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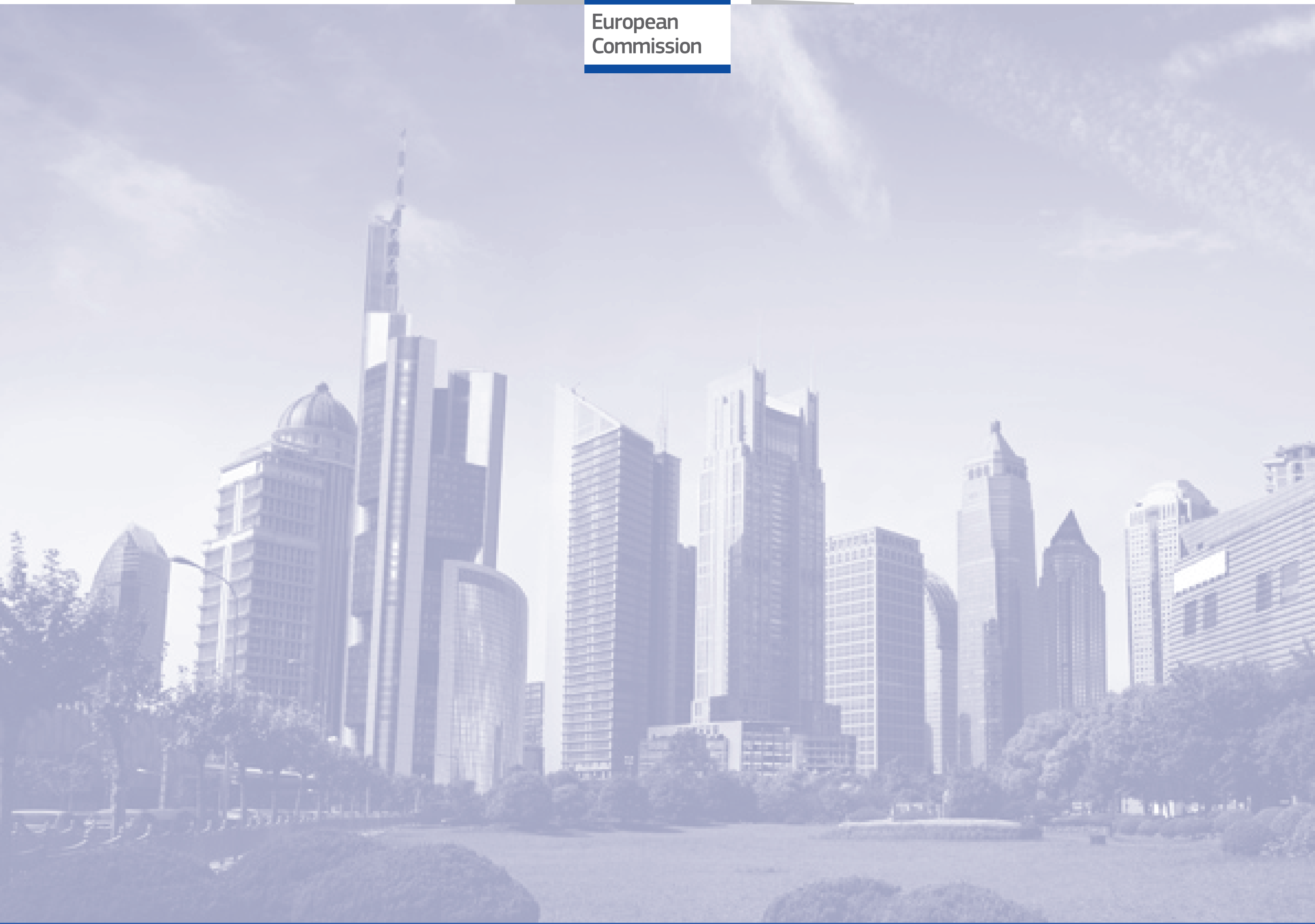

Smart Cities

Stakeholder Platform

Smart Grid Systems

Key to Innovation Integrated Solution

Smart Grid Systems

Document information	
Prepared by:	Filippo Gasparin (Enel), combined by ECN and REC
Edited by:	Platform Management Team
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INTRODUCTION

The Key Innovations (KIs) are a key output of the Smart Cities Stakeholder Platform. The Platform promotes innovation and is part of the Smart Cities and Communities European Innovation Partnership of the European Union. It aims to accelerate the development and market deployment of energy efficiency and low-carbon technology applications in the urban environment. The emphasis will be on their integration, which is a key challenge particularly for Smart Cities' technologies. The Platform aims to bring together technology providers, financiers and specialists in implementing smart city strategies at local level.

The expert Working Groups of the Platform on Energy Efficiency and Buildings, Energy Supply and Networks, ICT, as well as Mobility and Transport select from the spectrum of Solution Proposals (SPs) submitted by stakeholders[1] the *most promising and fundamental* solutions to accelerate the development of smart cities. The focus is on specific promising innovations, considered pillars or technical leapfrogs for integrated solutions in smart cities, thus promising, but standalone solutions, will not be developed into key innovation files and toolkits.

Regardless, if an SP will be part or not of a key innovation document, all solution proposals will be published in the Platform and linked to city profiles. The Platform is not an evaluation body and is open to all relevant smart solutions, large or small scale for cities and their inhabitants.

The aim is to promote through the preparation of a detailed document, a guide for cities on the performance of the innovation, including in some cases wider impacts on city life (such as change of behaviour, environment, social inclusion etc.). For each innovation, this key innovation document will describe the methodology to deploy it, including the technical requirements and the necessary framework conditions, such as existing infrastructures, technical expertise, regulatory requirements as well as the financial costs involved. The document aims to promote the adoption of the key technology and to identify barriers to deployment to assist relevant authorities in developing solutions to remove them. The document will list the technology providers as well as information of a number of potential financial sources by the EU and other bodies which have supplied information to the platform.

The information in the Key Innovation documents will become an integral part of the recommendations of the Smart City 10 Year Rolling Agenda document the Platform will draft for the European Commission. This document will highlight identified actions at European level required to promote the adoption of key innovations, such as the removal of regulatory barriers or recommendations on the focus of the Horizon 2020.

It is important to stress that this document is not a set of technical proposal or a full evaluation of the innovation, but aims to assist for cities to identify potential solutions and understand their context and implementation needs. It does not exempt or substitute a detailed cost/benefit analysis and implementation plans for cities that wish to introduce the innovation. The Stakeholder Platform cannot take any responsibility for inaccuracies or missing information or specific problems in the implementation of the proposed Key Innovations or other Solution Proposals.

[1] Solution proposals are published on the web site: www.eu-smartcities.eu/ solution-proposals

Description of a Key Innovation

A key objective of the Smart Cities Stakeholder Platform is to identify Key Innovations (KIs) for the development of Smart Cities. The selection of an SP as KI is based on the following criteria: **applicability, simplicity, affordability**, **usability** the extent to which it addresses technology integration and if the potential impact is significant. Selected SPs will then be enhanced by the Platform's technical Working Groups (WGs) to develop KIs, adding the following aspects:

- Premises for the technology development and up-take (e.g. problems, what the technology is intended to achieve, other unforeseen benefits for the smart cities);
- Potential integration with other technologies and sectors, including use of ICT;
- If necessary, enhancing the information from the SP on the urban environment in which the technology can be applied;
- Key pre-requisites for the applicability of the key innovation, such as the required enabling environment;
- Instruments and market conditions needed to reach commercial viability.2

KIs will be completed by the technical WGs in collaboration with the Finance WG. This group will analyse the financial needs of the KI as well as their financial viability and bankability. The members of the WG will provide information on funding sources. The result will be published as a Key Innovation Toolkit.

The Toolkits thus provide practical solutions that can create an enabling environment for the application and replication of key innovations in a smart city.

[2] This includes a description of the main EU support instruments, such as the Risk Sharing Financing Facility

ABSTRACT

The Key Innovation (KI) based on smart grids technologies encompasses a set of innovative solutions enabling new products and services central to achieving a real Smart City.

The Smart Grid can:

- Provide the power quality for the range of needs;
- Accommodate all generation and storage options;
- Enable new products, services, and markets;
- Enable informed participation by customers;
- Optimize asset utilization and operating efficiently; and
- Operate resiliently to disturbances, attacks, and natural disasters.

Smart Grids are the backbone of a Smart City by enabling the integration of small distributed energy resources in the urban network, increasing the customers awareness, providing real-time optimization of energy flows at the urban level, enabling interdependence and facilitating a multi-services approach linking the electricity carrier and other infrastructure.

Increased use of ICT improves reliability, security, and efficiency of the electric grid through a dynamic optimization of grid operations and resources, (with full cyber security). Communication as a whole is the backbone of Smart Grid. Only by exchanging information on a syntactic and semantic level can the benefits of Smart Grid be achieved.

The KI on Smart Grid sets out various innovative solutions that allow for increasing the hosting capacity of the network, strengthening the security of supply in the urban area. The solutions described help avoiding additional investments to cover the peak load demand, while to increasing the network stability and reliability through better monitoring of network operating conditions. They offer improved quality of service for final costumers, new added value services for both market players/consumers, and help cities realise costs savings by optimising energy consumption.

The KI was developed according to measurable and updated outcomes of pilot projects currently ongoing, and in particular the Isernia Project, run by Enel Distribuzione and co-funded by the Italian National Regulatory Authority. The project foresees the demonstration, under real operating conditions, of an innovative model for the protection, automation and management of power generation in the distribution network.

The KI on Smart Grid has many interfaces with Key Innovations on Mobility and Buildings. The solutions that enable the integration are the Virtual Power Plant (VPP), storage systems and recharging infrastructure for Electric Vehicles (EV).

At the interface with Mobility, the Smart Grid enables the deployment and integration of advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid electric vehicles.

The solution so called Virtual Power Plant (VPP) helps compensating the volatility introduced by the Renewable Energy Sources (RES); in addition it enables the utilising the plug-in electric vehicles (EVs) as distributed energy storage systems to match the distributed electrical generation to the local demand.

The storage systems lay at the interface between the Smart Grid and Smart Heating & Cooling systems (at both district and building level). Thus the KI on Smart Grid systems

interacts with the Smart Thermal Grids as well as the Heating, Ventilation, and Air Conditioning (HVAC) systems in buildings.

The interaction between Smart Grids and innovative solutions in the built environment and in the transport sector can contribute to achieving the energy efficiency and mobility objectives both at urban and European level.

