Innovation Action

inteGRIDy

integrated Smart GRID Cross-Functional Solutions for Optimized Synergetic Energy Distribution, Utilization & Storage Technologies

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WP2 – Standardization Analysis, Regulations & Privacy Policy

D2.1 - Current standards & interoperability issues applicable to the inteGRIDy pilot cases

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Abstract:	This document offers an insight into current standards, national & EU regulatory developments, considering interoperability between metering, system operators and other participants in the electricity system and the empowerment of customers. The goal is to review the compliance in each of the inteGRIDy pilot use cases to the current standards, national & EU regulatory developments. The use of official open standards, further definition of profiles and conformance and interoperability will be the key success indicators assessed. The content represents the result of an in-depth analysis conducted by all partners involved.
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Executive Summary

The EU is committed to reducing greenhouse gas emissions by 40% by 2030 and reaching a 20% share of renewables by 2020 increasing to at least a 27% share by 2030. The electricity grid has a fundamental role in meeting these targets. The increased share of Renewable Energy Sources (RES) leads to a deep review in the energy infrastructure design, control and regulation logics. Moreover, the regulatory framework and the energy market infrastructure need also to be consequently updated.

In such context, inteGRIDy envisions the realisation and demonstration of a solution that helps to meet the challenges under a variety of environmental, market and societal conditions at 10 pilot and demonstration sites throughout EU.

Activities included under Standardization Analysis, Regulations and Privacy Policy (which are part of the first phase of inteGRIDy project) contribute to set the groundwork of the project and include all major common activities required. Thus, Phase one constitutes the foundation, cornerstone and connecting glue of the overall project.

The outcomes of Standardization Analysis, Regulations and Privacy Policy activities foresee as objectives:

- the identification, in relation to Smart Grids in context of each of the countries in which the inteGRIDy solution is to be piloted, of the following: (i) Current Standards & Interoperability; (ii) Legal, Regulatory & Market Design Issues and (iii) Regulations for Privacy & Cyber Security.
- guidelines for data management in the project which will be implemented across all other activities.

In particular D2.1 has to review the compliance in each of the pilot use cases to the current standards, national & EU regulatory developments, considering interoperability between metering, system operators and other participants in the electricity system and the empowerment of customers.

In this report, a description of the regulatory framework in place is provided. D2.1 supplies a list of the key standards and EU/national regulations that pilot sites need to check their compliance with, and an analysis of the compliance with these key standards and EU/national regulations in each pilot use case at each pilot site. The 10 Pilots are analysed.

The methodology used is a multi-structured approach including mainly: brainstorming; research work on focused subjects (original articles, websites screening of EU Official Journals websites), EU roadmaps in energy websites, Smart Grid and smart metering solutions websites, published standards, guidelines, white papers and innovation papers related to the reference domain - smartening the electricity grid - and the specific topics of the Project; collection of information available at Member States level.

The analysis shows that within the different Member States, there is still a significant gap concerning:

- Legislative maturity in the energy field;
- Quality of infrastructures;
- Effective penetration of market liberalization rules.

All EU countries have successfully transposed the EU Energy directives. However, transposition does not necessarily lead to implementation.

Some countries have already reached a certain degree of maturity in the legislative framework and in the implementation of EU rules; many others still need quite some effort to reach an acceptable level of integration and to be compatible with a common European infrastructure. For example:

- in Greece, the liberalization of the energy market did not yet take place (there is still a monopoly);
- in Cyprus, liberalization process started but there is in reality only one operator;
- in France, even if the liberalization of gas and electricity markets took place, and there is a mature level of infrastructure, the market historical operator still occupies the main positions;
- Romania lacks a consistent legal framework in energy sector and the costs of the liberalized market are higher than the captive market.

Nevertheless, from the present Report it emerges that all inteGRIDy pilots will be conducted in compliance with available standards and EU legislation transposed and currently in force in the country of reference.

It is clear that the different pilots have to face different rules and challenges, which means that, today, the integration process still looks complicated and that some Member States will need a longer period of time before reaching minimum level of compliance.

Nevertheless, the almost total absence of legislation and integration of smart grids, especially in some countries, can be taken as an advantage by the inteGRIDy project which aims at defining common standards in this field immediately prior to their effective implementation.

Finally, in all pilots, there is clear confidence in the achievable results and the willingness to demonstrate the opportunities that the implementation of smart grids within European networks can entail in terms of network robustness, flexibility, energy supply and environmental benefits.

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List of Acronyms and Abbreviations

Term	Description
VPS	Virtual Power System
VPP	Virtual Power Plant
RES	Renewable Energy Sources
CEN	European Committee for Standardization
IEC	International Electrotechnical Commission
EFTA	European Free Trade Association
ETSI	European Telecommunications Standards Institute
CENELEC	European Committee for Electrotechnical Standardization
SOA	Service-Oriented Architecture
AS	Application Server
AMI	Advanced Metering Infrastructure
DA	Distribution Automation
DER	Distributed Energy Resources
DMS	Distribution Management System
DR	Demand Response
DSO	Distribution System Operator
EMS	Energy Management System
CIM	Common Information Model
COSEM	Companion Specification for Energy Metering
BESS	Battery Energy Storage Systems

1.Introduction

1.1 Scope and objectives of the deliverable

This report deals with the current standards & interoperability issues applicable to the 10 inteGRIDy pilot cases, listed below:

- Isle of Wight, UK
- Terni, IT
- San Severino Marche, IT
- Barcelona, ES
- St-Jean, FR
- Lisbon, PT
- Nicosia, CY
- Xanthi, GR
- Thessaloniki, GR
- Ploiesti, RO

The main target of this report is to give readers information about the compliance in each of the pilot use cases to the current standards, EU & national regulatory developments, considering interoperability between metering, system operators and other participants in the electricity system and the empowerment of customers.

The analysis conducted considers International Electrotechnical Commission (IEC), CEN-CENELEC-ETSI [CEN17] standards and EU Directives and Recommendations (such as the 2012 /148/EU related to the roll out of smart metering) and the findings of the European Smart Grid Task Force.

1.2 Structure of the deliverable

The report is structured in 4 different chapters. Apart from this first introductory section, the following ones are described under these lines.

Chapter 2 presents a description of existing and applicable EU and international standards, EU Directives and Recommendations about smart grids and related issues. With regards to standards at international level, the International Electrotechnical Commission, IEC, dedicated effort to identify existing standardization of smart grid technologies and potential gaps relevant for smart grid implementation. At European level, three European Standardization Organizations (ESOs), namely CEN, CENELEC and ETSI are responsible for developing and defining voluntary standards to support the implementation of European legislation to pursue the successful integration of the European energy market and the implementation of the EU's climate and energy targets. Their work focuses on different aspects concerning Smart Grid development and interoperability as Energy Storage, Demand Response, E-Mobility and related technologies.

Considering EU Directives, the European Commission focuses mainly on the liberalization and regularization of gas and electricity markets guaranteeing a safe supply for electricity, gas and oil and boosting the Trans-European networks identifying projects of common interest and priority projects in the trans-European electricity and gas networks. Finally, it is highlighted the compliance between EU Recommendations about smart grid (Smart Grid Task Force) and the inteGRIDy project regarding privacy and data protection, smart metering, security, architecture, system aspects and interfaces, electromagnetic compatibility (EMC) and power quality and market's and consumers' needs.

Chapter 3 starts with the analysis of the national transposition of standards and EU Directives, to move to the analysis of the compliance of each inteGRIDy pilot cases to current standards, national and European regulatory developments. It provides information on the current national legislations about electricity grid and regulatory developments concerning smart grid solutions in the participant partners Countries: Cyprus, France, Greece, Italy, Portugal, Romania, Spain, United Kingdom.

Finally, **Chapter 4** presents the conclusions to the report with respect to all aforementioned topics covered on precedent chapters.

1.3 Relation to Other Tasks and Deliverables

Figure 1 illustrates the relationship between the research presented in the different deliverables produced by Standardization Analysis, Regulations & Privacy Policy activities.

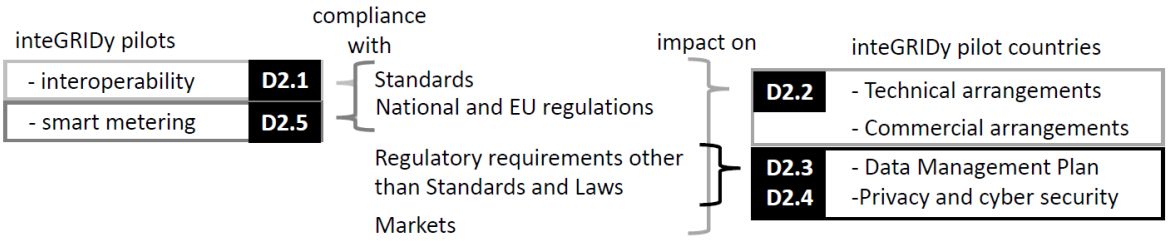

Figure 1. Standardization Analysis, Regulations & Privacy Policy deliverable relationship

D2.1 Supplies a concise justified description of the key standards and EU/national regulations that pilot sites need to check their compliance with, and an analysis of each pilot use case at each pilot site of their compliance with previously identified key standards and EU/national regulations.

Building on D2.1, D2.2 supplies a set of legal regulatory and market design issues and their impact on a clearly defined and justified set of technical and commercial arrangements for smart grid distribution networks in each pilot country.

D2.3 provides the project data management plan for participation to the 'pilot on Open Research Data in Horizon 2020. D2.4, which is an updated version of D2.3, adds the compliance with the regulations related to smart grids and privacy and cyber security at each of the demonstration sites.

Finally, D2.5 Looks at smart metering in depth in relation to compliance with EU regulations regarding standards, functionality connectivity and interoperability focusing on the regulation standards and functionality related to encouraging consumer interest in energy saving and demand flexibility actions.

2.Definition and collection of standards and legislation

This section addresses the relevant aspects of current standards and EU regulatory developments about smart grids and related issues.

The general work of international standardization is carried out by the **International Organization for Standardization (ISO)**. It publishes international standards to harmonize national standards. In the field of electricity, the **International Electrotechnical Commission (IEC)** constitutes the global standardization scale and has dedicated efforts to identify existing standardization and potential gaps relevant for Smart Grid implementation [IEC10], IEC identified a set of core standards valid or essential for nearly all Smart Grid applications, the "**core standards**". These core standards, presented below in section 2.1.1, are standards that have an enormous effect on any Smart Grid application and solution representing a backbone of Smart Grid technologies. Besides the core standards, IEC also offers a number of highly important standards for Smart Grid mainly focused on **interoperability issues**, namely the integration among items constituting a **Smart Grid system.**

Beyond the international efforts dedicated by IEC regarding the standardization of Smart Grid Technologies, there are mainly three European Standardization Organizations, **CEN, CENELEC and ETSI, responsible for defining and developing voluntary standards at European level**, to support the implementation of European legislation, the successful integration of the European energy market and the implementation of the EU's climate and energy targets.

The Members of CEN are the National Standardization Bodies of 34 European countries including all the Member States of the European Union (EU) and other countries that are part of the European Single Market. The **European Committee for Standardisation**, **CEN** [CEN17], provides a platform for the development of European Standards and other technical documents with regard to various kinds of products, materials, services and processes. **CEN works with its Members to develop and define European Standards in response to specific needs** that have been identified by businesses and other users of standards. **Each National Standardization Body that is part of the CEN system is obliged to adopt each European Standard as a national standard and make it available to customers in their country**. They also have to withdraw any existing national standard that conflicts with the new European Standard. Therefore, one European Standard (EN) becomes the national standard in all 34 CEN members' countries. **The main standards regulating the different aspects concerning Smart Grid technologies are illustrated in section 2.1.2**.

Concerning the EU regulatory developments about smart grids, this report analyses firstly **the three legislative packages of measures** that the European Commission adopted between 1996 and 2009 in order to harmonize, liberalize and build the EU's internal energy market; they focus on:

- market access and transparency and regulation;
- consumer protection;
- support for infrastructure interconnection and adequate supply levels.

The first legislative package (Directive 96/92/EC on common rules for the internal market in electricity and Directive 98/30/EC on common rules for the internal market in natural gas) was replaced in 2003 by a second legislative package that has allowed new gas and electricity suppliers to access markets in the Member States and has given consumers the possibility to choose their own gas and electricity providers. A **third legislative package (IME3)** was adopted in 2009 to further liberalize the internal electricity and gas markets. **It is**

one of the most important pieces of EU legislation on European gas and electricity markets. It came into force on September 2nd, 2009 and consists of three Regulations and two Directives.

The other relevant legislations included in this analysis are:

Directive 2005/89/EC, which lays down measures to safeguard the security of electricity supply, ensuring the proper functioning of the internal electricity market and an appropriate level of interconnection between Member States, an adequate level of generation capacity and optimal balance between supply and demand.

Directive 2008/92/EC, which intends to improve price transparency for gas and electricity final consumers by requiring to the Member States to ensure that prices and pricing systems used are communicated to Eurostat twice a year.

Regulation (EU) No. 1227/2011 on the Integrity and Transparency of the Wholesale Energy Market, which aims to ensure fair trade practices in European energy markets.

Directive 2012/27/EU on Energy Performance of Buildings and the **Directive 2010/31/EU** on Energy Efficiency, which provide the main legislative framework focused on the reduction of the energy consumption of buildings.

Directive 2009/28/EC of the European Parliament, which regulates the production and promotion of the use of energy from renewable sources in EU.

2.1 Standards

2.1.1 International level (IEC)

Table 1. Core Standards.

Standard or series	Topic
IEC 61970/61968	CIM Applying mainly to: Generation management systems, EMS, DMS (Distribution Management System); DA; SA; DER; AMI; DR; E-Storage.
IEC 62325	CIM based, Energy market information exchange Applying mainly to: Generation management systems, EMS; DMS; DER; AMI; DR; meter-related back-office systems; E-Storage
IEC 61850	Power Utility Automation, Hydro Energy Communication, Distributed Energy Resources Communication Applying mainly to: Generation management systems, EMS; DMS; DA; SA; DER E Storage; E-mobility
IEC 62056	COSEM Applying mainly to: DMS; DER; AMI; DR; Smart Home; E-Storage; E-mobility Data exchange for meter reading, tariff and load control
IEC 62351	Applying mainly to: Security for all systems
IEC 61508	Applying mainly to: Functional safety of electrical/electronic/programmable electronic safety-related systems

Besides the Core Standards, IEC also offers a number of highly important standards for Smart Grid mainly focused on integration among items constituting a **Smart Grid system on interoperability issues.**

Table 2. Other highly important standards.

