Mapping und Gap Analyse aktueller Smart Grid Demonstrationsprojekte in Europa

Bericht der EEGI Member States Initiative "A pathway towards functional projects for distribution grids"

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Berichte aus Energie- und Umweltforschung

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Mapping und Gap Analyse aktueller Smart Grid Demonstrationsprojekte in Europa

Report by the EEGI Member States Initiative
"A pathway towards functional projects for distribution grids"

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In cooperation with
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Wien, April 2012

Ein Projekt im Auftrag des Bundesministeriums für Verkehr, Innovation und Technologie

Vorbemerkung

In der Strategie der österreichischen Bundesregierung für Forschung, Technologie und Innovation ist deutlich verankert, dass Forschung und Technologieentwicklung zur Lösung der großen gesellschaftlichen Herausforderungen beizutragen hat, wobei die Energie-, Klima- und Ressourcenfrage explizit genannt wird. In der vom Rat für Forschung und Technologieentwicklung für Österreich entwickelten Energieforschungsstrategie wird der Anspruch an die Forschung durch das Motto „Making the Zero Carbon Society Possible!“ auf den Punkt gebracht. Um diesem hohen Anspruch gerecht zu werden sind jedoch erhebliche Anstrengungen erforderlich.

Im Bereich der Energieforschung wurden in den letzten Jahren die Forschungsausgaben deutlich gesteigert und mit Unterstützung ambitionierter Forschungs- und Entwicklungsprogramme international beachtete Ergebnisse erzielt. Neben der Finanzierung von innovativen Forschungsprojekten gilt es mit umfassenden Begleitmaßnahmen und geeigneten Rahmenbedingungen eine erfolgreiche Umsetzung der Forschungsergebnisse einzuleiten. Ein wesentlicher Erfolgsfaktor für die Umsetzung ist die weitgehende öffentliche Verfügbarkeit der Resultate. Die große Nachfrage und hohe Verwendungsquoten der zur Verfügung gestellten Ressourcen bestätigen die Sinnhaftigkeit dieser Maßnahme. Gleichzeitig stellen die veröffentlichten Ergebnisse eine gute Basis für weiterführende innovative Forschungsarbeiten dar. In diesem Sinne und entsprechend dem Grundsatz des „Open Access Approach“ steht Ihnen der vorliegende Projektbericht zur Verfügung. Weitere Berichte finden Sie unter www.NachhaltigWirtschaften.at.

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Vorbemerkung zur Smart Grids Begleitforschung

In den letzten Jahren setzt das BMVIT aufgrund der Aktualität des Themas einen strategischen Schwerpunkt im Bereich der Weiterentwicklung der Elektrizitätsversorgungsnetze. Dabei stehen insbesondere neue technische, aber auch sozio-technische und sozio-ökonomische Systemaspekte im Vordergrund.

Im Rahmen der „Smart Grids Begleitforschung“ wurden daher Fragestellungen von zentraler Bedeutung für die Weiterentwicklung diesbezüglicher F&E-Strategien identifiziert und dementsprechende Metastudien, Detailanalysen und Aktionspapiere initiiert und - zum Teil gemeinsam mit dem Klima- und Energiefonds - finanziert. Der gegenständliche Bericht dokumentiert eine in diesem Zusammenhang entstandene Arbeit, die nicht zwingend als Endergebnis zur jeweiligen Fragestellung zu verstehen ist, sondern vielmehr als Ausgangspunkt und Grundlage für weiterführende Forschung, Strategieentwicklung und Entscheidungsfindung.

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Content

1 Executive summary

The European Electricity Grid Initiative (EEGI) is an industrial initiative under the European Strategic Energy Technology Plan (SET-Plan) and aims to enable the distribution of up to 35% of electricity from dispersed and concentrated renewable sources by 2020. A 9-year research, development and demonstration programme and an implementation plan for 2010-2012 has been developed and costs of necessary developments are estimated to reach around EUR 2bn excluding deployment of the resulting solutions. The EU Member States committed to be actively involved in the programme and founded the present initiative to

- provide an overview of ongoing or finished smart grids projects in Europe, relevant regarding the EEGI implementation plan, and their contribution to the functional projects (mapping)
- locate the gaps between the results or expected results from these projects and the objectives defined in the EEGI implementation plan (gap analysis).

National key-experts, as nominated by the member states representatives in the EEGI team, compiled a list with selected national projects, their (expected) results and the allocation to functional projects. In order to enable a consistent allocation it was decided to put a lot of effort into improving the descriptions of functional projects by further defining demonstration and research needed to reach specific functional goals identified in the EEGI Roadmap. Overall, 203 projects from 22 European countries were identified. Figure 1 shows the number of projects contributing to the respective EEGI functional project. Additionally, it gives an indication for the time schedule, showing a high density of projects being realised in the years 2011-2012.

Cluster	Functional Project	YEAR												Number of projects
		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
Integration of Smart Customers	D1													74
	D2													42
Integration of Smart Metering	D3													43
	D4													39
Integration of DER and new users	D5													77
	D6													74
	D7													48
	D8													65
Smart Distribution Network	D9													59
	D10													58
	D11													43
	D12													61

Fig. 1: Smart Grids projects in Europe mapped to EEGI functional projects (Mapping)
Note: Darker colour indicates more projects running during that year.

With the knowledge of key experts and on the basis of the descriptions of selected projects a gap analysis could be undertaken. Figure 2 shows the main results: Major research needs have not only emerged in the technological field but also the framework needed for new structures as new market mechanisms for successful deployments and common standards. Cost-benefit analysis was also highlighted as an instrument to accelerate the implementation of innovative technologies and processes.

On the technological side, many gaps have been identified in the low voltage grid area from lacking monitoring data via simulation models to experiences on interaction with medium voltage networks. High costs of storage technologies and e-vehicles hamper projects dealing with their grid integration although quite a few projects have recently started on the latter topic. Smart meter infrastructure is well covered in existing projects but seem not to deal with management of different meter reading services, advanced meter management system and network security. In the ICT field, there is the need to start more projects on the integration of ICT systems into open service platforms and on the verification of latest communication technologies used in system control and automation.

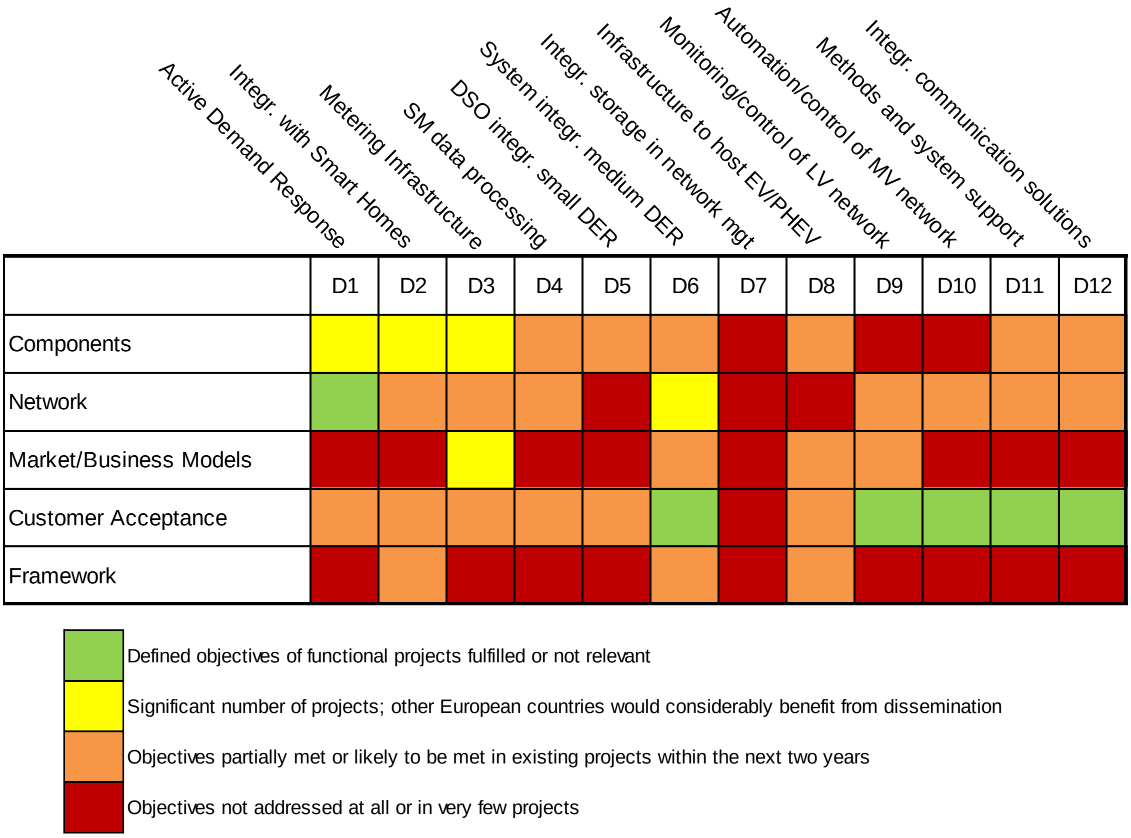

Fig. 2: Overview of the progress of functional projects D1-D12 (gap analysis)

Many results of various projects are expected to be obtained in the next two to three years. These relate in particular to e-mobility, active demand side management and voltage control concepts. Knowledge and experience already gained by individual countries should be transferred to others as they could provide valuable input from lessons learned and speed up the entire process up to the point of deployment. In areas as standardisation and data privacy rules only a European scale implementation makes sense.

The EEGI Member States Initiative has specified programming recommendations on national and on European level. The “families-of-projects concept” introduced in the EC Work Programme 2012 under the Seventh framework programme has proven as appropriate for the electricity system innovation topics. However, the gap analysis also highlights areas where dedicated research on technology is needed depending on the progress of the functional projects.

2 Introduction – starting point

Most of the European network has been built more than 30 years ago and has been designed for one-way energy flows from large centralized fully controllable power plants to the customer. Our energy system, however, is facing a profound change and integration of renewable energy requires new planning and operation procedures of high voltage networks as well as distribution networks. For that reason, the Strategic Energy Technologies Plan (SET Plan) identifies electricity grids as one of the critical areas that needs to be addressed to prepare for a low-carbon future. The European Electricity Grid Initiative (EEGI) has been launched and will be the enabler of all SET Plan technology initiatives.

The EEGI proposes a 9-year European research, development and demonstration (RD&D) programme defined by electricity transmission and distribution network operators. A Roadmap 2010-18 and a detailed implementation plan for 2010–2012[1] has been developed together with the European Commission, Member States, regulators and the European Technology Platform for Electricity Networks of the Future (Smart Grids ETP) and was published in May 2010. Costs of projects starting in the period 2010-2012 are estimated at EUR 1bn; costs of the entire programme will be around EUR 2bn excluding deployment solutions.

The programme focuses on electricity system innovation rather than technology innovation as basic technologies have already been developed. Today's challenge is to integrate innovative technologies in the system and validate their performance under real life working conditions. That gives network operators a leading role in the initiative as system-level innovation, its validation and replication as well as ensuring secure systems is the responsibility of network operators. However, all main stakeholders will be represented in the initiative: generators, manufacturers, retailers, aggregators, the ICT industry, consumers, RTD organisations and governmental/regulatory bodies.

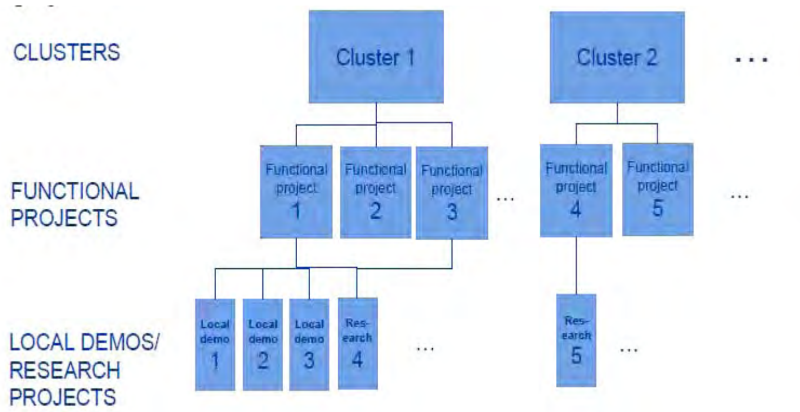

Fig. 3: Structure of research and demonstration projects according to the EEGI implementation plan

In the Roadmap, RD&D activities have been organised in a hierarchy of clusters, functional projects, local demonstration projects and research projects (Fig. 3). A cluster is a set of functional projects and the latter is a description/definition of a demonstration and/or research activity needed to reach specific functional goals.

Local demonstration projects are practical realisations of activities described in functional projects. Demonstration projects are performed under real network conditions with real customers. In order to cover different local conditions (network, climate, customer behavior etc) a number of local demonstration projects are necessary to fulfill the goals of a functional project. At the same time one demonstrator can cover more than one functional project (Fig. 4). Research projects are practical realisations of research activities as described in functional projects.

[1] http://www.smartgrids.eu/documents/EEGI/EEGI_Implementation_plan_May%202010.pdf

	Local Demo project A	Local Demo project B	Research project C	...
Functional project 1	X	X	X	
Functional project 2		X		...
Functional project 3	X		X	
....		...		

Fig. 4: Relationship between functional and demo projects

The EEGI implementation plan defines 13 functional projects (4 cluster) for the transmission network, 12 for the distribution network and 5 functional projects serve coordination and interaction activities of transmission and distribution networks. The EEGI Member States Initiative only deals with the 12 functional projects of distribution networks organized in the 4 clusters: Integration of smart customers, integration of smart metering, integration of distributed energy resources (DER and new uses and smart distribution network (Fig. 5).