1. PRESENTATION OF THE KEY INNOVATION

Submitted to the platform at date:	Body(ies) submitting the proposal(s):	IP right holders:	Maturity of innovation:	City	Parties or stakeholders involved:
1. Smarter and Upgraded Electricity Network in an urban context					
15 October 2012	**EDSO for Smart Grids** (European Distribution System Operators) http://edsoforsmartgrids.eu/		Pilot Project	Isernia	Consumers / Prosumers DNO, DER
2. So La BRISTOL					
04 October 2012	Dr Lorraine Hudson, Bristol City Council on behalf of **Western Power Distribution** (consortium lead by Bristol City Council in cooperation with Knowle West Media Centre, Siemens and the University of Bath)		Pilot Project	Bristol	Consumers / Prosumers, DNO, DER

1.1 Description of the innovation and rationale for selection

Load increase, aging infrastructures and equipment, as well increasing distributed energy generation lead to highly utilized networks during peak load conditions. In addition to the high power system loading, other technical challenges for ensuring reliable energy supply include the increasing distance between the central generation and load, increasing variability of supply, as well as the emerging new loads (e.g. from hybrid/electric vehicles). These trends coincide with a strong political and regulatory push for enhanced competition and thus lower energy prices, and increased energy efficiency.

Addressing these challenges in electricity networks in a traditional way by increasing and upgrading network capacity entails costly and time-intensive interventions. However increased use of ICT technologies enables new ways of operating power systems, combined in the Smart Grid concept. This includes increased interaction and integration of formerly separated systems to improve their observability and/or the controllability. Thereby Smart Grid technologies help to convert the power grid from static infrastructure being operated as designed, to a flexible, “living” infrastructure operated proactively based on the actual condition of the electricity system.

The main driver for Smart Grids deployment are the European environmental policy goals aiming at CO2 reduction, deployment of renewable energy sources, energy efficiency and the resulting requirements and needs of grid users. Moreover, an increased demand for flexibility emerges both in the transmission and in the distribution grids due to the massive deployment of variable generation.

Smart Grids employ innovative products and services together with intelligent monitoring, control, communication, and self-healing technologies. Inter alia, Smart Grids provide improved reliability and security of supply by allowing consumers to play a part in optimizing the operation of the system via a provision of information and choice of supply. The Smart Grid enables for adaptation of electricity demand to grid and market conditions, automatic grid reconfiguration to prevent or restore outages, and the safe integration of distributed generators, electric vehicles and large scale renewables.

- The advantages of a Smart Grid are summarised as follows:

- The Smart Grid requires an increased use of ICT to improve reliability, security, and efficiency of the electric grid through a dynamic optimization of grid operations and resources, (with full cyber security). Communication as a whole is the backbone of Smart Grid. Deployment and integration of distributed resources and generation, including renewable resources;

- Deployment of ‘‘smart’’ technologies for metering, communications concerning grid operations and status as well as distribution automation. Smart Meter is a generic term for electronic meters with a communication link. Advanced Metering Infrastructure allows remote meter configuration, dynamic tariffs, power quality monitoring and load control. Advanced systems integrate the metering infrastructure with distribution automation.

- Integration of ‘‘smart’’ appliances and consumer devices as well as provision of timely information and control options to consumers;

- Deployment and integration of advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid electric vehicles, and thermal-storage air conditioning;

There is no single, off-the-shelf Smart Grid solution as every electric utility operates somewhat uniquely. Smart Grids architecture includes the automation of the transmission and distribution network.

In the table below the major elements of a Smart Grid are shown:

<table>
<tr><th>Transmission</th><th>Distribution</th></tr>
<tr><td>Energy Management System (EMS) is the control centre for the Transmission Grid. An open architecture is required to enable an easy ICT integration and a better support to avoid blackouts.</td><td>Distribution Management System (DMS) is the control center for the distribution grid. Important components include outage management System, fault location and interfaces to Geographic Information Systems.</td></tr>
<tr><td colspan="2">Power Quality and Power Monitoring Systems are independent from Operation, Control and Management Systems and supervise all activities and assets/electrical equipments in a corresponding (transmission or distribution) grid. Therefore such systems can be used as “early warning systems” and are a must to analyze faults and to find out the corresponding reasons.</td></tr>
<tr><td>Transmission Automation and Protection: Advanced transmission automation concepts increase overall grid reliability and efficiency while reducing line losses and faults. It incorporates decentralized energy sources, such as offshore wind farms, and delivers electricity through the power lines on demand.</td><td>Distribution Automation and Protection: Advanced distribution automation concepts promote automatic self configuration features, reducing outage times to a minimum (“self-healing grids”). It enables the use of distributed energy resources to create self-contained cells (“MicroGrids”). MicroGrids can help to assure energy supply in distribution grids even when the transmission grid has a blackout.</td></tr>
<tr><td colspan="2">Substation Automation & Protection is the backbone for a secure transmission grid operation. Security is based on protection schemes.</td></tr>
<tr><td colspan="2">Power Electronics is among the “actuators” in the power grid that enable actual control of the power flow and can help to increase transport capacity without increasing short circuit power.</td></tr>
<tr><td colspan="2">Decision Support Systems and System Integrity Protection Schemes: it is a concept of</td></tr>
</table>

Transmission	Distribution
using system information from local as well as relevant remote sites and sending this information to a processing location to counteract propagation of the major disturbances in the power system. With the increased availability of advanced ICT technologies, more "intelligent" equipment can be used at the local level to improve the overall response. Traditional contingency dependant / event based systems is enhanced to include power system response based algorithms with proper local supervisions for security.	
Asset Management Systems and Condition Monitoring devices are promising tools to optimize the OpEx and CapEx spending of utilities. Condition-based maintenance, for example, allows the reduction of maintenance costs without sacrificing reliability. Furthermore they may also be used to utilize additional transport capacity due to better cooling of primary equipment, e.g. transmission lines on winter days.	

The selected **SPs** are focused on smartening the distribution grid through the following functionalities:

- **Smart distribution:** The distribution segment, where end users are connected, is the segment most affected by the development of the smart grid. The task is to integrate dispersed small and medium size generators and manage two-way power flows in a grid designed for a one-way flow. This new two-way communication channel with customers is used to collect data and to carry information, allowing a real-time response to network conditions through dynamic pricing and load shedding. It can be used to inform electricity providers of, for instance, the energy use of particular appliances and the location of the source of new power generated by plugged in electric vehicles.

- **Monitoring and Data Collection:** It is enabled via measurement at medium voltage (MV) network level (both at substations and customers) of active and reactive power, voltage and current including the interface between the transmission and distribution network to enable two way communication between DSO's/TSO's central systems;

- **Monitoring and control** of Medium Voltage / Low Voltage (MV/LV) networks to support and optimize the integration of Distributed Energy Resources (DER) in the urban network including the Voltage Control (mainly MV network Voltage Control using reactive power reduction/increase[3]);

- **Anti – Islanding:** Multilevel system operation of a distribution network is enabled through secondary substation(s) with an islanding capability of parts of a district to be activated in emergency situations - disconnection of Distributed Energy Resources (DER) in the event of unwanted islanding of the local network.

- **Fast Fault Selection**: New automatic MV fault selection and restoration procedures, exploiting communication between Intelligent Electronic Devices (IEDs) along a medium voltage line;

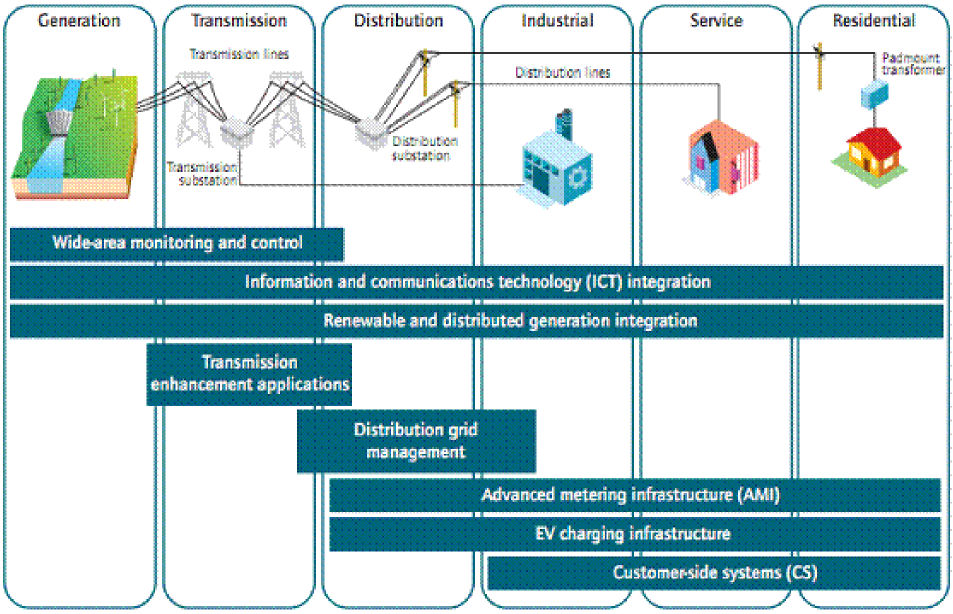
- **Electrical Vehicles (EV) Recharging Infrastructure:** During the first major wave of electric vehicle commercialization, plug-in electric vehicles and plug-in hybrid electric vehicles will be managed only as flexible loads due to actual vehicle technical constraints. The large scale integration of electrical vehicles will require intelligence to manage charging and discharging operations to meet the dynamic network load; this includes

[3] Distributed energy resources (DER) can have an important role in the supply of reactive power. Reactive power supply in most distribution systems is unevenly distributed and is typically available only in limited quantities. Reactive power could be supplied dynamically, that is, it could be increased or decreased quickly. Reactive power could be used to regulate voltage at the distribution level. Having a dynamic supply of reactive power available from the distribution system would make the entire grid more efficient and reliable.

turning off or reducing the charge rate and even recovering power during critical grid events. Owners of vehicles will of course need to consent to the use of their vehicles in this way.

- **Customers' awareness devices.** They support the implementation of Demand Response strategies thanks to direct consumption information to the final LV Customer; Economic incentives and real-time pricing are realistic ways to get customers involved in energy management.

In the graph below the Smart Grid set up is illustrated.



The selected SPs on Smart Grid Systems have proven that they can make substantial impacts in the **grid automation distribution, storage technology demonstration and wider uptake of home applications** to involve costumers in energy monitoring and management systems.

These SPs are focused on the following technical features:

1. **Costumer awareness and Active demand**: It is enabled by informed customers who use Smart Metering Infrastructure to measure energy consumption and provide real-time optimization of energy flows at the urban level. Devices supporting the active demand use the latest technology (e.g. In-Home Displays...) which helps to visualize and control the consumers' consumption;

2. **DER-RES integration**: The integration of small distributed energy resources in the urban network (comprising new loads/generation such as storage) is supported also by the following technologies: network monitoring/management/control system and related communication infrastructures. Remote control system for LV network switches and storage system is developed as well. The storage system may also be used for the management of medium voltage lines, or peak shavings and load profiling.