Standard or series	Topic
IEC 62357	Power utilities Reference Architecture – SOA Applying mainly to: Energy Management Systems; Distribution Management Systems; DER operation systems, market & trading systems, DR systems, meter-related back-office systems
IEC 60870-5	Telecontrol Applying mainly to: EMS; DMS; DA; SA
IEC 60870-6	TASE2 Inter Control Centre Communication Applying mainly to: EMS; DMS
IEC/TR 61334	(DLMS) Distribution Line Message Specification Applying mainly to: AMI
IEC 61400-25	Wind Power Communication Applying mainly to: DER operation systems (Wind farms); EMS; DMS;
IEC 61851	EV-Communication Applying mainly to: E-mobility; Home & Building management systems;
IEC 62051-54/58-59	Metering Standards Applying mainly to: DMS; DER; AMI; DR; Smart Home; E-Storage; E-mobility

2.1.2 European level (CEN-CENELEC-ETSI)

In March 2011, the European Commission and EFTA issued the Smart Grid Mandate M/490 which was accepted by the three European Standards Organizations (ESOs), CEN, CENELEC and ETSI in June 2011. M/490 requests CEN, CENELEC and ETSI to develop a framework to enable ESOs to perform continuous standard enhancement and development in the smart grid field. In order to perform the requested work, the ESOs combined their strategic approach and established in July 2011, together with the relevant stakeholders, the CEN-CENELEC-ETSI Smart Grid Coordination Group (SG-CG), responsible for coordinating the ESOs reply to M/490.

In the end 2014 CEN-CENELEC-ETSI Smart Grid Coordination Group finalized mandated reports concerning Smart Grid Technologies deployment, Methodology adopted, Interoperability and Information Security.

In [CCE13] attention is focused on different aspects of Smart Grid Technologies and identifies per each subsystem existing protocols or incoming ones.

Storage:

As regards the adoption and integration of batteries or energy storage solutions in Smart Grid applications, such aspects are detailed and discussed in the section dedicated to “Distributed Energy Resources Operation System”. The definition for a DER Operation System is the following:

DER Operation System is responsible for enterprise level management of the DER assets. It performs supervision and maintenance of the components, provides information to the operators and field crew personnel and controls actual generation. It can act as a technical VPP (tVPP) interacting directly with the DSO or as a commercial VPP (cVPP) interacting with the energy market. The system may control one or more DERs which can be geographically distributed. These DERs could be single generation plants or could be combined to VPPs.

The system provides information on the generation capabilities of the DER/VPP and the expected generation (forecast). It controls the actual generation and storage including VAR regulation and frequency support based on requests and schedules received from the market or DSO.

The main standards regulating the integration and the adoption of storage systems in the Smart Grid are the following:

Table 3. Main standards regulating energy storage integration.

Standard or series	Topic	Delivery Status
EN 61850-7-4 EN 61850-7-2 EN 61850-7-3 EN 61850-6	Core Information model and language for the IEC/EN 61850 series	Available
EN 61850-7-420	DER	Available
IEC 61499	Distributed control and automation	Available
IEC 61850-90-9	Batteries	Forthcoming

Demand Response:

The main issues related to Demand Response technologies and applications are discussed in section “Demand and production (generation) flexibility system”. In [CCE13] this class of solutions are defined as follow:

The aggregated prosumers management system comprises the AMI itself, the HAN gateway, customer energy management systems (CEM), building management systems and Smart devices. These are elements in a demand response management system, which offers alternative channels to the home/building, the AMI being one of them.

The major standards which regulate adoption of demand response technologies are listed as follows:

Table 4. Main standards for demand response adoption.

Standards or series	Topic	Delivery status
EN 61968	Information exchanges between electrical distribution systems	Available
IEC 62351	Cyber-security aspects	Updated version coming
IEC 62746	System interfaces and communication protocol profiles relevant for systems connected to the Smart Grid	Updated version coming
EN 62325	Framework market communication	Updated version coming
EN 50491-12	Smart grid - Application specification. Interface and framework for customer energy management	Forthcoming

E-Mobility:

In [CCE13] the section "E-Mobility System" is dedicated to identifying main standards affecting the integration of these solutions. E-mobility systems are described as follow:

E-mobility comprises all elements and interfaces which are needed to efficiently operate Electric Vehicles 3028 including the capability to consider them as a flexibility resource in a Smart Grid system. E-Mobility is one option for a Smart Grid in respect to the integration of energy storage and therefore the integration of renewable energies. Furthermore, it would serve the conservation of individual mobility in times of decreasing fossil fuel supply. The full scope of its capability, however, can only be achieved by seamless integration into a Smart Grid architecture. E-Mobility provides a large, flexible load and storage capacity for the Smart Grid. This however depends on the us e case, some of which are not capable of contributing to these advantages. Basic charging (charging the car at a today existing plug) does not offer the full scope of possibilities from a Smart Grid perspective. Battery swapping scenarios only contribute insofar as the batteries serve Smart Grid functions within the swapping station, not in the car itself. A seamless integration can be provided through bidirectional power flow, utilization of manageable loads and maximum information exchange between onboard and grid automation, including price information.

The main standards regulating E-Mobility applications are listed as follows:

Table 5. Main standards regulating -mobility.

Standards or series	Topic	Delivery status
EN 61850-7-420	Communication networks and systems for power utility automation	Available
ISO/IEC 15118	Road vehicles – Communication protocol between electric vehicle and grid	Available
EN 62443	Industrial communication networks – Network and system security	Available
EN 61851	Electric vehicle conductive charging system	Available
IEC 60783	Wiring and connectors for electric road vehicles	Available
IEC 60784	Instrumentation for electric road vehicles	Available
IEC 60785	Rotating machines for electric road vehicles	Available
IEC 60786	Controllers for electric road vehicles	Available
EN 60364	Electric road vehicles recharging stations	Available
ISO 8713	Electrically propelled road vehicles - Terminology	Available
IEC 61894	Preferred sizes and voltages of battery monoblocs for electric vehicle applications	Available
EN 61980	Electric equipment for the supply of energy to electric road vehicles using an inductive coupling	Available
IEC 61981	On board electric power equipment for electric road vehicles	Available
EN 61982	Secondary batteries for the propulsion of electric road vehicles	Available
EN 62196	Plugs, socket-outlets, vehicle couplers and vehicle inlets – Conductive charging of electric vehicles	Available

ISO 6469	Electrically propelled road vehicles - Safety specifications	Available
EN 61968	Common Information Model (CIM) / Distribution Management	Updated version coming
EN 61970	Energy Management System Application Program Interface (EMS-API)	Updated version coming
IEC 61850-90-8	Object models for electric mobility	Coming
EN 60364-7-722	Requirements for special installations or locations - Supply of Electric vehicle	Coming
IEC 62351	Cyber-security aspects	Coming

2.2 EU legislation

Developing carbon neutral technologies and making better and more rational use of energy and other natural resources have become essential for sustainable development of our society. This has been emphasized by the Europe 2020 objectives related to climate change and energy. The EU has set the targets of cutting greenhouse gas emissions by 20%, improving energy efficiency by 20% and raising the share of renewable energy to 20% by 2020. The EU framework on climate and energy for 2030 proposed by the European Commission in January 2014 presents targets that are more ambitious and aims to reduce greenhouse gas emissions by 40% and to increase the use of renewables to at least 27% by 2030. In addition, Europe is still going through a process of opening up of utilities markets including those for electricity and gas.

In the energy sector, the EU internal market requires the removal of many obstacles and trading barriers, the approximation of fiscal policies, prices or measures concerning regulations and standard as well as environmental and security provisions [STO16]. The main scope of EU is to boost an effective market that ensures access fairness and a high level of consumer protection as well as adequate levels of interconnection and generation capability. In February 2011, the European Council set the objective of completing the internal energy market by 2014 and of developing interconnections in order to put an end to all Member States' isolation by the European gas and electricity networks by 2015.

In order to harmonize and liberalize the EU's internal energy market the European Commission between 1996 and 2009 adopted three legislative packages of measures focused on:

- market access and transparency and regulation;
- consumer protection;
- support for infrastructure interconnection and adequate supply levels.

2.2.1 Liberalization of gas and electricity markets

The first legislative package (Directive 96/92/EC on common rules for the internal market in electricity and Directive 98/30/EC on common rules for the internal market in natural gas) was replaced in 2003 by a second legislative package that has allowed new gas and electricity suppliers to access markets in the Member States and has given consumers the choice of their own gas and electricity providers. A third legislative package was adopted in 2009 to further liberalize the internal electricity and gas market. The Third Package (IME3) is one of the most important pieces of EU legislation on European gas and electricity markets.

It came into force on September 2nd, 2009 and consists of the following three Regulations and two Directives:

- Directive 2009/72/EC concerning common rules for the internal market in electricity
- Directive 2009/73/EC concerning common rules for the internal market in gas
- Regulation (EC) No 713/2009 on the establishment of the Agency for the Cooperation of Energy Regulators ACER
- Regulation (EC) No 714/2009 on conditions for access to the network for cross-border exchange of electricity
- Regulation (EC) No 715/2009 on conditions for access to the natural gas transmission networks

Here only those regulations and directives concerned with Electricity markets are considered.

One of the key aims of the IME3 was to further liberalise European energy markets. As such one of the core provisions of the Third Package is ensuring that Transmission System Operators (TSOs) are unbundled from generation, production and supply activities and are certified as such. The IME3 also created a regulatory framework to support a single European Energy Market by developing Network Codes.

The new directives on Electricity (2009/72/EC), repealing Directive 2003/54/EC, and on gas (2009/73/EC), repealing Directive 2003/55/EC, aim to:

- Regulate the ownership of electricity and gas transmission networks by ensuring a clear separation between supply and production activities from one side and networks management on the other, through the definition of three organizational models: a) complete “ownership separation”, b) independent system operator, c) independent transmission / transport operator;
- Ensure more effective vigilance by national regulatory authorities, which are truly independent, by strengthening and harmonizing the competences and the independence of these authorities in order to assure a proper access to transmission/transport networks avoiding any form of discrimination;
- Strengthen consumer protection ensuring the tutelage of vulnerable consumers;
- Regulate third-party access to gas storage and liquefied natural gas (LNG) systems and to lay down rules on transparency and periodic reporting of gas reserves;
- Promote regional solidarity by requiring Member States to cooperate in the event of serious gas supply disturbance, coordinating national emergency measures and developing interconnections of gas networks.

In February 2015, the European Commission published a communication about the above-mentioned package specifying that the main objective of UE is to provide consumers with: “safe, sustainable and competitive energy at affordable prices” acting on the following leverages:

- Energy security, solidarity and trust;
- Full integration of the European energy market;
- Energy efficiency to contain demand;
- Decarbonisation of the economy;
- Research, innovation and competitiveness.

The European Commission also published its proposal for a Regulation on guidelines for Energy Infrastructure [ECP20] in Europe on 19th of October 2011. The Regulation, came into force in 2013, it covers both the gas and electricity markets and aims to ensure that strategic

energy networks and storage facilities are in place by 2020. The Commission Recommendation 2012 /148/EU related to the role out of smart metering is also of significance to the development of smart grids. European Energy Efficiency Directive and Network Codes have led to the inclusion of Demand Response in the European Commission's legislative proposals on Electricity Market Design within the Clean Energy Package, from November 2016 [SED17].

2.2.2 Regulating the Energy Market

In 2003 has been set the Group of European Regulators for Gas and Electricity with the scope of ensuring cooperation between different national regulatory authorities and the consistent application of the Internal Market Directives (Decision 2003/796/EC) within the Member States. In 2010 the Agency for the Cooperation of Energy Regulators (ACER) has been established with **Decision (CE) n. 713/2009**, starting its activities in 2011. As a monitoring body with an advisory role, the Agency presents recommendations to the Commission on market regulation and priorities for the transmission/transport infrastructures. The main competences of the Agency are the following:

- Promote cooperation between national regulatory authorities at regional and European level;
- Monitor the execution performances of the implementation for the ten-year network development plans;
- Monitor the internal markets for electricity and natural gas.

Two regulations have been adopted as further measures to create cooperation structures for the European Network of Transmission System Operators (REGST): a regulation for electricity (EC/714/2009) and one for gas (EC/715 / 2009). REGST and ACER define detailed network access codes and technical codes and ensure network management coordination through the exchange of operational data and the development of common safety and emergency procedures and standards. REGST also has a task to draw up a ten-year investment plan every two years, which is then reviewed by ACER. In October 2013, the Commission adopted the first global gas network code for cross-border capacity allocation (Commission Regulation (EU) No. 984/2013).

Directive 2008/92/EC intends to improve price transparency for gas and electricity final consumers by requiring to the Member States to ensure that prices and pricing systems used are communicated to Eurostat twice a year. In October 2011, the EU adopted **Regulation (EU) No. 1227/2011** on the Integrity and Transparency of the Wholesale Energy Market, which aims to ensure fair trade practices in European energy markets. It gives ACER the power to collect, examine and share data from wholesale energy markets, monitor markets and negotiate, investigate cases of market abuse and coordinate with Member States the appropriated sanctions to apply. The European Council of 22 May 2013 called on the Commission to present an analysis of the composition and the determinants of energy prices and costs in the Member States, which the Commission published in January 2014 (COM (2014) 0021 and SWD (2014) 0020).

Beyond this, in [EUC16] European Commission (COM (2016) 860) proposed a package of measures to keep the European Union competitive as the clean energy transition is changing global energy markets. The Commission wanted the EU to lead the clean energy transition, not only adapt to it. For this reason, the EU committed to cut CO2 emissions by at least 40% by 2030 while modernising the EU's economy and delivering on jobs and growth for all European citizens. The proposed package had three main goals: putting energy efficiency first, achieving global leadership in renewable energies and providing a fair deal for consumers.

2.2.3 Safe supply for electricity, natural gas and oil

Directive 2005/89/EC lays down measures to safeguard the security of electricity supply, ensuring the proper functioning of the internal electricity market and an appropriate level of interconnection between Member States, an adequate level of generation capacity and optimal balance between supply and demand. The strategy seeks to ensure the stability and abundance of energy supply for European citizens and for the economy. It illustrates measures such as increased energy efficiency and internal energy production or the completion of missing infrastructure links to divert energy wherever there is a need during a crisis.

2.2.4 Reduction of the energy consumption of buildings

The European Parliament, with the **Directive 2012/27/EU on Energy Performance of Buildings** and the **Directive 2010/31/EU on Energy Efficiency**, provided the main legislative framework focused on the reduction of the energy consumption of buildings.