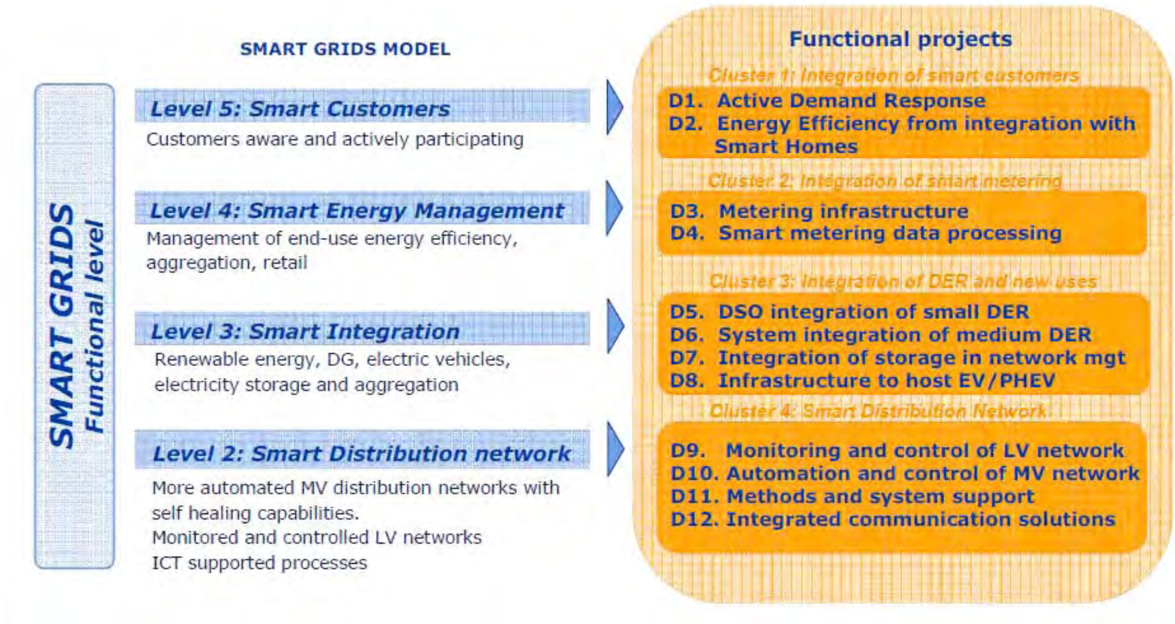

Fig. 5: EEGI Functional projects for DSOs

3 The Member States Initiative

The idea to the Member States Initiative evolved in one of the first Electricity Grid European Industrial Initiatives (EII) team meetings in 2011. The EII team is responsible for planning and programming actions to achieve the goals of the EEGI implementation plan. Soon it became clear that the team would need active support in order to cope with a large number of comprehensive tasks from surveying already existing projects in Europe and programs to finding gaps if compared with the objectives of the EEGI Roadmap and the kind of suitable instruments to close these gaps. Thus, the Austrian Federal Ministry for Transport, Innovation and Technology proposed to establish a joint member states activity and commissioned the Austrian Institute of Technology (AIT) to manage the process in the framework of ERA-Net Smart Grids.

Together with the EII team the process of the Member States Initiative had been set up (Fig. 6). First of all a cooperation structure had to be created so that existing projects could be collected and screened if they are relevant for the four distribution clusters of the EEGI Roadmap. The “Transmission” and the “Transmission/Distribution Coordination” Cluster was covered by workshops of the European Network of Transmission System Operators (ENTSO-E) and the Member States Initiative focused on distribution areas. An overall picture of the European smart grid landscape was achieved through the collection of finished and ongoing national and European-wide projects. In the gap analysis achievements of existing projects were compared with the goals of the EEGI implementation plan and identified the requirement of new research, demonstration and networking activities in specific areas. The latter resulted in programming recommendations for European and national calls.

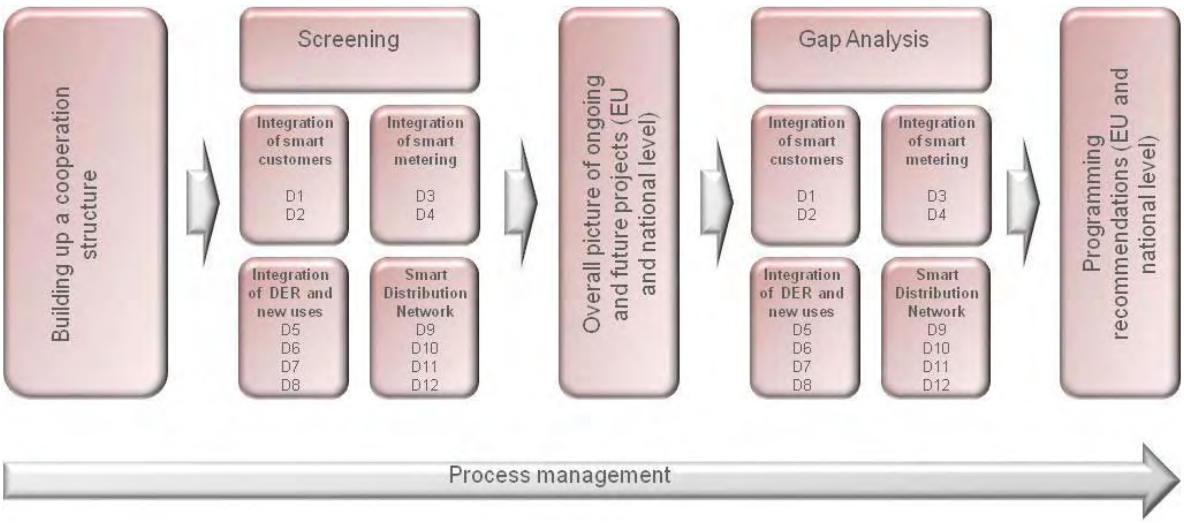

Fig. 6: EEGI Member States Initiative Process

3.1 Objectives of the Member States Initiative

Main goal of the Member States Initiative: “Pathway towards the coordination of functional projects” is to support the EEGI team in respect of the Implementation plan and to help member states and program coordinators to find similar and complementary projects in other parts of Europe. So they would benefit from emerging synergies and define new (and/or complementary) projects which contribute to the objectives of the EEGI implementation plan. In order to reach this goal, first of all a clear and common understanding of (expected) achievements of existing demonstration projects is required.

Further goals have been identified:

- Bringing the 12 DSO functional projects into life
- Bringing selected member state’s projects on EU level
- Agree on process and structure to work together on the development of functional demonstrators
- Initiation of international project proposals and coordination with the EEGI-Team

3.2 Cooperation structure

In order to reach a comprehensive overview of all national smart grid projects a key expert per country was nominated by EEGI member states representatives. The expert knows the national landscape very well, is in active contact with managers of smart grid project and is responsible to deliver relevant information into the working groups of the EEGI Member States Initiative. National experts might come from the industry, a research company or might be a project manager him-/herself. Certainly, they need to understand the EEGI Roadmap and the elaborated descriptions of functional projects. The experts are the links between project managers and table chairs who lead and organize the work in the respective cluster (Fig. 7). Names and institutions of the involved experts are provided in Annex I of this report.

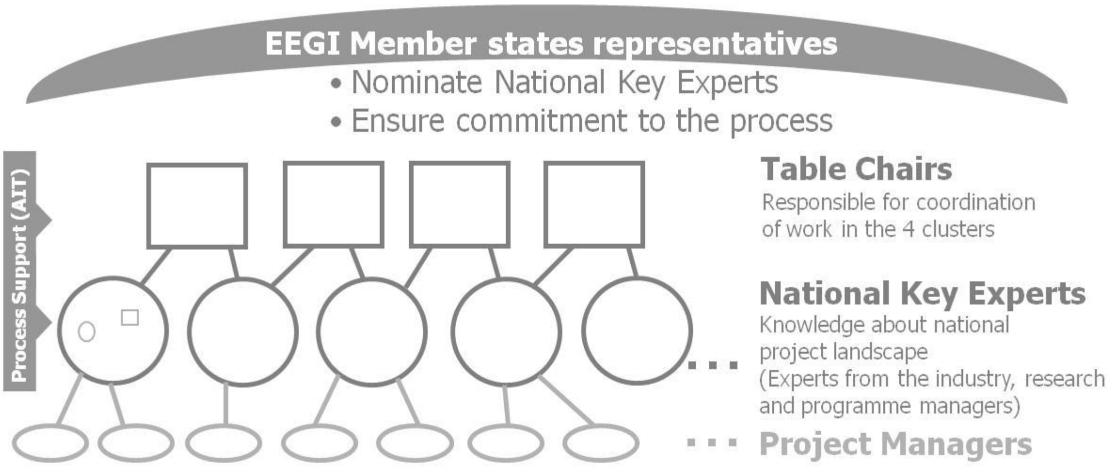

Fig. 7: EEGI Member States Initiative cooperation structure

3.3 Working procedure

The Member States Initiative retained the principal structure of clusters and functional projects as described in the EEGI implementation plan but elaborated on the content. One of the major tasks within the Initiative was a detailed description of all functional projects in order to reach common understanding in the working groups and a consistent allocation of national to functional projects.

At this point, features of functional projects should be listed while detailed descriptions are to be found in Annex II. A functional project according to the EEGI Implementation Plan:

- is a functional description.
- defines demonstration and/or research activities needed to reach specific functional goals.
- includes budget figures.
- includes key performance indicator (KPI) to monitor performance.
- is not a physical project.
- does not have a defined location.
- needs a set of local demonstration and accompanying research/development projects to be completed.
- covers different local conditions (climate, existing networks, regulatory regimes).
- tests alternative competing solution to the same problem.

The table chairs agreed on a general structure suitable for each functional project and divided these into the vertically integrated sub-themes components, network, market and business models, customer acceptance and the technological, economical and legal frameworks. The prepared proposals based on the EEGI implementation plan, input of the labeling group, own experiences and discussions in EEGI workshops. Each cluster was subject to a workshop which aimed in particular to reach a common understanding and an agreement of the descriptions of functional projects within the Initiative.

Secondly, national experts were required to allocate national to functional projects. For that purpose, several national projects/demonstrators focusing on one or two functional projects only were presented as well as already achieved or to be expected results. On basis of the presentations and individual experiences following questions were discussed for each cluster:

- What are the main problems that the projects are going to solve?
- What is the size / scope of these demo projects and what is / will be the real impact on the network?
- What is the status (specific results achieved so far) of these projects, and what can be expected and when?
- What are the relevance and the transnational or European dimension of these local projects?

Above questions and related discussions also had the purpose to serve as best practice example for the reallocation of national projects by national experts. In the initial allocation process 274 projects from 20 countries were submitted but the allocation to functional projects was not aligned. With the new descriptions for each functional project and the efforts in the workshops, an effective reallocation of already submitted national smart grid projects to functional projects could now be undertaken. National experts also had to evaluate if national projects are strategically relevant in an European context and for the EEGI implementation plan which finally reduced the number of submitted projects to around 200.

Both, the collection of smart grid projects as well as the description of functional projects form the fundament for the gap analysis and recommendations for future programming.

Fig. 8: EEGI Member States Initiative schedule

3.4 Links to other EEGI initiatives

Besides the EEGI Member States Initiative there are several other groups which support the EEGI team and make sure the objectives of the implementation plan will be reached.

3.4.1 Key Performance Indicators

The task of the KPI team (EC Joint Research Centre) is to develop a monitoring tool to evaluate the progress of the EEGI implementation in terms of cost effectiveness and technical progress. These KPI's will be applied on EEGI as a whole (cumulative projects); the KPI methodology at project level has to be defined by project coordinators. The team is still working on a reference system, baseline and targets and expects to start evaluation in 2012.

3.4.2 Labelling group

The labelling group will analyse projects and propose to the EEGI Team those projects that should be labeled as EEGI project. Final EEGI label approval is provided by the EEGI Team according to defined governance rules. The process includes following criteria: size, eligibility, network fitting criteria and technical fitting criteria. The criteria have not yet been tested on practical level but there might be a joint process with the Member States Initiative.

3.4.3 GRID+

The aim of the GRID+ project is to implement and support the management, planning and networking process of the EEGI over the years 2012-14, both within and beyond European borders. In line with the requirements of the energy call (2011.7.3-1 Network of projects developing the future European Electricity Networks), the coordination action will contribute to maximise the effectiveness of the EEGI by reinforcing the cooperation among key actors of the initiative, increasing the visibility, co-operation and impact of the projects funded at EU and local level, and providing the necessary identity and visibility for the EEGI.

The GRID+ projects team has identified 6 interlinked objectives:

- MAP: To map the research, development and demonstration activities in support of Smart Grid deployment at transmission and distribution level, in Europe and abroad, against the priorities and goals of the EEGI Roadmap
- INTERACT: To foster a networking process between EEGI projects and engage with other Smart Grids initiatives worldwide
- MONITOR: To support the definition, validation, updating and use of Key Performance Indicators (KPIs) in order to assess the progress of the initiative and the consistency of project proposals with the EEGI expected benefits and to achieve EEGI-related project goals.
- REPLICATE: To support scaling up and replication activities with the help of methodologies based on project KPIs.
- DISSEMINATE: To prepare the means and tools in view of the dissemination of the new knowledge from the demonstrators related to the EEGI towards the grids community and its stakeholders.
- UPDATE: To provide three revisions of the EEGI implementation plan which include a benefit assessment based on the program and project KPI.

The EEGI Member States Initiative provides data, reports and acquired experience to the GRID+ project team. Especially the description of functional projects will be an important input for the updates of the EEGI implementation plan.

While GRID+ is a project consisting of 12 project partners and relying on the cooperation of authorities, experts and project partners, the Member States Initiative has the advantage to have ensured committed resources from 21 European countries with interest to provide and to exchange know-how on project experiences. In that respect, the Initiative should be continued in following years and actively contributing to make GRID+ successful.

4 Overview of European projects

National experts from 22 countries submitted 203 projects strategically relevant in a European context and thus helping to achieving the aims of the EEGI Roadmap and Implementation Plan. They have identified the contributions of projects to the 12 functional projects in the four clusters. Fig. 9 shows the number of projects contributing to the respective functional project. Most of the projects address several functional projects and clusters, thus the summed up number of contributions exceeds the number of projects (203 in total).

More than a third of the projects are dealing with the integration of small or medium size distributed energy resources (DER) and in total, 146 projects contribute to cluster 3 “Integration of DER and new uses”. The first functional project “Active Demand Response” also combines a major part of research and demonstration efforts. Almost half of the submitted projects (86) aim to integrate smart customers (cluster 1). Although cluster 2 “Integration of Smart Metering” comprises fewer projects (59) than other clusters, the projects are well advanced and many concepts have been proven in field tests and demonstration projects. Cluster 4 “Smart Distribution Network” counts for 113 projects, most of them dealing with integrated communication solutions (Fig. 9). About half of the projects include a field test or a demonstration part.