3. **Electric Vehicles**: Development of EV charging infrastructures and a centralized remote management system that ensures an easy and not discriminatory access for all customers and suppliers (multivendor).

4. **Storage system**: The Isernia Project includes the installation of a charging station to power electric vehicles, integrated with a photovoltaic plant and a multi-functional storage system. The storage system may also be used for the management of medium voltage lines, or peak shavings and load profiling, and will be able to replace the charging system or receive energy directly from the photovoltaic plant.

The above features are based on the application of the following technological solutions / assets: (i) Site Preparation (e.g. new replacement cables and conductors, voltage levels unification, Infrastructural works in substations and systems, and introducing smart components); (ii) Broadband communication systems; (iii) Central and distributed devices of management and control; (iv) Logic, actuator devices and sensors for the network automation; (vi)New systems for protection and interface; (vi) Electric storage systems; (vii) Charging infrastructure for electric vehicles; (viii) Systems and devices of customer interface.

These Smart Grid features are discussed in greater detail in section 1.4.

1.2 Level of deployment

There are hundreds of projects running across Europe piloting or demonstrating different improvements in the energy supply and networks via smartening the transmission and/or distribution grids.

Joint Research Centre (JRC) commissioned a publication in 2011 on "Smart Grids in Europe, lessons learned and current developments". The following project categories are recognized in the publication: 1. Smart Meter and Advanced Metering Infrastructure; 2.Grid Automation Transmission; 3. Grid Automation Distribution; 4. Integrated System; 5. Home application / Customer Behaviour; 6. Specific Storage Technology Demonstration and 7. Others.

The analyzed projects span across all the stages of the innovation process, but the majority of them are concentrated in the R&D and demonstration phases. Only 7% of the projects are in the deployment phase while these 7% account for almost 60% of the investments. The majority of projects address smart metering which points to the fact that the regulatory frameworks are in favour of such grid improvements.

Based on the JRC catalogue of projects an estimation of investments in Smart Grids by 2010 is made along with supplying information on the source of funding and the status / forecast of the number of deployed smart meters.

Country / Region	Forecast Smart Grid investments (€/$)	Funding for Smart Grid development (€/$)	Number of smart meters deployed and/or planned
European Union	€56 billion by 2020 (estimated Smart Grid investments)	€184 million (FP6 and FP7 European funding for projects in the JRC catalogue). About €200 million from European Recovery Fund, ERDF, EERA.	45 million already installed (JRC Catalogue, 2011), 240 million by 2020

A recent report by Pike Research[4] forecasts that during the period from 2010 to 2020, cumulative European investment in Smart Grid technologies will reach €56.5 billion, with transmission counting for 37% of the total amount. The report also suggests that by 2020 almost 240 million smart meters will have been deployed in Europe.

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

Next to the JRC catalogue, another important source dealing with the deployment of the Smart Grid solutions is the Strategic Research Agenda (SRA) Smart Grids presented for the first time in 2007 by the European Technology Platform (ETP) for the Electricity Networks of the Future. Considering insights from research institutes, industry, regulators and utilities, the document identified the main areas requiring investigation in the short and medium term in Europe. Since then, it served as a decisive input to the European Electricity Grid Initiative (EEGI), laying out Smart Grids RD&D needs to achieve the EU's 20-20-20 targets by 2020.

[4] http://www.pikeresearch.com/

The goal of this new Smart Grids SRA 2035 (published in March 2012) is to determine longer term research and innovation potential in electricity networks and intelligent electric systems that will contribute to the EU's envisioned CO2 reduction of minimally 80% by 2050. The SRA promotes a smooth transition from today – via progress achieved through the SET plan initiatives by 2020 – towards an optimal smart energy system with flexibility in demand and generation by 2035. The SRA 2035 is a strategic document serving as key input to the next EU Framework Programme for research and innovation – starting in 2014 – as well as other SmartGrids RD&D initiatives both on national and European level.

The European Electricity Grids Initiative (EEGI) as one of the industrial initiatives of the European SET Plan, was launched 2010. During the last years a number of European member states have already started programmes and initiatives to develop Smart Grids demonstration projects and a number of FP 7 projects were started.

An overview over local demonstration projects is provided in "Smart Grids Country Snapshots and Country Fact sheets" (an EU funded publication released in April 2011). Brief information on demonstration projects in 18 EU Member Sates including the funding / programme mechanisms and the national thematic focus is highlighted in the following table:

Country	Ongoing Demo Projects	Accompanying research and/or activities	Funding / program mechanisms	National thematic focus
Austria	5 Upcoming Pioneer Regions, of which 3 in demonstration phase (Showcase Region Salzburg, Pioneer Region Upper Austria, DG-Demo Net);	National stakeholder working groups (SG Technology Platform); Accompanying Meta-Studies and accompanying coordinating management (starting 2010);	Grants; different funding rates according to national and EU funding guideline; Mission oriented research programs on energy systems;	Integrated planning and operation of distribution networks;
Belgium	10 demo-projects ongoing; Accelerating rollout of smart meters; 5 reference cities for large-scale integrated pilots;	Regional Smart Grids Platform with all stakeholders (Smart Grids Flanders); BelSET-platform for coordinating input to/from SET; B-EEGI platform joining Belgian Grid operators;	Individual Grants & living labs; Contours of support programs appearing; Most mechanisms are regional and not applicable in the entire Country; Relying partly on European support;	RES integration and cluster environmental technology;
Czech Republic	Smart region RES and DG integration; E-mobility; Advanced AMM; functionality; Multiutility – gas, water, heating; Smart metering communication infrastructure in 800 MV and LV substations; Interaction with customers		in accordance with national and EU funding guideline; key funding under national stakeholders and/or Distribution operator (at present)	Know-how in smart technologies; Advanced AMM functionality;
Croatia	Information System for Continuous Monitoring of Power Quality in MV and LV networks; DC Autonomous Microgrids; Guarantees of		Grants (World Bank, EBRD, Croatian Bank for Reconstruction and Development); Croatian Science Foundation, Distribution System Operator;	High level of distribution system Automatization; Smart metering for the customers above 30kW load demand; RES/CHP integration in MV

Country	Ongoing Demo Projects	Accompanying research and/or activities	Funding / program mechanisms	National thematic focus
	Origin; RES Information Systems			and LV networks; ICT support systems for market operation;
Denmark	Active Demand Response and integration with Smart Homes: EDISON; EcoGridEU; Smart Metering Infrastructure & Data Processing: SM data; Integration of RES, storage and EV: EcoGridEU; Planning, monitoring and control: EcoGridEU; Ancillary services provided by DSOs: TWENTIES	Task Force .– Future electricity system - a corporation between the Danish DSOs and the TSO;		Mobilising customers, short term markets; Balancing price flexible demand; Managing LV network with EV, PHEV & Heat Pumps; State Estimation, Asset management Automation; Standard: Information models Data security, Protocols Infrastructure, System security & architecture;
Finland	One large project starting 2011, several small demonstrations (> 10 pcs); Financed by: Industry and TEKES (Gov.) Funding EUR = 10 M€/a; Total budget EUR = 55 M€	17 industrial participants and 8 universities/research Institutes;	Industrial funding over 60 %	***Power Systems; Active resources; Energy Markets;***
Germany	6 model projects in the framework of E-Energy; 7 related projects on electric mobility;	Ancillary research group to deal with cross cutting topics; Cooperation structures (standardization, branch associations); Meta-Studies on Smart Grid scenarios and roadmaps; Smart Grids D-A-CH cooperation with Austria and Switzerland;	Program with contest; funding rates for enterprises and research institutions according to national and EU funding guideline; Orders to experts to produce studies on specific topics;	Integrating grid operation and electronic marketplace; Know how on interoperability, safety and security; Added value generation and business processes; Market potentials and improving consumers acceptance; Needs for changes in the legal framework;
Greece	New demo project "Green Island-Agios Efstratios"; 2011- 2014; Total budget: EUR 8.9 million	'Smart Grids': Technical study to maximize the penetration of renewables, to power quality, microgrids and distributed generation. Collaboration between NTUA, PPC and RAE for the islands:	EU "ELENA" financed through the Intelligent Energy	Islanding demonstration; Microgrids;

Country	Ongoing Demo Projects	Accompanying research and/or activities	Funding / program mechanisms	National thematic focus
		Lesbos, Lemnos, Andros, Santorini and Kythnos.		
Italy	10 demo projects ongoing, of which 9 can be brought on EU level: 2 single ("POI ENERGIA 2010-2013"); 8 have been clustered; Total overall demo budget: EUR ~200 mio.; 1 of the single demos = EUR 77 mio.; cluster of 8 projects = EUR 16.5 mio.	Fundamental research (SG part– EUR ~15 Mio/a)– public research; plus add. research in universities Italian Roundtable on Smart Grids: Initiative of Ministry of Economic Development; starting soon (incl. all stakeholders of the electric system) ISGAN "Int. SG Action Network": Italy is one of founding members; Permanent group of people working in the network;	"Poi Energia 2010-2013": funded by Ministry of Economic Development; On-going Cluster; Funded by regulator: Recognizes a higher Return on Investment rate to operators for these projects; starting mid 2011 - 3 years	Integration of RES in distribution network; Development of ICT; Customer Participation; E mobility;
Latvia	Distribution automation pilot project (2010-2013); Meter data collection, management and energy efficiency pilot project (2011 second half of year– 2014).	Smart Grid Competence Centre	DSO investment programme and Latvenergo investment programme	Integration of Smart Metering; Smart Distribution Network; Integration of Smart Costumers; Integration of DER and new users;
Norway	Total demo funding: EUR ~16.5 Mio. "SSMART" - Regional balancing, bottleneck management, risk management with SG roll-out	"Energy 21 initiative": Ministry of energy working group; developing roadmap for Norwegian energy system;	Grants; RENEGI Programme;	offshore grid; market design; asset management;
Poland	Implementation of AMI system (Energa Operator S.A.; total budget approx. EUR 300 Mio); upcoming at least 2 projects concerning massive Smart Metering deployment;	Consortium SmartPowerGrids Poland; National SG Technology Platform;	Programme Smart Grids (NFEP&WM); grants up to 30% of eligible costs; total budget approx. EUR 125 Mio;	Energy Regulatory Ofice requirements for creating System Smart Grid; Ready Smart Grid Law; Requirements and standards for AMI;
Portugal	4 Large Demonstration projects; Financed by: EU FP6, EU FP7, Portuguese Government QREN, Other Portuguese Funds;		Grants; different funding rates according to national and EU funding guideline; Mission oriented research programs on energy	Integration of Smart Metering; Integration of DER and new users; Smart Distribution Network; Transmission / Distribution coordination.