The Energy Performance of Buildings Directive has been updated on the 30 November 2016, the improvements mainly regarded the promotion of integration in smart technology in buildings and the creation of the EU Building Stock Observatory with the objective to track the energy performance of buildings across Europe.

The Energy Performance of Buildings Directive states the following:

- energy performance certificates are to be included in all advertisements for the sale or rental of buildings in the EU market;
- EU countries must establish inspection schemes for heating and air conditioning systems or put in place measures with equivalent effect;
- all new buildings must be nearly zero energy buildings by 31 December 2020 (public buildings by 31 December 2018);
- EU countries must set minimum energy performance requirements for new buildings, for the major renovation of buildings, and for the replacement or retrofit of building elements (heating and cooling systems, roofs, walls and so on);
- EU countries have to draw up lists of national financial measures to improve the energy efficiency of buildings.

In addition to these recommendations, Energy Efficiency Directive introduced the following regulations:

- EU countries make energy efficient renovations to at least 3% of buildings owned and occupied by central government;
- EU governments should only purchase buildings which are highly energy efficient;
- EU countries must draw-up long-term national building renovation strategies which can be included in their National Energy Efficiency Action Plans.

2.2.5 Renewable energy

The **Directive 2009/28/EC** of the European Parliament regulates the production and promotion of the use of energy from renewable sources in EU. The main objectives of the Directive concerned on satisfying at least 20% of total energy consumption through renewable energy sources and ensuring that at least 10% of transport fuels come from those sources by 2020.

On 30 November 2016, the Commission updated the target increasing to 27% the share of total energy consumption to be supplied with renewable sources by 2030.

For the achievement of common targets, the directive specifies for each state the objectives to be achieved on the basis of its own potential. The countries have to outline how they intend to reach these goals through the implementation of National Renewable Energy Action Plans.

Moreover, the directive defines mechanisms in order to support cooperation between countries helping them to reach their targets. This cooperation regards:

- statistical transfers of renewable energy;
- joint renewable energy projects;
- joint renewable energy support schemes.

As far as transport is concerned, the Directive defines the criteria for the production and consumption of biofuels in the EU in order to ensure sustainability.

2.3 EU Recommendations

According to [EUR12] smart grids mark a new development on the path towards greater consumer empowerment, greater integration of renewable energy sources into the grid and higher energy efficiency and contribute considerably to reduce greenhouse gas emissions, to create job opportunities and to foster technological development in the Union.

The **Smart Grids Task Force** was set up by the European Commission in 2009 to advice on issues related to smart grid deployment and development. It consists of **five Expert Groups** who focus on specific areas. Their work helps shape EU smart grid policies.

Expert Group 1 – Smart grid standards

Expert Group 1 was set up in 2009 to explore smart grid services and operation, and how best to deliver smart grids for the benefit of the energy system and its users. Successful smart grid deployment hinges on the technical standards and provisions designed to allow the interoperability of systems and technologies within a smart grid environment. This is the focus of attention for this expert group. The group provides guidance on how to ensure interoperability, connectivity and ultimately functionality of components and processes for the provision of smart energy grid services.

Expert Group 2 – Regulatory recommendations for privacy, data protection and cyber-security in the smart grid environment

In October 2014, the Smart-Grid Task Force launched an initiative aiming to mitigate the risks on personal data and security of smart metering systems.

The Commission, in collaboration with industry and other stakeholders, has conducted a two-year assessment process and delivered a full package of recommendations at the end of November 2016 to ensure privacy and cyber-security in smart-metering systems per the 10 minimum functional requirements set out in the **Commission Recommendation 2012 /148/EU** [ECR12].

2.3.1 Smart Grids Task Force Recommendations within inteGRIDy project

Privacy and data protection

Privacy and protection of personal data is of major concern. Regarding data protection in the Union, on network and information security, a coherent approach is ensured as the project takes the appropriate measures. These measures protect the contents and nature of the data

in order to safeguard the privacy of the consumer. inteGRIDy ensures that fundamental rights and freedoms of individuals as well as personal data are respected and the smart metering system applications are monitored. In accordance with commission recommendation, data protection impact assessments should make it possible to identify from the start data protection risks in smart grid developments. Data Protection Authorities (DPAs) need to be involved in the process and apply a set of definitions and responsibilities as analysed in **Error! Reference source not found.**.

inteGRIDy is aware of the envisaged processing operations and assessment of the risks to the rights and freedoms of data subjects and of the technical and organizational measures to ensure the protection of personal data. This will be done regarding to the state of the art and the cost of implementation (data protection by design). All required measures are applied in order not to identify the individual and data collection is limited to the minimum necessary. An analysis should be performed in order to specify the extent in which utilities can keep the personal data. inteGRIDy ensures that this analysis will be implemented for ensuring that only the necessary data are processed and they are not collected or retained beyond the minimum necessary (data protection by default). The principle of data minimisation, the principle of transparency and the empowerment of the consumer are taken into account.

Smart metering

inteGRIDy complies with the common rules for the internal market in electricity and ensures the implementation of smart metering systems that assist the active participation of consumers in the electricity supply. It deploys appropriate interoperability and standards for smart metering systems. The project follow arrangements in order to facilitate the linking between smart metering systems with standardised interfaces equipped with consumer oriented tools. Every smart meter for electricity comply with the sections provided in the Official Journal such as “providing readings directly to the customer and any third party designated by the consumer” and update these readings for the customer. Also complies with “allowing remote reading of meters by the operator”, “providing two-way communication between the smart metering system and external networks” and “allowing readings to be taken frequently enough for the information to be used for network planning”. For commercial aspects of energy supply with “supporting advanced tariff systems” and “allowing remote on/off control of the supply and/or flow or power limitation” and for security and data protection with “providing secure data communications”.

Deployment of smart metering applications requires measures to be taken in order to ensure that national legislation is respected when such technologies are deployed. Basic legal privacy requirements should be followed by all new technologies and services. Moreover, inteGRIDy ensures that data protection and information security features, which improve customers’ control over processing of personal data, are built into smart metering systems before used extensively and that personal data cannot be traced to an identified person by any means. Appropriate protective measures, which derive from the assessment of data protection impact, are to be monitored and reviewed throughout the lifetime of the smart meter.

Security

The adequate level of security is vital as well as the creation of a trustworthy network that will make accurate risk assessments. In inteGRIDy information about incidents and vulnerabilities will be shared intensively. As analysed in **Error! Reference source not found.** uninterrupted service is to be implemented in addition to robust functionalities. Processes will handle disruptions and be able to return to normal operations. For a trusted security concept, the smart meter infrastructure will be based on electronic certificates. Misuse of personal data will be cured with the use of encrypted channels and in case of a

threat the controller will notify without delay the supervisory authority and the data subject as recommended in [EUR12].

Regarding smart grid information security, the project will ensure that the system level information security requirements are covered in all relevant standards. Smart grid functions developed by inteGRIDy will be bound with smart grid information security and data protection/data security and privacy [ETS11].

Architecture, system aspects and interfaces

A functional architecture will be developed that takes into account all the generic, global aspects of smart grids as well as all the European specificities. Network architecture will take care of data protection in the design process and existing standards, requirements guidelines and schemes will be applied. It is important that the model that inteGRIDy will develop accommodates the harmonization of potentially different architectures produced during the definition of several smart grid applications as mentioned in [ETS11]. The communication architecture takes into account the large variety of network and connectivity scenarios involving communications interface and the security architecture a conformity assessment approach whenever applicable. An appropriate mechanism for re-aligning separately developed models will ensure the consistency of Information Model as required in [ETS11].

System interoperability [ETS11] will be addressed systematically and quality process for smart grid standards will be created. The work follows the recommendations to integrate different protocols with the existing standards and will be aligned on intra-domain standards between the advanced metering infrastructure and smart grid subsystems (such as EV charging and distributed energy resources metering).

Electromagnetic compatibility (EMC) and power quality

Concerning power quality and electromagnetic compatibility (EMC), inteGRIDy will review levels and characteristics and define the operating conditions in the context of smart grids as well as standardize on how to give a limitation to current emission by distributed energy resources equipment [ETS11]. Smart metering, building/home automation and electric vehicles are envisaged as elements in smart electricity grids, therefore they should be involved in the use cases taking care in their standardization work in these areas as will be implemented by the project. inteGRIDy will create a Demand Response task force encompassing, as proposed in [ETS11], the adaptation of demand response signals to manage distributed energy resources and electric vehicle charging issues and will ensure interoperability between the different standards. Finally, inteGRIDy complies with smart meters' and other measurement components' technical requirements.

Electricity markets

inteGRIDy will enable the possibility to exploit the benefits of modifying their flexible consumption and injection. The market should be free from barriers and provide equal access for existing parties. The project ensures that the participation of aggregated flexibility is legal and enabled in all markets and that the demand side flexibility is treated on an equal footing with generation as commented in [SGT15]. It is essential for the project that the flexibility maximized and continues to maximize in an evolving market over time.

Information about consumers

In order to raise awareness about protective measures and about how to reduce energy consumption inteGRIDy will provide information and tools to monitor and compare the energy consumption. The Regulatory Recommendations for the Deployment of Flexibility (2015)

[EG315] are addressed to the European Commission, to Member States, to National Regulatory Authorities (NRAs) or stakeholders such as TSOs and DSOs. The aim should be to ensure the equal access of demand side to electricity markets, and equal treatment of all relevant actors. The existing market model should allow the integration of new actors under necessary commercial arrangements and adjustment of rules. Network operators should be incentivised to enable and use flexibility in order to optimise grid operation and investments, while further collaboration between TSOs and DSOs for secure operation, is necessary. Transparent and non-discriminatory provision of data from data managers to relevant service providers should be guaranteed, in order to support the development of new products and competition in the market. Finally, a clear framework and necessary protections for domestic customers should be in place, while end-user prices and consumers' policies should incentivise consumers' participation and rewards in providing flexibility.

The project will define a standardised measurement methodology for flexibility and be based upon smart metering data as analysed in recommendation 6. Access to data is significant to the market and should be provided via appropriate market facilitation services. inteGRIDy will make sure that these data (like consumption information and accurate billing) are controlled by customers and that they always give their consent before the data are available to third parties (recommendation 7).

Smart Grid

Beyond that, the compliance between EU recommendations [EUR12] about inteGRIDy project as regards privacy and data protection, smart metering, security, architecture, electromagnetic compatibility and consumers' needs, should be compliance between EU recommendations about smart grid. Therefore, to achieve these goals, the following recommendations have been developed: the progress in rollout regarding the smart metering and H-interfaces should be reported in a new benchmark. In addition, access to data from smart meters should be provided via appropriate market facilitation services.

According to Smart grid standards [EUR15], in case the smart metering system is not used to implement functionality, it must be clear how consumers can check their consumption per tariff locally. However, a majority of Members States did not produce additional specifications or profiles to improve interoperability. Since various smart meter rollouts still have to start and, reaching interoperability requires certain measures to be taken, any interoperability issues that arise should be registered. Those Member States that did not define profiles / companion standards yet should be supported with explanation and examples.

Since no references have been made to the CENELEC TC205 standards [ECE] for the H-interfaces, the alignment between data definitions on the side of the CEM (Customer Energy Manager) and on the side of the AMI (Advanced Metering Infrastructure) should be checked: is the data provided by the AMI in line with the data needed for in-home energy management. This should be done on two levels:

1. At European level, alignment of the data formats by mapping the standards referred to for the H interfaces with e.g. the TC205 standards. This can be an action for the CENCENELEC-ETSI Smart Meters Coordination Group where all responsible Technical Committees are represented.

2. At national level, alignment of the data formats provided by the AMI and required for in home energy management. If deficiencies are identified, they need to be rectified. Appropriate measures must be proposed to guarantee interoperability on the information/data layer with the commercial channel in order to enable the development and provision of consumer-benefitting services and products

In addition to the recommendations above that are based on the survey results, it is recommended that consumers have: i) easy access to consumption information; ii) solutions "behind the meter" to present or process the "near real time" feedback on current usage; and iii) accurate billing and privacy and security of information. Action is also required to achieve the other desired consumer outcomes from smart metering by:

- Enabling all consumers to realize benefits from smart meters
- Ensuring that consumers have a high level of satisfaction with their experience of smart metering deployment
- Encouraging consumers to be actively engaged with the smart energy market

The key elements for each of these desired outcomes need to be defined in order to ensure that smart metering roll-out is a success for consumers, so that appropriate measures and metrics can be established at European level to gauge progress and identify shortcomings at national level.

3. Analysis of the compliance in each pilot use cases to the current standards, national & EU regulatory developments

3.1 National transposition of EU Directives and standards. Role of National Energy Authorities

3.1.1 United Kingdom

The UK energy markets comply with the liberalisation aims of the IME3. In the UK, the electricity industry was privatised in 1990-91 at the same time a regulatory body for electricity called OFFER was set up. The liberalisation of the utilities industries in England and Wales reached the stage at which all customers could choose their electricity and gas suppliers in the late 1990's.

The first section of the electricity market, covering about 5,000 customers, with a maximum demand of 1 MW and above, was opened to competition in 1990. In April 1994, a second section of the electricity market covering about 50,000 medium sized customers, with a maximum demand of 100KW was opened to competition. Competition in the final section of the UK's electricity supply market was phased in between September 1998 and May 1999. This included domestic customers and small businesses with an annual consumption of 12,000kwh and less.

The process of introducing competition in the gas supply market began in 1986, when competitive supply was introduced for large industrial and commercial customers, consuming 25000 therms and above per year. In August 1992, competition was introduced in smaller industrial and commercial markets i.e. those consuming between 2500 and 25000 therms per year. The domestic gas market, that is customers consuming less than 2500 therms per year, was opened up to competition between 1996 and 1998.

In 1999 OFFER was merged with OFGAS (the Office of Gas Supply), to form Ofgem which combines the functions and operations of the former gas and electricity regulators. Ofgem's primary duty is to protect the interests of existing and future consumers taken as a whole in relation to electricity and, wherever appropriate, achieve this by promoting effective competition (Utilities Act 2000).

In Great Britain, the transmission network is owned and maintained by regional transmission companies. The system as a whole is operated by a single Transmission System Operator (TSO) - National Grid Electricity Transmission plc - it is responsible for ensuring the stable and secure operation of the whole transmission system. The National Grid Electricity Transmission plc has been certified as unbundled in accordance with the aims of (IME3). In Northern Ireland, Northern Ireland Electricity owns the transmission assets and the System Operator Northern Ireland (SONI) is licensed as the TSO. Northern Ireland also operates a separate wholesale electricity market with a pool system, the Single Electricity Market (SEM), which is integrated with the wholesale electricity market in the Republic of Ireland. Given the distinct market that operates on the island of Ireland, and that the UK pilot site is in England, this report focuses primarily on the position in Great Britain.