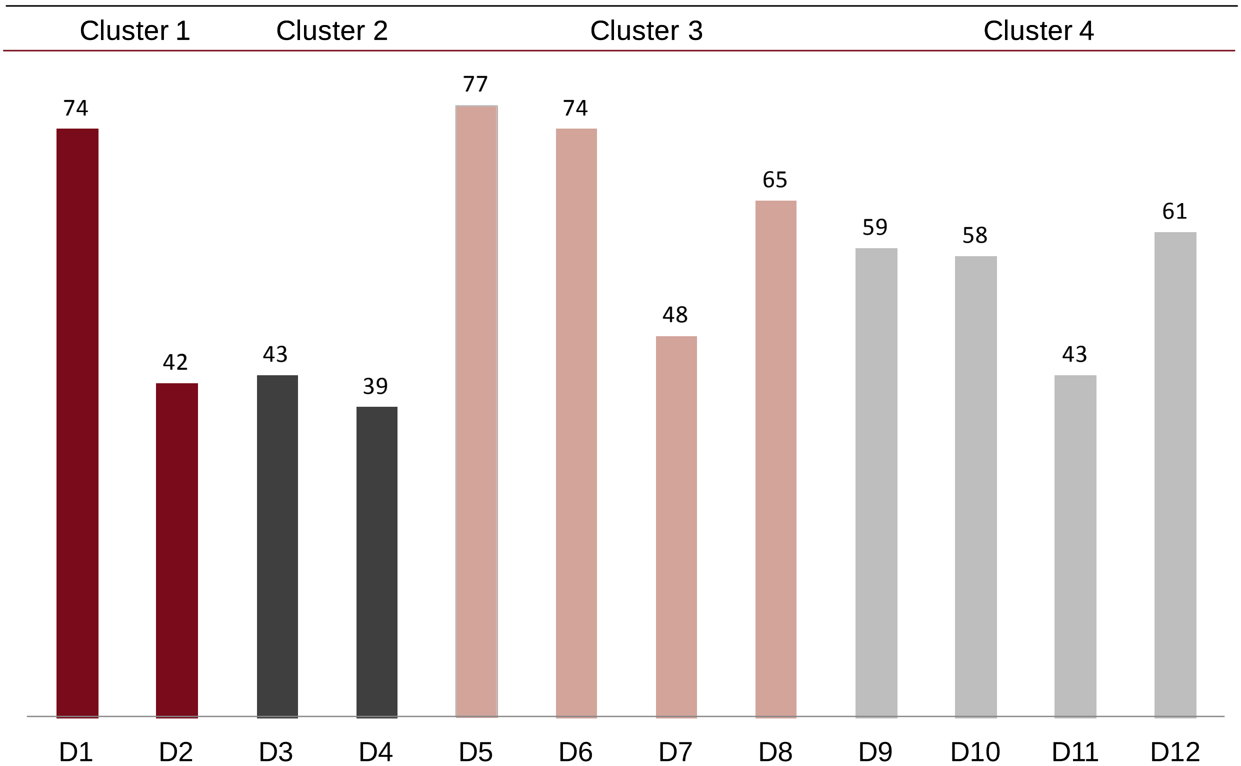

Fig. 9: European Smart Grid projects relevant to EEGI-
number of projects contributing to the respective functional project (D1-D12)
Note: Number of projects - 203 in total; projects usually address several functional projects.

The following table attempts to highlight the main foci of individual functional projects while deficiencies are described in more detail in the next chapter.

Functional Project	Thematic focus
D1: Active Demand Response	Large, fully-automated demand response.
D2: Energy efficiency from integration with Smart Homes	Development of “entry points” into homes; residential gateways to service platforms.
D3: Metering infrastructure	Effective deployment of smart metering infrastructure for remote metering processing.
D4: Smart metering data processing	Use of MDM systems to collect and organise basic information coming from smart meters.
D5: DSO integration of small DER	Voltage control concepts, local balancing taking into account DER units (esp PV), demand response, local storage, e-mobility.

D6: System integration of medium DER	Voltage control concepts to maximize DER hosting capacity; loss reduction in MV networks.
D7: Integration of storage in network mgt	Only few projects and almost none with European format. Main issue is high cost of storage technologies.
D8: Infrastructure to host EV/PHEV	Most of the projects are just about to start – results are expected within 2 years. Main issue is high cost of e-vehicles and their availability.
D9: Monitoring and control of LV network	Increase low voltage grid monitoring and control features especially for active resources.
D10: Automation and control of MV network	Increase in medium voltage grid automation and co ntrol for grid active resources.
D11: Methods and system support	Increase in distribution grid expert system, state estimation solutions and grid simulation methods.
D12: Integrated communication solutions	Development of ICT structures and systems including application layer communication models and protocols.

Table 1: Main thematic foci of existing research and demonstration projects

On average, the projects run for 4 years with a current emphasis on the years 2011 and 2012 (Fig. 10). The major phase out is to be seen in 2016 which means that many projects need to come online soon in order to address the gaps highlighted in chapter 5 and fulfill the objectives of the EEGI Roadmap by 2020.

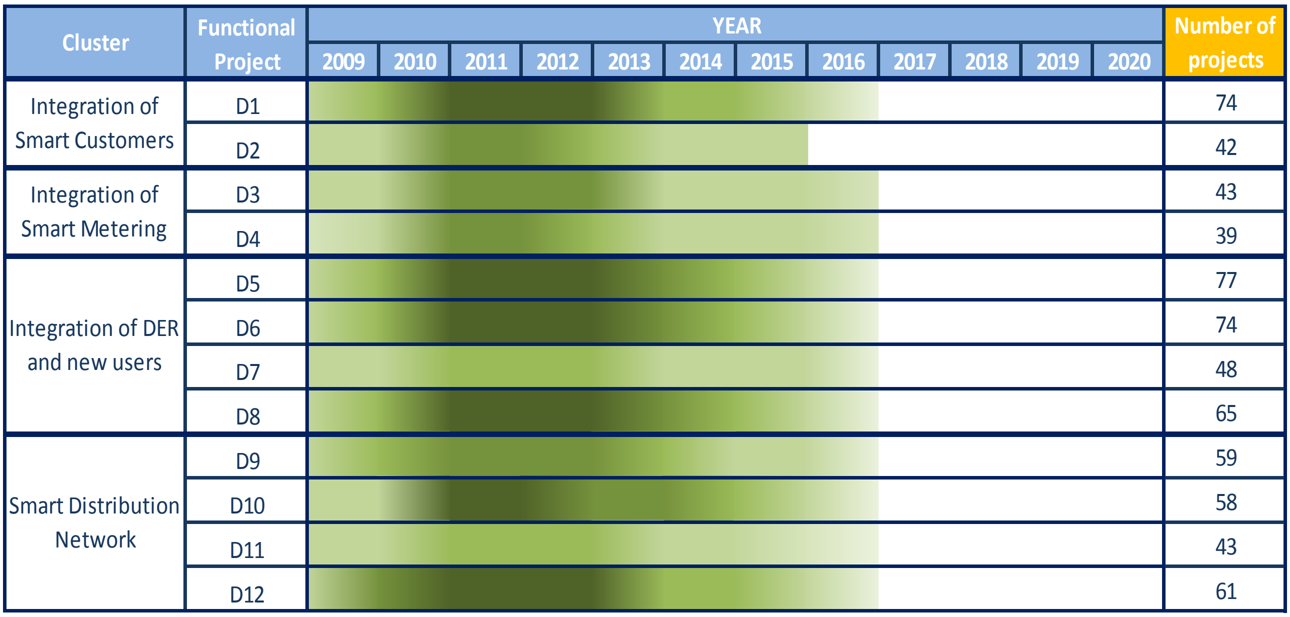

Fig. 10: European Smart Grid project durations

Note: Darker colour indicates more projects running during that year.

5 Gap analysis and Recommendations

The gap analysis is based on the objectives in the descriptions of functional projects (Annex II) and the projects of European format as submitted by national experts (Annex I). All national projects allocated to a specific functional project have been investigated in terms of content, goals and already achieved results and have then been compared to the objectives defined in the descriptions of functional projects. This resulted into a breakdown of three major areas for each functional project:

- Objectives not addressed at all in any of the collected national projects
- Objectives partially met or likely to be met in existing projects within the next two years
- Objectives met in few projects and other European countries could significantly benefit from dissemination of experiences and from know-how exchange

We would like to add that existing projects constantly deliver new results and that experts had no extra resources to collect up-to-the minute information. Thus, the data and the gap analysis represent the current status of knowledge of the national key experts and may have its limitation, but will be an excellent foundation for a more elaborated work on this topic.

5.1 Cluster 1: Integration of Smart Consumers

Smart grids fundamentally change the relationship between customer and energy providers. The latter is able to provide customized services due to new available data while smart customers are empowered to control their energy bills by deferring or reducing energy consumption in costly peaking generation. Both contribute to a better balanced and more efficient electricity market and thus reduce costs of infrastructure investments.

Different energy management systems and gateways have been implemented in several national projects and will need to be made compatible or interoperable in the near future. Further, the integration with DSO and TSO network management systems (SCADA) must be improved. Existing projects mostly look at the electricity network only and full integration of energy and their optimisation has not been addressed.

In general, most of the technological objectives seem to be achieved by national projects but there is high uncertainty about the economic framework. Cost-benefit analysis could be an instrument to lay ground for the development of end user acceptance programs. Social, psychological and marketing means should be investigated to foster end users' participation in demand response and energy efficiency projects.

5.1.1 D1: Active Demand Response

Many projects on active demand response have been started over the last few years. Some of them are pan-European (e.g. Address, EcoGRID), but most of them are national. There are major differences in both scope (number of participants) and the level of automation in the solutions that are being deployed.

There is a clear trend, however, towards larger and fully-automated demand response in more recently started (or conceived) projects. As a number of pilot projects and surveys have shown that customers have little incentives to perform manual consumption pattern adjustments and at the same time, the effect of in-house displays with energy advices and real-time consumption information is often not as effective as it is claimed to be. Grid4EU, ADDRESS and Ecogrid.EU are examples at the European level, but there are also R&D and demonstration projects in e.g. Latvia, Sweden (Stockholm Royal Seaport), Finland (Fish port Helsinki) or Germany (E-Energy). Existing approaches to smart grids mostly concentrate on the functions and services of smart meters. More advanced models call for a new function called “energy manager” which allows for decentralized control solutions.

In a technical sense, the objective of involving a higher number of customers by providing better interfaces and more transparency has largely been met by current and forthcoming projects. However, few projects (such as the E-Energy projects, Finnish Energy Markets R&D programme) tackle the question of business scenarios, new market places and cost split models. With today's regulatory framework such projects indicate valid business models mostly with enterprise customers (B2B business).

Objectives not met

- Establishment of coherent economic conditions for end users. Especially the integration of end user cost/benefit analyses in their business cases has been treated very poorly.

- Understanding of broader influencing factors in consumer behaviour is missing. The current generation of projects is very much focused on technology and the field of electricity grids as such and does not depart from the traditional model of this sector. There is little insight in the behaviour of consumers in a connected living environment. Nor is there a comprehensive view on the more active (market) positions consumers may occupy in future energy/electricity value chains.

The ERA-Net project IMPROSUME goes into the right direction, studying the role of prosumers in the future power market and developing strategies for active participation based on solid knowledge of prosumer behaviour. However, up to now the focus in most projects is on empowered customers rather than real consumers.

With the exception of very few cases (such as the VELIX model of VKW in Austria or the eFLEX project in Denmark) non-subsidized incentive models have not been considered. To allow for broad deployment of smart energy models, research and product offerings will have to adapt to changing societal values and lifestyles. Community models in the sense of «smart citizenship» have not yet been addressed.

Objectives partially met

The reported projects that address specifically D1 objectives are dealing with the following objectives:

- To improve economic conditions for end users and to motivate end users to participate in DR, one must consider advanced market places and new market roles. Few projects such as Smart Grid Gotland (SE) or the E-Energy projects (DE) are paving the way. Some (e. g. ForskEL 6329 in DK) consider demand response as a means for end users to participate in markets for regulating and reserve power. Success of such approaches depends on the development of new (electronic) markets and more favourable framework conditions.

- Electric vehicles (EV) can be integrated as active devices in the electricity grid. While technology to control charging processes and – at least to some degree – to feed energy into the grid from EV batteries is available, many projects are still investigating market models and incentives to establish those in large in a distributed and integrated market.

- Establishing commercial and technical VPPs, often in residential areas. Apart from the technological challenge (which has more or less been mastered for manageable numbers of participants), issues are being addressed on the relationships among participants (and between the VPP and external players like DSOs).

- Existing VPP approaches at large do not consider storages and consumer flexibility as special cases of power supply. Few projects only include both the management of generation and the management of consumption in a joint model (e. g. the VPS approach of AlpEnergy).

- While meanwhile there is quite some understanding of the privacy and security requirements E. g. in AMM project in CZ and E-Energy in DE), there is little insight in the solutions. State of the art understands security as a question of data protection in smart metering only. However, more complex smart grid scenarios could allow for various types of personal data abuse and cyber attacks. Privacy and security need to be tackled by design. This calls for a new approach which includes distributed data and control models.

Objectives have been met but need networking/know-how exchange

The improvement of customer acceptance is a main issue that has been addressed earlier. Especially concerns about privacy and improved ecological consciousness have been (partly) addressed before. The case of the smart meter rollout in the Netherlands that was halted because of privacy issues, comes to mind. Other experiences, like the one of Salzburg AG or VKW (AT), on offering consumers a more play-like interface and incentives have shown to improve acceptance.

There are many blanks, however, that need to be filled by sharing experience from individual projects. This way, concerns about privacy, complexity and uncertainty can be addressed.

Many national projects are addressing the needs and chances of advanced energy supply with respect to their national requirements and established systems. However, these are very distinct in European countries. There is a clear need for transnational cooperation as well in joint development projects and by building and maintaining cooperation platform (as it has been started with the GRID+ project)

Recommendations – how to close these gaps?

Active demand response has been in the centre of attention for some time now. This has been translated in the rise of VPPs over the past few years. The approach until now has been very technological and has taken the existing market situation and players as a reference. Results have been achieved in developing and fine tuning technological solutions and deploying them with a sizeable sample of users. In addition, we need anthropological analysis of preferences and interests that may lead customers to participate actively and make their flexibility available to the power system.

The main gaps are therefore in the non-technological field. Key items that appear from this analysis

- The acceptance of new energy systems (tackling the concerns about privacy and the fear of degraded quality of supply)
- The behaviour of individual consumers (including the chances of non-monetary incentives by applying psychological, marketing and societal means)
- The positioning of final consumers in the new energy/electricity landscape (including the legal and regulatory framework for advanced market models)
- The relation between the Smart Grid and the Smart Home discussion (concentrating on the improvement of comfort with advanced energy technology)
- Economic framework/business models implying all stakeholders (also home automation provider)

Many national projects are addressing the needs and chances of advanced energy supply with respect to their national requirements and established systems. However, these are very distinct in European countries. There is a clear need for transnational cooperation as well in joint development projects and by building and maintaining cooperation platform (as it has been started with the GRID+ project).

5.1.2 D2: Energy Efficiency from integration with Smart Homes

Smart homes are increasingly seen as the central nodes in future grids. The main activity over the past years has been on the development of “connection nodes” to the home. Both smart meters and non-meter residential gateways have been installed in numerous Proof of Concept and demonstration projects (e.g. Linear in Belgium). The gateways provide access to a service platform that manages the energy profile of the household.

In terms of objectives, this implies that the objectives on the development of gateways and the creation of network-level entities have been met to some extent.

Objectives not met

Nothing is being said on the following D2 objectives:

- Initiation of viable local energy markets: Technological solutions for supplying energy services have been deployed, but there is no (local) economic framework to use them in. The attempts at setting up the new kinds of players that are needed here (Esco's, aggregators) have been timid at best. Do note that there exist projects on demand response and actively participating customers, but not targeted at the local level where individual buildings interact.
- Integration of all energy and information flows in buildings: Projects look mostly at the electricity networks in and between houses. Full integration of all flows (electricity, gas, heat, information) and their optimisation has not been addressed.

Objectives partially met

The reported projects that address specifically D2 objectives are dealing with the following objectives:

- Different energy management systems and gateways will be made compatible or interoperable in the near future. The integration with DSO and TSO network management systems (Scada) is also improving
- Clustering of smart homes. The rise of the smart city concept brings with it the attention to smart districts. Interconnection and storage at the level of several buildings concentrated in one geographic area are appearing (e.g. Royal Seaport in Stockholm)

Objectives have been met but need networking/know-how exchange

The acceptance of smart homes and of active demand response is linked. Many countries have gained experience in creating a beginning of smart homes. Moreover, a number of projects will be launched focusing on really developing and demonstration the concept. The lessons learned need to be shared to speed up the rollout of smart homes, districts, cities and grids.

