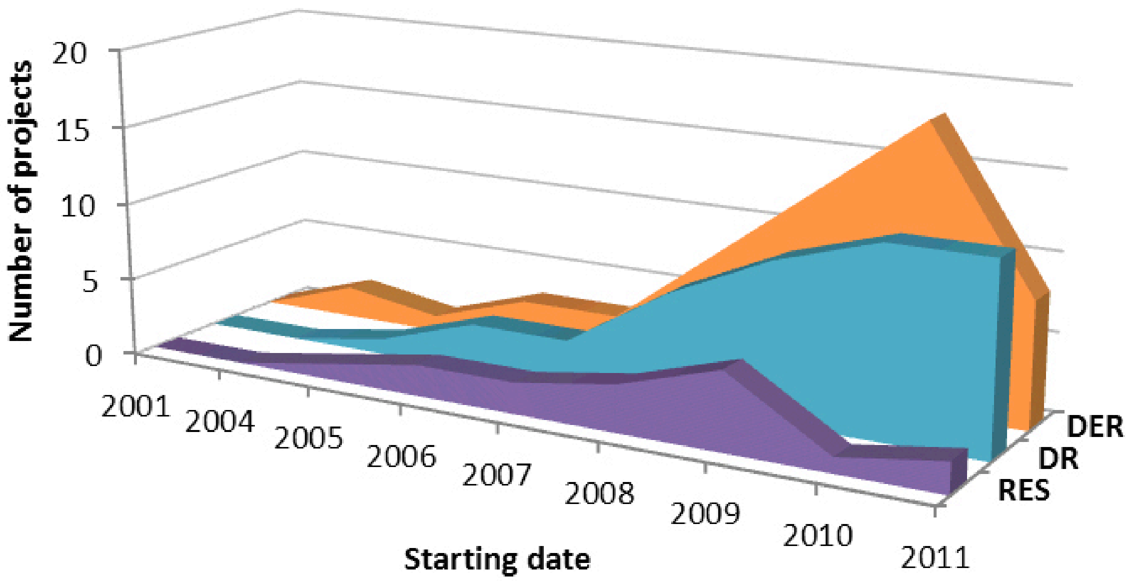


Figure 10. Trend in the number of projects focusing on integration of Distributed Energy Resources, Demand Response and large-scale Renewable Energy Sources over time

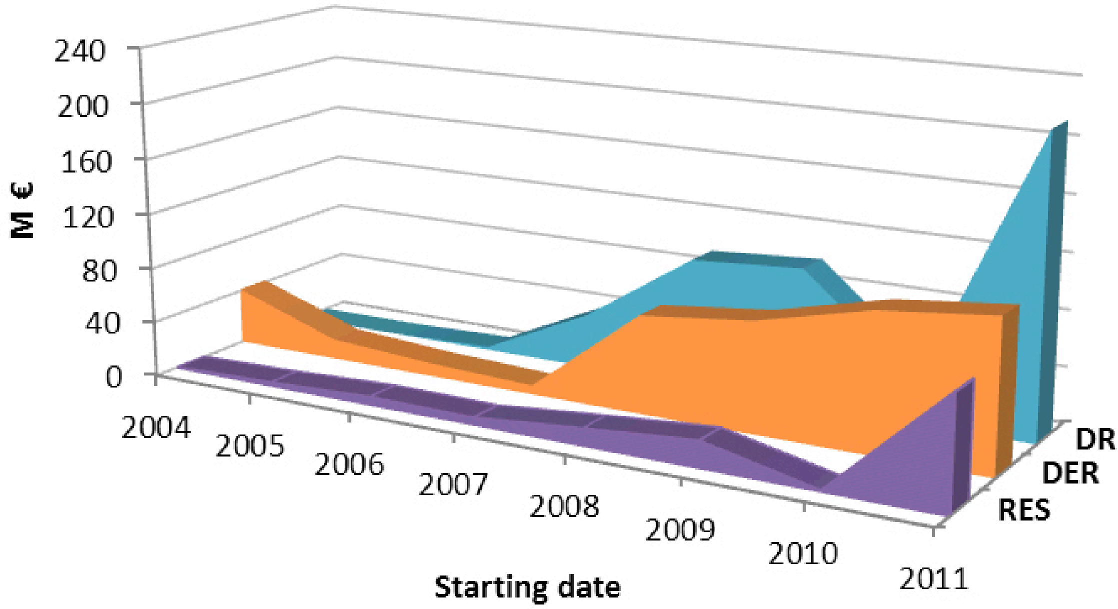
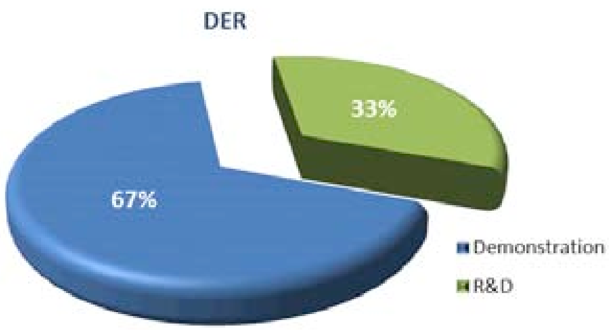
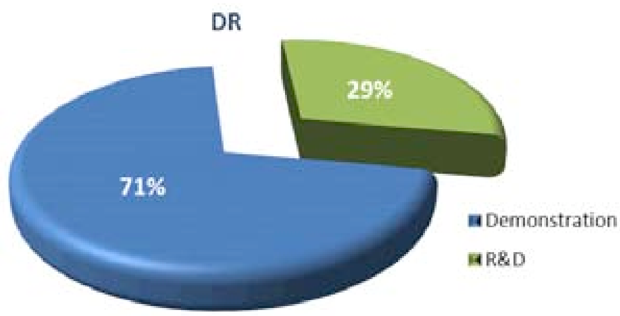


Figure 11. Budget allocated to projects focusing on the integration of Distributed Energy Resources, Demand Response and large-scale Renewable Energy Sources over time





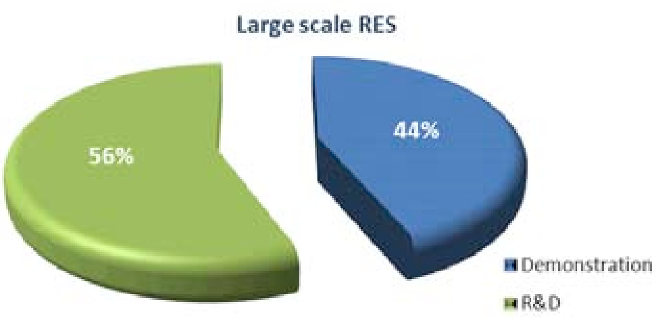


Figure 12. Level of maturity of projects focusing on the integration of Distributed Energy Resources, Demand Response and large-scale Renewable Energy Sources

Finally, Figure 13 shows the maturity level of smart meters, a key enabler of many Smart Grid applications. Over 30% of smart meter projects are in the deployment phase, while the R&D stage comprises a very limited number of projects (e.g. see projects *OpenNode*, *OpenMeter*, *SyM2*). The demonstration and deployment of smart meters has made R&D and demonstration activities in other Smart Grid areas possible. In particular, many demonstration projects combine the installation of smart meters with Demand Response programmes (e.g. see projects *MeRegio*, *ESB Smart Meter*, *E-telligence*).

Figures 12 and 13 also confirm what we have already observed in the previous paragraphs. R&D and demonstration projects are smaller in size and they have a wider portfolio of technologies and applications.

2.4 Who is investing?

A wide variety of respondent organisations are investing in the Smart Grid projects of the catalogue. Taking stock of the work presented by [17], we have grouped the leading organisations of the projects in the following categories:

1. Energy Companies (e.g. EDF)
2. Distribution System Operators (e.g. Enel Distribution)
3. Transmission System Operators
4. Service Providers (manufacturers, aggregators, retailers, IT companies etc.)
5. Universities, Research Centres, Public Organisations

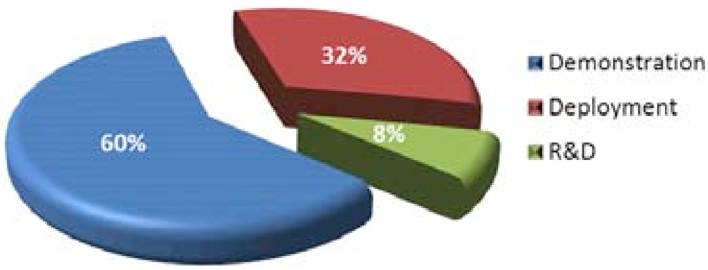


Figure 13. Level of maturity of projects focusing on smart meters

Figure 14 shows the progression of investments by leading organisations over time. The high figure for 2001 is due to the national smart meter roll-out run by Enel in Italy (*Telegestore* project). The decrease in investments in 2011 is due to the fact that many projects planned to start this year have not answered to our survey yet.

The players leading and participating in the projects in the catalogue are diverse, as the increased complexity of the electricity system requires multidisciplinary consortia. Network operators are establishing fruitful cooperation with diverse partner organisations, ranging from academia and research centres to manufacturers and service providers, particularly IT companies. As a whole, the implementation of Smart Grids is a significant opportunity for the European industry to research, market and export new technologies, to create new jobs, to keep global technological leadership and to contribute to achieving the environmental targets the EU has set (see also [10]).

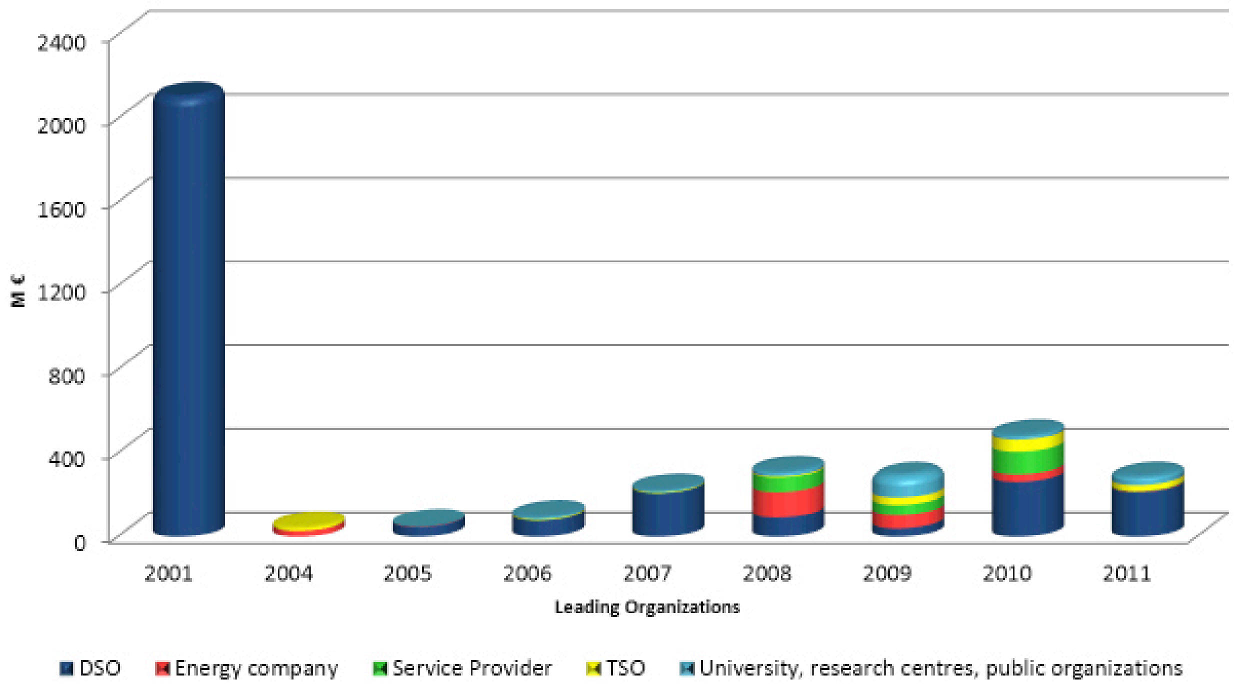


Figure 14. Starting time across budget (€ million) and leading organisations

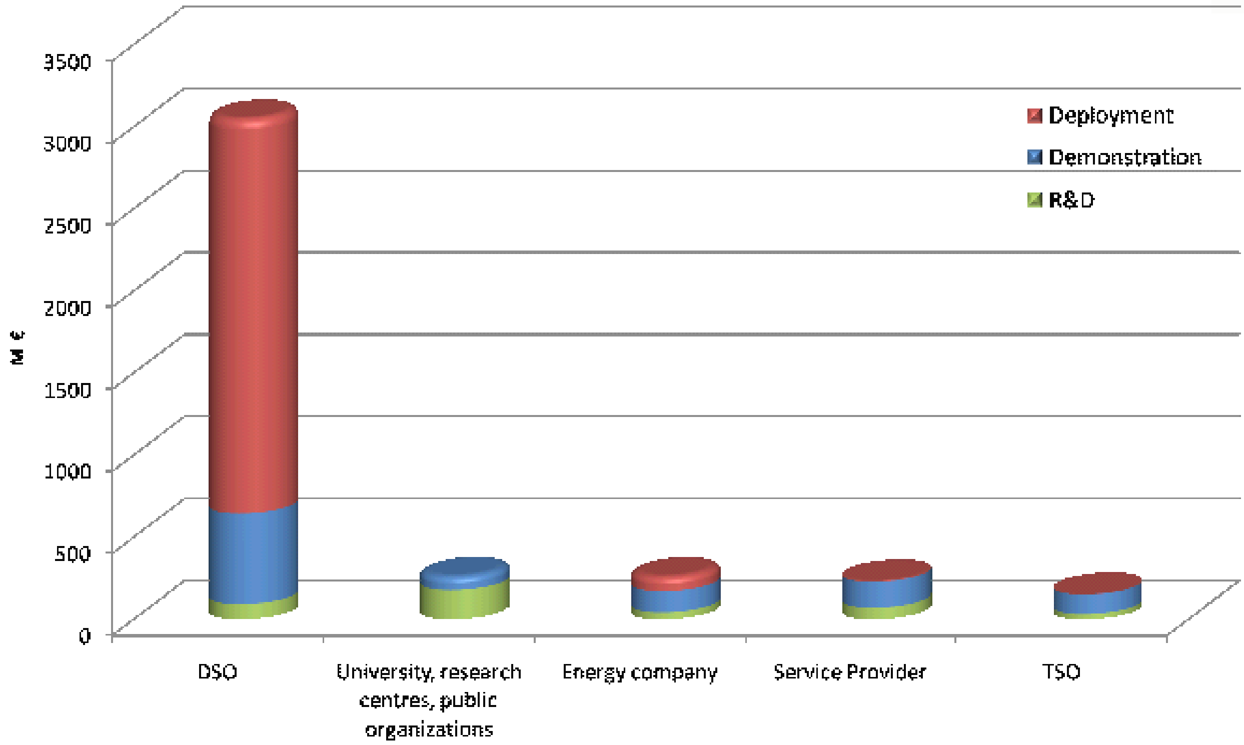


Figure 15. Investment distribution across leading organizations

Figure 15 shows the cumulated investments of different leading organisations across our catalogue. The data seems to confirm the leading role DSOs play in promoting Smart Grid development in Europe. Current total investment in projects led by DSOs amounts to over €3 billion.

To leverage further investments for the rapid development of Smart Grids and ensure the necessary involvement of risk-averse network operators, it is necessary to find the right balance in sharing costs, benefits and risks. The main responsibility for achieving this balance lies with regulators.

The high number of DSO-led projects in our catalogue allowed us to get an insight into the source of financing of these projects. Generally speaking, investment costs of DSO-led projects are mainly covered either through tariffs or through funding made available at European or national level. In many cases costs were covered through a combination of both.

The majority of DSO-led projects in our catalogue are financed by DSOs themselves, i.e. through revenues received from tariffs charged to the end user for distribution of electricity in the Low Voltage grid.

Other examples of tariff-based funding are regulatory incentives funded through tariffs, such as the UK's Innovation Funding Incentive introduced in 2005 by the regulator OFGEM, allowing up to 0.5% of annual revenue to be spent on innovation. In 2010, OFGEM established the Low Carbon Network Fund (LCNF), which allows up to £500 (€577) million specifically in support of DSO-sponsored projects testing operating and commercial arrangements, and new technology. In fact, all DSO-led projects from the UK included in our catalogue are supported by the LCNF, enabling a total investment of €118 million.

Another best-practice scheme, though not part of our catalogue, is implemented by the Italian energy regulator AEEG who recently launched a competition-based procedure providing specific incentives for Smart Grid demonstration projects related to the active distribution network. The motivation for DSOs to invest is that they are guaranteed an extra 2% return on capital on distribution network related investments for a period of 12 years [38].

In terms of public financing for Smart Grid investments, the European Commission funds a whole series of projects dealing with different issues concerning the implementation of Smart

Grid technologies. The EC's contribution toward the projects considered in our catalogue amounts to about €184 million, 25% of which went to DSO-led projects (Figure 16).

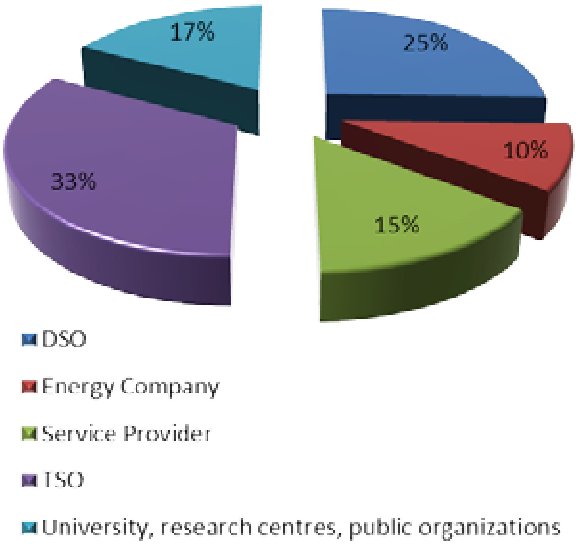


Figure 16. Distribution of EC Funding across Leading Organisations

The majority of EC funded projects in the catalogue are supported either by the 6th or the 7th EU Framework Programme for Research and Technological Development (FP6 or FP7, respectively, see Box 5). However, project funding was also received from the European Regional Development Fund as well as the EU Recovery Plan. In all, 9% of DSO-led projects are supported with funding by the EC.

Box 5. FP6 and FP7 projects in the catalogue

- 8 projects financed by FP6 framework funding – total financing €38 million
- 23 projects financed by FP7 framework funding – total financing €146 million

About 10% of DSO-led projects are co-financed by national funding schemes, such as the Austrian Climate and Energy Fund KLIEN, which funds Austrian projects included in the catalogue worth €33.5 million. The fund was set up in 2007 by the Federal Ministry of Transport, Innovation and Technology in support of sustainable energy supply and the reduction of GHG emissions.

Other examples of national co-funding represented in the catalogue include financial support from the Portuguese National Strategic Reference Framework (QREN), the Spanish Ministry of Science and Innovation's Centre for Industrial Technology Development (CDTI) and the German Federal Ministry for Economics and Technology's funding program "E-Energy".

Figure 17 reports the number of DSO-led projects and the corresponding investments in key technological applications: Advanced Metering Infrastructure, Integration of DERs and Demand Response. DSO-led projects are concentrated on smart metering whose business case is mainly based on savings in areas like revenue protection (e.g. energy theft), logistics, field operations (e.g. readings, activation/deactivation) and customer service (e.g. bad-payers, invoicing), resulting in the reduction of operation costs (see Box 1 for more details).

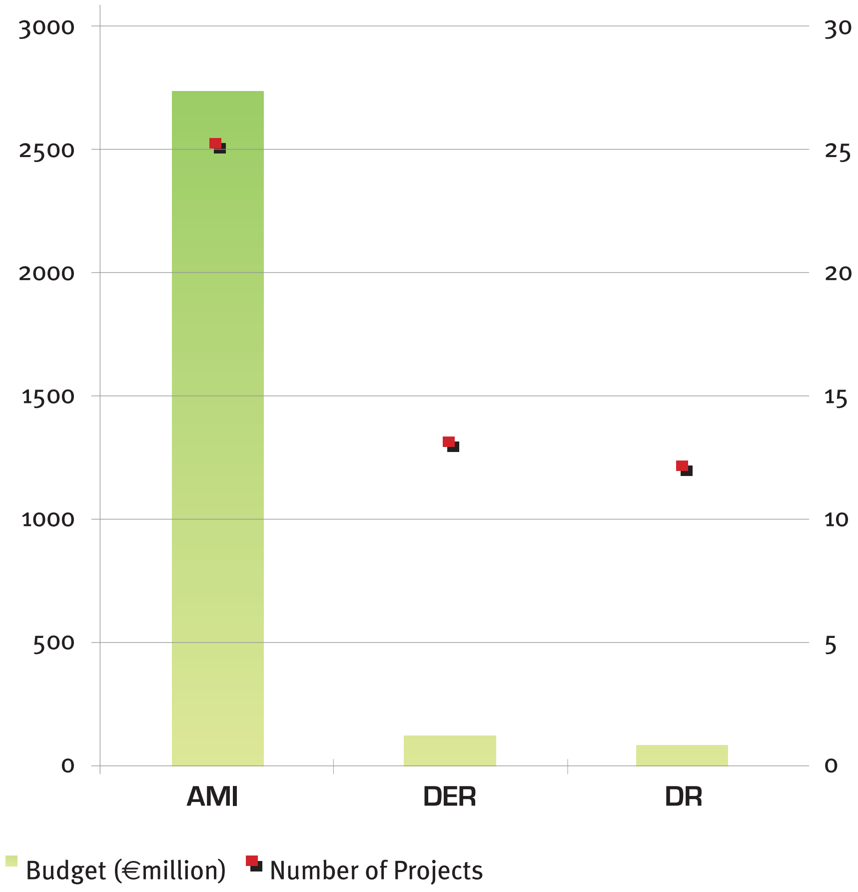


Figure 17. Investments in DSO-led projects by application

For other deployments, such as that of the electric vehicles (EV) charging infrastructure, the business case of DSOs is still unclear (see Box 6). The main problem is the uncertainty regarding the demand side. Whether a "pay-per-use" model (consumers pay per kWh charged) or a subscription model (consumers pay an annual or monthly subscription fee) is applied, expected utilisation rates as well as the expected number of charging stations per car are currently still unclear. In our catalogue 11% of DSO-led projects, about 50% of DER projects, study consumers' EV charging behaviour indicating quite some interest towards the uptake of charging infrastructure among European network operators.

BOX 6. EV Charging infrastructure

- Whether or not the charging infrastructure is to be a regulated asset is still a much debated issue, which makes the business case for DSOs ambiguous. It can be considered as an extension of the distribution grid, much like a telephone booth in the phone infrastructure. In this case direct governmental intervention would allow DSOs to socialize the costs. Rather than operating them, DSOs could generate revenue by selling charging equipment as well as related consulting services to public or private entities. Alternatively, charging infrastructure can be regarded as a post-sale service comparable to a fuelling gas station, in which case private companies are entirely responsible for its provision as well as operation

- The MiniE-Berlin project (50 customers and 100 recharging stations 50 public stations and 50 home stations) pursues an open access approach. Customers can buy specific electricity product of their dedicated electricity provider. Contrary to a roaming approach, a customer could only buy the electricity product from the owner of the charging spot.

- In the e-Mobility project (100 customers and 400 recharging stations - 300 public stations and 100 home stations) the charging infrastructure is built by a DSO (Enel Distribuzione) and is likely to be considered a regulated asset. The same open access approach of the MiniE-Berlin project is pursued.

- Caution in performing charging spots roll-outs is an indication of the lack of a strong business case, which is largely due to uncertainties regarding future demand.

At the transmission level, projects are exploring new technologies (e.g. High Voltage Direct Current - HVDC, Flexible AC Transmission Systems - FACTS) and new tools to increase transfer capacity, enhance cooperative and flexible operation and cope with permit limitations and high costs of new grid infrastructures. The amount of investment already committed/mobilised for transmission projects in our catalogue is around €45 million for research and €95 million for demonstrations. According to [12], required R&D investments for transmission projects amount to €270 million for research and €290 million for demonstrations over the next ten years.

The gap between the investments already mobilised and those required can be partly explained by the fact that transmission operators are mainly and heavily investing in what can be defined as strengthening rather than smartening the transmission grid, as one can claim that the transmission system is already partly a smart system capable of managing and balancing the resources (currently) connected to it. These investments do not appear in the catalogue, which only focuses on Smart Grid projects.

Furthermore, considering that the demonstration projects at the transmission level are particularly capital intensive, TSOs need to carefully plan R&D projects and move to the demonstration phase with vey well tested solutions. In this perspective, TSOs are increasingly teaming up with research centres, universities and industrial partners. Also, another step in the right direction is the set-up of joint projects by different TSOs (e.g. projects *Twenties*, *Optimate*). The coordination of R&D efforts reduces R&D and demonstration costs and facilitates a common European network operation.

3 BUILDING THE SMART GRID SYSTEM

Successful Smart Grid deployment requires a systemic perspective, as most of Smart Grid benefits are systemic in nature. As aptly stated in [32] "*In a major infrastructural shift, technologies do not replace technologies, rather systems replace systems*". Individual technologies should not be considered "*just an add-on feature to be fit in established existing electricity systems, otherwise their disruptive impact cannot be captured and their business case is negatively biased*" [59]. In the current playing field, each individual new technology faces significant barriers for its widespread market adoption against established business practices, consumers' habits and regulation. Market forces alone can take many years to fit new Smart Grid applications into the existing electricity system.

The majority of benefits arising from Smart Grids are revealed in the long-term and can only be captured when the whole system is in place. However, the Smart Grid needs to be built brick by brick. The challenge is to ensure that at every step of the way intermediate benefits or the clear prospects of final benefits can support the business case for investments.

Key elements to build the Smart Grid are:

- System integration to enhance the business case of individual Smart Grid technologies and to fairly share costs and benefits among players.
- Full engagement of consumers through clear tangible benefits, understanding and trust.

In this perspective, using data from collected projects, the main questions we want to address in this chapter are:

- How can system integration create business value?
- What is in it for consumers?

3.1 System integration – Smart Grid as a market platform

ICT integration is transforming the power system from a merely physical platform for one-way transactions of electricity supply for passive consumers into a market platform for the transactions of electricity supply and services among several heterogeneous and distributed grid users (see e.g. [58]). As stated in [35], "*a Smart Grid is a rich transactional environment, a market platform, a network connecting producers and consumers who contract and negotiate their mutual exchange of value (product, service) for value (payment). A Smart Grid is a transactive grid*".