Also, in accordance with the Third Energy Package (IME3), OFFER has an additional duty to promote the internal energy market and to remove restrictions to trade between EU member states. Ofgem has far reaching powers in regulating the industry. Up to March 2005 the electricity markets of Scotland and England and Wales operated independently. The Utilities Act of 2000 led to the introduction of the New Electricity Trading Arrangements (NETA). NETA was introduced following concerns about competition and price-setting in the Pool. NETA's central theme is that the wholesale market for electricity should be similar to other

commodity markets. NETA has been subject to numerous modifications over the years, including an extension to incorporate Scotland in 2005, under the British Electricity Trading and Transmission Arrangements (BETTA). Despite these changes, many of the same broad market arrangements that were implemented in 2001 remain in place today.

There are more than 18 Energy companies in Great Britain supplying electricity; most of these sell both electricity and gas. There are numerous companies generating electricity but six of the big energy suppliers own a large proportion of electricity generation capacity: together they own 68,926 MW, 71 per cent of total capacity (96,715 MW).There are 14 licensed DNOs in Great Britain and each is responsible for a regional distribution services area. The 14 DNOs are owned by six different groups. Under the utilities act 2000 DNOs are prevented from supplying electricity and even if distribution and supply companies are owned by the same umbrella company they legally have to operate independently unless an exemption licence can be obtained.

It must also be noted that in Great Britain as well as the 14 DNOs there are 11 Independent Distribution network operators (IDNOs), namely Energy Assets Power Networks Limited, Energetics Electricity Limited, ESP Electricity Limited, G2 Energy IDNO Limited, Harlaxton Energy Networks Limited, Independent Power Networks Limited, Peel Electricity Network Limited, The Electricity Network Company Limited, UK Power Distribution Limited, Utility Assets Limited and Utility Distribution Networks Ltd. While each DNO covers a separate geographical location of Great Britain within some of the DNOs geographical areas smaller local networks are operated by IDNOs. These are mainly extensions to the DNO's networks serving new housing and commercial developments.

The UKs National Grid's transmission system, covering England and Wales, is linked by interconnectors to the transmission systems of France and The Netherlands. In addition to jointly owning and operating the England-France and England-Netherlands interconnectors, they are developing proposals on a number of other interconnector projects. These interconnectors are unbundled by Intercommentors Limited that is classified as a TSO and certified as Ownership unbundled in compliance with IME3.

Demand Response empowers consumers (residential, commercial, or industrial) by providing control signals and/or financial incentives to adjust their use of demand-side resources at strategic times. These demand-side resources may include their consumption, use of distributed generation and/or storage capabilities. There are essentially two forms of demand response implicit and explicit. In Implicit Demand Response (also called "price-based"), consumers react to dynamic market or network pricing signals. In Explicit Demand Response (sometimes called "incentive-based") the aggregated demand-side resources are traded in the wholesale, balancing, and, where applicable, Capacity Mechanisms. The involvement of end consumers in Demand Response, both in the GB market and internationally, has been relatively limited with flexibility being mainly procured from fossil-fuelled generation [PAC16].

In the UK implicit demand response is largely limited to large consumers for whom distribution Use of System (DUoS) charges vary by Time of Use (i.e.by season and by time of the day), and by voltage level. However, residential consumers are typically exposed to a more limited range of TOU tariffs, with most residential consumers paying only a fixed unit charge for the use of the distribution network [PAC16].

The compliance of the UK with explicit demand response is summarised below:

- Almost all balancing services are open to Demand Response and aggregated load is accepted, although the product design is not optimal for customer participation.
- The Capacity mechanism is also open to Demand Response, but not on comparable terms to generation.

- The Balancing Mechanism remains closed to independent aggregators.
- The wholesale markets remain closed to independent aggregators [SED17].

The UK government has committed to the rollout of smart meters for both electricity and gas in all homes and most small businesses by the end of 2020. However as discussed in an earlier deliverable of the inteGRIDy project (D1.1) the smart metering rollout in not going as planned in the UK. At the beginning of 2017 there were only 6.783,4 million smart and advanced meters operating across homes and businesses in Great Britain, by both large and small energy suppliers [DBE17]. This falls far short of the policy expectation that by the end of 2020, some 53 million smart meters will be fitted in more than 30 million premises (households and businesses) across Wales, Scotland and England.

3.1.2 Italy

In 1962, Law 1643 determined the nationalization of the electrical sector, entrusting ENEL of the various phases constituting the electrical supply chain (production - distribution - sale).

Law 9/91 was the first step towards the liberalization of the sector, making electricity production free, provided that from renewable and assimilated sources, such as cogeneration and waste, are used.

In 1995, by Law 481/95, the Electricity and Gas Authority was set up (AEEG).

Legislative Decree 79/99 (also known as Decree Bersani) has transposed Directive 96/92/EC, laying down common rules for Member States' internal electricity markets to liberalize demand, access to networks and supply of energy and an effective transition from monopoly to market.

The activity in the electrical sector can be divided into four phases: production and import, transmission and dispatching, distribution, sales.

Production is a liberalized activity and the generated electricity can be self-consumed, sold through bilateral contracts, sold to the grid as an excess or sold through the power exchange, which came into operation in April 2004.

Import is regulated by the Authority, according to MSE's guidance, through the issuance of specific resolutions, which provide Terna with the necessary instructions for the allocation of available cross-border capacity. The remainder of the imports is divided between existing long-term contracts in favour of the market and foreign network operators, who have their own allocation.

The transmission consists of the transport of electricity on HV and EHV lines, whose management was entrusted to Terna. The transmission network has been identified with a special MSE Decree (see Terna website). The latter manages also dispatching.

The distribution activity is inherent in the transport and supply of electricity on MV and LV lines and is entrusted by MAP through thirty-year concessions.

Sale to final users is a free activity; all Italian consumers are eligible consumers, and can negotiate their supply with retailers. A regulated tariff for household consumers is still in place (phase out in the coming two years).

The Italian Regulatory Authority for Electricity Gas and Water is the independent regulatory body of the energy markets and the integrated water services. It was established by law 14 November 1995, n.481 with the purpose to protect the interests of users and consumers,

promote competition and ensure efficient, cost-effective and profitable nationwide services with satisfactory quality levels in the electricity and gas sectors. With law 22 December 2011, n. 214, new regulatory competences in the integrated water services sector were attributed to the Authority, while Legislative decree 4 July 2014, n. 102, assigned new tasks in the district heating and cooling sector.

The Authority core competences refer to the definition and maintenance of a reliable and transparent tariff system; a balance is found between the economic goals of operators and general social objectives and promoting environmental protection and the efficient use of energy; a strong importance goes with the setting quality of service standards and the definition of a framework aimed at the protection and empowerment of consumers in competitive markets. The Authority is governed by a Board of Commissioners in charge for seven years. The Authority is fully financed through a levy on regulated entities and it is completely independent from the State budget.

Concerning connection standards, Italian Law 481/95 at Article 2 comma 12 letter d states that the Authority shall define technical and economic conditions of access and interconnection to networks; according to Article 2, paragraph 12, letter h, of the same law, the Authority shall issue directives concerning the production and delivery of services by users and generators, in particular concerning the connection to electrical networks.

Italian Regulatory Authority, with Deliberation 29th July 2004, n. 136/04, initiated a process aimed at a whole revision of the technical-economic conditions required for accessing power distribution networks. Finally, according to Deliberation n° 136/04, the Italian Electrotechnical Committee (CEI) was involved in the process, constituting a technical working group, with the aim of setting up a technical rule about the connections to HV and MV power distribution networks. The first edition of technical connection rules for MV was issued in 2008; LV grids were ruled in 2012.

More recently, Article 5 of Directive 2009/72 / EC requires Member States or Authorities of Regulation, where the Member States have arranged so, to ensure, between other things, the minimum technical design and operating requirements for connection to the electric system, which are defined as objective and non-discriminatory technical standards. Directive 714/2009 established non-discriminatory rules governing the access to the network for cross-border exchanges of electricity in order to ensure the proper functioning of the internal market for electricity. It, amongst others, highlights that, to ensure the security of the transmission system, it is essential to establish a common interpretation of requirements applicable to the connections (whether they are production plants or units of consumption). This leads to the opportunity to define harmonized standards of connection to network with a view to establishing a clear legal framework, facilitating trade in electricity on the territory of the European Union, to ensure the security of system, facilitating the integration of renewable energies, encouraging competition and enabling more efficient use of the network and resources, for the benefit of consumers.

On the basis of Regulation 714/2009, the European Commission has issued three regulations:

- the RfG - Requirements for Generators, which establishes a code for setting the requirements for connection of generation plants to electricity network. It entered into force on 17 May 2016 and will be applied from 27 April 2019 for "new" generation groups as detailed in Article 3 of the same regulation;
- the DCC - Demand Connection Code, which establishes a code with the requirements for:
    - power supply installations connected to the transmission system;

- distribution systems connected to the transmission system, Distribution systems, including closed distribution systems (Followed by: SDC);
- consumable units, used by a consumer plant or by a closed distribution system to provide management services request to relevant system operators and relevant Transmission System Operator (TSO).

It entered into force on 7 September 2016 and will be applicable since August 18, 2019 for the "new" consumer systems and systems as best Detailed in Article 3 of that Regulation;

- HVDC - High-Voltage Direct Current setting up a code that meets the requirements for connection to the network of high voltage direct current systems (HVDC) and direct current generation parks. It came into force on 28 September 2016 and will find it application from 8 September 2019 for "new" systems such as more detailed in Article 3 of that Regulation.

The Italian Regulator is on the way of harmonizing the existing Technical connection rules with the new EU framework (RfG).

The Italian Regulator launched a call for smart grids projects, to be put in place by DSOs, with Regulatory Order 39/10; the San Severino pilot and the Terni pilot were selected among these projects.

More recently, in year 2017, in the context of an ongoing reform of the Italian Energy Market, which involves several aspects, and following many different initiatives taken in the last decade of regulation activity, the Deliberation 300/17 was issued, which foresees the starting of many pilot projects about innovative dispatching, including:

- the participation of the demand and of non-enabled units to the ancillary services provision process;
- the utilization of energy storage systems (as stand-alone or plant-coupled solutions) to optimize the interconnection of units to the network;
- the aggregation of diverse units under the same Balancing Service Provider;
- the remuneration foreseen for the ancillary services provision.

All these aspects, together with the definition of a new tariff framework, are correlated to the building of a proper regulatory framework able to support the transition towards a more sustainable electricity system, including the full deployment of smart grids.

3.1.3 Spain

The Spanish energy sector has been liberalised in the late 1990s. The key pieces of legislation introduced to liberalise the industry are: the Electricity Law (Ley del Sector Eléctrico) in 1997 for the electricity market, and the Hydrocarbons Law (Ley de Hidrocarburos) in 1998 for the gas market. The main features of the regulatory reform of the industry were:

(a) the creation of a wholesale electricity market,
(b) vertical unbundling of the gas and electricity networks, and
(c) a gradual liberalization of the gas and electricity retail markets.

Since the liberalization of the industry in the late 1990s, there has been intense regulatory activity in the Spanish energy sector. This trend has continued in the recent past, most notably in the electricity sector. One of the key and most topical policy issues in the electricity sector remains the growing shortfall between revenues from regulated tariffs and wholesale electricity prices. This so-called “tariff deficit” increased very significantly in 2005 and 2006

(when wholesale prices increased rapidly and retail tariffs did not adjust) and a similar outcome characterized 2008.

Electricity distribution network operators (DSOs) in Spain are regulated by an ex-ante revenue cap. Allowed revenues of a DSO are determined based on unit reference costs (norm price list) for both CAPEX and OPEX and investment plans.

Capital and operating costs related to physical assets on high and low voltage level as well as other assets needed to perform the distribution activity, are valued at unit reference costs by the regulatory authority (CNMC), with final values to be determined by the Ministry of Industry, Energy and Tourism. The unit reference cost values of CAPEX are determined by taking the average of representative infrastructure costs of high and low voltage installations respectively that are considered as standard on the Spanish peninsula (replacement costs) taking into account possible efficiency improvements compared to European DSO standards for distribution activities. The unit reference cost values of OPEX (related to the physical assets) are calculated as a fixed percentage of the investment costs of the respective asset group.

The value of the efficiency coefficient for CAPEX (that is the assessment of the efficiency of the size and the number of assets) describes the inefficiency of a DSO compared to an efficient DSO based on calculations conducted by the regulatory authority within a reference network model. Similarly, the efficiency coefficient for OPEX (related to the physical assets) considers the efficiency of the size and the number of distribution network assets installed.

In addition to CAPEX and OPEX associated with the physical network assets, a number of further cost categories related to other tasks and activities of the regulated distribution business are subject to specific reference unit values and to be passed-through to network users:

- Metering costs (including costs for the meters and for meter reading)
- Billing (including debt management) costs
- Call centre costs
- Network planning and development costs
- Overhead / shared service costs

DSOs submit three-year investment plans to local authorities and to the Ministry of Industry, Energy and Tourism for ex-ante approval (possibly requesting changes of the investment plans) each year.

DSOs in Spain can realise additional profits, if they manage to construct their network assets below the unit reference costs or if they manage to conduct the operation and management of their network at unit costs below the unit reference costs. In addition, DSOs may realise additional (temporary) profits from cost savings within a regulatory period, resulting from lower investment levels or avoided network expansions, which are only partially to be shared with network users by adjusting allowed revenues in the remaining years of the regulatory period. The regulatory regime also encourages the continued use of assets after the end of their useful regulatory lifetime, by allowing DSO to recover part of the operating and maintenance costs through the application of a specific extension factor for years beyond the regulatory lifetime.

DSOs are obliged to connect all network users (generation and load). Costs related to network connection are recovered through separate connection charges in Spain, which are generally calculated on a shallow basis (i.e. only covering the costs to the point of connection to the network). The connection charges (determined by the Ministry of Industry, Energy and

Tourism) are calculated on a standard cost basis and expressed in € per kW of required extension capacity.