Recommendations – how to close these gaps?

Industry is quickly developing solutions for Smart Homes. They concentrate on improving comfort with all types of home automation systems. However, in few cases these applications involve improvement in the field of efficient and flexible and energy consumption. European R&D should open ways so that industry and societal interests (e. g. carbon free energy supply) can be joined.

Despite the spike of interest in Smart Homes, most Smart Grid projects have not yet gone beyond the deployment of meters or gateways. Therefore major points of attention for future projects are

- The development of individual dwellings into truly smart homes, focusing on all energy carriers (include O&M – needs to be simple to have public acceptance)
- Tying the smart homes together at the local level to enable direct interaction among them (to build local cells with balanced energy production and consumption that allow for efficient use of energy and existing grids and for islanding in case of emergency)
- Specific product developments improving efficiency in secondary and tertiary sectors
- Creating the economic (market) framework to make the local interactions also economically viable (for example by providing market places for a new type of market roles in the field of managing homes)

5.2 Cluster 2: Integration of Smart Metering

Most of national projects refer to both smart metering infrastructure and data processing. While many of the infrastructure objectives seem to be more or less covered, data processing objectives are hardly being achieved. First of all, consumer participation in relation to their energy choice, personalised energy offers, reaction to collected data streams and potential energy savings are being neglected. Secondly, there are not evidences that projects aim at the management of different meter reading services, advanced meter management system and network security, and just a few of them deals with the use of smart metering data for improving network observability.

A majority of results is expected to be obtained in the next years. These relate to the integration of smart meters with smart homes, active demand side management and improvement of grid control. Knowledge and experience already gained by individual countries should be transferred to others as they could provide valuable input in terms of planning, logistics and specifications of smart meter roll outs and in the use of open communication protocols. Issues like customer data privacy rules and data processing tools should be developed by a transnational team in order to secure European implementation.

5.2.1 D3: Metering infrastructure

The large majority of the 49 projects reported across Europe that deals with Cluster 2 Integration of smart metering, are directly linked to D3 Metering infrastructure.
Many of these projects are part of large smart grids integrated projects deployed at national level, and most of them are also driven by the EU directive for the roll out of smart metering across Europe.

The main focus on these ongoing projects is the effective deployment of smart metering infrastructure for remote metering processing. ICTs integrated technologies, based on open communication standards are being tested.

Other objectives that are being achieved are:

- Issues related to customer acceptance: Information and awareness about the possibilities to save energy, ways of presenting energy consumption to impact on their energy behaviour.
- Improvement of logistic procedures for Smart Meter (SM) rollout
- Remote firmware download for components in the field

Objectives not met

From the description of the projects reported by the national experts, all the objectives identified in the D3 functional project description are somehow listed in any national demonstration projects. However, some of them seem to be either poorly covered or not included in large size demonstrations. These objectives are:

- Allowing active technical management of the networks exploiting microgeneration, medium scale Distributed Generation systems and active demand side management.
- Deployment of highly scalable smart metering network intrusion detection

Objectives partially met

Some of the D3 objectives seem to have been achieved in one or two specific projects. It might be necessary to address these particular objectives in other Regions and under different circumstances before considering as fully achieved objectives. These objectives are:

- Possibility of deploying shared smart metering infrastructure for different meter reading services
- Cross-vendor standardisation of the devices in electrical, mechanical and data technology (PRIME has already delivered results)
- Enabling the network to integrate users with new requirements (including the consumers that also have installed micro generation devices and or have home Electric Vehicle charging systems)
- Development of more effective authorisation access mechanisms

Most of the projects have key objectives identified for the next years, as a “second phase” of the smart metering roll out. These are very much related to the integration of SM with smart homes and the empowering of customers to participate in the management of the grid, and according to the project schedules they will be achieved in the next years. These objectives are:

- Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management
- Empowering consumers to become active participants in their energy choice
- Offering energy saving and home automation programs for homeowners
- Integration with smart homes
- Identification of potential to enhance energy efficiency for residential customers through intelligent counter and by feed-back systems, and dynamic tariffs
- Determination of the potential to increase process efficiency for energy suppliers utilising smart metering and communication systems (advanced meter management systems, AMM)
- Stimulation of end users concerning energy efficiency and DER
- Ensuring network security, system control and quality of supply
- Enhancing the observability and control of MV and LV distribution networks using smart meters
- Allowing active technical management of the networks exploiting microgeneration, medium scale Distributed Generation systems and active demand side management.
- Enhancing the observability and control of MV and LV distribution networks using smart meters (Finnish SGEM programme is used for monitoring faults in the LV network) – sending events from LM faults to network control center, using this data for fault location

Objectives have been met but need networking/know-how exchange

The knowledge and experience gained by the EU countries that go ahead in the roll out of the smart meters is very valuable for those countries that are starting to do it. Issues like roll out planning, logistics, drafting of functional specifications, etc. are clear examples of experiences that can be transferred.

The potential and benefits of the different open communication standards that are being used in some countries are another topic for know-how exchange that is already being taken in consideration Europe.

The use of smart metering infrastructure for interacting with smart homes and empowering residential customers to participate in demand response programs is a common objective for the next years in several EU countries. It will be very profitable to share these experiences from the very beginning. One hand, to exchange ideas in terms of customer involvement across Europe in energy efficiency programs could be very useful for some countries, and other hand to compare different technical approaches and to share cost-benefit analysis will pave the way for a future customer-centric retail market in Europe.

Recommendations – how to close these gaps?

Smart metering infrastructure roll out is considered to be one of the pillars of the smart grids. Most of the European countries are already deploying these infrastructures encouraged by the EU Directive in this field. However, additional functions and full exploitation of smart metering capabilities is still to be demonstrated.

The following recommendations are proposed to cover these gaps:

- Those EU countries that have already deployed (or almost) their smart metering infrastructure should share their experiences and best practices with those countries that are planning or starting to do it.
- Exchange information and evaluate pros and cons on the different open communication standards that are being used in EU
- Promote the deployment of large scale demonstration projects to evaluate the different alternatives to use the smart metering infrastructure to enable residential customers to participate in the active management of the grid. Consider different technical solutions in different market environments.
- Some Research effort is still needed to get the most of smart metering infrastructure. Tools for enhancing the LV/MV observability or to accommodate a larger share of small DER are clear examples of this.

- Research in communication reliability, speed and capacity in order to get more data more frequent. Convergence with control communication will imply a more efficient system.
- Research in basic mater sensors for compact and cheaper solutions

5.2.2 D4: Smart metering data processing

Most of the reported projects referred to Cluster 2 Integration of smart metering, have been identified by national experts as projects related to D4 functional project, too.
That means in short, that the majority of the projects addressed to deploy some smart metering infrastructure have as a secondary objective to perform some smart metering data processing as well.

However, when looking to the description details of the projects, many of these projects hardly lists a few of the expected objectives of D4 functional projects.

Looking to the reported information, the only main general objective that seems to be already fulfilled, or is in the way to, is the use of MDM systems to collect and organise basic information coming from smart meters. It is supposed that this is just for energy measuring and billing purpose.

Only a few exceptions talk about the development and testing of some advanced processing for interacting with other utility business systems. There are some good examples of that in Austria and Latvia.

Objectives not met

Nothing is being said on the following D4 objectives:

- Possibility of collection and management of different meter reading services
- Better knowledge of different consumption profiles
- Possibility of personalized energy offers to different segment of customers
- Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management
- Empowering consumers to become active participants in their energy choice
- Identifying behaviors and trends from consumers (and even microgenerators) when exploiting large data streams collected from smart meters
- Identification of potential to enhance energy efficiency for residential customers through intelligent counter and by feed-back systems, and dynamic tariffs
- Determination of the potential to increase process efficiency for energy suppliers utilising smart metering and communication systems (advanced meter management systems, AMM)
- Ensuring network security, system control and quality of supply
- Information Technology for Trustworthy Smart Grids
- Distributed online analytical stream processing system with spatial and temporal dimensions

Objectives partially met

The very few reported projects that address specifically D4 objectives are dealing with the following objectives:

- Enhancing the observability and control of MV and LV distribution networks using smart meters
- Allowing active technical management of the networks exploiting microgeneration, medium scale Distributed Generation systems and active demand side management (including electric vehicle charging)
- Improvement of grid control
- Improvement of network planning, utilising metering data for advanced calculation of network losses, enabling more optimized network planning
- Enhancing efficiency in day-to-day grid operation

The work on these issues has recently started. Some immediate results have already been obtained but the most promising ones will come in the next years.

It is considered that to successfully cover these objectives, it is needed some more R&D effort in several EU regions. This is the reason why the above mentioned objectives can only be considered as "partly achieved"

Objectives have been met but need networking/know-how exchange

Issues like methods and common rules to ensure the customer data privacy are clear examples of common work and agreement between the different stakeholders.

Although not already achieved, the necessary R&D effort for data processing tools for network control is also a good space for collaboration, because there are a large variety of MV/LV models and topologies in Europe and collaboration between network experts in Europe will be necessary to efficiently cope with this topic.

Recommendations – how to close these gaps?

There is a lot to do to fulfil the objectives of this functional project, and collaboration across Europe is absolutely necessary, not only for Demonstration but also for Scientific and Technical development.

The following recommendations are proposed to cover these gaps:

- Agree clear common rules to ensure the customer data privacy
- Promote European wide R&D projects to investigate and test methods and tools for getting the most of smart metering data for:
    - Innovative Energy Management Systems to control consumer loads and decentralised plants
    - Provide customized tariffs for different consumer segments (eg. Residential sector vs large office blocks)
    - Facilitating new business models of providing meter reading services, and other energy services.

5.3 Cluster 3: Integration of DER and new uses

The majority of projects allocated to cluster 3 is dealing with medium scale DER integration while there is only a limited amount of projects particularly focusing on the low voltage network. Often, both MV and LV networks are considered in the same project but the latter topic shows much less research and demonstration efforts. Besides gaps in the technological area, for instance the need of prediction tools for system operators, the projects would benefit from a clearer economical and regulatory framework. New market mechanisms for a successful deployment of DER integration are required as well as standards for network interconnections.

There is almost no ongoing project with European format on storage integration. Several projects are considering storage as an additional degree of freedom for large scale distributed generation integration. Main barrier are the actual costs of different storage technologies, thus the short time goal should be to reduce their costs. Electric vehicles struggle with similar problems although quite a few projects have recently started and a significant amount of results and experiences should be available within two years.

5.3.1 D5: DSO integration of small DER

In general, only a few projects have a specific focus on low voltage networks but LV is often also considered in MV network projects. Several projects are currently dealing with detailed modelling and understanding of low voltage networks for the integration of a high share of DER (distributed generation, storage and e-mobility) as well as related smart grid controls. Smart metering is often thought of monitoring technology as well as provider of information and communication infrastructure. Only a few field test and demonstration activities are currently running or planned within the next 2 years. Most of the projects are focusing on voltage control concepts and local balancing with taking into account distributed generation units, demand response, local storage as well as e-mobility. Main barrier for developing system related approaches is a lack of understanding of the real behaviour of low voltage systems as well as a lack of low voltage network simulation models.

The dominating generation technology in LV network related projects is system integration of photovoltaics. Thus different projects (including small scale field tests) on future functionalities of PV inverters (e.g. reactive and active power control) are currently in progress.

Objectives not met

The following objectives, mainly dealing with legal and economic aspects as well as interoperability and standardisation, are almost not addressed by the collected projects:

- New frameworks for network interconnection, interconnection standards
- Recommendations and solutions to remove barriers considering economic, regulatory, societal and cultural aspects
- Device and system level interoperability (e.g. communication interfaces)
- Necessary incentives/market mechanisms (e.g. for ancillary services)
- Grid losses reduction by small scale DER
- Islanding operation and black start capability with support of DER

Objectives partially met

- “Grid friendly” behaviour of PV inverters (ancillary services like e.g. reactive and active power control, frequency control, harmonics filtering)
- Improved network assets (e.g. distribution transformers with on load tap changing)
- Network monitoring systems and related communication infrastructure supporting small scale DER integration in low voltage networks
- Monitoring and modelling of LV networks
- Control approaches to increase LV network hosting capacity

- Voltage control and congestion management in LV network by reactive and active power management
- Interaction of small scale distributed generation, storage, demand response and e-mobility
- Generation-load balancing
- Coordination between technical grid control and market based power balancing (e.g. technical virtual power plant vs. market based virtual power plant)
- Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management while ensuring non-discrimination
- Testing demand response mechanisms in low voltage networks
- Explore how new tariffs can alter customer behaviour
- Integration of home automation systems in network management for demand side management and demand response purpose
- ICT infrastructure in low voltage networks for monitoring and control of SDER

Objectives have been met but need networking/know-how exchange

Within the next two years first results for "Grid-friendly" behaviour of PV inverters (ancillary services like e.g. reactive and active power control, frequency control, harmonics filtering), network monitoring systems and related communication infrastructure, voltage control and congestion management in LV network by reactive and active power management will be available. Additionally, the topic of low voltage network modelling will be elaborated. European wide networking and know-how exchange should take place in the mentioned areas.

Recommendations – how to close these gaps?

In general the focus should be on launching a significant number of additional projects dealing on integration of DER in low voltage networks on national and European level including field tests and demonstration activities to get a critical mass of experience. This will be the basis for extracting concrete recommendation toward small scale DER integration on European level (family of projects) within the next 3 to 6 years.

