LIBERA UNIVERSITÀ INTERNAZIONALE DEGLI STUDI SOCIALI

Department of Impresa e Management

Chair in Energy Economics

Smart Grid: From an isolated, passive and centralized production, management and distribution of energy, to an integrated, active and decentralized one

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Table of contents

Abstract

Global warming, growing costs associated to the use of fossil fuels and the energy price that is higher day after day represent prevailing problems that affected our life have stimulated society as a whole to undertake several projects for the Smart Grid implementation.[1] The thesis develops itself in four parts: The Smart Grid System; Electrics Vehicles System; Smart Grid in Europe's environment and the Italian Energy Market; Enel Group's key role and its projects in Italy; The effort of LUISS to redefine its shape.

Introduction

Hard times, the world's population has almost reached 7,5 billion but the resources seem to diminish with the opposite rate of growth, efficient management of resources and spaces is the only possible solution to go forward, the cooperation will be the key to the functioning of a society that is increasingly global and homogenous, an organization by the size never seen before. Energy, a projection of nature, passing from one body to another can change the very nature of things, among the many, include electricity, force resulted from electric fields where charged particles are accumulated, the effect caused by this astonishing mechanism is the movement, the same motion that allows operation of our cities, which hold on the society. An efficient electricity system is a prerequisite for adequate protection of the interests and safety of citizens, to a life not dominated by chaos, for a community that can count on tomorrow. Fossil fuels, today are the prime source of energy but represent also one of the causes of the decline of our society. Recalling the main, oil, coal and natural gas, there are two underlying problems to associated with them:

-the emission of carbon dioxide and its impact on the environment.

- The need to build a system of production, management and distribution of energy more efficient that considers current and future needs..

About the former, it is known the need to find new sources of renewable energy, in fact these offer many advantages from the aspect green, their use does not cause the emission of CO2; to continue with

[1] Daphne Mah, Peter Hills, Victor O.K. Li, Richard Balme, 2014

the fact that for physiognomy can support the long-term development, in fact are not exhausted; finally with their perfect substitutability in respect of fossil fuels. The most important among the renewable sources are wind, hydro, solar, tides, geothermal energy and waste.[2]

About the latter, the current electric infrastructure is too old for the demands which it must satisfy in fact it is continuously exploited beyond its capacity. The modernization of the grid toward a more intelligent, therefore, reliable, flexible and safe is necessary so that actually there are examples in the world of state of the art facilities that take advantage of the new technologies to manage, control, produce energy in the best of ways; to communicate quickly and in an integrated manner; anticipating the future needs of the system; preventing and avoiding every form default. Consumers can better manage their own energy consumption and costs because they have easier access to their own data, due to these devices is possible make aware anyone of their expenditure. This point is crucial because currently the awareness of wastes is something unknown and thus it is the first achievement to be reached, in fact what might appear an innocent habitude could reveal itself a relevance source of cost; for example there are a lot of firms that have already understood that they could save million just by turning off the PC at 7 p.m. instead 8. The role of customers is drastically changing from a passive position to an active one, it has a double meaning this issue, on one hand they are active becoming energy managers also checking and shifting the consumptions depending on energy demand and supply, on the other becoming also producers if they want, in fact a bidirectional energy transmission, key point of a Smart Grid, enable them to buy or sell energy on the basis of the daily needs, moreover with the help of devices that automate this process by making it simple for anyone. Utilities also benefit from a modernized grid, including improved security, reduced peak loads, increased integration of renewables, lower operational costs and its application to the Electric Vehicles world. [3]

Smart Grid is the solution to both of the problems. For this reason, the purpose of the thesis is to clarify its concept, implications and them strictly associated; to explain the difference between the traditional electricity net and the future one, how Smart Grids are finding their place in the world and how the world is leaving them the space that they need for developing themselves.

In the first chapter will be introduced the concept of Smart Grid closely correlated with that of Internet of Things, will continue with a detailed description of all the actors that make up the system and how

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[2] Wenye Wang, Yi Xu, Mohit Khanna, 2017

[3] U.S. Department of Energy, 2008

their interaction has been made possible. In the second chapter will be analyzed the world of electric vehicles and its role in order to ensure an efficient Smart Grid; being an indispensable piece of the puzzle will be also presented practical examples, in particular some of the major projects implemented. The third chapter is divided into two parts, in the first one will be exposed the European vision regarding the topic, the main international projects and the main standards promulgated to encourage the Smart Grid implementation; in the second part there will be an analytical exposure of the legislative process which has led to the liberalization of the Italian electricity market. The object of study of the fourth chapter will be the Enel Group, a pioneer in the Smart Meter Technologies, Italian pride in any project related to the Smart Grids, are thus presented and described his masterpieces. In the last chapter LUISS Guido Carli will be taken into consideration, in particular the office in Viale Romania, for the theoretical application of the main technologies discussed and the concepts of which they are the expression.

Figure 1 Smart Grid[4]

[4] www.shutterstock.com

1. The Smart Grid System

In this chapter the main features of the Smart Grid System are going to be covered along with the differences between the new architecture of the electrical networks and the traditional one. Furthermore an explanation of the communication infrastructure will be provided with a brief focus on the revolutionary ZigBee System and the standards that regulate and discipline this reality. Moreover every actor that interacts and belongs to this outstanding and innovative structure will be presented and described under both positive and negative aspects. Table 1-2 SG's Framework[5]

Acronym	Definition
AMI	Automatic metering infrastructure
AMR	Automatic meter reading
BAS	Building automation system
DER	Distributed energy resource
DLC	Direct load control
DMS	Distribution management system
DR	Demand response
EMS	Energy management system
ESI	Energy services interface
GPS	Global positioning system
IED	Intelligent electronic device
IEM	Intelligent energy management
IFM	Intelligent fault management
IHD	In-home display
ISO	Independent system operator
LMS	Load management system
MDMS	Metering data management system
OMS	Outage management system
PEV	Plug-in electric vehicle
PLC	Power line communication
PMU	Phasor measurement unit
PTP	Precision time protocol
RTO	Regional transmission operator
RTP	Real Time Pricing
RTU	Remote terminal unit
SCADA	Supervisory control and data acquisition
STNP	Simple time network protocol
WACS	Wide area control system
WAMS	Wide area monitoring system
WAPS	Wide area protection system
WASA	Wide area situational awareness

The Smart grid framework is complex, for this reason is exposed in the figure above the list of Acronyms of the several actors that interact in the system and the Definitions associated to them.

[5] Wenye Wang, Yi Xu, Mohit Khanna, 2017

1.1. WHAT IS A SMART GRID?

"A Smart Grid is self-healing, enables active participation of consumers, operates resiliently against attack and natural disasters, accommodates all generation and storage options, enables introduction of new products, services and markets, optimizes asset utilization and operates efficiently, provides power quality for the digital economy."[6]

According to the definition provided by US Department of Energy this new incredible system is changing entirely the known way to producing, managing and distributing energy. Flexibility and decentralization guarantees an elastic system able to operate efficiently in any condition and react immediately to any kind of problem. Due to bidirectional transmission, sensorial and control system, consumers cover an active role being at the same time users and if they want producers as well, they are at the basis of correct functioning of Smart Grid.

In fact "A Smart Grid is an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both – in order to efficiently delivering sustainable, economic and secure electricity supplies."[7]

"Smart grid" technologies are made possible by two-way communication technologies, control systems, and computer processing.

