SECTOR DIALOGUES

EUROPEAN UNION BRAZIL

REGULATION IN SMART GRIDS

BRAZIL - EUROPEAN UNION

2016

INSTITUIÇÕES RESPONSÁVEIS

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA, INOVAÇÕES E COMUNICAÇÕES (MCTIC)

Ministro
Gilberto Kassab

Secretário de Desenvolvimento Tecnológico e Inovação
Alvaro Toubes Prata

Coordenador-Geral de Tecnologias Setoriais
Eduardo Soriano Lousada

Coordenador Técnico do Documento
Dante Hollanda

Autor
Perito Sênior Externo
Nouredine Hadjsaid

CENTRO COMUM DE INVESTIGAÇÃO DA COMISSÃO EUROPEIA (JRC)

Diretor da Unidade de Segurança, Sistemas e Mercado Energéticos
Marcelo Masera

COORDENAÇÃO

DELEGAÇÃO DA UNIÃO EUROPEIA NO BRASIL

Embaixador Chefe
João Gomes Cravinho

Ministro Conselheiro - Chefe de Cooperação
Thierry Dudermel

Adido de Cooperação - Coordenador do Projeto Apoio aos Diálogos Setoriais UE-Brasil
Asier Santillan Luzuriaga

Consórcio executor
CESO Development Consultants/FIIAPP/INA/CEPS

MINISTÉRIO DO PLANEJAMENTO, DESENVOLVIMENTO E GESTÃO

Ministro
Dyogo Oliveira

Secretário de Gestão
Gleisson Cardoso Rubin

Diretor Nacional do Projeto
Marcelo Mendes Barbosa

CONTATOS

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA, INOVAÇÕES E COMUNICAÇÕES (MCTIC)
Secretaria de Desenvolvimento Tecnológico e Inovação
+55 61 2033-7800
setec@mcti.gov.br

DIREÇÃO NACIONAL DO PROJETO DIÁLOGOS SETORIAIS UNIÃO EUROPEIA-BRASIL
Secretaria de Gestão Pública
Ministério do Planejamento, Desenvolvimento e Gestão
+ 55 61 2020. 4645/4168/4785
dialogos.setoriais@planejamento.gov.br
www.dialogossetoriais.org

RESPONSIBLE INSTITUTIONS

MINISTRY OF SCIENCE, TECHNOLOGY, INNOVATIONS AND COMMUNICATIONS (MCTIC)

Minister
Gilberto Kassab

Secretary of Technological Development and Innovation
Alvaro Toubes Prata

General-Coordinator of Sectoral Technologies
Eduardo Soriano Lousada

Technical Coordinator of the Document
Dante Hollanda

AUTHOR
Senior External Expert
Nouredine Hadjsaid

JOINT RESEARCH CENTRE (JRC)

Head of Unit Energy Security, Systems and Market
Marcelo Masera

COORDINATION

EUROPEAN UNION DELEGATION TO BRAZIL

Head of the European Union Delegation
João Gomes Cravinho

Minister Counsellor - Head of Development and Cooperation Section
Thierry Dudermel

Cooperation Attaché – EU-Brazil Sector Dialogues Support Facility Coordinator
Asier Santillan Luzuriaga

Implementing consortium
CESO Development Consultants/FIIAPP/INA/CEPS

MINISTRY OF PLANNING, DEVELOPMENT AND MANAGEMENT

Minister
Dyogo Oliveira

Secretary of Management
Gleisson Cardoso Rubin

Project National Director
Marcelo Mendes Barbosa

CONTACTS

MINISTRY OF SCIENCE, TECHNOLOGY, INNOVATIONS AND COMMUNICATIONS (MCTIC)
Secretariat of Technological Development and Innovation
+55 61 2033-7800
setec@mcti.gov.br

PROJECT COORDINATION UNIT
EUROPEAN UNION-BRAZIL SECTOR DIALOGUES SUPPORT FACILITY
Secretariat of Public Management
Minister of Planning, Development and Management
+ 55 61 2020.4645/4168/4785
dialogos.setoriais@planejamento.gov.br
www.dialogossetoriais.org

INTRODUCTORY NOTE

The present document, written by Prof. Nouredine Hadjsaid, was an international challenge in the 8th Call for the Sector Dialogues Project. After several hours of work, the document built in three parts reveals a better understanding of the Regulation in Smart Grids in Europe and stimulates Brazilian actors to develop their activities in the theme.

Part I (Smart Grid oriented regulatory policies: a review in five EU leading countries) investigates five countries (UK, Italy, France, Germany and Denmark) on Smart Grids–oriented regulatory policies, since 2006, and respective information related to: i) distributed generation; ii) electric vehicles; iii) distribution automation; iv) smart metering systems; v) storage systems.

Part II (Smart Grid projects supported by Energy Regulators – Lessons learned and recommendations for future projects) identifies and describes the main projects supported by the regulatory energy regulators. The projects mapped cover the same topics mentioned in Part I: i) implementation obstacles and difficulties faced during the execution of the project; ii) identification of financial, social and political variables; iii) lessons learned during the execution of these projects and; iv) recommendations for the Brazilian Smart Grid Regulation.

Part III (Issues for the development of Smart Grid projects in European countries – From promotion to evaluation of projects) identifies and analyses specific issues for the Smart Grids, such as: i) managing and monitoring implementation plans; ii) incentives for demonstration projects; iii) cost-benefit analysis; iv) grid related performance indicators and; v) incentive schemes.

With this document, it is hoped the movement of others Brazilian governmental players, as well as entrepreneurial and academic actors. The publication stands as one of the pillars for accelerating public policies in Smart Grids.

INDEX

PART 1

PART II

PART III

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

AEEGSI	Autorità per l'energia elettrica e il gas ed il sistema idrico (Regulatory Authority for Electricity, Gas and Water)
ADEME	French Agency for Environment and Energy Management
ANM	Advanced Network Management
BAU	Business As Usual
BMWi	Federal Ministry of Economics and Technology
CAPEX	CAPital EXpenditure
CBA	Cost-Benefit Analysis
CEER	Council of European Energy Regulators
CFP	Call for proposal
CHP	Combined Heat and Power
CLNR	Customer-Led Network Revolution
CM	Capacity Market
CPS	Carbon Price Support
CRE	French Regulatory Commission of Energy
CSPE	Contribution au Service Public de l'Electricté
DCC	Data and Communication Company
DECC	Department of Energy & Climate Change
DERA	Danish Energy Regulator Authority
DG	Distributed Generation
DNO	Distribution Network Operator
DR	Demand Response
DSM	Demand Side Management
DSO	Distribution System Operator
DSR	Demand-Side Response
EC	European Commission
ECP	Engaged Customer Panel

EDSO4SG	European Sistribution System Operators for Smart Grids
EEC	Energy Efficiency Certificates
EHV	Extra High Voltage
EMR	Electricity Market Reform
ENTSO-E	European Network of Transmission System Operators for Electricity
EPSR	The Engineering and Physical Sciences Research Council
ER	Energy Regulators
ERGEG	European Regulators' Group for Electricity and Gas
ESCO	Energy Service COmpany
ESS	Energy Storage System
ETI	Energy Technologies Institute
EU	European Union
EV	Electric Vehicle
FITNESS	Future Intelligent Transmission Network SubStation
FITs	Feed-In Tariffs
GB	Great Britain
GUS	Grand Unified Scheme
HEVs	Hybrid Electrical Vehicles
HV	High-Voltage
I&C	Industrial & Commercial
ICT	Information and Communication Technologies
IFI	Innovation Funding Incentive
JRC	Joint Research Centre
KPI	Key Performance Indicators
LCL	Low Carbon London
LCN	Low Carbon Networks
LCNF	Low Carbon Network Fund

LCT	Low Carbon Technologies
LV	Low-Voltage
MV	Medium-Voltage
NCA	National Competition Authority
NGET	National Grid Electricity Transmission
NIA	Network Innovation Allowance
NIC	Network Innovation Competitions
NOP	Normally Open Point
NPV	Net present Value
NRA	National Regulatory Authority
NTC	Net Transfer Capacity
OFGEM	Office of Gas and Electricity Markets
OLEV	Office for Low Emission Vehicles
OPEX	OPerating EXpenditure
PHS	Pump Hydro Storage
PIPs	Plugged-in Places
PSO	Public Service Obligation
PV	PhotoVoltaic
R&D	Research and Development
RD&D	Research, Development and Demonstration
RES	Renewable Energy Sources
RHI	Renewable Heat Incentive
RIG	Reporting Instructions and Guidance
RIIO	Revenue=Incentives+ Innovation + Outputs
ROC	Renewables Obligations Certificates
ROI	Return of Investment

RTU	Remote Terminal Unit
SFCLs	Superconducting Fault Current Limiters
SG	Smart Grids
SLC	Standard License Condition
TOE	Tons of Oil Equivalent
ToU	Time-of-Use tariff
TSB	Technology Strategy Board
TSO	Transmission System Operator
TURPE	Tarrif d'Utilisation du Réseau Public d'Electricité
WACC	Weighted Average Cost of Capital

PART I

SMART GRID ORIENTED REGULATORY POLICIES: A REVIEW IN FIVE EU LEADING COUNTRIES

1 INTRODUCTION

The European Union (EU) has been a leader in sponsoring programs related to the reduction of humanity's carbon footprint (1). The best-known agenda is the 20/20/20 target for the year 2020. The goals of this agenda are: the growth of the energy supply from renewable sources up to 20% of total supply, reduction of energy consumption by 20% compared to 2020 forecasts and reduction of greenhouse emissions (GE) by 20%, in relation to levels in 1990 (2).

These targets, adopted by the EU member states, are being updated for more ambitious objectives in compliance with the energy transition process and bills of each member state. This can be illustrated by the French bill on energy transition setting an objective of reducing energy consumption by 50% at the horizon of 2050.

The electricity sector is a major user of primary energy and greenhouse gas emitter; therefore, it plays a key role in achieving the 20/20/20 agenda targets, which can be only reached by involving all the stakeholders in a wide sector range. For example, regulatory authorities have the crucial task of stimulating the development of new cost-effective and innovative solutions in order to create benefits for the whole community. Distribution system operators (DSO) and transmission system operators (TSO) should economically foster grid developments (while informing consumers that higher tariffs come from investments).

2 METHODOLOGY

This report provides a general overview on the regulatory policies oriented to the development of Smart Grids (SG). First, policies, initiatives, drivers and rules of stakeholders at EU level are described. Then, these topics are investigated in five EU markets: UK, Italy, France, Germany and Denmark. All these countries share the EU guidelines for the implementation of ever smarter grids. Nevertheless, thanks to different characteristics and dynamics in each grid as well as energy priorities of each member state, decisions and outcomes are various. The work is completed with specific conclusions per each part and finally with general conclusions.

2.1 MAIN AND SPECIFIC CHARACTERISTICS OF THE SELECTED EU COUNTRIES:

2.1.1 The case of UK: For UK, the regulator OFGEM (office of Gas and Electricity Markets) has a particular role with regards to the development of SG technologies. OFGEM has for example a key role in funding directly R&D programs and projects on SG (Figure 1). Renewable Energy Sources (RES) development is also highly encouraged and significant penetration of RES is achieved (mainly wind power generation).

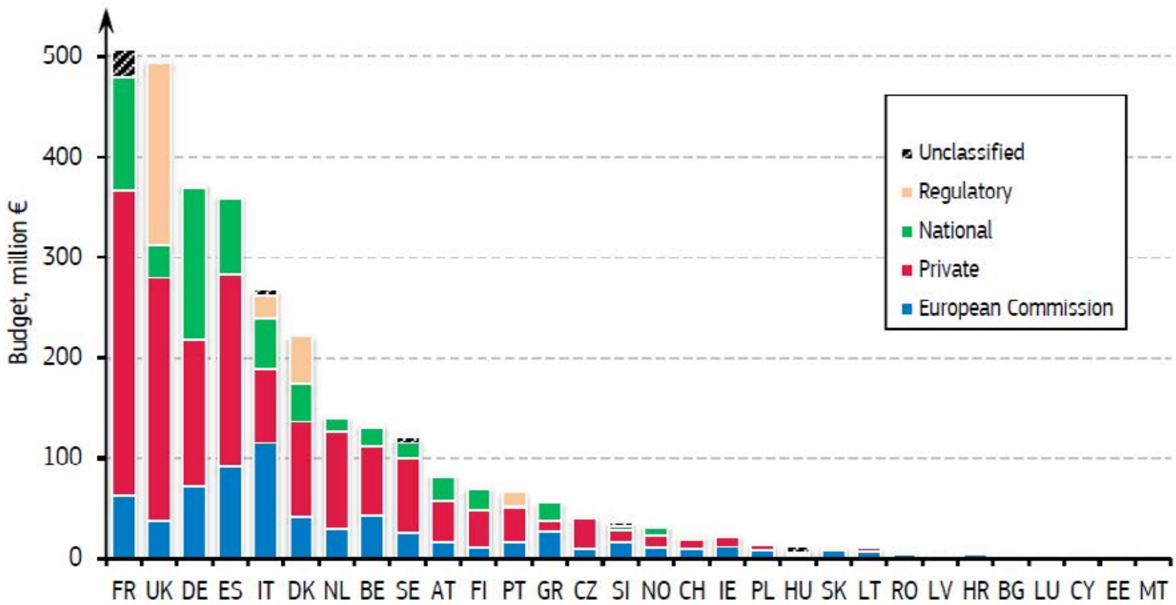


Fig. 1: Distribution of budget per funding source and country for the development of SG projects in EU countries (source JRC)

2.1.2 The case of Italy: Italy is the first EU country to initiate a massive roll out of smart meters (about 30 million customers) based on the framework of PLC towards a data concentrator at MV/LV substation and then GPRS transmission to a central hub. In addition, Italy has a significant development of RES, in particular wind and PV. In addition, Italy has also achieved successfully a remarkable progress in its quality of supply by implementing appropriate distribution grid automation in particular with respect to fault management techniques.

2.1.3 The case of France: France is characterized by an energy mix dominated by Nuclear energy (about 75%); the second energy source being hydro power. A significant amount of power can also be obtained from hydro pump storage (about 6 GW) and can be used for storage capabilities. In addition, France has initiated the largest massive roll out of smart meters with the Linky Meter (35 million customers with a budget of about € 5 billion). With regards to SG projects, France has dedicated the largest budget for SG projects (R&D, Demo and deployment) among the EU countries (Figure 2).

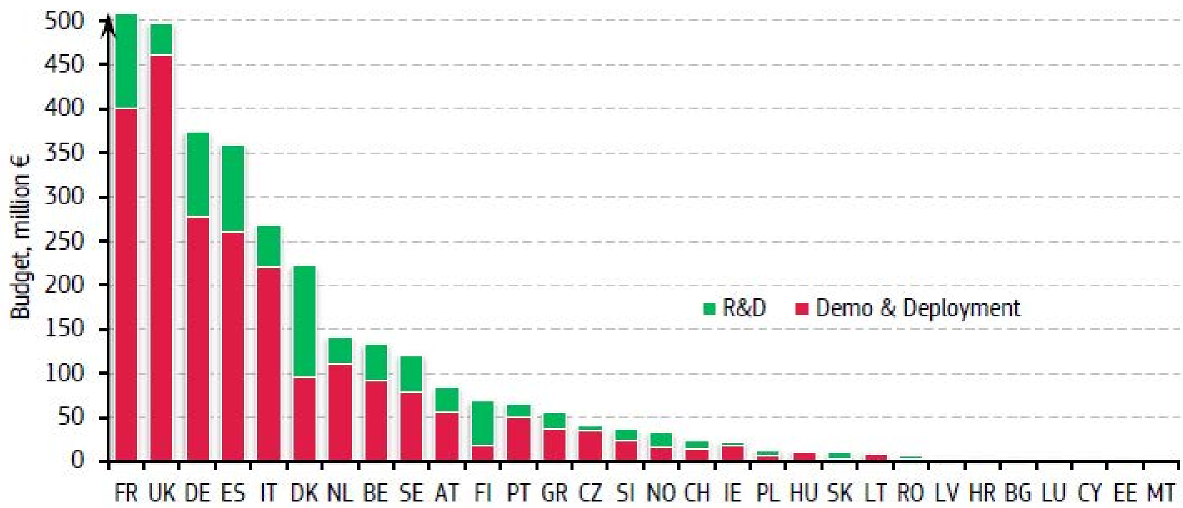


Fig. 2: Distribution of total budget per stage for the development of SG projects in EU countries (source JRC)

Similarly with regards to plug in electrical vehicles, France has set ambitious objectives for the 2030 horizon (about nine million). Other objectives in terms of energy consumption reduction and RES penetration rate are defined in the newly issued "Energy Transition Law".

With regards to R&D funding, the French energy regulator requires TSO/DSOs to dedicate a portion of the grid access fees to R&D investment.

2.1.4 The case of Germany: Germany has the largest installed capacity of wind and PV power generation in Europe. Germany has even the largest amount of PV with residential storage in the world. It is also the most advanced member state in terms of incentives for self-consumption of energy generated locally form RES. In addition, as a federal organized country, it has four main TSO and a special organization of the distribution grid in particular with regards to the special local energy management such as the case of *stadtwerke model*. The German Energiewende has defined the transition towards a more sustainable energy model from local to global perspective.

2.1.5 The case of Denmark: Denmark is the first EU country to develop at a large scale non-conventional RES based mainly on wind power generation supplemented with CHP (Combined Heat and Power). The process was launched as early as mid-90s. This RES development has led the country to exceed the 2020 EU target in terms the share of renewable energy sources in gross final energy consumption. With regards to SG projects development, Denmark has dedicated the largest investment per electricity consumption unit and per capita among EU counties (figures 3 and 4 below):

Fig. 3: Investment in SG projects across Europe divided to the electricity consumption (source JRC)

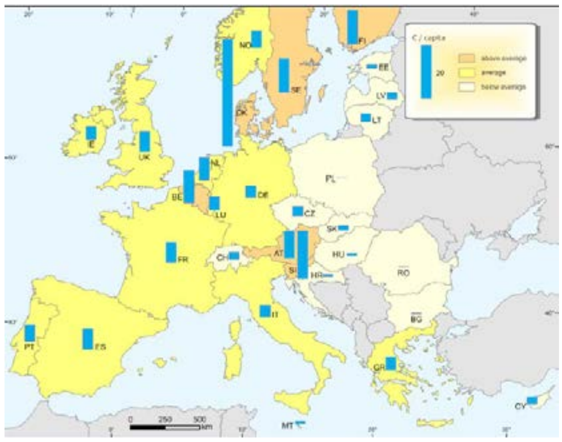


Fig. 4: Investment in SG projects across Europe per capita (source JRC)

The five selected countries will be considered in details in sections 5-9.

3. SMART GRID-ORIENTED REGULATORY POLICIES AT EU LEVEL

3.1 DEFINITION OF "SMART GRID"

What is a "Smart Grid"? This term is defined in many ways; nevertheless, the definition used in European Energy Regulators documents is the following:

"*A Smart Grid is an electricity network that can cost-efficiently integrate the behavior and actions of all users connected to it (generators, consumers and those that do both) in order to ensure economically efficient, sustainable power systems with low losses and high level of quality and security of supply and safety*" (3).

The Council of European Energy Regulators (CEER) is a not-for-profit association that is joined by Europe's national regulators of electricity and gas (4). The main goal of the CEER is to facilitate the creation of an EU energy market, in order to create benefits for the whole community. This association publishes periodically reports and reviews about topics related to SG, and based on the "*CEER Status review of regulatory approaches to smart electricity grids*" document; it is considered that the recent developments in SG do not affect the abovementioned definition (5).

3.2 EU POLICY DRIVERS FOR SMART GRIDS

EC defines energy policies by three basic types of EU legislation: regulations, directives and decisions. The EU commission defines them in this way: "A regulation is similar to a national law with the difference that it is applicable in all EU countries. Directives set out general rules to be transferred into national law by each country, as they deem appropriate. A decision only deals with a particular issue and specifically mentioned persons or organizations (6).

The most important regulations for the development of SG are: the "European Union's Third Energy Package", the "Regulation on Energy Market Integrity and Transparency", the "Energy Efficiency Directive" and the "Renewables Directive".

3.2.1 EUROPEAN UNION'S THIRD ENERGY PACKAGE

The "European Union's Third Energy Package" is a legislative package, composed by two Directives and three Regulations, for an internal electricity and gas market in the EU. Its purpose is to further open up the gas and electricity markets in the European Union. The package was proposed by the European Commission (EC) in September 2007 and entered into force on September 3rd 2009.

The "Third Energy Package" focuses on five main areas (6):

1. Unbundling energy suppliers from network operators: the separation of companies working in generation and sale operations from the transmission management is mandatory to ensure competition and avoid higher prices for consumers (7);

2. Independent regulators: the regulators must be independent from both industry interests and government. They can impose penalties to counteract abuses and they must collaborate with regulators from the others EU countries (8) (9);

3. Creation of the Agency for the Cooperation of Energy Regulators (ACER): it is an independent agency that works for the integration and the harmonization of regulatory frameworks in both gas and electricity EU markets (10);

4. Creation of the European Networks for Transmission System Operators (ENTSO-E) and the European Network for Transmission System Operators for Gas (ENTSO-G): their mission is to develop a cross-border cooperation between transmission system operators and promote investments in the interconnected European grids (11) (12);

5. Increase of transparency in retail markets to benefit consumers: for example, the right to choose or change suppliers without extra charges, a quick and cheap resolution of disputes and the receipt of information on energy bills (13).

3.2.2 OTHER REGULATIONS RELATED TO SMART GRID

Energy Efficiency Directive (2006/32/EC, Annex3) requires that EU countries use energy more efficiently at all stages of the energy chain from its production to its final consumption. As request by EU commission, EU countries transposed the Directive's provisions into their national laws before July 2014. With relation to SG, smart meters are identified as one of the main instruments that can be used to improve the overall energy efficiency. For example, they can facilitate tariff innovation, improve efficiency in end-uses and bring direct savings to the consumers. However, the actions required to achieve energy efficiency are many (14) and the only roll-out of smart meters is not sufficient to reach the proposed energy goals (15). For example, "Energy Efficiency Directive" drives:

- Energy distributors or retail energy sales companies to achieve 1.5% energy savings per year. EU countries can achieve these savings through other actions such as improving the efficiency of heating systems or increasing buildings insulation;

- The public sector in EU countries to choose energy efficient buildings, products and services every year;

- EU governments to improve the energy efficiency on at least 3% of their buildings every year;

- Large companies to make detailed energy audits to identify sources of losses and possible efficiency actions.

Finally, "Renewables Directive" (2009/28/EC, Art16) views SG as fundamental for the integration of increasing renewable energy sources into the grid and it requires the UE members to develop transmission and grid infrastructures for achieving this aim (16).

3.2.3 RELATED LEGISLATION

The most important related documents are the following:

- Common Rules for the Internal Market in Electricity Directive (2009/72/EC) (17);
- Common Rules for the Internal Market in Natural Gas Directive (2009/73/EC) (18);
- Regulation Establishing an Agency for the Cooperation of Energy Regulators (713/2009/EC) (19);
- Regulation on Conditions for Access to the Network for Cross-Border Exchanges in Electricity (714/2009/EC) (20);
- Regulation on Conditions for Access to the Natural Gas Transmission Networks (715/2009/EC) (21).

3.3 EU INITIATIVES FOR SMART GRIDS

An efficient interconnected European grid is possible only if the implementation of SG occurs in all EU countries. However, actually SG speed diffusion is different across member states. In order to ensure coordination, EC created a special task force to facilitate the sharing of information, best practices and lesson learned from projects and pilots. The steps for the achievement of this goal are:

- Funding for R&D;
- Development of equipment;
- Data collection and share from pilot projects;
- Implementation of new solutions.

3.3.1 FUNDING FOR R&D

In order to help R&D development, EU commission creates a research and innovation program "Horizon 2020" with a budget of € 80 billion (22). The target is to reduce the gap between research and market and it is divided in tree sections: Excellent Science, Industrial Leadership and tackling Societal Challenges. In the first section, there is a topic entitled "Secure, clean and efficient energy" (with a budget of about € 6 billion).

3.3.2 SYSTEM INNOVATION

The European Electricity Grid Initiative (EEGI) is a European Industrial Initiative under the Strategic Energy Technologies Plan (SET-PLAN). It created a 9-year European research, development and demonstration program to increase innovation. It also works to develop smart electricity networks of the future in EU. The program focuses mainly on system innovation (rather than on technology innovation) and wants to integrate new technologies in the real life and validate the results. EEGI's objectives are the base of the EEGI Roadmap 2010-18 and Implementation Plan 2010-12. It has been prepared by ENTSO-E and EDSO4SG in close collaboration with the EC, ERGEG and other important stakeholders. This Implementation Plan has been formally endorsed at the SET-PLAN conference in 2010 (23).

3.3.3 POLICY AND REGULATORY FRAMEWORKS

The Smart Grid Task Force (SGTF) was created in 2009 and it works to assisting the Commission on policy and regulatory frameworks for the implementation of SG under the Third Energy Package. This task force brings together different stakeholders and experts. The task force is divided in four groups focusing on: standardization, data protection, regulatory issues and infrastructures. They periodically investigate on main issues related to SG and publish reports through the EU commission website.

4 DEVELOPMENT OF SMART GRID IN EU COUNTRIES: A COMPARISON

EU shared guidelines for the implementation of SG, nevertheless each country preserves its independence regarding specific decisions and ways to pursue the objectives, due to different dynamics and local conditions. In next paragraphs, the five market chosen UK, Italy, France, Germany and Denmark, show various starting points, evolutions and results in function of the different policies.

In order to assess the progress of SG implementation, the adopted policies and results in EU, CEER developed a questionnaire for all the member states. With all these information, CEER published, during 2013, the document "A Status review of regulatory of smart metering" (24). Moreover, in year 2014, CEER updated the 2011 CEER Status Review of Regulatory Approaches to Smart Electricity Grids with an new overview of regulatory in 2013 (25).

4.1 STAKEHOLDER INVOLVEMENT

The results of the 2014 questionnaire (25) have shown that while the role of stakeholders in SG development varies widely from country to country, some broad trends can be identified.

In the majority of countries, the distribution system operator (DSO) plays a major role in SG development and they are always deeply involved in demand side management (DSM)[1]. Other important stakeholders are:

- Governments institutions including energy agencies and funding authorities;
- TSOs;
- Technology providers (in particular Energy and ICT; Information and Communication Technologies);
- National Regulatory Authority for Energy (NRAs);
- Energy Service Companies (ESCOs) providers and aggregators;
- Other small stakeholders such as local authorities, energy producers, universities, research institutes, external consultants and associations.

1. In the majority of countries, static time of use tariffs and load control through remote means are used to incentivize demand side response. In France, demand response operators will receive an additional payment that takes into account the benefits demand response has provided. In Italy, load control is currently limited to very large industrial customers through remote means.

4.2 INSTRUMENTS TO FACILITATE SMART GRIDS DEVELOPMENT

4.2.1 REGULATORY INSTRUMENTS

A large part of EU countries use tools for price regulation to facilitate SG development. The most common instruments are: performance indicators, tools to regulate information provision and finally charges and licensing (used to a lesser extent). In the majority of countries, these regulatory instruments will need to be adapted for SG development[2]. Opinions about the actual situation of investment incentives and performance indicators are different: many stakeholders consider them as instruments that should be adapted/updated for SG development. However, a large number of European NRAs (more than half) believe that the existing regulation already enables the deployment of SG.

4.2.2 INCENTIVES

In (25), CEER asked EU members to rank SG incentives in order of importance. The result of the interview was that the most important incentives concern the encouragement of network operators to choose investment options that offer the most cost-effective solutions. Then, in order of importance, there are incentives that encourage network operators to choose innovative solutions or encourage efficient use of electricity and renewable electricity. Other incentives work in order to activate participation in the development of SG by stakeholders, to encourage the introduction of new services and to encourage a more efficient network use.

2. In Great Britain, investment incentives will need to reflect the true value of demand side response to the system. In Italy, the “input-based” incentive regulation is already used in transmission grid and has been used for promoting pilot projects of SG at distribution level (23).

4.3 OBSTACLES TO SMART GRID DEPLOYMENT

4.3.1 THE USE AND ACCESS OF SMART METERS DATA FOR SMART GRIDS

Smart Grid developments and smart meters roll-out are linked; they cannot occur without the other one. However, EU governments are still working on sharing energy information and related privacy problem. In the majority of countries, consumers and suppliers have or will have access to consumption and pricing data, while in a smaller number of countries, consumers will also have access to power quality and technical data. NRAs will mostly have access to power quality and consumption data, but DSOs, and to some extent TSOs, will have access to power quality data, technical data and consumption data (not pricing data). Furthermore, ESCOs will also have access to consumption data in Germany and Great Britain. In France, ESCOs will have access to this data, but only if the customer gives their consent.

There was no clear consensus on whether the NRA will be involved in data security regulation for smart meter data. In France, data security will be the responsibility of a separate and dedicated agency in charge of data security. In Germany, this is the responsibility of the Federal Office for Information Security. In the UK, the NRA will approve data aggregation plans from the DSO, and data privacy requirements are covered under license conditions.

4.3.2 UNBUNDLING RULES

In France, the opinion of the Governments is that existing unbundling rules may obstruct or delay the progress of the deployment of SG equipment. In some cases, the economic results of SG developments projects are difficult to evaluate, as most of the costs are located at DSO level while benefits are spread all over the value chain. For this reason, French Regulatory Commission of Energy (CRE) is currently working on regulatory arrangements, which could facilitate SG development.

Great Britain is currently investigating on the effect of unbundling rules: the government's opinion is that there are situations where they could become harmful for SG development, for instance where storage is sponsored by the DSO for network reinforcement. This would separate consumer involvement in the SG and make it harder for customers to be involved.

4.3.3 REGULATORY AND COMMERCIAL BARRIERS

Several NRAs in EU countries (France, Great Britain and Italy included) identified a number of different actual barriers to SG implementation. Examples of these barriers relate to the following areas:

- High expected immediate investment for long terms ROI;
- Limited network development funds;
- Uncertainty around the direction of planned national action plans including the evolution of energy regulation;
- Restrictive data protection laws;
- The lack of clear responsibilities for the role of stakeholders;
- Technologies maturity and risk;
- Need of more work in Standardization;
- Customer involvement.

4.4 PLANS FOR THE IMPLEMENTATION OF SMART GRIDS

The EC's SGTF (26) called for and recommended greater commitment by European countries towards establishing/implementing national models for the deployment of SG. EU Member States are invited to define national models and/or platforms, ensuring in particular the dissemination, and exchange of experiences and lessons learned. Currently France, Italy and Denmark have already published their national implementation plans (27) (28) (29). In Great Britain, although an implementation plan has not been created, a high-level roadmap has been developed (30). Many countries did not publish any implementation plan.

4.4.1 TIMEFRAME OF THE IMPLEMENTATION PLAN

There is no clear consensus with regards to the timeframe for the implementation of SG in EU countries, but generally, the objective is to improve SG in the next 10 years. For example, the French implementation plan is set over a period of 10 years, while, there are two roadmaps in Great Britain, an integrated roadmap out to 2020 and a high-level roadmap out to 2050.

4.4.2 MONITORING OF IMPLEMENTATION PLANS AND PROJECTS

About monitoring of progress in SG projects, in EU countries, NRAs are generally responsible for monitoring implementation plans and sometime responsibility is shared between the NRA and other stakeholders.

In France, projects are monitored through project steering committees. CRE plans to define indicators with DSOs and TSOs. In Germany, as part of the process for selecting which projects are funded, companies' approaches on progress reporting and disseminating learning are evaluated. High quality learning dissemination activities that either build on best practice from other demonstration projects or incorporate innovative approaches are expected.

In Great Britain, all companies running projects must produce progress reports every six months. These reports must include the progress they have made against their project plan and the learning that the project has delivered in the previous six months. The company must also explain the activities that it has undertaken to disseminate the learning. In Italy, for projects approved by NRA, a work progress report has to be sent by the involved DSOs to the NRA every six months. Thereafter, monitoring is through ad-hoc meetings and result dissemination.

4.5 EVALUATION OF PLANS IMPLEMENTATION: PERFORMANCE INDICATORS

In the "2010 Smart Grids Conclusions Paper" (3), European energy regulators identified a list of performance indicators to evaluate grid performance. These indicators can be also used to quantify the "smartness" of a network and related benefits. Furthermore, the recent EC Communication on Smart Grid (31) states that "regulatory incentives should encourage a network operator to earn revenue in ways that are not linked to additional sales, but are rather based on efficiency gains and lower peak investment needs, i.e. moving from a 'volume-based' business model to a quality (and efficiency) based model".

Table 1 below summarizes the list of SG indicators, which are currently in use in EU countries (with a special focus on the five selected countries). In the following paragraphs, the most important indicators are described with further details (25).