In short term the following topics should be addressed:
- Monitoring and modelling of LV networks (different types and topologies all over Europe)
- Control approaches to increase LV network hosting capacity
- Interaction of small scale distributed generation, storage, demand response and e-mobility
- Launching more projects including field tests and demonstrators

On technology level further projects are required:
- ICT infrastructure on LV networks
- Applicability of smart metering infrastructure for monitoring and control of LV networks
- Secondary substation automation (e.g. OLTC transformer MV/LV)
- Power electronic at distribution network level (SVC, STATCOMS)

In medium term (2-4 years) the following issues should be addressed by national and international projects:
- Comparison of different control approaches
- Interaction of small scale distributed generation, storage, demand response and e-mobility
- Local coordination of small scale DER in cases of call islanding
- Cost benefit analysis of approaches for small scale DER integration
- Investigation and comparison of market driven and network driven control approaches
- LV network planning approaches (how can new control strategies be integrated in network planning)
- Identify best practise examples and investigation of transferability and scalability on European level
- Interoperability of different approaches in different network structures as well as different climatic and cultural environment
- Interaction with medium voltage networks
- Network interconnection requirements
- Large scale field test and demonstration

In long term (>4 years) the focus should be on:
- Large scale integration of smart home applications in LV network operation

- Business and market models for small scale DER integration
- Interoperability
- Standardisation

5.3.2 D6: System integration of medium DER

Currently a significant number of projects addressing the integration of DER in medium voltage networks are in progress all over Europe. The focus is on voltage control concepts to maximize the MV network DER hosting capacity as well as loss reduction in MV networks. Several field test and demonstrators have recently started or will soon be starting. Following objectives will (soon) be fulfilled by different projects:

- Increase in the medium voltage grid hosting capacity for medium scale distributed generation resources
- Optimisation of existing network assets utilisation
- Increase in network availability/power quality in presence of large penetration of medium DER
- Reduction in DER cut-off due to congestion
- Cost reduction for medium scale DER integration
- Optimisation of load flows
- Reduction in network losses
- Containment of costs compared with a “business as usual” approach (building new lines and substations)

Objectives not met

The following objectives are almost not addressed by the collected projects:

- Prediction tools for system operators (for consumption and local generation)
- Intelligent planning of DER integration and implementation of related control approaches

Objectives partially met

- Distribution Management Systems – Automation of MV networks with high DER penetration
- Grid loss reduction through reactive power compensation provided by DER
- Monitoring of MV networks (Distribution management systems, SCADA systems)
- Generation-load balancing including storage
- Better exploitation of the existing medium voltage infrastructure in order to increase hosting capacity for medium scale DER
- Voltage control and congestion management in the entire network by reactive and active power management
- Reducing costs of DER integration – cost benefit analysis
- Necessary incentives/market mechanisms (e.g. for ancillary services)
- New market rules necessary for successful deployment of DER in medium voltage networks
- Coordination between technical grid control and market based power balancing (e.g. technical virtual power plant vs. market based virtual power plant)
- Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management in medium voltage networks
- Testing demand response mechanisms
- Explore how new tariffs can alter customer behaviour
- Network interconnection requirements
- Device and system level interoperability (e.g. communication interfaces)
- Standardisation based on IEC 61850 and 61970/61968 (CIM)
- What regulatory changes would be needed (for project execution and deployment)?
- European and national (local demonstrator) energy policies and energy strategies
- Recommendations and solutions to remove barriers considering economic, regulatory, societal and cultural aspects

Objectives have been met but need networking/know-how exchange

Within the next two years experiences from field tests dealing with voltage control concepts and congestion management in MV networks by reactive and active power management as well as loss reduction will be available and should be distributed European wide.

Recommendations – how to close these gaps?

In general one focus should be on comparing the different solutions for small scale DER integration all over Europe with the focus on interoperability, scalability and transferability. In short term following activities should be preferred:

- Sharing experiences and results of ongoing projects
- Identify best practice examples
- Scalability and transferability
- Interoperability of the different approaches and technologies in different network structure as well as different climatic and cultural environment
- Enabling and integration of demand response on medium voltage level (small industry)
- Coordination between technical grid control and market/tariff based control (e.g. technical virtual power plant vs. market based virtual power plant)
- Cost benefit analysis of control approaches
- Business and market models for medium scale DER integration in Europe
- Planning of medium scale DER integration
- Network interconnection requirements

Medium term:

- From field test to large scale demonstration projects
- Standardisation
- Interaction of medium voltage networks with high share of DER and new control approaches with high voltage and transmission networks

Long term

- Technology based development of solutions for large scale deployment of the solutions

5.3.3 D7: Integration of storage in network management

There is almost no ongoing project with European format specifically focusing on storage integration in distribution networks. Several projects are considering storage as an additional degree of freedom for large scale distributed generation integration. The main barrier are high costs of different storage technologies and thus the short time goal should be on technology based research for reducing the cost of storage technologies.

Recommendations – how to close these gaps?

Due to the lack of projects on storage integration mainly because of missing cost efficient storage technologies as well as business cases for storage integration following topics should be addressed on the technology side in short terrn:

- Storage systems and behaviour of storage technologies and ability for network support (e.g. voltage control, frequency control)
- Power electronics for network interconnection of storage systems
- PV hybrid systems (photovoltaics and storage)
- Market and business models for storage integration
- Technologies for reducing costs of storage systems
- Optimal trade-off between local and central storage

Medium term:

- Integration of storage in concepts for increasing DER hosting capacity of distribution networks
- “second life” of e-mobilty batteries for stationary solutions
- Islanding operation of distribution networks
- Cost benefit analysis
- Planning approaches for storage integration (technology, sizing, location…)

Long term:

- Large scale demonstrators and field tests including storage technologies

5.3.4 D8: Infrastructure to host EV/PHEV

Recently a lot of projects with European format focusing on infrastructure for hosting e-mobility and its network integration have been started. So far, just a few results have been published and no general conclusion can be made regarding their achievements and further research needs. However, main barriers seem to be the actual cost of e-vehicles as well as the availability of cars for field tests and demonstrators. So, in short time the focus should be on technology based research for reducing the cost of e-mobility and on functionalities of charging infrastructure to enable flexible integration of e-mobility.

Recommendations – how to close these gaps?

In general there is a lack of experiences from already finished projects. Recently a lot of different projects on infrastructure to host electric vehicles have been started and so only a few concrete first results are available. Until recently there was a lack of available cars and so there is no big experience based on field test and demonstrators available. Within the next 2 years a significant amount of first results and experiences will be available:

Short term recommendations:

- Research projects on the influence of different scenarios of future e-mobility development on electricity networks and charging infrastructure
- Impact of EV/PHEV on the distribution network depending on charging behaviour and local/regional conditions
- Power electronics for flexible charging stations
- Technology based research for reducing the costs of e-mobility and related charging infrastructure
- Addressing changes to existing standards regarding integration of electric mobility in the grid

Medium term recommendations:

- Voltage control, frequency control and congestion management by EV/PHEV
- Prediction tools for EV charging for system operators
- Charging station integration planning (power and location), interaction with DER
- Field test and demonstrators with a high share of e-mobility
- Participation of EV in islanding operation and black start schemes of distribution grids with active generation, load and storage devices
- Business and market models for networks integration of e-mobility (aggregators)
- Standardisation
- Interoperability

Long term recommendations:

- Large scale demonstrators and field tests including e-mobility and charging infrastructure

5.4 Cluster 4: Smart Distribution Network

In order to reach the major goal of optimising the utilisation of the current electricity grid to avoid huge costs on infrastructure several aspects need to be further investigated: network availability/power quality in presence of high penetration of active resources, interaction of LV networks with a high share of renewable with MV networks, advanced stand-alone power electronics solutions in LV and MV networks (compensation of disturbances, current limiters, interconnection of feeders, etc), optimisation of load flows and network ageing. Furthermore, AMI data should serve advanced load modelling and new methods and algorithms for smart control of active customer gateway need to be developed. In the ICT field, there is the need to start more projects on the integration of ICT systems into open service platforms and on the verification of latest communication technologies used in system control and automation.

Benefits of transnational cooperation projects are especially seen in the areas of ICT management systems, grid simulation methods and grid monitoring.

5.4.1 D9: Monitoring and control of LV network

Main focus of national projects referring to this functional project is on the increase of low voltage grid monitoring and control features especially for active resources. Further knowledge on the latter will help to reduce network losses by optimising the utilisation of existing LV network assets and the integration of storages which are also issues looked at in the majority of European projects.

Objectives not met

- Increase the network availability/power quality in presence of high penetration of active resources
- Interaction of LV distribution networks with high share of active resources with medium voltage networks
- Advanced stand-alone power electronics solutions in LV networks (eg compensation of disturbances)
- MV/LV transformers (OLTC)
- LV DC equipment

Objectives partially met

- Increase the low voltage grid monitoring and control features especially for active resources (e.g. PV, EV, storages)
- Optimisation of the utilisation of existing LV network assets
- Involvement of storage uses in LV network
- Enable increased participation of grid users in network operation/ energy markets
- Containment of costs compared with a “business as usual” approach (network reinforcement)
- Develop and monitor LV protection systems for two-way power flow in LV networks
- Reduction in network losses
- Open new business opportunities related to “ancillary services” (e.g. voltage control, reactive power provision) for the low voltage network
- LVDC network architecture, enabling better throughput of energy in LV network and easier connection point for DG units (piloted in Finland within SGEM program)

Objectives have been met but need networking/know-how exchange

- Increase the low voltage grid monitoring and control features especially for active resources

Recommendations – how to close these gaps?

- none of the objectives is completely finished
- to start with networking/know-how exchange in the area of the main focus of national demonstration projects (LV grid monitoring and control)

- to start with large-scale demonstration and supporting R&D projects in the area of partly achieved objectives:
    - Increase the low voltage grid monitoring and control features especially for active resources (e.g. PV, EV, storages)
    - Optimisation of the utilisation of existing LV network assets
    - Involvement of storage uses in LV network
    - Enable increased participation of grid users in network operation/energy markets
    - Containment of costs compared with a “business as usual” approach (network reinforcement)
- to start with R&D and small demonstration projects in the area of located gaps:
    - Increase the network availability/power quality in presence of high penetration of active resources
    - Interaction of LV distribution networks with high share of active resources with medium voltage networks
    - Advanced stand-alone power electronics solutions in LV networks
    - MV/LV transformers (OLTC**)**
    - LV DC equipment

5.4.2 D10: Automation and control of MV network

As in D9, also in D10 the main focus lies on grid automation, control for grid active resources and the optimisation of existing network assets. Other important aspects are the introduction of self-healing networks and the interaction of distribution with transmission networks.

Objectives not met

- Optimisation of load flows
- Advanced stand-alone power electronics solutions (compensation of disturbances, current limiters, interconnection of feeders, …)
- Network ageing
- Materials and network construction “Carbon” content
- Materials required for advanced new sensors for the MV grid (reliability, cost, precision)

Objectives partially met

- Increase in the medium voltage grid automation and control for grid active resources
- Interaction of distribution networks with high share of active resources with transmission networks
- Containment of costs compared with a “business as usual” approach
- Optimisation of the utilisation of existing network assets and planning
- Increase in network availability/power quality in presence of active resources
- Introduction of self-healing networks and increasing the automation level of distribution substations
- Cost reduction by automation, control and self-healing features
- Reduction in network losses
- Enable increased participation of grid users in network operation/energy markets
- Open new business opportunities related to “ancillary services” for the MV network

Objectives have been met but need networking/know-how exchange

- Increase in the medium voltage grid automation and control for grid active resources
- Interaction of distribution networks with high share of active resources with transmission networks

Recommendations – how to close these gaps?

- none of the objectives is completely finished
- to start with networking/know-how exchange in the area of the main focus of national demonstration projects (grid automation and control)

- to start with large-scale demonstration and supporting R&D projects in the area of partly achieved objectives, especially self-healing network features:
  - Increase in the medium voltage grid automation and control for grid active resources
  - Interaction of distribution networks with high share of active resources with transmission networks
  - Containment of costs compared with a “business as usual” approach
- to start with R&D and small demonstration projects in the area of located gaps:
  - Optimisation of load flows
  - Advanced stand-alone power electronics solutions in MV networks (compensation of disturbances, current limiters, interconnection of feeders, …)
  - Network ageing
  - Materials and network construction “Carbon” content
  - New operation models with dynamic rating information and risk based criteria

5.4.3 D11: Methods and system support

The majority of the projects relevant to D11 concentrate on the increase of distribution grid expert systems, state estimation solutions and grid simulation methods. There have also been improvements on power quality management and micro grid operation.

Objectives not met

- Demonstration of AMI impact on grid simulation methods
- Advanced load modelling based on AMI data and customer re-classification
- Development of methods and algorithms for smart control of active customer gateway (based on needs of customer, producer, DSO, TSO, energy supplier, aggregator)
- Reduce network costs
- Optimisation of load flows
- Reduction in network losses
- Open new business opportunities related to “ancillary services” by expert system technologies

Objectives partially met

- Increase in the distribution grid expert systems, state estimation solutions and grid simulation methods
- Improvement on network availability/power quality (power quality management) through active state estimation
- Reduction in active resources impact on asset exploitation and investment level
- Optimisation of the utilisation of existing network assets
- Islanding and micro grid operation
- Advanced load modelling based on AMI data and customer re-classification, first results derived from SGEM program in Finland

Objectives have been met but need networking/know-how exchange

- Increase in the distribution grid expert systems, state estimation solutions and grid simulation methods

Recommendations – how to close these gaps?

- none of the objectives is completely finished
- to start with networking/know-how exchange in the area of the main focus of national demonstration projects (LV grid monitoring and control)
- to start with large-scale demonstration and supporting R&D projects in the area of partly achieved objectives:

- Increase in the distribution grid expert systems, state estimation solutions and grid simulation methods
  - Improvement on network availability/power quality (power quality management) through active state estimation
- to start with R&D and small demonstration projects in the area of located gaps:
  - Demonstration of AMI impact on grid simulation methods
  - Advanced load modeling based on AMI data and customer re-classification
  - Development of methods and algorithms for smart control of active customer gateway (based on needs of customer, producer, DSO, TSO, energy supplier, aggregator)
  - Reduce network costs
  - Open new business opportunities related to “ancillary services” by expert system technologies
  - Distributed intelligence with hierarchical distributed control by network cells models should be investigated

5.4.4 D12: Integrated communication solutions

Development of ICT structures and systems for overall management of active resources are among the key research areas within the functional project D12. This includes active gateways and application layer communication models and protocols.

Objectives not met

- Integration of the grid ICT system into open service platform (business communications, SmartHome, e-Health, e-Education, Intelligent Transportation, etc)
- Testing and verification of latest communication technologies to be used in system control and automation, like LTE
- Verification of solutions by large scale simulations and laboratory and field test installations

Objectives partially met

- Development of ICT structures and systems for overall management of active resources and their active gateways including application layer communication models and protocols
- Developing and testing technical solutions for interactive gateway and ICT systems; tools for customer, DSO, TSO, supplier, aggregator and other actors
- Impacts of data security vulnerabilities on the selection of implementation techniques Network integration of charging infrastructure
- Specification and architecture work for utilizing 4G/LTE technology in Smart Grid communication, pilots planned for 2012
- Utilizing public cellular networks in Smart Grid communication, in cooperation with telecom operators and DSOs
- Standardised MV communication technology for seamless smart grid communication deployment

Objectives have been met but need networking/know-how exchange

- Development of ICT structures and systems for overall management of active resources and their active gateways including application layer communication models and protocols

Recommendations – how to close these gaps?

- none of the objectives is completely finished
- to start with networking/know-how exchange in the area of the main focus of national demonstration projects (technical solutions for ICT systems)
- to start with large-scale demonstration and supporting R&D projects in the area of partly achieved objectives:
  - Integration of the grid ICT system into open service platform (business communications, SmartHome, e-Health, e-Education, Intelligent Transportation, etc)

- Testing and verification of latest communication technologies to be used in system control and automation, like LTE etc.
    - Verification of solutions by large scale simulations and laboratory and field test installations
- to start with R&D and small demonstration projects in the area of located gaps
- customer energy data needs and communication data channels (social networks, smart phones, etc)

6 Conclusions

The Energy Work Programme 2012 under the Seventh framework programme focuses on the SET-Plan and in reference to smart grids, it has been designed to support research and demonstration needs stated in the EEGI Roadmap and Implementation Plan. One of the major objectives is to implement the “families-of-projects concept”. This means local pilot or demonstration projects, primarily supported at national or regional level, with the same or similar goals, should be incentivised to collaborate and to enable synergies. Several projects complemented by common R&D work packages for cross-border cooperation and thus brought on European level would facilitate to achieve the requirements of specific functional projects.