Unlike the current electrical structure, the future one, will be characterized by the exploitation of technological tools able to manage and optimize the use of energy and not only, in fact at the base of the Smart Grid there is the upstream integration of renewable energy, fossil fuels that belong to the past are gradually leaving the field for renewable sources of energy that instead represent the future. Automating many of the processes that today require human intervention will make these sources of energy more safe and reliable and this is precisely the goal, use it to the full for economic development, eco-sustainable. There are many advantages of this new system, control in real time of consumption as well as many other processes related to the distribution and transmission. Be aware of consumption did not will only customers but also every single actor belonging to the infrastructure, in this way the quality of the service will improve beyond any expectation. The information regarding the status or

[6] U.S. Department of Energy, 2008

[7] European Technology Platform Smart Grids, 2010

control must be able to be transmitted nimbly, thing that the current system does not allow or at least not beyond areas, this for example is one of the advantages that will be guaranteed by the SCADA system, communication, control, supervision and data acquisition. For the generation of electric power you can entrust to generators distributed in the various areas and then employed at the same time however all lead to the same management. Fundamental aspect is the bi-directional communication requirement needed for the efficient management of the system. With the advent of the internet, wireless networks, it would be possible to enjoy a communicative network secure and timely when you need, instead today the electric network does not take full advantage of these technologies, the Smart Grid is instead based on these tools for its correct operation.[8]

1.2. HOW THE ELECTRIC SYSTEM HAS BEEN CHANGING IN THE LAST DECADE

In the figure below the structure of a Smart Grid System is confronted with the structure of a traditional Grid.

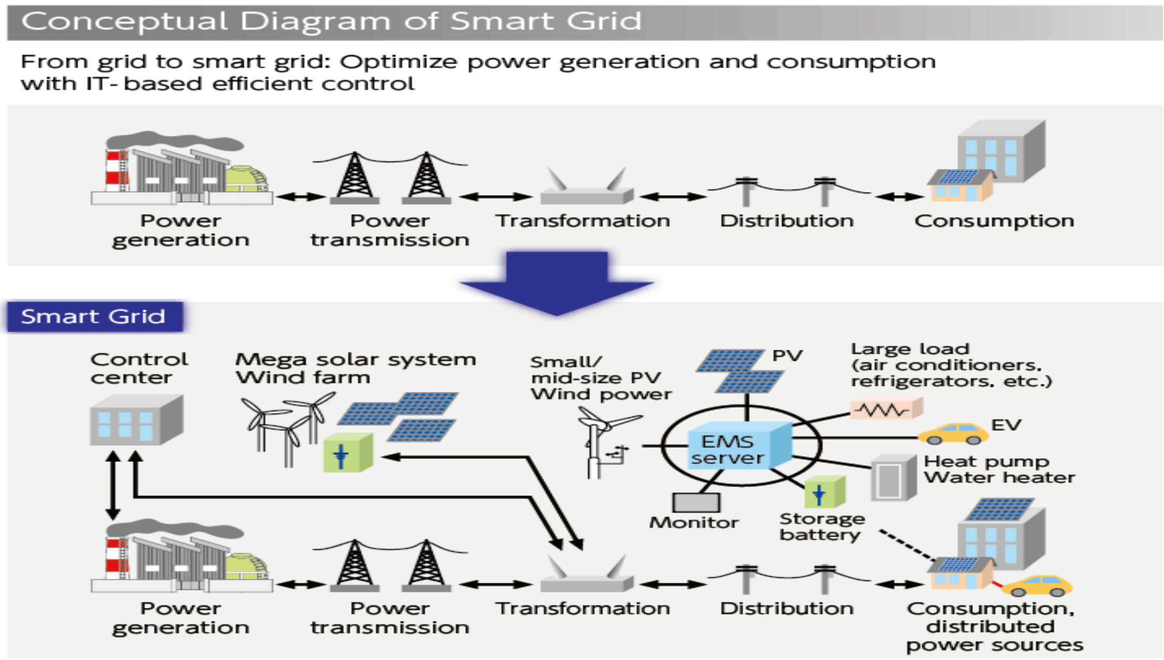

Figure 2 Conceptual Structure of a SG System and structure of an old one[9]

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[8] Wenye Wang, Yi Xu, Mohit Khanna, 2017

[9] http://global-sei.com/csr/feature/2011/images/table011.gif

Architecture of a Traditional Net

As is possible observe on the figure n.2 from the left to the right energy has been produced (through different sources, as for example nuclear, hydroelectric, eolica, solar, etc.), later has been transmitted through the net of high tension, it is distributed through the net of low tension and it is finally furnished to the consumers such as industrial, commercial or residential. Naturally it is observed, that the flow of energy happens in an only direction, that is from the generation to the consumers. This system has been being used all over the world for the century XX with notable success. Even if one have been considered of the most important inventions of the century, it is possible to find some weak point:

- It is an enough inefficient system, there is a notable difference between the middle value and the maximum one of the demanded.

- It doesn't deal with a safe system.

- It is too much to rigid net, since it sufficiently is not flexible to satisfy new types of consumers (for example the electric car). It is necessary to incorporate distributed generation.

- The quality of the service must have been improved. Hence it needs to reduce the breakdowns in the different elements of the system.

- It is too much to polluting system because of the issues of CO2 that happen during the generation of energy [10].

The features that characterized the new net areas:

- Elevated efficiency: Trying to reduce the losses that happen in all the elements that belong to the system.

- Elevated level of reliability: The use of intelligent sensors, installed in different stung by the net, it will allow to locate the breakdowns that happen inside the electric system in a fast way and possibly solve it. Therefore, the net will become more reliable.

[10] Tesi di Gustavo Barbera, 2012

- Safety and acceptable quality of the service: The nets of the future must guarantee to the consumers a quality better than that furnished today.

- Low environmental impact: Through the integration of renewable sources of energy in the system of distribution.

- Flexibility to satisfy the electric mobility: Through the installation of centers of recharge in the places[11].

In the figure n.3 are summarized the concept discussed so far.

Traditional and Smart Grid

Traditional Grid	Smart Grid
Electromechanical	Digital/Microprocessor
One way communication	Global/Integrated two way communication
Centralized generation	Distributed generation
Limited monitoring, protection and control systems	Adaptive protection
Manual monitoring	Self monitoring
Manual restoration	Automated
Check equipment manually	Monitor equipment remotely
Few customer choice	Many customer choice

Figure 3 A confront between the traditional grid and the smart grid[12]

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[11] Tesi di Gustavo Barbera, 2012