This concept is widely represented in the catalogue. Several projects focus on the set-up of market platforms for the transactions of a wide range of electricity services: ancillary services, Demand Response, aggregation of DERs and V2G[6] services.

In the *Web2energy project*, a large number of small power producers (PV, CHP, wind etc.), storage and controllable loads (industry) are connected through Remote Terminal Units with a Control Center, which coordinates the exchange of power and energy services among the producers and consumers (Virtual power plant)[7]. The platform components include 11 MW of intermittent power (wind, PV) and 300 MW of controllable power (controllable loads, CHP, storage, gas turbine etc.). Through the installation of smart meters, domestic consumers are also connected with the Control Center and have access to variable tariffs mainly to reduce their consumption during peak hours. Their controllable load is mainly thermal storage heating.

In the *Lastbeg project*, a platform is set up for the coordination of 200MW RES (wind-based), a pumped storage power plant (PSPP) facility and a Demand Response aggregated output of 5,000 customers endowed with smart meters. The interaction among the platform participants enables predictive power balancing and a more efficient and reliable power supply.

[6] Vehicle-to-grid (V2G) describes a system in which plug-in electric vehicles, such as electric cars (BEVs) and plug-in hybrids (PHEVs), communicate with the power grid to sell demand response services by either delivering electricity into the grid or by throttling their charging rate.

[7] A virtual power plant is a cluster of distributed generation installations (such as CHP, wind turbines, small hydro etc.) which are collectively run by a central control entity.

These examples suggest how the set-up of market platforms for the transaction of electricity services can create systemic benefits from the interactions of different grid users.

The set-up of such platforms requires the integration into a coherent system of:

1. a physical layer (i.e. optimal and secure infrastructure for power/data flows among producers and consumers);
2. a market layer (i.e. efficient mechanisms for coordinated transactions among system operators, prosumers, aggregators etc.).

Most of the scanned projects, in one way or another, are contributing to either the physical or market layer or both.

From an engineering perspective, scanned projects focus on digital communication and control capabilities to enable a two way power and information flows across the whole grid. The goal is to accommodate a whole new set of distributed technological applications, optimize overall grid management, increase reliability and self-healing capabilities.

From a functional perspective, projects focus on coordination mechanisms to set transactions among a network of distributed grid users.

Physical layer System operators are the main investors in the set-up of the physical layer of the Smart Grid. At the transmission level, since building or upgrading conventional overhead lines to increase the transmission capacity is becoming progressively more difficult, alternative technologies are either being deployed or are under development. High Voltage Direct Current (HVDC) systems, already mature for long distance and undersea transmission (also suitable for connecting offshore wind farms) may contribute to regulate the current flow through the network. Flexible AC Transmission Systems (FACTS), gradually more deployed, are power electronics-based devices aiming to increase the control over voltages and power flows in the grid (see e.g. projects *TWENTIES, ICOEUR, 220 kV SSSC device for power flow control*).

Advanced network sensing and control capabilities (e.g. wide area monitoring systems) are employed to improve the observability of the transmission grid, increase safety margins and facilitates the safe integration of renewables (e.g. projects *Cell Controller, PEGASE*). A lot of work is also devoted to improve tools to analyze expansion options and to assess system vulnerability (e.g. projects *ALMACENA, REALISEGRID*). At the distribution level, as partly shown in Chapter 2, investments presently concentrate on smart meters, network automation, and physical integration of DERs (including EV charging infrastructure).

A key component of the physical layer is an ICT infrastructure to share information, price and control signals among distributed users and producers (see e.g. projects *E-telligence, Web2Energy, Cell Controller, Virtual Power Plant*). The set-up of an ICT infrastructure is a precondition to create a distributed collaborative market, and allow the integration of new technological applications (e.g. EVs, DER) and the participation of new energy players (aggregators, prosumers, RES producers etc.). Energy management devices (see Box 7) for consumers (e.g. Energy boxes - *ADDRESS* project, Energiebutler - *Model City Manheim* project) or DER management systems (*Fenix* Box – Fenix project, DEMS – *Virtual Power Plant* project) and smart meters represent grid users' gateways to the ICT infrastructure.

Market layer With the physical layer in place, consumers, producers and prosumers are interconnected with two way power and information flows. Transactions of a wide range of electricity services among them then become possible.

Electric vehicles are used as storage devices to provide ancillary services in presence of a high level of renewables (*Mini E Berlin project*). The outputs of distributed generators are monitored and coordinated to control voltage levels in specific portions of the grid (*ISOLVES, DG Demonet* projects) or aggregated to provide the required amount of reactive power (*Cell Controller* project).

The concept of aggregation is central in this context (see Box 8 for more details). For example, on behalf of consumers, aggregators can buy and sell load flexibilities on the electricity markets (see e.g. *ADDRESS* project) or provide V2G services to optimize EV use (see e.g. *Charging infrastructure* project). Aggregated demand can be controlled to reduce peaks, to help DSOs to dispatch the system or to reduce risk exposure of retailers (*ADDRESS* project).

Through aggregation, Distributed Generators can provide ancillary services and contribute to dispatching tasks of DSOs. For instance, the goal of the *E-telligence* project is to use the reactive power of CHP to actively control the voltage gradients on the medium voltage lines. The *EDISON* project is testing an EV charging system that optimizes EV charging based on EV and grid conditions. The *From wind to heat pumps* project links aggregation of DER on the supply and on the demand side by investigating the use of heat pumps as heat storage devices of wind power.

Finally, as advanced ICT capabilities make it possible to measure electricity attributes (power quality, generation source, real-time price etc.) and consumers' profiles, energy players are able to bundle value-added services to the electricity commodity and offer tailored products to consumers according to specific preferences and to real-time grid conditions. For example, the *Smart Watts* project aims at implementing solutions to inform customers about where and how the electricity was produced, how it was transported and how much the power currently costs. The *Smart Charging* project is setting up a charging infrastructure for electric vehicles that explicitly introduces the concept of mobility service for EVs. The charging costs of EVs can be measured in terms of Kilometres rather than kWhs. The association of business value to electricity services rather than kWhs makes it possible to include efficiency and sustainability as part of the electricity service (see e.g. [29]).

BOX 7. Energy Management Devices

An energy management device is the 'consumer's interface with the external world. It can be the hub for smart home energy services and can be used to automatically reshape the energy profile of the house by reacting to aggregators' signals. It connects consumers with aggregators and automatically controls electric appliances (loads) in response to price signals, requests from the aggregator and consumers' energy preferences. (e.g. the "Energy Butler" in the *Model city Mannheim* project). It facilitates customers' individual energy management as well as the implementation of dynamic pricing and active demand mechanisms. For example, customers will have the option of switching electric power consumption to off-peak times or switching appliances off when the electricity does not come from a renewable source. The *MeRegio* project provides another example where household appliances are interlinked via communication devices and connected to an energy management system. The electric vehicle battery is automatically charged whenever the mini-CHP installed in households generates more electric power than the grid requires. Vice versa, electricity from the battery can be fed into the grid whenever the need arises.

3.1.1 Business models for a transactive grid

With the physical and market layers in place, systemic benefits arise from the collective participation and interaction of the different grid users. In a Demand Response application, for example, aggregators mediate interactions among different grid users, like collecting demand flexibilities from consumers and selling them to retailers and DSOs. The more members of one party join the platform (e.g. consumers), the more members of the other parties have an incentive to join (e.g. retailers, DSOs, Smart Appliance manufacturers).

In related literature, these market structures are called multi-sided platforms (MSP). According to [26], "*A Multi-Sided platform provides goods or services to two or more distinct groups of customers who need each other in some way and who rely on the platform to intermediate transactions between them*". Business models based on MSPs have gained prominent economic importance with the advent of Internet because they represent an efficient way of creating business value out of the interactions among different consumer groups ([58]).

The costs of establishing market platforms for transaction of electricity services (by setting up its physical and market layers) require facing upfront costs and investment risks before the platform can pay back. However, once in place, the platform can provide systemic benefits to its participants and provide a business case for investments to players that may not enter the market individually (aggregators, prosumers, EV producers etc.). In the context of Smart Grids, the costs of building the physical layer of the platform are typically incurred by DSOs, whereas a key role in the set-up of the market layer of the platform is played by aggregators.

Under current regulation, DSOs might not have the business case to sustain the investments to build the physical layer, as potential indirect systemic benefits (e.g. peak load shaving and deferred investments due to Demand Response) cannot be factored in to receive regulatory support. Also, as several players share the final benefits of the complete market platform, it is necessary to fairly share costs and benefits and avoid free-rider effects.

Presently the electricity system is mainly based on the exchange of electricity commodity and current regulation recognizes rates of return based on the quantity of electricity delivered. Regulation should encourage DSOs to contribute to the set-up of market platforms for the transactions of electricity services by stimulating innovation and specifically rewarding the provision of services.

3.1.2 Case studies

In this section we present two case studies from our catalogue to illustrate the process of setting up platforms for the transaction of electricity services and to discuss concretely the integration of the physical and market layers. Each case study results from linking together different projects from the catalogue. We will use these case studies to discuss three key points highlighted in this chapter: the set-up of a market platform for Demand Response (case study 1) and for DER aggregation (case study 2).

Case study 1 - From smart metering to Demand Response

In case study 1, we analyze through a set of projects (see table II), the path envisioned by Enel (leading Italian DSO) to move from the roll-out of smart meters to the set-up of a Demand Response market platform (see Box 9).

1. With the *Telegestore* project (**2001-2006**), Enel has performed the roll-out of 32 million smart meters in Italy. With the *StAMI* project (**2010-2011**) Enel has developed a dedicated web interface to collect, on demand and real-time, accurate data stored in smart meters for grid optimisation.

2. The smart meter deployment (total budget 2.1 billion) has been financed through tariffs and resulted in reduced operational expenditures of 500 million a year. The business case for investments focused on concrete benefits on the utility side, which should then trickle down to consumers through reduced tariffs. The new applications a smart meter would enable (e.g. Demand Response) and the consequent benefits for consumers have not been factored in to justify the investment.

Table II Selected Projects Case Study 1

Project Name	Leading Organisation	Budget (€ million)	Stage	Location	Dates	Description
Telegestore	Enel	2100	Deployment	IT	2001-2006	Roll-out of 32 million smart meters. Focus on the physical layer
StAMI	Enel	2,1	Deployment	IT	2010-2011	Use of smart metering data for grid optimisation. Focus on the physical layer
Energy@Home	Enel	n/a	R&D	IT	2009-2011	Interface between smart meter and home energy management device for the provision of value added services. Focus on the link between the physical and market layers
ADDRESS	Enel	4.27	R&D	IT	2008-2012	Market structure to aggregate and integrate Demand Response. Focus on the market layer

3. With smart meters in place, in **2008** Enel launched a 1,000 households trial of an in-home display (Smart Info) connected to the smart meter, to show consumption and prices. In-home displays encouraged 57% of the involved consumers to change their behaviour. At this stage, the physical layer is completed, but the inclusion of consumers is rather limited. Promising initial benefits for consumers refer to the growing number of consumers switching energy retailer every year and the possibility for consumers to opt for dynamic tariffs (in 2008, 6 million customers were in the free market; 2 million consumers switch energy retailer every year)

4. With the *Energy@Home* project (**2009-2011**), Enel aims at testing the link between the physical and the market layer. The goal of the *Energy@Home* project is to demonstrate the integration of the Smart Meter/Smart Info with the Energy Management device (e.g. Energy Box, Energy Butler etc.) which performs automatic energy management in the household and represents the consumer's gateway toward the electricity market.

5. The *ADDRESS* project (**2008-2012**) goes a step further and focuses on the establishment of a market layer for Demand Response. It assumes the presence of a smart meter (for billing purposes) and of an Energy Management Device (Energy Box) to act as a consumer interface for the aggregator. The Demand Response platform analyzed in the *ADDRESS* project is a MSP (led by an aggregator) where platform participants can interact with each other to buy and sell load flexibility. The profitability of the platform is linked to the number of participating consumers. One of the project's focus is in fact the engagement of consumers.

6. When the platform (composed of a physical and of a market layer) is in place, new benefits can be shared among participants. The DSO can benefit from demand-side management (even if these benefits could not be considered in the smart metering business case). It can possibly shave peaks, postpone network reinforcements, and have more options for ancillary services. Aggregators can make profits by offering electricity services. By participating in the electricity market, consumers can sell load flexibilities, optimize consumption and have a better business case for purchasing DERs (e.g. EVs, heat pumps, smart appliances).

BOX 8. AGGREGATION

An aggregator can be defined as an entity, which groups individual load or generation profiles of consumers, producer and/or those that do both (prosumers) and introduces them to the electric system a single, large(r) power unit. The single, large power unit does not really exist; rather its existence is virtual, enabled by a software used to manage the various flows.

Aggregators act as mediators between small producers and/or consumers and the markets (refer e.g. to *ADDRESS* project). The primary role of an aggregator is to provide energy-related support services to key participants of the power system (consumers, producers, system operators, electricity traders, etc) by managing a diversified portfolio of (dispersed) power flows, thereby fostering the implementation of concepts of the smart electricity system.

The goal of the *ADDRESS* project, for example, is to enable active participation of small and commercial consumers in market-related activities, i.e. provision of services to the different players of the power system. This is achieved by aggregating consumers' reduced load into larger amounts for participation in market sales (e.g. to sell to network companies, balancing responsible parties, owners of non-controllable generation, etc.). The aggregator uses consumers' 'demand modifications', i.e. the deviation from the anticipated load size rather than a specific level of demand to form the active demand it sells.

BOX 9. CASE STUDY 1 - LESSONS LEARNED

Systemic benefits - The business case of a single technology plugged in the existing system is conservative; it does not include the future applications and functionalities that the new technology enables. Smart Metering might represent a positive exception, but it is true that the business case for Smart Grid investments can be difficult and unclear because potential long-term benefits are systemic, i.e. can be obtained only if a system is built around the single new component.

Fair sharing between short term investment and long term benefits

Network owners/operators are supposed to sustain the main investments for a demand response platform (establishment of the physical layer through an Advanced Metering Infrastructure to make billing data available to all participants), whereas all players can get benefits out of it. Smart metering projects are at the deployment stage as Enel managed to recover investments independently from the setup of a demand response platform. Instead, the business case to move the other projects (still at the demonstration or R&D stage) to the deployment phase depends on the systemic benefits deriving from the setup of the Demand Response platform.

To unlock further investments there is a need to balance short-term investment costs and long-term benefits. Unless a fair cost sharing model is developed, the willingness of grid operators to undertake any substantial investment might be limited.

Multidisciplinary consortia Diverse companies are brought together in multi-disciplinary consortia to undertake Smart Grid projects (R&D and demonstrations mainly). In the *Energy@Home* project, Enel has teamed up with an appliance manufacturer and a Telecom company. In the *ADDRESS* project, Enel has teamed up with several other DSOs, energy retailers, manufacturers and research centres.

Consumers - Consumers can get most of tangible benefits when the whole system is in place, i.e. when both the physical and market layers are established.

The profitability of Demand Response platforms depends on the number of participating consumers. A lack of transparency on privacy issues or excessive use complexity might severely hinder the participation of consumers and consequently the profitability of the Demand Response platform.

Topology constraints The topological relations between the physical and service layer need to be taken into account to ensure its proper functioning. Clear coordination mechanisms and protocols among the owner of the physical and of the service platforms (typically DSOs and aggregators) need to be in place to map geographical areas to network users and to ensure the compatibility of transacted services with physical constraints. Any necessary information about geographical characteristics of platforms should also be readily available to all relevant platform participants. (*ADDRESS* project).

Case study 2 - Setting up a platform for aggregation of Distributed Energy Resources

In case study 2, we analyze through another set of projects (see table III), the different steps needed to set-up a market platform for the aggregation of DERs. On the basis of project data, we will then derive some lessons learned on the concrete steps and the key challenges to achieve this objective (see Box 10).

Table III Selected Projects Case Study 2

Project Name	Leading Organisation	Budget (€ million)	Stage	Dates	Location	Description
Cell Controller	Energinet	13.4	Demo	2004-2011	DK	Control architecture for the central coordination of DERs
Virtual Power Plant	RWE	0.8	Demo	2008-2010	DE	Demonstration of the technical and economical feasibility of the VPP concept (aggregation of CHP, Biomass or Windturbines).
EcoGrid EU	Energinet	8.3	Demo	2011-2014	DK	Set-up of a complete platform for the transactions of electricity services through DERs

1. Setting up the physical layer - The set-up of the physical layer for a market platform for DER starts with the deployment of advanced grid monitoring and control capabilities. In this area, the primary goal is to grant safe access to DERs especially on the supply side (distributed generators). The benefits for utilities range from operational improvements to reduced number of outages and voltage oscillations.

   An essential component of the physical layer is then the ICT infrastructure to aggregate DERs. By interlinking DERs via ICT, the market layer can be set up and new benefits achieved. Once the physical layer is completed, the market layer can be established through market mechanisms for the aggregation of DERs.

2. Setting up the market layer - First of all, DERs can be coordinated by a DSO for system management services (voltage control, balancing). The aggregation of DERs for system management purposes is called technical virtual power plant (*FENIX* project). Technical virtual power plant aggregates resources from the same geographical area.

   Secondly DERs can be coordinated by an aggregator and reach a size that is sufficient to enter energy power markets and have positive economic margins. Commercial virtual power plants aggregate DERs that are not necessarily from the same geographical area.

Technical Virtual power plant In the *Cell Controller* Project an ICT infrastructure and an innovative control scheme demonstrates the coordination of a high number of distributed energy resources, particularly CHPs and wind turbines. Each unit is endowed with an industry central processing unit (CPU), a remote terminal unit (RTU) or a smart meter. Important applications are achieved through coordination of individual units: islanding operation, black-starting, voltage control, reactive power control. DSOs are in charge of technical virtual power plants and assume a dispatching role similar to the role of TSOs at the transmission level. The rationale for investments include the following benefits: solving voltage band violations, reduced grid expansion costs, reduced outage times through self-healing capabilities, asset optimisation and improved efficiency, improved planning. Typically, the benefits are mainly on the utility side.

Commercial Virtual power plant In the *Virtual Power Plant* project led by RWE (DE), distributed generators (CHP, biomass and wind) are interlinked via ICT to form a VPP. All the DGs are endowed with a DER controller connected with a distributed energy management system (DEMS). The DEMS collects information from DERs and enables a demand-driven production planning of individual DGs. RWE has currently about 10MW integrated into its first Virtual Power Plant (VPP). Through VPP, small producers can offset the communication and the transaction costs for their participation in the market (according to the EU-DEEP project, participation to VPPs is economically efficient for generation units with a minimum capacity of 500 kW).Using DEMS, DERs are able to predict more precisely energy availability and demand and reduce stand-by-costs and penalties for incorrect forecasts.

3. Integration of DER on the demand side – By building on the physical architecture of the Cell Controller project, the *ECO-Grid EU* project (Bornholm, Denmark) goes a step further and includes market mechanisms for aggregation not only on the supply but also on the demand side. The project is testing a complete integrated market platform for the exchange of electricity services through aggregation of DERs, with no restriction on power size. The project develops a real-time distributed market (5 minutes update of price signals) which includes distributed generators, heat pumps and EVs, with a total penetration of more than 50% of the electricity consumption. 2,000 residential consumers are able to benefit from the participation in Demand Response market. The diffusion of demand side management strengthens the business case for the purchase of EVs and heat pumps. On the same distribution network, multiple aggregated portfolios of DERs participate in the market. By setting up a complete market platform, the ECO-Grid EU project aims at complementing several other projects in Bornholm (roll-out of PVs, heat pumps, EV charging infrastructures, smart appliances) and enhancing the benefits of each of these projects. Systemic benefits include: small consumers able to access balancing market, improvement of production forecasts, minimisation of balancing costs, and targeted roll-out of Smart Grid solutions.

BOX 10. CASE STUDY 2 - LESSONS LEARNED

- Steps for the set-up of a market platform for the aggregation of DERs:

  1. Physical layer:

     a) Advanced grid monitoring and control capabilities

     b) ICT infrastructure to interlink DERs

  2. Market Layer

     a) Aggregation of DERs on the supply side (distributed generators): technical/ commercial VPP

     b) Aggregation of DERs on the demand side also (e.g. heat pumps and EVs)

- A new real-time market for electricity services through aggregation of DERs is based on a open, reliable and secure ICT platform to transmit information and price signals to market participants and operational units.

- Once the physical layer is completed and the technical integration of DERs in the grid is in place, the market layer can be established through market mechanisms for the aggregation of DERs. Projects look into the range of new services that can be provided through the physical infrastructure. New business models are needed to maximize the business value of the market platform for several players.

- In some areas, integration of DER on the supply side (especially distributed generators) has already reached commercial maturity (according to the *EU-DEEP* project, participation to VPPs is economically efficient for generation units with a minimum capacity of 500 kW). The integration of DER on the demand side (e.g. heat pumps, EVs) is the natural complement, but more demonstrations are needed.

- An emerging trend is that DSOs will increasingly perform dispatching of distributed resources, will rely on voltage control through distributed generators and will coordinate more tightly with TSOs. IT infrastructure of the distribution operators will need to be tightly connected with that of the transmission operator.

3.2 What is in it for consumers?

For Smart Grids to be economically and socially sustainable, consumers need to be engaged through understanding, trust and clear tangible benefits. Customers will need to recognize the value that these technologies can provide and be willing to make behavioural changes and pay for the products and services on offer [62].

Benefits for Consumers

A scan of collected projects highlights that, with the Smart Grid in place, potential benefits for consumers are numerous: reduction of outages, more transparent and frequent billing information, participation in the electricity market via aggregators, energy savings (see more details in Box 11).

On the consumption side, consumers could reduce their energy use or shift it over time in response to electricity prices. They could choose among a wider range of providers (energy retailers, aggregators etc.) and power options (e.g. green electricity and power quality premiums). On the production side, the Smart Grid can increase consumers' opportunities in the electricity market by supporting the connection and use of distributed generation (e.g. PV) and energy storage (e.g. EV). New players (e.g. aggregators) and new devices (e.g. home energy controllers) can provide consumers with opportunities and means to take advantage of these options. However, as stressed before, most of these benefits for consumers are systemic in nature; to be captured, the whole system (consisting of physical and market layers) needs to be in place.

Also, it is worth remarking that not all consumers will benefit to the same extent from Smart Grid applications. For example, not all consumers will be able to shift consumption according to price signals and benefit from Demand Response. In this context, transparency over the different options and benefits available to different consumers is necessary.

BOX 11. Benefits for consumers – Some examples from collected projects

- The deployment of 32 million smart meters in Italy provides a first example of the potential outcomes of a national roll-out. The large market test carried out at the beginning of 2008 shows that the deployment of smart meters and home displays encouraged 57% of the involved customers to change their behaviours (29.3% delayed the use of domestic appliances to the evening; 11.9% avoided the simultaneous use of different appliances; 7.5% switched off appliances instead of leaving them in standby; 6.6% used less the white-goods) (*Telegestore*);

- In the *Storstad Smart Metering* project in Sweden, the deployment of about 370,000 smart meters contributed to a significant change in customer interest in their electricity consumption. Customer contacts regarding meter readings or estimated reads has decreased significantly (approx 60%) and was replaced by contacts more related to energy consumption or energy usage;

- The introduction of hourly energy price can encourage consumers to react by modifying their loads in order to reduce their bills (deferring or decreasing their consumption). The forecasts developed by the *GAD* project show that a usual consumer could save 15% of his total energy consumption;

- The introduction of time-based rates is expected to reduce energy consumption by 5-10% and shift 1% of the energy demand to low peak load times (*Telegestore* project). Other projects under preparation expect higher benefits for consumers;

- The development of enabling structures and technologies, such as smart meters, can foster the emergence of new partnerships where the customer may at times turn into a supplier. The business models tested in the framework of the *EU Deep* project showed that it is possible, under specific market conditions, to run aggregation businesses that can spare up to 3% of today's annual electricity bill (*EU Deep* project);

- With the roll-out of smart meters, the time to correct the billing and settlement was shortened from 13 months to 2 months. Lead time for exporting meter readings to suppliers was shortened from 30 days to 5 days (*Project AMR*).

Consumers and electricity market platforms

- The emergence of two classes of small consumers—active and non-active— and the increasing importance of aggregators, may lead to unexpected cross-subsidies; as aggregators potentially hurt the business of retailers, retailers might try to recoup losses through higher rates for non-active consumers (*ADDRESS* project).

- Profitability of market platforms depends on consumer engagement. The more consumers join, the higher the business value of the platform. It is imperative to ensure tangible benefits, privacy and easy access for consumers; and to grant open access and fair competition among energy players.

- Project results confirm that energy management devices and aggregators can provide consumers with more effective and compelling incentives to take advantage of efficiency, conservation and sustainability opportunities offered by new Smart Grid technologies.

Consumers' Behaviour and Needs

It is necessary to offer clear tangible benefits to engage consumers. However, the whole system needs to be in place to deliver most of the benefits, and to this end, full consumer participation is necessary.

To solve this deadlock, the starting point is to make sure that consumers have trust and understanding in the whole Smart Grid development. It is necessary to involve consumers early on in trials and demonstrations, to target early adopters before moving to full-scale deployment, and to give consumers the freedom to choose their level of involvement. Special attention needs to be devoted to the needs of vulnerable consumers. An effective set of marketing and outreach activities is integral to the success of consumer-centric projects to counter negative consumer perceptions and to build trust and understanding between the consumer, the utility/consortia and smart technologies [36, 63].

Some projects in the catalogue are going in this direction. The participation in Demand Response actions in *Model City Manheim*'s field test, for instance, is on a completely voluntary basis. Participants have the freedom to choose whether or not to react to the information displayed by the energy box installed in their homes, e.g. displaying varying electricity prices. Furthermore, if they choose to respond to dynamic pricing, there is no financial risk for customers as they are guaranteed not to pay more than they would have under the old pricing scheme. This help to mitigate consumer fears and encourages participation.

According to a questionnaire distributed to about 2,000 customers within the *GAD* project, 62% of consumers would modify their behaviour if they were notified when the current energy production came from renewable energies. More than 55% of the consumers would also modify their habits if the energy price varied during different hours of the day. Another survey conducted at the end of the *GAD* project among 300 advanced users revealed that 65% would use the system in the short term if the cost did not exceed €500.

In the *Inovgrid* project the installation of energy boxes led to an increase of efficiency levels in customers' energy consumption by about 20% as a result of increased awareness of power consumption.