For the upcoming call, the Member States Initiative recommends maintaining the families-of-project concept for technological advanced functional projects where system innovation now is priority. To accelerate deployment of proven technologies and concepts, support programmes have to concentrate on information exchange and know-how dissemination. However, the gap analysis also highlights areas where dedicated research on technology is needed depending on the progress of functional projects.

Annex I: List of national experts and table chairs

Country	Name	Organisation
Austria	Helfried Brunner	Austrian Institute of Technology (AIT)
Belgium	Guy Vekemans	Vito
Belgium	Peter Verboven	Vito
Croatia	Davor Škrlec	Ministry of Science, Education and Sports
Czech Republic	Lubomír Mazouch	Ministry of Industry
Denmark	Allan Norsk Jensen	Danish Energy Association / DNO
Finland	Kari Koivuranta	Fortum Distribution
France	Axel Strang	Ministry of Ecology, Transportation and Housing
Germany	Ludwig Karg	B.A.U.M. Consult
Germany	Ute Roewer	Projektträger Jülich / Forschungszentrum Jülich GmbH
Greece	Stathis Tselepis	Center for Renewable Energy Resources (CRES)
Ireland	Fergal Egan	ESB RD&D Coordinator
Italy	Michele de Nigris	RSE S.p.A
Latvia	Gunta Šlihta	Latvian Academy of Sciences
Norway	Erland Eggen	Energidata Consulting
Poland	Marcin Jamiołkowski	National Fund for Environmental Protection & Water Mgm.
Portugal	Joao Pecas Lopes	INESC Porto
Slovenia	Igor Papič	University of Ljubljana
Spain	Angel Díaz Gallo	Tecnalia
Sweden	Fredrik Lundström	Swedish Energy Agency
Sweden	Fredrik Brändström	Swedish Energy Agency
Switzerland	Rainer Bacher	Bacher Energie AG
The Netherlands	André Postma	Enexis
The Netherlands	Marcel van Hest	Alliander
Turkey	Abdullah Nadar	Tübitak Uzay
United Kingdom	John Christie	Department of Energy and Climate Change (DECC)

Cluster	Table Chair	Deputy
1: Integration of Smart Customers	Peter Verboven (Vito, BE)	Ludwig Karg (B.A.U.M., DE)
2: Integration of Smart Metering	Angel Díaz Gallo (Tecnalia, ES)	Joao Pecas Lopes (INESC Porto, PT) Michele De Nigris (RSE, IT)
3: Integration of DER and new uses	Wolfgang Hribernik (AIT, AT)	John Christie (DECC, UK)
4: Smart Distribution Network	Igor Papič (Univ. Ljubljana, SI)	Kari Koivuranta (Fortum, FI)

Annex II: Descriptions of functional projects D1-D12

Cluster 1: Integration of smart customers

The overall focus of cluster 1 is on the role and position of the smart/empowered consumer in smart grids. There are two aspects to this role.
On the one hand, an energy prosumer will get more options to shift their consumption or production in time to achieve the best overall balance in the network – and the most economically advantageous terms as a consequence. This active demand response is the subject of functional project 1.
On the other hand, the demand response - and overall energy efficiency - of domestic prosumers is dependent on the extent to which homes will be equipped with sensing technologies and intelligence. Dwellings will become active and autonomous units within the overall electricity networks, interacting to use or produce energy efficiently and to achieve grid balance. The second functional project of cluster 1 is concerned with such integration of smart homes in the entire system.
This document outlines the general philosophy for each of the functional projects and then proceeds to a more detailed discussion of the four defining features of each project, ie:

- The components of the entire smart grid the project focuses on
- The level of analysis at which the components are networked
- The market and business models that are needed to motivate end users to take part in DSM or home automation
- The crucial elements for customers to accept – and actively use - the solutions proposed in this field

Finally, the complementarity of both projects is highlighted. Common framework conditions and an integrated approach to both demand response and smart houses, are key to successfully develop activities in cluster 1.

D1 Active demand response

Main/general objective:
Active demand response aims to demonstrate ways to let end users participate actively in the balancing of the electricity grid by adapting their energy consumption and production. Demand response is a core concept in smart grids that is covered in other functional projects as well (eg. cluster 3). The approach in here, however, is squarely focused on the individual (residential) user. All technological developments and framework conditions covered in this functional project, therefore take the (residential) user, his interests and business cases as the point of reference.

The consequence of radically adopting the end user perspective, is a changing view of the smart grids landscape. End users are consumers in the broadest sense, caring relatively little about their energy supply. This is just one (tiny) part of the context they live in. Their way of approaching it, is mostly influenced by factors fully out of the scope of players in the traditional smart grids space. The challenge will therefore be to bridge the gap between the world of consumers (rather than "customers") and the vision of customers (rather than "consumers") as the recipients of energy at the end of the chain.
Bridging the gap requires a unique mix of technological solutions, economic incentives and entirely non-economic and non-technological insights in user behavior.

Objectives and Benefits:
- Development of more effective user interfaces
    - Motivation of users to act based on interface
    - Larger scale deployment

- Development of (commercial) virtual power plants, mostly in residential areas
    - Robust integration of DER, even with higher numbers of participants
    - Positioning of VPP in relationship to players, like DSOs
    - Establishment of roles and relationships within (c)VPPs

- Establishment of coherent economic conditions for end users
    - Creation of framework to motivate end users to participate in DR
    - Development of sustainable (non-subsidized) incentive models
    - Integration of existing cost/benefit analyses in new work on consumer business cases

- Understanding of broader influencing factors in consumer behavior
    - Insight into the dynamics and the motivation of connected living
    - Translation of broader trends to electricity/grids context
    - Trade-off between economics (monetary incentives) and non-economic motivators (e.g. ease of use)
    - Re-positioning of end customers in the smart grids value chain

- Improvement of customer acceptance
    - Privacy issues
    - Fear of complexity
    - Fear of uncertainty (disruption of supply)
    - Ecological consciousness

	D1 Active demand response
Component	• User interfaces (e.g. displays)
Network	• Commercial VPPs
Market/ BModels	• Variable energy pricing schemes • Incentive schemes • (Capacity-based) distribution tariffs
Customer Acceptance	• Tangible, short-term benefit creation • Peer pressure and social desirability • Alignment with broader trends

D2 energy efficiency from integration with smart homes

Main/general objective:
Energy efficiency from integration with smart homes aims to provide the solutions to physically and logically integrate individual homes (*or buildings*) into a smart grid. In comparison to functional project 1, the accent is more on the technological solutions than on the motivation of individual consumers. In functional project 2, smart consumers are modeled as smart buildings that are interconnected and interact continuously and – mostly – automatically.

When considering intelligent buildings, the focus needs to be sufficiently broad.
First of all, it is about more than only electricity. An integration of all energy flows, together with the data flows that are necessary to govern them, is needed. The interplay of heat, cold, electricity and ICT is necessary to reach a global optimum.
Secondly, both the flows as such as well as their storage have to be taken into account. Finally, a home is not to be considered in isolation, but as an element of an interconnected system.

Objectives and Benefits:

- Development of residential gateways
    - Robustness of the energy management system when higher numbers of connected houses/devices are involved
    - Compatibility of gateways and systems
    - Compatibility of the overall system with existing TSO, DSO and supplier (eg. billing) ICT-systems
    - Data protection and security
    - Energy consumption of the energy management system and gateway as compared to the overall energy savings.

- Integration of all energy and information flows in homes and buildings
    - Connection between electricity and heat flows within homes (heat pumps, μCHP, ORC, etc)
    - Home energy flow modeling and optimisation
    - Energy storage and interconnection

- Clustering of smart homes
    - Street and neighbourhood balancing
    - Shared storage
    - Interconnection between electricity and heat networks

- Creation of network-level entities
    - In-home home-automation networks (behind the gateway) of heterogeneous components (compatibility of devices)
    - Development of local cells on the distribution grid, managed by remote software agents, responsible for balancing demand in their cell.
    - Integration of the network-level entities in a smart grids reference architecture

- Initiation of viable local energy markets
    - Development of market concepts, roles and incentives for a wider rollout of local energy markets
    - Cost-benefit analysis for local markets, taking into account regional differences within Europe.
    - Study into the roles and the type of players that will likely stand up (existing ones extending their roles or new ones)

- Customer acceptance of smart homes
    - Ensuring a widespread familiarity with connected living in all areas of life
    - Good and effective man-machine interfaces, ensuring – and reassuring - the consumer that he or she is in charge.

- Creation of (network) of living labs where alternative solutions can be tested in real-life conditions

	D2 Energy Efficiency from integration with smart homes
Component	• Energy manager + gateway • Appliances
Network	• Home automation • Cells/Agents
Market/ BModels	• (Local) Market places • Cost-benefits • Market roles + players
Customer Acceptance	• Connected living • Men-machine interface

Common framework conditions and challenges for D1 & D2

Framework	• Legal: Closed networks; privacy framework; anti-trust • Technology: smart meters • Economic: Higher cost of non-renewables • ICT: Open communication standards

Both functional project 1 (demand response) and 2 (smart homes) share a set of common framework conditions:

- Legal and regulatory context:
  Closed networks, energy supply authorisations, privacy regulation, anti-trust laws
- Technological context:
  Existence and distribution of smart meters and their compatibility
- Economic context:
  Cost of renewables coming down while conventional sources become more expensive

Cluster 2: Integration of smart metering

D3 Metering infrastructure

Main/general objective:
Leveraging on the rollouts of smart meters that are being done in most of the EU countries, the main objective of the project is to validate common, open standard solutions for next generation of smart meter infrastructure including solutions to provide customer with electricity consumption information in their homes.

Objectives and Benefits:

- Cost reduction
  - Remote management of metering infrastructure and data collection
  - Possibility of deploying shared smart metering infrastructure for different meter reading services

- Customer integration
  - Enabling the network to integrate users with new requirements (including the consumers that also have installed micro generation devices and or have home Electric Vehicle charging systems)
  - Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management
  - Empowering consumers to become active participants in their energy choice
  - Offering energy saving and home automation programs for homeowners
  - Integration with smart homes

- Increase of energy efficiency
  - Enhancing efficiency in day-to-day grid operation
  - Identification of potential to enhance energy efficiency for residential customers through intelligent counter and by feed-back systems, and dynamic tariffs
  - Determination of the potential to increase process efficiency for energy suppliers utilising smart metering and communication systems (advanced meter management systems, AMM)
  - Stimulation of end users concerning energy efficiency and DER

- Improvement of grid control
  - Ensuring network security, system control and quality of supply
  - Enhancing the observability and control of MV and LV distribution networks using smart meters
  - Allowing active technical management of the networks exploiting microgeneration, medium scale Distributed Generation systems and active demand side management.

- Interoperability
  - Cross-vendor standardisation of the devices in electrical, mechanical and data technology

- Information Technology for Trustworthy Smart Metering
  - Development of more effective authorisation access mechanisms
  - Deployment of highly scalable smart metering network intrusion detection

D3 Metering infrastructure	
Component	• Smart metering infrastructure as ICT bases for smart grid application in LV networks • Building automation systems that control heating, ventilation, air conditioning and lighting systems while ensuring the security of the premises. • Use of future communication technology (such as push mode) • Remote firmware download for components in the field • Interactive customer gateway (including advanced functions based on local intelligence) • Information Technology for Trustworthy Smart Metering
Network	• Innovative Energy Management Systems to control consumer loads (including Electric Vehicle charging) and decentralised plants • Customer web portal
Market/Models	• Different approaches for different consumer segments (eg. Residential sector vs large office blocks) • New business models of providing new meter reading services, and other energy services.
Customer Acceptance	• Information and awareness about the possibilities and opportunities of demand response through smart metering infrastructure; e.g., daily energy forecast through TV • Ways of presenting energy consumption to customers to impact on their energy behavior
Framework	• Legal: transposition of smart metering EU Directive to the Member States • Standardisation of metering and communication systems • Developing of new, flexible electricity tariff structure for energy saving promotion.

D4 Smart metering data processing

Main/general objective:
Meter Data Management (MDM) system is a backbone for metering data management and data exchange between Meter Data collection system and other business systems. Definition and implementation of proper MDM system functionality, as well as adaptation and streamlining of metering related DSO business processes are of utmost importance before mass rollout of smart metering can be started.

This functional project aims at validating cost-effective setups for information exchange between stakeholders and adequate processing of the data to maximise the benefits of smart metering.

Objectives and Benefits:

- Cost reduction
  - Remote management of metering infrastructure and data collection
  - Possibility of collection and management of different meter reading services

- Improvement of services for customers
  - Better knowledge of different consumption profiles
  - Possibility of personalized energy offers to different segment of customers
  - Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management
  - Empowering consumers to become active participants in their energy choice
  - Offering energy saving and home automation programs for homeowners
  - Integration with smart homes

- Increase of energy efficiency
    - Enhancing efficiency in day-to-day grid operation
    - Identifying behaviors and trends from consumers (and even microgenerators) when exploiting large data streams collected from smart meters
    - Identification of potential to enhance energy efficiency for residential customers through intelligent counter and by feed-back systems, and dynamic tariffs
    - Determination of the potential to increase process efficiency for energy suppliers utilising smart metering and communication systems (advanced meter management systems, AMM)

- Improvement of grid control
    - Ensuring network security, system control and quality of supply
    - Enhancing the observability and control of MV and LV distribution networks using smart meters
    - Allowing active technical management of the networks exploiting microgeneration, medium scale Distributed Generation systems and active demand side management (including electric vehicle charging)

- Interoperability
    - Standardisation of protocols and data models

- Information Technology for Trustworthy Smart Grids
    - Distributed online analytical stream processing system with spatial and temporal dimensions

D4 Smart metering data processing	
Component	• Smart metering infrastructure as ICT bases for smart grid application in LV networks • Building automation systems that control heating, ventilation, air conditioning and lighting systems while ensuring the security of the premises. • Use of future communication technology (such as push mode) • Remote firmware download for components in the field • Interactive customer gateway (including advanced functions based on local intelligence)
Network	• Innovative Energy Management Systems to control consumer loads and decentralised plants • Customer web portal • Meter Data collection system, • Billing systems • Data processing and optimisation tools • Data encryption tools • Distributed online analytical stream processing system with spatial and temporal dimensions
Market/Models	• Different approaches for different consumer segments (eg. Residential sector vs large office blocks) • New business models of providing new meter reading services, and other energy services.
Customer Acceptance	• Data privacy • Ways of presenting energy consumption to customers to impact on their energy behaviour
Framework	• Legal: transposition of smart metering EU Directive to the Member States • Standardisation of data models and communication systems • Smart regulations to provide personalized services and tariffs to individual customers

Cluster 3: DER (Distributed Energy Resources) Integration

In general, cluster 3 focuses on DER integration in distribution networks (medium and low voltage level). Four main topics were identified and formulated as functional projects:

- Increasing **DER hosting capacity of low voltage networks** - Integration of small renewable in the distribution network (D5)
- Increasing **DER hosting capacity of medium voltage networks** - System Integration of medium size renewables in the distribution network (D6)
- Integration of **storage in distribution networks** (medium and low voltage level) - Integration of storage in network management (D7)
- Integration of **electric vehicles (EV) and plug in hybrid electric vehicles (PHEV) in distribution networks** (medium and low voltage level) - Infrastructure to host electric vehicles (D8)

Due to the systemic view on electricity networks, there are a lot of overlaps and synergies between the individual functional projects. The main difference is given as following:

- D5 focus is on low voltage networks
- D6 focus in on medium voltage networks
- D7 focus is on storage in distribution networks
- D8 focus is on EV and PHEV infrastructure in distribution networks

D5 Integration of small renewable in the distribution network

Main/general objective:
The main objective of the project is to demonstrate, if **low voltage (LV) network hosting capacity** for small scale distributed energy resources (SDER) can be economically increased by monitoring and control of small scale distributed energy resources as well as by enhanced network planning and operation strategies. It will bring related solutions from “small pilot stage” to a maturity level sufficient for full deployment.