[12] Jenifer Pushpa Samuel, 2016

1.3. HOW THE SMART GRID SYSTEM WORKS

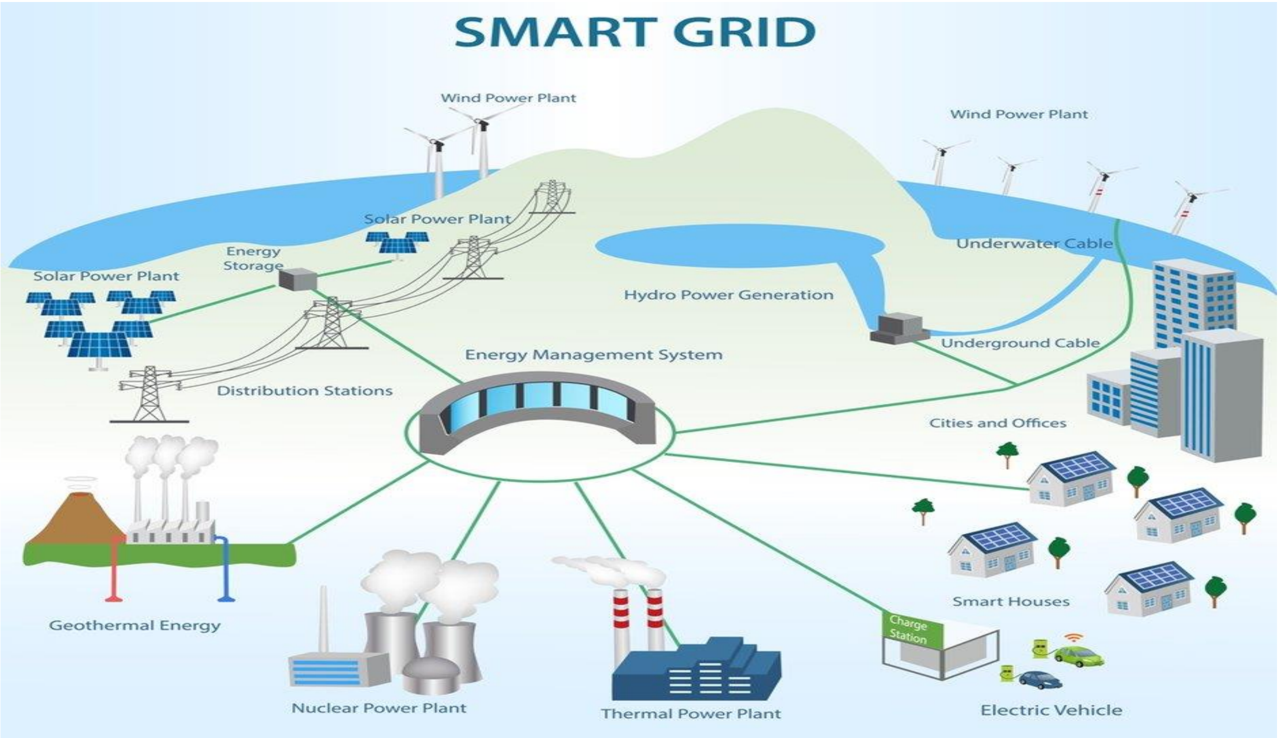

Figure 4 SG Diagram[13]

Now, it will be necessary start the description of the entire process from the center, Energy Management System, then it will be the time of an explanation of the devices that allow to the Smart Grid to be integrated, the Communication Infrastructure. Afterwards all the factors that concern the system will be analyzed.

1.3.1. Energy Management System

Is a huge argument inherent to the most important steps about this topic: the control, the management and the accumulation of energy in each sectors which the society is composed by.

To define briefly the concept of energy management system, it consists of:

-The process of monitoring energy consumptions;

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[13] www. Shutterstock.com

-Discover new ways to save energy and accumulate it;

- To find and understand lacks of efficiency in the system to improve it continually.

Is fundamental understand that implementation of Energy Management System is useful not only for firms or governments but also and especially for last utilizers of energy, in fact for the common people are detected highest consumptions and wastes of energy.

There are some specific devices utilized by EMS to achieve the results anticipate above:

-The SCADA system that has the aim to monitor, control and acquire information on large scale but not only, in fact it also includes alarm for faults of the network or historical data.

-Generation Dispatch and Control: GDC provides the functions required for dispatch and closed loop digital control of multiple generators in an economic fashion and at the same time considering interchange schedules, dynamic schedules (load or generation in an out of the area), inadvertent interchange payback, time error correction, reserve requirements and security constraints of the transmission network.

-Energy Scheduling and Accounting that covers the role to provide with information about production costs, exchange planning and future demand depending on forecasts of the weather.

-The Transmission Security Management takes up to detect faults of the network to manage the transmission in the best way[14][15].

1.3.2. Internet of things

Before starting with the explanation of the Communication Infrastructure, I would like to expose the concept of “Internet of things” because it is at the base of the CI implemented in the Smart Grid System, a new vision on the communication field and consequentially is one of the factors that make the SM such revolutionary as it is.

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[14]MHT Lighting WebSite, 2014

[15] Imagination at Work, 2011

IOT operation is collocated in the society system, it alludes to a communication network where interacts any kind of device susceptible to installation of a mechanism that allow to access to internet. Due to the capability to switch on and off the access to internet, may be connected anything you can think of included people.

[16]The new rule for the future is going to be, "Anything that can be connected, will be connected." But why on earth would you want so many connected devices talking to each other? There are many examples for what this might look like or what the potential value might be. What if for example you've just woke up and you don't have the time to make a coffee but thanks to the wireless connection your clock had synchronized alarm with the coffee maker that will let you find ready an hot coffee when you wake up.

The reality is that the IoT opens the door to a wide range of opportunities, many of which we can't even think of or fully understand the impact on common life. It's obvious the actuality of the topic, it certainly opens the door to a lot of opportunities but also to many challenges. In fact privacy is a big issue that has to be faced, starting from security of the simplest information of common citizens till the more complex that regard world of business, is necessary find the way to make sure the information flux thus will be possible share it with selected actors. Moreover many companies are going to be faced with is around the massive amounts of data that all of these devices are going to produce, so they need to figure out a way to store, track, analyze and make sense of the vast amounts of data that will be generated.

On a broader scale, the IoT can be applied to things like transportation networks: "smart cities" which can help us reduce waste and improve efficiency for things such as energy use; this helping us understand and improve how we work and live.

Discussions about the IoT have been taking place all over the world as we seek to understand how this will impact our lives. We are also trying to understand what the many opportunities and challenges are going to be as more and more devices start to join the IoT. For now the best thing that we can do is educate ourselves about what the IoT is and the potential impacts that can be seen on how we work and live.

[16] Jacob Morgan, 2014

1.4. COMMUNICATION INFRASTRUCTURE

The technology represents the core element in the construction and implementation of a smart grid, in fact the innovative systems that characterize the grid and confer it the flexibility, the dynamism and the certainty that does not find a feedback only in the stability and continuity of the system but also in the decisions taken by consumers that being informed on their own consumptions and the needs of the market, are able to organize energy usage. The programming of consumption is in fact a key aspect because it redefines the role of consumers from passive to active; moreover with the integration of renewable energy sources are still more responsible for the correct operation of the electric system. All this is possible thanks to tools highly technological that constantly monitor the system, the flows of energy production and consumption and communicate in real time the information obtained.[17][18].

1.4.1. Wide area networks

They represent the fulcrum of the communicative network with regard to the connection between the networks extended in each specific zone to provide power to the places which require it. If the secondary station or consumers are quite distant from each other then it uses as an intermediary a control center located usually halfway to which the WAN communicate the necessary instructions used then also from EMS . To optimize the operation of the WAN using regional actors of transmission which use in real time of the PMUs are positioned along the substations, which provide detailed information on the status of the network due to a sampling procedure on the vectors up to a speed of 60Hz. A further task of the WAN is to integrate the local information, from intelligent electronic devices, installed in the transmission network, in order to transmit to it then to the control center. So that everything can happen is required a broadband network to support receiving high-speed of the PMUs.[19].