Table 1: Performance indicators for SG analysis in the selected EU countries

	Performance indicators	Used for monitoring	Used as revenue driver
	Increased sustainability		
1	Quantified reduction of carbon emissions	*	GB
2	Environmental impact of electrical grid infrastructure	GB, IT, *	GB
	Adequate capacity of transmission and distribution grids for “collecting” and bringing electricity to consumers		
3	Hosting capacity for distributed energy resources in distribution grids	DE, *	IT, *
4	Allowable maximum injection of power without congestion risks in transmission networks	IT, DE, *	
5	Energy not withdrawn from renewable sources due to congestion and/or security risks	DE, *	GB, *
	Adequate grid connection and access for all kind of grid users		
6	First connection charges for generators, consumers and those that do both	*	DE, *
7	Grid tariffs for generators, consumers and those that do both	DE, *	DE
8	Methods adopted to calculate charges and tariffs	*	*
9	Time to connect a new user	GB, *	*
	Satisfactory levels of security and quality of supply		
10	Ratio of reliably available generation capacity and peak supply	GB, IT, *	
11	Share of electrical energy produced by renewable sources	GB, IT, *	
12	Measured satisfaction of grid users for the “grid” services they receive	*	GB
13	Power system stability performance	*	
14	Duration and frequency of interruptions per customer	DE, *	GB, IT, *
15	Voltage quality performance of electricity grids	IT, *	*
	Enhanced efficiency and better service in electricity supply and grid operation		
16	Level of losses in transmission and in distribution networks (absolute or percentage)	DE, IT, *	IT, *
17	Ratio between minimum and maximum electricity demand within a defined time period	*	
18	Percentage utilization (i.e. average loading) of electricity grid elements	GB, *	

19	Availability of network components (related to planned and unplanned maintenance) and its impact on network performances	GB, *	*
20	Actual availability of network capacity with respect to its standard value	GB, *	*
	Effective support of trans-national electricity markets		
21	Ratio between interconnection capacity of one country/region and its electricity demand	*	
22	Exploitation of interconnection capacity	*	
23	Congestion rents across interconnectors	*	*
	Coordinated grid development through common European, regional and local grid planning to optimize transmission grid infrastructure		
24	Impact of congestion on outcomes and prices of national/regional markets	GB, *	
25	Societal benefit/cost ratio of a proposed infrastructure investment	GB, *	*
26	Overall welfare increase (i.e. always running the cheapest generators to supply the actual demand)	*	
27	Time for licensing/authorization of a new electricity transmission infrastructure	*	
28	Time for construction of new electricity transmission infrastructure	*	
	Enhanced consumer awareness and participation in the market by new players		
29	Demand side participation in electricity markets and in energy efficiency measures	IT, *	
30	Percentage of consumers on time-of-use/critical peak/real-time dynamic pricing	*	
31	Measured modifications of electricity consumption patterns after new pricing schemes	*	
32	Percentage of users available to behave as interruptible load	*	*
33	Percentage of load demand participating in market-like schemes for demand flexibility	IT	
34	Percentage participation of users connected to lower voltage levels to ancillary services	*	*

*Other EU countries

4.5.1 HOSTING CAPACITY FOR DISTRIBUTED ENERGY RESOURCES IN DISTRIBUTION GRIDS

Hosting capacity is defined as "the amount of electricity production that can be connected to the distribution network without endangering the voltage quality and reliability for other grid users" (25). To calculate this parameter, performance requirements for voltage quality and reliability must be respected. The hosting capacity calculation depends on the type of electricity production. Therefore, wrong calculation of definition of the index could result in new technology increasing the actual hosting capacity, but not the index. The hosting capacity indicator, when used as a revenue driver, must not incentivize the network operator to excessive unnecessary investments in the grid and should increase the use of cost-effective technologies. This indicator is used in Italy (and in Norway) as a revenue driver and used for monitoring in Denmark (and in Austria, Belgium, Finland, Norway, Portugal, Slovenia, Spain and Netherlands).

4.5.2 ALLOWABLE MAXIMUM INJECTION OF POWER WITHOUT CONGESTION RISKS IN TRANSMISSION NETWORKS

The calculation of the allowable maximum injection of power (without congestion risks in transmission networks) gives the same information of the "hosting capacity", but it works for the transmission system. It can also be seen as "the net transfer capacity from a (hypothetical) production unit to the rest of the grid" (25). The condition "without congestion risks" should be interpreted as respecting requirements for operational security.

This indicator can be calculated on an hourly basis, considering the actual availability of network components and the actual power flows through the network. The result is an indicator changing with time. It can also be calculated as a fixed value, if pre-defined worst-case power flows and a pre-defined outage level is supposed. The resulting value would give the largest size of production unit that can be connected without risking power curtailment.

As well as with the previous factor, if this indicator will be used as a revenue driver, the incentive mechanism should not result in excessive unnecessary investments and the method for calculating the index should not favor one technology above another.

This indicator is used for monitoring purposes in Germany and Italy (and Belgium, Lithuania, Portugal, Slovenia, Spain and Netherlands), but no country uses this indicator as a revenue driver.

4.5.3 ENERGY NOT WITHDRAWN FROM RENEWABLE SOURCES DUE TO CONGESTION AND/OR SECURITY RISKS

The indicator, which quantifies the ability of the network to host renewable electricity production, without congestion and/or security risks, is similar to indicators such as hosting capacity and allowable maximum injection of power. However, while the other two indicators only quantify the actual limits of the network, the "energy not withdrawn" quantifies how much the limits are exceeded. The value of this index cannot be easily determined in advance and there are many assumptions. The calculation is rather similar to the calculation of energy not delivered, an indicator that is commonly used for continuity of supply. The main assumption to be made is the energy that would have been produced during curtailment or disconnection of the production unit.

An advantage of using the actual energy not withdrawn as an indicator, especially when used as a revenue driver, is that there is no risk of the network operator investing heavily in a network to be prepared for production capacity that never arrives. The disadvantage is that this indicator will give less incentive to invest before the massive arrival of new renewable electricity. This could result in the network not ready for a sudden increase in the amount of renewable electricity production.

This indicator is used in Germany and Italy (and Belgium, Finland, Portugal, Spain, Netherlands) for monitoring and in Great Britain as a revenue driver.

4.5.4 MEASURED SATISFACTION OF GRID USERS FOR THE GRID SERVICES THEY RECEIVE

This indicator would in principle be the ultimate indicator; after all, the grid is there for its users. However, it is not straightforward to quantify satisfaction of grid users in an objective way. Some of the customer-quality indicators presented in the CEER Benchmarking Reports on quality of electricity supply (9) are strongly related to this issue.

This indicator is used in Great Britain as a revenue driver and in four other EU countries (Finland, Portugal, Slovenia and Netherlands) for monitoring purposes.

4.5.5 LEVEL OF LOSSES IN TRANSMISSION AND DISTRIBUTION NETWORKS

The transport of electrical energy through the distribution or transmission network is associated with a certain amount of losses. Therefore, the amount of energy being produced has to be a few percentage points higher than consumption levels. When the large part of electricity production is based on fossil fuel (the most common situation in EU), the losses result in additional carbon-dioxide emissions. The impact of renewable generation can decrease or increase losses (it depends on localization and time profile of renewable generation).

The costs associated with the losses occurring during the transport of power through a network are in principle recovered by the network operator through tariffs. When the losses are fully recovered through the tariffs, this removes any economic incentive for the network operator to reduce the losses. Putting a maximum amount on the costs associated with losses that can be recovered from the tariffs will create an incentive to prevent high losses. A fixed compensation for losses per network operator per year gives a direct incentive to reduce losses. However, losses are not fully controllable by the network operator and can put it at risk. There is a significant amount of experience in the use of this indicator, because losses in the distribution and transmission networks are calculated and observed in a lot of countries. However, the indicator is calculated in different ways in different countries.[3]

This indicator is used in Great Britain and Italy (and Austria, Lithuania, Norway, Poland, Portugal, Slovenia and Spain) as a revenue driver and in Germany, France and Italy (and Belgium, Finland, Lithuania, Norway, Slovenia, Spain and Netherlands) for monitoring. This indicator can be determined for both distribution and transmission networks.

4.5.6 ACTUAL AVAILABILITY OF NETWORK CAPACITY WITH RESPECT TO ITS STANDARD VALUE

"Actual availability of network capacity" is a factor that evaluates the availability of network capacity compared to a reference value at national or local level. It can also refer to the availability of network capacity in particular lines or network cross-sections compared to their normal capacity. The calculation of network capacity is not trivial and several variables need to be considered (e.g. thermal capacity of network elements, the need for operating reserve and stability reasons and permissible voltage variations).

This type of indicator is monitored in Great Britain (and Austria, Finland, Lithuania, Norway and Spain) and in one country (Spain) as a revenue driver.

4.5.7 RATIO BETWEEN INTERCONNECTION CAPACITY OF ONE COUNTRY/REGION AND ITS ELECTRICITY DEMAND

The limited capacity of international interconnections between EU countries is a barrier to have a real international grid and market. The calculation is the same for capacity indicators and suffers from the same limitations (e.g. operational security rules have to be considered).

This indicator is used in five countries (Austria, Norway Slovenia, Spain and Netherlands) for monitoring and it is not used as a revenue driver.

4.5.8 EXPLOITATION OF INTERCONNECTION CAPACITY

The "exploitation of interconnection capacity" factor is related to maximization of capacity according to the regulation on electricity cross-border exchanges and the congestion management guidelines. The basic elements of the indicators are currently monitored by the each country's TSO and reported by ENTSO-E on a European level in their statistical yearbooks.

This indicator is used in some EU countries (Austria, Finland, Norway, Portugal, Slovenia, Spain, the Netherlands) for monitoring purposes, but it is not used as a revenue driver.

3. The different procedures (used in different countries) for calculation of losses can change the results and make them not comparable. There are often differences in network structure, like typical length of lines and cables, and network components, which may make comparison between countries and even between network operators in the same country difficult. More details on methods in use for calculating losses and related results are available in (62) and (63).

4.6 SMART METERS ROLL-OUT IN EU COUNTRIES

The "European Union's Third Energy Package" promote the roll-out of smart meters in order to increase energy efficiency, demand-side management measures and secondly to develop the active participation of customers in the market (6).

4.6.1 PROGRESS OF SMART METERING DEPLOYMENT

Italy has completed a metering roll-out in the electricity market and is rolling-out in the gas market. In Denmark, distribution companies have rolled out smart meters up to 60% of total consumers and it is expected that they will rapidly reach totality total deployment. France and UK have made a formal decision and the diffusion of smart meters is in progress for both electricity and gas. In almost all cases in which there is a formal decision or a plan, the target for the roll-out is to reach at least the 95% of the national consumers. Only in Germany, the planned target is 15%, with selective roll-out by 2020 (e.g. large customers and new buildings).

4.6.2 FUNCTIONALITY OF SMART METERS & PROMOTION OF TIME OF USE TARIFFS

Table 2 shows the functionalities of smart meters in the five analyzed countries (year 2013). In Denmark and Germany, all the most common functionalities are available for smart meters for electricity; on the contrary, they are not present in smart meters for gas market. Full functionalities are performed by smart meters in UK and almost all in Italy and France. In particular, in Italy, smart meters cannot provide home automation for electricity, and in France, remote management is not possible for gas.

Table 2: Functionality of smart meters in UE countries

	Remote reading		Two-way communication		Interval metering		Remote management		Home automation		Web portal	
	Elec	Gas	Elec	Gas	Elec	Gas	Elec	Gas	Elec	Gas	Elec	Gas
DK	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
FR	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
DE	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N
GB	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
IT	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y

All the five analyzed countries, French excluded, have regulation allowing or promoting time of use electricity, but no one promote similar arrangements for gas consumption. UK and Italy are currently working to increase more the tariff complexity (32) (33).

5 SMART GRID-ORIENTED REGULATORY POLICIES IN UK

In UK, nuclear and coal power plant, near the end of their operational life, are currently operating (corresponding to a quarter of the total installed capacity) and need to be replaced. On the other hand, volatile and unpredictable energy production from renewable sources (mainly wind) is increasing rapidly. Old UK energy policies were no longer suitable in this new situation; therefore UK Government is working to change the operation and regulation of the grid in order to face the new environmental and security supply issues. UK Government is also heavily investing in infrastructures, R&D and pilot projects.

5.1 DISTRIBUTED GENERATION

The main mechanisms in UK to support the growth of Renewable Energy Sources (RES) are based on Renewables Obligations Certificates (ROCs) for large electric RES (34), Feed-In Tariffs (FITs) for small e-RES (35), and Renewable Heat Incentives (RHIs).

5.1.1 RENEWABLES OBLIGATIONS CERTIFICATES

ROCs are at the base of a quota mechanism, which creates demand for production from RES amongst supply companies. They must increase proportion of the electricity they supply from renewable sources to avoid paying a penalty (36). Operators can trade ROCs with other parties and these certify are used by suppliers to demonstrate that they have met their obligation.

5.1.2 FEED IN TARIFFS

FITs promote the uptake of small-scale renewable and low-carbon electricity generation technologies (plants under 5 MW). The FIT scheme policy is set by the government and the UK Office of Gas and Electricity Markets (OFGEM) is responsible for administration aspects (37). This incentive scheme uses tariff rates that fluctuate with inflation and, after entry into force in year 2010, suffered numerous changes to take into account the falling prices for installation of RES systems (38).

5.1.3 RENEWABLE HEAT INCENTIVE

The Renewable Heat Incentive (RHI) is an incentive to increase the uptake of heat production from renewables (e.g. biomass, waste Combined Heat and Power (CHP) and heat pumps). It provides money differently for domestic and non-domestic users (39) (40). This incentive stimulated growth in the deployment of renewable heat, with around 16.4 TWh of energy generated from all renewable heat sources in 2012 (7% more than 2011).[4]

4. In the document "Smart Grid vision and Roadmap" (30), from UK

5.1.4 CARBON PRICE SUPPORT

Another policy that can work for the diffusion of RES is the Carbon Price Support (CPS) rate. This tax must be paid in function of the quantity of CO_2 emitted by fossil fuels and biofuels used in electricity generation. The CPS was announced in the 2011 budget and the intention was that it will start around 15.70 £/t_{CO2} on its introduction in 2013 and rise constantly to 30 £/t_{CO2} by 2020, then continue rising to 70 £/t_{CO2} in 2030. Nevertheless, in 2015 the carbon price floor is capped at 15.70 £/t_{CO2} from 2016-17 to 2019-20. This will have the effect of freezing the CPS rates for each of the individual taxable commodities across this period at around 2015-16 levels (41).

5.1.5 RESULTS OF THE POLICIES

The results of the policies to support the growth of electric RES are the followings[5]: RES reached 47.5 TWh in June 2013, increasing by 24% compared to the same period the year before. The generation share of electricity was at 15.5% in the same year.

The UK has the world's biggest offshore capacity than in any other country in the word. Offshore and onshore wind plants increased by 2.6 GW in 2013, bringing the total installed capacity to 10.5 GW in June 2013. Generation rose to 14.2 TWh for the year 2013, increasing by 2.8 TWh on the year before. The Government's forecast models for deployment for renewable technologies presented in the "Delivery Plan for EMR-*Electricity Market Reform*" set the potential installed capacity of offshore wind: up to 16 GW by 2020, and 39 GW by 2030. Moreover, in order to deal with the increased capacity of offshore wind power plants, concentrated in the Scottish Territorial Waters, transmission capacity to offshore plants was increased by 30% during 2013 (42).[6]

5.2 DISTRIBUTION AUTOMATION

The DNOs operating in Great Britain are six private companies that control fourteen distribution networks. They are limited in the way they can achieve revenues, even if the legislation related to these limitations is currently under review. The Electricity and Gas Markets Regulator (OFGEM) works in order to encourage DNOs to develop new technologies, without preferences on the typology. It facilitates the market system to bring innovation, supervises the development of the grids and protects the consumers (37).

Department of Energy and Climate Change, the diffusion of heat pumps will be huge with a total number varying between 1 and 7.5 million by 2030. The future shift to electrical grid will change the traditional season load profiles (due to heating) and increase dramatically the peaks (due to cooling, which previously was not used by domestic users). Therefore, SG, storage systems and new management techniques will be mandatory to meet the new peaks and load profiles (46).

5. FITs and other similar incentives can turn simple consumers in millions of "prosumers" (producers & consumers), creating an high quantity of incontrollable and unpredictable generation that can challenges for the grid and it will make necessary new management solutions from distribution right down to micro-grid level (45).

6. The Department of Energy and Climate Change's (DECC), since entry into force of the incentives, had expected that the great part of the new electric RES capacity will come from offshore and onshore wind and biomass (50).

5.2.1 RIIO: REVENUE = INCENTIVES + INNOVATION + OUTPUTS

Every five year a distribution price control review is published (the last runs from 2010 to 2015). The current price control review is called "RIIO" (Revenue = Incentives + Innovation + Outputs model) (44) and replace the previous one, called "RPI-X" (45). RIIO-edition1 covers an eight-year period from April 1st 2015 to March 31st 2023.

OFGEM reports that RIIO is: "*designed to encourage network companies to: put stakeholders at the heart of their decision-making process, invest efficiently to ensure continued safe and reliable services, innovate to reduce network costs for current and future consumers, play a full role in delivering a low carbon economy and wider environmental objectives*".[7]

In simple terms, RIIO is based on broad-scale performance incentives with revenue caps: the expenditure allowed for the network is defined and according to that, the possible income for the DNO can be calculated. Furthermore, DNOs have to reach performance goals, otherwise they are penalized. After the achievement of these obligations, they can operate to maximize their monetary gain[8].

7. However, the work in (54), on policies and regulation for SG in the UK, shows that, actual regulation incentives short-term investments in innovation, with small incremental changes, while long term benefits (achievable thanks to SG, new management techniques and two-way system power flow) were not encouraged. For this reason, it is necessary a continuous updating of methodologies.

8. The RIIO model is complex; for more details, OFGEM provides a useful guide to better understand the calculations (48).

5.2.2 CAPACITY MARKET

In the past, the energy market had an "energy-only" design and it did not care about the volatile and unpredictable generation from renewable sources. Therefore, the UK Government reforming process of the grid includes the creation of a "Capacity Market" (CM) to ensure security of electricity supply by providing a payment for reliable sources of capacity. This should encourage investment to replace older power stations and provide backup for more intermittent and inflexible low carbon generation sources (46).

5.2.3 FUNDS FOR RESEARCH AND DEVELOPMENT

From the point of view of funds in R&D, the Technology Strategy Board (TSB), now called "Innovate UK" (47), an executive non-departmental public body sponsored by the Department for Business, Innovation & Skills, is active in this field. It recently accepted proposals for its new Smart Power Distribution and Demand program, which will provide £ 2.4 million for feasibility studies related to automated power distribution and demand management. TSB also maps and coordinates research in this area.

5.3 ELECTRIC VEHICLES

The Office for Low Emission Vehicles (OLEV) is an UK interdepartmental organization (it works with the Department for Transport, the Department for Business, the Innovation & Skills and the Department of Energy & Climate Change) (43). From year 2011, it combines policy and funds streams to simplify policy development and delivery for ultra-low emission vehicles in eight Plugged-in Places (PIPs) projects. In order to explore the effectiveness of different technologies, locations and strategies, all the projects were organized to take different approaches to setting up plug-in vehicle charging schemes. During the first three years of the projects, £ 340 million of funding for infrastructure investment were spent and recently the UK Government announced a further £ 500 million from 2015 to 2021 to support the UK ultra-low emission vehicle industry.[9]

The UK Government also helps the diffusion of electric vehicles by grants for cars and vans. Grants are available for 35% off the cost of a car, up to a maximum of £ 5,000, and 20% of the cost of a van, up to a maximum of £ 8,000. OLEV published grant eligibility guidance in order to ensure that vehicles meet an agreed level of safety and performance.[10] There are also regional policies offering benefits to low carbon vehicles such as free parking.[11]

9. One of the aims of OLEV is to share the results obtained, and all the information related to PIPs projects are available in (49).
10. Safety and performance criteria are available in (43).
11. Starting from EV uptake estimations from UK government (the number of EV in the UK by 2020 could increase from 100,000 up to 1.5 million), many scenarios, that predict the electrification of transport, are performed in (44). The authors, using deterministic and probabilistic approaches, described the challenges for the grid in year 2030 in case of low, medium and high EV uptake levels. The results of the simulations show that a low EV uptake level may be safely integrated with regards to network constraints, by upgrading the underground cables and the distribution transformers. Otherwise, it was found that to safely integrate a high EV diffusion in distribution networks, EV battery management, high penetration of embedded generation and network reinforcements are necessary.

5.4 STORAGE SYSTEMS

The main energy storage R&D efforts in the UK are focused on reducing costs of the electricity storage technologies most suited to providing flexible local energy storage to electricity distribution networks. These technologies include battery systems (mainly lithium batteries), super-capacitors, flywheels, compressed air systems and thermal-to-electric systems.

The UK Government is supporting storage through demonstrations and policies. The UK Minister of State (Michael Fallon) said in June 2014:

"*DECC also regards storage, along with demand side response (DSR), as essential for a better functioning electricity market and both play an important role in ensuring security of supply. The Government is implementing measures to establish broader and more flexible DSR and Storage sectors as part of the Electricity Market Reform program. Specifically, DECC will run two Capacity Market transitional auctions in 2015 and 2016, ahead of the Capacity Market's first full delivery year in 2018/19. These 'transitional arrangements' will help grow the demand side and sub-50MW storage industries and ensure effective competition between traditional power plants and new forms of capacity, driving down future costs for consumers*" (48).

OFGEM, The Engineering and Physical Sciences Research Council (EPSRC), Energy Technologies Institute (ETI), Department of Energy and Climate Change (DECC) and other UK organizations support storage development with multi-year budgets generally up to tens of million pounds (in same cases also up to hundreds of millions) (49) (50):

- EPSRC has invested £ 30 million in five projects to accelerate the development of national scale electricity storage. In year 2014, EPSRC, within the Research Councils UK Energy Program (RCUK), announced £ 4 million fund for collaboration between academics and industry (51);

- ETI supported many projects and companies, within the "Energy Storage and Distribution Program", including project of £ 14 million investment to build a 1.5 MW storage system at a Western Power Distribution substation;

- OFGEM established the Low Carbon Networks (LCN) fund as part of the electricity distribution price control that runs until March 31st 2015. Overall, the LCN fund allows up to £ 500 million supporting projects sponsored by DSOs to try out new technologies. Up to £ 100 million are reserved to projects that demonstrate the possible developments of storage technologies (52).

DECC supports innovation programs for all energy R&D fields up to £ 200 million found for the period 2011/12 to 2014/15. For energy storage, it includes (50):

- £ 3 million for Component Research and Feasibility Study Scheme (redox batteries, fuel cells, hydrogen safety, small scale batteries and novel pumped storage);

- £ 17 million for Technology Demonstration Competition (compressed air storage, thermal storage, redox batteries, back up resilient power for local wind and solar sources, flywheel);

- £ 3 million for heat storage;

- £ 10 million for Energy Entrepreneurs Fund (fuel cells, heat storage, super capacitors, flywheels, batteries) (50).

Energy storage in transport is not directly supported, but there are policies to support lower carbon vehicles (5.3).

5.5 SMART METERS ROLL-OUT

As mentioned in paragraph 4.4, UK policies for the replacement of gas and electricity meters with smart devices are concrete. UK intends to complete the installation in year 2019. Thanks to multiple benefits offered by smart meters, UK Government estimates, for domestic users, using gas and electricity: saving £ 26 per year by 2020, with the reduction rising to £ 43 per year by 2030 in comparison to a situation without smart meters.

The rules of the stakeholder involved in the smart meters roll-out are the followings:

- Gas and electricity suppliers plan, deliver and install smart meters. They must meet the Government's overall timescale and targets[12];

- DECC manage the implementation of the program and monitor its progress;

- OFGEM protects consumers' interests during the installation phase and beyond;

- DCC provide communication between central hub and the all the smart meters.

12. Roll-out plans are different and depend on factors such as the location of their main customer base.

Data and Communication Company (DCC) is a private limited company that received from DECC a license in 2013 to "*establish and manage the data and communications network to connect smart meters to the business systems of energy suppliers, network operators and other authorized service users of the network*" (53).

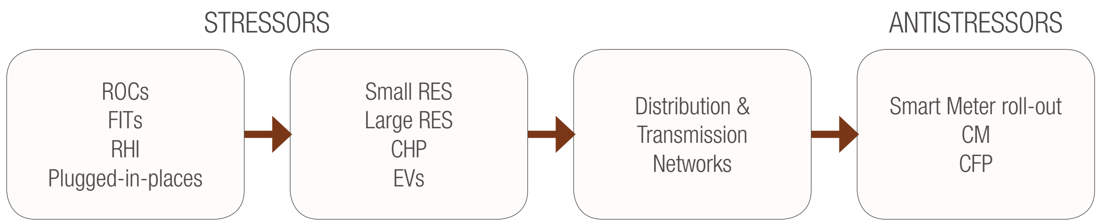
DCC also works in the management of data that will pass to the different stakeholders. The data processing is an important issue for all the stakeholders. For example, consumer right groups want to defend privacy, while DNOs highlighted that a correct management of the grid is easier with high quality information of consumption[13].

5.6 REMARKS ON THE UK

UK energy market is highly liberalized, competitive and with many operators. Generally, private stakeholders try to reach their maximum economic gain and for this reason, the whole systems suffered a decline in innovation and the past situation discouraged the creation of SG. Government is actually working in two directions to change the market and support the development of SG: first, it is using its flexible regulation mechanism to create obligations and incentives, and second it is making large investments in R&D and pilot projects[14].

Figure 5 shows how major policy instruments work to stimulate development of SG in UK. Incentives are used to stress the market to invest in different sizes and kind of projects (e.g. ROCs, FITs and plugged-in-places help the diffusion of RES CHP and EVs)[15]. On the other hand, Governments also created innovation instruments (e.g. Smart Meter roll-out, CM and CFP) that can be used to fight the market stressors (54).

Fig. 5: Major policy instruments to stimulate development of SG in UK.



13. In UK, the privacy preservation is fundamental. The Government works to create rules for a system where non-essential information for the network management (e.g. payment history of consumers) is private. UK had already in place the "Data Protection Act 1988", which sets out guidance for the treatment of consumers data. From 2010, with the collaboration of all the stakeholders, it is improving and updating a guideline to perform data collection that is secure, allow correct analysis and permit improvements in grid management (42).
14. The European JRC (43) ranked UK as a leader in funding R&D projects for SG through the regulator.
15. UK Government and OFGEM launched the "Smart markets work program" in which the market developments are studied to encourage the participation of small layers (54).

Parallel work is done with huge investments in R&D and pilot projects. Due to change of traditional production and load profiles, e.g. due to an ever higher penetration of volatile RES and heat pumps, it is not possible to map-out the evolution of the network. For this reason, UK Government considers fundamental the information from pilot project to roll-out new technologies, solutions and also regulation and tools to improve the grid expansion.

6 SMART GRID-ORIENTED REGULATORY POLICIES IN ITALY

The Italian energy system, before market liberalization in 1999, was completely controlled by Government; production, import, transmission, distribution and sale systems were propriety of the national company "ENEL" (55). In 1999, Decree No. 79/99 unbundled various subsystems of the national electricity system: the generation and import activities become part of a free market, in which everyone can produce and import energy. In order to create a real free market with more operators, the monopoly of ENEL has been eliminated through selling some power plants. As for the electricity distribution sector, *Enel Distribuzione* (55) is the largest operator, with 86% of the total volume, followed by *A2A Reti Elettriche* (4%), *Acea Distribuzione* (3%) and *Aem Torino Distribuzione* (1%). The other operators have only marginal quotas (56).

In 2010, the electricity demand in Italy was above 300 TWh. 86% of the demand was covered by national production, while imports provide the rest. Renewable energy sources produced 75 TWh, corresponding to a 9% increase with respect to the previous year. A remarkable growth was registered in wind production, biomass/waste and photovoltaic.

6.1 DISTRIBUTED GENERATION

Distributed generation is incentivized; energy producers can self-consume energy (best economic option) or sell it to the grid, with a rate depending on the power plant size. In particular, incentive programs for PV installations are designed to provide the basis for medium to long-term growth, with the goal of grid parity by the end of 2016[16].

The result of the feed-in-tariffs is the enormous increasing of DG (mainly PV and wind systems). At the end of 2015, wind farms were more than 800 in number, with a gross maximum capacity of about 8 GW; a large majority of those plants has a maximum capacity above 10 MW and is connected to the transmission network. They are also highly concentrated in South and Central Italy: nearly 90% of wind power capacity is located in the southern regions and in the islands. Italy had less than 60 GW of peak demand and the installed capacity of photovoltaic plants (PV) had reached about 15 GW at the end of 2015, an enormous increase with respect to the 431 MW installed in 2008. Almost all PV units were connected to the distribution network and were mostly located in the central and southern regions[17] (57).

16. The grid parity means that the cost of PV-produced energy will be the same as that of fossil-based energy.
17. Data about the renewable energy penetration in Italian grid is

As a result, Italy is one of the countries with the highest penetration of intermittent and dispersed generation (mainly due to very generous State incentives). Since the last five years, there are particular days and regions (e.g., daytime hours of sunny, summer Sundays in the South of Italy) when RES generation, essentially wind and PV, supplies almost the totality of the demand (58).

6.1.1 RENEWABLE ENERGY CERTIFICATE SYSTEM (RECS)

Italy supports RECS. The Renewable Energy Certificates are mandatory for electricity and gas distributors, and can be purchased from the specific market or directly from renewable energy producers. In order to be able to sell their energy, fossil energy producers must buy enough energy certificates to simulate that a specific percentage of the sold energy (quantity defined by Government) is produced by renewables (56).

6.1.2 ENERGY EFFICIENCY CERTIFICATE SYSTEM (WHITE CERTIFICATES)

White certificates, also known as "Energy Efficiency Certificates" (EEC), are tradable instruments giving proof of the achievement of "end-use energy savings" through energy efficiency improvement initiatives and projects. The white certificates scheme was introduced into the Italian legislation in 2004. Under this scheme, electricity and natural-gas distributors must achieve yearly quantitative primary-energy saving targets, expressed in Tons of Oil Equivalent (TOE) saved[18]. Electricity and gas distributors may fulfil their obligation thanks to energy efficiency projects entitling to white certificates or by buying white certificates from other stakeholders in the Energy Efficiency Certificates Market that is under supervision of GME[19] [20]. The regulatory framework was recently changed by the Decree of 28 Dec. 2012. It sets national quantitative energy-saving targets (increasing year by year) for electricity and gas distributors from 2013 to 2016. The decree also introduces new typologies of stakeholders that can submit energy efficiency projects to obtain white certificates. Parties eligible to submit projects are:

- Electricity and gas distributors with more than 50,000 final customers (obliged);
- Non-obliged distributors;
- Private companies operating in the sector of energy services (ESCOs);
- Companies or organizations having an energy manager or an ISO 50001-certified energy management system in place.

From 2013, the management of the energy certificates system is transferred from AEEGSI to GSE (59).

available in the TSO website (57).

18. Each certificate is worth one tonne of oil equivalent (toe) saved.

19. GME is the energy certifications market manager. It is wholly owned by Gestore dei Servizi Energetici-GSE S.p.A., which is in turn wholly owned by the Italian Ministry of Economy and Finance (106).

20. High-Efficiency Cogeneration (HEC) units may access the white certificates scheme under the terms, conditions and procedures established by the Ministerial Decree of 5 September 2011 (106).

6.2 DISTRIBUTION AUTOMATION

In order to guarantee universal access to the network, transmission and dispatching activities are not liberalized. The national operator also has the obligation of grid maintenance and extension. The Italian government controls and owns the transmission network by one company only, namely "*Terna Rete Elettrica Nazionale S.p.A.*" (57), which is part of the ENEL group[21]. Distribution activities, which are also of national interest, are not in the free market, but are given in grants from the state to different operators through public tender, for a period not exceeding twelve years (56).

In Italy (as in other EU countries), regulation of electricity networks has traditionally focused to increase efficiency. To reach this goal, a price cap mechanism was introduced in the year 2000 (with regulatory periods of four years) and it still working today to operational expenditures: OPerating EXpenditure (OPEX) are required to decrease with an X efficiency factor in both the transmission and the distribution sectors (the X factor changes every three years). The cost of capital is remunerated with a fixed rate of return, estimated with a Weighted Average Cost of Capital (WACC) methodology and, since the year 2004, it is paid by end user consumers. The metering service, unbundled from the distribution tariff in 2008, has since received specific incentives on both OPEX and CAPital EXpenditure (CAPEX). In addition to productive efficiency, network regulation has been traditionally concerned with other issues as well; for instance, as for transmission, the level of service quality, congestion management and supply security and, as for distribution, again service quality, as well as energy losses (58).

In order to create consumer awareness of the price differences of energy throughout the day, AEEGSI, the Italian regulator for electricity, gas and water, introduced a Time-of-Use (ToU) tariff for residential and small commercial consumers within the Universal Supply Regime (fully operational from 2012) (56).

6.3 ELECTRIC VEHICLES

In order to achieve the overall European Union targets established for 2020 on energy efficiency, renewable energy share, and greenhouse gas (GHG) reduction, Italian Government indirectly and directly support the use of EVs. There have been some ongoing and prospective legislative initiatives to support research and the introduction of EVs and HEVs involving several ministries and the parliament.

National standard-setting bodies developed, and periodically update, dedicated standards for HEVs and related components (e.g., supercapacitors and lithium batteries) as part of an international standardization collaboration promoted by the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) (62).

21. TERNA is the first European TSO for kilometers of electricity lines managed.

6.3.1 REGULATION & FINANCIAL INITIATIVES

In 2010, AEEGSI started the work to help the development of EVs, introducing simplifications in rules about connection to the electricity grid. The first regulatory action removed restrictions on private sector introducing dedicated electrical meters for EVs charging stations. Thanks to AEEGSI, it is possible (since 2011) to install more than one supply points in private houses as well as in common areas of a housing building. Each supply point can have its own meter and can be dedicated to charge EVs. It also gives the possibility to create charging points to commercial users. These recharging points will pay the same network tariff that is already in use for non-residential customers, regardless of whether the final user is a family or a company[22] (58).

Moreover, the EV market was helped through new regulations for experimental demonstrations aimed at verifying business models and various EV and infrastructure technologies. New specific rules have been defined for transmission, dispatch and distribution services and for electrical energy measurement in EV charging point. These rules were applied in pilot demonstration projects in agreement with AEEGSI and in collaboration with service providers (62).

6.3.2 ON THE ROAD

In Italy, there are about 52 million vehicles on the road. At the end of 2010, there were:

- About 19,000 were hybrid electric vehicles;
- About 218,000 electric cars;
- About 10,000 electric bicycles or motorcycles[23].

The market of EV in Italy is developed and many models are available; prices range from a few hundred euros for power-assisted bikes to hundreds of thousands of euros for hybrid buses. An EV still costs about two or three times more than a conventional vehicle while HEVs have much less of a price differential (62).

6.3.3 INDUSTRY

In 2010, a periodic survey by the Italian Electric Road Vehicle Association (CIVES) confirmed that around 50 producers, assemblers, and importers in the country are able to manufacture or supply HEVs and EVs. Most of these companies are small and medium enterprises, but Italy also has larger companies which are developing EVs and fuel cell vehicles (e.g. Fiat and Pininfarina for EV, FIAMM for batteries). Heavy-duty vehicle manufacturers (Breda Menarini, Piaggio, Cacciamali, and IVECO) introduced many innovative products such as a new model of an efficient and less polluting hybrid drivetrain.

6.4 STORAGE SYSTEMS

In Italy, the high and rapid increase in RES (mainly photovoltaic and wind systems) makes new

22. The price will depend on the contract stipulated with the supplier.

23. Including power-assisted bikes and scooters (with two, three, or four wheels).

legislative initiatives and proposals necessary to be passed. The Legislative Decree 28/11 implementing directive 2009/28/EC calls on the Italian TSO (Terna) to identify network reinforcements (including ESS-Energy Storage Systems) to enable energy from RES to be fully dispatchable. The TSO should follow the EC legislation on unbundling (e.g. it should not be the owner of production systems), but the subsequent Legislative Decree 93/11 defined that TSOs and DSOs can own and control dispersed ESS (including batteries) in order to solve problems identified on their networks in a cost-effective way. However, the TSOs or DSOs are not allowed to receive compensation from ESS implementation greater than the cost of an alternative solution (61) (62).