Quality of supply (reliability) is regulated through a specific bonus-penalty scheme for electricity distribution on low and medium voltage level. According to the scheme, allowed revenues of a DSO are adjusted in a year up to a cap (+2% / -3%) based on the levels of TIEPI (time of equivalent interruption per power installed) and NIEPI (number of equivalent interruptions per power installed) of the DSO in previous years (year n-5 to n-3 versus year n-4 to n-2). In addition, it is taken into account whether the relative TIEPI levels in the last 6 years have been lower or higher than the national average, i.e. companies with above average TIEPI levels in the past will only benefit financially from further improvements above their past quality levels and companies with below average TIEPI levels in the past will only be punished if their quality levels have further decreased to the past levels. Furthermore, deductions are applied for any zones in any given year between n-2 and n-4, where quality of supply levels have exceeded the minimum threshold of TIEPI.

Similar to quality of supply, an incentive scheme for the reduction of network losses is applied in Spain, calculated for each DSO in year n based on the level of network losses in its network in previous years (i.e. years n-5 to n-3 and years n-4 to n-2). In addition, it is taken into account whether the relative network losses in the previous 6 years have been lower or higher than the national average, i.e. companies with above average losses in the past will only be punished if their network losses have further increased and companies with below average losses in the past will only benefit financially from further reductions of network losses above their past levels. The maximum revenue exposure under the incentive for the reduction losses in a given year is capped at +1% and -2% of the total allowed revenues of that year (excluding the incentive scheme).

Furthermore, an incentive for fraud reduction was introduced to govern the performance of electricity DSOs as network owners and responsible for metering. The incentives for fraud reduction are calculated for each DSO in year n based on the fraud detected and disclosed in year n-2. The DSO will be compensated for 20% of the value of fraud declared in n-2. This incentive can only be positive (i.e. there are no penalties) and will be limited to +1.5% of the regulated allowed revenue for the year (excluding the incentive schemes).

The Spanish regulatory framework does not provide specific regulatory mechanisms, incentive schemes or funds for smart grid investments (except for general funds for research and demonstration projects); where the implementation of technological innovations increases technical and economic efficiency, shorter regulatory useful lives could – by special decision of the regulatory authority – be applied for these assets.

Network tariff levels and tariff structures are defined within an ordinance, not designed by the DSO. Network tariffs are paid by all consumers and generators. For some customer groups tariffs with more than two-time periods are already applied in Spain.

Spain was one of the first European countries to apply regulation for smart metering. Royal Decree 1634/2006 established a meter substitution plan for all consumers contracted with less than 15 kW by the end of 2018.

The functionalities of the next generation smart meters used in the Spanish roll-out cover the vast automated functionalities such as demand response control, load management, remote firmware upgrade, quality control and fraud detection as well as a variety of data profiles to guarantee personalised user consumption profiles. The Spanish smart metering architecture solution is based on a fully interoperable design, using multi-vendor devices, based on open standards which are exchangeable at any time and place.

System operation is conducted by the TSO in Spain. DSOs are not allowed to engage in demand side management, to dispatch embedded generators or to own or operate electricity storages or distributed energy resources.

There is no specific regulation about smart grids in Spain, but certain related aspects are covered by several laws.

3.1.4 France

Law No. 2010-1488 of 7 December 2010 on the organization of the electricity market, known as the Nome Act, is intended to enable the market to be effectively opened up, when EDF, the market historical operator, was in a position of a quasi-monopoly on the electricity generation sector in France. The objective is to protect the interests of consumers while encouraging investments so that they can be part of the development of the European electricity market.

The three main principles of the NOME Act of 7 December 2010 are as follows:

1. Provide electricity suppliers with regulated access to EDF's basic electricity under the same economic conditions as EDF (with a ceiling of 100 TWh): it is the implementation of Regulated Access to The Historical Nuclear Electricity (ARENH). The ARENH must be a driving force in the development of competition.
   The price of ARENH should reflect operating costs, investment, maintenance or life extension costs, long-term costs (waste life cycle and dismantling).
2. Strengthen the security of supply in France by requiring all suppliers to have, directly or indirectly, sufficient production or cut-off capacities to supply their customers at any time. This is the capacity market to be established in 2017
3. Strengthen regulated sales tariffs for small consumers (blue tariffs), but allow their extinction for large consumers (yellow and green tariffs) by the end of 2015. These customers will have to subscribe to a market offer.

The Commission for the regulation of energy, CRE, is the national energy authority in France. It is an independent administrative authority responsible for ensuring the proper functioning of the electricity and gas markets in France. The CRE contributes to the good functioning of the electricity and natural gas markets for the benefit of final consumers and in line with the objectives of the energy policy.

The CRE put forward a series of recommendations to accelerate the development of smart grids in France. These recommendations also aim to enhance the stability of the electrical system. In particular, the followings deal with storage, demand response and electric mobility aspects:

1. *Storage:*

The CRE asks distribution system operators to take into account electricity storage facilities in order to be in accordance with the principles arising from the CRE's deliberation of 25 April 2013 to 'Ensure objective, transparent and non-discriminatory treatment of such requests. CRE requests distribution system operators to certify their procedures, contractual documents and technical reference documents to facilitate the reception on the network of electricity storage facilities

2. *Demand Response:*

The CRE supports legislative change, to define the economic modalities for making available to the system the flexibility offered by temporary modulations to increase/decrease

consumption. This amendment will thus make it possible to complete the legislative framework on the flexibility of consumption.

3. *E-Mobility:*

The CRE supports the development of electric vehicle charging solutions. In particular, the CRE supports recharging devices being able to communicate with the various players in the electricity system and, in particular, taking into account the price signals (price signal from the supplier, and/or distribution system operator).

Concerning the Energy Market, two types of offers coexist in the electricity retail market:

- Market offers, the prices of which are set freely by the suppliers;
- The regulated sales prices fixed jointly by the ministers responsible for the economy and energy, on the advice of the CRE.

All suppliers can offer market offers. Conversely, regulated sales prices are offered only by the historical suppliers, namely EDF or local distribution companies. Suppliers that are not historical are called alternative suppliers. They are new players who have entered the retail electricity market following the liberalization.

Market results at 31 December 2016:

At 31 December 2016, 83% of the sites are at the regulated rate of sale, which represents 38% of electricity consumption. Market opening is much more advanced in the industrial customer segment than in the residential customer segment. The detailed data are available quarterly in the market observatory.

The energy code establishes an obligation of capacity. It stipulates that "each electricity supplier contributes to the security of electricity supply, depending on the consumption characteristics of its customers, in terms of power and energy in the continental metropolitan area". Thus, each supplier has to obtain supplies of capacity guarantees in order to cover the consumption of its customer portfolio during periods of peak consumption. These guarantees can be obtained by investing in new means of production or effacing, or by obtaining them from the capacity operators. These operators are granted by RTE (a subsidiary of EDF, which manages the public high-voltage electricity transport network in metropolitan France) which guarantees for their capacities for the availability of these during periods of intensive use of the electrical system. In return, operators must ensure the effective availability of their capacities, controlled by RTE.

3.1.5 Portugal

The Portuguese national energy authority is the Energy Service Regulating Entity (ERSE), responsible for the regulation of the electricity and natural gas sectors. Its statuses have been approved by the Portuguese parliament on the Decree-law (DL) 97/2002, 12th April, reviewed on DL 212/2012, 25th September and on DL 84/2013, 25th June. Its mission is to protect the final customer interests, promote the competition among market players, contribute to the continuous improvement of economic and environmental conditions and to provide judgement and solutions for litigation. The Law 9/2013, 28th January approved the sanctionary regime for the energy sector, establishing sanctionary duties to ERSE, in the context of the National Natural Gas System (SNGN) and National Electric System (SEN).

In Portugal, a phased transition to a liberal market was fully achieved from 1995 to 2006, following the methodologies implemented by other countries in the EU, starting with the largest consumers and highest voltage levels, followed by the small domestic consumer.

Since 4th September 2006, all consumers in the Portuguese continental territory can choose their electricity provider. This date anticipated the accomplishment of Directive 2003/54/CE, which had established 1st of July 2007 as the final date for full transition to liberal market for every consumer.

With the development of a liberal market, new rules and principles were required for an appropriate regulation of the relations between all intervening parties. Nevertheless, some of these regulations' executability depends on the approval of more detailed and purpose-oriented contents, to allow its implementation. This task should then account for the participation of some intervening parties, namely the operating companies. It is expected from these, based on their market experience, to provide educated proposals for the regulations for ERSE to approve. The Commercial Relations Regulation, approved by Regulation 561/2014, 22th September, states the obligation of definition of a Guide of Measurement.

The recent Decree-Law no. 38/2017, of March, establishes the legal regime applicable to the activity of logistic operator of change of commercialization supplier (OLMC) within the scope of the National Electric System (SEN) and the National Natural Gas System (SNGN). Concerning the feed-in tariffs the Regulation for Tariffs of the Electric Sector Regulation, 551/2014, 15th December is important. Concerning quality of service, Regulation 455/2013, 30th October, is the most important, containing a guide of procedures for the electricity sector quality of service.

Dynamic Tariffs

Although market liberalization has been a reality for the Portuguese electric system for almost a decade now, the electricity traders or retailers still struggle to offer larger clients (medium to high installed voltage) dynamic tariffs which make use of market fluctuations, improving their offer and bringing satisfaction to both parties. This is mostly due to some existing risk in case they contract an insufficient energy amount on a short-scale and end up paying penalty tariffs to the DSO, or sometimes due to general lack of awareness from the final user for their potential to shift the Demand Response according to a dynamic tariff. In fact, there wasn't yet a significant increase of competition within the market.

In Portugal, this kind of tariff is already possible for the medium voltage (MT) customers, however it is only dependent on the price of the Iberian Electricity Market (MIBEL), ie indexed to market. For the domestic customers, this option is not available yet.

The concept of the dynamic tariffs was introduced in the Tariff Regulations in 2011. Article 39 of the Portuguese Regulation Nr 551/2014 published by ERSE (Energy Service Regulatory Authority), approves the new Tariff Regulations of the electricity sector, repeals the previous tariff regulations and approves the rules for the implementation of the pilot projects of dynamic tariffs in mainland Portugal and in the Autonomous Regions of the Azores and Madeira.

Today, the document "Characterization of Demand for Electricity in 2017", ERSE states that: *The tariff regulation establishes the obligation of network operators to submit to ERSE a Plan for the implementation of Pilot Projects that allow the testing of new tariff strictures, that are more appropriate to the costs caused by each consumer, namely dynamic tariffs*.

Regarding the pilot projects of the dynamic tariffs, the Portuguese DSO EDP Distribuição carried out a cost-benefit analysis for the implementation of pilot projects, which showed a positive net benefit. According to the Tariffs Regulation Annex, EDP Distribuição sends to ERSE a Plan for the implementation of a pilot project, which will integrate, in addition to the

dynamic network access tariffs, a new static more sophisticated than those currently in force, integrating more time periods and a higher seasonality of prices.

Smart Metering

The Directive 5/2016, 26th February, establishes the Guide for Metering, Reading and Availability of Data of the electricity sector in Portugal. This measurement guide is a very detailed document, describing almost all aspects related with legal obligations about metering for the several agents: retail and commercialization companies, DSO, TSO, producers, market operators, facilitators (aggregators) and mobility network operators.

The guide of metering presents the description of the following aspects:

- Describe the procedures of supply and installation of metering equipment
- Technical requirements of meters, telecommunication and information system management.
- Procedures of metering
- Methods of detecting, correcting errors and methods of estimation measure series
- Rules and penalties for fraudulent procedures
- Definition of typical profiles for consumption, production and losses
- Rules applicable for special cases of tariffs and consumption
- Implementation, operation, verification and maintenance of the ICT system associated with the metering system.
- Methods of adjustment between the energy metered and commercialized.
- Procedures of information exchange between the metering operator and the commercialization companies.
- Procedures of metering for self-consumption
- Procedures of metering for electric vehicle changing points.

Besides the metering guide, more legislation is relevant. Directive 10/2012, 5th July, details the monetary compensation for metering errors. The Ordinance 231/2013, 22th July, describes the technical and functional requirements of smart meters.

PV distributed generation incentives schemes

Before 2014, the PV distributed generation incentives were built upon a feed-in tariff (FiT) scheme, for mini and micro-generation. However, that experience demonstrated that technologic development allowed for developing projects with less investment which justified a better fitting of the tariffs for the energy produced that way. The government in its turn recognized the potential of production for self-consumption (SC), as a means to promote a better knowledge of the consumers' own profiles, leading to energy efficiency behaviours, contributing to the optimization of resources and benefitting the electrical system by reducing its losses.

In October 2014, the government approved a decree law (DL 153/2014, 20th October) which merged the micro-generation and mini-generation framework, while promoting production for SC, using simplified licensing procedures and reducing the regulatory burden. This legislation framework is the one presently active to install and integrate distributed generation in electricity consuming installations. Under this SC regime, energy is remunerated at market price levels and in line with the free market approach.

The new regulatory framework is applicable to production based on any kind of resource for self-consumption (no capacity limit) and in a residual part to small-scale RES production with grid injection and a FiT (up to 250 kW). Licensing is conducted online via Internet, using the

Electronic System for Registration of Generation Units (SERUP), allowing two regimes, self-consumption units (UPAC in Portuguese) and small generation units (UPP in Portuguese).

Financial instruments

Some public financial support instruments should also be accounted at this stage, such as the FAI (Innovation Support Fund), created in 2008, which supports innovation, technological development and investment in renewable energy and energy efficiency areas. For instance, FAI supported the Mobi.E project (https://www.mobie.pt/), which created and continues to grow the first national electric mobility network, with thousands of EV charging stations spread around the country, as well as many RES based electricity generation projects as solar PV plants and floating offshore wind platforms, and some additional energy efficiency projects in smart grids, transport and buildings. The FEE (Energy Efficiency Fund) is another financial support public instrument, created in 2010 and focusing on programs and measures as outlined by the PNAEE (National Energy Efficiency Action Plan).

3.1.6 Cyprus

The full liberalisation of the electricity market in Cyprus was formally achieved on 1st January 2014, but it is not yet implemented in practice, as EAC, a semi-public body, is currently the sole supplier.

For the proper regulation of the electricity market and with the aim of securing competition and for the protection of all consumers, the following infrastructures were established:

- Following a decision by the Council of Ministers, the Cyprus Energy Regulatory Authority (CERA) was established. It is an independent authority responsible for the regulation of the electricity and gas market with exclusive rights to issue licenses for all activities relating to electricity and gas, to approve tariffs, to dissolve disputes, to protect consumers and to secure a reliable electricity system.
- Following a decision by the Council of Ministers, the Director of the Transmission System Operator was appointed, with exclusive duties to operate, synchronize and control the transmission system with objective, non-discriminatory criteria, to secure the proper maintenance and development of the electricity network and to arrange for the trading of electricity on a daily basis.