1.4.2. Field area networks

They have the aim to guarantee the correct operation of the distribution system. The IED, the electrical sensor anticipated above, receives information and orders by the Distribution Management System, the

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[17] B.E. Bilgin ⥣, V.C. Gungor 2012

[18] Wenye Wang, Yi Xu, Mohit Khanna, 2017

[19] Wenye Wang, Yi Xu, Mohit Khanna, 2017

charging stations of electric vehicles and the Distributed Energy Resource. The transmission system exploits the FAN for data sharing and interchanging.

Moreover associated to FAN is possible to recognize two categories based on facilities who takes advantages from the application of them. The first one composed by OMS(Outage Management System), SCADA applications, DER monitoring and control for industrial users for example while the second one composed by AMI, DR(Demand Response), LMS(Load Management System), MDMS(Metering Data Management System) especially addressed to individual end-users. Field based applications on the other hand are more time sensitive in nature. Hence the utilities have a choice in adopting either communication networks dedicated to each class of applications or a single shared communication network for both classes. The utilities may choose if to select one class or to shared field area network with both for example diminishing development costs[20].

1.4.3. Home area networks

To make possible the operability of some smart devices such as AMI or Demand response, customers need of Home area networks. The ESI(Energy Services Interface) consists in a bidirectional communication that connects customers with the facilities, for example it provide them with information about special events and prices. The ESI may be linked both with hardwired and home area network, to a smart meter able to send information detected and communication to the facilities. The Energy service interface also receives Real Time Pricing from the facilities and communicates it to the clients. The customers may use a digital interface linked to it or a web-based customer EMS to manage their consumptions. Utilities and ESI provide utility with the ability to apply its load-control schedule by entering on the control-enabled devices at the customer site.

The DR works thanks to the joint action of Home area networks , AMI and ESI; thus is possible its application through four steps:

“-DR through AMI gateway that usually is used for automatic billing through AMR, can be used to send load control commands to the smart devices using the ESI and allowing that the load control algorithm could reside with it.

[20] Wenye Wang, Yi Xu, Mohit Khanna, 2017

-DLC, that thanks to the utility or an authorized energy service provider may directly control the smart appliances or DERs configured with such capability. The energy service provider may act as an aggregator of individual customers, negotiate RTP prices with the utility companies, and determine the demand response policy for the registered customers.

-BAS, that uses the RTP information available on the public channel of the ESI. A BAS has load controllers linked to security installations and building HVAC systems through wireline (e.g., ethernet) or wireless (e.g., ZigBee) communication medium and can exercise demand response.

-Embedded control. In this case, the smart device not only has a communication link to the home area network, but also its own load control algorithm. The smart device receives RTP information from the public ESI interface and exercises demand response."[21]

1.4.4. Supporting network technologies

With regard to the theme of communications, it represents a fundamental aspect in the context of transmission, distribution and networks of the clients, in fact there are several devices adoptable, but need to carefully choose which apply definitively because each one is more performant in specific circumstances and then addressed to a specific segment of the process. At this point it becomes relevant analysis used to understand what could be the best tool for each group of power and for each feeding system in relation to the properties they enjoy. The most important facilities are:

-Communication through power line: networks of power transmission can also be used to transmit information through modular signals, where the processor is not able to do so. Is rarely used in environments out-door since the main advantage that offers is that of a communicative network efficient, i.e. broadband, without having built a ad hoc. To remember that the work of the supply lines would otherwise be limited to each span which connects two transformers, to a transmission speed equal to 100/200 bits per sec.

- Communication through wires: If you do not want to use the transmission network also for the communications is possible to build an ad hoc network which offers the advantage of a greater power/speed and the disadvantage of requiring obviously further investments. Follow the four most valid solutions to the intention announced. 1- SONET/SDH which through optical fibers provides a

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[21] Wenye Wang, Yi Xu, Mohit Khanna, 2017

power of :155 Mbps-160Gbps; 2- Ethernet suitable for homes and offices: 1 Mbps-10Gbps; 3- DSL and coaxial cable to exploit the internet network: up to 10Mbps.

- Communication without wires: With the advent of technology has been made possible the transmission of data without wires, obviously for the moment it is still subject to limitations of various kinds (few data and short distances) but undoubtedly represents the instrument of communication of the future. There are three standards and the related transmission capacity: 1-802.11: 150 Mbps for max 250 meters; 2- 802.15 (ZigBee networks): 20kbps/55kbps for a maximum of 10 meters; 3- 802.16: 100 Mbps for a maximum distance of 50 km. The instruments of communication as already anticipate they need different support for this reason it is possible to install different in different areas so as to allow all the players to be able to communicate with each other without being connected with the wires. Wireless communication represents one of the most important tools for an efficient application of the Smart Grid, in fact many of the instruments by which it is made use of communication networks without wires thus increasing the speed and the radius of action[22].

1.4.5. ZigBee

In the footsteps of the standard 802.15.4 was created the ZigBee Smart Energy, i.e. a platforms that allows multiple electrical instruments to communicate between them at low cost and low power consumption. The transmitted data may be of different genre, the communications system errors to data related to the energy consumption. The profile ZigBee Smart Energy may take various forms, for example, ESP (Energy Services portal) or PCT (Programmable communicating thermostat). Its main features are:

-Consumers are able to know the instantaneous consumption and the historical series of those that have passed.

-Consumers are able to know in real time the price of energy on the basis of the current state of balance between supply and demand.

-On the basis of the demand and the supply side of energy the intelligent tools as the Smart Info or Smart Gathering are able to program the consumption of electrical appliances and therefore their operation.

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[22] Wenye Wang, Yi Xu, Mohit Khanna, 2017

The main disadvantages that concern the ZigBee profile are:

-Low speed of data transmission.

-Risk of overlap of its signal with that of other electrical appliances such as radio or the oven.

For all these reasons it is recommended to adopt this wireless communication system only in certain circumstances so as to avoid poor results caused for example by interference.

The ZigBee profile consists in four main layers:

"The application (APL) layer, the network (NWK) layer, the medium access control (MAC) layer, and the physical (PHY) layer. While the NWK and APL layers of the ZigBee protocol are defined by the ZigBee specification, the PHY and MAC layers are defined by the IEEE 802.15.4 standard. The functionalities of network layer include maintenance, providing and organizing routing over a multi-hop network, route discovery. There are three different devices supported by ZigBee, which are ZigBee Routers (ZR) responsible to perform the routing packet of IEEE 802.15.4, ZigBee Coordinator (ZC) that has the aim to integrate all utilities in the system and ZigBee End Devices (ZED) that are simple devices. A framework for communication and applications in the network are provided by the application layer. ZigBee Cluster Library (ZCL) provides functionalities to cluster, such as to turn on/off a device to on/off clusters. The functionalities in the ZCL are sensing, HVAC, lighting, security, and safety."[23]

As has already been explained the wireless connection has revolutionised the traditional network transforming it into intelligent, thanks to this new system it is possible to detect in real time information concerning the amount of electricity transmitted, his power, temperature, so as to be able to continuously update the central system of the status of the networks and not only. To obtain the full awareness of the status is required a highly decentralized so as to be able to detect and communicate to the system any problems wherever it is come to form.