6.5 SMART METERS ROLL-OUT

To promote a more interactive role by consumers, AEEGSI rolled out programs to push the deployment of smart meters, allowing operators to recover investment costs through tariffs. These programs were a success; in 2001, ENEL started the replacement of the old meters with the new smart ones and in 2005, it deployed smart meters to the almost the totality of costumers (more than 95% of the Italian LV final users).

More sophisticated internet-linked meters, allowing the consumers to be engaged and being a dynamic part of the system to enable benefit sharing throughout the value chain, are also being developed. Such new demonstration projects should promote innovation and adoption, and lead to active management of the grid.

6.6 REMARKS ON ITALY

In Italy, traditional regulation has been progressively modified: new target have entered in the regulatory agenda, and the necessity of development of SG innovative solutions have allowed several initiatives to be launched. The regulation is changing because traditional regulatory instruments (input-based and output-based incentives and requirements for network users) were not completely appropriate for the development of SG. Due to novelty of the subject and uncertainties on the technological and organizational evolutions, the support of selected demonstration projects and the study of related results, are supposed to be the best solutions for the development of SG. The acquisition of experience and knowledge in this phase is considered essential to achieve a more efficient regulation after the deployment phase (58).

For the promotion of an innovative SG transition, a more active behavior on the part of traditional network users is pursued: for example, harmonized requirements for power producers are introduced and advanced pricing schemes for residential and small commercial consumers are already working. Less traditional regulated subjects include charging service providers, which were included in the call for demonstration projects on EVs (58).

In order to balance costs and benefits in all areas related to SG, the grid regulator made sure that all stakeholders shared the benefits of the new technological and organizational developments. For example, the obligation to full disclosure the results for demonstration projects and smart meters is required to really enable improved services to consumers.

One of the results of demonstration projects, carried out by DSOs for SG and by both DSOs and service providers for EVs, is that the preservation of competition is important for innovation. Competition ensures cost-effectiveness and incentivizes participants to find effective solutions that can be used in the deployment phase.

Regarding smart metering, a new technology was already installed and the question was how regulation could maximize the benefit. Regarding to EVs, new regulations that will allow the deployment of a new technology is under study (58).

7 SMART GRID-ORIENTED REGULATORY POLICIES IN FRANCE

The French energy sector (Commission de Régulation de l'Énergie, 2011) has traditionally been dominated by high share of nuclear power, while renewable sources had no significant growth during the last 20 years. Due to extensive hydro resources, France began from a substantial share of renewable electricity, which was 14.8% in 1990 and almost the same (14.9%) in 2010 (including large hydro). Nuclear power represents 74.2% of the generation mix (2010), while fossil fuels only account for 10.8%.

The French wholesale market is characterized by a high degree of concentration and with the incumbents exerting significant market power. For example, the main energy producer in France is EDF, which delivers 91% of the installed power. Starting in 2001, after a decision of the EC, EDF launched a number of auctions to sell off virtual power plant capacity to companies that would act as energy resellers, still EDF maintained its dominant position.

The French transmission system operator is RTE (Réseau de Transport d'Électricité), a subsidiary of EDF. RTE was established in 2000 as a result of the unbundling European Directive, earlier EDF was controlling all generation and transmission activities. The dominating French distribution system operator is ERDF (Électricité Réseau Distribution France), which is also a subsidiary of EDF and is responsible for 95% of the French distribution grid. The remaining 5% are operated by 160 local electricity distribution enterprises.

France opened its retail markets to competition in 2007, allowing all consumers to choose their electricity supplier in the free market. The French retail electricity market is highly concentrated and in 2010, still 93.6% of the consumption sites were supplied by the three historical suppliers.

France supports the RECS system (Sustainable Real Estate Roundtable, 2011) and, as far as smart meters are concerned, it is estimated that 95% of meters will be replaced by smart meters by 2021.

Self-consumption of electricity produced by independent producers is legally permitted if duly authorized by or declared to the relevant administrative authority; however, only "for their own use". Resale to any other legal entity, such as tenants or neighbors is not authorized. The purchase scheme of the surplus of electricity fed into the grid is mandatory, and EDF or the local distributor is obliged to sign an electricity purchase agreement with the facility owner (56).

The French Energy Regulator, CRE, is playing a key with regards to the development of SG. This role encompasses different aspects such as organization of forums and workshops with all SG stakeholders, deliberations, recommendations, call for tenders, R&D, technical analyses, grid access fees, market monitoring, and customer protection.

The latest deliberation of CRE on this issue, that followed numerous and large consultations of the various actors and stakeholders involved in the French SG (since 2010), was on June 12th 2014 with 41 recommendations for facilitating the deployment at large scale of SG. The objectives of these recommendations can be summarized as:

- Fostering the development of new services for the users of distribution grids;
- Improving the performances of low voltage distribution grids;
- Contributing to the overall performance of the power grid.

As such, CRE has requested from the French TSO (RTE) and all French DSOs having more than 100,000 customers to provide CRE with respective roadmaps[24] for the implementation of these recommendations. They were provided by November 2014. Subsequently, CRE has defined the procedures for monitoring these roadmaps and requires further actions on data management, development of self-production, analysis of the added value of SG, including island areas, and the possibility of coupling different energy networks (heat, gas, electricity).

CRE considers that it is necessary to give visibility to the various stakeholders on various actions undertaken or planned by the network operators for SG. Accordingly, CRE requires from these network operators to provide, by November 1st of each year, an addendum to the roadmaps transmitted in the month of November 2014 with the progress of the actions undertaken, and any schedule changes and challenges. These addenda will made public by CRE.

CRE also follows up the progress of the various and numerous SG demo and pilot project through all over the French territory.

7.1 DISTRIBUTED GENERATION

With respect to the energy-climate package, the first step for the French Government is to transpose the European Directives in French law. For the deployment of renewable energies in general, and photovoltaic energy more particularly, the French Government wrote laws, decrees and orders, according the European Directives. But each European country has its own electrical mix.

Actually, since 2007 the Government[25] wrote laws in order to protect the environment called *Grenelle Environnement*. 268 commitments have been made in consultation with all the stakeholders

24. http://www.cre.fr/reseaux/reseaux-intelligents/reseaux-electriques-intelligents

25. http://www.legrenelle-environnement.fr/-Processus-du-Grenelle-.html

concerned by the environmental problems: the French Government, NGO, local authorities, industry, system operators, etc. The *Grenelle Environnement* laws are shared in two parts: the *Grenelle 1* and the *Grenelle 2*. In the *Grenelle 1*, in terms of energy the objectives are to[26]:

- Divide by four the greenhouse gases emissions for 2050;
- Have 23% of renewable energies according to the European " *3x20* "[27].

The objectives set by *Grennelle 1* and *Grennelle 2* have been further pushed forward in the context of the new "Energy Transition" (2015), in particular with respect to the development of renewable energies (32% by 2030).

Hence, the development of renewable energies, in particular wind and PV sources, has been particularly encouraged through purchase obligation and feed in tariffs. However, the FIT has evolved over time (decreasing) and is currently revised every trimester for PV installation depending on the peak power and if they are integrated or not to the building (or houses). In addition, some regions or local authorities add grants-in-aids, reduction of taxes, etc.

The consequence of this favorable environment is a significant development of DG based particularly on wind and PV power generation but also biomass. The number of DG installation is currently exceeding 300,000 units.

26. http://www.legrenelle-environnement.fr/Loi-Grenelle-1,74.html
27. http://ec.europa.eu

Fig. 6: Evolution of wind generation in France since 2005 (source France Energie Eolienne 2015)

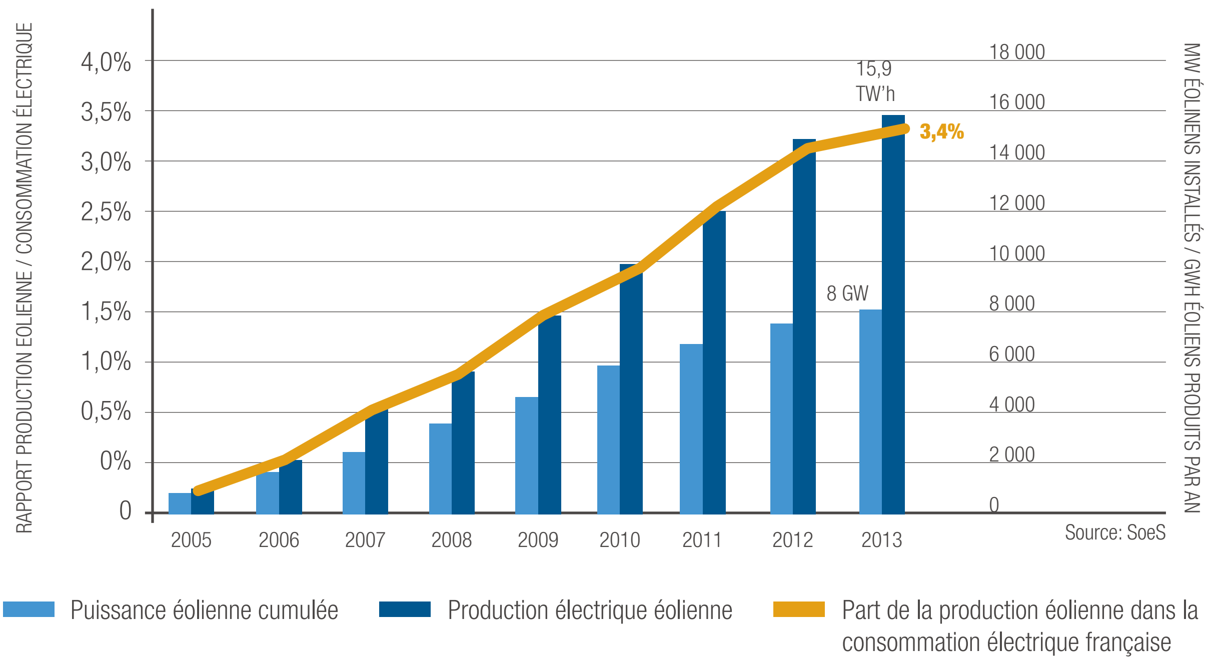
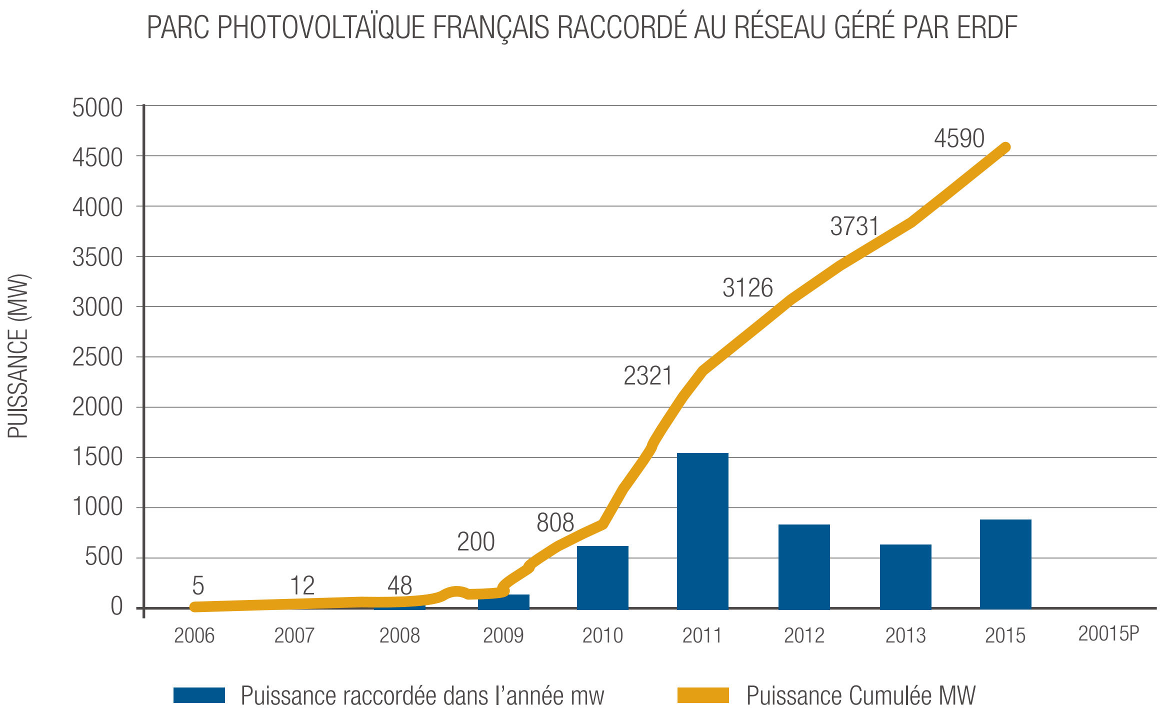


Fig. 7: Evolution of PV generation connected to ERDF grid in France since 2006 (source Hespul)

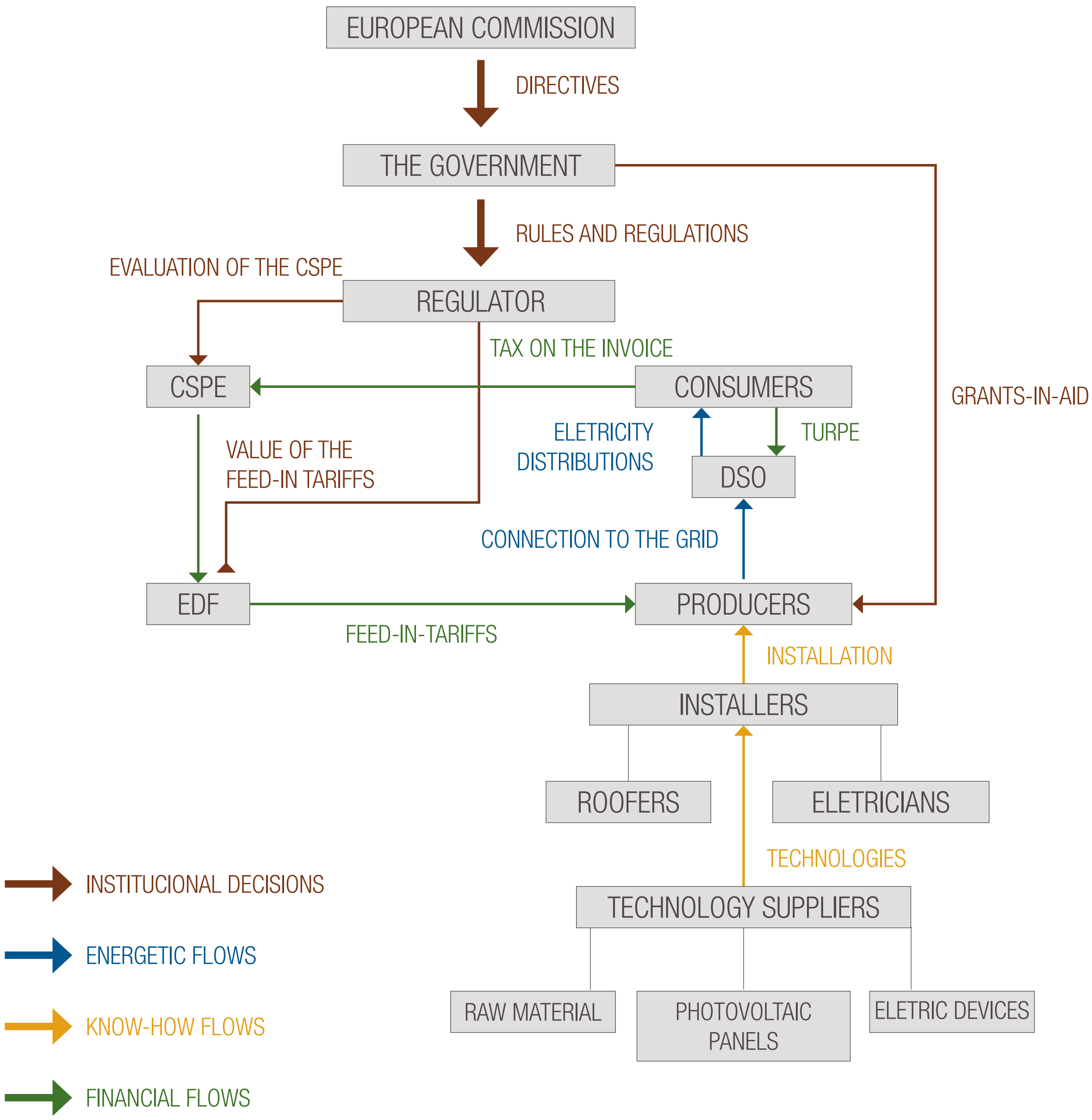


Since July 2011 every quarter the FITs are reviewed by the CRE. This obligation has been put in place by the Government to control the number of new installations. For example if the number of connection requests is higher (respectively lower) than expected to reach the goal of 5.4 GW of installed photovoltaic panels in 2020, then the FITs will decrease (respectively increase).

In addition, the CRE is in charge of the CSPE (taxes for the public service of electricity). These taxes consider different charges: the tariff balancing out in the island zones, social aids for the customers in precariousness situations and also the support for the renewable energies and the combined heat and power. The law imposes to the historical energy suppliers to exercise the public service missions which are compensated by the CSPE paid by all the electricity users.

Figure 8 below illustrates the position of the regulator with respect to the involved stakeholders in the distributed generation context (particularly for PV within distribution grids).

Fig. 8: Diagram of the different interactions between the different stakeholders of the PV (source CRE)



With respect to the grid connection, according to the Energy Code article L342-2[28] when the connection is between a production installation and the distribution network the producer has to pay all the investment of the connection. By Order of the August 28th 2007, article 2[29] the calculation of the connection cost depends on each DSO. The scale is established in accordance with the CRE and then published. However, the regulation continuously evolves with respect to these issues depending on the maturity of technologies, the rate of penetration of RES, the law on energy transition, etc.

Also the CRE is in charge of the adjustment of the TURPE[30] (tariff for the use of the public electricity grid). According to the CRE[31], the price considers different elements:

- The annual management component(s);
- The annual metering component(s);
- The annual injection component;
- The annual decanting component;
- The monthly components of the exceeding power subscribed;
- The annual component of the supplementary and reserve supply;
- The conventional grouping of the connection point component;
- The annual component of the punctual excess programmed;
- The annual component of reactive energy.

This tariff allows the exploitation and the maintenance by the grid operators of the electrical grids. It permits to cover the expenses of the investment and exploitation and maintenance made every day by the DSOs and the TSO. One particular issue is that TURPE integrate the expenses dedicated to R&D efforts by TSO/DSOs. Every year this tariff is revised by the CRE on August 1st and put in application accordingly to the Government.

In short, the TURPE is calculated by the regulator, approved by the Government, paid by the end-users and used by the grid operators.

7.2 DISTRIBUTION AUTOMATION

Distribution grids are the most affected infrastructure in the SG development. Indeed, distribution grids are in the forefront for distributed generation connection and management, plug-in electric vehicles, prosumers and consum'actors. In addition, this infrastructure was not designed for this upheaval of the energy paradigm as it was designed in the objective of "power delivery", i.e.

28. *Code de l'énergie > Partie Législative > Livre III : les dispositions relatives à l'électricité > Titre IV : l'accès et le raccordement aux réseaux > Chapitre II : le raccordement au réseau > Article L342-2*
http://www.legifrance.gouv.fr/affichCodeArticle.do;jsessionid=47EA5050B2C993804A50421428873521.tpdjo06v_2?cidTexte=LEGITEXT000023983208&idArticle=LEGIARTI000023986740&dateTexte=20120616&categorieLien=cid
29. 2007, *Arrêté du 28 Août 2007, article 2* http://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000000795938
30. : CRE > Réseaux > Réseaux publics d'électricité > Tarifs d'accès et prestations annexes http://www.cre.fr/reseaux/reseaux-publics-d-electricite/tarifs-d-acces-et-prestations-annexes
31. : Août 2011, *Règles tarifaires pour l'utilisation des réseaux publics d'électricité*, CRE

assuring the delivery of the last kWh to the end user where most of the energy is collected through the substation (interface between transmission and distribution). In addition, unlike transmission grids, the embedded technologies within distribution grids for observability, fault and constraint management, advance communication, voltage control, and so on, are weekly developed. As a consequence, DSOs are faced to two options with respect to the remarkable challenges they are facing: either they overinvest in the distribution grid with the process of BAU to accommodate the growing complexity brought by DG, EVs, need for better energy quality, and so on, or introduce more intelligence that would ultimately optimize the required additional investments. As a consequence, the French DSOs have been heavily involved in this transition primarily through SG demo and pilot projects. For example, ERDF is participating and mostly leading 18 demo projects (presented in the Part II) all over the French territory.

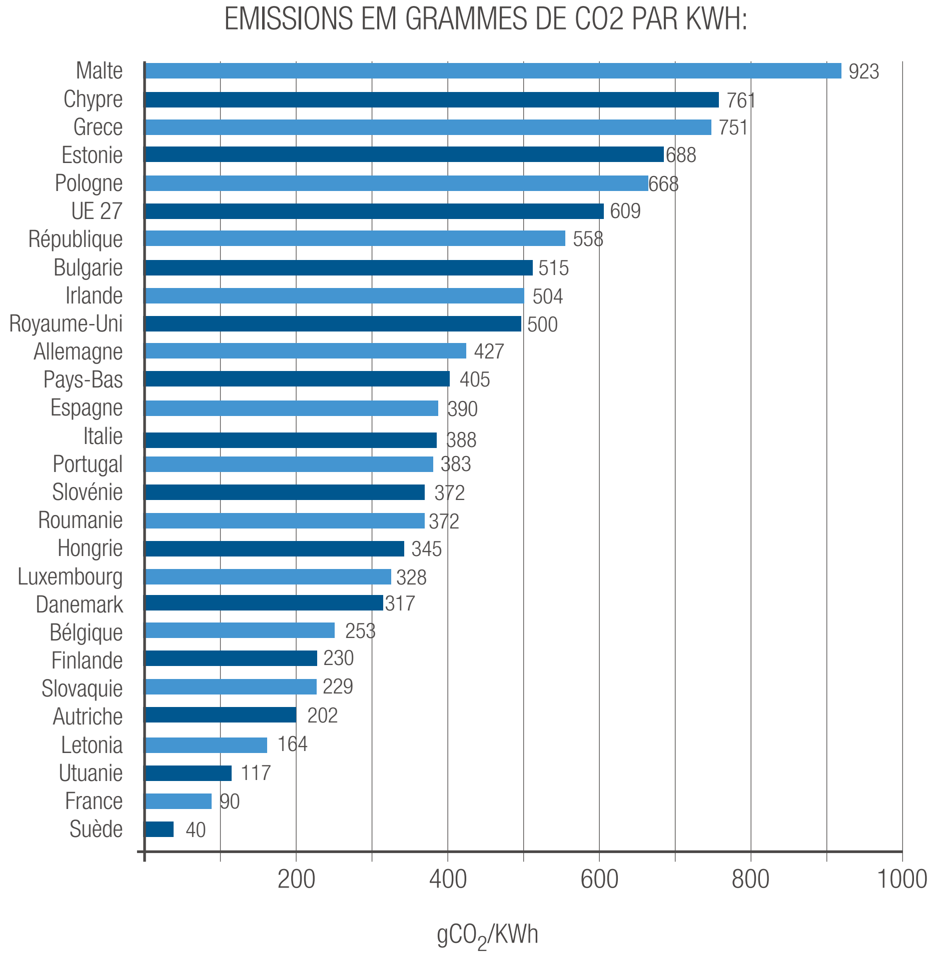
Several technologies for distribution automation are under testing. Among these technologies, one can mention: self-healing distribution grids, smart substation, adaptive voltage control, intelligent protection, optimized grid topologies, etc.

The CRE is following closely the progress of these demo projects and is concerned about the TURPE and grid development, grid power quality, customer protection, business models, and the massive deployment of SG technologies.

7.3 ELECTRIC VEHICLES

In France the electric vehicle is a real chance to decrease the CO_2 emissions. In fact, in France the energy mix for the electricity sector, which is dominated by nuclear energy, does not produce a lot of CO_2. It is one of the less polluting of Europe (with 90 g of CO_2 per kWh).

Fig. 9: CO_2 emission by kWh produced by country (source IEA)



Sources: AIE statistics / source CO2 emissions from fuel combustion 2009

In this context, the deployment of Plug-in Electric Vehicles (PEV) and Plug-in Hybrid Electric Vehicles (PHEV) in France is a subject that is closely looked at by the French government whom has identified national objectives of penetration of PEV/PHEV at the horizon 2025.

The launch of electric vehicles has already been tried before the years 2000 in various countries (e.g. in Europe, USA, and Japan) but without visible success. In order to not reproduce the past failure situation, the French government is putting significant effort in making the various stakeholders work together.

In addition to various in-situ demonstration projects nation-wide (Grenoble, Rouen, Strasbourg, etc.) with respect to EV integration, the government placed a public order of 100,000 electric vehicles by 2015 in order to attract the interested car manufacturers and boost the various stakeholders.

In term of charging stations:

- More than 90% should be slow charging (3 kVA) at home at off-peak hours (night);

- 7-8% will be secondary slow or accelerated charging (3, 22 kVA);

- Only 2-3% of public charging spots will be dedicated for fast charging (43 kVA).

The development and deployment of PEVs/PHEVs will involve several stakeholders (as detailed above) and the related business model is still not settled. Therefore, regulation needs to be defined with respect to the proper interaction of these stakeholders as well as with respect to defining appropriate incentives. As such, both the French government and the CRE (French Regulatory Commission) form the regulatory stakeholders in France.

Energy agencies such as ADEME are also involved in supporting research and demonstration projects as well as development roadmaps for PEVs/PHEVs in France.

7.3.1 GOVERNMENT PLAN

The French government launched (in October 2009) a national plan for the deployment of PEVs and PHEVs in France. This plan contains key points centered on three axes:

- The development of a strong and efficient industrial and research EV field:

Research for sustainable mobility: funding of pilot cases, systematically including EVs in new mobility solutions;

Industrial EV field: creation of a "EV batteries" field, initiation of the EV market thanks to a public order of 100,000 vehicles and financial discounts when buying an EV.

- The anticipation and the development of a favorable environment for EV usages:

Charging facilities development at home and at work: possibility to use classic domestic plugs, charging terminals compulsory in car parks of new construction, facilitating regulation for the installation of charging terminals in already existing buildings, facilitation and obligation of installation of charging terminals in working buildings car parks, etc.;

Developing public charging facilities in public places: European plug type normalization independent of the charging power, funding for helping cities developing their public charging station network, creation of a decision helping committee aimed at cities inviting tenders, etc.

- Environmental issues: assuring a non-fossil source of energy for the EVs electric needs (working force on EV peak demand shifting), recycling of the batteries and their elements.

These initiatives have been further enforced in the framework of the energy transition law, namely with respect to the subsidies for individual buyers of EVs that can reach € 10,000 per EV. The law also sets an objective for seven million charging points in France by 2030. It will also be required to install charging terminals during construction on public and private parking.

However one important problem is the cost of the battery. In fact today most of the batteries are lithium-ion batteries, but even if the technology is quite mature, the market is not yet fully established. Today the price of the battery can represent up to 50% of the car price, according to the CRE[32]. That is why some car manufacturers are looking for solutions to launch the market. For example, the French car manufacturer Renault has chosen a rent solution. Instead of buying an electric car with an expensive battery, the customer buy a car at a "normal" price but he rents a battery he pays every month for. The battery is chosen according to the number of kilometers made per year, and the monthly cost of rent depends on the wished-duration contract (between 12 and 72 months). According to Renault[33], during all the period of the contract the customer can have a new battery (without paying more) in case of problem.

Another challenge related to the development of EVs is its potential technical impact on the electrical grid. Indeed, the massive integration of EV is not without any consequence for the network. In fact one of the major problems of this deployment is the modification of the load profile. "The slow charging of two million of EVs simultaneously in France is equivalent of up to a 10% increase in national peak load", according to EDF[34].

The CRE is also involved in the development of EV in France through stakeholders' consultations and recommendations including charging stations.

Furthermore, Law No. 2014-877 of August 4th 2014 facilitating the deployment of a network of electric vehicle charging infrastructure in public spaces stipulates for example:

"The modalities for implementing charging infrastructure [...] are subject to a consultation between the project carrier, local authorities and public entities in charge of managing the concerned public domain, the authority or authorities organizing the electricity distribution network, when they are in charge of the development of public distribution networks electricity as well as DSOs under their exclusive service area pursuant to Article L. 322-8 of the energy code."

7.4 STORAGE SYSTEMS

The most developed storage technology in France is PHS (Pump Hydro Storage). It has been widely developed following the extensive development of the French Nuclear power generation program in the 70s-80s. As nuclear power plant as pretty much suitable for base load operation, PHS was

32. [32]: smartgrids-cre >Dossiers >economic models >Example of electric vehicle (page 5) http://www.smartgrids-cre.fr/index.php?rubrique=dossiers&srub=modeles&page=5
33. : http://www.renault-ze.com/fr-fr/gamme-z.e./zoe/renault-zoe-life-12.html

34. : 25 Avril 2012, *The Inter project (Intégration du Transport Electrique dans le R*éseau), Gaizka Alberdi (EDF R&D) http://www.ieadsm.org/Files/Tasks/Task%20XVII%20-%20Integration%20of%20Demand%20Side%20Management,%20Energy%20Efficiency,%20Distributed%20Generation%20and%20Renewable%20Energy%20Sources/Arnhem%20public%20workshop/Gaizka%20Alberdi%20-%20The%20INTER%20Project.pdf

encouraged so that they can be used during light load conditions as loads (pump) and during peak load conditions as generators. Actually, even before the event of nuclear generation, the first French PHS was installed as early as 1933 (on the Lac Noir, 80 MW rated capacity), used for regulating the production of the hydro power plant of Kemps on the Rhin river. The installed PHS capacity in France is about 5 GW.

Nowadays, with the event of RES and their rapid development especially the ones that are variable (intermittent) in nature and not really controllable, their impact especially on the generation-consumption balance (but also on voltage, congestion, and other grid constraints) need to be constantly mitigated. In addition, the perspective of having a large share of these RES in the energy mix (even with 100%) will even put a harder challenge on this balance and grid stability. In this context, new emphasis is put on the development of storage technologies especially to support the development of these RES. However, in the present condition of the energy mix and the current energy price, the adequate business model for storage is still to be tracked. Furthermore, the unbundling of the energy segment put even the traditional business model of PHS (developed in the framework of vertically integrated utility of EDF) into difficulty as PHS has to pay access charge during loading conditions.

Therefore France has encouraged the development and testing in real life conditions several ESS in the framework of SG demo projects partly funded by the Ademe Agency (Sustainable Development Agency). Hence, several technologies are being tested with capacities ranging from some hundreds of kW to some MW. The technologies tested for stationary purposes are mostly NaS and Li-ion.

Fig. 10: 1 MW storage demo project in Reunion Island under Millener project (Batterie NaS sur le site de Saint André). Source: sei.edf.com.

The CRE is involved in the storage development at different levels: Level of stakeholders' consultation and SG forum contributions, level of recommendations, and level of call for proposals on combined storage and PV especially on non-interconnected zones (islands). Examples of recommendations are listed below[35]:

- *The CRE proposes that the regulations on general technical requirements for the design and operation should be amended to take into account the specific characteristics of certain electricity storage facilities that may lead to difficulties in terms of quality of supply and grid security. Any differences in treatment established between facilities should result*

35. http://www.smartgrids-cre.fr/index.php?p=stockage-recom-mandations-cre

- *on objective criteria and be directly related to the technical reasons related to the safety and security of networks and the quality of their operation;*

- *The CRE asks the distribution system operators to make explicit in their referred technical documentation the way current regulatory provisions are implemented for a power storage facility;*

- *In the absence of regulatory provisions allowing the specific characteristics of the electricity storage facilities to be taken into account, the CRE also asked to distribution system operators to define rules relating to technical design and operational requirements applicable to an electricity storage facility.*

Currently, extensive efforts are being dedicated to R&D on storage for improving the efficiency, energy density, grid integration and business models[36].

7.5 SMART METERS ROLL-OUT

In France, ERDF (63) is the company responsible for deployment, with a total of 35 million smart meters to be installed by 2021.

The used smart metering model, the Linky project, was successfully tested in pilot projects in Indre-et-Loire (100,000 meters) and Lyon (200,000 meters) in 2010 and 2011. Before the end of 2016 the number of devices installed is expected to reach three million meters and 80 000 hubs. The most important functions of French smart meters are the abilities to: monitoring the status of the low voltage network in order to improve responsiveness in the event of a fault, controlling the production of electricity in the low voltage network, and managing the charging of electric vehicles (64). There are many other functions; for example, the smart meters can also send information about energy use to the user's PC or mobile phone and thereby provide analysis, historical records and an alert system in the event of excessive energy consumption (65).

The smart metering plays an important role in the deployment of the SG. It is the first step of the demand side management (DSM) but also in the development of the open access, settled, since the energy market liberalization.