Consumer Segmentation

Up to now, energy players have made little distinction among small consumers. With few exceptions, prices, services and communication have been the same.

Through energy management devices and smart meters, with consumer's consent, it is possible to segment consumers and target different consumers in different ways. The *Inovgrid* project, for example, segments consumers according to consumption of electricity in view of offering tailored tariffs and/or conservation advice to increase customers' efficiency. Consumer segmentation is useful to contribute to an open and competitive retail market, as it implies (1) more tailored electricity services to meet consumers' needs with possibly a higher rate of acceptance of new products and services and (2) the possibility to target energy-savvy and wealthy consumers as early adopters of new technologies.
At this stage, in several projects consumers are recruited based on their technical interest and are therefore not representative of the entire population. They can be targeted as early adopters rather than a reliable test group before full-scale deployment.

Segmentation of consumers is also necessary to understand the consumer interactions and age dependent behaviours. In some projects, the use of social media has proven successful in increasing interaction between the utility and consumers. In the pilot project *Märkisches Viertel*, customers can access historical and real-time consumption data on their electricity consumption via meter display, TV, smart phone/tab devices or an online portal. About 14% of customers in the project chose the in-house (TV or smart phone/tab devices) or online visualisation of data. Similarly, the *BeWare* project enables its customers to access information on the energy consumption of their appliances in an engaging user interface as a web application running on smart phone. This allows users to track their consumption habits and how much energy they are saving for individual appliances as well as the entire household.

However, the effectiveness of these tools can significantly depend on the age of consumers. According to [57], over 55 year-old people consider their governments a trusted information source on energy matters, while 18-24 year-old see internet collaborative platforms and social networking as important sources.

This generational gap should also be taken into account to protect vulnerable consumers. For instance, using prices to control demand might be especially hard on less technically savvy people, like the elderly. The impact of higher energy prices is often overlooked in relation to the most vulnerable members of society.

Free Rider Effects

Finally, possible free rider effects should be dealt with, in order to guarantee a sense of fairness in consumers. For example, dynamic pricing and Demand Response can lead to peak load shaving. The consequent reduction of peak electricity costs are spread across all consumers, including those who did not shift their consumptions. Also, the emergence of two classes of small consumers— active and non-active— and the increasing importance of aggregators, may lead to unexpected cross-subsidies; as aggregators potentially hurt the business of retailers, retailers might try to recoup losses through higher rates for non-active consumers (*ADDRESS* project);

Social impact

A scan of collected projects seems to suggest a lack of specific attention to the social implications of Smart Grids. Only one project (*Distribution Automation* project) clearly mentions among its goals the need to "anticipate the shortages of technical workforce due to the 'field workforce ageing".

However, a literature review of available public reports and scientific publications on the future Smart Grids have highlighted other social aspects of Smart Grids that should be taken into consideration for the future Smart Grids to be successful. These are detailed in Box 12.

BOX 12. Social impact of Smart Grid implementation

- Jobs. In USA 280,000 new direct jobs (2009-2012) and more than 140,000 new indirect jobs will persist beyond Smart Grid deployment [34]; job creation will provide an annual benefit of $215 million [41]; in the US electricity sector a major job market for early-career engineers is shaping up: the power industry needs to hire thousands of new engineers by 2030" [54]. At the same time, in EU15 almost 250,000 jobs were lost in the electricity sector since 1995 [25]. Mergers and acquisitions will also play a part in employment decline with large scale operations rendering many employees redundant [25].

- Ageing work force – gap in skills and personnel. "Greying workforce": in the next five to 10 years many utilities will lose their current workforce to retirement [63]; nearly 25 to 35% of utility technical workforce will retire within 5 years [4]; in the USA the average utility worker is 48 year old, five years older than the median age for US workers; the power industry needs to hire thousands of new engineers by 2030 [54]; 'field force ageing, i.e. shortages of qualified technical personnel (refer to e.g. *Distribution Automation* project).

- New skill requirements – training. New job profiles: high level of flexibility, adaptability, customer-focused approach, sales skills, regulatory expertise. Need for investment in the development of relevant undergraduate, postgraduate and vocational training to ensure the building of a sufficient pipeline of next generation, Smart Grid savvy electrical engineers [62]. Adequate training, re-skilling, up-skilling of the workforce is essential.

- New pools of skills and knowledge. China is the largest producer of engineering graduates in the world: 600,000 engineering graduates in 2009. India: 500,000 engineering graduates a year. United States: 70,000 engineering graduates every year. All of Europe: 100,000 engineering graduates [63]. There is the need for Smart Grid investors to look beyond national borders.

- Organizational and management issues. Shift from SMEs (small and medium enterprises) to big corporation due to mergers and acquisitions [9, 25]; changing views on personnel and human resources that start to be considered as highly strategic [25].

- Safety. Reduction of hazard exposure with annual benefit $1 million [41, 63]; fewer field workers due to remote reading through smart meters [4].

- Privacy. Detailed information about electricity use could be used by insurers, market analysts, or even criminals to track the daily routine of consumers [52]; 35% customers would not allow the utility to control thermostats in their homes at any price [53].

- Gender issues. In EU women represent only 15% of the workforce in the energy sector and the share has not been rising; gender issues have been put in focus only recently and up to now little has been done to make jobs in energy sector more appealing to women; initiative in the areas of flexible working time, equal pay for equal work, monitoring schemes and gender focused recruitment could be carried out in order to attract more female workers and managers in the electricity sector [25].

4 SMART GRID CONTRIBUTION TO POLICY GOALS

In the following sections, we will perform an analysis of specific project results in terms of their relevance to the European energy policy goals: sustainability, competitiveness and security of supply.

4.1. Sustainability

4.1.1 Reduction of CO_2 emissions

The reduction of CO2 emissions is one of the drivers of the scanned projects, even though only few of them have tried to quantify the impacts of the deployed solutions over the business as usual scenario (see Box 13).

Demand response Demand Response has an important potential for energy saving and peak load shaving and can therefore produce measurable reductions in customers' total energy use and associated emissions. Demand Response contributes to reduce consumption during peak times, but the shifted usage does not always "rebound" at other times of day, entailing a net reduction of kWh. Many scanned projects have explored the effectiveness of such mechanisms in reducing and shifting energy consumption.

For the success of Demand Response and energy conservation projects, end-user awareness and participation is a crucial point. The deployment of smart meters and in-home displays is a main enabler of Demand Response and energy conservation projects. When smart meters are coupled with the appropriate in-home interfaces, customers can receive time-based easy-to-read price signals that encourage them to reduce their consumption or to postpone it to times when the electricity price is lower. Many demonstration projects have coupled the installation of smart meters with in-home interfaces and dynamic pricing (i.e. *Model city Manheim, Etelligence, ESB Smart Meter Project, MeRegio*).

BOX 13. Energy savings and CO_2 reduction – Some project highlights

Telegestore: According to a large market test carried out at the beginning of 2008 in Italy, the deployment of smart meters coupled with the supply of in-home displays encouraged 57% of the customers involved to change their behaviours. The following changes were observed: 29.3% moved the usage of white goods to the evening hours; 11.9% alternated usage of white goods; 7.5% switched off electronic appliances instead of leaving them in standby modus; 6.6% reduced the usage of white goods. Enel estimates that at national level, the introduction of time-based rates, made possible by the roll-out of smart meters, could reduce energy consumption by 5-10% and shift 1% of the energy demand to low peak load times.

Inovgrid (PT): The deployment in the Portuguese city of Evora of an integrated system including several components (among which an energy box), is expected to deliver a reduction of 378 tons of CO2 (considering an average annual household consumption of 3,5MWh, an emission factor of 360g/kWh and an annual reduction in consumption of 1%). According to the project developers, the nationwide replication of the entire project could account for 8% of the national CO2 reduction target by 2020.

Energy forecast: The introduction of tailored and simple power supply agreements at national level (Denmark), coupled with customer information and awareness, has a potential impact of about 50 MW of reduced peak capacity.

GAD: The developed forecasts show that, following the introduction of hourly energy prices, a usual consumer could save 15% of his/her total energy consumption (12% due to a decrease of the consumption; 3% due to a deferral of the energy consumption from the appliances).

Fenix: Large-scale use of flexible operational aggregation of distributed energy resources by a virtual power plant can result in reduction of system gas consumption and therefore in CO2 emission reductions. According to the economy-wide scenarios developed within the Fenix project, by 2020, CO2 emissions in the electricity sector could be reduced by 7.5 kg CO2/kWflexibleDG/year in a northern European scenario and by 13 kg CO2/kWflexibleDG/year in a southern European scenario, compared to the reference case.

In order to deliver energy savings and to reduce CO_2 emissions from the generation sector, Demand Response will need to be complemented by the deployment of smart appliances and by the emergence of a service-based market platform where energy players (aggregators) can trade load flexibility on consumers' behalf.
The regulatory framework will play an important role in supporting these changes. Regulatory incentives should encourage network operators to move from a 'volume-based' business model to a service-based model focused on quality and efficiency.

System losses - Smart Grid solutions can contribute to the reduction of transmission and distribution losses and therefore to the reduction of the amount of generation (and related emissions) needed to serve a given load (*Smart Green Circuit; Optimal Power network Design and Operation*). The deployment of smart meters can contribute to the reduction of grid losses in several ways. In particular, the reduction can derive from decreased technical losses (faulty meters which were not detected before); decreased administrative losses (consumption that was not measured before) and the fact that the internal consumption of electronic meters is lower that the consumption of electromechanical meters (*Storstad Smart Metering*).

Transportation sector Important CO2 reductions can derive from the Smart Grids' ability to support a deeper penetration of electric vehicles, particularly in the case of renewable electricity use and off-peak charging (i.e. *Charge stand; EV Network integration; Large-scale demonstration of charging of electric vehicles; Fieldtrail Mobile Smart Grid*)

4.1.2 Integration of DER

Another major driver of the scanned projects is the integration of large amounts of DERs, including renewables and storage, into the grid (see Box 14). The large-scale deployment of these technologies entails a high potential for emissions reductions and, at the same time, it can have a positive impact on the diversification of the energy mix and therefore on energy security.

Box 14. Integration of DER – Some project highlights

Inovgrid: The implementation of a fully active distribution network is an important step towards the integration of greater amounts of RES and DER into the electrical grids. The Inovgrid project is testing a new grid architecture in an urban area with about 32,000 customers in Portugal. The project is expected to: increase the capability to integrate RES into the grid by 10-50% through enhanced planning; increase the integration of RES into the grid by 50-100% through active asset management; increase the integration of EVs into the grid by 50% through active network and charging management. The project developers believe that the nationwide replication of the project could account for 3.5% of the national RES target by 2020.

However, the accommodation of a large number of disparate generation and storage resources into the grid poses the challenge of anticipating intermittency and unavailability, while guaranteeing system reliability and economic efficiency. To meet these challenges, Smart Grid projects are researching and testing different solutions.

DER aggregation As already discussed, across the collected projects, particular attention has been devoted to the viability of VPP and Demand Response (i.e. *Fenix, Cell controller, Heat Pumps as an active tool in the energy supply system, Regenerative Modellregion Harz, Virtual Power Plant Germany, Integral – PowerMatchingCity, Smart Power System*).

Large-scale use of flexible operational aggregation of distributed energy resources by a virtual power plant allows more penetration of renewables/DER in distribution. This is possible thanks to direct control of DER from the network control programs, which avoids overloads/voltage violations, and releases the hard regulatory limits to DER (Fenix). Preliminary results show that both VPPs and active demand can help absorb fluctuating renewables at lower costs, reduce CO_2 emissions and improve market functioning. Aggregation business models can play a key role for the success of DER but there is a strong need for regulatory and contractual frameworks, as results from the *EU-Deep* and *Fenix* projects.

Demand response Through smart metering, consumers will also be able to select how their electricity is generated. Green conscious consumers might be willing to opt for green electricity at home and accept the extra costs (e.g. *Dynamic tariffs, Energy @ home, Smart Watts*).

Electric vehicles as storage capacity for renewable energy resources Finally, projects investigate and test the viability of using electric vehicle batteries as storage capacity to help balancing the grid during periods of high energy feed-ins by fluctuating renewable energy sources (e.g.: *Mini E Berlin, Charge stands, EV network integration, Harz. EEMobility, Eflex*). This solution has mainly been tested with excess wind energy but clearly it can be applied to other flexible energy sources.

4.2 Competitiveness - Open and efficient market

From the scanned projects, we have identified two contributions to a more open and efficient electricity market:

1. Increased market participation (lower market barriers) through

- the aggregation of distributed energy resources
- the establishment of multi-sided open market platforms (MSP)

2. Increased efficiency of interregional markets: coordination mechanisms among TSOs, new interconnectors for large-scale renewables

4.2.1 Increased market participation through aggregation

Smart Grids are considered key enablers for an open and efficient energy market in Europe. The current electrical system has been designed to accommodate a limited number of large, centralized power plants. For this reason distributed generation and/or responsive loads, which are limited in size and boundless in number, are neither fully integrated into power system operation activities nor into the power market. The aggregation of these sources, allowing small producers as well as consumers to access the electricity market, enables market entry to otherwise restricted participants and allows for a more efficient market through the optimisation of operations. In this sense the concept of aggregation has a potentially huge contribution to make to the openness and efficiency of the power market.

Aggregation of Distributed Generation *FENIX* project is one demonstration of the aggregation of different DG units to a single Virtual Power Plant. It aims at maximizing voltage control capacity of VPPs with the use of a distribution management application, which helps determine what measures need to be taken in order to maintain voltage levels. The application can determine the reactive power needed from each DG unit, prompting the VPP to alter the reactive power output of appropriate units. This approach increases the participation of a multitude of small DG that could not otherwise take part in market-related activities.

Aggregation of Storage The main idea behind the aggregation of storage is to accumulate electricity when demand is low relative to power supply and inject stored electricity into the system at peak loads or to compensate fluctuating output of RE generation.

The aggregation of heat pumps is one example of how the integration of DG can be facilitated. The Danish project *From wind power to heat pumps*, for instance, proposes to store electricity, derived from wind power, in the form of heat by aggregating 300 smart heat pumps into one huge energy storage facility. Estimates show that 32,000 heat pumps generate an approximate output of 200 MW, which corresponds to a large amount of flexible load adjustable according to wind speed.

The integration of storage facilities not only assists in counterbalancing stochastic generation profiles often encountered in distributed generation but it also allows house owners to make an active contribution to the electric power system in unprecedented ways. Considering the outcome of the Danish project and given that there are currently about 80,000 heat pumps installed in Denmark, the potential of widespread active participation of consumers through the integration of the concept of storage is huge.

Other examples include the aggregation of water heating storage. The *EUDEEP* project tested this concept in a residential area (10 customers) in Berlin, Germany, allowing heat generated from Micro-CHP installed in the households to be stored whenever there was no instantaneous heat demand. Alternatively, the battery of electric vehicles (EVs) can be used as a storage facility. The *MeRegio* project, among others, applied this concept by automatically charging batteries whenever the mini-CHP installed in model households generated more electric power than the grid required. Aggregated electricity from customers' vehicles batteries could then be fed into the grid whenever needed.

Aggregation of Demand Response. Projects in this category suggest that the aggregation of a large number of reduced loads potentially translates into a rather significant total load cut, which can be used to balance varying output of renewable energy sources (RES).

Aggregation of Demand Response enables active participation of small and commercial consumers in market-related activities, i.e. provision of services to the different players of the power system (e.g. network companies, balancing responsible parties, owners of non-controllable generation, etc.).

A primary focus is on integrating domestic consumers who, as opposed to DG and large industrial consumers, are less motivated by purely economic concerns (minimal gains). Furthermore they are generally unable to make precise predictions on their available load flexibilities; therefore it is difficult for them to 'offer' services in the classical sense. Rather, the idea is for their services to be made available at the market's 'request', i.e. through price and/or volume signal mechanisms, and for the provision of services to be on a voluntary and contractual basis.

Other projects focus on the application of active demand for large consumers. For instance the *EU-DEEP* project explores the aggregation of small-scale (10 kW to 1.5 MW) load management in UK industrial and commercial market segments with a customer portfolio made up of industrial and commercial sites with different flexible loads (e.g. supermarket, shops, hotel, factory, cold store, offices). One notable result that emerged is that the current minimum requirement in the UK of 3 MW or more of steady demand reduction (or more generation) in order to provide Short Term Operating Reserve (STOR) can be reduced and sites as small as 500 kW could partake in the scheme. This increases electricity market participation potential significantly.

Improved market transparency through multisided platforms

As discussed in Chapter 3, in light of the growing trend toward distributed generation and increased electricity market participation, the set-up of open market platforms is a common theme of many collected projects. In general, a platform provides the possibility for buyers and/or sellers of products and services to interact, thereby lowering the costs of providing services (see e.g. [58]) Such a multi-sided platform (MSP) is instrumental for granting access to retailers, energy service companies, aggregators and for the increased market transparency and contributes to the functioning of a liberalized electricity market (see e.g. *ADDRESS* project).

As shown before, the profitability of a MSP based service (e.g. for Demand Response services) depends on the number of participating consumers. To ensure platform value, consumers need to be willing to actively access to the services provided by the platform (e.g. Demand Response, V2G services etc.). In this context, interoperability, user friendly interfaces and data protection are key elements to foster market participation.

Concerns over privacy issues and transparent access to the market (e.g. use of complicated hardware/software, need to do energy calculations) might severely hinder the participation of consumers and therefore the profitability of MSPs and of Smart Grid investments. Also, MSPs should be open to guarantee fair access to all players on board, prevent dominant positions and give consumers a wider choice of service providers. Consumers should have the possibility to easily switch from one service MSP to another without being locked in specific hardware/software choices.

4.2.2 Interregional markets

The lack of harmonized market rules in the different Member States can lead to market segmentation and higher transaction costs, even in regions where interconnection exists. TSOs are aware of the need for greater cooperation on planning and operation of transmission networks and are undertaking multinational projects on this topic. Project goals include (1) the development of common European models to simulate power flows and power and energy exchanges and (2) the definition of a set of common grid planning principles.

For instance, in the *Optimate* project five TSOs from Belgium, France, Germany and Spain are developing an open simulation platform with TSOs and market participants as key players. The idea is to analyze and validate new market designs aiming at the integration of flexible energy sources across several regional power markets.

A consistent number of FP7 projects (e.g. *Realisegrid, Pegase, Icoeur, Susplan*) investigate new planning tools to analyze options for a pan European network integration and expansion.

4.3 Security and quality of supply

Integration of DER Much attention has been given to synergies between DER and storage technologies to increase the reliability of supply. Intelligent, coordinated control of distributed generation, including storage can provide immediate backup when the primary source is lost.

Several projects have investigated intentional island operations[8] as a deliberate emergency measure or as the result of automatic protection or control action (e.g. see projects *Cell Controller; Control and regulation of modern distribution system; Agent based control of power systems; MoreMicrogrids; Smart Region*). Islanding is a situation in which a power system becomes electrically isolated from the remainder of the system and yet continues to be supplied by the Distributed Generation connected to it. Integrated distributed generation sources can therefore support the island operation during contingencies and contribute to maintaining the security of power supply.

Several projects focusing on this topic are located in Denmark, as the high penetration of distributed generation reached in the Country makes it ideally suited for such an investigation. The *Cell Controller* project is particularly interesting as it demonstrates the possibility of leveraging increasingly distributed resources so as to ensure secure supply to the majority of end-users in case of an outage of central generation or transmission. Under emergency conditions, the cell controller can disconnect a portion of a distribution network from the transmission grid, manage it as a stable, islanded network, and, on receiving a signal from the transmission system operator, resynchronize it with the grid.

Many other projects have investigated the potential of electric vehicles to contribute to securing the stability of the grid, otherwise endangered by fluctuating renewables in excess situations (e.g. see projects *Mini EBerlin; NetElan; Harz.EEMobility; Edison; Large-scale demonstration of charging of electric vehicles*).

Safe integration of large-scale RES The integration of large-scale fluctuating energy resources poses several challenges to the operation and management of the power system. Many projects in the catalogue focus on their safe integration in the electricity network. The most explored solutions are the development of balancing, grid integration of off-shore wind parks, the maximisation of the current operation limits of the network (e.g. Twenties project) and the improvement of production predictability (e.g. Safewind project). Wind is by far the most investigated energy resource.

Cyber security and data protection Cyber security is of great importance in order to avoid potential risks arising from external "attacks". Data protection with encrypted and authenticated algorithms should be always considered. (e.g. see projects *NES, Telegestore, Stami, MoreMicrogrids*). A more in-depth analysis of the challenges related to data protection and security can be found in Chapter 5.

Operational improvements The installation of smart metering infrastructures, SCADA[9] systems and supervising equipments open new possibilities to prevent and solve problems in the low voltage distribution network and to obtain further savings in the operational costs. Smart metering offers many advanced functions such as remote control, output control and various forms of quality control (see e.g. projects *Telegestore, Stami, Project AMR, Storstad Smart Metering*). Smart meters allow the collection of outage information, which can be used for statistical purposes and for the investigation of customer claims regarding quality of supply, and allows for the identification of the specific point of delivery affected by the problem (see e.g. *Storstad Smart Metering* project). More accurate settlement enables aggregators to make better forecasts and simplifies production planning for producers and system operators (e.g. *KEL project*).

[8] According to the definition adopted by ENTSOE, an island represents a portion of a power system or of several power systems that is electrically separated from the main interconnected system.

[9] Supervisory Control and Data Acquisition. It generally refers to industrial control systems: computer systems that monitor and control industrial, infrastructure, or facility-based processes.

BOX 15. Security and quality of supply – Some project highlights

Telegestore: Thanks to the Telegestore project, Enel reports that the indicator "minutes of interruption per year" decreased from 128 to 49 over the period 2001 – 2009. In the same period, thanks to the energy balance data from the smart metering system, the success rate of the verification activity has increased from 5% to 50%.

Storstad: The deployment of smart meters has allowed a significant reduction in customer service calls. Over a two year period, the number of calls for both meter-reading and invoice-related issues dropped by 56%.

Inovgrid: The Inovgrid project involves the deployment of advanced control and automation functionalities distributed over different levels of a hierarchical control structure that matches the physical structure of the electrical distribution grid. This system allows the active management of the distribution network by the DSO and entails the following envisaged results: 3-10% reduction of SAIDI (System Average Interruption Duration Index); 1-5% reduction of SAIFI (System Average Interruption Frequency Index).

As field data are transmitted to central control rooms, technical problems can be traced and solved more rapidly, reducing the duration of outages. As a consequence, the prevention of disturbances assures the uninterruptable power supply in feeders, the voltage quality and the voltage interruptions. Remote work and restoration of grid operation is also possible. Data acquisition is used for analysis and reporting, which can be very useful in statistics, maintenance and operation, troubleshooting activities.

Furthermore, continuous supervision of the grid leads to rapid detection of system stress and thus rapid actions in relief the network from conditions of peak loading, congestions and bottleneck. Equipment is not subject to stressful conditions and can work more efficiently and up to its operational life duration.

4.4 Activated Smart Grid services and benefits

In this section we characterise the contributions of the projects in our catalogue according to the definitions of Smart Grid services and benefits elaborated by the EC Smart Grid Task Force (see Annexes II and III). Services and benefits are very much linked to the EU policy goals that are driving the Smart Grid deployment. They can therefore be considered as useful indicators to evaluate the contribution of projects toward the achievement of these energy policy goals.

The Smart Grid services represent the characteristics of the "ideal" Smart Grid (see [18]). Progresses along these characteristics are directly linked to progresses toward the energy policy goals and the expected outcomes the ideal Smart Grid is an enabler for.

The Smart Grid benefits represent the outcomes deriving from the implementation of the ideal Smart Grid (see [18]). A characterisation of projects in terms of associated services and benefits is a useful tool to map the contribution of projects to different areas of the Smart Grid landscape.

In our questionnaire, we asked project coordinators to indicate the benefits and the services associated with their project and to fill in the merit deployment matrix proposed by [20].

Figures 18 and 19 show the cumulative benefits and services across the different projects split into different project typologies (R&D, Demonstration and Deployment). As not all respondents reported about the services and benefits pertinent to their projects, the diagrams refer to a restricted set of around 20 projects for Figure 18 and of around 80 projects for Figure 19. Also, only few project coordinators actually filled in the merit deployment matrix. In the update of this study, further work will be devoted to collect more data from project coordinators, in order to refine this analysis.