Country	Ongoing Demo Projects	Accompanying research and/or activities	Funding / program mechanisms	National thematic focus
			systems;	
Slovenia	Elektro Gorenjska – AMI (19.0 Mio. €); ELES– SmartGrids projects (4.7 Mio. €); Supermen (2.1 Mio. €), KiberNet (1.7 Mio. €), CC SURE (10.6 Mio. €€)	Smart Metering implementation plan (207 Mio. €); National Technology Platform for Smart Grids (36 stakeholders); National SmartGrids Roadmap (CC SURE);	100% funded by distribution and transmission network operators co-funded by Technology Agency, Ministry of Higher Education, Science and Technology , European Regional Development Fund;	Dynamic thermal rating WAMS (wide area measurement system) DSM / Ancillary services DCN (data communication network); AMI DSM/DR Voltage control / Automation Virtual Power Plant Infrastructure for e-mobility ICT infrastructure Efficient use of energy Smart Home;
Sweden	Stockholm Royal Seaport - Feasibility Study, Large Scale Urban SG Demo, Total Budget ~3.75 MEUR (40% funding); Smart Grid Gotland – Feasibility Study, Large Scale Rural SG Demo, Total Budget ~1.1 MEUR (40% funding);	Research Programmes: EKC2, ELEKTRA; EIT KIC InnoEnergy Sweden – European Node for Innovation on Smart Grids and Electricity Storage;	Grants; Funding rates According to National and EU Funding Guideline; Contributing Funds from Participating Organizations;	Integration of RES; Active consumers; Technologies and systems; Network Tariff Regulation model.
Switzerland	Vein; Swiss2G; ewz Smart Metering Pilot; aWattgarde;	D-A-CH cooperation	Grants; Different funding rates according to national funding guideline; Mission oriented research programs on energy systems;	Electricity grid; multi energy carriers; Flexible AC Transmission Systems (FACTS); Technologies to transfer coupled several energy carriers;
Spain	The largest demo projects are mostly supported by private funding (utilities); the main driver is smart metering deployment by 2018; 6 large National R&D projects - budget 135M€ (50% funded); 4 large National demo projects - budget 125 M€	Spanish R&D plan - CDTI and Ministry of Innovation; National stakeholder technology platform - FUTURED;	Public funding: from grants to loans.	network automation & control; Smart metering; end user Systems.
The Netherlands	Stimulating programme for e-mobility: 800,000 e-cars until 2020; total budget: EUR ~65 million;	Several working groups on specific Smart Grids topics; Smart Grid Initiative: "Smart	Public-private-funding: on average 30% public / 70% private;	Large scale wind; E-mobility; Smart Meter roll out;

Country	Ongoing Demo Projects	Accompanying research and/or activities	Funding / program mechanisms	National thematic focus
	Energy island in the North Sea: 20 GWh electricity by wind; 1.5 GW; Green Gas Field: feed gas into existing distribution system; Smart Meter for electricity & gas: roll-out of 250,000 SM; EUR 20 Mio.; Goal: 80% of all customers with smart meters until 2020; Smart charging:	Energy Collective"; planned/ started R&D projects until 2015; 8,000 households involved.		
Turkey	Implementation of Feeder Automation Project – TUDOSIS (TUBITAK UZAY for Bogazici DISCO; total budget approx. EUR 5 Mio); Implementation of Wind Power Monitoring and Forecast Center Establishment Project (EIE, TUBITAK, Turkish State Meteorological Service, Total Budget approx. EUR 10 Mio)) .– Upcoming for 21 DISCO in 5 years; (Total Budget approx. EUR 50 Mio)		Different funding rates according to different national sources: (TUBITAK, KAMAG, ARDEB, TEYDEB, TTGV, DPT, Industry) and international programmes (FPs, Eureka, Eurostars, etc)	Power Quality, .SCADA Systems; Distribution Automation; Smart Grid Systems; Smart Metering Systems; New and Efficient Sub-stations; Developing Regions Infrastructure; Loss/Fraud Protection; Other Investments

The analyzed are also in pilot / demonstration phase:

1. "**Smarter and Upgraded Electricity Network in an urban context"** – it is tested in 8000 households.

2. **"So La Bristol"** – it is tested in 10 schools, 1 office and 30 homes (all owned by the Council); it addresses issues associated with the large-scale deployment of photovoltaic (PV) generation, all connected to 13 distribution substations.

- As mentioned elsewhere, the Smart Grid technologies are available on the market; Smart Grid related technologies - information and communication technologies, software, equipment, devices[5] and other hardware, as well as services, are mostly available on the market.

- [5] Tools and devices referred to in this Key Innovation – sensors, control devices and smart meters contribute to more efficient grid management and monitoring, as well as addressing outages and power restoration.

- The Smart Grid concept, however, is still evolving. There are many pilot and demonstration projects whose results are to converge into fully functioning elements of the Smart Grid "system of systems." There is a need to demonstrate how this technologies work under real life working conditions for which a strong commitment of all the main stakeholders is essential to exploit the Smart Grid services to its full potential.

- Also, it is expected that new requirements and technologies will emerge along with gaining of new experience. Therefore it is not possible to define a timescale for the deployment of the Smart Grid system's technologies.

1.3 Impacts of the innovation: achieved and foreseen

The following benefits are anticipated by the SPs:

- Increased capacity of accommodating generation sources and load in the network and security of the electric system; also the smart grid enables to integrate DER more efficiently
- Optimization of energy consumption according to supply and the network conditions, and avoidance of additional investments to cover the peak load demand; improved planning of future investments
- Contribution to network stability and reliability through better monitoring of network operating conditions and increased observability of the network; higher operational efficiency, network security, system control and quality of services
- Higher involvement of the client in the management of energy consumption; improved market conditions and customer services
- CO_2 reduction linked to RES integration and energy consumption optimization
- Development of photovoltaic sector and new market opportunities
    - The impacts triggered by the implementation of smart grid measures have been split into four macro areas: Economic savings, Improved service quality, reduction of environmental impacts and increased turnover. Indications for each impact in monetary terms (units per customer) and avoided CO_2 emissions (units per costumer and EV) are provided below:
- Economic savings - 45€/costumer/year for savings in electricity consumption, 5€/costumer/year due to % reduction in the total duration of interruption to operations of remote control and automation (long + short); 11€ EVs/year as a result of avoided CO_2 emissions; 0,5 € customer/ year for avoided CO_2 emissions due to reduced consumption associated with active demand measures and raised awareness; 73.186 €/year as a result of avoided CO_2 emissions due to RES development.
- Improvement of service quality (reliability) - 20% reduction in the total duration of interruption to operations of remote control and automation (long + short)
- Reduction of the environmental impact – reduced 1,4 ton CO_2/EV/year; reduced 0,08 ton CO_2 / customer/ year due to reduced consumption associated with active demand measures and raised awareness; reduced 9.758 ton CO_2/year due to RES development.
- Development of photovoltaic sector and new market opportunities: overall amount 7 million €.

1.4 Technical feasibility and viability

The following paragraphs describe the technical status of three core elements of the Smart Grid concept: smart distribution network, active demand and customers awareness on energy consumption, RES integration, and electric vehicle integration. The information is based on the information highlighted in respective SPs and discussion during the breakout sessions organised at the second WG meeting in October 2012.

Smart Grid solutions are currently deployed in demonstration projects: both SPs that form the basis for this Key Innovation obtained funding from national funds in Italy and UK respectively.

- The project “Smarter and Upgraded Electricity Network in an urban context” won a competition-based procedure launched by the Italian regulator (AEEG) granting incentives to innovative smart grids pilot projects.
- The Project “SO La Bristol” is funded by the Ofgem`s Low Carbon Networks Fund. The Fund allows up to £500m support to projects sponsored by the distribution network operators (DNOs) to try out new technology, operating and commercial arrangements.

Active demand

Present status: currently, electricity demand from end-users is considered a given, determining the generation and network capacity required. Given the increasing (peak) load of the system and rising variability of supply, this approach is more and more costly.

Emerging Smart City solution: the pilot project “**Smarter and Upgraded Electricity Network in an urban context”** in Isernia **aims to raise the customers awareness through the installation of** the “smart info” tools in Isernia’ households that are connected to the low voltage grid. The device supplies information about energy consumptions enabling visualization and control of consumers’ consumption using the latest technology (e.g. In-Home Displays, Smart Phone or PC applications). The application interacts with Smart Energy management boxes - smart plugs and smart appliances in the domestic environment and the load control points within the distribution network. Consumption adjustments are possible on demand or automatically. The automatic switch off of appliances can be triggered based on a cap on energy consumption in Italy and reflecting the energy price in that time slot[6].

RES Integration

Present status: the variable nature of the supply of renewable energy implies that total supply will exceed demand or the ability of the network to accommodate the flows at certain times. This means that RES generation would need to be curtailed, wasting valuable renewable energy.

Emerging Smart City solution: the “So La BRISTOL” project deploys battery storage, demand response and DC networks to cope with the distribution network peaks and thermal overloads.

- Battery storage at the end-user property allows for using lighting and centrally located heat pumps even during network power outages. The storage systems can be sold to customers as a service. Distribution Network Operators (DNOs) and customers can also share battery storage on DC networks with a variable tariff to make battery storage financially viable.
- Low-power AC to DC converters have a simple, low-cost design, but they are electrically noisy and increase the network harmonics, which, if left unmanaged, may damage sensitive equipment of customers and DNOs. Supplying DC equipment using a DC network within buildings can help reduce network harmonics, phase distortion and improve voltage control.

[6] The mentioned time slots are set by the energy supplier / vendor.

- For demand response, "smart tariffs" are introduced to incentivise customers to reduce their peak demand using a combination of battery storage, on-site generation and smart appliances.

Despite the benefits of battery storage, several issues have to be addressed. Firstly, only DC appliances allow for storage at the moment; AC appliances, representing a larger share of total consumption, lack storage capability. Addressing this requires developing technologies for storing energy in AC appliances. Secondly, storage of electricity at building-level is costly for both consumers and DNOs. Commercially viable solutions combining building and district level storage systems can prove more cost-effective solutions, and should be explored taking into account the locally connected distributed generation and load density.

Electric Vehicle (EV) integration

Present status: EVs are currently only a minor share of the total vehicle fleet, so that their impact on electricity demand is small. However, that would change with their wider uptake, so that the electricity system needs to be adapted to manage this additional load.

Emerging Smart City solution: the "**Smarter and Upgraded Electricity Network in an urban context"** project develops EV charging infrastructure and centralized remote management system enabling EV smart charging. Charging is performed mainly in AC; this solution allows for recharging and EV in 30 minutes.

1.5 Financial viability / cost benefit analysis

For the "**Smarter and Upgraded Electricity Network in an urban context"** a full cost/benefit analysis was performed in compliance with the Guidelines for Cost Benefit Analyses of Smart Metering Deployment (JRC, 2012) and the Guide to Cost Benefit Analysis of Investment Projects (EC 2008).