The incumbent Electricity Authority of Cyprus (EAC) owns both the transmission and the distribution system. The TSO is legally but not functionally unbundled from EAC, since all its staff is seconded from EAC. The obligation of ownership unbundling of the TSO does not apply, since Cyprus has obtained derogation from Article 9 of the 2009/72/EC Directive. The DSO is responsible for managing, operating and developing the network, safeguarding access to the distribution network and equal treatment for all users. EAC has unbundled the accounts of the DSO.

Whilst full liberalisation of the market was legally achieved on 1st January 2014 when a derogation granted under the Second Energy Package pursuant to its status of small isolated system expired, Cyprus is not integrated and not interconnected with any neighbouring power systems. No wholesale market is currently operating in Cyprus; in the Memorandum of Understanding with the “Troika” (the European Commission, the International Monetary Fund and the European Central Bank) Cyprus engaged to develop open and competitive energy markets.

Currently, natural gas is not supplied to Cyprus. However, in December 2011, significant gas resources were discovered within the Eastern Mediterranean Sea. The Cypriot authorities

have established two National Hydrocarbons Companies whose respective tasks and functions are currently being defined: in principle EYK (formerly KRETYK) should be in charge of upstream and export issues, while DEFA should focus on the development of domestic market. Both have the legal form of private companies 100% owned by the State. In addition, an interim solution was planned for the supply of the electricity generation sector with natural gas until the indigenous natural gas reserves are made available.

Domestic consumers became legally eligible to switch suppliers on 1st January 2014. However, EAC is still the sole electricity supplier in Cyprus and thus switching procedures do not exist. Electricity prices are well above the EU average. The network component in households represented 15% of the total bill, while in industry it represented 11% of the end price (EUROSTAT).

According to EU law, Member States are obliged to ensure the deployment of smart metering systems, which may be subject to a cost-benefit analysis, on 80% of electricity customer premises by 2020 where positively assessed. To prepare for this medium-term goal, the EAC is in the process of implementing a pilot project of 3,000 smart meters.

The retail electricity market in Cyprus is performing just below the EU average and ranks 18th EU-wide. The proportion of consumers encountering problems in this market is the lowest in the EU. The consumer protection measures, including those set out in Annex I of the directives 2009/72/EC and 2009/73/EC, are effective and enforced through the Laws N.211(I)/2012 and N.219(I)/2013 on Regulating the Electricity and Gas Markets, respectively. As stated earlier, from 1st January 2014 the electricity market is technically fully liberalised, but there is still only one supplier, and no scope for switching. Energy poverty, vulnerable consumers' categories and measures to protect them were defined in a Ministerial Decree, which includes measures such as reduced prices on electricity tariffs and financial incentives for participating in a Plan for setting up a Photovoltaic system at their house, with a capacity of up to 5kW with the net-metering method.

3.1.7 Greece

The Greek electricity market has undergone significant changes over the last decades. Today it is organized on the basis of the Daily Energy Planning (DEP) model, which uses many regulatory parameters to determine the price of electricity. The Greek electricity market is still a monopoly with the PPC being the only public and vertically integrated company that produces, trades and supplies consumers with electricity. Greece liberalized electricity market design consist of two separated market, as follows:

1. *Wholesale electricity market*, which is structured around a gross mandatory pool in which energy and ancillary services are simultaneously traded in a day-ahead market and are dispatched on the available units. In essence, the Greek market design introduced a distinction between day-ahead market and the balancing mechanism.

2. *Capacity assurance market (CAM)*, which aims at complementing the energy market arrangements, stimulating suitable new investment ensuring thus long-term adequate generation capacity availability. In particular, this market is applied for the partial recovery of capital costs, with suppliers being obliged to buy capacity certificates from generators.

In Greece, the liberalized electricity market is operated by the Hellenic Transmission System Operator (HTSO) and is supervised by the Regulatory Authority for Energy (RAE). The HTSO and the RAE were established in 2000 as a result of the Directive 96/92/EC and later harmonized with Directive 2003/54/EC of the European Parliament and the Commission in an attempt to liberalize the electricity market in Europe.

However, the electricity market in Greece, is not in line with Third Energy Package of the European Union's internal energy market. The European Target Model, which is the expected model in the European Union, includes 4 core markets: Spot/Day Ahead Market, Spot/Intra-day Market, Balancing Market and Forward Market.

In order to give thrust in the procedures of harmonizing Greece with the Target Model, HTSO was abolished and the Operator of Electricity Market (LAGIE) and the Independent Power Transmission Operator for Electricity (ADMIE) has been established. Thus, the Greek electricity market is at the early stages of redefining itself with additional effort required to develop a competitive integrated market. From February 2012 onwards, an independent transmission operator (ITO) model was adopted for the Greek market and this implied the restructuring of the former TSO into two discrete entities:

- The Market Operator (LAGIE), which solves the day-ahead market, conducts its clearing, and engages into contracts with renewable producers. On 11th December 2015, following the decision of the Minister of Environment and Energy, LAGIE was designated as Nominated Electricity Market Operator (NEMO) to perform both the single day-ahead and intra-day coupling.
- The System Operator (ADMIE), which owns the network, as a subsidiary of Public Power Corporation (PPC), conducts the real-time dispatch, the clearing of the imbalance market and the settlement of all other charges or payments.

RAE is an independent administrative authority with legal personality which was established under Law 2773/1999 in order that harmonizing the Greek legislative and regulatory frameworks with the provisions of the latest EU Directives 2009/72 [EUE09] and 2009/73 / EC [EUG09] on common rules for the national electricity market.

The European Directives about the smart metering and DR are: 2006/32/EC which is on energy end-use efficiency and energy services, 2009/72/EC which is concerning common rules for the internal market in electricity applying on the Greek Electricity Market and 2012/27/EU which on energy efficiency.

On the subject, of the current European regulatory DR framework, the Energy Efficient Directive [EU12] constitutes a significant step towards the DR development in Europe. According to Article 15.8 of [EU12], consumer access to energy markets is established. Certainly, in Greece, for dynamic pricing, smart meter installation, which is underway, is a prerequisite, while it possible to manage peak demand by providing multi-brand tariff (day/night rates). Two DR interruptible programs have been established in Greece and have been launched in 2016. Albeit they do not as yet allow for aggregation, they are dynamic, auctioned on a monthly basis and intended for frequent use. Consumers with 5 MW of flexible load might participate. Greece is also carrying out a full regulatory review in preparation for a Capacity Remuneration Mechanism (CRM), and plans to define aggregation within this framework.

On the other hand, Battery Energy Storage Systems (BESS) is currently hampered by legislative barriers and disincentives both at EU and Greek level. There is lack of regulatory frameworks, therefore, they are normally treated as generation systems. According to [EUE09], the BESS utilization by grid operators is very limited at present, as unbundling requirements do not allow TSOs and DSOs to directly own, or control, energy storage infrastructure. Particularly, there is no definition of energy storage in the current EU legislative landscape, leading to a series of unintended barriers and thereby creating an uncertain investment environment.

Concerning the storage of electricity, there is a regulatory framework with the principles of operation of Hybrid Station (HS) in non-connected islands systems, which are combination of power generation units with energy storage systems [PAP10].

Besides that, the national market does not currently recognize the value of ancillary services to balance the grid, while some states impose double grid fees on storage systems or direct taxation on self-consumed energy. Consequently, the developed regulatory framework should recognize the importance of BESSs by the legislators, with the removal of legislative and market barriers. While the legislation of smart meters is available, the benefits of usage should be widespread. The Directive 2009/72/EC foreseen that 80% of consumers should be equipped with smart metering systems by 2020.

3.1.8 Romania

In Romania, the liberalisation process started in 2000 (the breakup of monopoles) and OPCOM, the Romanian electricity market operator has administered inter alia the daily market. In 2005, a new spot trading mechanism (day-ahead market) Centralized Market of Bilateral Contracts (CMBC) was launched at OPCOM. This platform allows two-side bidding which will further ensure the best liquidity in Eastern Europe. Since 2013, the consumers are able to switch energy suppliers without financial penalties

At this moment 30% of the electric energy price is set by government (i.e. ANRE) and 70% is bought from the free market (bourse). By the beginning of January 2018, the price of electric energy will rely 100% on the free market.

In September 2012, A.T. Kearney, commissioned by European Bank for Reconstruction and Development (EBRD), released a market feasibility study on Smart Metering in Romania which revealed that the electricity sector has a potential to be a profitable investment as opposed to gas [ATK12]. In March 2017, the National Plan of implementing Smart Metering (not yet approved) was published by Romanian Energy Regulatory Authority (ANRE) and the rollout was extended until 2026 for 100% coverage with smart meters.

The above-mentioned Plan provides high important elements concerning the smartening electricity as:

- The National Plan of Smart Grid Implementation
- The general Smart Grid Architecture
- The Smart Meters Functionalities
- The Smart Meters interoperability with the existing measurements systems
- The personal data security and population health security
- The evaluation and monitoring of the Smart Grid implementation
- Dissemination among the consumers.

Romania lacks a consistent legal framework in energy sector. There are two major laws in force in this domain, updated in time (Electricity and Natural Gas Law no123/2012 and Energy Efficiency Law no 121/2014), which are not quite incentive for the stakeholders to begin the process of analysis and implementation of smart grid systems. Moreover, there is no legal definition for the prosumer and the possibility to trade energy from DER provider is not yet regulated.

The Electric Energy and Natural Gas Law 123/2012, last time updated in 2016 defines for the energy sector the following:

- The general disposition for the natural gas and electric energy market;
- The energy strategy and policies, authorities and competence;

- The authorizations, licenses and concessions;
- The promotion of the renewable energy;
- The pricing and types of prices;
- Investigation procedures;
- Law breaking responsibilities;
- Transition and final dispositions.

The general measurement code (Codul de masurare energie electica last issue being from 2015, defines basic rules for data protection and impact assessment (DPIA), data security and privacy in the energy sector in Romania.

3.2 Analysis of the compliance with defined Directives and standards in each pilot use cases

3.2.1 Introduction to the pilot use cases

Isle of Wight (UK), TERNI (ITA), Nicosia (CY), Xanthi (GR) Pilots are related to **grids** in geographical islands or to **microgrids** (i.e. localized loads and generators that could operate connected to the traditional centralized electrical grid, but can disconnect and function autonomously). Actually, these pilots are addressed to effectively manage the intermittent renewable generation, avoiding costs for grid extension.

San Severino Marche (ITA), St-Jean (FRA) Pilots are also committed to tackle **renewables in a distribution grid**. In these pilots, the connection to the main grid is supposed to be strong, nevertheless significant needs are in the **optimization of the infrastructures management**, increasing the efficiency and the reliability, and in developing effective market structure, capable to open the electric pool both to the small (renewables) generators and to the loads.

The market organization is then the main target of Lisbon (PL), Ploiesti (RO), Thessaloniki (GR) Pilots. They are related to the **management of buildings'** (residential and commercial) energy needs (electric and thermal one) in order to identify effective **demand response** approaches.

3.2.2 Isle of Wight, UK

Isle of Wight (IoW) aims to be self-sufficient in electricity supply, i.e. no import from the mainland and meanwhile defer or avoid network reinforcement by adopting smart grid technologies and techniques.

Isle of Wight network is operated by local distribution network operator (DNO) Scottish & Southern Electricity Networks (SSEN). DNOs in the UK are regulated by office for gas and electricity markets (Ofgem). Along with the regulations detailed in section 2, UK DNOs are also required to follow the Distribution Code and the Electricity, Safety, Quality and Continuity Regulations. The Distribution Code contains requirements for levels of harmonic, the connection of generating plants to distribution systems, security of supply, voltage limits and the connection of type tested small-scale embedded generators in low voltage distribution networks.

IoW network is fed from the mainland through three 132kV subsea interconnectors. The island has a 140MW fossil fuel power station providing STOR service to national grid and over 80MW of distributed renewable generation granted planning permission. Peak demand of IoW is 130MVA. To facilitate this high penetration of renewable energy resource, an Active Network Management (ANM) system has been installed by SSEN. Smart grid solutions including energy storage and demand response which includes electric vehicle charging and

electric heating will be investigated. IWC and UNEW will work closely with SSEN to ensure all the EU standards, and UK engineering recommendations are met.

3.2.3 Terni, IT

Terni pilot is a project managed by ASM TERNI S.p.A. that operates and owns the local distribution grid. The need to test microgrid feasibility arises from the large deployment of DER, especially RES, of the last years; indeed, ASM TERNI grid is characterised by the presence of a large number of DER, up to an overall installed capacity of about 70 MW.

Microgrids represent a double opportunity as they provide higher reliability for electric service to the end customer, and also benefits for the local utility increasing the amount of dispatchable power available and allowing the postponement of grid upgrades. These aspects are in line with the concerns expressed several times by the Italian Regulation Authority (AEEGSI) about the management of the distribution grids; the Authority recommended the development of strategies that could take care of the requirements of both the utilities and the prosumers.

Terni pilot involves all the aspects that are at the core of the inteGRIDy project. In particular, demand response is developed on a cooperative business model between prosumers belonging to the microgrid and the DSO; this is done through a monitoring tool on the DSO side and a Flexibility Optimized Management Cockpit (FOMC) on the prosumers side. The real-time communication and interconnection between the resources of the DSO and the microgrid assets, and among the microgrid resources themselves, allows to ensure a constant optimization of the network management, smartening the operation of the microgrid considering the needs of the DSO and of the prosumers. The presence of a BESS allows maximizing the microgrid self-consumption and supporting the main grid in case of congestions or other problems. In addition to the storage system, in the next future EV charging points will be installed and EV could possibly contribute to the stability and the flexibility of the microgrid.

The Terni pilot aims also at proving the advantage introduced by microgrid utilization from the environmental, economic and sustainability point of view; in particular the exploitation of a microgrid equipped with smart metering allows improving the green energy consumption, maximizing the microgrid self-consumption, saving energy losses along the MV and HV feeders, and providing ancillary services also from distributed resources. This is in line with the policies put in place by the Italian Authority and the Government in the last decade, as suggested by EC strategies. Moreover, microgrid pilots define a proper equipment ranking to set up the needs from the technical and management point of view for the DSOs, the DERs and the stakeholders involved.