The smart meter has been developed through four different ideas:

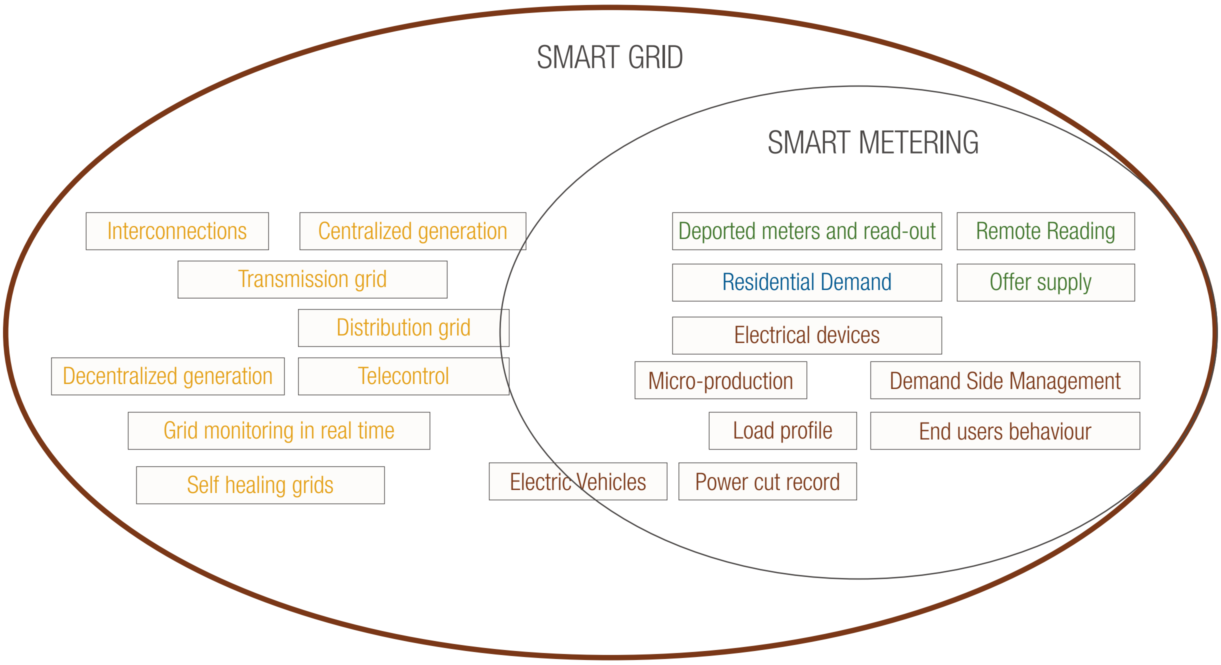
- The remote reading of the meter and the remote invoicing;
- The exploitation and the advanced monitoring of the grid;
- The DSM through the information provided to the end users (the consumer will be aware of what he/she is consuming);
- The DSM through the energy suppliers' offers.

Thanks to the smart meters it should be possible to manage even better the energetic flows between production and consumption sources particularly at the distribution level by enhancing its observability.

36. http://liten.cea.fr/cea-tech/liten

Thus, the challenge is more for the DSO than for the TSO because the transmission grid is already well equipped with all kind of sensors. In Figure 11, it is possible to see the integration of the smart-metering in the SG scheme:

Fig. 11: SG scheme. Source: CRE[37]



Of course the smart metering deployment enrolls in the context of the reduction of CO_2 emission, and of the massive insertion of renewable energies but also for the reduction of the electrical bill of the end-user.

- The French Government

The first step for the French Government is to transpose the European Directive in French laws. For example the decrees n° 2001-387 of the May 3rd 2001 and n°2006-447 of the April 12th 2006 transposed the directive 2004/22/CE of the March 31st 2004[38].

The French Government is the only national entity who has the power to decide of the application of a new technology. Without its agreement the development of the smart meter is not expected. It is empowered to transpose the European directives into national laws.

- Role in the smart metering deployment:

The Ministry of the Ecology, Sustainable Development, and Energy (MEDDE) is in charge of the smart metering deployment. Year after year the French Government wrote laws and decrees in

37. Smartgrids-CRE > Dossiers > Les compteurs évolués: http://www.smartgrids-cre.fr/index.php?p=compteurs

38. CRE > Réseaux > Réseaux publics d'électricité > Comptage électrique > Textes réglementaires : http://www.cre.fr/reseaux/reseaux-publics-d-electricite/comptage-electrique

order to help the deployment of the smart-metering. According to the French regulator (CRE) the important steps were[39]: the transposition of the European directive 2004/22/CE of the March 31st 2004 in two decrees n° 2001-387[40] and n° 2006-447[41]. The order of April 28th 2006 (resulting from those two decrees) gives the ability for a power-meter to furnish the power counting of course, but other functions too;

- The articles L.341-4[42] and 322-8[43] of the Energy Code that allow the DSOs and TSOs to establish ways for the energy suppliers to propose different tariffs for the end-users depending on the hour of the day and the moment in the year. The DSO is in charge of the metering;

- The law n°2009-967 of August 3rd 2009[44], which asks the generalization of the smart meters in order to contribute to the objectives of the "*Grenelle of Environment"*;

- The law n°2010-788 of July 12th 2010[45], which followed the "*Grenelle of Environment"* II and which requires the energy suppliers to communicate periodically the energetic consumption to the end-user with comparative elements and advices in order to make him/her reduce his/her consumption;

- The decree n°2010-1022 of August 31st 2010[46], which specifies the role of the different stakeholders (the experimentation for ERDF, the evaluation of this experimentation for the CRE and the decision for the generalization for the Government);

- The Government wrote on January 4th 2012[47] an Order describing the functionalities that need to be met by a smart-meter.

39. CRE > Réseaux > Réseaux publics d'électricité > Comptage électrique > Textes réglementaires: http://www.cre.fr/reseaux/reseaux-publics-d-electricite/comptage-electrique

40. Décret n° 2001-387 du 3 Mai 2001 relatif au contrôle des instruments de mesure: http://www.legifrance.gouv.fr/affichTexte.do;jsessionid=35215A4F1D89434F394F0CF52726A1C2.tpdjo08v_3?cidTexte=LEGITEXT000005630926&dateTexte=20100228

41. Décret nº2006-447, 12 Avril 2006 relatif à la mise sur le marché et à la miser en service de certains instruments de mesures: http://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000000423249&dateText

42. Code de l'énergie > Partie législative > Livre III: les dispositions relatives à l'électricité > Titre IV : l'accès et le raccordement aux réseaux, article L.341-4: http://www.legifrance.gouv.fr/affichCode.do;jsessionid=499B7C06EC709516850DB0AB780FAE33.tpdjo16v_2?idSectionTA=LEGISCTA000023986724&cidTexte=LEGITEXT000023983208&dateTexte=20110816

43. Code de l'énergie > Partie législative > Livre III: les dispositions relatives à l'électricité > Titre I: le transport et la distribution > Section 1, article L.322-8: http://www.ineris.fr/aida/?q=consult_doc/consultation/2.250.190.28.4.14972/docoid=2.250.190.28.8.14970

44. Loi n°2009-967 du 3 août 2009 de programmation relative à la mise en œuvre du Grenelle de l'environnement http://www.legifrance.gouv.fr/affichTexte.do;jsessionid=7BFFA2CB5838CE9A50F2224080027618.tpdjo14v_1?cidTexte=JORFTEXT000020949548&categorieLien=id

45. Loi n°2010-788 du 12 juillet 2010 portant engagement national pour l'environnement: http://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000022470434

46. Décret n°2010-1022 du 31 août 2010 relatif aux dispositifs de comptage sur les réseaux publics d'électricité en application du IV de l'article 4 de la loi n°2000-108 du 10 février 2000 relative à la modernisation et au développement du service public de l'électricité: http://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000022765140

47. Arrêté du 4 janvier 2012 pris en application de l'article 4 du décret n°2010-1022 du 31 août 2010 relatif aux dispositifs de comptage sur les réseaux publics d'électricité : http://www.legifrance.gouv.fr/affichTexte.do;jsessionid=0AFB4217EF47400D9D8D85D2EB758569.tpdjo02v_1?cidTexte=JORFTEXT000025126353&dateTexte=20120612

The massive roll-out has been finally approved to be started December 2015 with an objective of installing three million smart meters for the first year of roll out (2016).

- The regulator CRE

The CRE is especially in charge of the elaboration of the requirements for the Linky project, but also of the pre-evaluation of this project.

For the Linky smart meter more specifically, the CRE has made some orientations about the metering. In June 6th 2007 Communication[48], the CRE asked the French DSO, ERDF, to achieve experimentations before a smart meter generalization. After completing the Linky experimentation, the CRE has made some recommendations[49].

The CRE is an important stakeholder for the deployment of the smart-metering. This entity wrote several communications and deliberations on the subject, in order to advance the different regulations and legislative texts[50].

It has to be noted that the regulator suggested a proposition for February 12th 2009 decree about the implementation of the smart-metering.

Subsequent to the 2009 decree, the CRE made four deliberations:

- The February 11th 2010, on the technical criteria that will be used for the evaluation of the ERDF experimentation;
- The March 30th 2011, to say that the CRE is able to measure the conformity of the smart-meter with the functionalities decided on June 6th 2007;
- The July 7th 2011, to communicate the results of the Linky experimentation;
- The November 10th 2011, to propose a suggestion for an Order on the smart meters on the public electrical grids. It is an order project for the application of the article 4 of the decree n° 2010 1022 of the August 31st 2010.

The issue of the experimentation has been conclusive, and so the CRE suggested the generalization of the Linky project for 35 million of end users (the updated objective is 90% of the end users equipped with smart meters by December 31st 2021). Given the scale of the Linky project and the need to guard against any drift in costs and achievement planning, a specific regulatory framework has been implemented by the CRE to encourage operators to:

- Meet deployment schedules;
- Master the investment costs;
- Guarantee the level of performance expected from such advanced metering systems.

48. Communication de la CRE du 6 Juin 2007 sur l'évolution du comptage électrique de basse tension de faible puissance > Consulter la communication: http://www.cre.fr/documents/%28text%29/+6+juin+2007
49. July 7th 2011, Deliberation of the CRE, available for consultation on: http://www.cre.fr/documents/deliberations/%28text%29/linky
50. CRE communications and deliberations: http://www.cre.fr/reseaux/reseaux-publics-d-electricite/comptage-electrique

These regulatory frameworks were defined in the deliberations of the CRE of July 17th 2014, issued following a public consultation and consultation with the Higher Energy Council (CSE) and published in the Official Journal on July 30th 2014. These deliberations amend and supplement the Proceedings of December 12th 2013 on a decision on rates of use of a public electricity network in the voltage range HV or LV (TURPE 4).

7.6 REMARKS ON FRANCE

The French power system has special characteristics with respect to its energy mix, stakeholder organization, grid structure and the position of its grid operators. Following the transposition into the French law of the EC orders with regards to the energy liberalization and open access, the climate-energy package and the French law of energy transition, the French electric grid has undergone tremendous changes in several areas: renewable energy sources penetration, electric vehicles development branch, smart metering massive roll out, and significant effort on SG demo and in-situ projects (more than 100 projects all over the French territory). In additions, further ambitious perspectives are set under the energy transition law in terms of consumption reduction, RES and EVs development, reduction of nuclear generation share, and reduction of GhG emissions.

The distribution grid is the first infrastructure on the forefront of these changes. Distribution automation is rapidly increasing (ERDF is one of the first DSO to implement self-healing technologies at the MV grid) while on going experimentations are expected to provide the framework for technologies choices. Research projects on all issues on SG are in progress, and thanks to government and private funding several major innovations have already arisen while involving almost all SG stakeholders.

8 SMART GRID-ORIENTED REGULATORY POLICIES IN GERMANY

The German electricity market is fully opened at every level since 1998. From 2010, with France, Belgium and Netherlands, Germany forms the Central West European (CWE) energy area. The market model applied is zonal pricing with a market coupling mechanism, which means that area price is calculated for each country, with convergence when the transmission capacity is sufficient (56). The energy market was characterized by a high penetration of nuclear production. However, after the Fukushima disaster in 2011, the German government changed his positive position about nuclear energy and announced it would begin terminating all nuclear plants in the country. Compensation will be achieved through the construction of new coal power plants and renewables (56).

8.1 DISTRIBUTED GENERATION

The 20% of the total electricity generation in 2010 was due to renewable sources. Germany's National Renewable Energy Action Plan (66) predicts a renewable energy share of 38.6% by 2020. Wind energy, biomass and solar PV are the technologies that contribute the most to the distributed generation mix and photovoltaic technology was the one with the highest growth rate. On the other hand, electricity generation from hydro sources has remained nearly the same over time (67).

There is an indirect policy incentive for self-consumption of renewable energies, users consuming the energy they themselves produce receive a bonus, and it is higher when self-consumption is more than 30% of production. Operators of PV installations can sell electricity directly to third parties and it is well accepted by the German regulation[51] (56).

8.2 DISTRIBUTION AUTOMATION

The EEG (Erneuerbare-Energien-Gesetz; The *German* Renewable Energy Act) requires that renewable energy sources should be connected to the grid before conventional power plants.

The first FIT scheme (before year 2000) did not define the sharing of connection costs between the generator and the grid operator (DSO/TSO). The successive update, made in year 2000, requires that the connection of the power generation to the power grid is done to the most technically and economically appropriate connection point in the grid. This approach would help to prevent grid operators from using their dominant position to exclude potential competitors from power generation (68).

In terms of grid access, electric operators are required to prioritize the purchase, transport and distribution of all the renewable electricity. The renewable producer has to pay only the costs for connection to the grid to the closest (or technically and economically most suitable connection point) and also for the installation of metering devices. Any required additional work (e.g. network reinforcement) is paid by the grid system operator (DSO/TSO), but only if related costs are economically acceptable[52].

51. It must be communicated to the grid operator a month before the beginning of the new energy contract.

In order to facilitate the reduction of the generation output by DG in case of grid congestions and to call up the current electricity feed-in at any given point in time, grid operators need to take partial control of all the generators. Following the German Renewable Energy Act (66), all the installations with a capacity higher than 100 kW are required to install the control and communication equipment. Solar PV with a capacity between 30 kW and 100 kW can decide to install the control and communication equipment to allow the remote reduction of grid injection to be achieved or to limit maximum injection up to 70% of total installed capacity. The 95% of lost money, due to injection reduction during grid managements, is paid to the owner of the renewable generator. However, if the lost income in a year exceeds 1% of the annual income, the refund can be complete (56).

8.3 ELECTRIC VEHICLES

As part of the 2020 targets, German government has set and objective of one million electric

52. Germany was one of the first countries in Europe to implement a “shallow” connection charging approach. This approach starts with the liberalization of the electricity market and was done to speed up the liberalization process. The low-cost connection methodology applies to most types of renewable generation installations (offshore wind turbine are excluded) (66).

vehicles in the whole country. This objective is part of the National Development Plan for Electric Mobility, which the German government adopted in 2009. Initial research and development projects as well as projects in model regions have been launched as part of the German government's second stimulus package, which started with the allocation of about € 500 million between 2009 to 2011 (62).

In 2010, the German Government with leaders from industry, science, and other key stakeholders created a National Platform for Electric Mobility (NPE). The target of this association is to achieve two main goals. First, Germany aims to become a leading market in the electric mobility sector, with at least one million electric vehicles by 2020. Second, Germany wants to be a leading provider in the electric mobility sector[53] (62).

8.3.1 ON THE ROAD

In 2010, in Germany, there were 51 million vehicles: 38,000 were hybrids and 5,613 were electric vehicles. In order to improve EV development and commercialization, the Federal Government spent about € 500 million (from 2009 to 2011) in pilot projects. One of the main projects is called "Electric Mobility in Pilot Regions". This project was mainly funded by the Federal Ministry of Transport, Building and Urban Development, (€ 130 million) to eight pilot projects in Germany in Berlin/Potsdam, Hamburg, Bremen/Oldenburg, Rhein-Ruhr, Sachsen, Rhein-Main, Stuttgart, and Munich. The objective of the model regions was the connection of application-oriented research with customer-focused everyday use of electric vehicles[54].

53. Germany is one of the world's top exporters, thanks to the development and marketing highly innovative products. NPE published its third report in 2012 and stated that Germany is a leader for EV solutions and establish a well-functioning market by 2020. The report is available in (99).

8.3.2 RESEARCH

The general research strategy of the German government is diversified and focuses on various key areas of electromobility. Until 2016, the target of R&D funding (from all the stakeholders) will be the field tests, pilot project, and improvement and wide production of lithium-ion batteries.

8.3.3 INDUSTRY

All German car companies develop and test electric vehicles. All of them have introduced hybrid electric vehicles into their portfolios and from 2011, they are available in the market. The biggest player in EV development is the company "Bosch". It produces systems and components for all levels of hybridization. It is the second largest automotive supplier in the world and invests about € 400 million per year into EV technologies.

8.3.4 CHARGING INFRASTRUCTURE

The roll-out of EV strongly depends on the development of the charging infrastructure. Therefore, many vehicle projects also build the respective infrastructure. Within the "Electric Mobility in Pilot Regions" program, about 2,000

54. About 2,500 electric vehicles have been used and studied in the "Electric Mobility in Pilot Regions" project (60).

charging points have been built at the end of 2011. Germany's major utilities are actually working with the other EV stakeholders to develop charging infrastructures along with the market introduction of plug-in electric vehicles (62).

8.4 STORAGE SYSTEMS

The actual high RES integration in the grid has resulted in an increased unpredictable generation and in requirements for infrastructure upgrades. For this reason, the German government considers a key component the use of ESS to meet renewable targets.

Nevertheless, studies carried out by the German Energy Agency (DENA), on the changes required by the grid to allow the increasing of RES penetration, concluded that in currently grid conditions and thanks to high costs of storage technologies, the expansion of the transmission network provides a better solution than the deployment of ESS. However, DENA recommends incentives for ESS and, in particular, instruments to increase the coordination between stakeholders and grid operators to alleviate congestions on the transmission network and reduce total system costs. DENA also determined that after 2020, ESS would be cost-effective and practically useful in Germany for peak shaving, load following and power balancing (69).

A report on European regulatory aspects for electricity storage (70) concluded that "the lack of regulations, opportunities and mechanisms to support the competitive use of ESS is affecting the uptake of ESS in Germany. At present, PHS owners operating in the market have issues with finding the best split of ESS capacity for use in the spot and reserve markets based on market prices" (71) (72)

The actual regulation treats existing PHS systems as load, and they must pay grid access fees and taxes (73). There are no incentives for existent PHS available to better dispatch energy from renewables (74) and this lack limits the amount of investments (90).

On the other hand, new built PHS plants, expansions, and other new ESS are exempted from grid tariffs for 20 years. Moreover the Government updated grid rules to allow all ESS technologies to participate in the control energy (reserves) market (72) (73). New ESS systems providing electricity from stored RES will not pay grid access fees and taxes, and grid system operators are obligated to remunerate participants who feed stored power from RES to the grid in line with mandated renewable energy tariffs (70).

Recently, subsidies have been provided to support the deployment of ESS used in small PV systems (up to 30 kW) connected to the grid (95). These incentives were provided in the FIT scheme and they decrease in time with the cost of solar panels[55] (96). Incentives are provided also for biogas installations to mitigate intermittent wind power injection to the grid[56].

55. Actually, Germany has the largest amount of PV with residential storage in the world (96).
56. A medium to long term study, related to the potential of PHS in Germany and coordinating use of other EU storage facilities, is present in (67).

8.5 SMART METERS ROLL-OUT

Germany is in an initial stage of implementation. In July 2013, Germany's Federal Ministry of the Economy (BMWi) (75) published a cost/benefit analysis whose outcome was to recommend not carrying out the implementation of smart metering infrastructures in accordance with the European roadmap established for 2020. In other words, today, smart meters are installed only in new buildings, major consumers and in presence of renewable or co-generation (only if technically possible)[57].

The law requires that smart meters show current energy consumption and time of use; moreover, it must be integrated into a communications network. Standards and guidelines related to interoperability, data protection at all levels and interaction with manageable elements (such as electric vehicles and heat pumps) have not yet been developed.

In conclusion, the analyses carried out by different German institutions consider more important the economic sustainability of the system than an immediate large-scale and widespread deployment (76) (65).

8.6 REMARKS ON GERMANY

After the Fukushima disaster in 2011, the German government decided to give up nuclear energy and to increase production from coal power plants and renewables.

From the point of view of DG diffusion, PV and wind technologies have gained a certain legitimization by the government as a valid option to obtain the targets of reducing the dependency by fossil fuels. With a strong digression of RES cost in recent years, the German FIT has driven this development. In addition, with the self-consumption incentive tariff, it makes more cost-effective, for the PV system owner, to self-consume the PV generation, than make use of the FIT (77).

In order to face the strong increase of non-predictable energy production, German governments decided that (in currently grid conditions) the expansion of the transmission network is the best solution. Due to actual high costs of storage technologies, the deployment of ESS is of secondary importance. However, it is considered that in next year EES will be useful in Germany for peak shaving, load following and power balancing (thanks to future technological development and to decreasing prices). For these reason, recently, storage system for PV application are incentivized.

From the point of view of grid connections of RES, system operators is obligated to reinforce the network and transfer the related costs to final consumers, which can be translated in higher electricity tariffs. An interesting initiative is the recent implementation of the "Renewable Energy Sources Act 2014" (75) in Germany, which attempts to minimize the socialization of costs by the imposition of direct selling into the market from August 1st 2014 onwards. Nevertheless, initiatives to reduce the socialization of RES connection to the grid are not generally observed (78).

57. In the other cases, the implementation will be carried out only if it is economically convenient and technically feasible. Different standards aimed mainly at small consumers are available in (76).

With respect to the other EU countries studied in this work, the position of Germany about Smart metering system is different. The Germany approach did not give priority to an immediate large-scale and widespread deployment. Actually, this country is in an initial stage for smart meters implementation. The actual target is to reach the roll-out of 38.5 million smart meters in 2029.

About EV development, the German government wants to reach the use of one million electric vehicles countrywide by 2020. In support to this objective, the German government has dedicated specific funding for the R&D, the development of pilot projects and collaborations with all the stakeholders with respect to EV development.

9 SMART GRID-ORIENTED REGULATORY POLICIES IN DENMARK

The Danish electricity market was liberalized in 2003. It has a decentralized structure (similar to Germany) with a large number of private and public utilities. The system is characterized by the transmission system operator (Energinet) (79), which is an independent public company owned by the Danish state, and by a single independent energy regulator (Danish Energy Regulatory Agency) (80). In terms of generation, the market is dominated by central generation plants, the majority of them owned by DONG Energy (publicly-owned) and Vattenfall (Swedish-owned). The rest of generation systems are owned by other private companies, local authorities, larger industries and cooperatives.

By the end of 2012 the total generation capacity was around 14.17 GW mainly from combined heat and power systems (51% of total installed capacity). The share of renewable energy sources in gross final energy consumption has risen from 14.5% (2004) to 26% (2012) (78).

9.1 DISTRIBUTED GENERATION

The goal of the Danish Government is to produce 50% of the total Danish electricity consumption in 2020 from RES (wind farms) and that Denmark will be independent of fossil fuels in 2050. Massive investments are done in onshore and offshore wind systems. Actually, there are approximately 5,400 wind turbines in Denmark, and they currently represent most of the country's energy production from renewable energy sources, after the quantity of produced GWh increased by around 20% per year for 10 years (56).

Small energy producers sell the electricity either directly to an electricity supplier or to Nord Pool (the Nordic power exchange). The development, in Denmark, of small domestic renewable sources having a nominal installed power at maximum 6 kW has tremendously increased in the recent years. In fact, the number of grid-connected solar plants passed from 2,700 at the end of 2011 to more than 20,000 at end of 2012. If the prosumer annually consumes more energy than production, at the end of the year it will pay for the difference at normal energy price. If the production is higher, the prosumer will receive a fixed-rate payment (lower than the price for buying energy).

Before the liberalization of the electricity market, end users had to buy electricity from the electricity supplier in the area where the final user lived. Since the beginning of 2003, end users can choose the electricity supplier. There are many approved electricity suppliers on the Danish market, which buy electricity either at a power exchange (e.g. Nord Pool) or directly from an electricity producer, and deliver energy to the end-user. On an annual basis, about 6% of the electricity customers are switching supplier (56).

9.2 DISTRIBUTION AUTOMATION

According to national legislation (Electricity Supply Act) (81), electricity from renewable sources is not granted a priority connection, however installations that produce electricity from renewables or use waste products as decentralized co-generation plants have priority access to the grid[58].

Concerning connection cost, generators only pay the direct cost of connection to the nearest connection point to the electrical grid. Reinforcement costs are paid by the grid operator and they must require and receive a permission to precede upgrade works. The energy regulator has to approve the planned investment, because all electricity final customers pay reinforcement cost. In the case of wind energy plants with a capacity higher than 1.5 MW, the connection costs are paid by the wind generator and the grid operator. In addition, they are required to pay a fee to the distribution company for handing metering and administration[59] (78).

With regards to innovation in the distribution automation, Denmark has investigated the cell concept allowing an optimized management of distribution grids with significant penetration of DG. The ultimate objective is to be able to operate the distribution grid in independent or cooperative cells and even stand-alone grids.

9.3 ELECTRIC VEHICLES

9.3.1 POLICIES

The Danish Transport Authority established in 2009 creates the framework for a Danish center in the field of sustainable transport and to manage these initiatives. Projects include a transport certification program for municipalities and companies, an energy-efficient driving campaign, and energy labeling of light commercial vehicles. 28 million euros have been spent for demonstration projects between 2010 and 2013 to study environmental friendly and energy-efficient transport solutions, including test projects with alternative types of fuels, electric cars, buses and trucks (62).

Owners of EVs vehicles (equipped with batteries or fuel cells) are exempted from the registration tax and annual tax until the end of 2015. EVs are also exempted from the current expensive registration tax for passenger cars (based on the value of the car). Locally, there is free parking for EVs in major towns (62).

58. In the case of network constraints, renewables have priority over conventional energy sources. Renewable electricity generation with priority can be reduced only if the reduction of traditional generation is not enough to balance in the system. The priority access is also applicable to production from offshore wind farms, which can be curtailed only under special conditions subject to compensation for operational loss.

59. All generators must pay a tariff to the TSO for the use of the grid and charges are not differentiated by location.

9.3.2 ON THE ROAD

The total number of passenger cars in Denmark has passed two million and is slightly increasing; nevertheless there are few EVs. Actually the growth for EVs and PHEVs in Denmark is difficult to predict.

In 2009, the main energy utilities created the electric mobility operator, called "ChoosEV". The goal of ChoosEV is to lease and maintain electric vehicles and to create new charging stations. In 2010, it planned and initiated an EV test and demonstration program called "TestEnElbil", which was the largest EV program in Europe. In cooperation with many stakeholders, during a period of two years, it put EVs at the disposal of more than 2,000 families. During the project period about 300,000 battery charges profiles were collected for research and analysis. The project started in 2010 and finished in 2013. The data obtained from this project are used to study new solutions for the EV implementation and to find and face obstacles to the EV roll-out. Actually there are 50 fast charge stations across all Denmark, installed in specific locations in order to make possible to drive across the country in an EV (62) (84). Other projects the smart charging possibilities synchronized with the availability of RES energies.

9.3.3 RESEARCH

In 2009, the EDISON project for EVs and PHEVs started. It is an international collaboration that includes many Danish energy companies and the national TSO. The starting budget was about € 40 million. The project develops system solutions and technologies for EVs in order to enable a sustainable, economic, and reliable energy system with substantial fluctuating renewable energy (mainly wind). The other goal is the creation of a technical platform for Danish demonstrations of EVs with emphasis on power system integration.

However, despite the necessity of other activities that explore the potential for vehicle-to-grid (V2G) services that include EVs, the main focus of Danish research in transportation technologies has been on biofuels and hydrogen and fuel cells[60].

9.4 STORAGE SYSTEMS

In order to improve energy security, the Danish government is moving towards a green growth economy to be run on 100% renewable energy by 2050, and ESS has been identified as an essential element. This plan considers really important the strong connection with Norwegian grid. Hydroelectricity capabilities of Norway will be used as storage for interconnected countries, (also Germany and the rest of continental Europe and Russia via the Nordic power exchange). In particular, the Danish project includes the use of the high amount of wind penetration in Denmark, to store energy in Norway Hydroelectric storages[61]. (82). Hence, with their biggest challenge by 2020 being the storage and distribution of wind power, the Danish government has plans to further expand interconnections between Denmark and Germany, Norway and Sweden (83) (71).

60. More information is available in (84).
61. However, this is limited by transmission constraints between both countries (89).

Due to the intention of using hydroelectricity capabilities of Norway, the development of other storage technologies is not considered as a main goal[62], nevertheless other possible solutions are investigated:

- The creation of hydrogen from excess electricity produced by wind farm stored in the national natural gas infrastructure for later use and for electricity generation;

- Creating schemes for large scale district heating systems to store heat converted from surplus electricity by heat pumps.

9.5 SMART METERS ROLL-OUT

The distribution systems are owned and operated by local companies, among them 10 control most of the total distribution grid. These companies are in charge of the measuring and responsible for installation and reading of the meters (at least one read per year). The goal of these companies is to replace all the old meters with new smart meters by 2020.

In April 2013, the Danish Energy Agency declared (through a strategy) that half of the energy consumption in 2020 will be made by wind turbines and all the electricity meters have to be remotely read by the end of that year too, as part of the Danish Government's progressive SG Strategy which purpose to make the grid intelligent and suitable for the green transition. This strategy was called "SG Strategy" which set all the parameters to develop a SG that could make such green transition cheaper, provide savings on energy bills and help to promote new services to the benefit of consumers.

According to the government strategy, the development of a SG depends if consumers notice a value in making their flexible consumption available. For this reason, the government planned to encourage consumers to be actors with active electricity behavior having flexible electricity consumption. Such flexibility was provided with the option of hour-price settlement rather than by fixed-price settlement. To do so, the consumers required smart meters that could be programmed to set different prices and be accessed remotely (Danish Ministry of Climate, 2013). It is thus expected that all the consumers (3 million in total) have remotely read hourly meters installed by no later than 2020.

The technology used in Denmark is a combination of PLC (Power Line Carrier) and GPRS. PLC is used for the path meter-concentrator (protocols OSGP, DLSM/COSEM) and GPRS is used for the path concentrator-central system (protocol TCP-IP).

During the latest years, Kamstrup has been one of the most important manufacturers of smart meters for Denmark. In January 2014, a consortium of eight Danish utilities (so-called MV Group) acquired 153,000 electricity smart meters from such company over a three-year period. The same company has also chosen by the Danish energy supplier DONG Energy as partner for rolling out and operating about one million remotely read electricity meters.

62. The present regulation in Denmark treats ESS as loads; hence ESS is liable to grid charges for loads.

9.6 REMARKS ON DENMARK

Danish government is moving towards a green growth economy to be run on 100% renewable energy by 2050. Danish project includes the use of the high amount of wind penetration in Denmark, to store energy in Norway Hydroelectric storages; therefore the actual main goal is to strongly expand interconnections between Denmark and the other countries (especially Norway). The development of other storage technologies is not considered a main goal; nevertheless Danish government is actually funding minor projects.

From the point of view of grid connections of RES, system operators are obligated to reinforce the network and to transfer the related costs to end users as in Germany). This is reflected in the high electricity tariff that final energy users are required to pay.

Research projects about EV are in progress, and thanks to government funding's and organization, they include all the stakeholders. However, actually the main focus of Danish research in transportation technologies is the development of biofuels and hydrogen fuel cells.

Smart meters roll-out will is expected to be completed by 2020.

10 CONCLUSIONS OF PART I

Throughout this review, it sorted out that there is a lot of socialization of connection costs, especially in Germany and Denmark where the shallow approach is the connection methodology and the grid operator is obligated to reinforce the network and transfer the related costs to demand customers. This is reflected in the high electricity tariff that electricity customers from those countries are required to pay. In terms of subsidies, again Denmark and Germany are the ones with the most sophisticated methodologies. However, this sophistication remains in the subsidies and it is not evident in the business model for the connection of more DG in a cost efficient way. An interesting initiative is the recent implementation of the EEG (2014) in Germany which attempts to minimize the socialization of costs by the imposition of direct selling into the market from August 1st 2014 onwards. Nevertheless, initiatives to reduce the socialization of DG connection to the grid are not generally observed. In Denmark, the expense model proposed by Energinet is quite interesting but is still based on the option of reinforcing the network, and does not relate to the practice of smart connection arrangements that may help to defer investment and to avoid charging demand customers for what may be unnecessary network expansion.

France has a special position as it is highlighted above with respect to its energy mix and stakeholders' landscape. The cost of the electricity for the end user is almost 50% less than in Germany although the energy markets of these countries are coupled. France is also investing heavily in SG transition at all levels: R&D, Demo projects, industrial initiatives such as Linky project. It has also set ambitious objectives in terms of reduction of energy consumption, reduction of GhG, share of RES and EVs. The transformation of the French electric grid towards a carbon-free system is on the track while grid investments seem to be favored by the position of its TSO/DSOs (large companies able to cope with capital intensive investments).

UK is also undergoing changes in its electrical system for more smart technologies. Nevertheless, the market oriented decisions have somehow handicapped grid investments.

The electricity supply of Italy is linked to imports from neighboring countries. Therefore, the development of RES has been set as priority. In addition, Italy was the first country to initiate a massive roll out of a communicating meter. Similarly, Italy has achieved improved quality of supply through distribution grid automation. As such, Italy can be seen as an active country in the SG development.

For the all the selected countries, the regulation plays a key role at different levels of SG development and technologies penetration. However, the level of involvement is different from one country to another depending on several factors such as national and government energy policies, market design and structure, political organization, stakeholders' landscape, historical situation of the energy mix, etc.

PART II

SMART GRID PROJECTS SUPPORTED BY ENERGY REGULATORS

LESSONS LEARNED AND RECOMMENDATIONS FOR FUTURE PROJECTS

EXECUTIVE SUMMARY OF PART II

This report is focused on the identification and the description of some of the main SG projects supported by Energy Regulators (ER) in EU. After a general introduction and the description of the background, specific projects are analyzed with particular attention to obstacles and difficulties faced by the selected projects during their execution in particular with respect to the following topics: political, social and financial variables, implementation issues and lessons learned.

The review of the EU SG projects focused on R&D and Demonstration funded by energy regulators showed that in the majority of EU countries, a combination of sources is used to fund innovative and risky demonstration projects. Funding for demonstration projects has been through sources of finance such as industry/private funding, public funding institutions, the EC, integrated municipal energy suppliers and regulators.

Most of the regulators are not directly involved in funding the innovation in their respective countries (except UK and to some extent, Denmark and Italy). Also some of them are focused on monitoring and regulating the electricity market and protect customer interests during the technological transitions. Actually, even though most of the regulators do not directly fund all of the SG projects, they ensure that goals set by European regulators for smooth SG transition, de-carbonization and dynamic tariff implementation are met, but without any drastic negative impacts on the consumers (rather with positive impacts).

In this context, the UK energy regulator, OFGEM, has particularly showed a key role in not only directly funding innovative SG projects but also in providing technical opinions, management advices and the largest funds in EU for SG projects. Therefore, with respect to SG project examples, the report has specifically focused on OFGEM supported projects.

Some of the key project implementation difficulties and general recommendations have been stated in dedicated sections.

11 INTRODUCTION OF PART II

This report identifies and describes some of the main SG projects supported by Energy Regulators (ER) in EU. After a general introduction and the description of the background, the projects are analyzed with particular attention to the following topics: political, social and financial variables, lessons learned during the execution of the projects, implementation difficulties and obstacles. The work is completed with conclusions and recommendations.