One proceeds with some practical examples of the advantages achieved by the installation of these innovative systems:

-Renewable energy

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[23] B.E. Bilgin ⥣, V.C. Gungor, 2012

Reliability is not one of the main feature associated to renewable energy, in fact their efficiency depend on many factors that common people difficulty may detect. Thanks to Wireless Multimedia Sensor and Actor Networks (WMSANs) integrated with the Smart Grid is possible to forecast the weather and thus understand profitability of photovoltaic panels and eolic pales also detecting specific characteristics such as humidity or pressure.

-The temperature of the conductors

To guarantee power transmission efficiency is fundamental to monitor the temperature of the cables because it affects directly the quantity and the quality of the energy transmitted. The system wireless based present in the Smart Grid have the aim also to monitor continually the thermal condition of the cables and communicate summaries to the central system to decide how to solve the problems.

-The cable system below the surface of the ground

In terminations and joints happens that the system crashes, thus there are devices such as inductive sensors and coaxial cable sensors with the aim to lead diagnostic test to understand the entities of the problems, communicate them to the central system and if possible solve them remotely.

-Faults inherent to the environment

In the current grid, occurs that animals or natural entities such as tree have damaged the power line thus energy transmission efficiency has been limited and have provoked costs of different types. WSN-based Wireless Automatic Meter Reading (WAMR) systems, may guarantee huge savings correcting remotely the problems, avoiding blackouts, reducing human intervention and cables damages. Also have to be avoided energy frauds as illegal connections, thefts and other problems such as blackouts, in fact they are caused by the lack of an efficient connection and monitoring. The requirement of two-way communications in Wireless Automatic Meter Reading systems can be complied by the WSNs by providing low-cost and low power communications[24].

1.4.6. WASA

The System Wide Area Situational Awareness performs the task of collection of data concerning the status of the electric system, the transmission lines and the electrical cabins. Thanks to these data it is

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[24] B.E. Bilgin ⇑, V.C. Gungor, 2012

possible to implement other instruments connected to it as the Wide Area Monitoring System (WAMS) for monitoring , Wide Area Control System (WACS) for the control and the Wide Area Protection System (WAPS) for protection. By exploiting this network of systems, consumers of large or small entity, can foresee and prevent interruption of current so as to prevent huge losses. One of the distinctive features of these systems is the dynamic islanding, which allows the isolation of outages, thus avoiding blackout and providing automatic reparation of the system.

Given the importance of Wide Area Monitoring Systems get ahead with a brief focus on it[25].

1.4.6.1. WAMS

“The Institute of Electrical and Electronics Engineers (IEEE) has defined WAMS as a collective technology that monitors power system dynamics in real time, identifies system liability related weakness, helps to design and implement counter measures.

The system as each other device in the SMS depends on its environment, in this case the main components are:

-Phasor Measurement Unit (PMU) that is the most important

-Phasor Data Concentrator (PDC)

-Global Positioning System (GPS for TimeSynchronization of the phasors)

-Communication channel (Preferably optical fiber cable)

-Visualization and analysis tools

-Wide area situational awareness system.

-Wide area protection and control

Focus on PMU:

The Phasor Measurement Unit (PMU) is a Power System device capable of measuring the synchronized voltage, current Phasor in a Power System and other power system related quantities like

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[25] Wenye Wang, Yi Xu, Mohit Khanna, 2017

frequency. Synchronicity among his Units is achieved by same-time sampling of voltage and current waveforms using a common synchronizing signal from the global positioning satellite (GPS), due to this capability is one of the most valuable measuring devices."[26]

1.4.7. AMI

The Advanced Metering Infrastructure system is at the base of the bidirectional communication that allow to the actors of the entire system to interact with the Smart Grid devices such as Smart Meters. Utilization of AMI enable customers to manage their consumptions and to lead other actions placeable in the category called Demand Response. Moreover AMI allow the automatic data gathering provided by end-users; this work is addressed to the Automatic Meter Reading (AMR). Furthermore it also used by customers to require a remote reintegration or assistance.[27]

1.4.8. DR

In the electric sector the demand response system is revolutionary, in fact it provides customers with the opportunity to schedule their energy consumptions shifting it during the day to avoid peak power conditions. The DER system integrated with the DR enable clients to become vendors; as there is a derangement in the energy market, customers may help current supply if they have devices that furnish electricity. For example an end-user that has photovoltaic panels and one day they produce more energy that he needs to, he may sell it to the market getting easy incomes; while if he has a lack of energy because is a cloudy day the system automatically furnishes him energy that he needs. Considering the capability to shift consumptions is possible regulate easier energy distribution, in fact exploiting the system of Real Time Pricing consumers prefer delate the use of electric devices reducing their bills and the demand of energy. This will minimize the probability of an energy congestion or a blackout that currently provoke to the society huge economic losses.

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[26] Vaishali Rampurkar , 2016

[27] Wenye Wang, Yi Xu, Mohit Khanna, 2017

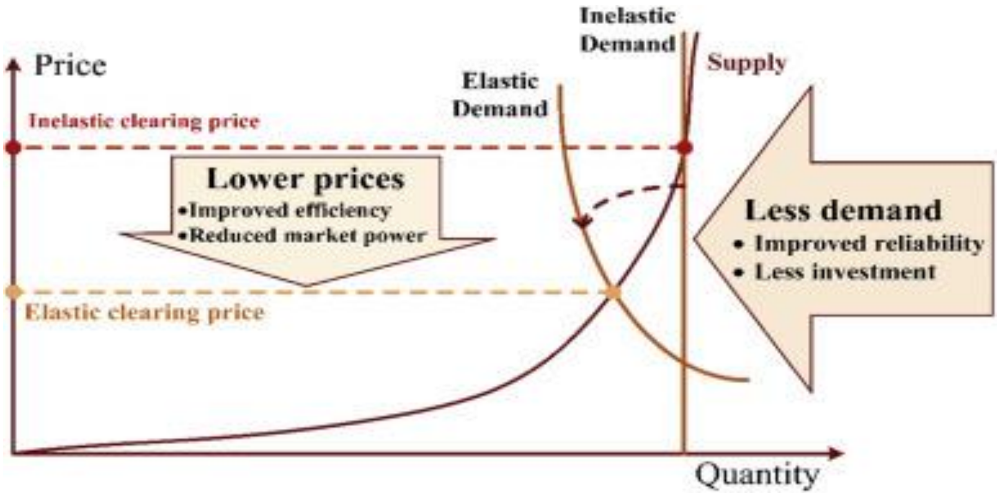

Figure 5 Demand and Supply in a SG System[28]

In the figure n.5 is possible to observe that thanks to SM devices, the Market is able to shift equilibrium point according to the needs of producers and customers. Demand Response Management can actually manage the energy requests of the supply and the demand, by reducing the gap the two sides. Of course, theoretically this system seems simple to be implemented but it isn't for many reasons.

1-Lack of an efficient infrastructure system able to comply the requests of DSM.

2-Often different actors use different communication devices depending on the protocol adopted, for this reason sometime may be difficult the efficient data transmission.

-Exists a serious privacy problem associated to the circulation of detailed data because sometime is difficult for example to avoid informatics attacks and thus the information are not subjected to a guaranteed protection.

-The network must be able to adapt continually the configuration of different consumers to the chaning conditions so that issue or latency are avoided.

-For a more efficient DSM is relevance the behavior of the customers, in fact is important that all of them have understood the functionalities of a Smart Grid to act, enabling the smart devices to optimize their operations and results[29][30].