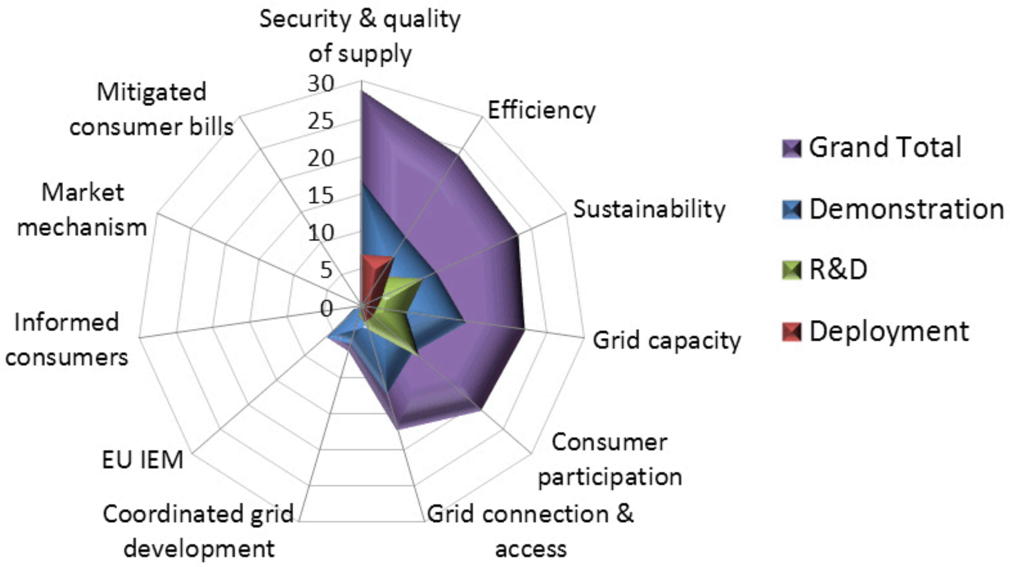


Figure 18. Cumulative activated benefits across projects

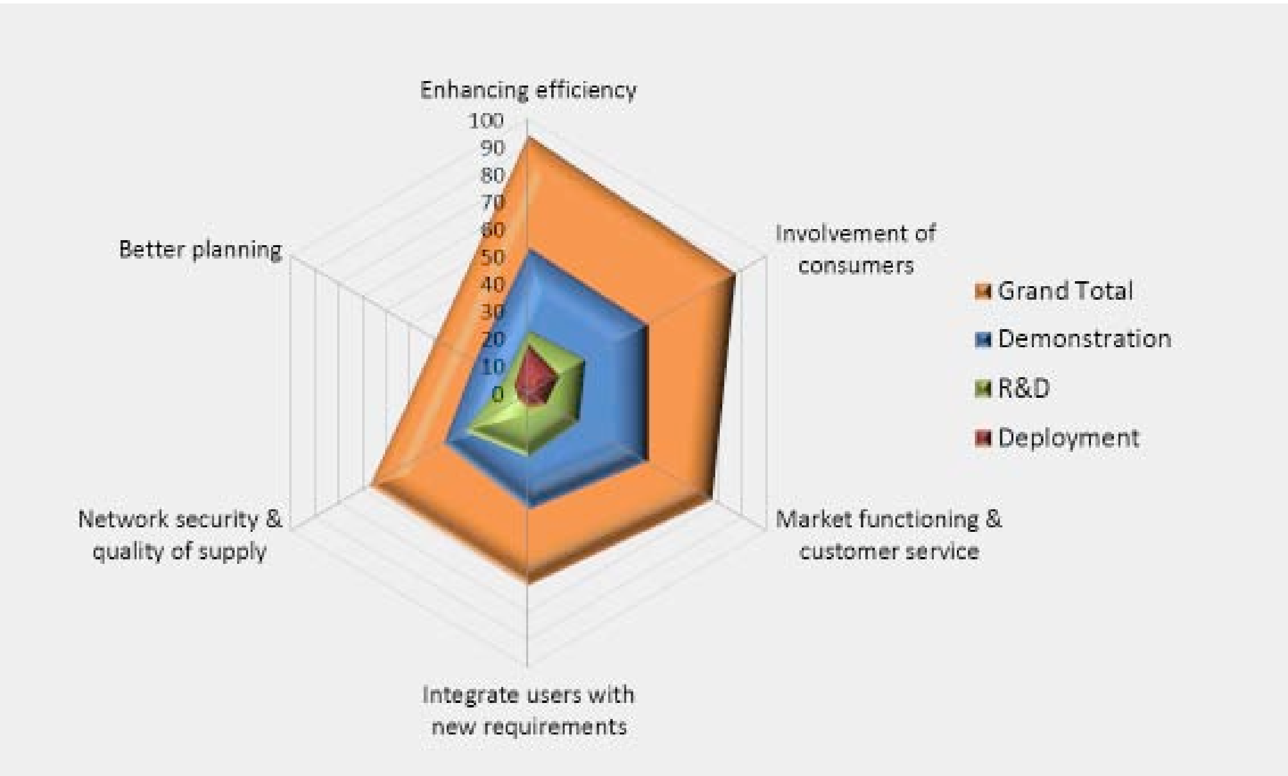


Figure 19. Cumulative activated services across projects

5 ANALYSIS OF DATA PROTECTION AND SECURITY ISSUES

Given the interdependence of existing energy and information infrastructures, the electricity sector also feels the impact of mounting cyber security concerns. Along with big opportunities of Smart Grids comes the bad news that the next generation of Europe's electricity grids will face a greater variety of cyber vulnerabilities than those of today. Therefore a special emphasis is put on critical infrastructure protection, especially infrastructure supporting energy, transport, telecommunications, and water [44].

Either directly or indirectly, consumers will be affected by several threats (natural threats, smart thieves, hackers, terrorism, warfare, accidental threats, intentional attacks, load shedding). Therefore consumers will also need to be informed about these threats, the potential attack vectors[10], and the protections needed to defend against them. To this aim, a combined effort from government, corporate, and consumer advocacy organisations will most likely develop a combined effort [28].

From the data protection and security point of view, five important challenges arise [46]:

1) the large amount of sensitive customer information the grid will transmit;

2) the greater number of control devices in the Smart Grid;

3) the poor physical security of a great proportion of these devices;

4) the use of Internet Protocol (IP) as a communication standard;

5) the greater number of stakeholders the grid will rely on for its smooth operation.

The responses we have received from project coordinators have been generally quite poor in data protection and security (see Figure 20). Therefore, the analysis in this section (see Box 16) is mostly based on the results of the *OpenMeter* project, by far the most significant and detailed project across our catalogue in this domain.

[10] Attack vector refers to any method or mode of attacks chosen by hackers or crackers to identify weak points or vulnerability on the client or server-end of a network for engineering defects in the user system or the server, mostly in order to infect or gain control over system resources.

BOX 16. Data Protection and Security Issues

- A scan of collected projects highlights the convergence towards IP communication and other standards-based solutions. The promises of Smart Grids will only realise if low-priced consumer devices are available.

- Proven standards and industry best practices used for IT systems should be considered and adapted, and security measures not reinvented. Open standards at the European and international level are necessary for updating and upgrading the security mechanisms of these devices as threats and risks evolve.

- Most of collected projects have not provided responses on data protection and security. It seems that the potential to tackle this issue is not fully exploited. New projects focusing on data handling would be useful to assess how data handling principles from other industries (e.g. banking industry) can be applied to Smart Grids.

- Smart Grid projects require the collaboration of several players with different competencies and background. Since security in the ICT infrastructure is a collective effort, it is imperative that roles and responsibilities are clearly defined and that both the energy and ICT communities work together to coordinate security measures to prevent blind spots.

- An open and secure ICT infrastructure is at the core of a successful Smart Grid implementation. Addressing interoperability, data privacy and cyber-security is a priority requirement to make the ICT infrastructure truly open and secure.

- A privacy-by-design approach needs to be adopted to ensure customer security. A wide consensus among stakeholders is emerging in Europe on this [19].

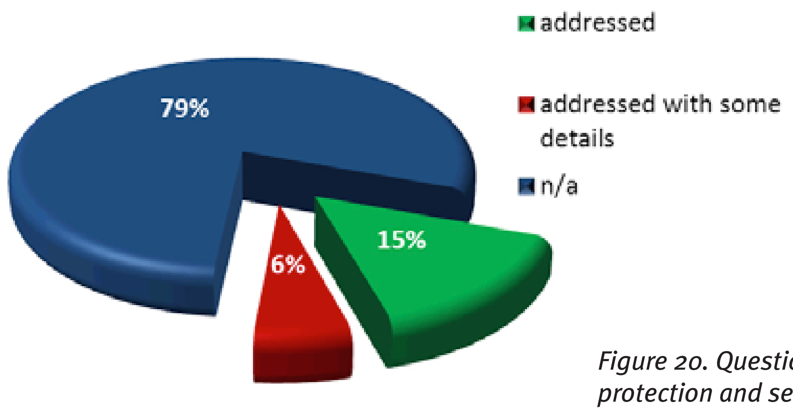


Figure 20. Questionnaire responses on data protection and security

5.1 Customer security

It seems clear that a paradigm shift is needed in energy industry from the current hardware-centric focus on system adequacy and reliability, towards the inclusion of a more directly consumer-oriented view of security. Security services are needed for each data, network and component of which the entire grid is composed. Customer privacy issues need to be addressed to protect confidential or otherwise sensitive data, but measures are also needed to ensure the supply of energy to customers and to make the grid even more reliable than currently in spite of cyber threats.

In the *Open Meter* project [44], minimum requirements are set to

- authenticate and authorise users, groups and devices on all interfaces (such as GUI and other IT systems)
- guarantee the integrity and confidentiality of data exchanged and stored
- recommend the use of certificates to enable application level security
- strongly encrypt the data in transit.

All of these requirements are satisfied by using already existing proven technologies and it is likely that further developments in ICT make the implementation even more feasible.

The legislative framework needs to support these technical developments. At the European level, there is a general agreement among stakeholders that Smart Grid solutions have to comply fully with the binding rules on privacy and data protection. As recommended by [19], a privacy-by-design[11] approach needs to be adopted to ensure customer security. This approach has been integrated in the Mandate M490[12] for European Smart Grid's standards, issued early in 2011. Furthermore, the European Commission is also ready to support the Member States in ensuring, when deciding of roles and responsibilities regarding ownership, possession and access to data [24].

5.2 A greater number of intelligent devices

It is inevitable that Smart Grids will be reliant on an exponentially greater number of digital devices than today's grids ranging from smart meters at home to centralised and well-protected Supervisory Control and Data Acquisition (SCADA) systems. The well-known concept of "defence in depth"[13] has to be applied to the global system: multiple, even redundant security techniques at each layer of the infrastructure to mitigate the risk of one component being compromised.

[11] Privacy by design aims at building privacy and data protection up front, into the design specifications and architecture of information and communication systems and technologies, in order to facilitate compliance with privacy and data protection principles http://www.edps.europa.eu/EDPSWEB/edps/EDPS

[12] http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/2011_03_01_mandate_m490_en.pdf

[13] Defense in depth is an information assurance (IA) strategy in which multiple layers of defense are placed throughout an information technology (IT) system. It addresses security vulnerabilities in personnel, technology and operations for the duration of the system's life cycle.

The much greater number of different types of intelligent devices in the power production/consumption chain can be seen as analogous to current mobile device networks which also have security concerns and are built on international standards and commercial technologies. Therefore the industry is likely to already have learned important lessons in managing such gigantic communication networks with billions of nodes.

Even if there were no plans to connect Smart Grids to the Internet, the possibility of a deeper convergence should not be left unanticipated (e.g. see *Internet of Energy* project).

5.3 The problem of physical security

Physical access to sensitive components should be secured, which is already the case with e.g. SCADA systems. Most attention will be needed at the level of the distribution network where the passive, radial architecture of the past will give way to a new meshed structural design that requires the introduction of many intelligent control devices where once there were few.

Systemic exposure to faults and malicious activity originating from smart meters at customers' homes will need to be minimized. The physical security at homes will be altogether impossible to guarantee, making intelligent devices at homes much more vulnerable and, given the two-way communication capabilities with the Smart Grid, also a theoretical point of access for malicious intentions.

The overarching principle of not compromising one component to compromise the whole system must apply also in the planning for risk mitigation for shortcomings in physical security. In the "Advanced Metering Infrastructure" specifications this has been addressed by specifying different profiles for different interfaces (*Open Meter* project [45]).

5.4 The use of IP and commercial off-the-shelf hardware and software

Because interoperability and affordability will be key challenges in the transition to Smart Grids, it will be difficult, if not impossible, to resist the broad use of IP and COTS[14] hardware and software in the networks of the future. A wealth of proven security standards and implementations exist on all layers of the TCP/IP protocol stack and choosing not to utilise this common accumulated knowledge seems hardly possible. Security risks do exist in any network technology and architecture. IP based networks, however, have by far the best proven track record as large-scale digital communication networks.

OpenMeter project recommends using proven standards and industry best practices used for IT systems in other domains. Additionally they recommend not reinventing security measures [44]. The vast market potential of Smart Grid devices and experience with other recent developments makes it very likely that COTS hardware and software, from grid's mission critical controllers to smart meters, are extensively and pervasively deployed. In this perspective, open standards are necessary for updating and upgrading the security mechanisms of these devices as threats and risks evolve.

5.5 More stakeholders

The number of active stakeholders in Smart Grids is increasing by definition as small scale generation units – and even home customers – become integral to supply in the market in the coming years. New value networks and new types of services are likely to appear which must be built on a network capable of guaranteeing high enough confidentiality, integrity and availability of the information.

As highlighted in the *OpenMeter* project, security is everywhere in the metering process, from the meter and the data concentrator to the back-office information system, including each network and media used to communicate. All partners, from manufacturers to suppliers and regulation authorities have to work together for awareness-raising and securing the future metering systems [44].

[14] Commercial off the shelf

6 SUMMARY AND FUTURE STEPS

6.1 Summary

A number of lessons learned and interesting developments have emerged from the analysis of the collected projects. They are summarised in Box 17.

BOX 17. SUMMARY AND CONCLUSIONS

- The difficulties encountered during the data collection process suggest the need for improvements in data collection/exchange. These include a common structure for data collection in terms of definitions, terminology, categories, and benchmarks, and strengthening project repositories at the national and European level.

- Lack of quantitative data to perform cost-benefit assessments.

SMART GRID LANDSCAPE IN EUROPE

- Projects in the catalogue are not evenly distributed across Europe. Most of the projects and of the investments are in EU15 countries. Smart Grids are deployed at different pace and not in a homogenous way across the Member States: this could lead to challenges both for trade and cross-border cooperation.

- There is a significant amount of investments in the project catalogue (over €5 billion), which, however, is still lagging behind compared to several estimates of required investments needed to realize smarter and stronger European grids (some€500 billion). We are just at the beginning of the Smart Grid transition.

- In almost all countries, a significant amount of investments has been devoted to projects which address the integration of different Smart Grid technologies and applications. Most of technologies are known, but their integration is the new challenge.

- The data in the catalogue confirms the leading role DSOs play in coordinating the Smart Grid deployment across Europe.

- Deployment covers the lion's share of investment commitments; 7% of the projects account for almost 60% of the investments. R&D and demonstration projects account for a much smaller share of the total budget. Most of these projects are small to medium sized, with an average budget of €4.4 million for R&D projects and about €12 million for demonstration projects.

LARGE SCALE MULTIDISCIPLINARY DEMONSTRATORS

- A consistent number of projects in the catalogue present promising results in small or medium scale implementations. As also recommended in the EEGI of the SET-Plan, large-scale demonstrators, involving a high number of sites and real communities, are needed to prove the up-scaling and reliability of technical, market and regulatory solutions and to better understand their social impact.

- The increased complexity of the electricity system requires multidisciplinary consortia to share competencies and hedge risks. Network operators are establishing fruitful cooperation with diverse partner organizations, ranging from academia and research centres to manufacturers and IT companies.

SETUP OF MARKET PLATFORMS FOR THE PROVISION OF SERVICES

- Current regulation in EU Member States generally provides network owners/operators with the incentive to improve cost-efficiency by reducing operation costs rather than by upgrading grids towards a smarter system. The regulatory incentive model should be revised in order to accelerate the investment potential of network owners/operators and to encourage them to move to a more service-based business model.

- Service-based business models, differently from volume-based, can make efficiency and sustainability part of the industry's mission, not simply a constraint to deal with.

- Most of Smart Grid benefits are systemic in nature. The set-up of service-based market platforms (e.g. Demand Response) is instrumental to offer a business case to several participants that may not enter the market individually.

- Regulation should also ensure a fair sharing of costs and benefits in the set-up of service-based market platforms. Network owners/operators are expected to sustain the majority of up-front investments whereas several players might get benefits when market platforms become operational.

CONSUMERS

- It is crucial to make sure that consumers have trust and understanding in the whole Smart Grid process and can receive clear tangible benefits. It is necessary to involve consumers early on in trials and demonstrations, to target early adopters before moving to full-scale deployment, and to give consumers the freedom to choose their level of involvement.

- Most projects require an active role of consumers. Grid-centric application and consumer-centric applications are equally important in the catalogue. Smart Grid players recognize that consumer engagement is crucial to have a business case for investments and to make electricity service platforms develop.

- Potential benefits for consumers are numerous: reduction of outages, more transparent and frequent billing information, participation in the electricity market via aggregators, energy savings. However, most of these benefits are systemic in nature; to be captured, the whole system (consisting of physical and market layers) needs to be in place.

- Segmentation of consumers is another hallmark of the Smart Grid. Consumer segmentation implies (1) more tailored energy services to meet consumers' needs with possibly a higher rate of acceptance of new products and services (2) possibility to target energy-savvy and wealthy consumers as early adopters of new technologies (3) possibility to guarantee different levels of involvement of consumers in Smart Grid applications and guarantee the protection of vulnerable consumers.

INTEROPERABILITY, DATA PROTECTION AND DATA SECURITY

- An open and secure ICT infrastructure is at the core of a successful Smart Grid implementation. Addressing interoperability, data privacy and security is a priority requirement to make the ICT infrastructure truly open and secure and reduce transaction costs among its users.

- A scan of collected projects highlights the convergence towards IP communication and other standards-based solutions. Proven standards and industry best practices used for IT systems should be considered and adapted, and security measures not reinvented.

- Smart Grid projects require the collaboration of several players with different competencies and background. Since security in the ICT infrastructure is a collective effort, it is imperative that roles and responsibilities are clearly defined and that both the energy and ICT communities work together to coordinate security measures to prevent blind spots.

- The legislative framework needs to support these developments. As stated in [24], the EC is ready to support the Member States in ensuring, when deciding roles and responsibilities regarding ownership, possession and access to data.

- Most of collected projects have not provided responses on data protection and security. It seems that the potential to tackle this issue is not fully exploited. New projects focusing on data handling would be useful to assess how data handling principles from other industries (e.g. banking industry) can be applied to Smart Grids. A privacy-by-design approach needs to be adopted [19].

6.2 Future work

As future work, we aim at achieving an exhaustive and continuous mapping of Smart Grid projects throughout Europe. Building upon the results and feedbacks of this first data collection exercise, we will continue to collect new Smart Grid projects and to include new available data on existing projects as projects progress. Also, acknowledging that projects aimed at making the grid stronger (e.g. through new lines and substations) cover a large share of the investment for the bulk power system, we aim at developing a data collection in this area as well. Accordingly, we intend to perform an exhaustive and continuous mapping of power system projects throughout Europe that will be presented in a review of the present study.

Future work will also be devoted to perform a quantitative analysis of the performance of collected projects, which has not been included in this report for the lack of quantitative data gathered. We are presently working on two different quantitative analyses: a performance assessment (Key Performance Indicator-KPI analysis) and a cost-benefit analysis. In the following, we briefly discuss the guidelines we are following for the application of both methodological approaches.

KPI analysis

As stated in section 4.4, we can evaluate the merit of the deployment of a Smart Grid project by measuring how much it contributes to progresses toward Smart Grids services and by measuring how much it contributes to progresses toward expected benefits and outcomes.

The performance assessment measures the contribution of a project toward the achievement of the benefits that are associated with the ideal functionalities of a Smart Grid. The analysis is based on the definitions of a set of KPIs to evaluate the benefits of a Smart Grid project.

The Smart Grid Task Force has elaborated a methodology to make the evaluation process structured and systematic. The merit deployment matrix introduced in [20] is used to identify the relationship between services/functionalities with corresponding benefits/KPI and to define the strength of the link.

The set of KPIs defined by the EC Task Force [20] is mainly focused on consumers' benefits and is meant to be used by regulators to assess the impact of project deployment using the merit deployment matrix.

At the European level, another set of KPIs is under discussion for the assessment of the contribution of EEGI projects to SET-Plan objectives [14].

The set of KPIs defined in this context is mainly focused on the technical performance of Smart Grid projects and is mainly tailored for grid operators rather than regulators.

Cost benefit analysis

The cost-benefit analysis weighs the investment costs against some concrete benefits that result from the implementation of the project.

As shown in section 2.1, the great majority of projects did not provide any data on cost-benefit analysis. Presumably, some projects did not perform a cost-benefit analysis as they have not been completed yet; others may have not shared the data for business confidentiality. In many other instances, however, a detailed cost-benefit analysis was not in the scope of the project, as most of the collected projects focused on testing the effectiveness of technologies, applications and solutions, rather than their business case. Overall, it emerged the need for the development of a common cost-benefit methodology and of a dedicated data collection template for fair comparisons.

We therefore conducted a wide literature review on this topic. It emerged that at the international level, the need to measure costs and benefits of Smart Grid projects is widespread. However, a structured approach to cost-benefit analysis in this field has not been tested yet on a concrete case study.

In related literature, the most advanced work on cost-benefit analysis for Smart Grids has been published by the Electrical Power Research Institute (EPRI) in 2010 [15]. The US Department of Energy (DoE) commissioned this study to perform a cost-benefit analysis on a set of 9 demonstrators that were financed in 2007. DoE and EPRI intend to use the cost-benefit methodology for ex-post evaluation.
In the framework of the EU-US Energy Council, the Commission is collaborating with the DoE. In this context, the JRC is working with industrial partners to adapt the EPRI methodology to the European context. Currently, a few case studies from the JRC catalogue are being used to test the EPRI methodology.

BOX 18. Future Work - Highlights

- We aim at an exhaustive and continuous mapping of Smart Grid projects throughout Europe. We will continue to collect new Smart Grid projects and to include new available data on existing projects as projects progress. Also, acknowledging that projects aiming at making the grid stronger (e.g. through new lines and substations) cover a large share of the investment for the bulk power system, we aim at developing a data collection in this area as well. Accordingly, a periodic review of this study will be presented.

- Coordination with other European initiatives on Smart Grids which the Commission expects to launch at the end of 2011. Further revisions of this study aim at closer collaboration with the EEGI. This is important to have clear in mind the common ground between the EEGI and the JRC mapping and keep track of and exchange data and results.

- KPI analysis – Presently, the Smart Grid Task Force and EEGI have developed two sets of KPIs to assess progresses in Smart Grids. The KPIs developed by the Task Force are intended for regulators. They cover not only technical aspects of Smart Grids and have a particular focus on the impact of Smart Grids on consumers. The KPIs developed by EEGI are particularly useful for utilities. They mainly cover technical aspects of Smart Grids. The Commission is working to ensure consistencies and synergies between the two sets of KPIs.

- Cost-Benefit analysis –In the framework of the EU-US Energy Council, the Commission is collaborating with the DoE on common assessment methodologies for Smart Grids. In this context, we plan to adapt the EPRI methodology to the European context. With this goal in mind, the JRC is collaborating with industrial partners to test a cost-benefit methodology on case studies from the catalogue.

REFERENCES

[1] AEA (Austrian Energy Agency) (2011), *European Smart Metering Landscape Report*, SmartRegions Deliverable 2.1, February 2011, AEA, Vienna.

[2] AUSTRADE (Australian Trade Commission) (2010), Australian Energy Efficiency Market Industry Capability Report, AUSTRADE, July 2010, available at: http://di.dk/SiteCollectionDocuments/Markedsudvikling/2%20Australian%20Energy%20Efficiency%20Industry%20Capability%20Report.pdf, accessed February 2011.

[3] Brown J., Hendry C. (2009), Public demonstration projects and field trials: Accelerating commercialization of sustainable technology in solar photovoltaics", *Energy Policy*, Vol. 37, pp. 2560-2573.

[4] Christensen, A., Green, J., Roberts, R. (2010), *Maximizing value from smart grids*, McKinsey on Smart Grid, Number 1, McKinsey&Company, available at: www.mckinsey.com/.../McK%20on%20smart%20grids/MoSG_MaxValue_VF.aspx, accessed February 2011.

[5] Chupka M.W., Earle R., Fox-Penner P., Hledik R. (2008), *Transforming America's Power Industry: The Investment Challenge 2010-2030*, The Edison Foundation, Washington, D.C., available at: http://www.eei.org/ourissues/finance/Documents/Transforming_Americas_Power_Industry.pdf, accessed January 2011.

[6] DECC (Department of Energy and Climate Change) (2009), *Smarter Grids: The Opportunity*, available at: http://www.decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/futureelectricitynetworks/1_20091203163757_e_@@_smartergridsopportunity.pdf, accessed January 2011.

[7] DOE (U.S. Department of Energy) (2009), *Guidebook for ARRA Smart Grid Program Metrics and Benefits*, US DOE: Washington, DC.

[8] DOE (U.S. Department of Energy) (2009), *Smart Grid System Report*, US DOE: Washington, DC.

[9] Eichin R., Heng A. (2010), *U.S. Smart Grid Vendor Ecosystem - Report on the companies and market dynamics shaping the current U.S. Smart Grid landscape*, Cleantech Group, available at: http://www.technologyresearch.org/wp-content/uploads/2010/09/SmartGridVendor.pdf, accessed January 2011.

[10] Electra (2009), *Twenty solutions for growth and investment to 2020 and beyond*, available at: http://ec.europa.eu/enterprise/sectors/electrical/files/electrareport_en.pdf, accessed December 2010.

[11] Elzen, B., Moon, D. (2000), *Demonstrating Cleaner Vehicles: Guidelines for Success*. Utopia. European Commission, Transport RTD Programme. EC contract UR-97-SC-2076, available at : http://www.transport-research.info/Upload/Documents/200310/utopia.pdf, accessed December 2010.

[12] ENTSOE (European Network of Transmission System Operators for Electricity) (2010), *Research and Development Plan, European Grid Towards 2020 Challenges and Beyond*, available at: https://www.entsoe.eu/fileadmin/user_upload/_library/Key_Documents/100331_ENTSOE_R_D_Plan_FINAL.pdf, accessed February 2011.

[13] ENTSOE (European Network of Transmission System Operators for Electricity) (2010), *Ten-Year Network Development Plan 2010-2020*, available at: https://www.entsoe.eu/fileadmin/user_upload/_library/SDC/TYNDP/TYNDP- final_document.pdf, accessed January 2011.

[14] ENTSOE (European Network of Transmission System Operators for Electricity) (2010), *The European Electricity Grid Initiative (EEGI) Roadmap 2010-18 and Detailed Implementation Plan 2010-12*, available at: http://ec.europa.eu/energy/technology/initiatives/doc/grid_implementation_plan_final.pdf, accessed January 2011.

[15] EPRI (Electric Power Research Institute) (2010), *Methodological Approach for Estimating the Benefits and Costs of Smart Grid Demonstration Projects*, EPRI, January 2010, available at: http://www.smartgrid.gov/sites/default/files/pdfs/methodological_approach_for_estimating_the_benefits_and_costs_of_sgdp.pdf, accessed December 2010.

[16] EPRI (Electric Power Research Institute) (2011), *Estimating the Costs and Benefits of the Smart Grid - A Preliminary Estimate of the Investment Requirements and the Resultant Benefits of a Fully Functioning Smart Grid*, EPRI, April 2011, available at: http://my.epri.com/portal/server.pt?space=CommunityPage&cached=true&parentname=ObjMgr&parentid=2&control=SetCommunity&CommunityID=404&RaiseDocID=000000000001022519&RaiseDocType=Abstract_id, accessed April 2011.

[17] ERGEG (European Regulators Group for Electricity and Gas) (2010), *Position Paper on Smart Grids - an ERGEG Conclusions Paper*, ERGEG, June 2010, available at: http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Electricity/2010/E10-EQS-38-05_SmartGrids_Conclusions_10-Jun-2010_Corrigendum.pdf, accessed December 2010.

[18] EU Commission Task Force for Smart Grids (2010), Expert Group 1: *Functionalities of smart grids and smart meters*, available at: http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/expert_group1.pdf, accessed February 2011.