The Business Case, presented here below is based on a generic smart grid project to be implemented in the Italian landscape.

Moreover due to the innovative dimension of the smart grid technologies and their early deployment stage, there is not a dedicated revenues` model to remunerate the DSO investment on this field.

Estimations made by the SP proponents show that there are economic / financial savings as a direct result of the project due to: deferred investments in generation and distribution, peak load transfer, reduced costs of maintenance, reduced claims, and optimization of energy consumption.

The analyses operated with the following assumptions: covered an **urban area of roughly 50.000 inhabitants; time frame of 20 years** was selected to reflect the average useful life of the equipment/manufactured goods – elements of the smart grid. The **discount rate was set at 5,5% with a fixed price**.

In addition, the following (average) unit costs were used:

- annual electricity bill (dual time, 50% f1, 50% f2 e f3) - 528,08 €/user;
- Unit price of CO2 emissions - 7,5 €/ton.
- Annual gas bills (higher tutelage) - 1427€/user.

Next to the above described assumptions, the following criteria were used in calculations:

- Number of users - 23.500
- Unit annual consumption of electricity - 2700kwh/year
- Increase in electricity consumption - 1,2% annually

- Reduction of energy consumption due to awareness - 6%
- Unit annual gas consumption - 1400mc/year
- Reductions expected of gas consumption due to raised awareness - 2%
- CO_2 emissions for each unit of electricity - 0,4kg/kwh
- CO_2 emissions per cubic metre gas - 2 kg/mc
- Minutes of interruption (SAIDI7 pre intervention) - 44min
- % SAIDI reduction post intervention % 20%
- Average figurative cost for each minute break - 0,5€
- Number of recharge infrastructures - 50
- Km travelled by a user in a day - 35km/day
- Autonomy of the electric - 120 km/car *year
- CO_2 reduced per km travelled with EV 110,8- g/km
- Ton CO_2 per user - 7,7ton/user/year
- Annual emission in one city - 386000ton/year
- Ton CO_2 avoided by smart city project - 16% ton/year
- Ton CO_2 avoided by smart grids project -15,8%ton/year

As discussed above, the deployment of smart grid systems involves investments into specific technological solutions and assets. For a project serving an urban area of 50,000 inhabitants, the following capital investments and operational costs will have to be born by the DSO:

    - Site Preparation (e.g. new replacement cables and conductors, voltage levels unification, Infrastructural works in substations and systems, and introducing smart components); **10 Mln €**

- Broadband communication systems; 1,2 Mln €
- Central and distributed devices of management and control - 4 Mln €
- Electric storage systems; 1,2 Mln €
- Smart Urban Services (Charging infrastructure for electric vehicles-Systems and devices of customer interface); 3,5 Mln €
- Operational costs~ 0,4 Mln € annually

The technical feasibility and viability is hindered by the inability of the industry to provide the required investments because of high capital and operating costs and existing regulatory frameworks not tailored to make operators recover from these investments. In fact in Italy, up until today, a revenue system concerning the smart grid investments doesn't exist. For this reason the DSO is the only player deemed to bear the whole investment burden. Therefore national public support in the form of grants and fiscal incentives as well as EU public support in the form of direct public aid is currently needed to achieve progress in the deployment status. Another prerequisite will be to grant the operators appropriate tariffs and incentives as soon as the

7 The System Average Interruption Duration Index (SAIDI)[1] is commonly used as a reliability indicator by electric power utilities. SAIDI is the average outage duration for each customer served

technologies are proven mature to move from demonstration to deployment. Section 3 describes these requirements in more detail.

2. Expected Impacts

2.1 Energy supplied or savings expected

The Smart Grid allows to integrate energy from unpredictable and intermittent renewable sources and to distribute power much more efficiently. A smart grid will deliver electricity more cost-effectively and with lower greenhouse gas emissions.

A smart grid not only can promote end-user efficiency but also promises to be a more efficient grid, reducing losses on the utility side of the meter in generation, transmission, and distribution of power. Smart grid capabilities across the transmission and distribution (T&D) network can allow T&D systems to operate more efficiently and responsively, reducing line losses and reducing excess generation needed to ensure grid stability. Smart grid systems would allow improved awareness of T&D system conditions in real time. This would allow the grid to be operated with tighter margins of error – and thus more efficiently[8]. The Electric Power Research Institute (EPRI) estimates that reductions in line loss attributable to voltage regulation[9] could save from 3.5 to 28 billion kWh in 2030[10].

In addition, as explained below, customer demand response can smooth loads and can shift loads in response to supply-side fluctuations and disruptions, allowing more use of efficient base-load power plants, fewer unused-but-operating power plants, and less strain on the grid[11].

As such cost savings directly accrue to utilities; efficiency gains in the grid should provide a significant incentive to the utilities and their regulators.

2.2 Expected impact on GHG emissions

Smart Grid has potential to reduce GHGs by deploying communications and infrastructure technology which contributes to additional end-use energy efficiency by providing information and affecting behaviour. Smart Grid helps maintaining the reliability with high levels of renewable generation (>20-25%). Reducing losses across electric transmission and distribution networks also indirectly impacts the GHG reduction.

Various sources[12] estimate potential GHG reductions from specific Smart Grid solutions as follows:

- 2% from distribution system efficiency;
- <0.1% from supporting more wind and solar generation;
- 5% if reinvest in demand response/ storage instead of power plants with renewables;
- 1% from enhanced energy efficiency programmes;
- 0.5% if reinvest savings into additional energy efficiency programs;
- 3% from consumer response to information;

[8] http://www.ase.org/resources/realizing-energy-efficiency-potential-smart-grid#_ftn9

[9] http://www.ase.org/resources/realizing-energy-efficiency-potential-smart-grid#_ftn10

[10] http://www.ase.org/resources/realizing-energy-efficiency-potential-smart-grid#_ftn11

[11] http://www.ase.org/resources/realizing-energy-efficiency-potential-smart-grid#_ftn12

[12] http://www.epa.gov/statelocalclimate/documents/pdf/angel_presentation_4-29-2010.pdf

- 3% from diagnostics in homes and small/medium buildings;
- 3% from supporting electric vehicles;
- <0.1% from using more efficient generation due to energy use changes;

Smart grid, however, does not directly reduce emissions; these are highly dependent on how the technology is used. Complementary policies are needed to realize desired environmental benefits.

2.3 Wider potential benefits for cities

Smart grids, or digitally enabled electrical grids, are very important because they will be essential to give shape to the transition to renewable energy sources, they make new services possible for consumers, and they will be necessary to meet future transportation demands.

Smart grids have many advantages such as:

- For consumers, smart grids lead to better options to contribute to a sustainable energy supply while maintaining a good standard of comfort.
- For municipalities, smart grids mean neighbourhoods that are more sustainable and liveable and citizens who are more involved and energy conscious. For the government, smart grids offer sustainable and affordable networks that maintain a reliable energy supply.
- For energy suppliers, smart grids offer a way to involve consumers in the energy supply.
- For the business community, smart grids open up new markets, in which EU based companies can take the lead.
- For system operators, smart grids form the ideal instrument to respond to the transition to renewable energy sources and to meet the challenges of rising demand for electricity.
- Finally, smart grids make it possible for society as a whole to optimise the energy system.

Smart grids offer a great deal of added value: They contribute to the integration of electricity production in all kinds of places in the grid. In principle, the directing and coordinating options make it possible to optimize energy use throughout the entire energy supply chain. Smart grids also make the energy user ‘intelligent’, because financial savings can be realised by flattening peaks in the power demand or at peak moments.

Furthermore, they offer opportunities for new, energy-related services. And finally, the application of smart grids makes the energy system more ‘dynamic’ and they help to improve security of supply. For these reasons, system operators support the development of smart grids.

2.4 Additional requirements on deployment

Energy efficiency

Demand response can help smooth load and match load to generation, thus avoiding the use of inefficient and stand-by generators. Planning for demand response programs should pursue activities that reduce total energy use in addition to reducing peak loads. Energy efficiency must be an integral goal of smart grid programs, from planning through to operation.

The Active Demand tool, for example, is primarily designed to reduce the costs for consumers (stimulating energy use when prices are low). Without active attention to energy efficiency and net demand reductions, the potential energy saving benefits of smart grid systems could be missed.

In addition, benefits other than those directly reflected in energy bill savings should be promoted to consumers, such as the grid stability (fewer blackouts), energy savings from grid efficiency, improved renewable energy integration, and reduced environmental impact as well as lower operational costs, (e.g. through automatic meter reading).

Lastly, the network interoperability must be fostered.

Access, standards and interoperability

From the viewpoint of Smart Grid, highly interoperable communication between all components is the major goal of smart grid communication. This means that the communication shall be based on a common semantic (data model), common syntax (protocol) and a common network concept. Therefore a convergence and a harmonization of subsystem communication shall be pursued.

General requirements are that the communication concept shall be future-proof. That means that it shall be open for future extensions regarding application fields as well as communication technologies. The concept shall be open regarding an efficient integration of state-of-the-art components, but also open for integration of legacy communication components. Real-time applications require system-wide time synchronization with high accuracy. In case of important and critical applications, the communication concept shall provide a high quality of service. Therefore enhanced redundancy concepts are essential.

As an essential part of a critical infrastructure, the communication concept shall be deterministic, transparent and fully comprehensible at any time.

In order to survive in the deregulated energy market, power supply companies today face the urgent task of optimizing their core processes. This is the only way that they can survive in this competitive environment. The vital step here is to combine the large number of autonomous IT systems into a homogeneous IT landscape. However, conventional network control systems can only be integrated with considerable effort because they do not use uniform data standards. Network control systems with a standardized data format for source data based on the standardized Common Information Model (CIM).

The CIM defines a common language and data modeling with the object of simplifying the exchange of information between the participating systems and applications via direct interfaces. The standardized CIM data model offers a very large number of advantages for power suppliers and manufacturers:

- Simple data exchange for companies that are near each other;
- Standardized CIM data remains stable, and data model expansions are simple to implement;
- As a result, simpler, faster and less risky upgrading of energy management systems and also, if necessary, migration to systems of other manufacturers;
- The CIM application program interface creates an open application interface. The aim is to use this to interconnect the application packages of all kinds of different suppliers using “Plug and Play”;

Although the focus of CIM and Service Oriented Architecture (SOA) is on the electric energy domain, the CIM and SOA concept is open and flexible to being adapted to non-electric domains. In the Distribution System Operation the gas and water supply is also managed. For a common concept of multi-utility management an integration of non-electric extensions of CIM and SOA shall be considered. Therefore investigating the multi-utility effects on the further development of related standards is essential.