The evaluation of the relationships between the pilot case and the Italian regulation must consider that microgrids entail aspects concerning both the connection of generators to the grid at MV and LV levels, and the management of DER; as for this last aspect, DER must face their condition on one hand of special entities from a juridical point of view when they are grouped together in a microgrid, and on the other hand of units providing services to sustain the network activity. In Italy, the connection and the management of DER has been a central theme: the Italian TSO (Terna) defined in 2012 the Annexes to the Grid Code A70 and A72, with the former approval of AEEGSI, concerning respectively the technical requirements for DER for the system regulation and the reduction of DER active power when the electric system faces emergency. Also, technical connection standards (CEI 0-16 and CEI 0-21) have many prescriptions on the point of DER connection and management. All the prescriptions defined by different entities are enforced by the Italian Authority, which verifies also their compatibility with the EU framework. Italian Authority hasn't yet provided any specific regulation regarding microgrid, whatever they are inserted in urban, rural or industrial

cluster. Despite this, as of today, microgrids need to face regulation concerning the so called Simple Systems of Production and Consumption (SSPC), which are however juridical entities still connected to the public network, whilst the islanded operation is not foreseen. The possibility for a microgrid to be officially recognized as a juridical entity having determined characteristics implies several advantages among which the most important is for sure a discount on the electricity price, as for all the self-consumed energy it is foreseen an exemption from the grid and the general system charges. The last issue that a microgrid project such as the one of Terni needs to face from a regulatory point of view deals with the provision of the ancillary services to the main grid; from this point of view, the Grid Code, ruled by Terna and approved and managed by the Authority, prescribes all the requirements to be respected.

Moreover, in line with the policies put in place in the last decade, the regulatory framework is evolving towards a structure able to involve as soon as possible the DER in the provision of ancillary services. The Italian Authority, with the Deliberation 300/17, has started a testing activity foreseeing the implementation of pilot projects to test the participation of production and consumption units to the Italian Ancillary Service Market in an aggregated form. This suggests that in the future several microgrid such as the one of Terni could be aggregated and could cooperate among themselves and with the main grid. The final target is to provide flexibility to the TSO, and to improve the effect of DERs on power quality and network efficiency by means of voltage regulation, peak shaving, reverse power flow mitigation, power losses reduction and recovery from outages. The advantages coming from microgrids, and in general from optimal management of DERs, consist in a maximization of the green energy consumption, a higher network reliability and a resilience improvement; moreover, concerning the DSOs activity, it is expected a network loss reduction and a power quality improvement, aiming at reducing voltage fluctuations and SAIFI and SADI values.

As for the future evolutions, it has to be mentioned that a regulatory framework begins to arise, after the experiments incentivized by Resolution 39/10, and after Resolution 114/15, which promoted research about integrated ICT system for DR applied to small users including flexible pricing, load shedding or distributed generation.

The definition of a new regulatory framework is expected, in order to grant to DSOs or to other stakeholders to qualify as facilitators for prosumers' clusters, and also to give new opportunities for customers (DR mechanisms; flexibility; etc).

3.2.4 San Severino Marche, IT

The San Severino pilot aims at investigating the possibility to effectively manage the DERs and maximize the hosting capacity of the distribution network; the San Severino area is suitable for this purpose not only for the high penetration of DERs, but also thanks to the presence of telecommunication systems (i.e. fibre Optic, Wi-Fi bridges and LTE) put in place by previous projects carried out in this area. The main goals of the pilot concern the advanced monitoring of the grid, the forecast of the power flows and the day-ahead topology optimization of the grid. The forecast of power flows and the advanced monitoring will allow managing the network properly, ensuring accuracy and reliability of electric protection and control systems, and optimizing the activity and the efficiency of the grid.

San Severino pilot deals with the most important aspects related to the inteGRIDy project. First of all, demand response will be achieved by using the local distribution grid as a place where aggregators and market actors interested could purchase resources. Through a proper market platform the needed price signals and the aggregator response will be simulated, particularly for what concerns the capacity to coordinate several resources distributed in the grid.

A metering infrastructure deployed along the MV grid provides data to the ASSEM control centre thanks to a TLC network; these data are processed by the DSO's network management tool to define the optimal topology of the grid in terms of losses and operational indicators.

Storage systems (molten-salt sodium-nickel batteries) will be installed, in order to minimize the capital costs, either in big storage plants, or in a decentralized manner, in order to provide regulation close to the edge of the grid.

The main targets of the San Severino pilots are correlated to the recent and future evolution of the Italian regulation. In particular, the role of the DSO has been subjected in the last years to an important evolution; the Italian Authority put in place a mechanism of rewards and penalties based on the values of some indexes of Quality of Service, namely SAIDI and SAIFI. Because of this incentive system, DSOs have been pushed to better managing and structuring their grids, improving the reliability and the resilience of lines and electrical equipment.

Again on the point of MV grid topology, the Italian Authority, with the Resolution 301/12, defined the loss factors for HV, MV and LV networks; according to these factors losses of energy are refunded to the system operators; this pushes TSOs and DSOs towards a grid management aimed at lowering losses, so that the difference between the refunded and the actual losses can represent for the operator an income, despite of being a possible cost.

During the last years, also the connection and the management of DER has been a central theme: the Italian TSO (Terna) defined in 2012 the Annexes to the Grid Code A70 and A72, with the former approval of AEEGSI, concerning respectively the technical requirements for DER for the system regulation and the reduction of DER active power when the electric system faces emergency conditions. Also, technical connection standards (CEI 0-16 and CEI 0-21) have many prescriptions on the point of DER connection and management. All the prescriptions defined by different entities are enforced by the Italian Authority, which verifies also their compatibility. One of the core points of the San Severino pilot deals with the participation of the DERs in the management of the local and the main network through the provision of ancillary services. Under this light the project stresses the role of the DSO as the subject which collects the required services, from both passive and active users, and checks the compliance of the provided services with the constraints of the local network. This concept is in line with the possible future evolution of the ancillary services and network management foreseen in the Consultation Document 354/13 of the Italian Authority, and by the recent Resolution 300/17. In this recent Resolution, also the role of demand response is highlighted, with the possible use of storage systems.

The pilot is hence following the same path established by the Authority, individuating in the aggregator the figure that, as a new market actor, could allow performing the transition towards an interconnected network where DERs could be able to fully provide their contribution maximizing the efficiency and the sustainability of the electric grid.

The grid arranged by the San Severino pilot meets two different interests: on one hand, the DSOs one, that thanks to the optimal management of the local grid is able to increase the grid performance parameters and minimize the congestions and the reverse power flow problems; on the other hand, the final user will have an economic gain from the demand response service provision, eventually also thanks to the use of storage systems in order to minimize their electricity bill.

3.2.5 Barcelona, ES

In the pilot use case in Barcelona various energy saving measures are going to be implemented, besides developing a tool to optimize Demand Response. Therefore, different DR strategies are going to be designed depending on the on-site PV generation, grid availability and storage. When it comes to storage, Lithium-ion batteries are going to be used for electricity, whereas on thermal side the pool is going to be used as virtual storage.

The Spanish electricity market has been fully liberalized since 2009, so consumers can choose the distributor or the tariff that they desire, however, there is also a fixed tariff regulated by the government for small consumers with less than 10 kW of contracted power. Even though the market is liberalized, the companies that had the monopoly before liberalization still own the transmission and distribution lines.

As far as DR strategies are concerned, Spain is currently undergoing a process of installing smart meters to consumers, expected to conclude in 2019, nonetheless, Claror Cartagena already possesses such meters and fulfils the measuring requirements collected in the RD (Royal Decree) 1110/2007, unified regulation of measurement points, and article 12 of the organic law 15/1999, which regulates data protection. In the Spanish electrical market, there are three main pricing tariffs. The first one, is General Flat Rate, where energy prices vary depending on spot price, but normally remain similar throughout the day. The second one, is Night Time Rate, where the day is divided in periods, the energy being cheapest at periods expected to have less consumption peaks. Finally, bearing a resemblance to the previous tariff, there is a Super Valley Rate, where the prices are much cheaper at night than during the day.

When RES is used in Spain, the RD 900/2015 of the ministry of industry, energy and tourism must be taken into account, it regulates consumption of on-site generation such as the PV panels expected to be installed in Claror. Since contracted power exceeds 100 kW in the pilot use case, the PV installation is going to have to be enrolled as a production installation and a toll must be paid for each kWh that the centre self-consumes. For the use of batteries, it is necessary to refer to the same RD, which defines a specific connection point for storage elements.

3.2.6 St-Jean, FR

The pilot use case in St-Jean-de-Maurienne, aims to be compliant with the main recommendations from the CRE, French Commission for the regulation of energy:

- The CRE asks the network operators to present all the technologies and functionalities they intend to implement. Such a publication would stimulate research in this area and thus contribute to accelerate the deployment of Smart Grids on an industrial scale.
- Sharing Energy Data: in the context of the deployment of smart grids, the issue of the publication and exploitation of consumption data is fundamental. The CRE invites network operators to improve their coordination in this area. The aim is to provide consumers, local authorities and all relevant stakeholders homogeneous and coherent data to facilitate their use.
- The sharing of lessons: a recommendation is also addressed to the promoters of demonstration projects. The CRE asks them "to systematically share with the CRE the conclusions from their experiments, in order to inform the CRE of the regulatory developments that would encourage the development of innovation".

Smart metering. In order to promote consumers' knowledge of the management of their installation, the CRE is in favour of allowing consumers to have access to an interface

enabling them to know the allocation to each time slot and, the typical uses associated with its. In order to make the best use of the potential of advanced counting systems, consumers should be able to easily modify this allocation.

Security. The CRE proposes that the regulatory concerning the general technical requirements for design and operation be modified to take in account the specific characteristics of electricity storage installations which may lead to difficulties in terms of supply quality and network security.

Electromagnetic compatibility (EMC) and power quality. The CRE is in favour of better protection of the current carrier signal from electromagnetic disturbances and recommends the introduction of regulation to protect the frequency bands of the CPL (power line communication), as are the radio frequencies in the Decree of 18 October 2006; - the development of an international standard on compatibility levels defining maximum emission levels to avoid disturbances and degrees of immunity to ensure robustness in line with ongoing work within the IEC.

3.2.7 Nicosia, CY

The pilot case in Cyprus aims to address demand response possibilities and ways of smartening the distribution grid by utilizing the smart facilities at the University of Cyprus and of prosumers directly connected to the DSO.

Cyprus has fully transposed all electricity and gas directives to binding national legislation but the market so liberalized is still in its infancy since it is a small energy isolated market and there was no real push for implementing a competitive market. For this reason, the market rules although functional do not support storage systems, data handling and emerging market participants such as aggregators. Smart meters are not deployed and hence no possibility for introducing Time of Use Tariffs to support effective Demand Side Management. Ancillary services are totally restricted to the incumbent and e-mobility is still being debated as to who is to take the responsibility to develop the required infrastructure.

On the other hand, Cyprus has fully adapted the European Standards for activating the full functionality of advanced inverters in support of RES penetration without creating unbearable side effects on the integrated grid. These standards have been incorporated in the current version of the Grid Rules and are included as mandatory in the grid connection rules for all new RES systems. Moreover, all European Standards are adapted in Cyprus and hence the functionalities of Smart Meters as dictated by the EU Mandates and interoperability requirements as identified through the various EN and IEC standards are included in the specifications for the planned infrastructure.

3.2.8 Lisbon, PT

In the Lisbon pilot, three use cases are identified, being the first a study of DR shift potential in the building which will be developed using the predicted charge profile that will be applied in the building electric consumption profile. This will be linked with the smart meters in the building to assess the positive effect in the charging system devices (thermal – ice tanks; and electrical – EV), crossing information with VPS data managing system. The investment in this use case will be in a small PV plant to be installed in the rooftop of the building alongside with data readers for the energy that will be produced in the PV plant. This PV plant to be installed will be subject to the regulations mentioned in section 2, being in this case for full self-consumption since its planned maximum capacity is lower than the building consumption power value for any daily period.

The second case study will assess the technical potential of an ice bank as energy storage system to provide the required DR shift according to a virtual tariff flexibility as outlined by the partner PH. This potential will be optimized through investment in equipment to regulate the ice banks thermal energy heat transfer capacity in order to fit its transfer power with DR needs. Being this a case study characterized by a technical approach, no interoperability or compliance issues are identified regarding legislation.

The third case study will address the potential to adapt the EV charging cycles to dynamic tariffs, replacing the already used fixed-tariff system. This adapting procedure will later be implemented in a Building Energy Management System, with differentiation between the normal and fast EV chargers, with different charging characteristics, thus different potentials to exploit the tariff changes during time periods. To achieve this, smart meters will be installed, subject to the aforementioned Guide for Metering, Reading and Availability of Data of the electricity sector in Portugal (3.1.5), as well as being compliant with additional regulation Directive 10/2012 and Ordinance 231/2013.

3.2.9 Xanthi, GR

Pilot 8 implements an autonomous smart grid. The scope of the pilot is to integrate different energy sources and energy storage technologies in order to satisfy the demand of an isolated area. Furthermore, the pilot focuses on smart management of the equipment, in order to succeed a sufficiently optimized solution.

Sun, wind and diesel are the energy sources that are going to be used. Lead-acid batteries and Polymer Electrolyte Membrane (PEM) electrolyser that produces and store hydrogen are going to be used for energy storage. Finally, to complete the grid, a load and appropriate connections among units will be needed. More specifically:

Equipment that uses energy sources directly:

- PV rated at 12.7kW, 15.4kW and 15kW will be used to for exploiting solar energy.
- Wind generators of 3kWp each for exploiting wind energy.
- Diesel Generator (DG) of 1.1kVA as a transducer of chemical to electric power.

Equipment for storing energy:

- Lead-acid battery (BAT) arrays of 2000Ah, 2000Ah and 2000Ah
- Polymer Electrolyte Membrane (PEM) electrolyser that produces and stores hydrogen at 30bar pressure cylinders and a PEM FC system that produces power by using the stored hydrogen

Equipment to achieve connection between production and storing units:

- DC Buck/Boost converters at each node of 1kW each
- Power Converters to connect DC and AC busses
- 300V DC bus bar is used to exchange the power between the nodes

The implementation of the pilot 8 will take place at N.Olvio in Xanthi in Greece. The experimental grid will not have any connection to factory's grid, it will be totally isolated. In Greece, there is no legislation for autonomous power supply of buildings [LAP17], therefore the European Union regulations apply. The Greek legislation occurs only if a connection to national grid is going to be established (ΦΕΚ Ά 118/24.6.1965, ΦΕΚ ΄Β 844/16.5.2004), but the equipment that's being used must be subjected to legislation.

The equipment that is going to be used in pilot 8 is for experimental use due to fact that SUNLIGHT has R&D department for batteries meets all the necessary conditions and regulations for the use of the equipment. For future use, in order to install and function an isolated smart grid in Greece, the equipment must meet the defined standards (e.g. ISO) and the installer should have the appropriate planning permissions in order to proceed in the implementation process.