[19] EU Commission Task Force for Smart Grids (2011), Expert Group 2: *Regulatory Recommendations for Data Safety, Data Handling and Data Protection*, available at: http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/expert_group2.pdf, accessed March 2011.

[20] EU Commission Task Force for Smart Grids (2011), Expert Group 3: *Roles and Responsibilities of Actors involved in the Smart Grids Deployment*, available at: http://ec.europa.eu/energy/gas_electricity/smartgrids/doc/expert_group3.pdf, accessed May 2011.

[21] EUROPEAN COMMISSION (2006) Directorate-General for Research, *European Smart Grids Technology Platform: Vision and Strategy for Europe's Electricity Networks of the Future*, Brussels 2006, available at: http://ec.europa.eu/research/energy/pdf/smartgrids_en.pdf, accessed December 2010.

[22] EUROPEAN COMMISSION (2007) Communication from the Commission to the European Council and the European Parliament, *An Energy Policy for Europe*, Brussels, 10.1.2007 COM(2007) 1 final, available at: http://ec.europa.eu/energy/energy_policy/doc/01_energy_policy_for_europe_en.pdf, accessed January 2011.

[23] EUROPEAN COMMISSION (2007) Directorate-General for Research, *Strategic Research Agenda for Europe's Electricity Networks of the Future*, Brussels 2007, available at: http://bookshop.europa.eu/is-bin/INTERSHOP.enfinity/WFS/EU-Bookshop-Site/en_GB/-/EUR/ViewPublication-Start?PublicationKey=KINA22580, accessed December 2010.

[24] EUROPEAN COMMISSION (2011) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, *Smart Grids: From Innovation to Deploymen*t, Brussels, 12.4.2011, COM(2011) 202 final, available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0202:FIN:EN:PDF, accessed April 2011.

[25] European Foundation for the Improvement of Living and Working Conditions (EUROFUND) (2008), *Trends and drivers of change in the European energy sector: Mapping report*, available at: http://www.eurofound.europa.eu/pubdocs/2008/12/en/1/ef0812en.pdf, accessed January 2011.

[26] Evans D. S. (2003), Some Empirical Aspects of Multi-sided Platform Industries, *Review of Network Economics*, Vol.2 Issue 3 – 2003.

[27] Faruqui A., Harris D., Hledik R. (2009) Unlocking the €53 Billion Savings from Smart Meters in the EU - How increasing the adoption of dynamic tariffs could make or break the EU's smart grid investment, The Brattle Group, Discussion Paper, October 2009, available at: http://www.brattle.com/_documents/uploadlibrary/upload805.pdf, accessed January 2011.

[28] Flink T., Morehouse J. (2010), *Securing the Smart Grids. Next Generation power grids security*, October 2010, Syngress, Burlington.

[29] Fox-Penner P. (2010), *Smart Power. Climate Change, the Smart Grid and the Future of Electric Utilities*, April 2010, Island Press, Washington DC.

[30] IEA (International Energy Agency) (2008), *World Energy Outloo*k 2008, OECD/IEA, Paris.

[31] Innovation Observatory (2011), *Smart Grid Technology Investment: Forecast for 2010-2030*, February 2011.

[32] Johnson, M. W., Suskewicz, J. (2009), How to jump-start the clean-tech economy, *Harvard Business Review*, Harvard Business Publishing, Boston, available at http://hbr.org/2009/11/how-to-jump-start-the-clean-tech-economy/ar/1, accessed February 2011.

[33] Karlstrom, M., Sanden B.A. (2004), Selecting and assessing demonstration projects for technology assessment: The cases of fuel cells and hydrogen systems in Sweden, *Innovation: management and policy practice*, Vol. 6, pp. 286-293.

[34] KEMA (2008), *The U.S. Smart Grid Revolution – KEMA's Perspectives for Job Creation*, prepared for the GridWise Alliance, December 2008, available at: http://www.smartgridnews.com/artman/uploads/1/KEMA_s_Perspectives_for_Job_Creation.pdf, accessed December 2010.

[35] Kiesling, L. (2009), *A smart grid is a transactive grid*, Kellogg Graduate School of Management, Northwestern University.

[36] Kostyk, T. (2010, February 16), Smart Grid Backlash: How to Put an End to Consumer Resistance, *SmartGridNews.com*, available at: http://www.smartgridnews.com/artman/publish/ Business_Planning_News/Smart-Grid-Backlash-How-to-Put-an-End-to-Consumer-Resistance-1887.html, accessed March 2011.

[37] Leeds D.J. (2009), *The Smart Grid In 2010: Market Segments, Applications and Industry Players*, GTM research, July 2009, available at: http://www.greentechmedia.com/research/report/smart-grid-in-2010, accessed February 2011.

[38] Lo Schiavo, L. (2011), *Smart Metering and Smart Grids: The Italian Regulatory Experience*, prepared for the KSA Smart Grid Workshop, 8-9 January 2001, Riyadh, available at: http://ksasmartgrid.org/Content/Mr_Luca_Lo_Schiavo.pdf, accessed March 2011.

[39] Miyoung, K. (2010, January 25), South Korea targets $24 billion smart grid spending by 2030, *Reuters*, available at http://www.reuters.com/article/2010/01/25/us-smartgrid-korea-idUSTRE60O0YC20100125, accessed March 2011.

[40] NETL (National Energy Technology Laboratory) (2010) *Understanding the Benefits of the Smart Grid*, U.S. Department of Energy (DOE), available at: http://www.netl.doe.gov/smartgrid/referenceshelf/whitepapers/ 06.18.2010_Understanding%20Smart%20Grid%20Benefits.pdf, accessed February 2011.

[41] NETL (National Energy Technology Laboratory) (2010), *West Virginia Smart Grid Implementation Plan – Roadmap Framework*, U.S. Department of Energy (DOE) , prepared for GridWeek 2010, October 18 2010, Washington, DC, available at http://www.smartgrid.gov/sites/default/files/pdfs/10182010_gw_wv_sgip.pdf, accessed February 2011.

[42] NIST (National Institute of Standards and Technology) (2010), *NIST Framework and Roadmap for Smart Grid Interoperability Standards – Release 1.0*, U.S. Department of Commerce, NIST Special Publication 1108, available at: http://www.nist.gov/public_affairs/releases/upload/smartgrid_interoperability_final.pdf, accessed March 2011.

[43] OECD (Organisation for Economic Co-operation and Development) (2002), *Frascati Manual 2002: Proposed Standard Practice for Surveys on Research and Experimental Development*, OECD: Paris.

[44] OpenMeter Deliverable D1.1 (2010), *Report on the Identification and Specification of Functional, Technical, Economical and General Requirements of Advanced Multi-Metering Infrastructure, Including Security Requirement*s, OPEN Meter Energy Project No 226369. Funded by EC. Available at: http://www.openmeter.com/files/deliverables/Open%20Meter_D3%201_Architecture_v6_.pdf, accessed March 2011.

[45] OpenMeter Deliverable D3.1 (2010), *Design of the Overall System Architecture*, OPEN meter, Energy Project No 226369. Funded by EC. Available at: http://www.openmeter.com/files/deliverables/Open%20Meter_D3%201_Architecture_v6_.pdf, accessed April 2011.

[46] Pearson I.L.G. (2011), Smart grid cyber security for Europe. *Energy Policy* (2011), doi:10.1016/j.enpol.2011.05.043.

[47] Pike Research (2011), *Smart Grids in Europe*, Pike Research Cleantech Market Intelligence, available at: http://www.pikeresearch.com/research/smart-grids-in-europe, accessed February 2011.

[48] Sakamaki S. (2011), Japan to Consider Using Energy-Saving, Smart Grid Technologies, *Bloomberg*, available at: http://www.bloomberg.com/news/2011-05-18/japan-to-consider-using-energy-saving-smart-grid-technologies-edano-says.html, accessed March 2011.

[49] SmartGridnews.com (2010, January 27), *Smart Grid Snapshot: China Tops Stimulus Funding*, SmartGridNews.com, available at: http://www.smartgridnews.com/artman/publish/ Stimulus_News_Digest_Products/Smart-Grid-Snapshot-China-Tops-Stimulus-Funding-1827.html, accessed March 2011.

[50] Smartmeters.com (2011, January 1), *Smart Meters Deployment Looks Strong for 2011*, available at: http://www.smartmeters.com/the-news/1476-smart-meters-deployment-looks-strong-for-2011.html, accessed January 2011.

[51] Stromback, J., Dromacque, C. (2010), *Evaluation of residential smart meter policies, WEC-ADEME Case studies on Energy Efficiency Measures and Policies*, VaasaETT Global Energy Think Tank, available at: http://worldenergy.org/documents/ ee_case_study__smart_meters.pdf, accessed March 2011.

[52] The Economist (2008, March 6), *Power plays*, available at: http://www.economist.com/ node/10789425, accessed January 2011.

[53] The Economist (2010, February 26), *Home sweet passive home – A lazy man's guide to cutting energy costs*, available at: http://www.economist.com/node/ 15585504?story_id =15585504, accessed February 2011.

[54] Thornton, J. (2010), Growth of Opportunity, *Mechanical Engineering*, Vol. 132(10).

[55] Union of the Electricity Industry–EURELECTRIC (2007), *The Role of Electricity A New Path to Secure, Competitive Energy in a Carbon-Constrained World*, EURELECTRIC, June 2007, available at: http://www2.eurelectric.org/DocShareNoFrame/Docs/2/MCDCHIMBLGDIPAEBLJOHILBKFAY1YD1HYO5CM1OLFLM6/Eurelectric/docs/DLS/FullreportCOMPLETEfinallayout040607-2007-030-0612-2-.pdf, accessed December 2010.

[56] Union of the Electricity Industry–EURELECTRIC (2009), *Smart Grids and Networks of the Future - EURELECTRIC Views*, EURELECTRIC, May 2009, Brussels, available at: www.eurelectric.org/Download/Download.aspx?DocumentID=26620, accessed December 2010.

[57] Valocchi M., Juliano J., Schurr A. (2009), *Lighting the way, Understanding the smart energy consumer*, February 2009, IBM Global Services, Somers.

[58] Valocchi M., Juliano J., Schurr A. (2010), *Switching perspectives - Creating new business models for a changing world of energy*, IBM Institute for Business Value, Executive report, available at: http://public.dhe.ibm.com/common/ssi/ecm/en/gbe03289usen/GBE03289USEN.PDF, accessed February 2011.

[59] Valocchi M., Schurr A., Juliano J., Nelson E. (2007), *Plugging in the Consumer Innovating Utility Business Models for the Future*, 2007, IBM Global Services, Somers.

[60] Vasconcelos, J. (2009), *Smart Metering: An Overview of Regulatory and Technological Challenges*, Florence School of Regulation Seminar, February 6 2009, Florence, available at: http://www.florence-school.eu/portal/page/portal/FSR_HOME/ENERGY/Policy_Events/Workshops/2009/Smart_Metering1/VASCONCELOS.pdf, accessed December 2010.

[61] Watson-Currie, E. (2010, February 9), Blowback Attack: The Smart Grid's Greatest Danger?, SmartGridNews.com, available at http://www.smartgridnews.com/artman/publish/ Business_Strategy/Blowback-Attack-The-Smart-Grid-s-Greatest-Danger-1875.html, accessed March 2011.

[62] WEF (World Economic Forum) (2009), *Accelerating Successful Smart Grid Investments*, WEF in partnership with Accenture, WEF: Geneva.

[63] WEF (World Economic Forum) (2010), *Accelerating Successful Smart Grid Pilots*, WEF in partnership with Accenture, WEF: Geneva.

[64] Zheng, A. Y. (2007), *A Smarter Grid for India*, SmartGridNews.com, available at http://www.smartgridnews.com/artman/publish/article_303.html, accessed February 2011.

[65] Zypryme Research & Consulting (2011), *China: Rise of the Smart Grid*, Special Report by Zypryme's Smart Grid Insights, available at: http://www.zpryme.com/SmartGridInsights/China_Rise_of_the_Smart_Grid_January_2011_Zpryme_Research.pdf, accessed February 2011.

ABBREVIATIONS AND ACRONYMS

AEEG	Autorità per l'Energia Elettrica e il Gas (IT)
AMI	Advanced Metering Infrastructure
CHP	Combined Heat and Power
CO_2	Carbon Dioxide
COTS	Commercial off-the-shelf
DEMS	Distributed Energy Management System
DER	Distributed Energy Resources
DG ENER	Directorate-General for Energy
DG	Distributed Generation
DMS	Distribution Management System
DR	Demand Response
DSO	Distribution System Operator
EC	European Commission
EEGI	European Electricity Grid Initiative
EU	European Union
EV	Electric Vehicle
FP6	Sixth Framework Program
FP7	Seventh Framework Program
GHG	Greenhouse Gas
ICT	Information and Communication Technologies
IEA	International Energy Agency
IP	Internet Protocol
IT	Information Technologies
JRC	Joint Research Centre
KPI	Key Performance Indicator
KWh	Kilowatt-Hour
MSP	Multi-Sided Platform
OFGEM	Office of the Gas and Electricity Markets (UK)
PV	Photovoltaics
R&D	Research and Development
RES	Renewable Energy Sources
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
SET-Plan	Strategic Energy Technology Plan
SMEs	Small and Medium Enterprises
TSO	Transmission System Operator
V2G	Vehicle to Grid
VPP	Virtual Power Plant

COUNTRY CODES

AT	Austria
BE	Belgium
BG	Bulgaria
CH	Switzerland, Helvetia
CY	Cyprus
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
EL	Greece
ES	Spain
FI	Finland, Suomi
FR	France
HR	Croatia
HU	Hungary
IE	Ireland
IT	Italy
LI	Liechtenstein
LT	Lithuania
LU	Luxemburg
LV	Latvia
MK	Macedonia
MT	Malta
NL	Netherlands, The
NO	Norway
PL	Poland
PT	Portugal
RO	Romania
SE	Sweden
SI	Slovenia
SK	Slovakia
UK	United Kingdom
USA	United States of America

ANNEX I - DATA COLLECTION TEMPLATE

Qualitative assessment:

PILOT PROJECT DESCRIPTION

Project name	
Leading Organization (Name and Country)	
Other Participants (Names and Countries)	
Contact Person (Name, Phone Email) and Project Website	
Start date and duration of the project	
Budget and contributing organizations (indicating share of contribution)	
Location/s	
Project category (a) (If more than one category applies, please express the relevance of the category with a number between 0 and 1)	
Quantitative sizing of the project: number of metering points, average and peak power delivered, number of generators directly involved	
Duration of the data collection within the operational pilot	
How are actors involved representative of a full deployment (socially, technically, geographically, motivation, etc.)?	

Summary of Project goals and expected benefits (max 50 words):	
Project Summary (max 200 words):	
List of deployed enabling assets/ technologies/applications (max 50 words):	
List of pertinent Smart Grid functionalities (as per Task Force EG1) (max 100 words):	
Specific data protection and security issues (if addressed) (max 100 words):	
Key project outcomes and overview of estimated costs/ benefits (max 200 words):	

Quantitative assessment:

1) If you have performed a cost-benefit assessment of the project, please provide the study or provide a summary which includes at least the following elements:

- Description of the baseline (i.e. the system condition that would have occurred had the project not been taken)
- Description of the assumptions made
- Description of the conditions (e.g. hourly consumption, CO_2 emissions, congestions (MW) etc.) that have been monitored to assess the impact of the pilot project
- Quantification (and, possibly, monetization) of the benefits via suitable metrics
- Quantification of the costs for both baseline and project conditions
- Main results and figures, including assessment of beneficiaries

2) It might be possible that you have not performed a cost-benefit assessment of the project but you have data that are useful for the estimation of benefits and costs. In this case, in order to perform a cost-benefit assessment to be included in the report, please provide the data by following these steps:

a) Choose the relevant benefits/criteria from the list provided in Task Force EG3.

b) According to the data in your possession, please advise a metric that might be used to quantify the benefits/criteria.

c) Please provide all the data that may be useful to calculate the relevant benefit metric, both with and without the project in place

Here is an example of the breakdown to link data to benefits:

Example of map benefit-data

Benefit	Benefit Criteria	Metric	Necessary Data
Informed consumers' decisions	Coherence between tariffs and behaviors	E.g. Price elasticity	Hourly consumption data and prices (with and without the project in place)

d) For each benefit, please provide a brief qualitative description of the expected impact on beneficiaries, as reported in the hypothetical example below:

Example of map benefit-beneficiaries

Benefit	Benefit Criteria	Beneficiaries		
		Consumers	DSO	Society
Informed consumers' decisions	Coherence between tariffs and behaviors	Lower electricity bills	Peak load reduction	Lower emissions due to demand side management

e) Please provide annual cost estimate for both baseline and project conditions

3) Finally, we would like to use the benefit-functionality matrix developed in Task Force EG 3 to further analyze the impact of selected pilot projects on Smart Grid Functionalities. To contribute to this exercise, please follow the following steps:

   a) Identify benefits/criteria and functionalities that are relevant to your pilot project. Select the corresponding matching cells.

   b) For each cell, briefly explain project contribution and assign a weight to it (0 for no contribution, 1 for high contribution and a value between 0 and 1 for some degree of contribution)

The table below reports an illustrative example, in which a pilot project delivers one benefit through the activation of two functionalities. Corresponding matrix cells (highlighted in grey) report how the project links the functionalities with the benefit and the weight of the contribution.

Benefit	Benefit Criteria	Activated functionalities	
		Consumption/injection data and price signals by different means	Improve energy usage information
Informed consumers' decisions	Coherence between tariffs and behaviors	Installation of in-home display and smart meter to stimulate Demand Response	Installation of in-home display and smart meter to stimulate Demand Response
		Contribution: 0.6	Contribution: 0.3

ANNEX II – SMART GRID SERVICES (SMART GRID TASK FORCE)

A. Enabling the network to integrate users with new requirements

Outcome:	Guarantee the integration of distributed energy resources (both large and small-scale stochastic renewable generation, heat pumps, electric vehicles and storage) connected to the distribution network.
Provider:	DSOs
Primary beneficiaries:	Generators, consumers (including mobile consumers), storage owners.

B. Enhancing efficiency in day-to-day grid operation

Outcome:	Optimise the operation of distribution assets and improve the efficiency of the network through enhanced automation, monitoring, protection and real time operation. Faster fault identification/resolution will help improve continuity of supply levels. Better understanding and management of technical and nontechnical losses, and optimised asset maintenance activities based on detailed operational information.
Provider:	DSOs, metering operators
Primary beneficiaries:	Consumers, generators, suppliers, DSOs.

C. Ensuring network security, system control and quality of supply

Outcome:	Foster system security through an intelligent and more effective control of distributed energy resources, ancillary backup reserves and other ancillary services. Maximise the capability of the network to manage intermittent generation, without adversely affecting quality of supply parameters.
Provider:	DSOs, aggregators, suppliers.
Primary beneficiaries:	Generators, consumers, aggregators, DSOs, TSOs.

D. Enabling better planning of future network investment

Outcome:	Collection and use of data to enable more accurate modelling of networks especially at LV level, also taking into account new grid users, in order to optimise infrastructure requirements and so reduce their environmental impact. Introduction of new methodologies for more 'active' distribution, exploiting active and reactive control capabilities of distributed energy resources.
Provider:	DSOs, metering operators.
Primary beneficiaries:	Consumers, generators, storage owners.

E. Improving market functioning and customer service

Outcome:	Increase the performance and reliability of current market processes through improved data and data flows between market participants, and so enhance customer experience.
Provider:	Suppliers (with applications and services providers), power exchange platform providers, DSOs, metering operators.
Primary beneficiaries:	Consumers, suppliers, applications and services providers.

F. Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management

Outcome:	Foster greater consumption awareness taking advantage of Smart Metering systems and improved customer information, in order to allow consumers to modify their behaviour according to price and load signals and related information. Promote the active participation of all actors to the electricity market, through Demand Response programmes and a more effective management of the variable and nonprogrammable generation. Obtain the consequent system benefits: peak reduction, reduced network investments, ability to integrate more intermittent generation.
Provider:	Suppliers (with metering operators and DSOs), ESCOs.
Primary beneficiaries:	Consumers, generators. The only primary beneficiary which is present in all services is the consumer. Indeed, consumers will benefit: - either because these services will contribute to the 20/20/20 targets - or directly through improvement of quality of supply and other services

The hypothesis made here is that company efficiency and the benefit of the competitive market will be passed to consumers– at least partly in the form of tariff or price optimisation, and is dependent on effective regulation and markets.

ANNEX III SMART GRID BENEFITS AND KPIS (SMART GRID TASK FORCE)

Benefit	Potential key performance indicators[1]
(1) Increased sustainability	Quantified reduction of carbon emissions Environmental impact of electricity grid infrastructure Quantified reduction of accidents and risk associated to generation technologies (during mining, production, installations, etc.)
(2) Adequate capacity of transmission and distribution grids for "collecting" and bringing electricity to the consumers	Hosting capacity for distributed energy resources in distribution grids Allowable maximum injection of power without congestion risks in transmission networks Energy not withdrawn from renewable sources due to congestion and/or security risks An optimized use of capital and assets
(3) Adequate grid connection and access for all kind of grid users	Benefit (3) could be partly assessed by: first connection charges for generators, consumers and those that do both grid tariffs for generators, consumers and those that do both methods adopted to calculate charges and tariffs time to connect a new user optimisation of new equipment design resulting in best cost/benefit faster speed of successful innovation against clear standards
(4) Satisfactory levels of security and quality of supply	Ratio of reliably available generation capacity and peak demand Share of electrical energy produced by renewable sources Measured satisfaction of grid users with the "grid" services they receive Power system stability Duration and frequency of interruptions per customer Voltage quality performance of electricity grids (e.g. voltage dips, voltage and frequency deviations)
(5) Enhanced efficiency and better service in electricity supply and grid operation	Level of losses in transmission and in distribution networks (absolute or percentage)[2]. Storage induces losses too, but also active flow control increases losses. Ratio between minimum and maximum electricity demand within a defined time period (e.g. one day, one week)[3] Percentage utilisation (i.e. average loading) of electricity grid elements Demand side participation in electricity markets and in energy efficiency measures Availability of network components (related to planned and unplanned maintenance) and its impact on network performances Actual availability of network capacity with respect to its standard value (e.g. net transfer capacity in transmission grids, DER hosting capacity in distribution grids)

Benefit	Potential key performance indicators[1]
(6) Effective support of transnational electricity markets by load-flow control to alleviate loop-flows and increased interconnection capacities	Ratio between interconnection capacity of one Country/region and its electricity demand Exploitation of interconnection capacities (ratio between mono-directional energy transfers and net transfer capacity), particularly related to maximisation of capacities according to the Regulation of electricity cross-border exchanges and the congestion management guidelines Congestion rents across interconnections
(7) Coordinated grid development through common European, regional and local grid planning to optimize transmission grid infrastructure	Benefit (7) could be partly assessed by: impact of congestion on outcomes and prices of national/regional markets societal benefit/cost ratio of a proposed infrastructure investment overall welfare increase, i.e. running always the cheapest generators to supply the actual demand → this is also an indicator for the benefit (6) above Time for licensing/authorisation of a new electricity transmission infrastructure. Time for construction (i.e. after authorisation) of a new electricity transmission infrastructure.
(8) Enhanced consumer awareness and participation in the market by new players	Demand side participation in electricity markets and in energy efficiency measures Percentage of consumers on (opt-in) time-of-use / critical peak / real time dynamic pricing Measured modifications of electricity consumption patterns after new (op-tin) pricing schemes. Percentage of users available to behave as interruptible load. Percentage of load demand participating in market-like schemes for demand flexibility. Percentage participation of users connected to lower voltage levels to ancillary services
(9) Enable consumers to make informed decisions related to their energy to meet the EU Energy Efficiency targets	Base to peak load ratio Relation between power demand and market price for electricity Consumers can comprehend their actual energy consumption and receive, understand and act on free information they need / ask for Consumers are able to access their historic energy consumption information for free in a format that enables them to make like for like comparisons with deals available on the market. Ability to participate in relevant energy market to purchase and/or sell electricity Coherent link is established between the energy prices and consumer behaviour
(10) Create a market mechanism for new energy services such as energy efficiency or energy consulting for customers	'Simple' and/or automated changes to consumers' energy consumption in reply to demand/response signals, are enabled Data ownership is clearly defined and data processes in place to allow for service providers to be active with customer consent Physical grid related data are available in an accessible form Transparency of physical connection authorisation, requirements and charges Effective consumer complaint handling and redress. This includes clear lines of responsibility should things go wrong

Benefit	Potential key performance indicators[1]
(11)Consumer bills are either reduced or upward pressure on them is mitigated	Transparent, robust processes to assess whether the benefits of implementation exceed the costs in each area where roll-out is considered are in place, and a commitment to act on the findings is ensured by all involved parties Regulatory mechanisms exist, that ensure that these benefits are appropriately reflected in consumer bills and do not simply result in windfall profits for the industry New smart tariffs (energy prices) deliver tangible benefits to consumers or society in a progressive way Market design is compatible with the way the consumers use the grid

[1] Some of these indicators are already used today in different EU Member States.
[2] In case of comparison, the level of losses should be corrected by structural parameters (e.g. by the presence of distributed generation in distribution grids and its production pattern). Moreover a possibly conflicting character of e.g. aiming at higher network elements' utilization (loading) vs. higher losses, should be considered accordingly.
[3] In case of comparison, a structural difference in the indicator should be taken into account due e.g. to electrical heating and weather conditions, shares of industrial and domestic loads.