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[28] Omar Ellabban, Haitham Abu-Rub, 2016

[29] Wenye Wang, Yi Xu, Mohit Khanna, 2017

1.5. STANDARDIZATION ACTIVITIES

Exists a great number of protocols that have been promulgated to give a track for the construction of the structure of the electric power system. These standards cover a huge number of specific aspects generally technical features, for example inherent to the automation of energy management or the requirements of the networks. Follow the principal protocols in the communication field[31].

1.5.1. DNP

"It first appeared in 1998 and after a number of revisions has become Distributed Network Protocol 3, the current version. This standard prescribes the protocols used for substation monitoring and control automation through local or wide area networks. It is used to implement the SCADA control system in a substation. Electric devices compatible with the DNP3 communication protocols can exchange status and control information to automate substation management. Moreover it employs the Internet protocol suite to transport packets. Accordingly, it assumes a layered architecture and all the DNP3 defined packets are encapsulated into TCP or UDP packets during the transmission. Security mechanisms are provided in the forms of virtual private network (VPN) and IPsec, which are functions of the Internet protocol suite. DNP3 is currently used in substations for equipment monitoring and control. It implements the basic functions of an automated system to communicate equipment states to the control station and deliver configuration commands to the electric equipment. However, DNP3 cannot be applied in the SMS because the communication quality in is not strictly guaranteed, communication delays are not defined and delay requirements are not specified."[32]

1.5.2. IEEE standards

IEEE has proposed a huge number of protocols inherent to the communications in the electric system, including: C37.1; IEEE 1379; IEEE 1547; IEEE 1646 and IEEE 802.15.4. Follow also an explanation of the IEC standards.

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[30] Omar Ellabban, Haitham Abu-Rub, 2016

[31] Wenye Wang, Yi Xu, Mohit Khanna, 2017

[32] Wenye Wang, Yi Xu, Mohit Khanna, 2017

-"IEEE C37.1: It describes the functional requirements of IEEE on SCADA and automation systems. This standard provides the basis for the definition, specification, performance analysis and application of SCADA and automation systems in electric substations. It defines the system architectures and functions in a substation including protocol selections, human machine interfaces and implementation issues. It also specifies the network performance requirements on reliability, maintainability, availability, security, expandability and changeability."[33]

-"IEEE 1379: It recommends implementation guidelines and practices for communications and interoperations of IEDs and RTUs in an electric substation. It provides examples of communication support in substations by using existing protocols. Specifically, it describes the communication protocol stack mapping of the substation network to DNP3 and IEC 60870-5."[34]

-"IEEE 1547: It defines and specifies the electric power system that interconnects distributed resources, thus it offers a huge range of tests to guarantee an implemented system to work as expected. It consists of three parts: the electric power system, the information exchange and the compliance test. The first one alludes to the requirements on different power conversion technologies and the requirements on their interconnection to provide quality electricity services, particularly to ensure power quality, respond to power system abnormal conditions and form subsystem islands. The information exchange part specifies the requirements on power system monitoring and control through data networks, especially interoperability, performance and extensibility. The conformance test part establishes the procedures to verify the compliance of an interconnection system to the standard."[35]

-"IEEE 1646: It specifies the requirements on communication delivery times within and external to an electric substation. Given the diversity of communication types, the standard classifies substation communications into different categories and defines the communication delay requirement for each category. Moreover, it defines the communication delay as the time spent in the network between the applications running at the two end systems. Therefore, the packet processing time should also be considered into the delay such that the combination of processing and transmission times does not exceed the required delay bound. Since delays are introduced in both the end system processing phase

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[33] Wenye Wang, Yi Xu, Mohit Khanna, 2017

[34] Wenye Wang, Yi Xu, Mohit Khanna, 2017

[35] Wenye Wang, Yi Xu, Mohit Khanna, 2017

and the network transmission phase, the standard discusses further on the system and communication capabilities required to deliver information on time."[36]

-"IEC standards: The International Electrotechnical Commission (IEC) has proposed a number of standards on the communication and control of electric power systems. The standard 60870 contains six parts and it defines the communication systems used for power system control to guarantee interoperability and high performance. The standard 61850, focused on the substation automated control, defines comprehensive system management functions and communication requirements. The management perspectives include the system availability, reliability, maintainability, security, integrity and general environmental conditions. The standards 61968 and 61970 provide common information model for data exchange between devices and networks in the power distribution domain and the power transmission domain respectively. Cyber security of the IEC protocols is addressed in the standard 62351 , which specifies the requirements to achieve different security objectives including data authentication, data confidentiality, access control and intrusion detection."[37]

-"IEEE 802.15.4 standard: It is a low in cost, power consumption, and data rate wireless communications standard for Low Rate Wireless Personal Area Networks (LR-WPANs). The standard is based on PHY and MAC layers. The former main tasks include channel frequency selection, transceiver activation and deactivation, energy detection, clear channel assessment, link quality indication, data transmission and reception. The latter primarily offers two operational modes, beacon-enabled, where in each Beacon Interval (BI) a beacon is transmitted by the PAN coordinator to synchronize devices and non-beacon-enabled modes, where an unslotted CSMA-CA channel access mechanism is used to transmit data packets. The IEEE 802.15.4-based devices can utilize one of three frequency bands for operation. The first one is 868 MHz band with 20 kbps in Europe. The second one is 914 MHz band with 40 kbps in the USA. The last one is 2.4 GHz band with 250 kbps in the worldwide. There are 27 channels in IEEE 802.15.4, 1 of them is in 868 MHz band, 10 of them is in 915 MHz band and 16 of them in 2.4 GHz band. 64-bit IEEE address or a 16-bit short address is used in all devices in IEEE 802.15.4 network. There can be 65,536 devices at maximum in the IEEE

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[36] Wenye Wang, Yi Xu, Mohit Khanna, 2017

[37] Wenye Wang, Yi Xu, Mohit Khanna, 2017

802.15.4 network . Moreover, the IEEE 802.15.4 standard has two types of devices, Full Function Devices (FFDs) and Reduced Function Devices (RFDs)."[38]

1.6. MASSIVENESS GENERATION

Most of the energy produced is integrated and conveyed in the system through multiple connections, in fact thanks to wireless networks enters in contact with the market and then with the local domains thanks to WAN. One of its peculiarity is to be able to integrate each energy source and then also these renewable, then channel them in networks according to the needs of the system, this means that if there is a surplus, the excess is collected in the accumulators to then be used when the requires the market. For its correct operation employs tools highly technological and specific licenses as one RTU so that it is always aware of the current situation of the network.[39].

1.7. THE TRANSMISSION

The electrical network, both primary and secondary has the task of transmitting to the distributive nodes the electricity produced. To absolve this job are usually the operator of regional transmission (RTO) in particular as regards the balance in the market regional electrical and the independent operator for the transmission (ISO). For an efficient management even in these case are required large amounts of information that are transferred just obtained from and among the various components of the Smart Grid.[40].

1.7.1. High Voltage Direct Current Classic

HDDC Classic is an innovative technology resulted by a thyristor or silicon controlled rectifier approach and furnishes electricity equal to six gigawatts (GW) at a voltage level of ±600 kV until 10 GW at ±800 kV. Follow the main advantages offered:

-High efficiency in the transmission over long distances without economic wastes.