This functional project needs a set of local, national demonstration projects to cover different conditions needed for a comprehensive test of solutions. The conditions include different generation technologies (e.g. solar, micro CHP, Wind) as well as different network topologies (e.g. rural/urban) as well as cultural and climatic conditions (e.g. north/south). It is estimated that for this functional project the number of local projects, that will be needed to cover the different conditions all over Europe should be 4 – 6, considering that a single local project will cover different conditions.

Objectives and Benefits:

- Increase the low voltage grid hosting capacity for small scale distributed generation resources mainly based on renewable energy resources (e.g. PV)
- Better monitoring of LV network operating conditions
- Optimisation of the utilisation of existing LV network assets
- Increase/Maintain the network availability/power quality in presence of high penetration of small scale DER
- Reduction in SDER cut-off due to congestion (power curtailment)
- Cost reduction for medium scale DER integration
- Enable increased participation of grid users in network operation/ energy markets
- Reduction in network losses
- Interaction of LV distribution networks with high share of small scale DER with medium voltage networks
- Containment of costs compared with a “business as usual” approach (network reinforcement)
- Open new business opportunities related to “ancillary services” (e.g. voltage control, reactive power provision) for the low voltage network
- Create new business opportunities for equipment manufacturers
- Give a technological leading position to European equipment manufacturers
- Reduction of CO_2, direct and indirect

	D5 Integration of small renewable in the distribution network
Component	• "Grid friendly" behaviour of PV inverters (ancillary services like e.g. reactive and active power control, frequency control, harmonics filtering) • Improved network assets (e.g. distribution transformers with on load tap changing) • Network monitoring systems and related communication infrastructure supporting small scale DER integration in low voltage networks • Interfacing with new generation of controlled power converters for small production units and loads
Network	• Better exploitation of the existing low voltage infrastructure in order to increase hosting capacity for small scale DER • Monitoring of LV networks (e.g. smart meter as monitoring device) • Voltage control and congestion management in LV network by reactive and active power management • Generation-load balancing • Improved power quality (reduction of voltage unbalance, flicker and harmonics) • Grid losses reduction by SDER • Intelligent LV network planning for an optimal integration of small scale DER • ICT infrastructure in low voltage networks for monitoring and control of SDER
Market/Models	• Reducing costs of SDER integration - cost benefit analysis • Necessary incentives/market mechanisms (e.g. for ancillary services) • New market rules necessary for successful deployment of small scale DER • Coordination between technical grid control and market based power balancing (e.g. technical virtual power plant vs. market based virtual power plant) • Real-time markets and customer behaviour • Market design for all involved stakeholders and interaction: Equipment manufacturers, ICT and system architecture companies, retailers, generators, consumers and prosumers on LV-level, DSOs, regulators
Customer Acceptance	• Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management, while ensuring non discrimination • Testing demand response mechanisms in low voltage networks • Explore how new tariffs can alter customer behaviour • Integration of home automation systems in network management for demand side management and demand response purpose
Framework	• New frameworks for network interconnection, interconnection standards • Investigation of mandatory requirements for SDER vs. remunerated ancillary services • Device and system level interoperability (e.g. communication interfaces) • Standardisation based on IEC 61850 and 61970/61968 (CIM) • What regulatory changes would be needed (for project execution and deployment)? • European and national (local demonstrator) energy policies and energy strategies • Recommendations and solutions to remove barriers considering economic, regulatory, societal and cultural aspects

D6 System Integration of medium size renewables in the distribution network

Main/general objective:
The main objective of the project is to demonstrate, under real operating conditions, how the **medium voltage (MV) network hosting capacity** for distributed energy resources can be increased by measures like active network control, DER control (e.g. voltage control, reactive power management) and demand response (i.e. controllable loads and storage). It will bring related solutions from "small pilot stage" to a maturity level sufficient for full deployment.

This functional project needs a set of local, national demonstration projects to cover different conditions needed for a comprehensive test of the solutions. The conditions include different generation technologies (e.g. wind, solar, small hydro power, and biomass) as well as different network topologies (e.g. rural/urban, radial/meshed, different MV voltage level). It is estimated that for this functional project the number of local projects, that will be needed to cover the different conditions all over Europe should be 4 – 6, considering that a single local project will cover different conditions.

Objectives and Benefits:

- Increase in the medium voltage grid hosting capacity for medium scale distributed generation resources mainly based on renewable energy resources
- Optimisation of the utilisation of existing network assets
- Increase in network availability/power quality in presence of large penetration of medium DER
- Reduction in DER cut-off due to congestion
- Cost reduction for medium scale DER integration
- Optimisation of load flows
- Reduction in network losses
- Enable increased participation of grid users in network operation/ energy markets
- Interaction of distribution networks with high share of DER with transmission networks
- Containment of costs compared with a "business as usual" approach (building new lines and substations)
- Open new business opportunities related to "ancillary services" for the MV network
- Create new business opportunities for equipment manufacturers
- Give a technological leading position to European equipment manufacturers
- Reduction of CO_2, direct and indirect

D6 System Integration of medium size renewables in the distribution network	
Component	• "Grid friendly" behaviour of generators (e.g. ancillary services like reactive and active power control, frequency control, harmonics filtering) • Ancillary Services by different generation technologies (e.g. PV, Wind, Hydro, Loads) • Network monitoring systems and related communication infrastructure supporting DER integration • Interfacing with new generation of controlled inverters for large and medium renewable production units and loads
Network	• Better exploitation of the existing medium voltage infrastructure in order to increase hosting capacity for medium scale DER • Voltage control and congestion management in the entire network by reactive and active power management • Improve power quality (flicker and harmonics) • Monitoring of MV networks (Distribution management systems, SCADA systems) • Generation-load balancing including storage • Prediction tools for system operators (for consumption and local generation) • Grid losses reduction through reactive power compensation provided by DER • Improved asset management

	• Demand response approaches (focused on energy management of DER in the MV network) • Intelligent planning of DER integration • Distribution Management Systems – Automation of MV networks with high DER penetration
Market/BModels	• Reducing costs of DER integration – cost benefit analysis • Necessary incentives/market mechanisms (e.g. for ancillary services) • New market rules necessary for successful deployment of DER in medium voltage networks • Coordination between technical grid control and market based power balancing (e.g. technical virtual power plant vs. market based virtual power plant) • Market design for all involved stakeholders and interaction: Equipment manufacturers, ICT and system architecture companies, retailers, generators, consumers and prosumers on MV-level, DSOs, regulators • Real-time markets and customer behaviour
Customer Acceptance	• Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management in medium voltage networks • Testing demand response mechanisms • Explore how new tariffs can alter customer behaviour
Framework	• Network interconnection requirements • Mandatory requirements for DER vs. remunerated ancillary services • Device and system level interoperability (e.g. communication interfaces) • Standardisation based on IEC 61850 and 61970/61968 (CIM) • What regulatory changes would be needed (for project execution and deployment)? • European and national (local demonstrator) energy policies and energy strategies • Recommendations and solutions to remove barriers considering economic, regulatory, societal and cultural aspects • Mechanisms to coordinate the provision of services serving different actors (DSO/TSO)

D7 Integration of storage in network management

Main/general objective:

The main objective of the project is to demonstrate, how distribution networks operation and related power quality parameters, can be supported by **integration of storage or Storage type technologies in distribution networks (medium and low voltage networks).** The aim is to integrate storage for optimizing power flows in order to ensure the compliance with operation rules (voltage levels and congestions) and therefore support an increasing network hosting capacity for fluctuating renewable energy resources.

The main objective is to demonstrate under real operating conditions and on large scale new advanced network operation and energy management capabilities based on the use and integration of electricity storage technologies, including storage deveices smart storage heaters and heat pumps as well as traditional battery storage mechanisms in the network. Furthermore existing gaps (on technical, economical, energy markets level) for a massive deployment of the storage technologies will be investigated. This project shall provide solutions to the challenges of integrating large amounts of fluctuating generators into distribution networks.

Objectives and Benefits:

- Increase in the distribution grid hosting capacity for distributed generation resources mainly based on renewable energy resources supported by storage technologies and systems
- Generation and load balancing with storage
- Increase in network availability/power quality (power quality management)
- Reduction in DER cut-off due to congestion
- Reduce network congestions
- Optimisation of load flows
- Reduction in network losses
- Optimisation of the utilisation of existing network assets
- Islanding and local black start and micro grid operation
- Containment of storage costs compared with a “business as usual” approach (building new lines and substations)
- Open new business opportunities related to “ancillary services” by storage technologies
- Create new business opportunities for equipment manufacturers
- Carry out a holistic and complete cost benefit analysis on the benefits of different forms of storage devices when operated optimally.
- Give a technological leading position to European equipment manufacturers
- Reduction of CO_2, direct and indirect

	D7 Integration of storage in network management
Component	• Storage systems (solutions, technologies and control) • Behaviour of storage technologies and ability for network support (e.g. voltage control, frequency control) • Power electronics for network interconnection of storage systems • PV hybrid systems (photovoltaics and storage) • Interfaces
Network	• Better exploit existing infrastructure and capacity of the system in order to increase hosting capacity for DER • Prediction tools to help manage storage devices operation (for consumption and local generation) • Voltage control, frequency control and congestion management by storage • Advanced integrated management strategies for islanding operation and local black start under a microgrid or multi-microgrid paradigm • Generation-load balancing by storage • Grid losses reduction • Storage integration planning (power, capacity and location of storage systems) • Sizing of storage for specific applications

Market/BModels	• Reducing costs of storage and DER integration - cost benefit analysis • Necessary incentives/market mechanisms • Reducing costs of storage • New market rules necessary for successful deployment • Coordination between technical grid control and market based power balancing with storage (e.g. technical virtual power plant vs. market based virtual power plant)
Customer Acceptance	• Testing demand response mechanisms with storage
Framework	• Network interconnection requirements • Device and system level interoperability (e.g. communication interfaces) • Standardisation based on IEC 61850 and 61970/61968 (CIM) • What regulatory changes would be needed (for project execution and deployment)? • European and national (local demonstrator) energy policies and energy strategies • Recommendations and solutions to remove barriers considering economic, regulatory, social and cultural aspects

D8 Infrastructure to host electric vehicles

Main/general objective:
The main objective of the project is to demonstrate how **distribution networks infrastructure (medium and low voltage level) can host a large amount of electric vehicles**.

Objectives and Benefits:

- Increase the distribution grid hosting capacity for E-Vehicles and related infrastructure (charging stations)
- Investigation of different charging infrastructures (public and private)
- Network integration of charging infrastructure
- Network services by EV/PHEV (e.g. voltage and load-frequency control)
- EV and PHEV aggregators
- Charging and recharging behavior
- Related business models and tariff (incentives for grid-friendly behavior, e.g. avoiding network congestions)
- Design of smart charging solutions involving optimisation algorithms and interactions between aggregators and system operators (DSO and TSO) for validation of charging profiles
- Optimisation of load flows

D8 Infrastructure to host electric vehicles	
Component	• Charging infrastructure in private areas and charging infrastructure in public areas • Fast charging and slow charging stations • Communication solutions for charging stations • Smart Metering • Charging interfaces to allow controoled charging and provision of ancillary services from plugged-in Electric Vehicles
Network	• Better exploit existing infrastructure and capacity of the system in order to increase hosting capacity for EV/PHEV • Impact of EV/PHEV on the network depending on charging behaviour • Design of smart charging solutions dealing with technical and economic constraints

	• Voltage control, frequency control and congestion management by EV/PHEV • Prediction tools for EV charging for system operators • Charging station integration planning (power and location), interaction with DER • Network services by EV/PHEV • Load-frequency control by EV • Participation of EV in islanding operation of distribution grids with active generation, load and storage devices
Market/BModels	• Necessary incentives/market mechanisms • New market rules necessary for successful deployment • Network requirements vs. energy market requirements • Design aggregators markets (requirements form mobility behaviour vs. energy markets, vs. network demand) • Real-time markets and customer behaviour
Customer Acceptance	• Charging and recharging behavior • Enabling and encouraging stronger and more direct involvement of consumers • Testing demand response mechanisms • Explore how new tariffs can alter customer behaviour
Framework	• Network interconnection requirements • Device and system level interoperability (e.g. communication interfaces) • Standardisation based on IEC 61850 and 61970/61968 (CIM) • What regulatory changes would be needed (for project execution and deployment)? • European and national mobility and energy policies and mobility energy strategies • Recommendations and solutions to remove barriers considering economic, regulatory, social and cultural aspects

Cluster 4: Smart Distribution Network

In general, cluster 4 focuses on smart distribution networks (medium and low voltage level). Four main topics were identified and formulated as functional projects:

- Increasing **Monitoring and control of low voltage networks** - Integration of automation and local power production in the LV distribution network (D9)
- Increasing **Automation and control of medium voltage networks** - Integration of advanced automation solution with local power production and two-way of power flow in the MV distribution network (D10)
- Integration of **Methods and system support** (medium and low voltage level) - Integration of state estimation, maintenance, planning and asset management in network management (D11)
- Integration of **Integrated communication solutions in distribution networks** – Widespread communication solutions, standardized (D12)

Due to the systemic view on electricity networks, there are a lot of overlaps and synergies between the individual functional projects. The main difference is given as following:

- D9 focus is on low voltage networks
- D10 focus in on medium voltage networks
- D11 focus is on overall system support
- D12 focus is on ICT solutions in distribution network perspective

Interdependence between the required new infrastructure at the level of primary network equipment and secondary systems and new business models like the DSM, VPP, e-mobility, ancillary services .
Cluster 4 is more general than the DER integration cluster, e.g. generating reactive power with DER and providing it as an additional service to the network should be part of the DER cluster; how to use that reactive power in the system should be part of this cluster,
Cluster 4 covers horizontal layers, primarily a new ICT infrastructure in a power network and secondary systems: monitoring, control, protection, automation, asset management, etc
Development of "distribution power technologies" is not properly addressed (MV/LV transformers with voltage control ability, stand-alone power electronics equipment).