The developments at Pilot 8 will be based on widely used standards to ensure interoperability and compliance for the system operator and the rest of the involved participants (e.g. inteGRIDy's common modular platform (CMP). The entire infrastructure is developed using market available standards. There are four levels of communication and information transfer. Each one uses a different approach based on the needs for data exchange and capabilities for communication set by the equipment provider:

- At the I/O field level a number of different industrial-grade or common standards are used that are dictated by the hardware vendor (e.g. Profibus, CANBus, RS-232, RS-485).
- The internal node-level communication is based on OPC-related communication allowing for the appropriate information to be transferred among the various involved subsystems (from the DaQ concentrator to the SCADA system).
- The data exchange between the nodes (DC/DC converters) is based on TPC/IP communication
- The external level which will be reachable to the CMP will be based on IoT (MQTT), IEC61850 and Restful services.

Each of these different access/communication methods will be selected based on the provided service and the requirements for data exchange.

3.2.10 Thessaloniki, GR

The current pilot features three use cases, as presented in Task 1.3, namely: (a) a set of 100 residential buildings with various load profiles, (b) a group of about 10 households with installed BESS, and (c) targeted areas of a commercial building, more specifically the training courts and some offices of PAOK Sports Arena, where BESS's will further be installed in the DR frame.

The core technologies for the implementation of the proposed DR methods which presented in Task 1.2 are as follows: (i) Smart -metering or advanced metering infrastructure (AMI), (ii) Battery Energy Storage Systems (BESS's) and (iii) Multiple, wireless, environmental sensors (of temperature, lighting and occupancy) will be used to optimize the energy consumption in the investigated properties.

In recent years, in Greece, electricity prices have risen steeply, in response to the removal of price caps and market liberalization. This pass-through of the energy component is influenced by the degree of competition in the market and the regulation of market prices. Consequently, it is crucial that consumers are provided with services (such as participation in DR) and the ability to better control their costs in the upcoming future. Characteristic examples of this framework are: (i) a discount of 10% on PPC rates for companies with annual consumption of over 1,000 GWh, and (ii) an additional discount of 25% on its night and weekend rates for industries with annual consumption below 1.000 GWh [BER07].

Regarding the Battery Energy Storage Systems (BESS) in Greece, there is lack of regulatory frameworks; therefore, they are normally treated as generation systems. Although several regulatory efforts have been conducted to ensure these systems are covered by a legislative framework, these actions have not given any thrust. The Greek Association of Photovoltaic

Companies highlighted the need for the establishment of specifications required for the installation of accumulators in photovoltaic auto-production systems by the HEDNO (Hellenic Electricity Distribution Network Operator). While such specifications have not yet been established, the HEDNO decided in the meantime that “an electrical configuration of the parallel operation of the storage system (e.g. batteries) and the photovoltaic system within the self-production program with energy offset is not acceptable”. At the same time, the Ministry of Economy, Development and Tourism announced the action of NSRF which subsidizes the installation of photovoltaic and storage systems in enterprises [STE16].

Concerning the privacy and ethics issues, the Law 3471/2006 of the Hellenic Parliament protects fundamental rights and privacy in particular, and establishes the conditions for the processing of personal data and the reservation of communication confidentiality in the electronic communications sectors. The proposed solutions do not expose, use or analyse personal data for any purpose and, therefore, no ethical issues are raised by the technologies to be employed in Pilot sites foreseen in Greece.

Existing legislation on electricity management tools along with relevant legislation of privacy and ethics issues for personal data may encourage customers to change their energy consumption behaviour. And also empowering the customers to influence the timeline of their energy demand based on their needs.

3.2.11 Ploiesti, RO

According to the project plan proposal from Romania, the installed Smart Meters will include flexible programs and equipment that will assure the interoperability between inteGRIDy system and the other existing systems of monitoring and administration of the electric energy. It will be also assured the interoperability between inteGRIDy system and the communication related the data transfer with other SEN and from the energy market operators.

The DSO is going to implement and administrate the MDMS centre for storage and processing the data provided by HES unites and smart meters. It will also be implemented and administrated the interface containing the invoicing applications, consumers notifications, prognosing etc.

In the project plan proposal, it is also stipulated that the DSO is going to assure the organizing and storage data according to the measurement points dedicated for the transfer to suppliers, to consumers and other assigned parties. The transfer will be done in the formats established by the in-force regulation.

The installed meters and data concentrators shall permit to be updated and upgraded (software and hardware) for at least ten years, without being necessary their replacement.

4. Conclusions

The existing policies and the related regulatory frameworks were investigated in all inteGRIDy countries; a pre-analysis of the main legislation, standards and interoperability issues has been performed.

All EU countries have successfully transposed the related EU Energy Directives; nevertheless, full implementation has not been completed in certain Member States, as shown in Table 6 (X* = transposed but not implemented).

Table 6. Transposition of EU directives across EU countries.

	EU Legislation					
	Market Liberalization IME3	Regulation (EC) No 713/2009	Safe Supply 2005/89 / EC	Directive 2008/92/EC on price transparency & Regulation (EU) No. 1227/2011	Reduction of Energy Consumption 2012/27 / EU - 2010/31 / EU	Renewable Energy 2009/28 / EC
Country						
United Kingdom	X	X	X	X	X	X
Italy	X	X	X	X	X	X
Spain	X	X	X	X	X	X
France	X	X	X	X	X	X
Portugal	X	X	X	X	X	X
Cyprus	X*	X	X	X	X	X
Greece	X*	X	X	X	X	X
Romania	X*	X	X	X	X*	X

In Greece, the liberalization of the energy market did not yet take place (there is still a monopoly); in Cyprus, liberalization process started but there is in reality only one operator; Romania lacks a consistent legal framework in energy sector and the costs of the liberalized market are higher than the captive market; in France, even if the liberalization of gas and electricity markets took place, and there is a mature level of infrastructure, the market historical operator still occupies the main positions.

Concerning the standards, a list to check compliance with, in the different pilot cases, has been collected and summarized in Table 7.

Table 7. inteGRIDy pilot compliance across standards.

List of Standards to check compliance with in the pilot sites															
	EN 61970	EN 61968	EN 62325	EN 62056	EN 62351	EN 61508	EN 61851	EN 61850-6 61850-7-2 61850-7-3 61850-7-4	IEC 61850-7-420	IEC 61850-90-9	EN 61499	EN 50491-12	IEC 62443	EN 62196	IEC 62746
Pilot Cases															
Isle of Wight	X	X	N/A	N/A	N/A	N/A	X	X	N/A	N/A	X	X	X	X	X
Terni	X	X	N/A	X	X	X	X	X	X	X	X	X	X	X	X
San Severino Marche	X	X	N/A	X	X	X	N/A	X	X	X	X	X	X	N/A	X
Barcellona	X	X	N/A	N/A	N/A	N/A	N/A	X	X	X	X	N/A	N/A	N/A	N/A
St-Jean	N/A	N/A	X	N/A	X	X	N/A	N/A	N/A	N/A	N/A	X	N/A	N/A	X
Lisbona	X	X	N/A	X	N/A	X	X	X	X	X	X	X	X	X	N/A
Nicosia	X	X	X	X	X	N/A	X	N/A	N/A	N/A	N/A	X	X	X	N/A
Xanthi	X	X	N/A	N/A	N/A	N/A	N/A	X	X	X	N/A	N/A	N/A	N/A	N/A
Thessaloniki	X	X	N/A	X	N/A	X	N/A	X	X	X	N/A	X	N/A	N/A	X
Ploiesti	X	X	X	X	X	N/A	N/A	X	X	X	N/A	X	X	N/A	X

N/A = Not Applicable

Efforts made by all actors to comply with the rules in force are remarkable; however, there are some aspects of testing and analysis that will be carried out in the absence of a national legislative reference, such as, for example, the smart grid (microgrid) implementation in Italy or the connection of storage systems in Greece.

In general, in all Pilots an evolution of the regulatory framework is necessary in order to implement innovative energy approaches (demand response, energy storage exploitation) and in order to have an economic viability of the renewables exploitation (opening the ancillary services markets today somehow confined to traditional power plants).

Actually, the current European regulatory framework on demand response states that National regulatory authorities shall encourage demand response to participate alongside supply in wholesale, balancing, ancillary services and retail markets and should define technical modalities for the participation of demand response in balancing reserves and other system service markets on the basis of the technical requirements of these markets.

Peculiarities of the Pilots follow below.

Isle of Wight pilot network is fed from the mainland through three 132kV subsea interconnectors. The island has a 140MW fossil fuel power station providing STOR service to national grid and over 80MW of distributed renewable generation granted planning permission. Peak demand of IoW is 130MVA. To facilitate this high penetration of renewable energy resource, an Active network management (ANM) system has been installed by SSEN. Smart grid solutions including energy storage and demand response which includes electric vehicle charging and electric heating will be investigated. IWC and UNEW will work closely with SSEN to ensure all the EU standards; UK engineering recommendation be met.

Italy in general has successfully transposed the EU Energy Directives and Italian Pilots comply with all defined standards, but new standards are required to guarantee interoperability of Smart Grid technologies. For example, the current adopted meters (1G) are not suitable to sustain DR services; their substitution is therefore necessary with more sophisticated meters (2G). Since interoperability is fundamental within Smart Grid technology, the definition of new standards is strictly necessary. Today, the Italian Regulation Authority, AEEGSI, is working on the second generation of smart meters (2Gs), identifying new consumer services, and is promoting several initiatives to define new standards for dispatching services in line with European code. In **San Severino** pilot, the current regulatory framework still does not allow small users and DERs to participate to ASM; remote control of active/passive users for DR strategies is also not possible (and foreseen only for DERs ≥ 1 MW); new actors (e.g. aggregator) and strategies (e.g. DR) need to be defined and regulated in the regulatory framework in force. Regarding the hybrid business model to be demonstrated in the **Terni pilot,** the site has to manage the trial in compliance with the legislation laid down for non-domestic prosumers having several production plants connected to the electrical distribution network, because the Authority does not provide any definition of the microgrid for an urban, rural or industrial cluster.

Concerning **Barcelona,** the General Electricity Law 54/1997 (supersede by Electricity Law 24/2013) liberalised the electricity sector and established the FIT for “special regime” generation plants, and the Royal Decree 1634/2006 started deployment of smart meters.

St-Jean, in France, aims to be compliant with the main recommendations from the CRE, French Commission for the regulation of energy.

In **Cyprus**, as mentioned before, the full liberalization of market has been legislated, but not implemented yet. The market operation is expected by 2019. Cyprus has fully transposed all electricity and gas directives to binding national legislation but Market rules do not support

storage systems, data handling and emerging market participants such as aggregators. National grid codes and standards have been harmonized with the existing EU Directives (Third Energy Package, Directive on Measuring Instruments, Energy Efficiency Directive, Electricity market and consumers, Renewables & bioenergy sustainability) and Smart Meters functionalities, as dictated by EU Mandates, are included in the specifications foreseen for **Nicosia pilot.** Also, interoperability requirements, as identified through various EN and IEC standards, are included in the specifications for the planned infrastructure.

In **Portugal**, the transition to a liberal market was fully achieved between1995 and 2006. Nevertheless, the electricity traders or retailers still struggle to offer larger clients dynamic tariffs which make use of market fluctuations, improving their offer and bringing satisfaction to both parties. This is mostly due to lack of regulations (since December 2014, the Portuguese Energy Services Regulatory Authority allows the implementation of dynamic tariffs in pilot projects, but the national legislation process is not fully developed); to some existing risk in case they contract an insufficient energy amount on a short-scale and end up paying penalty tariffs to the DSO, or sometimes, due to general lack of awareness from the final user for their potential to shift the Demand Response according to a dynamic tariff. In fact, there wasn't yet a significant increase of competition within the market.

In the **Lisbon** pilot, three use cases are identified, all related to the management of buildings' (residential and commercial) energy needs (electric and thermal one) in order to identify effective demand response approaches. In the first use case, PV plant to be installed will be subject to the regulations mentioned in section 2. It means that the self-consumption regime, since its planned maximum capacity, is lower than the building consumption power value for any daily period. The second case study will assess the technical potential of an ice bank as energy storage system; in this case the study is characterized by a technical approach, no interoperability or compliance issues are identified regarding legislation. Finally, the third case study will address the potential to adapt the EV charging cycles to dynamic tariffs, replacing the already used fixed-tariff system. This adapting procedure will later be implemented in a Building Energy Management System; smart meters will be installed, subject to the aforementioned Guide for Metering, Reading and Availability of Data of the electricity sector in Portugal, as well as being compliant with additional regulation Directive 10/2012 and Ordinance 231/2013.

In **Greece**, the liberalized electricity market is operated by DSO and is supervised by RAE, which was established under L.2773/1999 to harmonizing the Greek regulatory frameworks with the EU Directives 2009/72/EC and 2009/73/EC concerning rules for the internal market in electricity. **Thessaloniki** and **Xanthi** pilot will be developed with no national available legislations for autonomous power supply of buildings; only European Union regulations will apply. The Greek legislation occurs only if a connection to national grid is going to be established (ΦΕΚ Ά 118/24.6.1965, ΦΕΚ ΄Β 844/16.5.2004), but the equipment that's being used must be subjected to legislation. The equipment though meets the defined standards and the entire infrastructure is developed using market's available standards. The developments at Pilot 8 will be based on widely used standards to ensure interoperability and compliance for the system operator and the rest of the involved participants (e.g. inteGRIDy's common modular platform (CMP).

Ploiesti pilot in **Romania** will suffer from the absence of a consistent legal framework in energy sector. There are two major laws in force in this domain, updated in time (Electricity and Natural Gas Law no123/2012 and Energy Efficiency Law no 121/2014), which are not quite incentive for the stakeholders to begin the process of analysis and implementation of smart grid systems. Moreover, there is no legal definition for the prosumer and the possibility to trade energy from DER provider is not yet regulated. Nevertheless, according to the project plan proposal for **Ploiesti**, the installed Smart Meters will include flexible programs and equipment that will assure the interoperability between inteGRIDy system and the other

existing systems of monitoring and administration of the electric energy. It will be also assured the interoperability between inteGRIDy system and the communication related the data transfer with other SEN and from the energy market operators.

For the general conclusion, it is possible to affirm that the almost total absence of legislation and integration of smart grids, especially in some countries, can be taken as an advantage by the inteGRIDy project which aims at defining common standards in this field immediately prior to their effective implementation.

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