ANNEX IV - PROJECT CATALOGUE

	Project name	Organization name	Brief project description	Period	Country*	Project category
1	0.4 kV remote control	Not available	Opportunities to establish remote control/DNM of the 0.4 kV grids have been analyzed. The opportunities for integrations from the cable registration to the remote control have been investigated and pilot projects have been performed with integrations of sections of the low-voltage grid.	Not available	DK	Smart Meter and AMI
2	220 kV SSSC device for power flow control	Red Eléctrica de España (ES)	Design, construct, set up in operation and test a FACTS (SSSC) to prevent overload situations in the 220 kV transmission grid and reduce the measures that the System Operator has to make for solving overloads, like reduce the meshing of the network or curtail wind production.	Jul 2009-Jul 2014	ES	Grid Automation Transmission
3	A complete and normalized 61850 substation	Red Eléctrica de España S.A. (ES)	Use the standard IEC61850 as a means to improve the design, maintenance and operation of the substation automation systems. Design a standard substation considering the existing and new solutions developed by the vendors collaborating in the project. Build and set-up in operation a IEC61850 HV substation.	Oct 2009-Dec 2015	ES	Grid Automation Transmission
4	Activation of 200 MW refuse-generated CHP upward regulation effect	EMD International A/S, (DK)	Waste CHP plants can be used in the electricity market for upward regulation by bypassing the steam turbine. The technical design for this purpose must ensure that factors such as response and activation time do not result in more expensive turbine maintenance.	Jul 2009 - Dec 2010	DK	Integrated System
5	Active Network Management	Smart Grid Solutions (UK)	Delivering a fully automated, remotely configurable and self healing power distribution Network that will allow grid wide demand / load management in real time.	Apr 2010-Apr 2011	UK	Grid Automation Distribution
6	Almacena	Red Eléctrica de España (ES)	Installation and testing of 1 MW electrochemical battery in a substation of the transmission grid.	Sept 2009 - Dec 2013	ES	Specific Storage Technology Demonstration Grid Automation Distribution
7	Address	Enel Distribuzione (IT)	The project aims at delivering a comprehensive commercial and technical framework for the development of “Active Demand” in the smart grids of the future. ADDRESS investigates how to effectively activate participation of domestic and small commercial customers in power system markets and in the provision of services to the different power system participants.	Jun 2008 - Jun 2012	ES FR IT CH SE	Integrated System Home application - Customer Behavior
8	ADELE Project AA-CAES	RWE Power AG, (DE)	Compresses-air energy storage (case) as buffer for electricity from wind and sun.	Dec 2009 - Dec 2013	DE	Specific Storage Technology Demonstration

	Project name	Organization name	Brief project description	Period	Country*	Project category
9	Advanced Systems of Efficient Use of Electrical Energy - SURE	Teces (SL)	The main purpose of the project is to build active network concepts based on new technological solutions and to test these solutions in actual power networks. In the frame of the project a number of demonstration projects in the field of active networks will be carried out.	Jan 2011 - Jan 2014	SI	Integrated System Home application - Customer Behavior
10	AFTER - A Framework for electrical power sysTems vulnerability identification, dEfense and Restoration	RSE – Ricerca sul Sistema Energetico (IT)	AFTER addresses vulnerability evaluation and contingency planning of the energy grids and energy plants considering also the ICT systems used in protection and control. Main addressed problems concern high impact, wide spread, multiple contingencies and cascading.	2011 - 2014	IT NO IE UK FR DE BE CZ	Grid Automation Transmission
11	Agent based control of power systems, ForskEL	CET-DTU, (DK)	The purpose is to explore the possibilities of using agent technology to dynamic breakdown of electrical power supply system for example. “Islanding” of subsystems and to study how agents can be used for implementation of flexible control strategies.	Apr 2006 - Mar 2010	DK	Smart Meter and AMI Grid Automation Distribution
12	AMI	Elektro Gorenjska d.d. (SL)	The purpose of the project “AMI system for the Elektro Gorenjska” is the introduction of remote meter reading, control and demand management of the electricity and also water, gas and heat consumption in the area of Gorenjska.		SI	Smart Meter and AMI Integrated System
13	AMI	ENERGA-OPERATOR SA (PL)	The project is focused on Increasing the effectiveness of operational activity and facilitating management of the network and its development; Remote management of meter systems and obtaining meter data; Activation of clients in energy effectiveness and dispersed generation; Completion of regulatory requirements in the scope of meter readings; Facilitating unrestricted access to the network.	2010-2017	PL	Smart Meter and AMI
14	AMIS	Energie AG OÖ Netz GmbH (AT)	Automation of metering- and customer processes, further automation of grid components, creation of a technology platform for smart grid applications, technology platform for customer applications.	Jan 2005 – Jun 2012	AT	Integrated System

	Project name	Organization name	Brief project description	Period	Country*	Project category
15	Application of smart grid in photovoltaic power sys-tems, ForskEL	Danfoss Solar Inverters, (DK)	The target of the proposed project is to study how to integrate large amount of Renewable Energy Sources (RES) into the network, without having to reinforce the network. This is done by examining different types of grid voltage control, applying Smart Grid functionalities and introducing other ancillary services integrated into the RES.	Oct 2010 - Dec 2013	DK	Smart Meter and AMI Integrated System Grid Automation Distribution
16	Automation and security of Supply	Not available	The company in focus has established DSO – Distribution – Control – Surveillance at individual stations. On these 10/0.4 kV stations there is full remote control, with commands, reports, metering and alarms, which in a fault situation makes it possible to quickly gain an overview of the grid status for the medium-voltage grid.	Not available	DK	Grid Automation Distribution
17	Automation systems for Demand Response, ForskEL	Danish Energy Industries Federation (DK)	More than 500 households with electric heating participated in a demonstration project about demand response. Participants paid for electricity based on spot prices. The groups notified of the next day's prices by E-mail and/or SMS did not change their demand pattern.	Mar 2006 - Jul 2009	DK	Smart Meter and AMI Integrated System
18	BeAware	Teknillinen Korkeakoulu (FI)	BeAware studies how ubiquitous information can turn energy consumers into active players by developing: -An open and capillary infrastructure sensing wirelessly energy consumption at appliance level in the home; -Ambient and mobile interaction to integrate energy use profiles into users' everyday life; -Value added service platforms and models where consumers can act on ubiquitous energy information and energy producers and other stakeholders gain new business opportunities.	May 2010 -May 2013	FI IT SE	Home application - Customer Behavior
19	BeyWatch	Telefonica Investigacion y Desarrollo SA, (ES)	BeyWatch will develop an energy-aware and user-centric solution, able to provide intelligent energy monitoring/control and power demand balancing at home/building & neighborhood level.	Dec 2008- May 2011	FR UK SI EL IT ES	Home application - Customer Behavior

	Project name	Organization name	Brief project description	Period	Country*	Project category
20	Belgium east loop active network management	Ores (BE) Elia (BE)	The project aims at designing an active network solution based on the power systems analysis. It will define principles of access for generators to perform a curtailment assessment that will help to estimate how often limits are challenged. This will lead to the generators modulation necessary to keep power flows within limits. The project will provide guidelines for the active network solution deployment as well as a cost estimation.	Sept 2010 - Jun 2011	BE	Grid Automation Distribution Grid Automation Transmission
21	Building to Grid (B2G)	Salzburg AG (AT)	In the context of so-called smart grids, buildings are expected to integrate in a cooperative manner and to expose their currently unused flexibility of operations, supported by building automation and information technology.	Jul 2010 - Dec 2013	AT	Home application - Customer Behavior
22	Central Networks Low Carbon Hub - Optimizing renewable energy resources in Lincolnshire	Central Networks UK)	The low Carbon Hub will demonstrate how substantial levels of renewable generation can be connected to a primary distribution network.	Jan 2011-Dec 2014	UK	Grid Automation Distribution Other
23	CET2001 Customer Led Network Revolution	CE Electric (UK)	This project will explore how new tariffs can alter customer behavior, enable networks to respond more flexibly to customers by using advanced voltage control devices, explore ways for networks and smart meters to communicate, monitor 600 intelligent white goods and 14,000 smart meters.	Jan 2011-Dec 2013	UK	Smart Meter and AMI Grid Automation Distribution Home application - Customer Behavior Specific Storage Technology Demonstration
24	Charge stands	SydEnergi, (DSO), (DK)	Gain knowledge of whether it is technically possible and financially/ environmentally advantageous for the customer and the electricity system to offer owners of electrical vehicles an intelligent charging facility comprising possible use of spot electricity agreements, and the choice of charging most cheaply or most greenly.	Jan 2010 - Not available	DK	Smart Meter and AMI Integrated System
25	Charging Infrastructure for Electric Vehicles	Goteborg Energy AB (SE)	The project built and tested approximately 50 charging points, all of them equipped with smart meters enabling sub-metering at user specific level and remote on-off functionality. A one-stop-shop charging offer was tested on the market and further developed within the project. An internal development plan for charging of electrical vehicles was produced.	Jan 2008 - Dec 2010	SE	Integrated System
26	Clyde Gateway	Scottish Power (UK)	To demonstrate the latest smart grid technology and use the learning to develop proposals for wider and larger scale smart grid applications across Glasgow and UK operations.	Apr 2010- Apr 2011	UK	Grid Automation Distribution

	Project name	Organization name	Brief project description	Period	Country*	Project category
27	Concept for Management of the Future Electricity System	Energinet.dk, (TSO), (DK)	To develop and describe a concept for the necessary and sufficient management of the future power system in 2025. The concept description should be at a level that allows a subsequent breakdown in specific projects to an early-stage phased rollout.	Jan 2009 - Dec 2011	DK	Other
28	Consumer to Grid (C2G)	Salzburg AG (AT)	This study investigates the way in which information about potential energy savings is best presented to the consumer in order to reduce energy consumption in the smart-grid.	Jul 2010-Jun2012	AT	Home application - Customer Behavior
29	Consumer web	Vestforsyning A/S (DSO), (DK)	Make consumption data available to consumers in a way that: helps them to understand their own consumption, their consumption pattern and energy consumption in general; motivates them to optimize their consumption; and enables them to achieve energy savings. Gives stronger communication with customers in order to achieve better and faster customer service and more services.	Jan 2010 - Jan 2011	DK	Home application - Customer Behavior Smart Meter and AMI
30	Control and regulation of modern distribution system, ForskEL	Department of Energy Technology- Aalborg University (DK)	The project's objective is to study the effects of load management systems and online real time electricity pricing systems in modern distribution systems and to develop the models, operation and control strategies for such distribution systems and finally to establish the control approach for the systems in contingency situations, i.e. island operation.	Oct 2006 - Dec 2010	DK	Grid Automation Distribution Smart Meter and AMI
31	Cost benefit analysis for the implementation of smart metering with pilot project	Ministry of economy of the Slovak republic (SK)	Primary project goals are to find relevant facts and proofs for which segments of customers the smart metering could be economical.	Jan 2011-Dec 2011	SK	Smart Meter and AMI Home application - Customer Behavior
32	Cryogenic Storage	High view Power Storage (UK)	The project is being run in two phases: Phase 1: the CryoGenset pilot demonstrator has been commissioned for six months and runs on a regular basis exporting electricity to the National Grid. Phase 2: the fully integrated CryoEnergy System.	Apr 2010-Apr 2011	UK	Specific Storage Technology Demonstration
33	Customer Value Proposition Smart Grid (KEL)	Goteborg Energy AB (SE)	The company is undergoing an extensive change process going from partly manual to fully automated processes for energy consumption measurement on hourly basis and invoicing based on this. The project concerns the launching of hourly measuring and new hourly based tariffs.	Jan 2008 - Dec 2012	SE	Smart Meter and AMI Home application - Customer Behavior
34	Cyprus Smart metering demo	Electricity Authority of Cyprus (EAC), (CY)	Installation of 3000 smart meters with the required infrastructure for full functionality evaluation of the best practice approach for full roll out.	Jul 2010 - Jul 2012	CY	Smart Meter and AMI
35	DA (Distribution Automation)	Enexis BV (NL)	Building an integrated architecture (i.c.: interaction between business-processes, information-architecture and primary network layout) to maximize Enexis' MV-grid performance (10-20 kV).	2007-2010	NL	Grid Automation Distribution

	Project name	Organization name	Brief project description	Period	Country*	Project category
36	Data Exchange	National Grid (UK)	The Data Exchange was established to identify an enduring solution to the interaction between the STC and Grid Code regarding the exchange of User data.	Apr 2010-Apr 2011	UK	Grid Automation Transmission
37	DCN4TSO	Elektro-Slovenija (TSO), (SI)	DCN system will enable smart protection, metering, energy management, automation and data exchange with other European TSO using standard protocols.	2004	SI	Grid Automation Transmission Integrated System
38	DataHub project	Energinet.dk, (TSO), (DK)	A more free competition in the Danish electricity market, easier access to information, and more transparency for consumers who choose to switch supplier, a desire for more standardized communication between players on the Danish electricity market.	Apr 2009 - Apr 2012	DK	Smart Meter and AMI
39	Decentralized customer-level under frequency load shed-ding in Switzerland	University of Applied Sciences, Northwestern Switzer-land (CH) Swiss Federal Institute of Technology, Zurich (CH)	The project focuses on a smart demand side management of household consumers. Modern communication technology enables the management of large groups of distributed loads under a single innovative control schemes to use the flexibility of electrical loads for power system purposes.	Sept 2010-Feb 2012	CH	Integrated System
40	Demand response medium sized industry consumers	Danish Technological Institute, (DK)	To investigate the possibility of introducing flexible electricity demand and regulation power in Danish Industry consumers via a price- and control signal from the supplier of electricity. The aim is to develop a valuable solution for the industry consumers giving them various benefits and afterwards to test the system.	Jan 2009 - Dec 2011	DK	Integrated System
41	DER-IREC 22@Microgrid	GTD Sistemas de Informacion SA (ES)	DER - IREC 22 @ MICROGRID is a research project focused to create products and services around Distributed Energy Resources (DER) and EV. The main goal is to build a platform where research could be done in order to integrate all those components into a new system of energy supply.	Jun 2009 - Nov 2011	ES	Integrated System
42	Development of Early Warning Systems (PMU/WAMS)	Energinet.dk, (TSO), (DK)	The purpose is to develop systems that can monitor the overall power system state and alert system operators and other protection systems for critical situations in the power system.	2006 - 2012	DK	Grid Automation Transmission
43	Development of a Secure, Economic and Environ-mentally friendly Modern Power System	Department of Energy Technology- Aalborg University, (DK)	The project develops a number of new concepts and intelligent approaches for a modern power system which includes renewable energy, storage units, distributed generation, plug-in hybrid electric vehicles.	Jan 2010 - Dec 2014	DK	Smart Meter and AMI Grid Automation Distribution Integrated System

	Project name	Organization name	Brief project description	Period	Country*	Project category
44	DG Demonet Smart LV Grid	Austrian Institute of Technology (AT)	The project aims to enable an efficient and cost effective use of existing grid infrastructures based on a three-step concept: intelligent planning, on-line monitoring and active grid management. Communication-based systems for automatic control concepts for low voltage networks will be developed and evaluated by putting them into practice.	Mar 2011 - Mar 14	AT	Integrated System Grid Automation Distribution Smart Meter and AMI
45	DG Demonetz Validierung	AIT Austria (AT)	The project "DG DemoNet – Smart LV Grid" searches for solutions for an active network operation at the low voltage level. The project develops and evaluates smart planning, monitoring, management and control approaches for the system integration of local energy production and flexible loads in low voltage networks. The project objective is to solve above challenges with acceptable costs regarding investment, maintenance and operation.	Jan 2006 - Feb 2013	AT	Grid Automation Distribution
46	Demonstration project Smart Charging	Enexis (NL)	Test and demonstrate an environment in which commercial market parties are enabled to provide charge services to EV customers in cooperation with EV infrastructure parties and grid operators.	Sept 2010- Dec 2011	NL	Grid Automation Distribution Integrated System Home application - Customer Behavior
47	Distributed connected wind farms	ESB Networks (IE)	This project comprises three independent strands, all with the goal of enabling maximum wind generation penetration on the distribution system.	May 2009 - Apr 2012	IE	Other
48	Distribution System planning for Smart Grids, ForskEL	Risø DTU, (DK)	The purpose of the project is to identify limitations of existing simulation and planning tools for distribution grids, with a particular focus on the challenges imposed by the introduction of Smart Grid technologies.	Mar 2011 - Jul 2012	DK	Other
49	DLC+VIT4IP	Kema Nederland BV (NL)	DLC+VIT4IP will develop, verify and test a high-speed narrow-band power line communications infrastructure using the Internet Protocol (IP) which is capable of supporting existing and extending new and multiple communication applications. These shall include the existing power distribution network for novel services in smart electricity distribution networks such as demand side management, control of distributed generation and customer integration.	Jan 2010 - Jan 2013	DE AT UK NL IT BE IL	Other

	Project name	Organization name	Brief project description	Period	Country*	Project category
50	DSO-pilot project	SydEnergi, (DSO), (DK)	The test will be the basis to better utilization of information from the network, for example. for faster action by mistakes and to reduce the outage. Furthermore it allows for automation by switching on failure.	2009-2010	DK	Smart Meter and AMI
51	DSO-Pilot project - Automatic receipt of short circuiting indicators	Not available	Automatic receipt of short-circuiting indicators from the 10 kV grid ensures rapid information to the duty officer in the event of high-voltage faults.	Jun 2009 - Dec 2010	DK	Smart Meter and AMI
52	Dynamic tariffs	Not available	To investigate the opportunities for and effects of changed tariffs for electricity with the special objective of better integration of renewable energy from, among other things, ever-increasing wind power production.	Jan 2010 - Jun 2010	DK	Other
53	Easy Street	Enexis (NL)	Insight into the workings of technology, incentives and interaction in order to mobilize flexibility from customer's electricity usage.	Jan 2011-Jun 2014	NL	Integrated System Home application - Customer Behavior
54	EcoGrid Denmark, ForskEL	Danish Technological Institute, (DK)	To develop new long term technologies and market solutions for power systems with increased share of distributed generation and renewable energy sources while maintaining the reliability of supply.	May 2007 - Apr 2009	DK	Integrated System Grid Automation Distribution Smart Meter and AMI
55	EcoGrid EU	Energinet.dk, (DK)	To build and demonstrate a complete prototype of the future power system with more than 50% renewable energy. The primary focus is on market integration and inclusion of electricity customers in the building of tomorrows Smart Grid.	Jan 2011 - Dec 2014	DK	Integrated System Grid Automation Distribution Smart Meter and AMI
56	EDISON	Danish Energy Association, (DK)	The project will assess the introduction of electrical vehicles in the Danish electricity system and develop frameworks and technical solutions that enable a more wide-scale demonstration. The solutions must allow the electrical vehicles to be charged intelligently in terms of system stability and bottlenecks in the local electricity grid.	Feb 2009 - Dec 2011	DK	Grid Automation Distribution Smart Meter and AMI
57	E-DeMa	RWE RWN, (DE)	The goal of E-DeMa is to reach more energy benefits and efficiency for electricity generators, municipal utilities, device manufacturers and above all customers.	2009-2014	DE	Integrated System Home application - Customer Behavior

	Project name	Organization name	Brief project description	Period	Country*	Project category
58	E-Energy Project “MeRegio”	EnBW Energie Baden-Württemberg AG (EnBW)(DE)	The Project MeRegio aims to demonstrate that a shift from the present day power supply system to “minimum emission regions” is possible by intelligently combining technical energy management and innovative ICT.	2008-2012	DE	Integrated System
59	eFlex	DONG Energy, (DSO), (DK)	The purpose of eFlex project is to gain experience with mobilization of private customers’ flexible energy consumption, especially from electric cars, electric heating and heat pumps.	2010 - 2011	DK	Grid Automation Distribution Smart Meter and AMI
60	Electrical vehicles impacts on the grids	Ores (BE)	Measurements and models of impact of electrical vehicles slow and fast charging on the Ores grid.	Sept 2010 - Dec 2011	BE	Grid Automation Distribution Home application - Customer Behavior
61	Electricity demand as frequency controlled re-serves, ENS	CET-DTU, (DK)	Through 11 work packages, including hardware, design, development, laboratory test, practical implementation, data analyses, etc., a technology will be developed in which the electricity consumption will be used as a frequency-controlled reserve (DFR).	Apr 2009 - Mar 2012	DK	Integrated System
62	Electricity demand as frequency controlled re-serves, ForskEL	CET-DTU, (DK)	The project developed technology for demand frequency controlled reserve (DFR) implementation, a system that automatically stops or starts electricity consumption in response to system frequency variations.	Apr 2006 - Jun 2008	DK	Integrated System
63	Electricity storage for short term power system service	Materials Research Division at Riso DTU, (DK)	To evaluate and compare – technically and economically – the available options for using dedicated electricity storage units to provide short term system services at transmission system level in the Danish power system.	Mar 2010 - Dec 2010	DK	Specific Storage Technology Demonstration
64	E-mobility	Enel (IT) Daimler (DE)	E-mobility Italy enables the diffusion and the use of electric vehicles, with state of the art recharging technologies, thanks to ad-hoc development of recharging infrastructure, offering intelligent and secure services and respecting the environment. Smart® Electric vehicles will be provided to 100 customers and 400 recharging stations (300 public stations and 100 home stations) will be installed by Enel in Rome, Milan and Pisa. The new charging points will leverage Enel’s technology, including the Enel smart meter as a kernel for providing all certified metering functionalities and guaranteeing uniformity with regard to data acquisition and final customer billing management.	Dec 2008 - Dec 2013	IT	Integrated System

	Project name	Organization name	Brief project description	Period	Country*	Project category
65	Elforsk Smart grid programme	Elforsk AB (SE)	Elforsk Smart Grid Program is driven as a national programmer for four years with financing and participating from Swedish utilities and other companies. A common steering group takes decision for each project/ sub project in the program. The normal delivery from a project will be an open report available for all participants and normally also put on internet as a public document. The program will also interact with other large pilot projects as Stockholm Royal Seaport with Fortum and ABB and Gotland Smart Grid project with Vattenfall and ABB.	Jan 2011 - Dec 2014	SE	Smart Meter and AMI Grid Automation Transmission Grid Automation Distribution Integrated System Home application - Customer Behavior Specific Storage Technology Demonstration Other
66	Electricity for road transport, flexible power sys-tems and wind power	Risø DTU, (DK)	The project aims to analyze the interaction between the electricity/ CHP industry and the trans-port industry in a situation of increased use of electric cars and plug-in hybrid cars. The project focuses on all the technical aspects in the chain: the status of the electric car, testing of hybrid cars in a local electricity grid, connection points as well as the load and capacity requirements of the electricity grid.	Jan 2008 - Jan 2011	DK	Grid Automation Distribution Integrated System
67	E-mobility	ELM -ÉMÁSZ Nyrt., (HU)	To get feed back about customer's expectations for e vehicles and charging infrastructure. To get information about charging behavior and load profiles. Analysis of requirements of charging infrastructure. Defining home charging infrastructure, and developing new tariffs.	Not Available	HU	Integrated System Specific Storage Technology Demonstration
68	EMPORA 1 + 2 - E-Mobile Power Austria	VERBUND AG (AT)	The emporA projects bring together automobile industry, infrastructure technology, and energy supply sectors in order to achieve a complete system for electric mobility in a user-oriented and international coordinated way.	Jan 2010 – Jun 2014	AT	Grid Automation Distribution Integrated System Specific Storage Technology Demonstration
69	ENERGOZ	Institute of Technology, Slovak Academy of Sciences, Bratislava, (SK)	Applied research in the field of efficient production, use and storage of energy from renewable sources. Maximizing the socio - economic effect of the research in the field of renewable energy.	May 2010- May 2013	SK	Integrated System

	Project name	Organization name	Brief project description	Period	Country*	Project category
70	Energy @ home	Indesit (IT) Enel Distribuzione (IT) Telecom Italia (IT) Electrolux (IT)	“Energy@Home” project aims to develop a system in which “smart appliances” can manage themselves by adjusting power consumption depending on power supply and prices, or in order to avoid overloads within the house. In addition Energy@Home provides information to the user, such as power consumption of appliances, hourly cost of energy, green level of the energy being supplied; this information is made available on the user’s PC, mobile or on the display of the appliance.	Jan 2009 - Dec 2011	IT	Home application - Customer Behavior Smart Meter and AMI Integrated System
71	Energy Forecast, ForskEL	Rambøll, (DK)	The purpose of this project is to address the following barriers: 1. Lack of suitable power supply agreements, meeting both the clients’ demand for cost stability and - at the same time - encourages a demand response. 2. Lack of information and awareness about the possibilities and opportunities of demand response.	Feb 2007 - Mar 2010	DK	Smart Meter and AMI Home application - Customer Behavior
72	E-price	Eindhoven University of Technology (NL)	This project proposes an advanced ICT and control framework for ancillary services (reserve capacity) which allows a more intelligent solution by giving consumers and producers clear, real-time financial incentives to adapt their consumption/production according to the actual needs of the power system. This demand-side management is being made possible by the large scale introduction of Smart meters.	Feb 2010 - Feb 2013	NL IT CH	Grid Automation Transmission Grid Automation Distribution
73	ESB Smart Meter Projects	Electricity Supply Board - Networks (IE)	The project aims at: - assessing the impact of Time of Use pricing and billing/information stimuli on the Customer Behavior; - assessing the available technologies for AMI roll out in an Irish context. The above will input to the cost benefit analysis for the full roll out of AMI in Ireland.	Jan 2009 - Apr 2011	IE	Smart Meter and AMI Home application - Customer Behavior
74	ESTER, Enel integrated System for TEsts on stoRage	ENEL, (IT)	Not available	Apr 2009 - Apr 2013	IT	Specific Storage Technology Demonstration
75	E-telligence	EWE AG (DE)	The idea behind eTelligence is the intelligent system integration of electricity generation and consumption. To this aim, the project will develop and field-tests: • a regional market place for electricity; • feedback systems, tariffs and incentive programs; • power generation and demand side control systems; • modern ICT and international standards.	Nov 2009 - Oct 2012	DE	Integrated System Smart Meter and AMI Home application - Customer Behavior

	Project name	Organization name	Brief project description	Period	Country*	Project category
76	ETM (Distribution Network Automation on 10 kV cable line stations)	ELMŰ Hálózati Kft. (HU)	Nearly 760 pieces of 10 kV switching stations (on cable networks) will be equipped by RTUs, to provide remote observability and remote control. The communication (connection) is established via GSM network.	2009-2013	HU	Grid Automation Distribution
77	EU-DEEP	GDF Suez (FR)	The project brings together eight European energy utilities and aims at removing most of the technical and non-technical barriers that prevent a massive deployment of distributed energy resources (DER) in Europe. In partnership with manufacturers, research organizations, professionals, national agencies and a bank, they implemented a demand-pull rather than technology-push approach. This new approach provided three tentative "fast-tracks options" to speed up the large-scale implementation of DER in Europe, by defining three client portfolios in various market segments which could benefit from DER solutions, and by fostering the R&D required to adapt DER technologies to the demands of these segments.	Jan 2004 - Jun 2009	FR EL UK DE BE ES SE PL LV AT HU IT FI CY CZ TR	Integrated System
78	EVCOM	Energinet.dk, (TSO), (DK)	The primary purpose is to establish a concept for electric vehicles and their communication with the power system. The concept disseminated to the standardization work and to relevant stakeholders.	Jan 2008 - Dec 2010	DK	Smart Meter and AMI Integrated System