12 SUPPORTS FROM EU ENERGY REGULATORS IN SMART GRID PROJECTS

For most of the EU countries, funding innovation and particularly incentives to encourage DSO innovation are achieved through network charges (in 75% of countries). National government funding and European funding are also used to a great extent, while many countries use a combination of funding sources. The EU Governments, in collaboration with the respective energy regulators, work in order to increase the number and the effectiveness of SG projects. The most common methods adopted by Energy Regulators (ER) are the followings:

- Creation or management of incentive schemes (FITs, prices control, caps schemes, etc.);
- Introduction of simplifications in rules related to energy fields;
- Removal of previous and not anymore necessary restrictions in energy regulation;
- Complete or partial funding of private and public projects, selected by defined procedures;
- Provision of economic and technical opinions for future projects.

12.1 FUNDS FROM EU ENERGY REGULATORS FOR SMART GRID PROJECTS

Most EU countries have launched large number of SG projects particularly during the last five years. Most of these projects deal with real life demonstration of various functionalities of SG. These projects have been funded through different channels: private investors, EC funding, national funding and regulatory funding. However, only a small portion of this funding comes from (or managed directly by) the regulator (about 9%; Figure 12) used by few countries such as UK, Denmark and to some extent Italy on a total budget of about € 3150 million (107). It has to be noted that the largest share of the SG funding comes from private investors and from countries dedicating the largest budgets for these projects such as France and UK. This indicates that business and market potential as well as high investment return expected from implementing SG technologies are somehow foreseen and integrated in these countries.

Fig. 12: Distribution of cumulated funding source for EU SG projects (107)

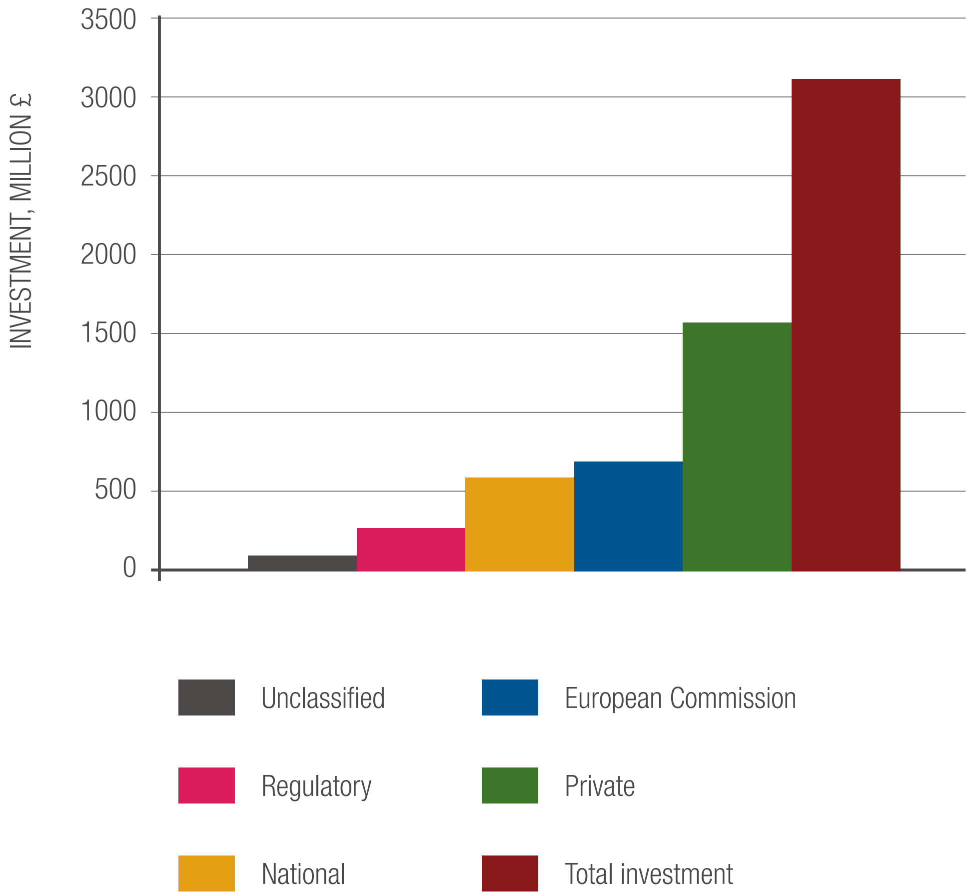
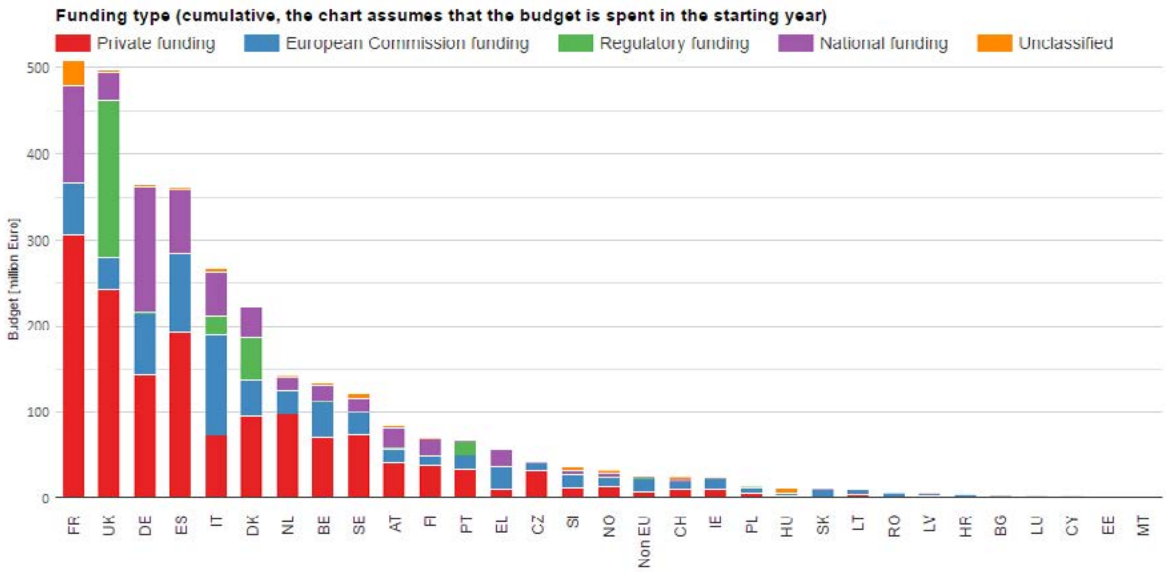


Figure 13 shows cumulative data regarding the allocation of the budget of SG projects in Europe between diverse funding sources. The chart refers to budgets spent in 2014.

Fig. 13: Source of funds for SG projects in Europe – year 2014 (107)



The graph shows with green color the budget managed by energy regulators to support innovative SG projects. It has to be noted that the level of regulatory funding (specific funding from national regulators to support SG projects) is perceived differently among the EU countries supporting SG projects. In this context, a significant contribution, by far, comes from the OFGEM through the 'Low Carbon Networks Fund' initiative in the UK[63]. This already represents a considerable effort and the scope for increasing this support will arguably depend on local conditions. However, the regulatory funding is not sufficient to support projects in all areas of the SG. For example, in countries where regulatory support has already been allocated to capital-intensive transmission or distribution reinforcements or to smart metering, it might be difficult to raise additional support for a wide range of SG R&D and demonstration projects (107).

In UK, since 2010, the energy regulator OFGEM has set-up the Low Carbon Networks Fund (LCNF) to provide regulatory funding for particularly innovative SG projects. In other countries, regulators are supporting the development of SG with specific tariff schemes guaranteeing an additional rate of return on SG investments. For example, in Italy, an additional 2% rate of return is given for SG investments which fulfil certain innovation criteria (107). Similarly, more than 50% of the Danish projects in 2014 are supported by the Forskel program, which is financed from tariffs.

63. As part of the electricity distribution price control that ran until March 31st 2015, OFGEM established the Low Carbon Networks (LCN) Fund. The LCN Fund allowed up to £ 500 million to support projects sponsored by the Distribution Network Operators (DNOs) to try out new technology, operating and commercial arrangements.

The UK energy regulator (OFGEM) supports innovative SG projects with technical opinions, management advices and with the largest funding in Europe dedicated to SG projects. According to OFGEM rules (in order to receive funding), the SG project manager must periodically publish detailed reports of the work achieved and ensure learning dissemination.

In this document, due to the important role of the ER and thanks to details provided about the projects, the examples of SG projects will be specifically focused on those supported by OFGEM and performed in UK. However, although the focus is on OFGEM supported projects, the feedback experience, difficulties experienced and issued recommendations are often the same as those experienced by other SG funded projects outside UK and thus can be considered as sufficiently generic to be generalized.

12.2 THE ROLE OF UK ENERGY REGULATOR

OFGEM (Office of Gas and Electricity Markets) is a UK non-ministerial government department and an independent National Regulatory Authority, recognized by EU Directives. Their principal function, stated by OFGEM, is the following: "*Our principal objective when carrying out our functions is to protect the interests of existing and future electricity and gas consumers*" (44).

As part of the RIIO[64] price controls, OFGEM has introduced Network Innovation Allowance (NIA)

64. RIIO: Revenue=Incentives+ Innovation + Outputs

and Network Innovation Competitions (NIC's). The NICs are annual competitions for electricity and gas, where network companies compete for funding for research, development and testing of new technologies, operating and commercial arrangements. These funding mechanisms aim at providing a financial catalyst for innovation on Great Britain electricity and gas distribution and transmission networks. In this context, funding will be provided for the best innovation projects which meet specific evaluation criteria[65] (108) and which help all network operators understand what they need in order to provide environmental benefits and security of supply at value for money as Great Britain. The progress achieved by the projects funded through this mechanism has allowed OFGEM acquiring more detailed understanding of benefits of SG, challenges and actions needed to address in the context mentioned above.

12.2.1 THE 2015 COMPETITION

OFGEM received seven submissions for the 2015 Electricity NIC asking for a total of £ 68.4 million. Five projects were approved for funding and two were unsuccessful. The following successful projects will receive a total of £ 44.9 million:

- "ANGLE DC (Scottish Power Manweb Plc): ANGLE-DC aims to demonstrate a novel network reinforcement technique by converting an existing 33kV AC circuit to DC operation. The technique could be used by DNOs as an efficient solution to create network capacity headroom and facilitate GB's objective for the shift towards a low carbon economy";

- "Celsius (Electricity North West): Celsius aims to be an innovative, cost-effective approach to managing potentially excessive temperatures at distribution substations, which may constrain the connection of low carbon technologies. By delivering new solutions to manage these 'thermal pinch points', Celsius could release additional capacity from existing assets, reducing long-term costs for customers and avoiding early asset replacement";

- "Future Intelligent Transmission Network SubStation (FITNESS) (Scottish Power Transmission): FITNESS aims to deliver the pilot GB live multi-vendor digital substation instrumentation system to protect, monitor and control the transmission network using digital communication over fiber to replace copper hardwiring, reducing cost, risk and environmental impact, and increasing flexibility, controllability and availability";

- "New Suite of Transmission Structures (NeSTS) (Scottish Hydro Electric Transmission): Overhead lines (OHLS) are the most recognizable aspects of the transmission network. The New Suite of Transmission Structures project aims to create a new breed of overhead line supports that are smaller, better for the environment and could save up to £ 174 million for customers before 2050";

- "Offline Substation Environment for the Acceleration of Innovative Technologies (OSEAIT) (National Grid Electricity Transmission): The project aims to modify an existing 400kV electricity substation into a field

65. OFGEM is supported in the review and assessment of the projects by an independent expert panel for each competition.

trial facility. This offgrid site will fully replicate a live substation environment to host electricity related innovation projects. This will be available for utilities to fast track the implementation of innovative new ideas on the electricity network" (109).

12.2.2 ANALYZED PROJECTS

Projects recently approved (described in the previous section) are in initial stage and there are no detailed data, especially related to faced issues. In the following sections, some important projects started before year 2015 will be analyzed, in order to provide useful information, also related to difficulties and obstacles in the implementation. The selected five projects are the followings:

- Project #1: "Low Carbon London" is a SG project in which measurements and evaluations of the impact of a variety of low carbon technologies are performed on London's electricity distribution network;

- Project #2: "Demonstrating the benefits of short-term discharge energy storage on an 11kV distribution network" is a SG project oriented to explore how electricity could be stored to overcome the challenge of intermittent power production from renewable sources;

- Project #3: "Capacity to Customers" is a SG project oriented to test the effects of a combination of enhanced automation technology, non-conventional network operational practices (i.e. increased network interconnection) and commercial demand side response (DSR) contracts, on the management of a HV system;

- Project #4: "33kV Super Conducting Fault Current Limiter" is a SG project oriented to facilitate the faster connection of distributed generation (DG) from renewable sources at the distribution level, by mitigating possible fault current management constraints;

- Project #5: "Customer-led network revolution" is a SG project oriented to study the combination of network technologies, such as enhanced automatic voltage control, real time thermal rating and electrical storage, and flexible customer response from both demand and generation, in order to reduce network investments and the use of carbon technologies.

13 PROJECT #1: LOW CARBON LONDON

13.1 BACKGROUND

The "Low Carbon London" (LCL) project was a large-scale and complex work. The goal was to measure and evaluate the impact of a variety of Low Carbon Technologies (LCTs) on London's electricity distribution network, through a series of demonstration projects. The LCL project was established in January 2011 and completed in December 2014 with the findings, conclusions and recommendations contained in a portfolio of 27 final reports produced throughout 2014[66] (110).

66. The project also carried out a wide ranging learning dissemination program to communicate these outputs to other Distribution Network Operators (DNOs), industry bodies and other

The project gained approval from OFGEM on December 17th 2010, and formally commenced work on January 4th 2011 and completed work on December 31st 2014. The project applied and had approved a single change request in December 2012 with approved funding of £ 21.7 million from OFGEM.

13.2 GENERAL DESCRIPTION

The project was contracted to introduce, test and prove three fundamental methods and elements of operating and managing electricity distribution networks:

- New commercial arrangements to maximize network utilization and improve load factor;
- New system design and planning practices that leverage the benefits of active network management and customer participation;
- New operational practices such as active management of demand, generation and network configuration to optimize network power flows and minimize constraints.

In the provided project reports and related information, the work related to load-shift is described with these words: "*In conventional circumstances, network utilization and load factor is determined by the need to meet peak demand, even if this peak demand is relatively short-lived, and assumes that existing customers cannot shift their load. The project's methodology explored the ability to shift load. Separately the project measured the impacts and the opportunities offered by LCTs connected to the distribution network, through a series of experiments and trials*" (110).

13.3 PARTNERS

The project partners ranged from:

- London government agencies such as Transport for London and the Office of the Mayor of London (which also incorporated the previous London Development Agency);
- electricity distributors system operator (DSO): UK Power Networks;
- electricity demand aggregators and energy companies: EDF Energy, Flexitricity, EnerNOC, Smarter Grid Solutions, CGI, Siemens;
- academic partner: the Imperial College institution (110).

13.4 LESSONS LEARNED FOR FUTURE INNOVATION PROJECTS

13.4.1 TRIAL PARTICIPANTS

The recruitment of Industrial and Commercial (I&C) DG trial participants took an extended period to complete. It was due to multi-layered approvals required in prospective participant organizations. It was a problem particularly where DG installations were managed by outsourced management organizations and the permissions require the work of numerous separate organizations. Similarly, the negotiations of trial commercial collaboration took a lot of time, in part due to

interested parties through a series of roadshows and public events.

the novelty of the proposals[67]. Another problem, concerning the collaboration with institutional high profile partners, is the reluctance to consider any proposition that was defined “trial”, as it was deemed as an unacceptable risk, sometimes without understanding any of the detail of the proposition.

A suggestion for future projects is that, commercial organizations are required to document formally their participation, perhaps through a Letter of Intent, as part of the bid process. In addition, trial recruitment processes should identify contingency options as part of the initial solution design submitted to OFGEM (110).

13.4.2 CENTRAL PROJECT MANAGEMENT AND CONTROL BY THE DNO

At the beginning of the project, the DNO decided to actively lead and manage all aspects of LCL project. It reduced management risks and ensured that all the project’s various activities remained true to the original aims and objectives[68]. To permit the control of every part of the project and to reach the dissemination targets (according to OFGEM rules) the DNO obligated the compilation of reports to be adhered to throughout the project by all project team members, whether from the own DNO or from a partner organization (110).

67. The trial participants need a lot of time to understand and assess the ramifications in organization and management.
68. To control every step of the project, the DNO needed to have a detailed oversight of the entire project’s work at all times; that required to the DNO to place a number of its own personnel in key positions in the project (e.g. in the solution design and architecture office or in leading key project workstreams).

13.4.3 OPTIMUM PARTNER SIZE AND MIX

LCL was a project led by UK Power Networks with many other partners. Such a large and diverse range of interests presented unique challenges to the project in keeping partners engaged all over the project (four years). The general nature of London’s high levels of economic activity meant that several key partner project personnel changed through the project due to individuals changing jobs and employers, which at times presented additional risks and opportunities to the project.

The recommendation from the main stakeholders for future similar projects is to carry out these kinds of works with fewer partners, in a narrower scope and with shorter timescales (110).

13.4.4 SOLUTION DESIGN AND DEVELOPMENT

The LCL project required significant further solution design and development after the acceptance of the bid project approved by OFGEM. This activity occupied the first 12-15 months and the project was in “stand-by” mode during that time with little outward sign of progress (110).

The recommendation for future projects is that the SG project manager should define the level of maturity of the submitted draft design at the bid stage. It should indicate the remaining work envisaged to turn the submitted design into a workable detailed solution.

13.4.5 PROJECT REPLICATION AND SMART GRID TECHNOLOGIES

Smart Grid technologies are still at the early stages of development. Many areas are also subject to rapid technology refresh and innovation. For projects that have a lifespan of several years, as was the case with LCL work, this can have implications for how the project's findings and outcomes could be replicated, as much of the technology may either be obsolete or have been subsequently replaced with a more advanced and recent versions or alternative. LCL started with the best available Advanced Network Management (ANM) technologies in 2010 and 2011. At the end of the project (2015) they are already obsolete, no longer available and replaced by more advanced technologies: this can affect and delay the projects replication and must be taken into account (110).

13.4.6 REGULATORY BARRIERS

Throughout the program, the DNO has reviewed the potential to deploy or utilize all of the techniques investigated as part of the LCL project. This review has included consideration of any regulatory barriers to deployment. From a regulatory perspective, there have been no identified barriers to direct deployment of any techniques or commercial arrangements at the date of this report (110).

13.4.7 LEARNING DISSEMINATION

According to OFGEM rules, one of the goals of the project is the learning dissemination. The project appointed a learning dissemination manager who worked actively throughout the project to develop, review, consolidate and disseminate learning, using the following instruments:

- Partner communication steering group: best practice used elsewhere was brought into and used in LCL;
- Low Carbon London learning dissemination events: they have been held on a range of topics throughout the project with a wide variety of stakeholders attending, including other DNOs, DECC, OFGEM, press, energy suppliers, CHP operators, energy consultancies, EV public charge post operators, etc.;
- National and international conferences[69];
- Project website (111).

14 PROJECT #2: DEMONSTRATING THE BENEFITS OF SHORT-TERM DISCHARGE ENERGY STORAGE ON AN 11KV DISTRIBUTION NETWORK

14.1 BACKGROUND

UK Power Networks DNO installed a 200 kWh Li-Ion Energy Storage System (ESS) at an electricity substation site at Hemsby, near Great Yarmouth, to understand the impact and potential benefits of small-scale electricity storage on a distribution network. The battery was procured in 2007 as

69. More details are available in (110).

part of the AuraNMS (Autonomous Regional Active Network Management System) research project, which received support from the Engineering and Physical Sciences Research Council (EPSRC) and the Innovation Funding Incentive (IFI).

Having commissioned the device in April 2011, UK Power Networks registered the first Low Carbon Network Fund (LCNF) Tier 1 project to gain real, practical experience with the device and its capabilities, and to disseminate the findings to the other DNOs.

The project was awarded funding of £ 225,000 by OFGEM, under the LCNF scheme in December 2012 and will last four years, from January 2013 to December 2016 (112).

14.2 GENERAL DESCRIPTION

Martham primary substation is a primary substation on UK Power Networks' 11 kV networks with attached distributed generation (DG): a wind farm with 10 turbines (each of 200 kW generating capacity). The network is robust to all current combinations of load and generation; nevertheless the future load growth and additional distributed generators would eventually create technical and energy flow management problems.

The project included multiple objectives:

- "Test the storage device's capabilities on a real electricity network;

- Demonstrate load-shifting capability of the device;

- Study how a battery could manage larger amounts of demand or generation;

- Consider and rank the value of other proposed uses for batteries, both to electricity network operators and intermittent generators;

- Understand the potential lifetime of the battery;

- Embed the findings into a design tool for network planners and share the tool with other DNOs" (112).

In Figure 14 are shown the line diagram scheme including the main components of ESS and the installation as built.

Fig. 14: Left: Single line diagram showing main components of ESS;
Right: The ESS installation as built (112)

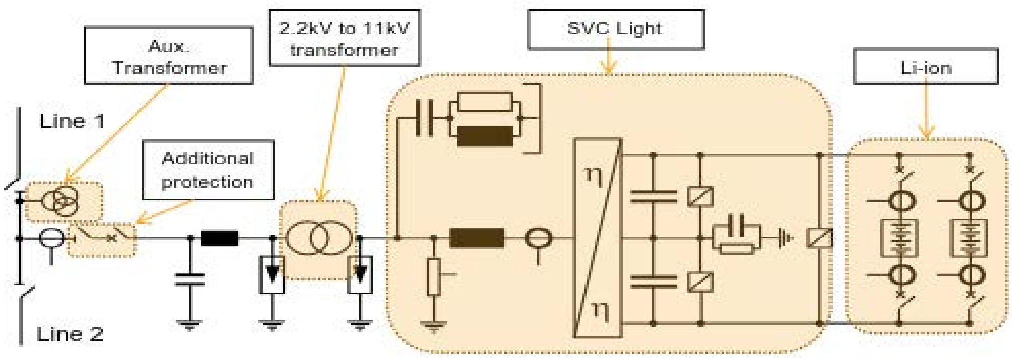


Figure 13 Singe Line Diagram showing main components of ESS

In the project, UK Power Networks also demonstrated a SG architecture comprising ABB's devices and which were demonstrated to support software written by a third party (neither UK Power Networks nor the vendor) and reacting to signals from multiple remote sites. Separation of software from hardware is considered as an important move towards open standards for future SG applications. The application in this trial is believed to be an industry first by UK Power Networks.

14.3 PARTNERS

The project partners are:

- UK Power Networks (DNO) as the leader of the project;

- ABB is a power and automation technologies international company that contributed with funding, hardware and software support and technical consultations;

- Newcastle University as academic partner (112).

14.4 LESSONS LEARNED FOR FUTURE INNOVATION PROJECTS

14.4.1 SYSTEM RELIABILITY AND PILOT SITE SELECTION

Over the course of the trial, full system reliability (of both the ESS and the remote monitoring network) was one of the major challenges. All components were commercially available, nevertheless when combined into one system, reliability was not guaranteed. The trial experienced numerous reliability issues: from the loss of communication to remote monitoring sites to disconnections of the ESS from the 11kV network. The main causes of these instabilities were: a poor GPRS connection in the remote location of the ESS system and the freezing of the Remote Terminal Units (RTU). These problems caused the unit to stop monitoring and transmitting data and required the mobilization of additional resource (an engineer) to go on site and reset the unit.

The suggestion for future projects is to choose a location for an innovation trial in a not so much remote area. It will improve operations and can strengthen the educational value. Due to the specificities of these projects, innovation projects require more attention and site visits than old technologies. Selecting a remote location, such as the rural one of this project, can pose operational issues, as the number of technical staff available for inspections and interventions will be limited. Distance to site from the main transport hubs also has an impact on the number of visitors willing to attend dissemination events. Other operational issues include the availability and reliability of communication channels such as GPRS and the suitability of road infrastructure, as roads can be too small to transport large equipment (112).

14.4.2 SECURE SUITABLE COST EFFECTIVE ENERGY CONTRACTS FOR SMALL SCALE ESS INSTALLATIONS

At the time of commissioning, the suite of contracts available to the Hemsby installation was limited, due to the limited available capacity that could be of value to an energy supplier and to novel nature of the installation for most suppliers. Where available, the contracts were typically either developed for demand or generation. This kind of contracts does not always fit the characteristics of a storage device, particularly when the charge and discharge patterns are unpredictable. Exploring suitable commercial arrangements with an energy supplier is a key point (which should be studied with the collaboration of all stockholders, especially the energy regulator) (112).

14.4.3 IMPLEMENTATIONS NEEDED FOR THE TRANSITION TO THE BUSINESS CASE

Thanks to experience in this ESS projects, some key points for the transition to the business case are defined in this words:

- "The financial business case and use case for maintaining and using the site has to be understood: nevertheless which stakeholder should be the controller and manager of the behavior of the plant must be defined;
- Control room visibility and integration is a key point: the control room needs to have visibility of the site, receive its alarms and understand the way it works and any possible peculiarities;
- The IT infrastructure has to be well integrated in the Corporate Network, including access right management, firewalls and communication line contracts in order to facilitate the remote management;
- The site reliability and availability are not trivial point and they should be more investigated also in other similar projects" (112).

14.4.4 OTHER RECOMMENDATIONS FOR FUTURE PROJECTS

When Hemsby started delivering its first learning, UK Power Networks concluded that "*the storage technology itself, although not yet mature, was not the main barrier for large scale application of storage*". It was UK Power Networks' view that the uptake was predominantly hindered by unclear economics and economic models of DNO owned energy storage (112). The conclusion is that the economic viability of DNO owned and/or third-party owned storage can be improved by the following methods:

- Reduction of the installation and operation costs[70];
- Increase benefits (income streams) by combining use cases[71].

14.4.5 LEARNING DISSEMINATION

According to OFGEM rules, one of the goals of the project is the learning dissemination. The project used the following instruments:

- Free access reports;
- National and international conferences[72];
- Project website (113).

70. This is an area of continuous effort by the energy storage industry and academic community.
71. This is an area of recommendation for the DNO community and for the energy regulator.
72. More details are available in (112).

15 PROJECT #3: CAPACITY TO CUSTOMERS

15.1 BACKGROUND

Meeting growing electricity demand requires additional network capacity and the use of traditional intensive reinforcement techniques requires significant investment. A 2009 OFGEM consultation document estimated that required investment in the GB transmission and distribution network could be as much as £ 53.4 billion between 2009 and 2025. In UK, the current planning and design standard, requires, in broad terms, that for every extra 10 MW of capacity installed, 20 MW of infrastructure is needed. Such investment would have to be paid for by customers through higher connection and use of system charges (114).

In summary the Project looked to test two different elements:

- The enhanced technology used to enable the Capacity to Customers (C_2C) Method;

- The customer engagement which facilitates the commercialization of the Method.

OFGEM has granted Electricity North West £ 10 million from the LCN Fund to develop its ground-breaking C_2C initiative, which lasted from April 2013 to December 2015 (114).

15.2 GENERAL DESCRIPTION

The objective of Capacity to Customers (C_2C) Project is described with these words: "*The objective of the C_2C Project was to test a combination of enhanced automation technology, non-conventional network operational practices (i.e. increased network interconnection), and commercial demand side response (DSR) contracts alongside customer acceptance to such changes. These innovations were trialed on defined trial circuits, representing approximately 10% of Electricity North West's high voltage (HV) system*"(114).

The Project aimed to prove that the techniques could efficiently release inherent capacity on EHV and HV systems to accommodate future forecast in demand and DG growth, whilst avoiding or deferring the cost and environmental impacts that are associated with traditional network reinforcement[73]. Specifically the C_2C method redesigns the network to allow the NOP (Normally Open Point) to be run closed, allowing the whole capacity of the grid loop to be used by joining the two circuits. To ensure that security of customer supply is maintained and supplies can be restored during fault outages, the C_2C method has developed and tested new post-fault demand response contracts which will allow DSO to either reduce consumption or reduce generation depending upon the nature of the post fault constraint being addressed (114).

73. Current EHV and HV networks use redundancy and network interconnection to achieve security of supply standards. Network feeders are interconnected by a normally open point (NOP) which is only utilized in the event of a network fault or planned outage. In UK, nearly half of circuits do not suffer any faults, and one third experience faults lasting 1–2 hours in any five-year period. Under such conditions, closing the NOP allows all customers affected by a fault outage to be re-supplied from the alternative circuit. This means EHV and HV circuits typically operate at only 50–60% of their rated capacity. It is this inherent capacity that the C_2C method seeks to release for use by customers for the connection of new loads and generation (114).

15.3 PARTNERS

The project partners ranged from:

- DSO: Electricity North West;
- TSO: National Grid Electricity Transmission (NGET);
- Demand response operators and energy companies: GE Energy, Parsons Brinckerhoff (PB) Ltd, Flexitricity, EnerNOC and Npower;
- Market research agency: Impact Research;
- Academic partners: University of Strathclyde and University of Manchester (114).

15.4 LESSONS LEARNED FOR FUTURE INNOVATION PROJECTS

15.4.1 CUSTOMER ENGAGEMENT AND FEEDBACK

15.4.4.1 Engaging and understanding Industrial & Commercial (I&C) customers

In order to recruit I&C customers to participate in the initial survey about energy contracts, the DSO provided the market research agency with a database of I&C customers on the selected C_2C circuits. However the database contained very few telephone numbers and one of the biggest barriers was the telephone number not being recognized[74].

As a distribution business, the absence of a detailed customer database also created challenges when attempting to contact role holders within organizations who were responsible for the energy usage. It took on average three calls to reach the most appropriate contact, which normally meant going through the switchboard, verifying the correct company, explaining the objective of research and then being referred on, which could involve multiple call backs. The switchboard can often be a blocker. Some companies operate a policy whereby they will not put callers through to the relevant department without a named contact. On these occasions list brokers and social media platforms like LinkedIn were used to source named contacts.

To replicate a similar activity, additional time should be allowed to source accurate telephone numbers and recruit customers to take part in the project. It is recommended that a suitable fieldwork period for recruiting I&C customers to take part in a survey is taken into account. A partnership with a supplier or appropriate third party would also be beneficial to help obtaining accurate customer data (114).

15.4.1.2 Incentives for collaboration

In order to ensure a fast survey completion, a number of incentives and support arrangements were implemented and are suggested for future similar projects:

- Online vouchers were offered and processed if customers took part within a specified time;

74. The lack of contact numbers is likely to be problem for any DNO whose customer records are sourced from the address management system (AMS) managed by suppliers as some customer records are incomplete or inaccurate.

- Donations were offered to a choice of several different charities.

Amongst the population that were recruited, one of the biggest barriers to completing the survey was customers not having time to take part within the survey fieldwork period allocated. The main issue was that the survey was considered important but not urgent hence, a lot of the 500 customers who had initially agreed to take part, did not, despite the significant effort that went into finding the most suitable person to speak to has followed by a number of reminders. It became apparent after a short time that I&C customers placed a much higher value on their time than anticipated and required a wider range of support and incentives to be offered, namely:

- A Kindle prize draw to all participants;

- Interviewer assisted telephone surveys instead of an online self-completion method;

- Appointments to complete the survey at convenient times for customers, sometimes out of hours;

- Providing proof of donations to charities on request.

This led to an increase in the number of completed surveys during the later stages of fieldwork which meant a statistically robust sample size could be attained. When considering recruiting I&C customers to participate in research, consideration should be given to offering a wide range of support and incentives (114).

15.4.1.3 Communicating with domestic customers

The Engaged Customer Panel (ECP) demonstrated that customers have little or no information about:

· The network operators;

· The role of a DNO versus suppliers;

· The increasing demand for electricity;

· The need to potentially expand the electricity network.

Future participants need an understanding of these before the concept of C_2C could be introduced. To maintain interest and credibility, customers must also be reassured on the reliability of their supply. The ECP further demonstrated that the most effective way of communicating this information is through a simple question and answer factsheet, video material and a C_2C concept board[75].

A key learning outcome was that most customers needed “awareness” about the role of DNOs and why projects such as C_2C are necessary to meet future electricity demand. Only when this had been established, material on the project was effectively presented. (114).

15.4.2 OTHER FACED ISSUES

More information related to the difficulties faced during the execution of the project (from both management and technical points of view) are available in (114).

75. It explained the C_2C targets and how customers on a C_2C Trial circuit were affected.

15.4.3 PROJECT REPLICATION

During the lifetime of the project, the C_2C concept has become readily established and has subsequently been deployed by the Electricity North West DNO and that is now made available (would be transferable) to all UK DNOs. For Electricity North West, the C_2C method will form part of a suite of strategic interventions for RIIO-ED1 and where appropriate, actively implemented to defer or avoid network reinforcement issues.

15.4.4 LEARNING DISSEMINATION

According to OFGEM rules, one of the goals of the project is the learning dissemination. The project used the following instruments[76]:

- Free access reports;
- Dissemination events;
- National and international conferences;
- Project website (115).

16 PROJECT #4: 33KV SUPER CONDUCTING FAULT CURRENT LIMITER

16.1 BACKGROUND

To facilitate the connection of distributed generation from renewable sources at the distribution level, the network needs to be capable of dealing with the increase in fault level associated with such connections.

Strategically placed in distribution networks, Superconducting Fault Current Limiters (SFCLs) could improve the grid capability by limiting the fault current to within the rating of existing switchgear. The installation of these devices could allow the connection of higher number of renewable generators with reduced network reinforcements[77]. Currently in UK, a number of primary and supply point substations on the Northern Powergrid network have been identified as having a maximum switchgear duty greater than 95% of the make/break duty rating. This would be typical for the UK network as a whole. The connection of additional DG to these sites may increase the fault level beyond the switchgear rating (116).

16.2 GENERAL DESCRIPTION

This project was designed to test new equipment that has a direct impact on the operation and management of the distribution system. The description of the project is the following:

"*The first phase of the project was to identify suitable locations for the installation and undertake a feasibility and systems readiness study to analyze the network, outlining the optimum application and specification, and confirm the business and carbon cases. The second phase was to design, build, install and commission a three-phase 33kV superconducting fault current limiter on the Northern Powergrid distribution network. It was proposed, and following site surveys, agreed with National Grid, that the unit was installed at a*

76. More details are available in (114).

77. Network reinforcements are often required to cope with the increased fault level, typically before new DG can be connected.

275/33kV substation in South Yorkshire to facilitate future connection of DG and additional load by limiting the likely increase in fault current to within the rating of the 33kV switchgear. The increase in the fault level is typically managed through an operational management switching procedure which, in limited circumstances, may increase the risk of loss of supply to customers" (116).