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[38] B.E. Bilgin ⇑, V.C. Gungor, 2012

[39] Wenye Wang, Yi Xu, Mohit Khanna, 2017

[40] Wenye Wang, Yi Xu, Mohit Khanna, 2017

-It succeed in enabling the interaction among devices with different frequencies.

-A bidirectional monitoring of the energy offered.

-A continuous research of perfection related to the attempt to avoid blackouts in Alternative Current grids.

The growing demand of energy requires a day after day more efficient system of transmission and so as always a bigger capacity of transport.

Exists also an Alternating Current(AC) system much younger of the DC one, that is used in case ofdo easy voltage conversion. The difference between AC and DC system has to be explained because it is covered by a huge shadow sphere related to the different circumstances where are applied[41].

1.7.2. Which is the best solution between the Alternating Current and the Direct Current system

Advantages offered by a Direct Current system:

-It is characterized by a simple mechanism easy to be understood by anyone.

-Adapted for High Voltage Direct Current transmission, in fact one of the requirements of Fewer t-line is to transmit DC power.

-It can enable the interaction among AC systems with different frequencies.

-Is possible to transmit power through the water due to a Direct Current system.

Bad consequences of the application of a Direct Current System:

-It isn't adapted for the distribution of energy.

-Is possible to use HVDC system only with a station that convert it due to an Alternative Current system. This relationship means that higher power transmission is balanced with higher expenditures for the conversions.

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[41] Siemens Website, 2017

Alternative Current Systems

"AC systems are mostly designed as three phase systems and thanks to it is possible deliver more power than a two or one phase system but supporting higher infrastructure costs. Without reactive power support to long transmission lines (from the generators, capacitor banks, etc.) there will be a significant voltage drop at the end of the lines with the risk to damage equipment. For example in USA ,AC currents oscillate 60 times a second and this is in the electrical domain. In the mechanical domain, this equates to 1800 rpm for a 4-pole generator. If more than one 4-pole generator is connected to the power grid then all these generators must "swing" at 1800 rpm to produce AC power at 60Hz. Failure to do so will cause the generators to trip and shutdown leading to a system blackout."[42]

Advantages of an Alternative Current System

-Due to the presence of transformers Alternative Current system is able to transmit power over long distances.

-Unlike Direct Current the Alternative one is characterize by a simple structure, in fact it no needs the installation of a commutator or a brush.

Bad consequences of the application of an Alternative Current System

-It is not independent from voltage fluctuations.

-It isn't a simple system.

-There is the risk of a system crash if the devices run with different frequencies, moreover AC system has to fight with the savage nature of transmission line, for example against resistances.

The Smart Grid may use both the systems in fact each one is best suitable in different circumstances, for example the Direct Current is better for the movement of the largeness power at high voltage while the Alternative one is better to transfer power from users and generators faraway[43].

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[42] Aleen Mohammed, MSEE, Professional Engineer, 2011

[43] Aleen Mohammed, MSEE, Professional Engineer, 2011

1.8. THE DISTRIBUTION

Starting from the offer the distribution system tries to match every demands with the amount of energy required, so that it can take place it uses the information supplied by the grid and then by the sensing devices and control of consumptions. An efficient distribution must be supported by an equally efficient communication mechanism that may be wireless or wire-based.[44][45].

1.9. THE OPERATION

The operation domain has the aim to optimize steps of transmission and distribution utilizing an energy management system for the first and a distribution management system for the second one. Due to the SCADA is possible to implement data acquired to avoid any kind of issue. The operation exploits various devices to manage transmission and distribution, moreover to simplify the process it subdivides them in smaller domains.

Given the importance follows below a summary of Operation's aims:

-Manages and controls the electricity flow of all other domains in the smart grid.

-The use of bidirectional communications net to connect consumers and other technologies to the substations.

-It undertakes control and decision making process.

-It also conveys information in an individual brain to make the best decisions. [46][47].

1.10. THE MARKET

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[44] Vaishali Rampurkar , 2016

[45] B.E. Bilgin ⇑, V.C. Gungor, 2012

[46] Vaishali Rampurkar , 2016

[47] B.E. Bilgin ⇑, V.C. Gungor, 2012

For balancing the supply and the demand there is the market that play a fundamental role, in fact coordinating both of them it succeeds to guarantee to everyone energy needed, to avoid wastes and allow energy accumulation. [48][49].

1.11. THE CUSTOMER

With regard to consumer is now clear the magnitude of his role, in fact for the correct operation of the smart grid is necessary that his role has been constantly active. With active role does not allude only to the production of renewable energy through for example solar panels, but above all it is meant his participation with regard to the transmission of the information required by the system. Only with complete information it is possible to efficiently regulate the flow of energy, should be missing a piece to the puzzle, the system and for the precision the tools that compose it, would no longer be able to perform precise calculations, then to obtain significant and truthful results.[50][51].

1.12. THE SERVICE PROVIDER

The Service provider is who provides consumers with electricity, it has also the aim to deliver the bill, manage the supply of energy, control consumptions and detect faults.[52] [53].

Concluding, now have been furnished the necessary knowledge to understand how Smart Grid's mechanism operates, thus it's time to analyze particularly the key role played by electrics vehicles, in fact as anticipated they allow accumulation of energy and its transmission to and from the system depending on the needs.

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[48] Vaishali Rampurkar , 2016

[49] B.E. Bilgin ⇑, V.C. Gungor, 2012

[50] Vaishali Rampurkar , 2016

[51] B.E. Bilgin ⇑, V.C. Gungor, 2012

[52] Vaishali Rampurkar , 2016

[53] B.E. Bilgin ⇑, V.C. Gungor, 2012

2. Electric Vehicles System

Smart grids play a significant role for the sustainable use of energy in smart cities. It is necessary to develop new technologies and tools for energy management in which different components should be integrated: renewable resources, distributed generation, storage systems, active loads, and plug-in electric vehicles. In this chapter, attention is focused on the integration of electric vehicles (EVs) in smart grids and, specifically, on EVs and their active contribution to overall grid optimization adopting power modulation and setting V2G mode. Finally will be examined notable V2G projects[54].

2.1. EVS INTEGRATION INTO ELECTRIC GRID

The electrification of transportation sector appears to be one of the feasible solutions to the challenges such as global climate change, energy security and geopolitical concerns on the availability of fossil fuels. The EVs are potential on serving the electric grid as independent distributed energy source. It has been revealed by some studies that most vehicles are parked almost 95% of their time. In this case, they can remain connected to grid and be ready to deliver the energy stored in their batteries under the concept of vehicle to grid (V2G).

Besides, the integration of large renewable energy sources (RES) like wind and photovoltaic (PV) solar energies into the power system has grown up recently. These RES are intermittent in nature and their forecast is quite unpredictable. The penetration of the RES into the power market is enormously increased to meet the stringent energy policies and energy security issues.

This huge penetration of the RES into power system will require large energy storage systems (ESS) to smoothly support electric grids so that the electrical power demand and operating standards are met at all the times. In this case, the EV fleets are the possible candidate to play a major role as the dynamic energy storage systems using the V2G context.

[54] F. Laureri, L. Puliga, M. Robba, F. Delfino, G. Odena Bultò, 2016

Electric vehicles can provide ancillary services to the grid such as voltage and frequency regulation, peak power leveraging and reactive power support to enhance the operational efficiency, secure the electric grid and reduce power system operating cost. Of course, the deployment of the EVs into the smart grid system would be possible with the advanced communication, control and metering technologies.