	Project name	Organization name	Brief project description	Period	Country*	Project category
79	EV Network integration	ESB Networks (IE)	This project will take two typical LV (220V) circuits, one urban and one rural, and will examine in detail through modeling and through demonstration, the impact of EV's on the network.	Dec 2009 - Dec 2012	IE	Home application - Customer Behavior Specific Storage Technology Demonstration Other
80	EWIS - European wind integration study	ELIA SYSTEM OPERATOR SA (BE)	The project aims to work with all the relevant stakeholders especially representatives of wind generation developers. The study will use results from detailed network and market models of the European transmission system for scenarios representing immediate and longer-term needs. The recommendations will be aimed at developing, where possible and appropriate, common European solutions to wind integration challenges.	Jun 2007-Oct 2009	BE AT DE FR PT ES PL UK EL IE DK CZ NL	Other
81	ewz-Studie Smart Metering	ewz - Elektrizitätswerk der Stadt Zürich (CH)	Conducting a field experiment to provide basic data for decision making, whether or not to roll out home applications.	Jul 2010-Dec 2012	CH	Home application - Customer Behavior

	Project name	Organization name	Brief project description	Period	Country*	Project category
82	Fenix	Iberdrola Distribucion (ES)	The objective of FENIX is to boost DER (Distributed Energy Resources) by maximizing their contribution to the electric power system, through aggregation into Large Scale Virtual Power Plants (LSVPP) and decentralized management. The project is organized in three phases: § Analysis of the DER contribution to the electrical system, assessed in two future scenarios (Northern and Southern) with realistic DER penetration; § Development of a layered communication and control solution validated for a comprehensive set of network use cases , including normal and abnormal operation, as well as recommendations to adapt international power standards; § Validation through 2 large field deployments, one focused on domestic CHP aggregation, and the second aggregating large DER in LSVPPs (wind farms, industrial cogeneration), integrated with global network management and markets.	Oct 05 - Oct 2009	ES UK SI AT DE NL FR RO	Integrated System
83	Fieldtrail Mobile Smart Grid	Enexis (NL)	Demonstrate an earlier tested proof-of-concept (PoC) for demand response with one EV on multiple EVs and charge spots in one location based on individual driver demands.	Apr 2010- Apr 2011	NL	Grid Automation Distribution Integrated System
84	Flexcom, ForskEL	Risø DTU, (DK)	The project aims at producing a conceptual framework for the unified and extensible representation and exchange of power system information and data, it will focus on concept design and proof-of-concept testing, to provide input to the existing standardization effort.	Jun 2008 - May 2010	DK	Grid Automation Distribution
85	Flex power - perspectives of indirect power system control through dynamic power price	EA energianalyse, (DK)	The aim of the project is to develop, test, analyze perspectives of, identify challenges by, evaluate and recommend on methodologies to use dynamic, broadcasted, real-time power price's) for indirect control of the individual power flow of many, small, intelligent and controllable power units in the power system.	Jun 2010 - Jun 2013	DK	Integrated System Smart Meter and AMI Grid Automation Distribution
86	From wind power to heat pumps	Energinet.dk, (TSO), (DK)	Tto control 300 intelligent heat pumps as if they were one big energy storage facility capable of storing electricity as heat.	Nov 2009 - Dec 2011	DK	Integrated System Smart Meter and AMI

	Project name	Organization name	Brief project description	Period	Country*	Project category
87	G4V - Grid for Vehicles	RWE RHEINLAND WESTFALEN NETZ AG (DE)	The project of the G4V consortium will generate fast and openly available results: an analytical framework to evaluate the impact of a large scale introduction on the grid infrastructure and a visionary "road map" for the year 2020 and beyond.	Jan 2010 - Jun 2011	ES PT NL FR DE SE IT UK	Other
88	GAD	Iberdrola Distribucion (ES)	The first aim of the GAD Demand Side Management Project is to optimize electrical energy consumption and its associated costs at domestic level, while meeting consumer needs and maintaining quality standards.	Jan 2007 - Dec 2010	ES	Smart Meter and AMI Integrated System Home application - Customer Behavior
89	Generic virtual power plant for optimized micro CHP operation and integration	CET-DTU, (DK)	To develop, test, validate and evaluate a novel control architecture for optimized operation and seamless integration of micro CHP based on a generic virtual power plant (VPP) concept. The concept shall provide a foundation for future operation and integration of micro CHP.	Sept 2007 - Dec 2010	DK	Smart Meter and AMI Grid Automation Distribution
90	Grid4EU	ERDF (FR)	Grid4EU is led by a group of European DSOs and aims at testing in real size some innovative system concepts and technologies in order to highlight and help to remove some of the barriers to the smart grids deployment (technical, economic, societal, environmental or regulatory). It focuses on how DSOs can dynamically manage electricity supply and demand, which is crucial for integration of large amounts of renewable energy, and empowers consumers to become active participants in their energy choices.	Apr 2011 - Apr 15	DE SE ES IT CZ FR	Integrated System

	Project name	Organization name	Brief project description	Period	Country*	Project category
91	Grid-integration of Electricity Storage	Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V. (FhG), (DE)	Not available	Apr 2009 - Mar 2011	DE	Integrated System
92	Grid Integration of Offshore Windparks	Fraunhofer-Institut für Windenergie und Energiesystemtechnik (IWES), (DE)	With the WCMS the scattered wind farms have been combined in to a cluster and the control room of the relevant network operator is controlled centrally. While the wind farm cluster management system, provides calculus for the forecasting software wind power management system using artificial neural networks based on weather forecasts.	Jul 2008-Jun 2011	DE	Integrated System
93	GROW-DERS Demonstration of Grid Connected Electricity Systems	KEMA (NL)	The GROW-DERS project (Grid Reliability and Operability with Distributed Generation using Flexible Storage) investigates the implementation of (transportable) distributed storage systems in the networks.	Jul 2009 - Jul 2011	FR DE ES NL	Specific Storage Technology Demonstration
94	Harz.EE-Mobility	University Magdeburg (DE)	The Harz.EE-mobility project aims to harness as much of this renewable energy as possible to enhance passenger mobility. By doing so, the project also aims to ensure the stability of energy networks, to boost economic performance, and to foster energy security and climate protection.	Aug 2009-Jul 2011	DE	Integrated System Home application - Customer Behavior
95	Heat Pumps as an active tool in the energy supply system, ForskEL	Danish Technological Institute, (DK)	Heat pumps will provide flexibility due to the possibility to either increase, decrease or interrupt the power consumption. The project will deal with the ability of heat pumps to operate in so-called Virtual Power Plants, to deliver regulating power and to react on spot-market electricity prices.	Apr 2010 - Jul 2012	DK	Integrated System
96	HiperDNO	Brunel University UK)	The aim of this research project is to develop a new generation of distribution network management systems that exploits novel near to real-time HPC solutions with inherent security and intelligent communications for smart distribution network operation and management. Cost effective scalable HPC solutions will be developed and initially demonstrated for realistic distribution network data traffic and management scenarios via off-line field trials involving several distribution network owners and operators.	Feb 2010 - Jan 2013	SI ES UK FR DE IL	Grid Automation Distribution

	Project name	Organization name	Brief project description	Period	Country*	Project category
97	HiT	Salzburg AG (AT)	A demonstration building is to be planned and constructed as flagship project, in order to investigate the possibilities and benefits of Smart Grids in connection with buildings, which should then be brought to the attention of the broad public to make this topic visible and concrete.	Jan 2008 - Jan 2011	AT	Integrated System
98	Hydrogen - Sotavento projects	Gas Natural Fenosa (ES)	The main goal is to demonstrate a wind power management system based on H_2. The installation presented here is one of the largest global capacities, where hydrogen is used in the energy management of the production of a wind farm.	2005-2011	ES	Specific Storage Technology Demonstration Integrated System
99	ICOEUR	TECHNISCHE UNIVERSITAET DORTMUND (DE)	The development and prototypically implementation of new methods and tools is the major goal of the ICOEUR project. New technologies like Wide Area Monitoring, Control and Protection as well as advanced network controllers (FACTS) and HVDC systems will be considered. The project will investigate smart interconnection between continental Europe and Russian systems.	Jan 2009- Dec 2011	IT BE EE SI LV SE UK CH RU TR	Grid Automation Transmission
100	IMPROSUME - The Impact of Prosumers in a Smart Grid based Energy Market	Inkubator Halden, Norwegian Center of Expertise for Energy and Emission Trading (NO)	IMPROSUME will establish a better understanding of the prosumer's role in the future power market supported by a Smart Grid and associated technologies. The project will address stimuli that are likely to motion consumers to take an active role in the market also as suppliers.	Oct 2010 - Oct 2011	NO CH DK	Other Integrated System Other

	Project name	Organization name	Brief project description	Period	Country*	Project category
101	Increased energy supply flexibility and efficiency by using decentralized heat pumps in CHP stations	Danish Technological Institute (DTU), (DK)	The project demonstrates the newly developed heat pump technology in full scale at two decentralized CHP stations. Furthermore, a number of ideas concerning the integration of compression heat pumps in the energy system will be tested via simulation models and also in practice. Finally, heat pumps will be investigated in connection with reduction of grid loss in district heating (20-40%) via ultra-cold district heating.	Feb 2007 - Dec 2010	DK	Integrated System
102	Information and education of the future power consumer, ForskEL	Østkraft Holding A/S, (DSO), (DK)	This project focuses on customer behavior and what actions are needed to inform the customer. The project will result in brochures, a new energy consultancy service and education of teenagers following a youth education programs.	Jan 2011 - Dec 2014	DK	Home application - Customer Behavior
103	Information from the electricity grid - remote reading	Not available	The remote reading project in addition to consumption data also makes it possible to retrieve information on consumption patterns, loads, voltage variations. These are all related initiatives to achieve smart grid solutions on the low-voltage grid.	Not available	DK	Smart Meter and AMI
104	INOVGRID	EDP Distribucao SA (PT)	INOVGRID aims at replacing the current LV meters with electronic devices called Energy Boxes (EB), using AMM (Automated Meter Management) standards. These EB are integrated in an automated third generation electrical grid (smart grid) in which network devices are placed (DTC) that will manage the EB through new TI/SI solutions by aggregating the gathered information and providing new services to consumers.	2007 - 2011	PT	Integrated System Home application - Customer Behavior
105	Installation of remotely read electricity meters	Not available	Support for the business foundation of the company, and for meeting tomorrow's requirements for settlement and visualization of electricity consumption to consumers. The objectives are: precondition for the introduction and settlement of intelligent solutions in the electricity system of the future.	2005 - 2010	DK	Smart Meter and AMI
106	INTEGRAL	ECN, Energy research Centre of the Netherlands (NL)	The INTEGRAL project aims to build and demonstrate an industry-quality reference solution for DER aggregation-level control and coordination, based on commonly available ICT components, standards, and platforms.	2009-2010	NL ES FR	Integrated System
107	Integrated Utilities Business Systems	Enemalta Corporation and Water Services Corporation, (MT)	Replacement of 250,000 meters with smart meters and implementation of remote management. SCADA for voltage levels 132kV, and 33kV. Reengineering of the utilities processes.	Sept 2008 - Sept 2013	MT	Smart Meter and AMI Grid Automation Transmission

	Project name	Organization name	Brief project description	Period	Country*	Project category
108	Integration and management of wind power in the Danish electricity system, ForskEL	Department of Energy Technology–Aalborg University (DK)	The project establishes a new model of the Danish electricity system in the form of two buses, to which new models of load and production units are connected in the form of centralized and local power plants, onshore and offshore wind turbines and grid connections to Norway, Sweden and Germany.	2007 - Jun 2009	DK	Integrated System
109	Intelligent Energy Management	Linz Strom Netz GmbH, (AT)	Preparation of Linz Strom to fulfill future energy policy.	2008-2020	AT	Smart Meter and AMI Home application - Customer Behavior
110	Intelligent Remote Control for Heat Pumps, ForskEL	Nordjysk Elhandel A/S, (DK)	The project will develop and demonstrate an intelligent remote control system for individual heating pumps, enabling the balance responsible party to plan consumption and deliver regulatory power, internal balancing and possibly primary reserves.	Apr 2010 - Mar 2011	DK	Integrated System
111	Interactive meters, activating price flexible power consumption, ForskEL	DONG Energy A/S, (DK)	It is technically possible to manage and activate the potential for flexible electricity consumption in the segment of large office blocks and public buildings.	Jan 2006 - Jun 2009	DK	Smart Meter and AMI Integrated System
112	Internet of Energy	SINTEF (NO)	The objective of Internet of Energy (IoE) is to develop hardware, software and middleware for seamless, secure connectivity and interoperability achieved by connecting the Internet with the energy grids. The project will evaluate and develop the needed ICT for the efficient implementation in future smart grid structures.	Not available	NO AT DE FI IT NL ES FR CZ BE UK	Integrated System

	Project name	Organization name	Brief project description	Period	Country*	Project category
113	Introduction of emergency Demand Side Response (DSR) programs	PSE Operator S.A.(PL)	The main goal of the pilot project is to gain practical experience of the functioning of emergency DSR programs in Smart Grid/smart Meters environment. This experience will be used to develop the target DSR programs.	Jan 2011-Mar 2012	PL	Integrated System
114	iPower	Risø DTU, (DK)	The goal of the platform is to contribute to the development of an intelligent and flexible electricity system capable of handling a large part of sustainable electricity production in areas where production varies due to weather conditions (sun, wind etc).	Jan 2011 - Dec 2016	DK	Smart Meter and AMI Grid Automation Distribution Integrated System
115	IRIN	Verein zur Förderung der wissenschaftlichen Forschung (DE)	The research project aims to develop the institutional framework that guides efficient and effective network development towards smart grids.	Dec 2009-May 2011	DE	Other
116	Isolves PSSA-M	Austrian Institute of Technology (AT)	The objective of the project is to define and develop the required technical foundations to enable an increasing number of distributed energy feed-in opportunities in LV networks. For this purpose a method is developed to take an instantaneous image of the network, the so-called "Power Snap-Shot Analysis by Meters", and is applied together with adapted smart meters.	Jul 2009 - Jan 2012	AT	Smart Meter and AMI Integrated System
117	Kybernet	INEA d.o.o. (SL)	The project objective is the development of a system prototype for control of industrial loads and dispersed electrical power plants on a distribution electrical grid.	Jan 2009 - Jan 2011	SI	Grid Automation Distribution
118	Large-scale demonstration of charging of electric vehicles, ForskEL	ChoosEV A/S, (DK)	Developing of ChoosCOM for intelligent charging and communication with electric cars and is test it by 2400 families in 300 EVs. Main investigation is whether it is possible to move the charge of EVs to a more production and environmental friendly time – and is the EV owner interested in it.	Jan 2011 - Dec 2013	DK	Smart Meter and AMI Integrated System
119	LASTBEG - Large Scale Tool for Power Balancing in Electric Grid	NANOTECH SAS AIX EN PROVENCE (FR)	This project will demonstrate an optimization of renewable energy supplies (RES), primarily wind energy sourced onshore and offshore, with an existing pumped storage power plant (PSPP). It will integrate smart meters with power demand and supply forecasting to enable consistency of power supply in a small European country (Lithuania). The lessons learnt from this demonstration project will be disseminate directly to the participants in this project and indirectly through them to major global Transmission System Operators (TSOs), ensuring a two way exchange of best practice. This work will therefore enable a greater penetration of RES as part of the drive to meet the EC's 20:20:20 objectives.	Jan 2009-Oct 2009	FR LT UK DE ES HU	Integrated System

	Project name	Organization name	Brief project description	Period	Country*	Project category
120	LINEAR	VITO (BE)	LINEAR project is a first crucial step in the transition towards smart grids in Flanders. The project focuses on the realization of a technological and implementation breakthrough by innovative technological research and a large scale pilot in a residential area. This will be achieved in close collaboration with industrial partners and associated Flemish innovation platforms. Scope of the project: installing of distributed energy sources and load management at 1000 clients within the smart metering project in Hombeek and Leest.	2011-2014	BE	Integrated System
121	Low Carbon London – A Learning Journey	UK Power Networks (formerly EDF Energy Networks), (UK)	This project will implement new tariffs for EV's, set up a learning laboratory at Imperial College London to test how large scale low carbon technologies impact on networks, Install and monitor 5,000 smart meters and monitor EV charging patterns. An integrated, large-scale trial of the end-to-end electricity supply chain. Cumulative CO_2 savings of 0.6 billion tons between 2011 and 2050. In financial terms, the carbon benefits from a national rollout would give an NPV of £29 billion to 2050. £12 billion NPV of financial benefits for customers up to 2050.	Jan 2011-Jun 2014	UK	Smart Meter and AMI Grid Automation Distribution Integrated System Home application - Customer Behavior Other
122	LV Network Templates for a Low-carbon Future'	Western Power Distribution UK)	Assist in the design and planning of national networks in the future, in order to accommodate large-scale renewable generation and changes in customer utilization.	Jan 2011-Dec 2013	UK	Smart Meter and AMI Other
123	Manage Smart in Smart Grid	Tieto Energy AS(NO)	The project aims to establish understanding and models for efficient energy management for private and public end-users based on AMI/AMS and a smarter power grid.	Jan 2010-Dec 2012	NO	Integrated System Home application - Customer Behavior Smart Meter and AMI
124	Marina power dist. hub with smart-grid functionality, ForskEL	Danish Technological Institute, (DK)	Pilot project will analyze the need for and potential of a marina power distribution hub with smart-grid functionality for the expected increasing share of electrical tour- and pleasure boats in Denmark.	Feb 2011 - Jan 2012	DK	Smart Meter and AMI Integrated System
125	Market Based Demand Response	SINTEF Energy Research, (NO)	The main objectives of the pilot study were to achieve daily load shifting and to explore customer acceptance and load curve impacts of hourly based tariffs and automatic load control schemes.	2005-2008	NO	Smart Meter and AMI Home application - Customer Behavior
126	Matning 2009	Goteborg Energy AB (SE)	The smart metering project at Goteborg Energi includes all customers up to 63A and provides for the deployment of 265 000 smart meters.	Mar 2006 - Jul 2010	SE	Smart Meter and AMI

	Project name	Organization name	Brief project description	Period	Country*	Project category
127	MERGE - Mobile Energy Resources in Grids of Electricity	PUBLIC POWER CORPORATION S.A. (EL)	Electric power systems are facing a major new challenge: future massive integration in the electric grid of electric plug-in vehicles (EV). The project will address comprehensively the impact of electric plug-in vehicles (EV) presence regarding steady state operation, intermittent RES integration, system stability and dynamic behavior, system restoration, regulatory aspects and market arrangements.	Jan 2010 - Dec 2011	ES IE EL DE BE NO UK PT	Integrated System
128	Micro-Request-Based Aggregation, Forecasting and Scheduling of Energy Demand, Supply and Distribution (MIRACLE)	SAP AG (DE)	The project's main goal is to develop a concept for flex-offers that specify electricity demand and supply which is flexible in time and amount and an infrastructural approach to process lots of these flex-offers issued by small consumers and producers in near real-time. The possibility to shift demand within the mass of households developed within the MIRACLE project will allow for a higher share of fluctuating renewable energy sources in the energy mix on the grid and reduce the peak demand. We expect that the share of RES can be increased by 5% and that the peak demand can be reduced by 8-9% (but at least by 5%) for the total grid. We will furthermore reduce the mean time between transactions, which will result in more stability of the energy grid but also in reduction of costs of BRPs, by reducing the difference between their planned and actual electricity schedules.	Jan 2010 - Jan 2013	EL DE PT NL DK CH IT ES FR PL MK UK	Integrated System

	Project name	Organization name	Brief project description	Period	Country*	Project category
129	Mini Berlin powered by Vattenfall	Vattenfall Europe Innovation GmbH (DE)	The functional demonstration MINI E Berlin powered by Vattenfall is a co-operation between Vattenfall and BMW. There are 50 MINI E (35 kWh, range ~ 180-200 km, max speed 152 km/h) mostly used by Berlin residents but also in fleet applications.	Dec 2008 - Nov 2010	DE	Integrated System Home application - Customer Behavior
130	Model City Manheim	MW Energie (DE)	The project concentrates on an urban conurbation in which renewable and decentralized sources of energy are used to a large extent. Within the framework of the E-Energy project, a representative large-scale trial is being conducted both in Manheim and in Dresden to demonstrate the project can be applied and translated to other regions.	Nov 2008 - Oct 2012	DE	Integrated System
131	More Microgrids	ICCS/National Technical University of Athens (EL)	The aims of this Test Facility is to: • Test centralized and decentralized control strategies in grid interconnected mode; • Test communication protocols and components including aspects related to energy trading; • A control and monitoring system built around IEC 61850 standard designed and prototyped; • Control strategies resulting from agent software to make use of these control and monitoring functions; • Development of intelligent modules embedding the required functions to allow a full integration of each generating/load unit into the system.	Jan 2006 - Dec 2009	ES EL PT NL IT DK MK DE	Integrated System Smart Meter and AMI Grid Automation Distribution Home application - Customer Behavior
132	More PV2Grid	Fronius International GmbH (AT)	The project aims at developing and validating concepts for controlling the voltage with photovoltaic installations. The concepts allow numerous distributed PV-systems to contribute to voltage-keeping by autonomous adjustment of power and reactive power injection without super ordinate system and communication technology. These concepts shall ultimately allow the cost-effective integration of a large number of photovoltaic generators.	Mar 2010 - Mar 2013	AT	Integrated System
133	"Mülheim zählt" Smart Meter Programm	RWE DAG (DE)	RWE DAG installing up to 100.000 smart meters in the city of Mülheim in households.	2009-2011	DE	Smart Meter and AMI
134	NET-ELAN	Forschungszentrum Jülich GmbH (DE)	This project aims to answer the question of whether and how it can be in terms of a multi-sector system solution, a number of vehicles with electrified drive components used both useful as a distributed energy storage in the electric network and the consumer side demand management.	Dec 2008- Nov 2011	DE	Specific Storage Technology Demonstration Home application - Customer Behavior Integrated System

	Project name	Organization name	Brief project description	Period	Country*	Project category
135	Network design and management in a smart city with large deployment of DER	Ores (BE)	The project aims at integrating all smart technologies on the distribution grid of a given city and at defining new network design rules and management principles definition.	Dec 2010 - not available	BE	Smart Meter and AMI Integrated System Grid Automation Distribution Home application - Customer Behavior Specific Storage Technology Demonstration
136	Netze der Stromversorgung der Zukunft	RWE DAG (DE)	One of the most promising investigated grid structures will be demonstrated in a typical rural MV grid, which has to cope with a massive implementation of RES. Several technologies, like electronic sub-stations, automatic tap changer, the usage of the flexibility of an biogas plant etc. will be tested and demonstrated.	2008-2011	DE	Grid Automation Distribution
137	NextGen	CET-DTU, (DK)	To contribute to the development of next generation communication system for system integration of distributed generation (NextGen) based on the new international IEC61850-family of open standards developed in these years.	Apr 2006 -Jun 2010	DK	Smart Meter and AMI Grid Automation Distribution
138	NIGHT WIND	NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUUR-WETENSCHAPPELIJK ONDERZOEK (NL)	The Night Wind project proposes to design grid architectures for Wind Power Production combined with Energy Storage means of load management of Refrigerated Warehouses (Cold Stores), Refrigerated Warehouses are constant power users, day and night.	Jul 2006-Jun 2008	DK BG ES NL	Other
139	Open meter	Iberdrola (ES)	The main objective of the OPEN meter project is to specify a comprehensive set of open and public standards for Advanced Metering Infrastructure (AMI) supporting multi commodities (Electricity, Gas, Water and Heat), based on the agreement of the most relevant stakeholders in the area.	Jan 2009 - Jun 2011	ES IT DE FR NL CH BE	Smart Meter and AMI

	Project name	Organization name	Brief project description	Period	Country*	Project category
140	Open Node	Atos Origin Sae (ES)	OpenNode project is focused on the electrical distribution grid operation and explores answers on the three challenges introduced: • How to improve the distribution grid monitoring to cope with volatile states in the grid • How to integrate the "smart" substation automation devices to increase the efficiency of the distribution grid • How to interoperate with the different roles e.g. operation of the smart meters, power and grid operation	Jan 2010 - Jun 2012	ES FR PT NL DE AT	Integrated System
141	Opportunities to use Compressed air energy storage for storage of electricity in the electricity system of the future	DTU Mechanical Engineering, (DK)	The project objective is to determine whether Compressed Air Energy Storage (CAES) will be a sound alternative in financial and energy terms to other types of electricity storage (hydrogen, battery, pumped storage power stations abroad) and regulation methods in connection with electricity overflow and other regulation needs in the electricity system of the future.	Dec 2005 - Dec 2010	DK	Specific Storage Technology Demonstration
142	Optimal Power Network design and Operation	Norwegian University of Science and Technology (NO)	Improved power system stability, planning and operation, Training of PhD's, Improved understanding of electricity market design to minimize operational losses.	Jul 2011 - Jun 2014	NO	Grid Automation Transmission
143	OPTIMATE	TECHNOFI – (FR)	The project aims at developing a numerical test platform to analyze and to validate new market designs which may allow integrating massive flexible generation dispersed in several regional power markets.	2009-2012	FR DE ES BE DK IT UK	Integrated System

	Project name	Organization name	Brief project description	Period	Country*	Project category
144	PEGASE - Pan European Grid Advanced Simulation and state Estimation	TRACTEBEL ENGINEERING S.A. (BE)	PEGASE is a four year project dealing with the High and Extra High Voltage transmission and sub-transmission networks in Europe (designated as ETN) and implemented by a Consortium composed of 20 Partners including TSOs, expert companies and leading research centre's in power system analysis and applied mathematics. Its overall objectives are to define the most appropriate state estimation, optimization and simulation frameworks, their performance and dataflow requirements to achieve an integrated security analysis and control of the ETN.	Jul 2008-Jun 2012	BE DE ES LT FR HR RU UK TR PT BA LV RO NL	Other
145	Pilot Linky	ERDF (FR)	Linky pilot is an AMM pilot. It consists in the creation of a logic controller ("Linky IS") and in the experimental deployment of 300,000 meters + 5,000 concentrators. The creation of the entire system is based upon a PLC LAN and a GPRS WAN. Both meters and concentrators are designed to be interoperable.	2007 - 2011	FR	Smart Meter and AMI
146	Plugged in Places	Various UK)	The Plugged-in Places will provide the charge points to support 'Plug-in Cars' - pure electric vehicle (EVs), plug-in hybrid electric vehicles (PHEVs) and hydrogen cars. They are intended to demonstrate how electric vehicle charging works in practice in a range of different settings – urban, suburban and regional – as well as testing innovative technologies such as rapid charging, inductive charging and battery swap.	Apr 2010-Apr 2013	UK	Home application - Customer Behavior