MicroGrid will play an important role in the smart grid. Therefore, standards for MicroGrid interconnection with power networks or distribution system planning standards with MicroGrid incorporated are required. The standards for connecting MicroGrids with electric power systems may include the following contents:

- Design standard of MicroGrid. This includes equipment, protection schemes, and information system inside MicroGrid, etc.
- Standard for MicroGrid operating in island mode. This includes power management, voltage and frequency control, stability, protection, cold load pickup, monitoring and communication, power quality, installation and testing, etc.
- Standard for connecting MicroGrids with grid: Grid connection mode and conditions. This includes access mode (single PCC or multiple PCC), isolation mode, interconnection transformer, grounding mode, prevention of electromagnetic interference, withstanding voltage and current surge capacity, etc. Connection methods have major effects on the planning and operating of transmission system. Some organizations have their own standards for connection of wind power but up to now there has been no international standard for this. There are some national or international standards for PV connection, but they concern only distributed connection of small PV system.

Electric vehicles are another point in case. No standards for EV batteries and plugs have been universally adopted, potentially hindering wider replication of the proposed technology.

Standardized interoperability protocols, and “plug-and-play” capability for appliances across various utility smart grid systems, are important to ensure that consumers are not locked in to one utility’s, manufacturer’s or other vendor’s proprietary system and that data can be transferred without inconvenience to consumers. Interoperability would also increase competition and foster economies-of-scale in manufacturing, driving down prices as equipment becomes more of an interchangeable commodity. Therefore, adoption of standards for various elements of Smart Grids would contribute to their wider deployment.

Appliance standards, incentives and labeling have proven effective in encouraging improved energy efficiency in appliances and other equipment; similar policies can prove fruitful to encourage the manufacture of effective and user-oriented smart grid-capable equipment and for consumers to purchase it.

Engaging and involving consumers

Consumers must receive perceptible benefits from smart grid systems, especially smart meters and appliances. Such benefits can include the ability to analyze and reduce energy use, provided it is easily accessible and easy-to-use. Therefore consumers should be given access to their data and the tools to use the information, including technical assistance and financing.

To be able to design Smart Grid solutions to offer perceptible benefits, better insight into consumers’ interactions with data display systems is needed to enable more consumer engagement with smart technologies and better understand how to turn information into energy savings. In addition, the relationship between end-users, prosumers and network operators should be further explored in view of possible market interventions and business models.

Data use and privacy

Automatic control of consumption may suffer from a lack of consistent real-time information in case of central control (due to the distance and/or software incompatibility). Also, interfaces used by several utilities to present data gathered from smart meter systems, displays time intervals that do give a sense of general levels of energy use, but are not detailed enough to identify effects of turning on a specific appliance. Providing the main services of Smart Grids to end-users, including customer awareness devices and Active Demand solutions, may need more specific monitoring and control arrangements, as well as suitable market structures.

However, consumers may object to receiving the metering tools due to the related costs, privacy concerns (data ownership), difficulty in adapting to time-or-use pricing programs. The simplicity of the tool and data ownership should be carefully addressed in order to achieve the required output.

Cyber Security

Cyber Security is an important success criterion for a secure, efficient and reliable operation of the Smart Grid. The most important goal of Cyber Security is the protection of all relevant assets in the scope of the Smart Grid from any type of hazards such as deliberate cyber security attacks, inadvertent mistakes, equipment failures, information theft and natural disasters. These hazards predominantly concern the ICT infrastructure.

In order to achieve an adequate level of protection, classical security objectives such as confidentiality, integrity, availability, non-repudiation and privacy must be assured by the implementation of security controls. Any vulnerability could be exploited in order to attack the stability of the underlying systems with a fatal impact on energy supply and reliability. Because of the nature of the Smart Grid as a huge network of interconnected sub-networks and its inherent complexity, the aforementioned risks could quickly be increased. This comes along with a vast number of systems, interfaces, operational modes and policies implemented by the stakeholders involved which leads to more vulnerabilities and a higher probability that these will be exploited. In addition, new functionalities like smart metering introduce stronger requirements for data protection and privacy. As Smart Grid solutions require an enormous increase in the exchange of data both for observability but also for controllability, security of this data exchange and the physical components behind it is crucial.

The architecture of the Smart Grid will be complex with a very high number of endpoints, participants, interfaces and communication channels and with different levels of protection in the underlying systems. In general, it is always a challenge and requires effort to achieve an adequate level of protection for such a complex system. The introduction of Smart Metering systems and processes will increase the number of endpoints dramatically and will move them to private households. Physical security is hard to achieve in these scenarios.

Many components of the Smart Grid can be characterized as legacy where security has never been an important requirement. It is important to consider the impact of existing systems and interfaces that are already part of the Smart Grid. This constraint will affect the process of the definition of Cyber Security requirements at any time.

Cyber Security requirements for the Smart Grid do already partly exist in the different domains and specific applications. New requirements will evolve as those applications move forward to address Cyber Security as an important driver. In addition, the characteristic of the Smart Grid as a network of many inter-connected networks and applications will produce new and more common system-spanning Cyber Security requirements.

The mitigation of risks in order to achieve a stable and secure operation of the Smart Grid, Cyber Security requirements will be derived as a result of risk assessments and general architectural decisions. In order to achieve this in a comprehensive and granular manner, security objectives based on the classical security goals (confidentiality, integrity, availability, non-repudiation, and privacy) are a precondition. As a technical precondition, a detailed architecture and description of the Smart Grid needs to be elaborated. This architecture should reflect the specific applications and underlying domains as well as their relationship and interaction. The outcome of the risk assessment and risk management process will lead to a comprehensive security architecture which comprises all security controls.

In a final step, more granular Cyber Security requirements based on measurements and processes can be derived.

Furthermore, change and growth are significant characteristics of the Smart Grid. This makes a continuous cycle of risk assessments and subsequent adjustments of implemented security controls necessary. Finally, the high increase in ICT technologies and systems might create new requirements in the scope of power systems that already exist in these domains and which are covered by standards and recommendations.

2.5 Other expected impacts

Integration of Electric and hybrid vehicles

Excess base load capacity of the grid is a fundamental assumption towards integrating the EVs in the Smart Grid; fully understanding this assumption is integral to accurately predicting the impacts of EVs on the grid.

The value of the Smart Grid in managing and effectively utilizing the theoretical potential of EVs comes primarily in the form of demand response and the necessary data exchange to facilitate variable and complex charging and discharging schemes.

EVs include all vehicles that have some grid connected charging and/or vehicle-to-grid (V2G) component, including both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). Generally, both EV technologies will have similar interactions with the grid in the form of battery charging and potential distributed storage and generation capabilities.

Technologies that may be implemented as an alternative to battery power include compressed air technology, natural gas, and hydrogen. Hydrogen technology is far from commercially viable. Compressed air vehicles can have a short range (<50 miles), and even though the fuel economy is the range of EVs, the fuel cost is higher[13].

The further deployment of EVs depends mainly on the consumer perspective. Namely, the consumers are concerned with the battery range and refuelling location & timing. If it can be assumed that EVs will be charged at home, there arises an important question of when the recharging occurs. It could be late at night (which is beneficial to the utilities because it is off-peak time) or at other times throughout the day that are convenient for the drivers (e.g., in the evening, after the commute back home). Assessing the impacts of this critical question requires quantification of the effects of drivers' charging behavior on the grid from a technical and economic perspective. Further, the ability of consumers to decide based on their personal preference profile when to charge their vehicles will likely play a central role in their acceptance of EV technology, unless the utilities provide economic incentives that are high enough to change their behavior (e.g., reduced electricity costs during off-peak hours).

Various opportunistic charging schemes exist that utilize off-peak, idle generation capacity for EV battery charging. These methods are effective in the current dispatch curve, but are increasingly difficult to achieve as EV adoption rates increase. As the number of vehicles increases and user behavior is better understood, effectively managing charging patterns could prove difficult. If done improperly, there could be significant implication for electric utilities in terms of generation requirements and costs. However, with effective, Smart Grid-enabled charging dispatch, EVs could deliver energy costs savings to consumers and increased profits to electric utilities, not to mention reductions in GHG emissions and overall environmental impact from the transportation sector.

Vehicle-to-grid (V2G) describes the concept of using an EV's battery to provide regulation services for electricity markets when the vehicle is plugged in during the daytime. This could enable greater renewable power by supporting the electricity output swings and acting as a distributed storage source. This may become the only realistic form of opportunistic charging that has true long-term potential when scaled to ~100+ million vehicles. If consumer incentives are high enough, drivers may alter behavior significantly to reap revenue benefits from selling their battery's energy to the utility.

This would align consumer EV charging behavior with renewable energy generation utilization—which is a desirable outcome when renewable energy percentages increase past current state mandates of around 10 to 15 percent.

The V2G supporting Smart Grid technologies will, at a minimum, need to be capable of receiving and processing signals from individual vehicles. In this information exchange, electric vehicles will need to be able to communicate the current level of charge, the

[13] http://www.netl.doe.gov/energy-analyses/pubs/repVehicle_ElecGridImpact.pdf

quantity available for discharge (i.e., purchase by the utility), and prices to determine whether it is beneficial to charge or discharge to the grid. Further, system operators will need to know the amount of energy flowing into the system from EVs, pointing to the need for a Smart Grid network in order to accurately assess the generation requirements. It is precisely this information exchange and management that makes feasible the distributed storage and generation (from regenerative braking) capabilities of EVs.

3. Additional requirements on deployment

One central question where developments for 2035 must go beyond research for 2020 is the form and nature of the interactions between the transmission and distribution networks. Due to the massively changing nature of the grid users, with generation becoming less controllable and consumption becoming more controllable, the architecture of the involved transmission and distribution grids and their interaction will need to change.

Smart Grids research must analyze electricity systems as an integrated system, which could possibly be enhanced by other energy carriers for space and process heat and mobility demands.

The challenges will increase by 2035 also due to the increased presence of zero or even positive energy buildings. Smart Grids will need to cover the energy demands of time intervals during nights when PV is not generating electricity, on winter days in cold climate regions when not enough heat is generated by solar power on the house roof and in that time of the day (or even week) when planned power is not available for unforeseen reasons. Storage – both bulk in the mountain regions and distributed for example in batteries – will be a key element of Smart Grids. Also, the use of hybrid fossil-electric or fully electric vehicles with their need of fast and slow charging infrastructure will need to be considered.

In such a system, the following entities will have to be considered “users” within the Smart Grids system by 2035: any electricity or heat/cold conversion equipment, any mobility vehicle, any power transformation and any storage device. In such a system, users – both technology and human beings – can act individually or aggregate to participate in the market. Aggregated business entities can use standardized ontologies for communicating information to achieve common economic, environmental, security and quality of supply goals.