D9 Monitoring and control of LV network

Main/general objective:
The main objective of the project is to demonstrate, how **low voltage (LV) networks** should be monitored and controlled due to increase of small scale distributed energy resources as well as by enhanced network planning and operation strategies. It will bring related solutions from "small pilot stage" to a maturity level sufficient for full deployment.

This functional project needs a set of local, national demonstration projects to cover different conditions needed for a comprehensive test of solutions. The conditions include different monitoring and control technologies (e.g. automation, remote control, self-healing eg.) as well as different network topologies (e.g. rural/urban) as well as cultural and climatic conditions (e.g. north/south). It is estimated that for this functional project the number of local projects, that will be needed to cover the different conditions all over Europe should be 4 – 6, considering that a single local project will cover different conditions.

Objectives and Benefits:

- Increase the low voltage grid monitoring and control features especially for active resources (e.g. PV, EV, sorages)
- Optimisation of the utilisation of existing LV network assets
- Increase the network availability/power quality in presence of high penetration of active resources
- Develop and monitor LV protection systems for two-way power flow in LV networks
- Involvement of storage uses in LV network (eg. EV/PHEV batteries)
- Enable increased participation of grid users in network operation/ energy markets

- Reduction in network losses
- Interaction of LV distribution networks with high share of active resources with medium voltage networks
- Containment of costs compared with a “business as usual” approach (network reinforcement)
- Open new business opportunities related to “ancillary services” (e.g. voltage control, reactive power provision) for the low voltage network
- Create new business opportunities for equipment manufacturers
- Give a technological leading position to European equipment manufacturers
- Reduction of CO_2, direct and indirect

	D9 Integration of monitoring and control of LV network
Component	• Protection and control of two-way power flow in LV networks • Improved network assets (e.g. distribution transformers with on load tap changing) • Network monitoring systems and related communication infrastructure supporting integration in low voltage networks • Interfacing with new generation of controlled power converters for small production units and loads (PV inverters, …) • Interactive control units for customer interface • Universal communication interfaces on secondary substation level • Gateways converting the proprietary protocols and interfaces of various actors to IEC 61850 and/or CIM • Highly accurate phasor, frequency and voltage measurement devices • Latest-technology sensors and actuators • Latest smart meter technology • Storage to avoid grid expansion and analysis of aging process of batteries under different operating strategies • Combine PV with stationary storages and controllable load management of mobile batteries • Dynamic power electronic interfaces • SCADA systems • Information model aggregation using IEC 61850 • Management gateways to connect the actors to Virtual Power Plant or market place
Network	• Better exploitation of the existing low voltage infrastructure in order to increase hosting capacity for active resources • Monitoring of LV networks (e.g. smart meter as monitoring device) • Voltage control and congestion management in LV network by reactive and active power management • Advanced protection schemes for two-way power flow • Improved power quality (reduction of voltage unbalance, flicker and harmonics) • Grid losses reduction • Intelligent LV network planning • ICT infrastructure in low voltage networks for monitoring and control • Ancillary services by PV inverters • Development of detailed LV network simulation models • Automatic control concepts for low voltage networks • Integration of EV in LV network • Real time compensation system to avoid expensive grid upgrades • Enhancing efficiency in day-to-day grid operation • Control architecture for optimised operation • Island operation • Possibility of transferring from connected to island mode under several operating conditions • Algorithms to identify system topology

	• Active demand response and integration with Smart Homes • Distribution Management Systems
Market/Models	• Reducing costs of active resource integration • Necessary incentives/market mechanisms (e.g. for ancillary services) • New market rules necessary for successful deployment of active resources • Coordination between technical grid control and market based power balancing (e.g. technical virtual power plant vs. market based virtual power plant) • Real-time markets and customer behaviour • Market design for all involved stakeholders and interaction: Equipment manufacturers, ICT and system architecture companies, retailers, generators, consumers and prosumers on LV-level, DSOs, regulators • Economic and environmental friendly operation • Cost optimized ICT tools • Proactive users in the energy market • Virtual power plant (VPP) concept • Energy efficiency • Integration of EV in power markets • Design of DSO-market
Customer Acceptance	• Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management, while ensuring non discrimination • Testing demand response mechanisms in low voltage networks • Explore how new tariffs can alter customer behaviour • Integration of home automation systems in network management for demand side management and demand response purpose • Provide consumers with information about their electricity consumption – online real time electricity pricing system • Possibilities of electricity customers react flexibly to system needs • Mobilisation of private customers flexible energy consumption • Benefits for the different power system participants
Framework	• New frameworks for network interconnection, interconnection standards • Investigation of mandatory requirements for SDER vs. remunerated ancillary services • Device and system level interoperability (e.g. communication interfaces) • Standardisation based on IEC 61850 and 61970/61968 (CIM) • What regulatory changes would be needed (for project execution and deployment)? • European and national (local demonstrator) energy policies and energy strategies • Recommendations and solutions to remove barriers considering economic, regulatory, societal and cultural aspects

D10 Automation and control of MV network

Main/general objective:
The main objective of the project is to demonstrate, under real operating conditions, how the **medium voltage (MV) network automation and control** can be increased by measures like active resources and demand response (i.e. controllable loads and storage). It will bring related solutions from “small pilot stage” to a maturity level sufficient for full deployment.

This functional project needs a set of local, national demonstration projects to cover different conditions needed for a comprehensive test of the solutions. The conditions include different automation and control technologies as well as different network topologies (e.g. rural/urban, radial/meshed, different MV voltage level). It is estimated that for this functional project the number of local projects, that will be needed to cover the different conditions all over Europe should be 4 – 6, considering that a single local project will cover different conditions.

Objectives and Benefits:

- Increase in the medium voltage grid automation and control for grid active resources
- Optimisation of the utilisation of existing network assets and planning
- Increase in network availability/power quality in presence of active resources
- Introduction of self-healing networks
- Cost reduction by automation, control and self-healing features
- Optimisation of load flows
- Reduction in network losses
- Enable increased participation of grid users in network operation/ energy markets
- Interaction of distribution networks with high share of active resources with transmission networks
- Containment of costs compared with a "business as usual" approach (building new lines and substations)
- Open new business opportunities related to "ancillary services" for the MV network
- Create new business opportunities for equipment manufacturers
- Give a technological leading position to European equipment manufacturers
- Reduction of CO2, direct and indirect

D10 Automation and control of MV network	
Component	• Advanced self-healing features in network control devices (optimisation of DER management, sensors, indicators, RTUs, controlling devices, etc.) • Ancillary Services by different technologies (e.g. PV, Wind, Hydro, EVs, controllable loads) • Network control and monitoring systems and related communication infrastructure supporting two-way power flow • Components for new network configuration platform (primary and secondary equipment) • Universal communication interfaces on secondary substation level • Latest-technology sensors and actuators • ICT for monitoring and optimisation • Storage to avoid grid expansion • AMI • Quality of supply documentation and management • SCADA systems
Network	• Better exploitation of the existing medium voltage infrastructure in order to increase hosting capacity for active resources • Voltage control and congestion management in the entire network by reactive and active power management • Improve power quality (flicker and harmonics) • Monitoring of MV networks (Distribution management systems, SCADA systems, self-healing management and automation) • Generation-load balancing including storage • Prediction tools for system operators • Grid losses reduction through active resources and AMI features for new load curves • Demand response approaches • Intelligent planning of active resources management • Distribution Management Systems – Automation of MV networks with high active resources penetration • Advanced ICT infrastructure in MV networks for monitoring and control • Active integration of generation in network operation • Real time compensation system to avoid expensive grid upgrades • Power system stability analysis

	• Self-healing networks • Distribution grids in automatic island operation • Observability and control of MV distribution networks • Automatic fault detection, reconnection and reconfiguring systems • Network aging • Fault management
Market/BModels	• Reducing costs of active resources integration • Necessary incentives/market mechanisms (e.g. for ancillary services) • New market rules for deployment of active resources in medium MV networks • Coordination between technical grid control and market based power balancing • Market design for all involved stakeholders and interaction: Equipment manufacturers, ICT and system architecture companies, retailers, generators, consumers and prosumers on MV-level, DSOs, regulators • Real-time markets and customer behaviour • Interactive customer gateway • Virtual Power Plants • Demand Side Management • E-mobility • Cost optimized ICT tools • Real time electricity pricing systems • Investigation of VAR-markets
Customer Acceptance	• Enabling and encouraging stronger and more direct involvement of consumers in their energy usage and management in medium voltage networks • Deployment of demand response mechanisms • Explore how new tariffs can alter customer behaviour • demand response • Potential benefits for the different power system participants • Real-time markets and customer behaviour • Accompanying measures to deal with societal, cultural and behavioural aspects
Framework	• Network interconnection requirements • Modular communication architecture based on standardised communication protocols • Mandatory requirements for active resources vs. remunerated ancillary services • Device and system level interoperability (e.g. communication interfaces) • Standardisation based on IEC 61850 and 61970/61968 (CIM) • What regulatory changes would be needed (for project execution and deployment)? • European and national (local demonstrator) energy policies and energy strategies • Recommendations and solutions to remove barriers considering economic, regulatory, societal and cultural aspects • Mechanisms to coordinate the provision of services serving different actors (DSO/TSO)

D11 Methods and system support

Main/general objective:
The main objective of the project is to demonstrate, how distribution networks operation, planning and maintenance can be supported by **expert systems, state estimation and simulation models and methods (medium and low voltage networks).** The aim is to integrate expert systems, state estimation rules and simulation models/methods for optimizing power flows in order to ensure the compliance with operation and therefore support an increasing network hosting capacity for active resources. Impacts of AMI features in simulation models shall be investigated and demonstrated.
The main objective is to demonstrate under real operating conditions and on large scale new advanced network operation and energy management capabilities based on the use and simulation of expert system technologies in the network. Furthermore existing gaps (on technical, economical) for a massive deployment of those technologies will be investigated. This project shall provide solutions to the challenges of deploying large amounts of expert systems and simulation methods into distribution networks.

Objectives and Benefits:
- Increase in the distribution grid expert systems, state estimation solutions and grid simulation methods
- Demonstration of AMI impact on grid simulation methods
- Improvement on network availability/power quality (power quality management) through active state estimation
- Development of methods and algorithms for smart control of active customer gateway (based on needs of customer, producer, DSO, TSO, energy supplier, aggregator)
- Reduction in active resources impact on asset exploitation and investment level
- Reduce network costs
- Optimisation of load flows
- Reduction in network losses
- Optimisation of the utilisation of existing network assets
- Islanding and micro grid operation
- Open new business opportunities related to “ancillary services” by expert system technologies
- Create new business opportunities for solution providers
- Give a technological leading position to European solution providers
- Reduction of CO2, direct and indirect

	D11 Methods and system support
Component/ Solution	• Expert systems, state estimation rules, simulation models (solutions, technologies and control) • Behaviour of expert system technologies and ability for network support • ICT technology development • Interfaces into various systems (SCADA, DMS, GIS) • Tools for detecting partial discharging – PD • Quality of supply documentation and management • Improving SCADA performance in power system security management • Planning tools for Smart Grid • Life-cycle management of large power transformers
Network	• Better exploit existing infrastructure and capacity of the system in order to increase hosting capacity for active resources • Voltage control, frequency control and congestion management by expert systems and simulation models • Generation-load balancing • Grid losses reduction • System integration in planning grid • Power system stability analysis • MV state estimation and visualisation • Observability and control of MV distribution networks

	• Network aging • Fault management • Intelligent planning • Development of detailed LV network simulation models • Algorithms to identify system topology • Distribution Management Systems • Optimisation of combined electricity and natural gas networks • Long-term planning of generation portfolios • Demand frequency controlled reserve • Optimal reconfiguration and system restoration • Optimal RES size, type and placement • Robust methodology to analyse complex energy infrastructure
Market/BModels	• Reducing costs of active resources integration • Necessary incentives/market mechanisms • Reducing costs of network • New market rules necessary for successful deployment • Coordination between technical grid control and market based power balancing • Cost optimized ICT tools • Real time electricity pricing systems • Market models and service
Customer Acceptance	• Testing demand response mechanisms with active resources • Deployment of active customer interface by simulation models • Provide on-line information to customers for active market participation– online real time electricity pricing system • Mobilisation of private customers flexible energy consumption • Consumer awareness • Energy consultancy service and education
Framework	• Network interconnection requirements • Device and system level interoperability (e.g. communication interfaces) • Standardisation based on IEC 61850 and 61970/61968 (CIM) • What regulatory changes would be needed (for project execution and deployment)? • European and national (local demonstrator) energy policies and energy strategies • Recommendations and solutions to remove barriers considering economic, regulatory, social and cultural aspects • Smart Grid Roadmap

D12 Integrated communication solutions

Main/general objective:
The main objective of the project is to demonstrate how **distribution networks infrastructure (medium and low voltage level) can be operated via advanced and widespread communication solutions**.

Introduction of parallel communication channels for prioritized and non-prioritized data transmission.
System integration:

- Heterogeneous standardisation, regulation and market rules
- Interoperability with existing and future utility IT and control systems with long life cycles
- Conformance with the ongoing standards development such as CIM (Common Information Model) extensions for DER aggregation, IEC 61850 based application level protocols for DER management and control, application level view on protocols for smart metering based DER management and HAN/BAN protocols
- How to cope with increased system complexity efficiently and with modest costs of system management and services delivered.

Objectives and Benefits:

- Development of ICT structures and systems for overall management of active resources and their active gateways including application layer communication models and protocols
- Developing and testing technical solutions for interactive gateway and ICT systems; tools for customer, DSO, TSO, supplier, aggregator and other actors
- Verification of solutions by large scale simulations and laboratory and field test installations
- Impacts of data security vulnerabilities on the selection of implementation techniques Network integration of charging infrastructure

	D12 Integrated communication solutions
Component	• Communication devices • Communication solutions • Smart Metering • Standardisation • Universal communication interfaces on secondary substation level • gateways converting the proprietary protocols and interfaces of various actors to IEC 61850 and/or CIM • SCADA systems • Information model aggregation using IEC 61850 • ICT infrastructure for different smart grid functionalities • Digital electricity meters and gateways • Data centre for metering and pricing data • Bi-directional communication
Network	• RTU development • Data privacy • AMI • Communication technology • Interfaces • Prognosis and portfolio management system • Intelligent remote control system
Market/BModels	• Data privacy • New market rules necessary for successful deployment • Network requirements vs. energy market requirements • Design aggregators markets • Real-time markets and customer behaviour • Improving market functioning and customer service • Commercial Virtual Power Plants • System concept for the marketplace software

Customer Acceptance	• Changing in customer behavior • Enabling and encouraging stronger and more direct involvement of consumers • Testing active resources mechanisms • Data privacy • Demand side management for intelligent household appliances • User engagement
Framework	• Device and system level interoperability (e.g. communication interfaces) • Data privacy • Standardisation based on IEC 61850 and 61970/61968 (CIM) • Standardisation of EV communication • Standardized data communication interfaces • Demonstration and development of IEC 62351-8 • Smart Grid cyber security • Role based access control • Specification for ICT gateway • What regulatory changes would be needed (for project execution and deployment)? • European and national mobility and energy policies and mobility energy strategies • Recommendations and solutions to remove barriers considering economic, regulatory, social and cultural aspects