	Project name	Organization name	Brief project description	Period	Country*	Project category
147	Plug n' play-concept for intelligent indeklimastyring, ForskEL	Neogrid Technologies, (DK)	A concept for energy efficient control of air-air heat pumps and electric storage water heaters with focus on indoor climate, energy savings and demand response is developed.	Jan 2011 - Jan 2013	DK	Integrated System Home application - Customer Behavior Specific Storage Technology Demonstration
148	PMU/WAMS target area	Energinet.dk, (TSO), (DK)	The purpose is to develop systems that can monitor the overall power system state and alert system operators and other protection systems about forthcoming critical situations in the power system.	2006 - 2012	DK	Grid Automation Transmission
149	Pilotprojekt Markisches Viertel	Vattenfall Europe Distribution Berlin GmbH (DE)	Vattenfall supports the energy efficiency program in Berlin- Märkisches Viertel with installation of 10.000 smart meters. In Berlin Märkisches Viertel there are more than 10.000 apartments with more than 50.000 residents. The project aims at testing new meter technologies combined with new ICT-systems.	Jan 2010 - Jun 2011	DE	Smart Meter and AMI Home application - Customer Behavior
150	Pilot Smart Metering	Enexis (NL)	Research has been focused on alternative data-com infrastructures, AMI-system performances, standardization of meter requirements, possibilities of firmware upgrades, security & privacy guidelines and measures, mass roll out processes and customer satisfaction.	2007-2010	NL	Smart Meter and AMI
151	Power pit	DONG Energy, (DSO), (DK)	The purpose of the Power Pit project is state estimation in 10 kV network and visualization of results	2007 - 2009	DK	Grid Automation Distribution
152	Price elastic electricity consumption and electricity production in industry	Dansk Energi Analyze a/s (DK)	The project aims at promoting industry's access to price-elastic electricity consumption by creating interest among companies in the opportunity to maximize gains, and making it easier for them to assess their potential with dependence on e.g. the activation payment, and by developing the contractual conditions in the electricity markets.	Mar 2006 - Jun 2010	DK	Integrated System
153	Price elastic electricity consumption as reserve power - a demonstration project in the horticultural sector	DEG Green Team (DK)	The project objective is charting the scale of the realizable potential for price-elastic electricity consumption within the horticultural sector, and demonstration of the technical opportunities and the financial incentive for the individual market gardens to participate in the markets for regulated and reserve power via price-elastic electricity consumption.	Apr 2006 - Jun 2010	DK	Integrated System
154	Proactive participation of wind in the electricity markets, ForskEL	EMD International, (DK)	This project wants to demonstrate that wind turbines themselves may deliver an important part of the balancing tasks needed, thus reducing high unbalance prices and promoting the development of wind energy in Europe.	Jun 2009 - Dec 2010	DK	Integrated System

	Project name	Organization name	Brief project description	Period	Country*	Project category
155	Project AMR	Vattenfall AB (SE)	Echelon's Network Energy Services system provides Vattenfall with an open, bidirectional, and extensible infrastructure that enables a comprehensive range of utility applications that brings benefits to every aspect of their operation, from metering, to customer services, to distribution operations, to value-added services.	2006 - 2009	SE	Smart Meter and AMI
156	Project "Intelligent home"	SEAS-NVE, (DSO) (DK)	The aim is through information to customers to achieve energy saving behavior change by making visible the biggest energy consumers. The project also includes the management of individual components based on defined conditions.	2009-2011	DK	Smart Meter and AMI Home application - Customer Behavior
157	Project "The Island of Fur on the map"	Not available	The project has arisen in cooperation with Skive Municipality. The vision is to make Fur a VEØ (renewable energy island), that is independent of fossil fuels and thereby does not discharge CO_2 emissions to the environment.	Mar 2010 - Mar 2020	DK	Integrated System
158	Prøv1Elbil	Danish Technological Institute (DK)	The purpose of this project is to collect information on driving patterns, needs and user experiences, charging times and patterns and loads on the network.	Jan 2009 - Dec 2012	DK	Integrated System
159	PV-Island Bornholm, ForskEL	EnergiMidt A/S, (DK)	The "PV Island Bornholm" (PVIB) project aims at establishing 5 MWp PV on the island of Born-holm. App. 1MWp of them will be installed during this phase. PVIB will focus on demonstration and further utilization of PV and as such provide unique facilities to test how PV as a fluctuating energy source can be implemented in a future intelligent power system.	Jan 2010 - Dec 2012	DK	Integrated System
160	REALISEGRID	RSE (IT)	The objective of REALISEGRID is to develop a set of criteria, metrics, methods and tools to assess how the transmission infrastructure should be optimally developed to support the achievement of a reliable, competitive and sustainable electricity supply in the European Union (EU).	Sept 2008 - May 2011	IT NL AT FR RU DE UK SI BE	Other

	Project name	Organization name	Brief project description	Period	Country*	Project category
161	Real-time demonstration test and evaluation of Bornholm electricity network with high wind power penetration	CET-DTU, (DK)	Create a research platform, where elements of future the energy system can be tested. Testing can be performed from the laboratory level and up to full scale demonstration on Bornholm.	Oct 2009 - Dec 2012	DK	Smart Meter and AMI Grid Automation Distribution Integrated System
162	Regenerative Modellregion Harz (RegModHarz)	Fraunhofer IWES (DE)	Within this project, grid operators, energy suppliers, municipal utilities, wind farm operators, universities, research institutes and RES/ICT related companies will develop tools, infrastructures and strategies to supply a complete district with electricity solely from Renewable Energies.	2008-2012	DE	Smart Meter and AMI Grid Automation Distribution Integrated System Specific Storage Technology Demonstration
163	Regulated power, OUH	Not available	The project's mission is to contribute to the development of a sustainable energy system by being available to regulate out the varying services that wind turbines contribute to in the various weather conditions.	Jan 2009 - Jun 2009	DK	Integrated System
164	Remote Services for CHP, ForskEL	Eurisco, (DK)	The main purpose of the project is to analyze and develop a concept for remote supervision of Combined Heat and Power plants.	Apr 2009 - Dec 2010	DK	Integrated System
165	SAFEWIND	RTE, (FR)	The project will develop: New forecasting methods for wind generation focusing on uncertainty and challenging situations/extremes. - Models for "alarming": providing information for the level of predictability in the (very) short-term. - Models for "warning": providing information for the level of predictability in the medium-term (next day(s)).	Sept 2008 - Aug 2012	DK FR ES DE IE UK EL	Other
166	SACSe	DONG Energy, (DSO), (DK)	The objective of the SACSe project was automatic conversion in the 10 kV grid in order to improve supply quality in connection with 10 kV faults – the so called "self-healing" grid.	2008 - 2010	DK	Grid Automation Distribution

	Project name	Organization name	Brief project description	Period	Country*	Project category
167	Second1 - Security concept for DER	EURISCO ApS (DK)	The project objective is to analyze and implement a security concept that can be used in a power system with a high degree of decentralized production and with many actors in an unbundled market. It will also investigate various forms of role based access control (RBAC).	Mar 2010 - Jul 2011	DK	Smart Meter and AMI
168	Self-organizing distributed control of a distributed energy system with a high penetration of renew-able energy	DTU Informatics, (DK)	The project studied aspects of the basis for distributed resources such as wind turbines, photovoltaics and not least consumers participating in power system control, including the aspect of how build-up of such control can be automated.	Jan 2007 - Jun 2010	DK	Grid Automation Distribution
169	Service optimization of the distribution network	Not available	To investigate different parameters which can optimize the operation of the distribution network on the basis of The Danish Energy Regulatory Authority's regulation of the distribution network companies in the form of financial regulation and regulation of the security of supply.	2009 - 2010	DK	Integrated System
170	Smartcity Malaga	Endesa (ES)	The goals of SmartCity Málaga can be summarized into the following ones: - Test and deployment of the new energy management model; - Implementation and integration of Distributed Energy Resources, Energy Storage facilities, Electric Vehicles charging processes and intelligent Public Lighting devices into the new operation grid systems	Mar 2009 - Mar 2013	ES	Smart Meter and AMI Grid Automation Transmission Grid Automation Distribution Integrated System Home application - Customer Behavior Specific Storage Technology Demonstration
171	Smart Energy Collective	KEMA (NL)	The Smart Energy Collective is an industry-wide collective that is setting up 5 to 10 large-scale smart grids demonstration projects across the Netherlands with a total of around 5,000 private and small business end-users. This industry initiative is dedicated to the practical development of smart energy services and networks, integrating interoperable services, technologies, and infrastructures, i.e. electricity, gas, heat, and ICT.	2010-2013	NL	Grid Automation Distribution Integrated System Home application - Customer Behavior
172	SmartGen	Sweco Norge AS, (NO)	Demonstrate and quantify the benefits of combining SGT with DG and LM and share this knowledge with stakeholders and decision makers in private and public sector. Develop the "SmartGen Models" which illustrates both energy resources and grid information visually by combining SGT scenarios with input from GIS and NIS.	Oct 2010- Sept 2013	NO DK LV CH	Integrated System

	Project name	Organization name	Brief project description	Period	Country*	Project category
173	Smart green circuits, ESB Networks - Smart grid demonstration project	ESB Networks (IE)	This project aims to enable the creation of smart green circuits, through the implementation of technology to reduce distribution losses, improve continuity with self healing loops, optimally use distribution connected generation, evaluate and optimize system voltages and power factors and investigate optimal system sectionalization and power flows.	Jan 2010 - Dec 2012	IE	Grid Automation Distribution Integrated System Other
174	Smart Grid	SEAS NVE (DK)	SEAS NVE decided to deploy the NES system for all of its nearly 400,000 customers to assist with a goal toward energy independence. The system will help them to better understand the operation of their grid and communicate bi-directionally with their customers in order to better manage supply and demand.	2008 - 2011	DK	Smart Meter and AMI
175	Smart Grid Demonstration System	Arqiva (UK)	Arqiva will use its dedicated UHF spectrum, combined with Sensus' purpose designed security measures, to provide a bespoke communications network for independent use by the UK's water, gas and electric utilities.	Apr 2010- Apr 2011	UK	Integrated System
176	Smart grids and energy markets	Cleen Oy, (FI)	General objectives of the research program are: create an innovation foundation for new solutions, products and services to enable the implementation of the Smart Grids vision; demonstrations of solutions in real environment; cultivate the competence accumulation in the research and business environments to secure the long term competitiveness; international research cooperation is a pre-requisite to achieve the objectives.	Sept 2009 - Sept 2014	FI	Integrated System
177	Smart Grid Fuel Cell CHP on Bornholm, ForskEL	Dantherm Power A/S, (DK)	The project will introduce power producing elements to the Smart Grid implemented in the "Ec-oGrid.EU" project executed on Bornholm. The power producing elements will be based on fuel cell technology and will produce both electricity and heat for e.g. central/district heating, FCCHP units.	Jan 2011 -Oct 2011	DK	Integrated System
178	Smart Grid Gotland	Vattenfall AB (SE)	The Smart Grid Gotland R&D demonstration project intends to develop strategies for the planning, construction and operation of a fully developed, large-scale smart grid, including a large share of intermittent production, primarily from wind power in the distribution network.	Nov 2010 - Dec 2015	SE	Integrated System
179	Smart Grid Task Force project	Energinet.dk, (TSO), (DK)	To describe and calculate a "Danish business case for full Smart Grid dissemination" from a socio economical perspective.	Jan 2009 - Sept 2010	DK	Other
180	Smart Heat Networks	Salzburg AG (AT)	The objective is to analyze and evaluate the potential of Smart Grid concepts for district heating systems in the model region of Salzburg. Dynamic network simulation and model calculations are applied to investigate intelligent operation strategies and control mechanisms for the reduction of peak loads.	Mar 2010 -Dec 2012	AT	Integrated System

	Project name	Organization name	Brief project description	Period	Country*	Project category
181	SmartHouse/SmartGrid	SAP Research (DE)	The SmartHouse/SmartGrid project sets out to validate and test how ICT-enabled collaborative technical-commercial aggregations of Smart Houses provide an essential step to achieve the needed radically higher levels of energy efficiency in Europe.	Not available	NL DE EL	Home application - Customer Behavior
182	Smart Metering	Fortum (FI)	Fortum selected Echelon's NES Value-Added Reseller partner Telvent as prime contractor to supply the NES (Networked Energy Services) advanced metering system integrated with Telvent's Smart Metering Titanium for 550,000 customers in Finland in order to fulfill key objectives of offering energy saving and home automation programs for homeowners.	2010 - 2014	FI	Smart Meter and AMI
183	Smart metering	ZSE Distribúcia a.s. - E.ON group, (SK)	Test different types of two-way communication between the meter and central in typical areas of application. Assess the technical possibilities and identify open questions and problems.	Jul 2008-Oct 2010	SK	Smart Meter and AMI
184	Smart Metering Multi Utility Pilot	ELM Hálózati Kft. (Electricity, DSO), (HU)	The primary objective of the pilot project is to obtain experience in the field of establishing a pilot project, operating the installed pilot smart metering systems, and to obtain detailed and accurate information about the advantages and disadvantages, problems of the smart metering system.	Feb 2011- Aug 2012	HU	Smart Meter and AMI
185	Smart Metering NTA Roll Out	Enexis (NL)	To introduce the NTA-smart meter as the default meter in all processes and to be ready for the obligations introduced by the new law. Involving the contracting of installation capacity and training of people.	Jul 2010-Dec 2011	NL	Smart Meter and AMI
186	Smart metering proof of concept	Ores (BE)	1500 electricity and gas smart meters will be installed in the cities of Nivelles and Mare-en-Famenne.	Jun 2009 - Sept 2012	BE	Smart Meter and AMI
187	Smart neighboring heat supply based on ground heat pumps, ForskEL	Solrød Municipality (DK)	The proposed projects is to develop and demonstrate the concept of 'neighboring heating' based on smart control of a heat pump in a combination with a hot water storage, where the possibilities of 'tapping' cheap electricity from the grid in periods with low electricity demand or/ and high wind production are analyzed and demonstrated.	Jan 2011 - Apr 2012	DK	Integrated System Specific Storage Technology Demonstration
188	Smart Power System - First trial	ECN, Energy research Centre of the Netherlands (NL)	The main goal of the field test was to demonstrate the ability of such a VPP to reduce the local peak load on the single low-voltage grid segment.	2006-2007	NL	Integrated System
189	SyM2-Project	E.ON Netz AG, EnBW, RWE DAG (DE)	Together with the partners E.ON and EnBW in 2006 RWE launched a project to develop a new meter for industrial and commercial appliances (I&C meter). These kind of meters are deployed in Germany at costumers with an annual consumption ⇢ 100.000kWh.	Jun 2006- Dec 2009	DE	Smart Meter and AMI

	Project name	Organization name	Brief project description	Period	Country*	Project category
190	Smart Region	CEZ Distribuce a.s., (CZ)	Fully automated and monitored LV and MV grid, balanced distribution grid which can easily switch between island and normal operation mode, higher quality and security of power supply, CHP units and renewables operation.	2011-2014	CZ	Grid Automation Distribution Integrated System
191	Smart Synergy	Salzburg AG (AT)	For Smart Grid and e-mobility applications different data and information have to be recorded and distributed with different technical requirements, which also fundamentally affects the construction costs of ICT infrastructure. The synergistic uses of ICT infrastructure for multiple applications including the validation of the actual realizable synergies are key objectives of the project.	Jun 2010 -May2012	AT	Integrated System
192	Smart Watts	Utilicount GmbH & Co. KG, Aachen, (DE)	The Smart Watts projects implements the concept of the ‚smart watt', i.e. the intelligent kilowatt hour: an open system, which enables new services, value added and increased efficiency for utility companies, device manufacturers, service providers and consumers.	Nov 2008-Sept 2012	DE	Smart Meter and AMI Home application - Customer Behavior Integrated System
193	Smart Web Grid	Salzburg AG (AT)	Future smart grids will rely on data exchange between different applications and market participants. Smart Web Grid analyzes user interaction, technology, cost effectiveness and data security of such a data exchange by means of three concrete examples in the model region Salzburg. The goal is the conceptual design of an information model for Web service-based access to smart grids data sources.	Mar 2011 - Feb 2013	AT	Integrated System
194	STAmi: Advanced Metering Interface	Enel SpA (IT)	The project aims at developing a dedicated application for LV network management and business purposes which leverages the existing metering infrastructure. STAmi provides network operators with a dedicated web interface to collect, on demand and real-time, specific high quality and accurate data stored in smart meters without additional load for the Advanced Meter Management (AMM) system. Both the operators in the control room, in the back office and on field work operators (via tablet PC) are provided with a dedicated suite of functionalities and tools based on web interfaces.	Jan 2010 - Jan 2011	IT	Smart Meter and AMI
195	Star	Iberdrola Distribucion (ES)	The project aims at integrating 100k smart meters with a variety of equipment manufacturers and communications into an Advanced Metering Management (AMM) System and manage it remotely. Build an interoperable and future proof solution for smart metering.	Apr 2010 - Mar 2011	ES	Smart Meter and AMI Grid Automation Distribution Integrated System

	Project name	Organization name	Brief project description	Period	Country*	Project category
196	Steinkjer Pilot Project	The Norwegian Smart Grid Centre, (NO)	The project objective is to prepare for the national roll-out of smart metering infrastructure i.e. building knowledge, testing of different technologies and interoperability.	Jan 2011-Dec 2015	NO	Integrated System Home application - Customer Behavior
197	Stockholm Royal seaport pre-study phase	Fortum Distribution AB (FI)	The pre-study for Stockholm Royal Seaport - an urban smart grid area, will deliver a concept description including market models and description of technical solutions ready for implementation and testing as a new project phase.	Oct 2010 - Mar 2011	SE	Smart Meter and AMI Grid Automation Distribution Integrated System Home application - Customer Behavior Specific Storage Technology Demonstration Other
198	Storstad Smart Metering	E.ON Sverige AB (SE)	Echelon's Network Energy Services system provides E.ON with an open, bidirectional, and extensible infrastructure that enables a comprehensive range of utility applications that brings benefits to every aspect of their operation, from metering, to customer services, to distribution operations, to value-added services.	2006 - 2009	SE	Smart Meter and AMI
199	SUMO	Elektro-Slovenija (TSO), (SI)	Dynamic thermal rating will be incorporated in SCADA/EMS environment. Network analyses will use near real time system capabilities. Calculation of element ratings will use ambient parameters from relevant geographical areas.	2011-2014	SI	not available
200	Supermen	Iskra MIS d.d. (SL)	Optimization of the operation of distribution assets and improve the efficiency of the network through enhanced automation, monitoring, protection and real time operation. Faster fault identification/resolution will help improve continuity of supply levels.	Sept 2009 - Jan 2011	SI	Integrated System

	Project name	Organization name	Brief project description	Period	Country*	Project category
201	SUSPLAN	SINTEF ENERGIFORSKNING A/S (NO)	The overall impact from SUSPLAN is contribution to a substantially increased share of renewable energy sources (RES) in Europe at an acceptable level of cost, thereby increasing security of supply and competitiveness of RES industry. The main objective is to develop guidelines for more efficient integration of RES into future infrastructures as a support for decision makers at regional as well as Pan-European level. The guidelines shall consist of strategies, recommendations, criteria and benchmarks for political, infrastructure and network decision makers and power distributors with a time perspective 2030-2050.	Sept 2008-Sept 2011	PL RO DE AT UK NL ES BG CZ IT RS	Other
202	Sustainable urban living	Fortum Electricity solutions and distribution (FI)	Develop a new building concept for urban residential construction aiming to minimize the energy consumption and enable customers to make intelligent choice for conserving energy.	Sept 2009 - Dec 2013	FI	Integrated System Home application - Customer Behavior
203	Swiss2G	Kraftwerke Oberhasli (KWO), (CH)	The goal of the project is the development of an algorithm which allows a grid connected device to identify the status of the (distribution) grid and to make appropriate actions to stabilize and improve its behavior.	2010-2013	CH	Grid Automation Distribution
204	System output project	Not available	To achieve regulation resources that can support the safe and efficient operation of the electricity system and also create the basis for realization of continuous cost saving.	Jan 2010 - Dec 2010	DK	Integrated System
205	Systems with High Level Integration of Renewable Generation Units	Department of Energy Technology – Aalborg University, (DK)	The project developed probabilistic methods for optimum operation and planning of contemporary distribution systems, including probabilistic models for wind power, small-scale CHP plants and load.	Jan 2007 - Dec 2009	DK	Integrated System

	Project name	Organization name	Brief project description	Period	Country*	Project category
206	Telegestore	Enel Distribuzione (IT)	Enel's Telegestore Project provides the installation of more than 32 million smart meters. These smart meters allow Enel to periodically collect data on voltage quality and interruptions, daily consumptions, active and reactive energy measurements, and remotely manage contractual activities. Meters are able to transmit data regarding consumptions, receive updates of the contractual parameters and remotely manage the supply connectivity.	Dec 2001 - Dec 2006	IT	Smart Meter and AMI
207	Tertiary reserve power with zero CO_2 emission	Elektro-Slovenija (TSO), (SI)	Demand side management and renewable producers will be integrated in TSO's ancillary services as additional tertiary reserve power for load frequency control.	2011-2014	SI	not available
208	The cell controller project	Energinet.dk, (TSO), (DK)	Via a full-scale Smart Grid development and demonstration project in a 60 kV distribution grid it is sought to achieve sufficient knowledge and a basis for a long-term re-design process, in order to turn the traditional passive distribution grids into active grids that can optimally utilize the growing volume of decentralized production.	Nov 2004 - Oct 2011	DK	Grid Automation Distribution
209	The metering data processing and central repository concept	PSE Operator S.A.(PL)	The goal of the project is to prepare cost benefit analysis of smart metering implementation in Poland and to develop the legal and organizational framework to implement metering data processing and central repository concept.	Jan 2010-Mar 2011	PL	Integrated System
210	Trials with heat pumps on spot agreements	SydEnergi, (DSO), (DK)	The objective of the project is to gain knowledge of the technical challenges of establishing a heat pump solution in private households in order to plan the heat pump's electricity consumption for when electricity production is highest/greenest.	Mar 2010 - Dec 2011	DK	Smart Meter and AMI Grid Automation Distribution
211	TWENTIES	Red Eléctrica de España (REE) (ES)	TWENTIES Project aims to demonstrate through real-life, large-scale demonstrations, the benefits and impact of several critical types of technology required to improve the European transmission network, thus giving Europe the ability to increase the share of renewables in its energy mix by 2020 and beyond, while keeping its present reliability.	2010-2013	DK ES FR BE	Grid Automation Transmission
212	Vehicle to Grid - Interfaces	Salzburg AG (AT)	New concepts for user interfaces for e-mobility costumers within the Smart Grids model region of Salzburg are developed; parameters and cost/benefits of a future Vehicle to Grid implementation will be evaluated by this feasibility study.	Jun 2010-May 2011	AT	Other
213	Vehicle to Grid - Strategies	Salzburg AG (AT)	The options of system related e-mobility integration in urban and rural case studies are analyzed developing active grid integration as well as new business models for Grid to Vehicle and Vehicle to Grid concepts.	Jun 2010 - Dec 2012	AT	Other

	Project name	Organization name	Brief project description	Period	Country*	Project category
214	Virtual Power Plant	RWE DAG (DE)	The aim of this pilot project is the demonstration of the technical and economical feasibility of the VPP concept-Within the project duration further decentralized power producer, like CHP, Biomass or Wind turbines, will be included into the VPP.	2008-2010	DE	Integrated System
215	WAMPAC	Elektro-Slovenija (TSO), (SI)	Existing wide area measurement system will be upgraded with protection and control functions. Relevant critical operation scenarios will be investigated in due course.	2011-2014	SI	not available
216	web2energy	HSE AG (DE)	The project Web2Energy is directed to implement and approve all three pillars of "Smart Distribution". Smart Metering – the consumer participates in the energy market Smart Energy Management – Clustering of small power producers. Smart Distribution Automation – higher reliability of supply.	Jan 2010-Dec 2012	DE NL AT PL CH	Smart Meter and AMI Grid Automation Transmission Smart Meter and AMI Grid Automation Transmission
217	WINDGRID	RED ELECTRICA DE ESPAÑA, S.A. (ES)	Wind on the Grid is a project focused on preparation of the European electricity network for the large-scale integration of wind farms through the design, development and validation of new tools and devices for its planning, control and operation in a competitive market.	Dec 2006 -Dec 2009	ES PT DK SI IT CZ DE	Other
218	Zone concept and smart protection pilot	Fortum Sahkonsiirto Oy (FI)	The pilot aims to test a smart protection concept which should reduce the outage times and automation investment needs. The system consists of central unit in the primary substation which analyses the network status and faults.	2010 - 2013	FI	Grid Automation Distribution
219	ZUQDE	Salzburg AG (AT)	ZUQDE will develop further the DMS application Volt/var Control (VVC) to keep a certain voltage level in the whole distribution network with a high penetration of Distributed Generation (DG).	Jul 2010-May 2012	AT	Grid Automation Distribution

European Commission

EUR 24856 EN – Joint Research Centre – Institute for Energy

Title: **Smart Grid projects in Europe: lessons learned and current developments**

Authors: Vincenzo Giordano, Flavia Gangale, Gianluca Fulli (JRC-IE), Manuel Sánchez Jiménez (DG ENER)
Other JRC-IE contributors:
Ijeoma Onyeji, Alexandru Colta, Ioulia Papaioannou, Anna Mengolini, Corina Alecu, Tauno Ojala, Isabella Maschio

Luxembourg: Publications Office of the European Union
2011 – 118 pp. – 21.0 x 29.7 cm
EUR – Scientific and Technical Research series – ISSN 1831-9424

ISBN 978-92-79-20487-6
Catalogue number LD-NA-24856-EN-N
doi:10.2790/32946

Abstract
The main goal of this study is to provide a complete catalogue of Smart Grid projects in Europe to date and use project data to support analysis on trends and developments. The report looks into several aspects of the Smart Grids landscape to describe the state of the art of their implementation, the emerging hallmarks of the new electricity system and the foreseeable developments. A key focus of the Report is to describe how Smart Grid projects address and respond to the EU energy policy challenges and to point out potential benefits and beneficiaries. Particular attention is devoted to identifying the most important obstacles to investments and the possible solutions that could help to overcome them.

The mission of the Joint Research Centre (JRC) is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of European Union policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

JRC
EUROPEAN COMMISSION

LD-NA-24856-EN-N

Publications Office

ISBN 978-92-79-20487-6

9 789279 204876