The project was awarded funding of £ 3.2 million by OFGEM under the LCNF scheme in 2010 and lasted four years, to October 2014.

16.3 PARTNERS

The project partners ranged from:

· The UK electrical DSOs: Northern Powergrid and Scottish Power Energy;

· The UK electrical TSO: National Grid;

· Applied Superconductor Ltd (ASL): is an enterprise based in Blyth, Northumberland, with the aim to produce a superconducting fault current limiter (SFCL) suitable for use at 33kV[78];

· Atkins Company: it is a consultant company for the design and project management. It has acted as the key design and installation contractor and project management and engineering consultant (116).

16.4 LESSONS LEARNED FOR FUTURE INNOVATION PROJECTS

16.4.1 SUCCESS CRITERIA NOT MET

The project was concluded without the achievement of the objectives. The SFCL device has failed high voltage testing twice. As a result the requirements of both the installation outage schedule and the project time limits mandated by OFGEM have not been met. Consequently, at the conclusion of the project, the tested technology was not able to meet the required performance specification.

During the course of 2014, the original manufacturer of the SFCL had financial difficulties. The technology and the project were bought by ASG Company from Genoa, Italy. ASG is currently trying to address the design and manufacturing issues that caused the HV failures. If this is successful, according to the other stakeholders, the final installation phase of the project could be completed.

Although the project did not achieve its ultimate objective, learnings have been generated, particularly with regard to the circumstances under which an SFCL, or other fault current limiting device, might be specified and used. In particular the relative advantages and disadvantages of various installation configurations and location of the device within the circuit have been determined. More details are presented in appendices of the close-down report (116).

78. ASL was replaced by ASG Power Systems Limited in early 2014, the result of ASL financial difficulties.

16.4.2 STANDARD COMMERCIAL AND TECHNICAL BOUNDARY DEFINITIONS

The use of a jointly owned site has been particularly useful in the identification of implementation issues which are faced when the transmission and distribution networks managements interact. The results of the work show that it is not possible to conduct a project of this type, if the boundary between the systems (distribution and transmission) is considered to sit at the ownership boundary of TSO and DSO. In the present case, the benefit of the device is on the distribution network, but the installation is on the transmission network and in order to obtain the maximum effect, and therefore the max cost benefit, the new devices were embedded in the transmission network[79] [80].

The project has been able to overcome the boundary issues, mostly as the result of very close working between all the stakeholders. This high level of cooperation requires high resources (workers and money); therefore it looks as it cannot be easily applied for BAU implementations and a standard approach needs to be agreed to avoid this. The final embodiment of this is likely to be a complex commercial and legal issue (116).

For this project, the installation boundaries and how the various responsibilities were allocated can be summarized as per the following table:

79. As well as for this specific device, this is likely to be the case for other types of technology in the future which improve the overall effectiveness of the system as a whole.

80. In order to consider the new interactions in future SG systems, new technical, operational and contractual arrangements need to be developed to allow the cost effective evolution of the total network system to accommodate low carbon technologies or other approaches to maximize value for money for the customer.

Table 3: TSO and DSO responsibilities (116)

	Standards	Ownership	Operational
Civils	TSO	TSO	TSO
Fault current limiter	TSO	DSO	TSO
Isolators	TSO	DSO	TSO
Bypass breaker	TSO	DSO	TSO
Low voltage supply	TSO	TSO	DSO
Protection - Bypass	TSO	DSO	DSO
Protection - Trip	DSO	DSO	DSO
Maintenance	TSO	TSO	TSO
National Grid Scada	TSO	TSO	TSO
Northern Powergrid Scada	DSO	TSO	DSO

Safety	TSO	TSO	TSO
Power quality meters	TSO	DSO	DSO
Magnetic field	TSO	DSO	TSO
Land	TSO	TSO	TSO

Another significant issue that arose from the nature of the boundary was the type registration of equipment. Type registration is required for equipment on the National Grid network but such registration is often not available for 33kV equipment, for which National Grid does not generally have a requirement[81].

16.4.3 FURTHER IMPLEMENTATION OF FAULT CURRENT LIMITERS

The site closedown has preserved the option to resurrect and complete this project at a later date. There is a large amount of sunk cost and the additional resources required to meet the final implementation and learning objectives are relatively small. This is entirely dependent on the ability of ASG to identify and rectify the root cause of the testing failure and to successfully complete all of the required functional HV testing. If these conditions can be met a decision will be taken regarding project completion, probably funded under the new ED1 Network Innovation Allowance. This decision will be based on the potential cost to completion, the value of the additional potential learning and the technical state of the art, with respect to such fault current limiting devices, and other DNO's project outcomes at that time.

81. Specific type registration issues for key equipment are discussed with details in (116).

A full assessment of the project and benefits to the customers will be made, in line with innovation stimulus governance procedures and business investment appraisal, before any new project is initiated.

This approach has been agreed in principle with OFGEM but will be subject to further discussion, at the appropriate time, if it is believed that the completion of the project learning provides value for the customers' money required (116).

17 PROJECT #5: CUSTOMER-LED NETWORK REVOLUTION

17.1 BACKGROUND

The growth in low carbon technologies places additional strain on electricity distribution networks, which were not designed for a large penetration of these technologies. The "Customer-led network project" aim to reduce costs associated with mass uptake of green technologies by using a combination of:

- New network technologies, such as enhanced automatic voltage control, real time thermal rating and electrical storage;

· Flexible customer response from both demand and generation[82].

The project manager used these words to describe the innovation introduced by this work: "*While network management and demand response technologies already exist and are well documented, they had not previously been deployed at distribution level in a market with the degree of vertical separation of Great Britain. The Customer-Led Network Revolution (CLNR) project aimed at providing the knowledge and experience necessary to bridge this gap*" (117).

The project began in January 2011 with approved funding of £ 27 million and completed work on December 31st 2014.

17.2 GENERAL DESCRIPTION

The project started with the analysis of the basic demand profiles of typical business and domestic customers and those with heat pumps, electric vehicles, micro-CHP and PV systems (using smart meters) and the more detailed disaggregation of some customer load profiles down to individual appliances (using additional metering). This was performed in order to update the statistical analysis of the existing standard for the design of low voltage radial networks. The final goal is to improve the planning of future LV networks and to provide a baseline against which to measure the impact of demand-side response projects[83].

After the demand profile analyses, the development of various tariffs (and other interventions for domestic and business customers) was performed with and without LCTs to test their weakness in providing a DSR, in helping reduction of peak loading and in preventing thermal and/or voltage constraints on the network.

Then the work continued in order to understand how to make the network more flexible and determine the costs of the flexibility. It involved testing network technologies and an active network management (ANM) control system, called the Grand Unified Scheme (GUS) control system, in a series of large-scale field trials.

Another goal was to find the overall optimum solutions to resolve future network constraints which could result from the transition to a low carbon economy.

The last goal to achieve was to provide a framework for transition of the technologies and interventions tested by CLNR into BAU. For example, the outputs for DNOs include:

· The provision of a prototype software tool for network designers;

· Material for training courses;

· New operational procedures to define safe

82. This will only happen if new commercial arrangements between suppliers, distribution network operators (DNOs) and customers are developed.

83. The project monitored 10,006 domestic customers (9,096 general, 344 heat pumps (HP), 160 photovoltaic (PV), 14 micro-CHP, 159 electric vehicles (EVs) and 233 with electric hot water / storage heating), 1,880 small commercial customers; and 160 merchant generators) and analyzed the consumption data. Additionally, DNO metering data for 17,639 I&C customers was collated for analysis to support the time of use tariff signal effectiveness study" (117)

working practices for new technologies;

· Design policy guidance;

· Equipment specifications and equipment application documents;

· Recommendations to update national design standards (117).

17.3 PARTNERS

The project partners include:

· The UK electrical DSO: Northern Powergrid;

· British Gas is an important energy supplier that collaborate in the project working in customer recruitment and engagement activities;

· EA Technology is a private company that provided site-specific solutions, equipment specifications and technical support;

· Durham Energy Institute (part of Durham University) and Newcastle Institute for Research on Sustainability (NIReS) (part of Newcastle University) acted as academic partners (117).

17.4 LESSONS LEARNED FOR FUTURE INNOVATION PROJECTS

17.4.1 ISSUES RELATED TO THE INSTALLATION OF SMART APPLIANCES AND MONITORING EQUIPMENT

There was frequently long delays installation of new equipment in homes (as it often involved people having to take time off work). The reasons are the followings:

· Installation of secondary monitoring equipment (which was needed for non-British Gas customers) often necessitated installing an isolation switch. This could only be arranged through the meter operator for the customer's supplier;

· In some cases the equipment is bulk and require appropriate space for the installation: this has resulted in a problem for the customer and related delays;

· Many premises do not have access to broadband or even a telephone land line[84];

· Smart appliances are still at an immature product lifecycle stage (117).

There are issues of compatibility between devices and manufacturers, and communications issues. Inevitably, with such a large project, data issues arose. These included failure of data communication in customers' premises, data compatibility issues between project partners and the amount of effort needed to get the data into a suitable state for analysis. For future projects, the suggestion is to guarantee the presence of a data manager, whose role would be to ensure the end-to-end integrity and compatibility of data flows.

84. This is an important consideration for future project's installing smart appliances.

17.4.2 INDUSTRIAL & COMMERCIAL (I&C)

One of the goals of the project was to make I&C DSR ready to be BAU. Nevertheless DSR requires further innovation and the main faced issues are described with these words in the closed-down report of the project:

- "*The location of customers that are willing to offer the level of DSR response required by DNOs is difficult;*
- *The nature of call off required is likely to reduce the number of customers that are capable or willing to participate in these schemes;*
- *When targeting a tight geographic area the initial customer drop-out rates can be high. The DSR reliability levels experienced during the trials means that DNOs need to over-procure capacity to achieve the required level of network security;*
- *The contract arrangements need to be simple to understand, simple to operate and must offer a fair price to the provider and the DNO in order to be viable;*
- *It is easier to procure DSR from standby generation than find a truly flexible load*" (117).

17.4.3 SAFETY PROBLEMS

Where an innovation project involves network equipment, as a result of the experimentation, the suggestion is to engage with Health and Safety stakeholders within the DNO and the emergency services and industry working groups. The identification of hazards and the mitigation measures to reduce risk should give confidence to Health and Safety colleagues and other affected colleagues such as control, operations and protection engineers, to enable the tested equipment to be successfully deployed and operated on the live network. In some cases it may be necessary to also develop new procedures to cover the installation or operation of novel equipment or new methods of installation or operation (117).

17.4.4 TRANSITION TO BAU: POLICIES AND PROCEDURES

A successful on-site demonstration requires the participation from a wide number of areas of the business such as safety, control, operations, training and protection, etc. When then working towards transition from a trial to roll out into BAU, the methods associated with this new equipment will require integration into all these areas of the business and some more, such as system strategy, design and maintenance, and this will require updating a number of existing policy and procedural documents, and in some cases creation of entirely new material. Confidence in new technology is realized from experience with it, an amount of expert thinking time to consider all outcomes is essential and provision for this should be built into any project plan (117).

17.4.5 SYSTEMS RELIABILITY

As seen in other projects[85], the reliability of the

85. The reliability of the system was already discussed in

system is a parameter that must be defined a priori, when deciding on the communications infrastructure. For example, especially in rural areas, GPRS communications may not be able to provide the level of reliability that is required for control purposes, although it may be possible to cost effectively address this by use of roaming SIM contracts. By deciding what should be measured and controlled remotely rather than centrally, it may be possible to reduce the communications burden and infrastructure required, while at the same time form part of the fail-safe mechanism in the event of communications loss (117).

17.4.6 LEARNING DISSEMINATION

According to OFGEM rules, one of the goals of the project is the learning dissemination. The project used the following instruments:

- Free access reports;
- Dissemination events;
- National and international conferences[86];
- Project website (117).

18 OTHER ER FUNDED SMART GRID PROJECTS

As seen above, among the five selected and analyzed countries, apart from UK and OFGEM, two other ER, namely in Italy and Denmark, play a role in funding and monitoring SG projects. In Italy the projects under ER regulation are financed by electricity tariffs and monitored by AEEGSI (25). Other projects have been launched by the government under different funding mechanisms as for example through EC funding which is not monitored by AEEGSI.

18.1 ITALIAN REGULATOR OVERVIEW

The AEEGSI has been active in promoting the SG development in Italy by investing in research and development as well as in real life pilot projects to be able to speed up the SG era in Italy and modernize its electrical grid while encouraging renewable energy sources exploitation. To better do this, the regulator has been involved in incentivizing innovative solutions with an emphasis on promoting SG projects while tackling some grid issues such as reducing congestions in transmission networks, facilitating network modernization and adequacy, storage, etc. The remuneration scheme is guaranteed up to 8-12 years for new strategic investments meeting these interests (120).

The regulator is involved and supports the best projects (in Research Institutes, companies and University). This approach is designed around an input-based incentive scheme, awarded, on the basis of a competitive process, to a limited number of projects.

According to AEEGSI resolution, selected SG demonstration projects benefit from an extra remuneration of capital cost (+2% increase of the

Project#2
86. More details are available in (117).

WACC - Weighted Average Cost of Capital - for 12 years with respect to ordinary remuneration) for a period of 12 years (118) (119). This initiative is funded through the network tariffs, and so far has been awarded to eight demo projects. The admission procedure for demonstration projects states that the selected projects should show a definition of minimum requirements for SG demonstration projects. A committee of experts is appointed to evaluate and select the projects on the basis of KPI (Key Performance Indicators) approach and on the selection of the most cost-effective projects. The expected benefits are expressed in terms criteria based on increased acceptance of RES by the grid, participation of DG to voltage regulation, controlling power flows at the primary substation (DSO/TSO) namely to manage reverse flows, and replicability.

For example, the Enel Distribuzione's Smart Grid project on optimal regulation of the bi-directional flow of electricity generated from renewable resources on low and medium-voltage networks and enabling new uses of energy, was the winner of a competition conducted by the Italian regulator AEEGSI to award financial incentives for innovative SG solutions that sought to promote the involvement of both distributors and customers (119).

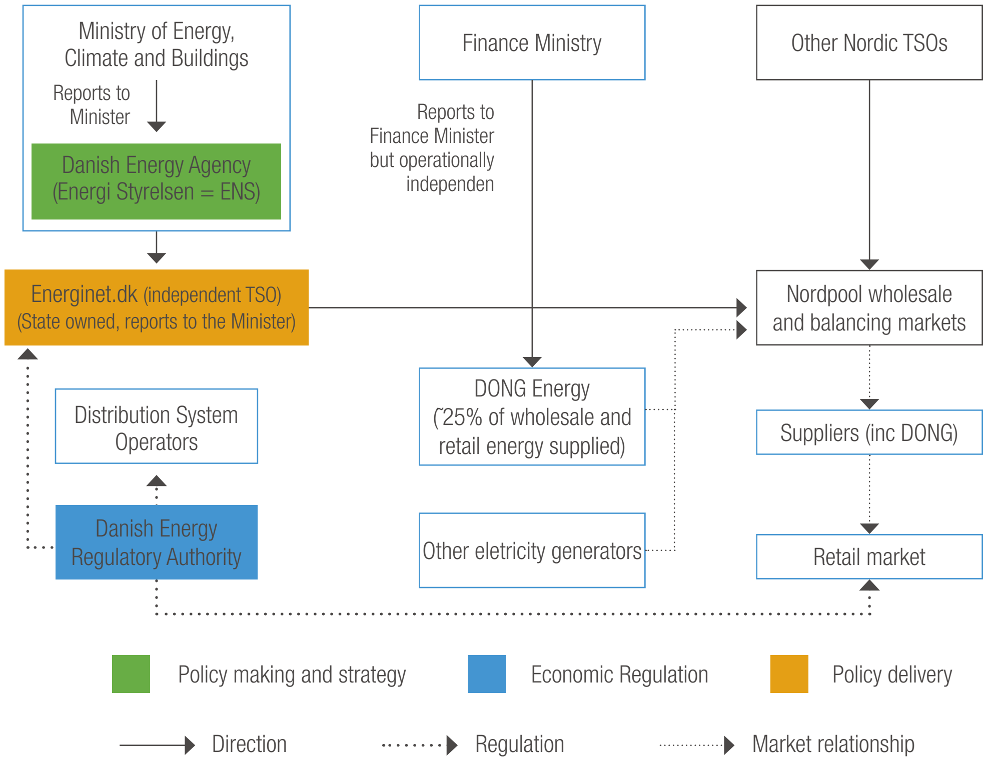
18.2 DANISH REGULATOR OVERVIEW

Denmark is well known as one of the world leaders in the transformation towards a sustainable energy future (e.g. in 2014 around 40% of the electricity were produced by wind farms). In 2012 an Energy Agreement has been set up, which states the target to reach 100% of renewable energies by 2050. This ambitious target can only be met with efficient actors and a suitable public motivation (121).

One of them is the Danish Energy Regulator Authority (DERA), which was established in 2012 in order to fulfill the third European Package on energy liberalization. Before 2012 the regulation in the energy sector has been done by the overall National Competition Authority (NCA). The DERA acts independent of the government and aims to ensure a well-functioning sector of electricity, gas and heating (121).

Since DERA focuses only on the implementations of regulations according to laws without doing any policy development, it is an economic regulator. Furthermore, because of its position (Figure 15) and its relation among all other actors, DERA has only a quite narrow role.

Fig. 15: Current Institutional arrangements in Denmark (121)



In contrast, the Danish Energy Agency for example, has overall responsibility for decarbonisation, cost and long-term security of supply. Furthermore, it acts as policy developer; it supports political processes and initiates research and development projects (121). As such, most of R&D and demo projects in the area of SG are conducted under Forskel and Energinet.dk program and support. For example, more than 50% of the Danish projects in 2014 are supported by the Forskel program, which is financed from tariffs. Indeed, Energinet.dk[87] is obliged to ensure research, development and demonstration activities necessary for the utilization of environmental friendly power generation technologies, including the development of an environmentally friendly and safe power system (122).

Energinet.dk administers the PSO[88]-financed Research, Development and Demonstration (RD&D) programs ForskEL and ForskVE (122). Both programs are financed through PSO paid for by all electricity consumers with around DKK 0.05/kWh (about € 0.007/kWh). These programs are developed at the request of the Minister for Climate and Energy, since 2009. The purpose of both programs is to promote and facilitate the transfer to a society of technologies based on renewables.

87. Danish TSO

88. Public Service Obligation

The specific purpose of ForskEL program is to support the development and integration of environmentally friendly power generation technologies for grid connection, and each year a call for funding is implemented. The program budget is determined by the Danish Minister for Energy, Utilities and Climate, who also approves the focus areas of the annual calls on Energinet.dk's recommendation. The annual provided funding dedicated to RD&D projects.is DKK 130 million (about € 17.5 million) (122).

The specific purpose ForskVE-program (122) is to disseminate minor renewable energy (RE) technologies like biogasification, photovoltaics and wave power. As the aim is dissemination, it is thus possible for the program to support projects nearing market maturity. Facilities established through support from the program must be connected to the grid and produce electricity. The annual provided funding dedicated to RD&D projects is DKK 25 million (about € 3.5 million) (122).

19 SUMMARY OF BARRIERS AND OBSTACLES

As far as SG demonstration and deployment are concerned, key difficulties, obstacles and challenges seen through the funded SG RD&D projects can be summarized below (not exhaustive):

- Stakeholders' interaction: funded SG innovative and demo projects are conducted through consortia grouping several types of stakeholders (TSO, DSO, vendors and manufacturers, universities and research centers, producers, associations, etc.). Consortium agreement often signed at the end of the project leaving stakeholders' interaction not rigorously governed. This has resulted in lower efficiency on project advances as some stakeholders are clearly in competition mode. This aspect is further highlighted by the lack of clear responsibilities for the role of stakeholders. However, as the arena of trial concerns power grids for most large scale SG projects, it is of prime importance that TSOs/DSOs act as project coordinator. Indeed these stakeholders are strongly regulated and have the obligation of equal and non-discriminatory treatment of the grid users;

- Technologies refresh and innovation progress: this is the case in particular with respect to ICT for projects that have a lifespan of several years (typically 4-5 years). This aspect is even critical when it comes to replication (as much of the technology may either be obsolete or have been subsequently replaced with a more advanced and recent versions or alternative: ex LCL UK);

- Standards: as indicated above, several stakeholders interact and collaborate for SG projects. In this context standardization play a major role in order to make the different equipment and technologies, "pushed" by different manufacturers and vendors, interoperable (equipment that talk to each other and easy for replication). Indeed, compatibility between devices and manufacturers, data compatibility issues between project partners as well as communications issues are often encountered during field tests. This aspect is seen as one of major obstacle for scalability and replication of SG innovative projects;

- CBA (Cost Benefits Analysis) is still difficult to conduct with a holistic approach that can consider not only the whole SG value chain but also gather detailed information with a shared methodology. System CBA studies are still few and appear as key elements for determining the propagation of value created at different segments on the SG value chain and its impact on individual SG stakeholders. This later aspect has also a clear impact on SG adoption and deployment;

- Unclear and unproved business models: they are often linked with CBA but for most stakeholders they are somehow linked to new usages and flexibilities highlighted by unbundling such as Demand Response, Storage and Electric Vehicles. In fact the business model related to the integration of EVs, storage, demand response and renewable energy strategies into the market is still under track. In addition, uncertainty persists in several countries over roles and responsibilities in new SG applications, sharing of costs and benefits and consequently new business models (including the uncertainty around the direction of planned national action plans);

- Installation delay of tested equipment and some failures in tested equipment: these aspects alter the KPI and particularly for achieving the stated objectives for which SG projects partners have been funded or have invested;

- Safety and norms at the customer side when it comes to his involvement in SG demo projects. It involves in particular legal issues and highly qualified resources;

- Cybersecurity and Data protection laws: as SG projects are heavily linked to the extensive use of ICT at all levels of the energy chain, cybersecurity issues are seen – despite or because technology advance, right or wrong reasons – as an obstacle for SG adoption and deployment. In the same context, issues related to data protection and privacy are still under discussion and have already been a major obstacle of deploying some smart meters projects (e.g. Netherlands);

- Customer recruitment to be involved in the SG field trial: indeed, a high degree of consumer reluctance to participating in SG field trials continues to be recorded throughout the EU. It has been noticed from the large variety of SG projects (irrelevant of the funding source) that this task is quite difficult due to several reasons: unawareness and even suspicious attitude of several categories of customers with respect to SG technologies and particularly in participating to DR programs, inefficient recruitment methods, lack of clear and customized incentives, etc. It clearly requires sociological studies, sophisticated recruitment methods, clear business models and incentives both for the end user and for stakeholders' involvement. In addition, even when the customer is involved for example in DR testing, the rate of response is not guaranteed adding thus uncertainties to end user behavior and to the business model;

- Market design and pricing mechanism: as SG projects are also often system view projects, there is a need for understanding the impact of the current wholesale and retail market schemes (and the related electricity prices and tariffs structures) on SG deployment opportunities;

- Current regulation and uncertainties in its evolution: For many stakeholders, key obstacles and challenges still appear to be at the social and regulatory levels (much more than at technical level). This is specifically the case when it comes to replicability and scalability as the range of legal and regulatory arrangements and instruments to facilitate SG development in Europe might present significant barriers to the replicability of project results in different areas and to the scalability of projects to larger regions.

In addition, very often the articulation and compliance of national funding for SG projects with EC fair competition rules are seen as an institutional difficulty. Feedback experience showed that this aspect has often resulted in delaying the starting of some key large scale EU projects.

20 SOME RECOMMENDATIONS

From the above review including the role of national ER, funding mechanisms and feedback experience of the SG funded innovative projects, some general recommendations can be drawn (in addition to the detailed ones indicated in Section 19) not only for the Brazilian ER but also for national ER in EU where the SG demo projects are the most advanced:

- Defining and establishing/implementing a national plan for the deployment of SG (like for EU countries) including the appointment of a responsible for this implementation plan (generally ER, DSO or TSO). The Energy Regulator can play this role as it is the case for some EU countries;

- Establishing incentive mechanisms for encouraging power grid companies and utilities to invest in innovation (technology, processes, methods, commercial arrangement, etc.) guaranteeing cost effective solutions for the benefits of the society as a whole including environmental benefits and security of supply. In this context, the adequate funding mechanism for RD&D SG projects is crucial as it is shown in this report where the countries investing most in SG projects are those who put in place effective funding mechanisms whether through grid tariffs or through the regulator itself (OFGEM);

- Performing transparent and shared CBA of the Demonstration and Deployment of SG

CBA including the evaluation of the propagation of the value created on the energy value chain and taking into account costs and benefits for each stakeholder and for the society as a whole;

- Defining performance and monitoring indicators encouraging cost-effective solutions on the basis of national SG plan that can include for example: quality and continuity of supply, grid hosting capacity for additional DG and new usages such as EV, technical and non-technical losses, commercial quality which may include time to connect new users, satisfaction of grid users, energy efficiency achieved, involvement of stakeholders in new usages including DR, innovation leading to employment creation, etc.;

- Favoring stakeholders' cooperation with emphasis on standardization while identifying possible barriers and obstacles to SG development and deployment;

- Ensuring processes and mechanisms for good and continuous communication, learning and dissemination of the results and lessons learned from SG demonstration projects funded from grid tariffs or through the regulator while helping mitigation of trial duplication.

21 CONCLUSIONS OF PART II

This report identifies and describes several SG projects supported by the Energy Regulator. Particular attention was paid about implementation variables, lessons learned during the execution of the projects, implementation difficulties and obstacles.

In a majority of EU countries, a combination of sources is used to fund demonstration projects. Funding for demonstration projects has been through sources of finance such as industry/ private funding, public funding institutions, the EC, integrated municipal energy suppliers and regulators.

Most of the regulators, as it has been shown in this report, are not directly involved in funding the innovation in their respective countries (except UK and to some extent, Denmark and Italy). Also some of them are involved strictly on the regulation side as their aim is to monitor and regulate the electricity market and protect customer interests during the technological transitions. Actually, even though most of the regulators do not directly fund all of the SG projects, they ensure that goals set by European regulators for smooth SG transition, de-carbonization and dynamic tariff implementation are met, but without any drastic negative impacts on the consumers (rather with positive impacts).

France and UK appear to be the countries investing the most in research and development with regards to SG RD&D and the five countries of study here are actually the five major investors (Part I of this document). Part of these funds may or may not come from the regulator itself. Therefore, with respect to SG project examples, the report has specifically focused on OFGEM supported projects. Indeed, the UK energy regulator (OFGEM) is taken

as an example, because of its leadership in Europe in the support/funding of innovative SG projects: it provides technical opinions, management advices and the largest funds in EU for SG projects.

Innovation Competitions for energy network companies resulted to be a winning strategy. Power system operators and utilities, which are generally not interested in intense and widespread innovation, compete for additional funding for the research, development and demonstration of new technologies, operating strategies and business models. In addition, it has clearly fostered the cooperation among the various stakeholders involved in SG innovation. Funding is provided for those innovation projects which meet specific evaluation criteria. The Energy Regulator is supported by independent expert panels in defining the performance criteria to be fulfilled as well as in the review and assessment of the awarded projects.

In order to follow up the progress of each SG project, to reduce risks inherent to any innovative project and to reach the dissemination targets, the Energy Regulator can require the compilation of reports to be adhered to throughout the project by all the main stakeholders. A suggestion for other ER is to actively collaborate in the project and require detailed reports, a precise schedule of the project and appropriate tools for disseminating learnings (such as a dissemination manager who works actively throughout the project to develop, review, consolidate and disseminate learning in conferences, seminars and with website and other instruments – see OFGEM supported projects).

A project can end up with or without the achievement of the promised objectives: such situations are not unusual for innovative "risky" projects as there are several non-predictable variables. Possible issues are numerous and can range from management problems (e.g. interaction and collaboration of large number of stakeholders or the interaction with costumers) to technical problems (e.g. reliability problems, often correlated to communication issues, interoperability - interaction of third-party technologies (hardware and software) - and the creation of new tools that have never been used before). As such, the ER can be involved in performing deep analyses of previous similar projects, before the acceptance of the proposed one, in order to assimilate the related lessons learned and drive all the stakeholders to a successful conclusion.

PART III

ISSUES FOR THE DEVELOPMENT OF SMART GRID PROJECTS IN EUROPEAN COUNTRIES

FROM PROMOTION TO EVALUATION OF PROJECTS

22 METHODOLOGY OF PART III

This paper identifies and describes some of the issues related to the development of SG projects in EU. After a brief introduction, issues are analyzed with particular attention to the following topics: the implementation, management and monitoring of plans, incentives for demonstration projects, CBA, grid related performance indicators and incentive schemes. These topics are investigated for EU countries with special attention to five EU markets: UK, Italy, France, Germany and Denmark. The work is completed with conclusions and recommendations.

23 INTRODUCTION OF PART III

EC shares general guidelines for the implementation of SG; nevertheless each country preserves its independence regarding specific decisions and ways to pursue the objectives, due to different dynamics and local conditions. In the next paragraphs, the different methods, rules and obtained results for the five markets chosen, UK, Italy, France, Germany and Denmark, will be shown.

Council of European Energy Regulators (CEER)

The Council of European Energy Regulators (CEER) is a not-for-profit association that is joined by Europe's national regulators of electricity and gas (4). The main goal of the CEER is to facilitate the creation of a European energy market in order to create benefits for the whole EU community. This association publishes periodically reports and reviews about topics related to SG (5). In order to assess the progress of SG implementation, the adopted methods, policies, issues and results in EU, a questionnaire is issued by CEER for all the member states. With all these information, CEER published, during 2013, the document "A Status review of regulatory of smart metering" (24). Moreover, in the year 2014, CEER updated the 2011 CEER Status Review of Regulatory Approaches to Smart Electricity Grids with a new overview of regulatory in 2013 (25). The review defined active innovation/demonstration projects as:

'A project that involves the trialing on a distribution or transmission system of at least one of the following issue:

- *A specific piece of new (i.e. unproven) equipment (including control and communication systems and software) that has a direct impact on the distribution or transmission system;*
- *A novel arrangement or application of existing distribution/transmission system equipment (including control and communications systems software);*
- *A novel operational practice directly related to the operation of the distribution/transmission system;*
- *A novel commercial arrangement.*

The majority of EU countries (19 out of the 22 responding) answered the CEER 2014 questionnaire and stated that demonstration projects have already started in their respective country[89].

24 INSTRUMENTS TO FACILITATE SMART GRID DEVELOPMENT

A large part of EU countries use price regulation tools to help SG development. The most common instruments are: performance indicators, tools to regulate information provision and finally charges and licensing (used to a lesser extent). In the majority of countries, these regulatory instruments will need to be adapted for SG development[90]. Opinions about the actual situation of investment's incentives and performance indicators are

89. This represents an increase in demonstration projects as compared with information contained in 2011 Status Review, which indicated that only 14 countries had started demo projects.
90. In Great Britain, investment incentives will need to reflect the true value of demand side response to the system. In Italy, the "input-based" incentive regulation is already used in transmission grid and has been used for promoting pilot projects of SG at distribution level (25)

different: many stakeholders consider them as instruments that should be adapted/updated for SG development. However, a large number of European NRAs (more than half) believe that the existing regulation already enables the deployment of SG.

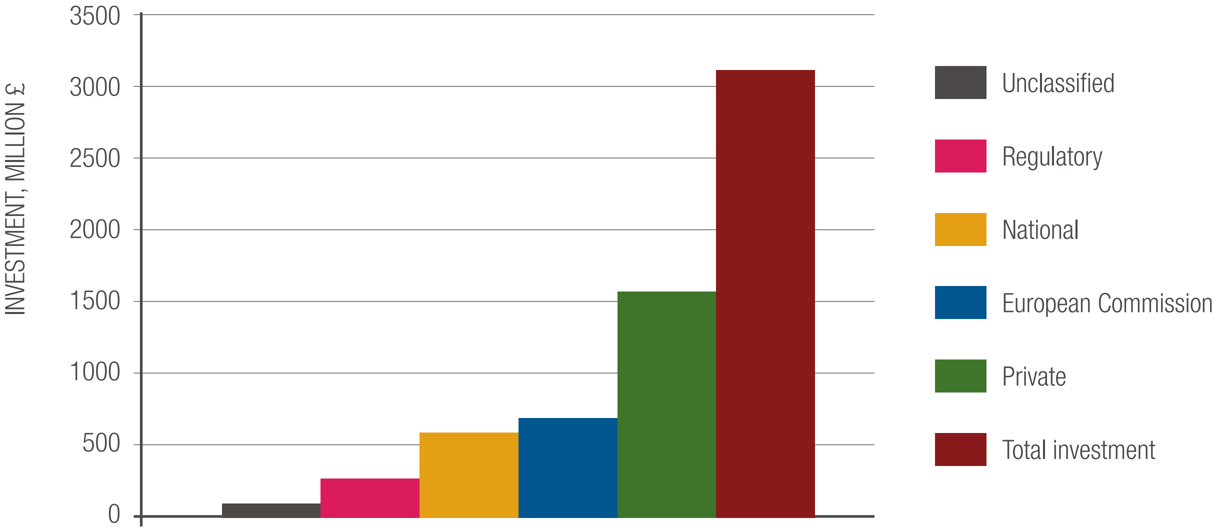
24.1 TYPOLOGIES OF INCENTIVES

In (25), CEER asked EU members to rank SG incentives in order of importance. The result of the interview was that the most effective incentives encourage network operators to choose investment options that offer the most cost-effective solutions. Then, in order of importance, there are incentives that encourage network operators to choose innovative solutions or encourage efficient use of electricity and renewable electricity. Other incentives work in order to activate participation in the development of SG by stakeholders, to encourage the introduction of new services and to encourage a more efficient network use.