Such a vision must be accompanied by Smart Grids research to define how the stakeholders and their business models will need to move towards 2035, based on the new system that will be in place by 2020. Key factors to be researched and analysed include: the associated legal frameworks and rules, the regulatory institutions and the Smart Grids component technologies, and above all, the Smart Grids systems goals such as high quality and security of supply and high sustainability at low cost.

For this transition period, research is needed to determine how the functions and the actions of an initially low number of new actors should be regulated. Designing a legal framework with regulated and measurable goals for each stakeholder will make it necessary to incorporate an increased level of intelligent functionalities, thus supporting the overall Smart Grids systems goals. Research must be done to analyze how this system intelligence can be made easily accessible to the largest majority of the users, while keeping costs as low as possible. Research will also be needed to determine how this intelligence can be made available to all smart grids parties: bringing intelligence from electricity transmission down to the household plug, from inter-TSO communication for preventing blackouts, down to inter-household communication within small communities to support prevention of local or community disturbances.

Adapted legal frameworks must go along with this evolution of the electric system and grids. This means that the tasks, obligations and business activities of those actors that will intervene in the electric system must be clearly defined. The existing interfaces between today’s unbundled regulated grid monopolies and competitive business activities will be challenged due to the closer technical interactions among all system actors. Among others, questions of market power and of equal access to information such as real-time system models, prices, actions limited by system constraints and market bids of actors must certainly be considered. Also, the question of who is responsible for supplying energy under abnormal system states must be fundamentally considered in such a smart, future electricity system.

Consumers (industrial, small and medium size enterprises and residential) will play a role in the retail / commodity market, and will participate through new energy services based e.g. on real-time pricing, thus facilitating small-scale generation and storage of electricity. This development does require the use of proper component and systems technology to support emerging markets and new participants.

Until approximately 2020, solutions for these challenges are mostly component, single point related. They work, but cannot be integrated with each other or with similar or competitive systems. They are not modular, are not based on standards. There is the danger of technology lock-in, which is not very desirable. For the 2020 SmartGrids based system, the pilots and small-scale rollouts are justified in this phase of 'proof of principle' and 'proof of concept'. But for a large scale rollout by 2035 these systems must be able to co-operate and be interchangeable.

3.1 Governance and regulation

Smart Grid deployment must include not only technology, market and commercial considerations, environmental impact, regulatory framework, standardization usage, ICT (Information & Communication Technology) and migration strategy but also societal requirements and governmental edicts.

Permitting

As discussed above, the Smart Grid encompasses different elements; thus the scope of interventions varying upon different infrastructural conditions in the project area, topology, applied tools / devices etc., entails the development of project documentation at different stages. Project preparation may range from Feasibility Studies, complex technical and other designs integrating also SEA / EIA processes, to a simple purchase and installation of tools / equipment.

Permits are an important milestone on the way to smartening the electric grids. Issuing of various permits may be required by either a single authority (national, regional or local), or by multiple authorities in case of bigger interventions and / or due to certain legal requirements. It must be noted that an EIA is required for the installation of a primary substation; the involvement of environmental authorities in the permitting of less extensive infrastructural interventions (secondary substation, optic fibres etc.) may be required by some local regulations.

In some areas the permitting implies lengthy and costly procedures; therefore there is room to optimise procedures.

During the Smart Grid systems development (design, permitting and the implementation) various stakeholders need to cooperate such as:

- Public stakeholders – owners of infrastructure (and/or public operators) and/or authorities involved in permitting
- Private stakeholders – private network operators, broadband communication service providers, car manufacturers etc.
- Cooperation with numerous stakeholders with varying interests may be difficult. The cooperation with private stakeholders is eased by commercial agreements; however, the interaction with public stakeholders may be hampered due to the lack of sufficient legal framework to regulate the Smart Grids sector.

Standards

From the viewpoint of Smart Grid, highly interoperable communication between all components is the major goal of smart grid communication. This means that the communication shall be based on a common semantic (data model), common syntax (protocol) and a common network concept. Therefore a convergence and a harmonization of subsystem communication shall be pursued.

General requirements are that the communication concept shall be future-proof. That means that it shall be open for future extensions regarding application fields as well as communication technologies.

The concept shall be open regarding an efficient integration of state-of-the-art components, but also open for integration of legacy communication components.

As an essential part of a critical infrastructure, the communication concept shall be deterministic, transparent and fully comprehensible at any time.

Real-time applications require system-wide time synchronization with high accuracy. In case of important and critical applications, the communication concept shall provide a high quality of service. Therefore enhanced redundancy concepts are essential.

In order to survive in the deregulated energy market, power supply companies today face the urgent task of optimizing their core processes. This is the only way that they can survive in this competitive environment. The vital step here is to combine the large number of autonomous IT systems into a homogeneous IT landscape. However, conventional network control systems can only be integrated with considerable effort because they do not use uniform data standards. Network control systems with a standardized data format for source data based on the standardized Common Information Model (CIM), in accordance with IEC 61970, offer the best basis for IT integration.

The CIM defines a common language and data modeling with the object of simplifying the exchange of information between the participating systems and applications via direct interfaces. The CIM was adopted by IEC TC 57 and fast-tracked for international standardization. The standardized CIM data model offers a very large number of advantages for power suppliers and manufacturers:

- Simple data exchange for companies that are near each other
- Standardized CIM data remains stable, and data model expansions are simple to implement
- As a result, simpler, faster and less risky upgrading of energy management systems and also, if necessary, migration to systems of other manufacturers
- The CIM application program interface creates an open application interface. The aim is to use this to interconnect the application packages of all kinds of different suppliers using “Plug and Play” to create an EMS.

Although the focus of CIM and Service Oriented Architecture (SOA) is on the electric energy domain, the CIM and SOA concept is open and flexible to being adapted to non-electric domains. In the Distribution System Operation the gas and water supply is also managed. For a common concept of multi-utility management an integration of non-electric extensions of CIM and SOA shall be considered.

Investigate multi-utility effects on the further development of related standards.

- As a result of the problems discussed above (primarily the insufficient legal framework and the lack of standards) the following major risks may be anticipated:
- Uncertain market environment whereas the Smart Grid investments are to be born by the DSO without any possibility for recovery of these investments;
- Lack of standards to ensure interoperability and evolution of technologies without rendering the already installed smart grid elements obsolete;
- Need to build human resources of the stakeholders that are to cooperate towards smartening of electric grids

- Need to raise the awareness of the consumers for the use of smart info devices, recharging equipment for EVs etc.

Note: The above risks are faced in Italy; in other countries some other risks can be more valid – this is to check in different KIs and discuss during the WG meetings.

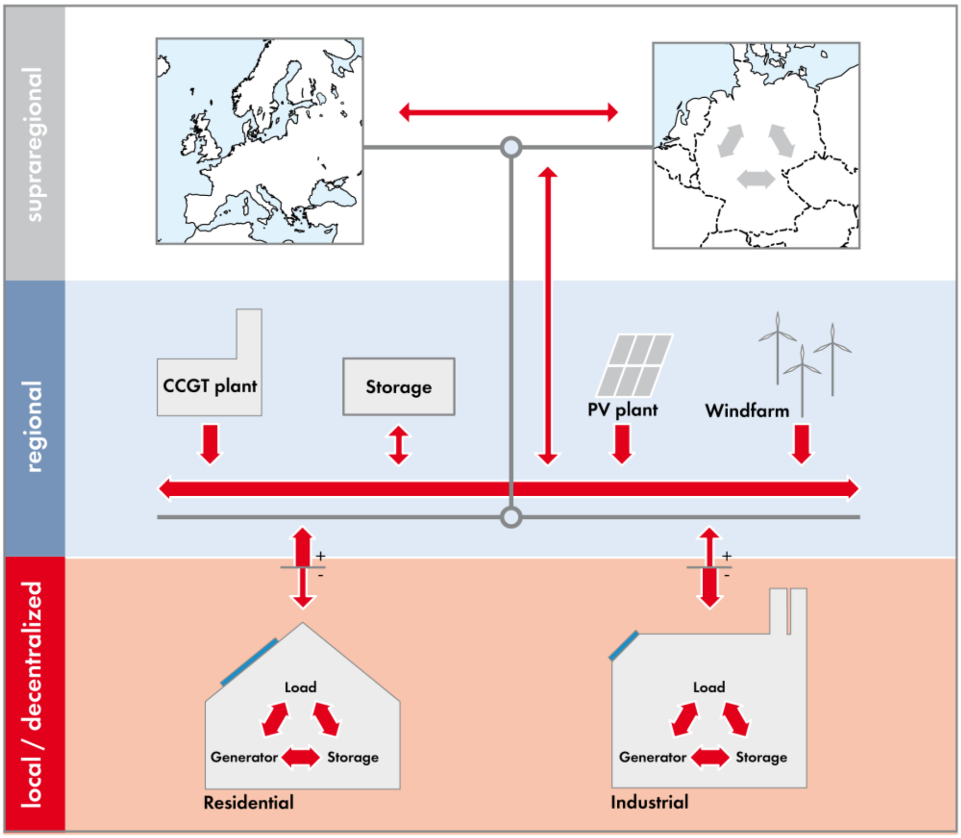
3.2 Suitable local conditions

Smart Grid encompasses different elements; thus the architecture varying upon different infrastructural conditions in the project area, topology, applied tools / devices etc.

The most variable element of a Smart Grid is the storage. The storage can differ as a result of the grid configuration and load density.

Decentralized storage systems are the key to converting the electricity supply into a smart-grid based on renewables. The fluctuating power generation capacity using renewable energy needs to be balanced on all levels, from international, national and regional power distribution grids to the household grids of private and commercial plant operators (Fig. below). This requires the ability to not only store energy on a temporary basis, but also load management and feed-in management.

In cases when the landscape is rural while the PV power comes from smaller PV systems feeding into the low-voltage grid the need for installing decentralised storage is greater. As this is the same voltage level where the majority of power is consumed, a decentralized balancing of power can benefit from short distances between the power generator, load and storage system and therefore minimize transmission losses and grid load.



Nevertheless, storage devices, standardized architectures and techniques for distributed intelligence and smart power systems as well as planning tools and models to aid the integration of energy storage systems are still lagging behind.

3.3 Stakeholders to involve

The SRA[14] 2035 classifies the most important involved non-research stakeholders as shown in the following table. In the list certain new roles towards the year 2035 are assumed. The future role of each stakeholder is, however, subject to research itself.

Stakeholder	Role/ how to be involved
Consumer	Consumption of energy products and services. This is the end-user of electricity. Categories of consumers are residentials, households, and communities. As consumers we also consider SMEs, industries and electricity-intensive industries. A specific example of a consumer category is the set of users with specialized mobility requirements for hybrid or pure electric vehicles. These users need mobility interfaces with quality and security of supply of the electricity system.
Prosumer	Consumers with the additional role of self-provided (owned) electricity generation and/or storage for private, daily life needs, comfort and SME business needs.
Energy retailers	Selling energy and other (related) services and products to consumers. Retailers will develop consumer oriented programmes and offerings.
Aggregators	Broking energy on behalf of a group or groups of prosumers
Energy Service Companies (ESCOs)	Provision of a broad range of comprehensive energy solutions, including designs and implementation of energy savings projects, energy conservation, energy infrastructure outsourcing, power generation and energy supply and risk management.
Electric Appliance users	The use of electrical appliances at consumer sites for daily life and business needs will increase due to substitution of (fossil based) space heating requirements. The users will be required to interface their needs with quality and security of supply needs of the electricity system.
Electric Vehicle users	A hybrid or pure electric vehicle is a specialized electricity consumer with mobility requirements. The users will be required to interface mobility needs with quality and security of supply needs of the electricity system.
Generators	Large scale centralized generation including wind farms.
Distributed Generators	Small- and medium-scale generation of mainly renewable based electricity either for third party consumers or for own consumption.
Storage Providers	Delivery of storage products and services, including their maintenance and operation thereby shifting electricity and energy consumption in time

[14] http://setis.ec.europa.eu/newsroom-items-folder/latest-smart-grids-strategic-research-agenda-sets-out-r-d-plans-towards-2035

Stakeholder	Role/ how to be involved
	either for third parties or own purposes.
Ancillary Service Providers	Provision of services such as Power Balancing, Voltage Profile Support, Frequency and Time and Blackstart
ICT equipment and systems providers	Sales of Information and Communication Technology (ICT System) products and services.
Telecommunications providers	Provision of telecommunication services, based on dedicated or public infrastructure
Data processing service providers	Provision of data processing services respecting consumer privacy
Energy Equipment & Systems Manufacturers	Sales of Electro-technology (System) products and services.
Distribution System Operators (DSOs)	Provision of services for secure, efficient and sustainable operation of electricity distribution systems. Legal obligation of a high quality, secure planning, operation and maintenance of the distribution grid.
Transmission System Operators (TSOs)	Provision of services for a secure, efficient and sustainable operation of transmission system. Legal obligation of a high quality, secure planning, operation and maintenance of the transmission grid.
Wholesale Electricity Market Traders	Provision of market based prices for products and services by liquid electricity markets
Policy makers, Regulators	Setup and control of natural monopoly requirements and for highly effective electricity markets.
Financial Institutions	To identify the financial tools needed to step up the smart cities deployment.
R&D institutes and universities	To carry out an applied and corss-border research in the field of smart cities
Inhabitants (life-long horizon)	Inhabitant must be involved in the development of smart cities project in order to spread the public acceptance and to enable them to take immediately advantage of the new technological solutions
STANDARDISATION BODIES	SUCH AS CENELEC TO SUPPORT THE INTEROPERABILITY PROCESS
Mayors, politicians	To gather bottom-up instances from the public and private sector concerning the “smart project” needed to reach Smart Cities.
City administration	To ensure the stability of the “transformation process” of the cities regardless the political changes. To improve the competence of the civil servants to streamline the permitting procedures.

3.4 Interfaces with other technologies

This section should present cross-sector, e.g. household electricity use and electric car. It describes how far urban mobility will be improved, e.g. by shifts to more sustainable modes or by reducing mobility demand.

Links with End-User Energy Efficiency technologies and measures

Access to real time data on energy use (provided under the Active Monitoring tool) would help identify building energy performance problems with much greater rapidity and could allow for better addressing them.

Combining real-time or near-real-time data on energy use with periodic or ongoing building commissioning could provide a comprehensive understanding of building performance metrics and effectively diagnose performance issues. Access to shorter-interval data than is currently offered by conventional energy meters would help identify building performance problems with much greater rapidity and could allow for more rapid trouble-shooting of building energy performance problems. Greater awareness of building systems would allow greater optimization of those systems' performance.

Links with Transport & Mobility technologies and measures

Smart grids facilitate the integration of EVs into the electricity system. The advanced metering equipment incorporated in Smart Grids enables a two-way flow of information and provides customers and utilities with real-time data that enables customers to schedule charging intelligently. This way, Smart Grid technology enables EV-charging (grid-to-vehicle, or G2V) load to be shifted to off-peak periods, thereby flattening the daily load curve. Effectively, Smart Grid technology can use EVs as distributed storage devices, feeding electricity stored in their batteries back into the system when needed (vehicle-to-grid, or V2G, supply). This can help to reduce electricity system costs by providing a cost-effective means of providing regulation services, spinning reserves and peak-shaving capacity.

In these ways, EVs could both benefit from and drive forward investment in smart grids. However, there are a number of technical, practical and economic barriers to such a development, including low battery discharge rates and storage capacity. Developments in battery technology will be critical to the future of V2G supply.

VPP

A VPP represents the intersection of a smart grid and distributed energy. A VPP is a technical, operational, and economic construct that aggregates distributed supply and demand resources in a manner that enables the VPP operator to treat the distributed energy resources, such as rooftop solar or customer-owned wind, as if they were a single power plant. VPPs are enabled by emerging smart grid capabilities or specifically, intelligent devices such as smart meters and grid sensors, pervasive broadband communications networks, and analytical software applications and are driven by the need to integrate increasing amounts of distributed energy resources into the overall energy resource portfolio.

The basic idea of a VPP is that a number of small scale production units of electricity can be operated as if they formed one huge power plant, like a conventional coal fuelled plant. In general, these generation units produce heating and cooling energy as well as electricity.

Individual units (especially wind turbines and solar farms) cannot guarantee a stable production level around the clock, but the combination of different sources can. By evening out the different peaks the energy production becomes much more predictable and stable. The basic idea of combining single production units gets more complicated when we incorporate the end users in the system. Balance within the system can then be reached in different ways. Switching off a number of electricity consuming installations has the same effect as raising the production of electricity. Or a decision can be made to switch on big power consuming units (like electrical cars that have to be charged) at the moment production in the system is at its peak.

However, the core of the Virtual Power Plant consist of a coordinating mechanism, that takes coherent decisions regarding a number of production facilities and end users of electricity, resulting in a predictable and stable outcome. This creates better conditions for the introduction of new renewable energy sources. And the owners of the Virtual Power Plant can negotiate a much more favourable contract with electricity companies.

First, a virtual power plant needs a bidirectional communication between the decentralized power units and the control centre of the energy management system. In the future, with an increasing number of small decentralized power units, communication channels and protocols will play a more important role.

The VPP can be used to balance the grid or enhance revenue. The VPP will evolve, requiring that utilities take VPP into consideration when approaching their business processes, enterprise architecture, and control systems. The real-time requirements of VPPs will introduce new complexities. Consequently, the control infrastructure to support the VPP will need to address flexible and scalable integration, control new distributed resources, and be based on standards that support interoperability.

4. FINANCIAL MODELS AND POTENTIAL FUNDING SOURCES

The Finance Group of the Stakeholder Platform has prepared documents on funding models and the use of EU Funding instruments, either from the EU budget or from the European Investment Bank. The documents are freely downloadable from the Stakeholder Platform's website.

- For funding models please refer to the **"Financing models for Smart Cities"** guidance document.
- For EU supported funding instruments please refer to the guidance document on **"Using EU Funding mechanisms for Smart Cities"**.

This section presents specific recommendations for financing models and potential sources suitable for this KI**".**

4.1 Financing models suitable for the innovation

There isn't any publicly available, independent, objective and comprehensive smart grid financial cost benefit financial model which may be applicable to individual electric coops and public utilities. The variables of such a model can be derived from evaluating individual smart grid investments, investment strategies and vendor proposals. The model itself could help in tracking investment costs and benefits and providing other smart grid financial evaluations.

Such a model could provide a 20-year, quarterly financial smart grid cost/benefit accounting framework; it would generate Utility-specific monthly kWh, peak kW, load profile forecasting models to determine smart grid hourly load program impacts by customer class and end-use. Such a model could enable an explicit representation of all important costs and benefits including avoided power purchase costs and avoided capacity investment costs for generation, transmission and distribution (as appropriate for each utility).

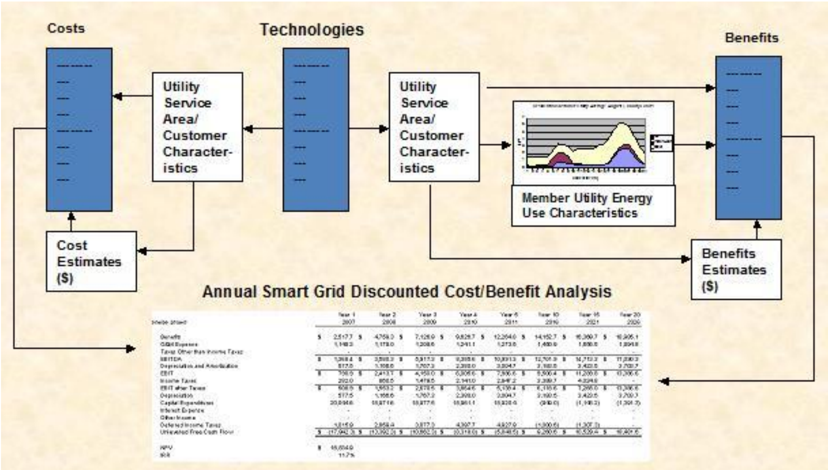
Based on present experience and collected from literature[15] a cost benefit model would entail the following variables:

- Cost/Benefit analysis of individual smart grid technologies and programs from the substation to behind-the-meter applications, including:
  - a. Advanced communications and metering
  - b. Distribution automation
  - c. Volt/VAR and conservation voltage regulation
  - d. Customer reliability valuations
  - e. Pricing programs
  - f. Direct load control
  - g. Programmable communicating thermostats and similar customer-facing technologies
  - h. Other demand response technologies and programs

[15] Smart Grid Business Case Analyses, http://www.smartgridresearchconsortium.org/smartgridbusinessmodels.htm

i. Impacts on utility management systems (OMS, DMS, etc.)

- Cost/benefit parameters, parameter ranges and guidelines to begin smart grid investment analysis at the utility
- Scenario, what-if, and other analysis features required to develop cost-effective smart grid investment strategies
  - In the graph below an example of modelling the costs and benefits associated with Smart Grid investments is shown.



4.2 Specific sources of funding for the KI

No specific information at this stage.

Smart Cities and Communities

Smart Cities Stakeholder Platform

...brings together people, industry and authorities from across Europe to make our cities more energy efficient, better to live in and growth-friendly.

...is about developing concrete innovative solutions for cities through tailored innovations.

...facilitates the exchange of knowledge and best solutions across smart cities in Europe.