24.2 SOURCES OF FUNDING FOR SMART GRID PROJECTS

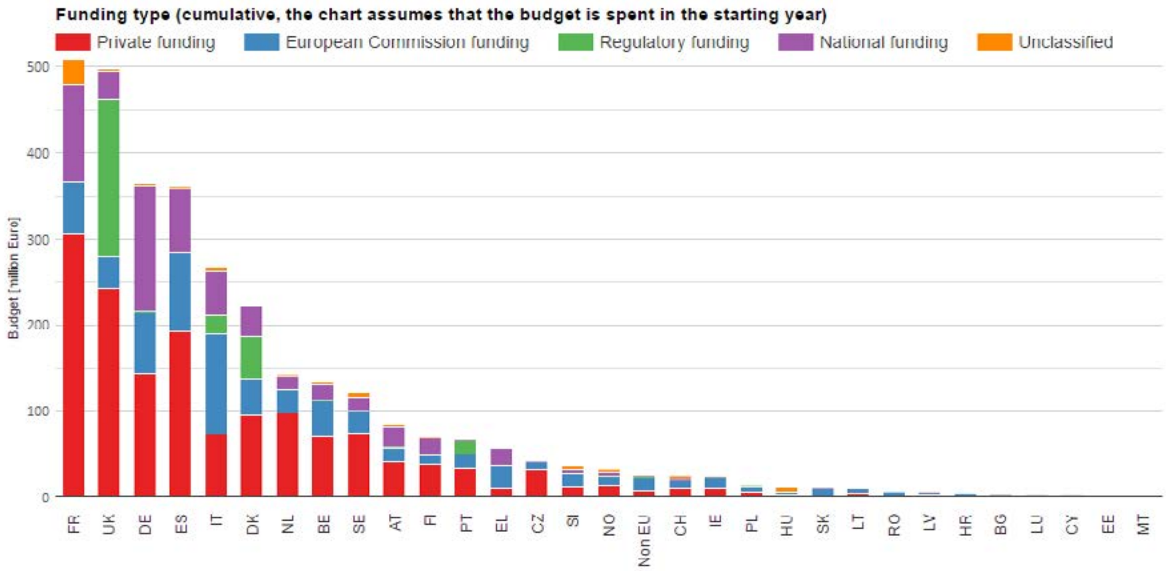
Most EU countries have launched large number of SG projects particularly during the last five years. Most of these projects deal with real life demonstration of various functionalities of SG. These projects have been funded through different channels: private investors, EC funding, National funding and regulatory funding. The largest share of the SG funding, with a total budget of about € 3150 million (123), comes from private investors and from countries dedicating the largest national budgets for these projects such as France and UK. Then, another small portion of total funding in EU countries comes, or is directly managed, from the energy regulator (about 9%; Figure 16). As such, the energy regulator is directly involved in few countries such as UK, Denmark and Italy. The high investments from private stakeholders show that business and market potential as well as high investment return are expected from implementing SG technologies.

Fig. 16: Distribution of cumulated funding source for EU SG projects (123)



The chart below shows cumulative data regarding the allocation of the budget of SG projects in Europe between diverse funding sources. The chart refers to budgets spent in 2014 (123).

Fig. 17: Source of funds for SG projects in Europe – European Commission: Smart Grid Projects Outlook 2014 (123)



The graph shows with green color the budget managed by energy regulators to support innovative SG projects. It has to be noted that the level of regulatory funding (specific funding from national regulators to support SG projects) is perceived differently among the EU countries supporting SG projects. In this context, a significant contribution, by far, comes from the OFGEM through the 'Low Carbon Network Fund' initiative in the UK[91]. This already represents a considerable effort and the scope for increasing this support will arguably depend on local conditions. However, the regulatory funding is not sufficient to support projects in all areas of the SG. For example, in countries where regulatory support has already been allocated to capital-intensive transmission or distribution reinforcements or to smart metering, it might be difficult to raise additional support for a wide range of SG R&D and demonstration projects (123).

A review of some key EU NRAs role in SG development is provided below (more details in Part II of this document).

91. As part of the electricity distribution price control that ran until March 31st 2015, OFGEM established the Low Carbon Networks (LCN) Fund. The LCN Fund allowed up to £ 500 million to support projects sponsored by the Distribution Network Operators (DNOs) to try out new technology, operating and commercial arrangements.

24.2.1 THE ROLE OF UK ENERGY REGULATOR

OFGEM (Office of Gas and Electricity Markets) is a UK non-ministerial government department and an independent NRA, recognized by EU Directives. Their principal function, stated by OFGEM, is the following: "*Our principal objective when carrying out our functions is to protect the interests of existing and future electricity and gas consumers*" (44).

As part of the RIIO price controls, OFGEM has introduced Network Innovation Allowance (NIA) and Network Innovation Competitions (NICs). The NICs are annual competitions for electricity and gas, where network companies compete to obtain funding for research, development and tests of new technologies, operating and commercial arrangements. These funding mechanisms aim at providing a financial catalyst for innovation on the UK electricity and gas distribution and transmission networks. In this context, funding will be provided for the best innovation projects which meet specific evaluation criteria[92] (108) and which help all network operators understand what they need in order to provide cost effectively environmental benefits and security of supply. This method permitted OFGEM to acquire detailed information about benefits of SG, challenges and actions that need to be addressed in the context abovementioned.

24.2.2 THE ROLE OF ITALIAN ENERGY REGULATOR

In 2010, the AEEGSI demonstration phase on SG was designed according to an input based incentive scheme and a competitive selection process in order to award a limited number of projects. According to AEEGSI resolution ARG/elt 39/10, the selected SG demonstration projects did benefit from an extra remuneration of capital cost (a 2% extra WACC in addition to the ordinary return) for a period of 12 years (123).

AEEGSI also changed the energy regulation in order to make easier the SG development. For example, in 2010, AEEGSI started the work to help the development of EVs, introducing simplifications in rules about the connection to the electricity grid. The first regulatory action removed restrictions on private sector introducing dedicated electrical meters for EVs charging stations. Thanks to AEEGSI, it is possible (since 2011) to install more than one supply points in private houses as well as in common areas of a housing building. Each supply point can have its own meter and can be dedicated to EVs charging. It is also possible to create charging points for commercial users. These recharging points will pay the same network tariff that is already in use for non-residential customers, regardless of whether the final user is a family or a company[93] (58).

92. OFGEM is supported in the review and assessment of the projects by an independent expert panel for each competition.

93. The price will depend on the contract stipulated with the supplier.

24.2.3 THE ROLE OF DANISH ENERGY REGULATOR

DERA is an energy regulator; nevertheless, its only objective is to reach economic efficiency[94]. DERA cannot do any policy development work or make changes to the regulatory regime, but it regulates a number of different aspects of the electricity system: it conducts benchmarking exercises for electricity network companies and sets revenue caps for them, which are currently based on allowed rates of return. When policies drive the system in an environmentally friendly direction, DERA ensures that it is done in a cost-effective manner. For these reasons, there are important debates: for example in the 2014 review of electricity regulation, DERA was keen on ensuring a focus on shorter-term efficiency incentives, whereas others wanted to prioritize the development of a SG[95] (121).

24.2.4 THE ROLE OF FRENCH ENERGY AGENCY

CRE is not involved directly in funding innovative SG projects in France. Rather, this role is devoted to ADEME, the French Agency for Environment and Energy Management. Indeed, ADEME started in 2010 a "SG Program" to monetary support SG R&D and demonstration projects. This funding mechanism allocated a budget of € 250 million through refundable grants and subsidies for the period 2010-14. For example, during 2010 and 2011, 10 SG projects have been selected and ADEME's total contribution for these projects amounted to about € 40 million. Out of the total budget of € 150 million (provided by many different stakeholders), 85% was for four large-scale projects with budgets higher than € 20 million: Greenlys, Millener, Venteea and NiceGrid. The main goal of these large scale projects is to well integrate a high capacity of PV, wind systems and storage into the distribution network[96]. The other six projects funded by ADEME were mainly small-medium projects with budgets less than € 10 million. Significant part of these projects are focused more on developing systems and business models in which new players such as aggregators will participate or on exploring the application of consumers' demand response (123).

24.2.5 THE ROLE OF GERMAN MINISTRY OF ECONOMICS AND TECHNOLOGY

In Germany, the Parliamentary State Secretary in the Federal Ministry of Economics and Technology (BMWi) initiated the 'E-Energy: IKT-based energy system of the future' competition providing national funding for SG projects (124). The goal of the programme was "to finance projects that demonstrate how ICT can be exploited to achieve even greater effectiveness, security of supply, and climate and environmental compatibility in electricity distribution" (123). The competition took place in 2008 and six winners were chosen from an independent jury: Smart W@TTS, RegModHarz, Model City Mannheim, MEREGIO, E-DeMa and eTelligence[97]. The main goal of the five-

94. In other countries, Regulators try to reach not only economic, but also social and environmental improvements.
95. However, DERA does not have the wider institutional power that Ofgem does in Britain

96. The NiceGrid project received both national and European funding since it is part of the European GRID4EU project (133).
97. The total budget for these projects was € 120 million, almost

years projects was to test aggregation/demand response in real conditions by creating technical and virtual platforms bringing together generators, consumers, energy service providers and network operators (123).

24.2.6 THE ROLE OF THE OTHER EU ENERGY REGULATORS

In the other EU countries, regulators generally are supporting the development of SG with specific tariff schemes guaranteeing an additional rate of return on SG investments.

25 OBSTACLES TO SMART GRID DEPLOYMENT

25.1 THE USE AND ACCESS OF SMART METERS DATA FOR SMART GRID

Smart Grid developments and smart meters roll-out are often linked; Smart meter is considered a basic "brick" in the SG value chain. However, EU governments are still working on sharing energy information and related privacy issues. In the majority of countries, consumers and suppliers have or will have access to consumption and pricing data, while in a smaller number of countries, consumers will also have access to power quality and technical data. NRAs will mostly have access to power quality and consumption data, but DSOs, and to some extent TSOs, will have access to power quality data, technical data and consumption data (not pricing data). Furthermore, ESCOs will also have access to consumption data in Germany and Great Britain. In France, ESCOs will have access to this data, but only if the customer gives their consent.

There was no clear consensus on whether the NRA will be involved in data security regulation for smart meter data. In France, data security will be the responsibility of a separate and dedicated agency in charge of data security. In Germany, this is the responsibility of the Federal Office for Information Security. In the UK, the NRA will approve data aggregation plans from the DNO, and data privacy requirements are covered under license conditions.

25.2 UNBUNDLING RULES

In France, the opinion of the Government is that existing unbundling rules may obstruct or delay the progress of the deployment of SG equipment. In some cases, the economic results of SG developments projects are difficult to evaluate, as most of the costs are located at DSO level while benefits are spread all over the value chain. For this reason, CRE is currently working on regulatory arrangements, which could facilitate SG development.

Great Britain is currently investigating on the effect of unbundling rules: the government's opinion is that there are situations where they could become harmful for SG development, for instance where storage is sponsored by the DSO for network reinforcement. This would separate consumer involvement in the SG and make it harder for customers to be involved.

half from E-Energy program. The projects were implemented in six different 'model regions'. BMWi provided up to € 40 million for four regions and the remaining € 20 million for the other two regions were provided by the Federal Ministry of the Environment, Nature Conservation and Nuclear Safety (BMU).

In general, in the other EU countries, NRAs stated that existing rules for unbundling do not hinder SG development.

25.3 REGULATORY, TECHNICAL AND COMMERCIAL BARRIERS

Several NRAs in EU countries (France, Great Britain and Italy included) identified a number of different actual barriers to SG implementation. Some examples of these barriers relate to the following areas:

- High expected immediate investment for long terms ROI;
- Limited network development funds;
- Uncertainty around the direction of planned national action plans including the evolution of energy regulation;
- Restrictive data protection laws;
- Lack of clear responsibilities for the role of stakeholders;
- Technologies maturity and risk;
- Need of more work in Standardization;
- Customer involvement.

Referring to regulatory and technical barriers, it should be noted that in large part of EU countries, SG are not limited to certain networks or voltage levels. Nevertheless in some countries the situation is different (e.g. in Italy, SG are limited to LV and MV networks). It happens because all high-voltage (HV) networks are included in the transmission grid that is already considered "Smart Grid" functional[98].

26 PLANS FOR THE IMPLEMENTATION OF SMART GRID

The EC's SGTF (26) called for and recommended greater commitment by European countries towards establishing/implementing national models for the deployment of SG. EU Member States were invited to define national models and/or platforms, ensuring in particular the dissemination, and exchange of experiences and lessons learned. Currently France, Italy and Denmark have already published their national implementation plans (27) (28) (29). In Great Britain, although an implementation plan has not been created, a high-level roadmap has been developed (30). Still, several countries did not publish any implementation plan, but some of them are however working in this direction.

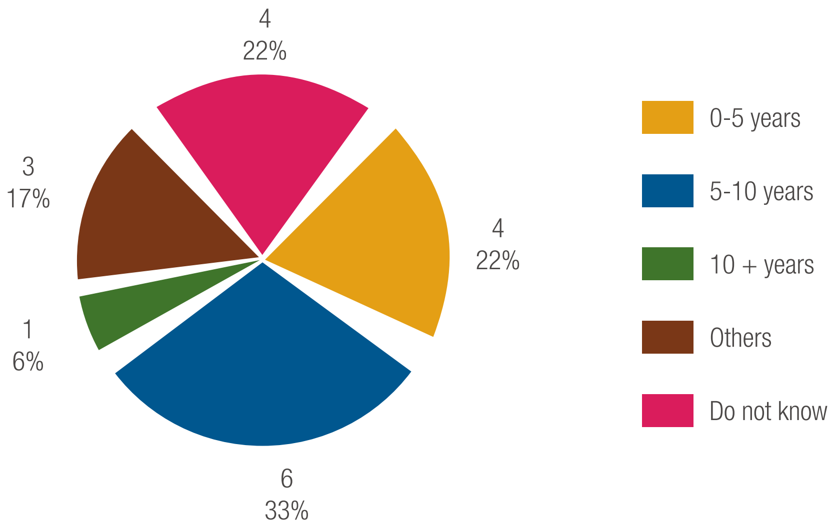
26.1 TIMEFRAME OF THE IMPLEMENTATION PLAN

There is no clear consensus with regards to the timeframe for the implementation of SG in EU countries, but generally, the objective is to improve SG development in the next 10 years.

Figure 18 shows the results of the interview made in (25): three countries have timeframes of between 0-5 years, six have timeframes of between 5-10 years and three noted that timeframes have not yet been determined.

98. In Greece, SG are limited to LV networks, while in Portugal they are limited to MV and LV networks.

Fig. 18: Timeframe for implementation of SG projects in Europe by number of countries and percentage (25).



The French implementation plan is set over a period of 10 years, while, there are two roadmaps in Great Britain, an integrated roadmap out to 2020 and a high-level roadmap out to 2050.

26.2 MONITORING OF IMPLEMENTATION PLANS AND PROJECTS

Regarding monitoring of progress for SG projects, in EU countries, NRAs are generally responsible for monitoring implementation plans and sometime responsibility is shared between the NRA and other stakeholders.

In France, projects are monitored through project steering committees. CRE plans to define indicators with DSOs and TSOs. In Germany, as part of the process for selecting which projects are funded, companies' approaches on progress reporting and disseminating learning are evaluated. High quality learning dissemination activities, that either build on best practices from other demonstration projects or incorporate innovative approaches, are expected.

In UK, all companies running projects must produce progress reports every six months. These reports must include the progress they have made with respect to their project plan and the learning that the project has delivered in the previous six months. The company must also explain the activities that it has undertaken to disseminate the learning. All companies must also produce a comprehensive report following the conclusion of the project. These reports must explain how other parties can replicate the implementation and outcomes of the project. Companies must also present the progress and learning from their projects at an annual conference.

In Italy, for projects approved by the NRA, a work progress report has to be sent by the involved DSOs to the NRA every six months. Thereafter, monitoring is through ad-hoc meetings and result dissemination.

26.3 KNOWLEDGE AND RESULTS DISSEMINATION

The results of the 2014 questionnaire (25) have shown that although methods vary widely from country to country, some broad trends can be identified. Referring to dissemination of learning and results coming from SG demonstration projects, the Status Review stated that:

- Projects should be made visible to interested parties in order to facilitate the sharing of knowledge and experience;
- Dissemination should help to mitigate trial duplication.

26.3.1 RESULTS DISSEMINATION IN U.K.

In Great Britain, dissemination mechanisms are in place on a mandatory basis. Learning is a key point of the LCN Fund and there is a range of measures to ensure that this goal is achieved: for example, knowledge dissemination events, an annual conference, a knowledge sharing portal and rules around DNOs having access to intellectual property generated through the projects.

Under the smaller First Tier projects, a DNO must report the required details for its projects as set out in Standard License Condition (SLC) and the LCN Fund Reporting Instructions and Guidance (RIGs). The DNO must provide a Close-Down Report and it must provide:

- Sufficient information for third parties to understand what has been learnt from the project;
- Sufficient information to minimize the likelihood that other DNOs will unnecessarily duplicate the Project using the First Tier Funding Mechanism in the future.

Furthermore, the project manager must collaborate with the other DNOs that are subject to the LCN Fund to organize an annual conference that will be held for the DNOs, External Collaborators and interested third parties.

The dissemination process for Second Tier projects is similar: progress reports must be produced every six months and they must include the progress they have made with respect to their project plan and the learning that the project has delivered. The project manager must also explain the activities that it has undertaken to disseminate the learning. All companies must also produce a comprehensive report following the conclusion of the project. These reports must explain how other parties can replicate the implementation and outcomes of the project. They must also make presentations on the progress and learning from their projects at an annual conference.

26.3.2 RESULTS DISSEMINATION IN GERMANY

In Germany, during the selection of projects that will be funded, companies must show how they intend to report and disseminate outcomes and learnings. These dissemination aspects are also evaluated. High quality learning dissemination activities that either build on best practices from other demonstration projects or incorporate innovative approaches is mandatory to obtain funds (25).

26.3.3 RESULTS DISSEMINATION IN FRANCE

In France, dissemination is organized and performed on a voluntary basis; workshops are organized by the French Energy Regulatory Commission (CRE), which share information on SG projects on its website (125). The different ongoing projects also organize on an annual basis specific progress and dissemination events/workshops with a support from the ADEME agency. Additionally, the ADEME, as a funding agency requests annual presentations of the results obtained in order to monitor the progress of these projects with respect to the planning and milestones objectives. These presentations are carried out only between the ADEME and the projects' teams. The intermediary funds will only be released once the project milestones are completed and the stated objectives are achieved.

26.3.4 RESULTS DISSEMINATION IN ITALY

In Italy, dissemination is mandatory: analysis of results and dissemination are considered as one of the main objectives of the demonstration process. Technical sheets and progress reports must be periodically produced: they must include the most critical issues related to the project and the learning that the project has delivered[99].

27 COST-BENEFIT ANALYSIS FOR THE DEMONSTRATION SMART GRID PROJECTS

27.1 STATUS OF COST-BENEFIT ANALYSIS ON SMART GRID EU COUNTRIES

In the 2009-2010 ERGEG Public Consultation Papers (126) (127), regulators supported the following recommendation:

"Recommendation 6 - To evaluate the breakdown of costs and benefits of possible demonstration projects for each network stakeholder and to take decisions or give advice to decision makers based on societal cost-benefit assessment which takes into account costs and benefits for each stakeholder and for society as a whole".

In order to understand if the recommendations were followed, in the 2014 questionnaire (25), CEER asked the NRAs to provide information related to the status of CBA for SG projects in their respective countries. The requested information concerns the following issues:

99. More information is available in (28).

- Whether CBA have been undertaken for SG projects;
- Geographical scope of the analysis (national, regional, demonstration project);
- Focus of the analysis;
- Status and the main results of the CBA (if completed);
- Responsibility for conducting the CBA.

As shown in Figure 19, the number of countries, in which a CBA is performed, increased from four in 2011 to nine in 2013. In particular:

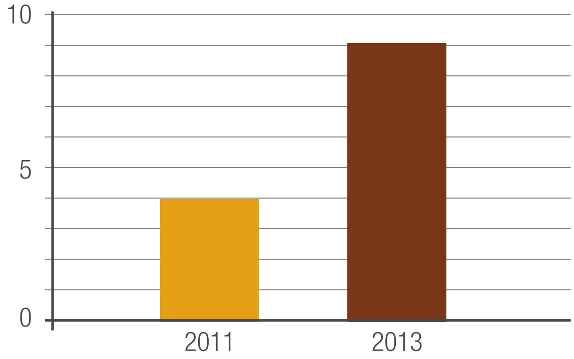
- A CBA on both deployment and demonstration has been undertaken in three countries;
- A CBA on SG deployment has been conducted in 4 countries;
- One CBA has been undertaken on demonstration;
- One country has not defined whether their CBA relates to deployment or demonstration.

Nevertheless, these nine countries represent only about 40% of the total number of NRAs which responded to the questionnaire (23 NRAs responded): this indicates that the diffusion of the CBA for SG projects still needs to be improved in EU[100].

100. However, in Austria, while no CBA has been undertaken at a national level, project applicants must demonstrate the effects and impacts of the project for society as a whole. In Belgium, a CBA has been partially undertaken, while it is under discussion in the Czech Republic. In Switzerland, Lithuania and Luxembourg, CBAs have only been undertaken on smart meters.

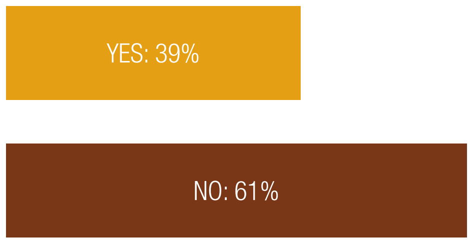
Fig. 19: Results of CEER questionnaire on CBAs diffusion in EU (on SG projects) (25)

NUMBER OF COUNTRIES WHERE A SMART GRID CBA HAS BEEN PERFORMED



EVOLUTION BETWEEN 2011 AND 2013 OF THE NUMBER OF COUNTRIES WHERE A CBA HAS BEEN PERFORMED

NRA ANSWERS TO THE QUESTION **"HAS A CBA BEEN UNDERTAKEN FOR SMART GRIDS?"** (23 NRAS ANSWERED THIS QUESTION)



PROPORTION OF COUNTRIES WHERE A CBA HAS BEEN PERFORMED (STATUS IN 2013)

27.1.1 COST-BENEFIT ANALYSIS LEVELS IN EU COUNTRIES

The questionnaire (25) collected information also on which level CBAs were performed and results are summarized in Table 4. In nearly all countries (among the countries which answered the question), CBAs were performed at national level. A CBA has been undertaken at regional level in Belgium and at demonstration level in Italy, Denmark, France and the Netherlands. In Great Britain and Denmark, CBAs have been undertaken at both regional and national level.

Table 4: Results of CEER questionnaire on CBA levels related to SG (25)

Geographical level	% of countries where a CBA is performed (among the countries which answered the question)	Countries
National level	88%	Denmark, Finland, France, Great Britain, Italy, Norway, The Netherlands
Regional level	38%	Belgium, Denmark, Great Britain
Demonstration project	50%	Denmark, France, Italy, The Netherlands

27.1.2 BENEFITS OF SMART GRID COMPARED TO BAU

In most countries, the CBA aims at identifying the net benefits of SG compared to BAU. Three countries also performed an analysis at the level of the demonstration projects in this perspective.

Table 5: Results of CEER questionnaire on CBAs related to SG

Focus of the CBA	% of countries where a CBA is performed (among the countries which answered the question)	Countries
Net benefits of SG compared to BAU	88%	Belgium, Denmark, Finland, France, Great Britain, Norway, The Netherlands
Demonstration projects	38%	France, Italy, The Netherlands

27.1.3 RESPONSIBILITY FOR CONDUCTING THE CBA

There was no clear consensus on the different market players that conducted these CBAs and the results were varied among the respondent countries. Governments, NRAs, TSOs, DSOs, national competition authorities, and in some cases a dedicated work streams gathering various market players, were listed as being responsible for conducting the CBAs.

27.2 EU GUIDELINES FOR COST-BENEFIT ANALYSIS

The JRC of the EC carried out a qualitative and quantitative analysis of past and current SG projects. It also provided a guide for the conduction of CBA, based also on the previous work performed in USA by the Electric Power Research Institute (EPRI) (128). The CBA guide helps to take into consideration local conditions, to calculate benefits and costs, to perform sensitivity analysis of the most critical variables and to identify externalities and social impacts. The Guide divides the CBA work in seven key points, which are briefly described in the following paragraphs. The complete document is available in (129).

27.2.1 REVIEW AND DESCRIPTION OF THE PROJECT

The first step of the work consists of a summary of the elements and goals of the project. It should include:

- Information related to the dimension and scale of the project (e.g. number of consumers involved, total energy produced or consumed in the project);
- Information on the technical characteristics (e.g. technologies used and the specifications

of the main components);

· Characteristics of the portion of the grid that is involved in the project;

· Roles of the main stakeholders;

· A clear statement of the project's objectives and its expected socio-economic impacts;

· Regulations.

27.2.2 MAP OF FUNCTIONALITIES

The second step of the work consists of the definition of the assets that are created thanks to SG functionalities. In order to facilitate it and better compare different works, EC asked the EC SGTF (26) to define a list of functionalities. They are very different and range from the improvement of market functioning and customer service to the insurance of network security and quality of supply. The complete list (including 33 items) is also available in Annex III of (129).

27.2.3 MAP OF FUNCTIONALITIES ON THE BENEFITS

The work consists of linking the functionalities defined in the second step to the benefits that they can provide. To easily complete it, it is suggested to divide benefits in sub-categories (e.g. economic, reliability, environmental and security). The result is Functionalities x Benefits Matrix containing all the links.

27.2.4 ESTABLISHMENT OF THE BASELINE

The definition of the baseline is necessary to evaluate the results of every different scenario, because the CBA of every investment must be compared to the situation in which that SG investment is not performed, called BAU scenario.

In case of projects that involve testing of new services or products (e.g. new electric tariffs or new smart meters), one of the goal is to evaluate how total energy consumption and power peaks change. In such situations, the baselines are comparable groups of randomly selected users, defined as "control groups". Control groups are better than historical consumption data, because old data does not take into account factors varying in time. Nevertheless, the selection of the costumers must be done in a proper way, following some suggestions:

· Costumers, with either a particularly high or low potential to reduce energy consumption, should not be selected to take part of control groups;

· Costumers, who voluntary ask to participate, should be refused;

· The selection should include not only costumers for which the collection of information is easy;

· The control groups should cover every type of costumers regardless of social status or education level;

· A statistical analysis of the refused costumers should be performed, in order to define the segment of costumers excluded and included in the study.

27.2.5 MONETIZATION OF BENEFITS AND IDENTIFICATION OF BENEFICIARIES

As previously defined, a benefit can be calculated as the difference between baseline and project conditions. This key point can involve the analysis of different kinds of information (e.g. raw hourly energy consumption data or data already analyzed such as line losses). The possible cases are numerous and the Annex Guide provides examples to help the user to complete this point (129).

27.2.6 IDENTIFICATION AND QUANTIFICATION OF COSTS

The quantification of a project cost is generally easier to evaluate than its benefits with respect to a specific reference. Some costs can be calculated thanks to quotations, consultation of investing companies and prices from marketplace. The calculation must take into account economic parameters such as depreciation, debit and handling capital costs. On the contrary, taxes should not be included in the CBA (130).

27.2.7 COMPARISON OF BENEFITS AND COSTS

There are several methods allowing benefits and costs to be compared and the cost-effectiveness of the project to be defined:

· Annual comparison: the annual comparison over the project life permits individual years in which costs are higher than benefits to be defined;

· Cumulative comparison: it considers the cost in a year as the sum of the costs of all the previous years and the same procedure is used to evaluate annual benefits. This method permits the break-even point (when benefits exceed costs) to be defined;

· Net Present Value (NPV): the Net Present Value is the sum of all the annual cash flows, during the life of the project, actualized at the beginning of the investment, applying a discount rate. This is one of most used method to compare investments;

· Benefit-cost ratio: this ratio easily represents the relation between the two quantities (the size of one with respect to the other); if the ratio between benefits and costs is higher than one, the project is cost-effective.

27.2.8 SENSITIVITY ANALYSIS

After the seven key points described above, the guide in (129) defines also the “sensitivity analysis” as an important extra step, necessary to complete the CBA work.

A CBA is based on forecast and estimations of many variables (e.g. electricity cost trends and energy demand grow rates). Generally the most probable parameters are used to make forecasts, nevertheless the forecasts cover long periods of time and future real parameters can be different from realized values. Therefore the goal of the sensitivity analysis is to find the range of variables that can permit to achieve an acceptable outcome of the projects (e.g. the cost-effectiveness is generally characterized by a positive NPV). The guide in (129) provides in depth discussion for this topic and provides many details and examples.

27.3 APPLICATION OF EU GUIDELINES FOR A CBA: PROJECT GRID4EU

In order to deeply understand the EU mythology suggested for carrying on a CBA related to SG projects, it can be useful to study examples of CBAs of some SG demo projects in the EU community. The Grid4EU project was created in response to a call for projects from the EC, in order to start the development of tomorrow's electricity grids.

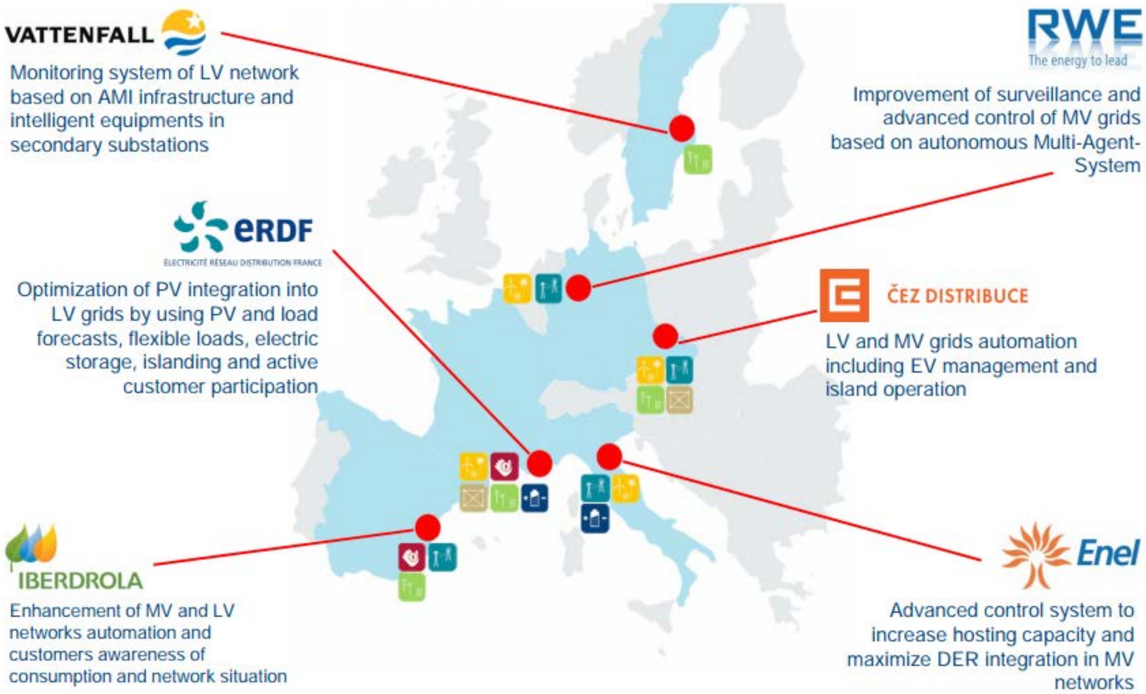
The Grid4EU project was financed with € 25 million from the EC and it had a total cost of € 54 million overall[101]. The projects involved six European energy distributors: ERDF, Enel Distribuzione, Iberdrola, CEZ Distribuce, Vattenfall Eldistribution and RWE. The goal was to test the potential of SG in different areas such as renewable energy integration, electric vehicle development, grid automation, energy storage, energy efficiency and load reduction. In particular, the main R&D challenges are summarized as the followings:

- “Using more Renewable Energy Sources connected to distribution networks;
- Implementing active, more efficient participation of customer to electricity markets;
- Securing energy supply - Network reliability;
- Achieving MV/LV network Supervision & Automation;
- Improving peak load management through increased interactions between network operation and electricity customers;
- Studying Demand Side Management (DSM), EV Storage, Micro Grids” (131).

101. It is one of the largest SG project funded by the European Union.

Figure 20 shows the European energy distributors involved in Grid4EU project and a short summary of related demonstrations sub-projects.

Fig. 20: Six European energy distributors involved in Grid4EU project and related demonstrations



GRID4EU consisted of six demonstrators, which were tested over a period of four years (November 2011 – January 2016) in each of the European countries represented in the consortium (France, Italy, Germany, Spain, Sweden and Czech Republic). The collaboration with other industrial and scientific partners, from around 10 different EU countries is also an important issue of the project (131).

27.3.1 CBA ANALYSIS AND PROJECTS RESULTS

The CBA analysis of the different parts of the GRID4EU projects was performed following the methodologies indicated in EU Guidelines.

The dissemination is a key point of the GRID4EU project. In the website (131), it is possible to find extensive information about all aspects of the performed work and the economic and technical results were deeply described and discussed during the GRID4EU Final event held in Paris (Palais de la découverte) on January 19th 2016. The final results (and all the information related to the CBA) should already be published in the final report of the whole project, nevertheless the work is delayed and it will be published later this year[102].

102. It is recommended that the reader consults the final report that will be published soon in (135).

27.4 APPLICATION OF EU GUIDELINES FOR A CBA: PROJECT GREEN-ME

Another example of the application of the EU methodology for CBAs can be found in GREEN-ME project (132). This project was created by the Italian and French TSOs and DSOs in order to face problems related to the increase of RES generation in the project regions[103].

The RES variability determines, in some circumstances, situations of over-generation which have a cross-border impact, particularly on the exploitation of Net Transfer Capacity (NTC). The main objective of the project is: “to increase monitoring, controllability and predictability of distribution generation for more efficient integration of renewables, thereby maintaining the reliability and security of the network, and in particular avoiding curtailments of NTC between the two involved countries in cases of over-generation from RES combined with low load conditions” (132).

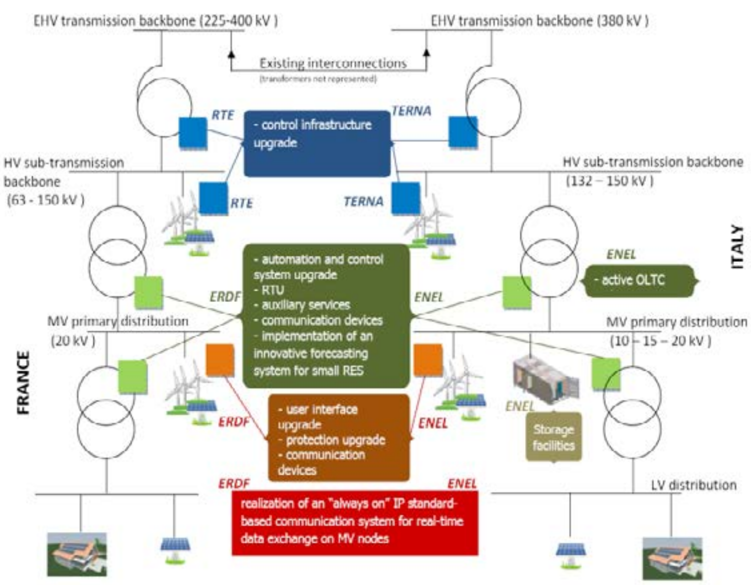
The activities performed under the project were divided into two phases:

· Phase 1: 34 new primary substations in the area (25 in France and 9 in Italy) were upgraded to enable SG functionalities;

· Phase 2: 55 more HV substations located in northern Italy, and possibly up to 86 primary substations (66 in Italy and 20 in France), were equipped over the whole area. Moreover, storage facilities were deployed in the Italian area on about 20% to 25% of the primary substations considered.

103. The main stakeholders involved are: 2 TSOs: RTE (Réseau de Transport d’Électricité) and TERNA, and 2 DSOs: ERDF (Électricité Réseau Distribution France) and ENEL (Ente Nazionale per l’energia Elettrica), from both France and Italy.

Fig. 21: GREEN-ME system architecture (132)



The outcomes of the project were (132):

- Increased integration of distributed generation from renewables;
- Ancillary services provision through DER;
- Management, collection and coordination of ancillary services by the TSOs and forecasts provided by DSOs and RES directly connected to the HV grids;
- Integration of the ancillary services and forecast information provided by the DSO with the TSO control infrastructure;
- Increased predictability of RES generation facilitating the management of the cross-border NTC.

27.4.1 PROJECTS ECONOMIC PERFORMANCE

The project proposal included an economic CBA, which detailed the estimated costs and benefits. EU guidelines are followed and the main monetary benefits and costs resulting from the development of the project are the followings[104]:

MAIN MONETARY BENEFITS:

- Avoided cost of distribution network reinforcements: investments are considered to enable the same hosting capacity in the reference scenario;
- Improved operational flexibility: utilization of interconnected capacity, optimization of distribution network operations and storage benefits;
- Reduced outages.

MAIN COSTS:

- Installation of HV substations automation systems;
- HV/MV substation control, automation and monitoring systems;
- Installation of control and communication systems of RES;
- Installation of storage systems;
- MV/LV substation automation and monitoring systems;
- Telecommunication infrastructure.

27.4.1.1 Sensitivity analysis

In the sensitivity analysis of GREEN-ME project, the following variable changes have been considered:

- A possible increase of total project costs up to 20%;
- Increased hosting capacity of 20% instead of 25%;
- The goal of interconnection optimization could not be achieved;
- A discount rate up to 5.5%.

The result of the sensitivity analysis is that under all the assumed conditions, the NPV remains positive.

104. In the project report, the considered elements are listed and described, but the procedure and calculations are not shown.

27.4.1.2 Non-monetary benefits

The proposal also reported potential additional benefits that the project could bring. These benefits were not monetized, because the project managers required more details to estimate the impacts:

- Quality and continuity of supply;
- Black-out risk reduction;
- Opportunity cost related to land that is saved with respect to construction of new overhead lines;
- Reduced environmental impact of electricity grid thanks to fewer overhead lines;
- Network user/consumer inclusion;
- Enabling new services and application and market entry to third parties;
- Dissemination of results;
- Safety (reduced number of manual operations).

27.4.1.3 Summary of evaluation

The Italian regulator (AEEGSI) and the French regulator (CRE) have communicated a positive technical evaluation of the GREEN-ME initial project. The project fulfilled the technical requirements and showed positive impacts with respect to the policy (KPI) and economic (CBA) criteria. Both regulators recommended pursuing the project but also recommended revising in more detail the business case and the economic assumptions included in the CBA.

27.4.1.4 Economic assessment

In societal terms, benefits largely exceed the costs. Main monetary benefits include:

- Avoided network reinforcement;
- Improved operational flexibility;
- Avoided costs of outages.

The investments costs are shared among DSOs and TSOs. Data provided show that the NPV is positive despite changes of some key variables (e.g. hosting capacity, PV penetration and percentage of flexible DG). The project proposal also reports that the project lacks commercial viability (132).

28 EVALUATION OF IMPLEMENTATION PLANS: PERFORMANCE INDICATORS

In the “2010 Smart Grid Conclusions Paper” (3), European energy regulators identified a list of performance indicators to evaluate grid performance. These indicators can be also used to quantify the “smartness” of a network and related benefits. Furthermore, the recent EC Communication on Smart Grid (31) states that “regulatory incentives should encourage a network operator to earn revenue in ways that are not linked to additional sales, but are rather based on efficiency gains and lower peak investment needs, i.e. moving from a ‘volume-based’ business model to a quality (and efficiency) based model”.

The list of SG indicators, which are currently in use in EU countries (in particular, with reference to countries under analysis), is in Table 2. In the following paragraphs some important indicators (in addition to those in Section 4.5) are described with further information (25). The selection was based on the total number of EU countries actually using the indicators and the following criteria:

· The variation of the indicator should determine a quantifiable benefit to grid users and, in general, to society as a whole[105];

· It is possible to determine (measure or calculate) the value of the index in a sufficiently accurate and objective way[106];

· The value of the index can be influenced (even if to a limited extent) by the network operator or the system operator; this includes metering[107];

· The index should be as far as possible, technology neutral[108].

105. The SG Conclusions Paper (129) states: "A regulatory scheme for promoting improvements in the performance of electricity networks requires the quantification, through appropriate indicators, of the effects and benefits of "smartness".
106. The SG Conclusions Paper (129) states: "Clear and transparent measurement rules are very important to make it possible to observe, quantify and verify such targets".
107. The SG Conclusions Paper (129) states: "Performance targets should be cleansed of external effects outside the control of network operators".
108. The SG Conclusions Paper (129) states that no regulatory scheme or requirement represents an (unintended) barrier for necessary development in technology and applied solutions in the grid.

28.1 INTERCONNECTION COUNTRY CAPACITY AND ELECTRICITY DEMAND RATIO

The limited capacity of international interconnections between EU countries is a barrier to have a real international grid and market. The calculation is the same for capacity indicators and suffers from the same limitations (e.g. operational security rules have to be considered).

This indicator is used in five countries (Austria, Norway Slovenia, Spain and Netherlands) for monitoring and it is not used as a revenue driver.

28.2 TIME FOR AUTHORIZATION OF A NEW TRANSMISSION INFRASTRUCTURE

The "time for licensing/authorization of a new electricity transmission infrastructure" can be defined in different ways. It can be read and used referring to:

· The time needed to obtain the licensing/approval of the project of a new transmission line by the NRA and/or the competent authority;

· The time needed to obtain permitting/authorization for the construction of the new transmission infrastructure.

This topic was discussed by the European Energy Regulators in 2007-2008 by means of the European Energy Regulators papers "Cross-Border Framework for Electricity Transmission Network Infrastructure" (133) and "Status Review on Building and Construction Authorization and Permit Process - Case Examples" (134).

More recently, the EC's Energy Infrastructure Communication identified the importance of faster and more transparent permit granting procedures. Also based on the common recommendations by all European stakeholders in (26), the Commission's Smart Grid Communication (31) reiterated that permitting procedures for the construction and renewal of energy grids have to be streamlined and optimized and regional regulatory barriers and resistances must be tackled.

This indicator is used in two countries (Finland and Spain) for monitoring; no country uses the indicator as a revenue driver.

29 CONCLUSIONS OF PART III

In the last years (mainly last 10 years) SG become (and still) an increasingly relevant topic in Europe. Even higher investments come from governments, regulators, TSOs/DSOs, and mainly from private stakeholders, showing that business and market potential as well as high economic return are expected from the implementation of SG technologies.

Due to different dynamics and local conditions in European countries, each of them preserves its independence regarding specific decisions and ways to pursue the developments of SG. Nevertheless, the methods follow the general guidelines from EC and there are many common characteristics.

The energy regulators are directly involved in some projects and help the development with different typologies of incentives. In many cases, demonstration projects developments on SG are designed according to an input based incentive scheme. The instrument is generally a competitive selection process that choses a limited number of projects which meet specific evaluation criteria. The projects must provide cost effectively environmental benefits, security of supply and details about benefits and principal issues, useful for future works.

In order to make easier the SG development, energy regulators are also changing the energy regulation: for example, they are working on the introduction of simplifications in rules, the abolition of previous restrictions and the investigating on the effects of unbundling rules. Another problem is the lack of co-operation between the different stakeholders, due to lack of definition of responsibilities and privacy issues; regulators are also working in order to find a solution to these problems.

An indispensable requirement for obtaining funds for the SG project is the conduction of a detailed CBA. JRC carried out an analysis of past and current SG projects and provided a guide. This guide helps to take into consideration local conditions, to calculate benefits and costs, to perform sensitivity analysis of the most critical variables and to identify externalities and social impacts. The results is an even higher number of performed CBAs; nevertheless the recent CEER questionnaire shows that the diffusion of the CBA for SG projects needs to be improved in EU, because there are still EU countries where a CBA is not applied to all project levels.

Another important recommendation, related to the evaluation of SG projects, is the calculation of parameters useful to quantify the "smartness" of a network and related benefits. The goal of EC is that regulatory incentives encourage a network operator to earn revenue in ways that are not linked to additional sales, but are rather based on efficiency gains and lower peak investment needs. These parameters are used by the project manager to evaluate their own projects in all respects and by the regulators, to decide how to improve SG deployment while ensuring benefits to all grid users.

30 REFERENCES

1. *Smart Grids in the EU with smart regulation: Experiences from UK, Italy and Portugal.* Joao Crispim, Josè Braz, Rui Castro, Jorge Esteves. 2014, UTILITIES POLICY, pp. 85-93.

2. Publications Office of the European Union. *ec.europa.eu/eurostat.* [Online] 2015. http://ec.europa.eu/eurostat/en/web/products-statistical-books/-/KS-EZ-14-001.

3. European Regulators Group for Electricity and Gas . *www.ceer.eu.* [Online] 2010. http://www.ceer.eu/portal/page/portal/EER_HOME/EER_CONSULT/CLOSED%20PUBLIC%20CONSULTATIONS/ELECTRICITY/Smart%20Grids/CD/E10-EQS-38-05_SmartGrids_Conclusions_10-Jun-2010_Corrige.pdf.

4. Council of European Energy Regulators. *www.ceer.eu.* [Online] 2015. http://www.ceer.eu/portal/page/portal/EER_HOME.

5. —. www.ceer.eu. *Status review of regulatory approaches to smart electricity grids.* [Online] 2011. http://www.ceer.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Electricity/2011/C11-EQS-45-04_SmartGridsApproach_6%20July%202011.pdf.

6. European Commission. [Online] 2015. http://ec.europa.eu/legislation/index_en.htm.

7. European Commission. *Market legislation - Unbundling.* [Online] 2015. https://ec.europa.eu/energy/en/topics/markets-and-consumers/market-legislation.

8. —. *Market legislation - Independent regulators.* [Online] 2015. http://ec.europa.eu/energy/sites/ener/files/documents/2010_01_21_the_regulatory_authorities.pdf.

9. —. *Market legislation.* [Online] 2015. https://ec.europa.eu/energy/sites/ener/files/documents/swd_2013_0177_en.pdf.

10. Agency for the Cooperation of Energy Regulators. [Online] 2015. http://www.acer.europa.eu/Pages/ACER.aspx.

11. European Network of Transmission System Operators. Electricity Transmission . [Online] 2015. https://www.entsoe.eu/Pages/default.aspx.

12. European Network of Transmission System Operators . Gas Transmission. [Online] 2015. http://www.entsog.eu/.

13. European Commission. Interpretative note on directive 2009/72/EC concerning common rules for the internal market in electricity and directive 2009/73/EC concerning common rules for the internal market in natural gas. [Online] 2010. https://ec.europa.eu/energy/sites/ener/files/documents/2010_01_21_retail_markets.pdf.

14. —. Energy Efficiency Directive. [Online] 2015. http://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive.

15. *Empowering the end-user in Smart Grids: Recommendations for the design of products and services.* Geelen D., Reinders A., Keyson D. s.l. : Energy Policy, 2013, Vol. 61.

16. European Commission. Directive 2009/28/EC of the European Parliament and of the Council of April 23rd 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC. [Online] http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:32009L0028.

17. —. *Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC .* [Online] http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32009L0072.

18. —. Directive 2009/73/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC. [Online] http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32009L0073.

19. European Union . *Access to European Union law.* [Online] 2015. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009R0713&from=EN.

20. European Commission. Regulation (EC) No 714/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the network for cross border exchanges in electricity and repealing Regulation (EC) No 1228/2003. [Online] http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32009R0714.

21. —. Regulation (EC) No 715/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the natural gas transmission networks and repealing Regulation (EC) No 1775/2005. [Online] 2015. http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32009R0715.

22. —. Horizon 2020. [Online] 2015. http://ec.europa.eu/programmes/horizon2020/what-horizon-2020.

23. EU technology platform for the electricity. European Electricity Grid Initiative. [Online] 2015. http://www.smartgrids.eu/Background.

24. Council of European Energy Regulators. *Status Review of Regulatory Aspects of Smart Metering.* [Online] 2013. http://www.ceer.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Customers/2013/7-1_C13-RMF-54-05-Status_Review_of_Regulatory_Aspects_of_Smart_Metering_FOR_PUBLICATION.pdf.

25. Council of European Energy Regulators. *CEER Status Review on European Regulatory Approaches Enabling Smart Grids Solutions ("Smart Regulation").* [Online] 2014. http://www.ceer.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Electricity/Tab3/C13-EQS-57-04_Regulatory%20Approaches%20to%20Smart%20Grids_21-Jan-2014-2.pdf.

26. European Commission. *Expert Group 3 – Regulatory recommendations for Smart Grid deployment.* [Online] 2015. https://ec.europa.eu/energy/en/topics/markets-and-consumers/smart-grids-and-meters/smart-grids-task-force.

27. France Energy Agency (ADEME). France – Smar Grid national implementation plans. [Online] http://www.ademe.fr/en.

28. Italian Energy Agency (AEEGSI). *Italy – Smart Grid national implementation plans.* [Online] http://www.autorita.energia.it/it/docs/10/039-10arg.htm#.

29. Danish Energy Agency (EFKM). *Denmark – Smart Grid national implementation plans.* [Online] http://www.efkm.dk/sites/kebmin.dk/files/klima-energi-bygningspolitik/dansk-klima-energi-bygningspolitik/energiforsyning-effektivitet/smart/smart%20grid-strategi%20web%20opslag.pdf.

30. Department of Energy and Climate Change. *UK Government.* [Online] 2011. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48128/2167-uk-renewable-energy-roadmap.pdf.

31. European Commission. Smart Grids: from innovation to deployment. [Online] 2011. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0202:FIN:EN:PDF.

32. UK Office of Gas and Electricity Markets. *Retail Market Review.* [Online] 2015. https://www.ofgem.gov.uk/electricity/retail-market/market-review-and-reform/retail-market-review.

33. Italian Regulatory Authority for Electricity

Gas and Water. *Electricity bill.* [Online] 2015. http://www.autorita.energia.it/it/consumatori/bollettatrasp_ele.htm.

34. Electricity and gas markets regulator in UK. OFGEM - Renewables Obligation (RO). *www.ofgem.gov.uk.* [Online] 2015. https://www.ofgem.gov.uk/environmental-programmes/renewables-obligation-ro.

35. —. OFGEM - Feed-in Tariff (FIT) scheme. *www.ofgem.gov.uk.* [Online] 2015. https://www.ofgem.gov.uk/environmental-programmes/feed-tariff-fit-scheme.

36. *Learning from experience? The development of the Renewables Obligation in England and Wales 2002–2010.* B. Woodman, C. Mitchell. 7, s.l. : Energy Policy, 2011, Vol. 39.

37. UK Office of Gas and Electricity Markets. OFGEM. [Online] 2015. https://www.ofgem.gov.uk/.

38. UK Office of Gas and Electricity markets. Changes to FIT scheme. [Online] 2012. https://www.ofgem.gov.uk/publications-and-updates/changes-fit-scheme-comprehensive-review-phases-1-2a-and-2b.

39. —. Renewable Heat Incentive (RHI) for non-domestic users. [Online] 2015. https://www.ofgem.gov.uk/environmental-programmes/non-domestic-renewable-heat-incentive-rhi.

40. —. *Renewable Heat Incentive (RHI) for domestic users.* [Online] 2015. https://www.ofgem.gov.uk/environmental-programmes/domestic-renewable-heat-incentive.

41. UK Government. Carbon price floor: reform. [Online] 2015. https://www.gov.uk/government/publications/carbon-price-floor-reform.

42. UK Department of Energy & Climate Change. The first delivery plan for Electricity Market Reform. [Online] 2013. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/268221/181213_2013_EMR_Delivery_Plan_FINAL.pdf.

43. *UK Office for Low Emission Vehicles.* [Online] 2015. https://www.gov.uk/government/organisations/office-for-low-emission-vehicles.

44. UK Office of Gas and Electricity Markets. Network regulation – the RIIO model. *UK Office of Gas and Electricity Markets.* [Online] 2015. https://www.ofgem.gov.uk/about-us/who-we-are.

45. —. *Background – RPI-X@20 Review.* [Online] 2015. https://www.ofgem.gov.uk/network-regulation-riio-model/background-rpi-x20-review.

46. UK Department of Energy and Climate Change. Consultation on reforms to the Capacity market. [Online] 2015. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/468173/Autumn_Consultation_Document.pdf.

47. UK government. *Technology Strategy Board: "Innovate UK".* [Online] 2015. https://www.gov.uk/government/organisations/technology-strategy-board.

48. Daily Hansard - Written Answers. *UK Parliamentary business.* [Online] 2015. http://www.publications.parliament.uk/pa/cm201415/cmhansrd/cm140708/text/140708w0002.htm#1407093000421.

49. UK Enginnering and Physical Sciences Research Coun. *Energy Storage.* [Online] 2015. https://www.epsrc.ac.uk/research/ourportfolio/researchareas/energystorage/.

50. Hough, David. Energy Storage R&D. *www.parliament.uk.* [Online] 2014. http://researchbriefings.files.parliament.uk/documents/SN06936/SN06936.pdf.

51. Engineering and Physical Sciences Research Council. Support by Research Area in Energy Storage. [Online] 2015. http://gow.epsrc.ac.uk/NGBOChooseTTS.aspx?Mode=ResearchArea&ItemDesc=Energy%20Storage.

52. UK Office of Gas and Electricity Markets. *Low Carbon Networks Fund.* [Online] 2015. https://www.ofgem.gov.uk/electricity/distribution-networks/network-innovation/low-carbon-networks-fund.

53. UK Data Communication Company. DCC. [Online] https://www.smartdcc.co.uk/about-dcc/.

54. *Policy and regulation for Smart Grids in the United Kingdom.* P. M. Connor, P. E.Baker, D.Xenias, N. Balta-Ozkan, C. J. Axon, Li. Cipcigan,. s.l. : Renewable and Sustainable Energy Reviews, 2014, Vol. 40.

55. ENEL Italian national energy company . [Online] 2015. https://www.enel.it/.

56. *Convergence to the European Energy Policy in European countries: case studies and comparison.* C. Teixeira, M. Albano, A. Skou, L. Pérez Dueñas. s.l. : SOCIAL TECHNOLOGIES, 2014, Vol. 4.

57. Italian national TSO - TERNA. Terna Rete Elettrica Nazionale S.p.A. . [Online] 2015. http://www.terna.it/.

58. *Changing the regulation for regulating the change: Innovation-driven regulatory developments for Smart Grids, smart metering and e-mobility in Italy.* L. Lo Schiavo, M. Delfanti, E. Fumagalli, V. Olivi. s.l. : Energy Policy, 2013, Vol. 57.

59. Italian energy services manager. GSE . *Gestore servizi energetici.* [Online] www.gse.it.

60. *A contribution on electricity storage: The case of hydro-pumped storage appraisal and commissioning in Italy and Spain.* B. Rangoni. London, UK : Utilities Policy, 2012, Vol. 23.

61. *An international review of the implications of regulatory and electricity market structures on the*

emergence of grid scale electricity storage. O. H. Anuta, P. Taylor, D. Jon, T. McEntee, N. Wade. s.l. : Renewable and Sustainable Energy Reviews, 2014, Vol. 38.

62. Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV). *IEA International Technology Co-operation Programme.* [Online] 2015. http://www.ieahev.org.

63. French electric utility company ERDF. [Online] 2015. http://www.erdf.fr/.

64. Electricity Distribution Grid of France. Frequently asked questions 2015. [Online] 2015. http://www.erdf.fr/ERDF_Questions_Frequentes_Linky.

65. *Smart metering trends, implications and necessities: A policy review.* J. Leiva, A. Palacios, J. A. Aguado. Renewable and Sustainable Energy Reviews : s.n., 2016, Vol. 55.

66. European Commission. National action plans - Germany Energy Plan. [Online] 2015. http://ec.europa.eu/energy/en/topics/renewable-energy/national-action-plans.

67. *Distributed generation in Germany: from policy planning to implementation to performance.* German Federal Ministry for the Environment, Nuclear Safety and Nature Conservation. Beijing : Great Wall Renewable Energy Forum 2012, Sino-German International Symposium on Renewable Energy and Distributed Generation, 2010.

68. D. Jacobs. *Renewable Energy Policy Convergence in the EU: The Evolution of Feed-in Tariffs in Germany, Spain and France.* Freie Universität Berlin, Germany : ASHGATE, 2012.

69. German Energy Agency. Dena Grid Study II – integration of renewable energy sources in the German power supply system from 2015–2020 with an outlook to 2025. [Online] 2011. http://www.dena.de/fileadmin/user_upload/Projekte/Erneuerbare/Dokumente/dena_Grid_Study_II_-_final_report.pdf.

70. Grid Reliability and Operability with distributed Ressources. EU Project. [Online] http://www.growders.eu/Publications.htm.

71. *An international review of the implications of regulatory and electricity market structures on the emergence of grid scale electricity storage.* O. H. Anuta, P. Taylor , J. Darren. s.l. : RenewableandSustainableEnergyReviews, 2014, Vol. 38.

72. J. Vasconcelos, Sophia Ruester, Xian He, Jean-Mich. Electricity storage: how to facilitate its deployment and operation in the EU. *European University Institute.* [Online] 2012. http://www.eui.eu/Projects/THINK/

Documents/Thinktopic/THINKTopic8online.pdf.

73. *Prospects for pumped-hydro storage in Germany.* B. Steffen. s.l. : Energy Policy, 2012, Vol. 45.

74. *Promoting the market and system integration of renewable energies through premium schemes—A case study of the German market premium.* E. Gawel, A. Purkus. s.l. : Energy Policy, 2013, Vol. 61.

75. Federal Ministry for Economic Affairs and Energy. [Online] http://www.bmwi.de/EN/root.html.

76. H. Edelmann, T. Kästner. Cost-benefit Analysis for the Comprehensive Use of Smart Metering, on behalf of the Federal Ministry of Economics and Technology. *Federal Ministry of Economics and Technology.* [Online] 2013. http://www.bmwi.de/EN/Service/publications,did=588534.html.

77. *Importance of policy for energy system transformation: Diffusion of PV technology in Japan and Germany.* S. Chowdhury, U. Sumita, A. Islam. s.l. : Energy Policy, 2014, Vol. 68.

78. *Integrating distributed generation: Regulation and trends in three leading countries.* K. L. Anaya, M. G. Pollitt. s.l. : Energy Policy, 2015, Vol. 85.

79. Danish national transmission system operator. [Online] 2015. http://www.energinet.dk/.

80. Danish energy regulator. [Online] 2015. http://www.ens.dk/en.

81. Council of European Energy Regulators (CEER). 2012 National Report Denmark. [Online] 2012.

82. *Dead battery? Wind power, the spot market, and hydro power.* J. Mauritzen. s.l. : Social Science Research Network, 2012.

83. Fischer, E. Fossil fuel free by 2050: Danish Energy Minister Martin Lidegaard explains how. *Power-technology.com.* [Online] 2012. http://www.power-technology.com/features/featurefossil-fuel-free-2050-denmark-wind-power.

84. CLEVER. Danish electric mobility operator . [Online] 2015. https://stateofgreen.com/en/profiles/choosev.

85. UK Office for Low Emission Vehicles. *Plug-in car grant eligibility guidance.* [Online] 2015. https://www.gov.uk/government/publications/plug-in-car-grant/plug-in-car-grant-eligibility-guidance.

86. *Electric vehicles' impact on british distribution networks.* Papadopoulos, P., et al., et al. 3, s.l.: Electrical Systems in Transportation, IET, 2012, Vol. 2.

87. *Goal-Oriented Prosumer Community Groups for the Smart Grid.* Rathnayaka, A.J.D., et al., et al. 1, 2014, Vol. 33.

88. *Building a Roadmap for Heat - 2050 scenarios and heat delivery in the UK.* Speirs, J., Gross, R., Deshmukh, S., Heptonstall, P., Munuera,

L., Leach, M. and Torriti, J.,. 2010.

89. UK Office of Gas and Electricity Markets. *RIIO-ED1 guidance documents.* [Online] 2015. https://www.ofgem.gov.uk/publications-and-updates/riio-ed1-guidance-documents.

90. UK office for low emission vehicles. *Lessons Learnt from the Plugged-in Places Projects.* [Online] 2013. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/236750/plugged-in-places-lessons-learnt.pdf.

91. UK Department of Energy & Climate Change. [Online] 2009. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/228866/7686.pdf.

92. UK Office of Gas and Electricity Markets. Smart metering implementation programme: data privacy and security. [Online] 2010. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/42730/232-smart-metering-imp-data-privacy-security.pdf.

93. European Joint Research Center. *JRC.* [Online] 2015. https://ec.europa.eu/jrc/.

94. UK Office of Gas and Electricity Markets. *Smarter Markets Programme.* [Online] 2015. https://www.ofgem.gov.uk/gas/retail-market/market-review-and-reform/smarter-markets-programme.

95. European Regulators Group for Electricity & Gas. Treatment of Losses by Network Operators ERGEG Position Paper for public consultation. [Online] 2008. http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_CONSULT/CLOSED%20PUBLIC%20CONSULTATIONS/ELECTRICITY/Treatment%20of%20Losses/CD/E08-ENM-04-03_Treatment-of-Losses_PC_2008-07-15.pdf.

96. —. *Treatment of Losses by Network Operators ERGEG Conclusion Paper.* [Online] 2009. http://www.ceer.eu/portal/page/portal/EER_HOME/EER_CONSULT/CLOSED%20PUBLIC%20CONSULTATIONS/ELECTRICITY/Treatment%20of%20Losses/CD/E08-ENM-04-03c_Treatment%20of%20losses_Conclusions_2009-02-1.pdf.

97. European Commission. The future role and challenges of Energy Storage. [Online] 2013. https://ec.europa.eu/energy/sites/ener/files/energy_storage.pdf.

98. Germany Federal Network Agency . Monitoring report 2013. [Online] 2013. http://www.bundesnetzagentur.de/SharedDocs/Pressemitteilungen/EN/2013/131219MonitoringReport2013.html.

99. *Integrating distributed generation: Regulation and trends in three leading countries.* K. L. Anaya, M. G. Pollitt. s.l. : Energy Policy, 2015, Vol. 85.

100. *Storing wind for a rainy day: what kind of electricity does Denmark export?* R. Green, N. Vasilakos. s.l. : Energy Journal, 2012.

101. *Occurrence of negative prices on the*

German spot market for electricity and their influence on balancing power markets. F. Genoese, M. Genoese, M. Wietschel. s.l. : 7th International Conference on the European Enegy Market, 2010.

102. Germany Trade & Invest . *economic development agency of the Federal Republic of Germany.* [Online] 2015. http://www.gtai.de/GTAI/Navigation/EN/Invest/Industries/Smarter-business/Smart-mobility/national-electromobility-development-plan.html.

103. Renewable Energy Sources Act 2014. *Federal Ministery for Economic Affairs and Energy.* [Online] 2014. http://www.bmwi.de/English/Redaktion/Pdf/renewable-energy-sources-act-eeg-2014,property=pdf,bereich=bmwi2012,sprache=en,rwb=true.pdf.

104. Electricity, Italian National Entity for. ENEL. [Online] www.enel.it.

105. Italian Energy Regulatory Authority . AEEGSI. [Online] http://www.autorita.energia.it/it/inglese/.

106. Italian Energy Certificates Market Manager. GME. *Gestore mercato elettrico.* [Online] http://www.mercatoelettrico.org/.

107. European Commission. *JRC Report, Smart Grid projects in Europe: Lessons learned and current developments with update* on outlook 2014.

108. —. Electricity network innovation competition. [Online] 2015. https://www.ofgem.gov.uk/network-regulation-riio-model/network-innovation/electricity-network-innovation-competition.

109. —. The 2015 Electricity Network Innovation Competition. [Online] https://www.ofgem.gov.uk/network-regulation-riio-model/network-innovation/electricity-network-innovation-competition.

110. —. UKPN's Low Carbon London Close-Down Report. [Online] 2015. https://www.ofgem.gov.uk/publications-and-updates/ukpn-s-low-carbon-london-close-down-report.

111. Power Network (UK DSO). Low carbon London. [Online] 2015. http://innovation.ukpowernetworks.co.uk/innovation/en/Projects/tier-2-projects/Low-Carbon-London-%28LCL%29/.

112. UK Office of Gas and Electricity Markets. Demonstrating the benefits of short-term discharge energy storage on an 11kV distribution network. [Online] 2015. https://www.ofgem.gov.uk/publications-and-updates/amended-proforma-first-tier-project-registration-edft1001-demonstrating-benefits-short-term-discharge-energy-storage-11kv-distribution-network-0.

113. Power Network (UK DSO). Short-term discharge energy storage. [Online] 2015. http://innovation.ukpowernetworks.co.uk/innovation/en/Projects/tier-1-projects/demonstrating-the-benefits-of-short-term-discharge-energy-storage.

114. UK Office of Gas and Electricity Markets.

Electricity North West Limited: Capacity to Customers - Close-Down Report. [Online] 2015. https://www.ofgem.gov.uk/publications-and-updates/electricity-north-west-limited-capacity-customers-close-down-report.

115. UK Office of Gas and Electricity Markets. 33kV Superconducting Fault Current Limiter Close Down Report . [Online] 2015. https://www.ofgem.gov.uk/ofgem-publications/94151/33kvsfclfinalclosedownreportver10final-pdf.

116. —. Northern Powergrid Northeast's Customer-Led Network Revolution Close-Down Report. [Online] https://www.ofgem.gov.uk/publications-and-updates/northern-powergrid-northeast-s-customer-led-network-revolution-close-down-report.

117. Network revolution project. Customer-led network revolution. [Online] 2015. http://www.networkrevolution.co.uk/the-project/whos-funded-the-project/.

118. http://www.smartgrids.eu/documents/4thGA/Oglietti1.pdf

119. http://www.energy-daily.com/reports/Italian_smart_grid_demo_project_under_way_999.html

120. http://www.autorita.energia.it/it/inglese/about/presentazione.htm#top

121. The Danish system of electricity policy – making and regulation, http://projects.exeter.ac.uk/igov/wp-content/uploads/2015/06/ML-Danish-model-of-regulation1.pdf, Matthew Lookwood, Sep 2015

122. https://www.forskel.dk and http://energinet.dk

123. European Commission. JRC Report, Smart Grid projects outlook 2014: http://ses.jrc.ec.europa.eu/sites/ses.jrc.ec.europa.eu/files/u24/2014/report/ld-na-26609-en-n_smart_grid_projects_outlook_2014_-_online.pdf

124. Germany's Energy Concept. [Online] http://www.gtai.de/GTAI/Navigation/EN/Invest/Industries/Smarter-business/Smart-energy/germanys-energy-concept,t=germanys-e-energy-model-projects,did=323796.html.

125. Commission de régulation de l'énergie. [Online] 2015. http://www.smartgrids-cre.fr/.

126. European Regulators' Group for Electricity and Gas. Position Paper on Smart Grids: An ERGEG Public Consultation Paper. [Online] 2009. http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_CONSULT/CLOSED%20PUBLIC%20CONSULTATIONS/ELECTRICITY/Smart%20Grids/CD/E09-EQS-30-04_SmartGrids_10%20Dec%202009_0.pdf.

127. —. Position Paper on Smart Grids – An ERGEG Public Consultation Paper. [Online] 2010. http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Electricity/2010/E10-EQS-38-05_SmartGrids_Conclusions_10-Jun-2010_Corrigendum.pdf.

128. Electric Power Research Institute, Inc. [Online] 2015. http://www.epri.com/.

129. EU Joint Research Center. Guidelines for conducting a cost-benefit analysis of Smart Grid Projects. [Online] 2012. http://ses.jrc.ec.europa.eu/smart-grid-cost-benefit-analysis.

130. —. Guide to cost-benefit analysis of investment projects. Directorate General for Energy Policies. [Online] 2008. http://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/cba_guide.pdf.

131. GRID4EU. Project overview. [Online] 2016. http://www.grid4eu.eu/overview.aspx.

132. European Commission. Evaluation of Smart Grid projects within the Smart Grid Task Force Expert Group 4. [Online] 2013. http://ses.jrc.ec.europa.eu/sites/ses.jrc.ec.europa.eu/files/publications/evaluation_of_smart_grid_projects_within_the_smart_grid_task_force_expert_group_4_eg4.pdf.

133. European Regulators' Group for Electricity and Gas. Cross Border Framework for Electricity Transmission Network Infrastructure - An ERGEG Conclusions Paper. [Online] 2007. http://www.energy-regulators.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Electricity/2007/E07-ETN-01-03_CB-Frameword-ETNI_V24-04.pdf.

134. —. ERGEG Status Review on Building and Construction Authorisation and Permit Process. [Online] 2008. http://www.ergeg.org/portal/page/portal/ERGEG_HOME/ERGEG_DOCS/ERGEG_DOCUMENTS_NEW/ELECTRICITY_FOCUS_GROUP/E08-EFG-27-04_BCAP_Case_Examples_06-Feb-08.pdf.

135. Nice Grid Project. [Online] http://www.nicegrid.fr/.

136. Grid4EU. Final report (forthcoming). [Online] 2016. http://www.grid4eu.eu/results.aspx.

137. CEER Benchmarking Report 5.2 on the Continuity of Electricity Supply Data update , Ref: C14-EQS-62-03 February 12th 2015

European Union

SECTOR DIALOGUES EUROPEAN UNION BRAZIL

MINISTRY OF PLANNING

MINISTRY OF SCIENCE, TECHNOLOGY INNOVATION AND COMMUNICATIONS

BRASIL BRAZILIAN GOVERNMENT