2.2. VEHICLE TO GRID (V2G) TECHNOLOGY

2.2.1. Development of V2G

Kempton and his colleagues developed the concept of V2G, controls for EVs and charging stations and the Grid Integrated Vehicle platform at the University of Delaware, beginning in 1997, and hold four patents in relation to it through UD's Office of Economic Innovation and Partnerships[55].

The original UD research team, which includes Fouad Kiamilev, professor of electrical and computer engineering (ECE) and a co-principal investigator on the project, Rodney McGee, also in ECE and lead electrical engineer on the project, and many others, has continued to conduct research and develop V2G technologies, making a practical production system.

Partnership has been a keystone in the V2G technology's development and advancement, and has led to collaborations with commercial partners in the automotive, electronics and energy industries.

To further develop the V2G platform and assess its technical and business potential, OEIP worked closely with UD's Office of General Counsel to help form a partnership with NRG (now operating as EVGo), one of the nation's largest power generation and retail electricity businesses. NRG licensed the UD technology in the United States. Nuvve, a startup company, subsequently licensed the V2G platform for use in Europe.

V2G enables vehicles not only to run on electricity alone but also to generate revenue for their owners by storing electricity and selling it back to utility companies. V2G, lets electricity flow from the car's battery to power lines and back.

[55] University of Delaware, 2011-2016

The concept has been a longtime labor of love for Willett Kempton, associate professor of marine policy, who began developing the technology more than a decade ago.

“When I get home, I’ll charge up the car’s batteries and then switch into V2G mode,” says Kempton, who routinely drives the vehicle around campus and beyond.

The researchers bought the converted Scion from California-based AC Propulsion. Under the hood, components include a three-phase alternating current motor in a composite-materials housing, a 400-volt battery and high-current power electronics. Additional batteries are located in the space once filled by a now-unnecessary gas tank. The motor’s temperature, which can reach 70 degrees Celsius, is monitored from the dashboard, and the batteries are cooled by fans or the car’s standard air-conditioning system.

“In a sense, the batteries work like a sponge,” says Ajay Prasad, professor of mechanical engineering and a member of the research team. “They store up power to run the car, and when they have excess power, it’s fed back to the electric power grid.”

When the car is in the V2G setting, the battery’s charge goes up or down depending on the needs of the grid operator, which sometimes must store surplus power and other times requires extra power to respond to surges in customer use. The ability of the V2G car’s battery to act like a sponge provides a solution for utilities, which pay millions to generating stations that help balance the grid, Kempton says. He estimates that the value for utilities could be up to $4,000 a year for the service, part of which could be paid to drivers.

The technology will work on a large scale, Kempton says, because on average 95 percent of all cars are parked at any given time. One hour a day of car usage is the average in America.

“A car sitting there with a tank of gasoline in it, that’s useless,” he says. “If it’s a battery storing a lot of electricity and a big plug that allows moving power back and forth quickly, then it’s valuable.” “The bigger the plug, the more power you can move, the more revenue,” Kempton says. But the smaller plug is seen as an important option for the convenience of consumers, who sometimes may want to plug in the car at their workplaces, motels or other locations away from home.

Such considerations are part of the research being conducted by Gardner, who brings her expertise in marketing and consumer behavior to the project. Some of her students have surveyed drivers at the Delaware Division of Motor Vehicles to try to gauge support for the V2G concept.

“We need to know how much consumers would be willing to pay for this type of vehicle, for example,” she says. “And we want to know the features that are important to them. How much space for passengers do they need? How do they feel about the maximum range of 150 miles a day?”

In addition to individual drivers, Gardner is examining the needs of fleet owners. Corporations might be especially interested in the new technology, she says, because employees typically drive a company car a relatively short distance each day and park it back at the business overnight. Also, with a large number of cars selling excess electricity back to the power grid, a fleet owner could reap larger financial rewards.

2.2.2. How does the energy flow from the car to the grid and back?

Vehicle-to-grid (V2G) describes a system in which plug-in electric vehicles, such as electric cars (BEV) and plug-in hybrids (PHEV), communicate with the power grid to sell demand response services by either returning electricity to the grid or by throttling their charging rate.

Vehicle-to-grid can be used with gridable vehicles, that is, plug-in electric vehicles (BEV and PHEV), with grid capacity. Since at any given time 95 percent of cars are parked, the batteries in electric vehicles could be used to let electricity flow from the car to the electric distribution network and back.

With the introduction of millions of EVs and PHEVs, then it is possible to use their batteries as a storage element to provide network services. In fact they can be used as a source to support load peaks, such as a spinning reserve (stored storage energy) or as tools for regulating the energy produced. The two-way interaction between the vehicle and the network is called Vehicle to Grid (V2G) and is only possible in a Smart Grid system[56].

Once electric vehicles are connected to the network, they offer a great deal of potential for managing the balance of network power. The V2G scenario also brings benefits to the consumer: he can resell energy, enter into electricity contracts, or get incentives to buy an electric vehicle or replace batteries.

2.2.3. Economics implications

[56] Dinh Thai Hoang, Ping Wang, Dusit Niyato, Ekram Hossain, 2017

V2G's application also brings other benefits: in addition to the reduction in pollution and environmental protection, there will be economic benefits for both the operator and the vehicle owner. The energy stored in the batteries can be used to meet a part of the local energy demand, thus lowering the load profile peaks. This reduces the stress on the plants, reduces the energy present in the distribution system and therefore reduces losses. Lowering the peak therefore reduces the cost of electricity over the peak loads.

The price of battery-based electrical services is more competitive than the one based on generators and electric vehicles offer a much more flexible and controllable power system. This shows how the distribution network operator has economic benefits from using V2G. Energy is stored in batteries overnight, when electricity costs less, and is released over peak times when it has its maximum cost.

By leveraging the price difference, the owner of the vehicle has a gain through which he can amortize the initial investment for the purchase of the electric vehicle. Other economic benefits for the V2G vehicle owner reside in the possible stipulation of an electricity contract that may include discounts on the price of electricity or incentives to buy a new battery that loses efficiency and useful life as the number of charge/discharge cycles due to V2G operations, increase.

2.2.4. EV charging and smart grid interaction

Is possible to program the act of charging of a vehicle connecting it in different moments, due to it you can save money because it cost less during the night for example and you can use renewable energy as these that come from sun or wind. The Smart Grid is necessary for an efficient charging network and also to control the bill. Managing demand and supply providing customers with information that they need, is possible achieve enormous savings, avoid distribution overloading and more awareness of consumptions. Thanks to transformers , Smart Meter and other specific devices the result will be reached.

The new concept of smart charging need to be supported by a grid that ensures:

- Safe connection system to support and intervene on the charger EVSE House is fundamental, foremost for the remote support and can eliminate unnecessary calls service in loco. For example, if there is a problem with a device EVSE, a utility with a smart communication infrastructure can resolve remotely the device and advise customers on actions to be taken without making a visit at home. Utility programs have the ability to communicate with the EVSE beyond the network of quarter area (NAN) or home area networks (HAN).

-Through the mechanisms of Demand Side Management (DSM) it must be possible to optimize the management of the charge EV. For management does not allude only to use but also for the purchase and supply or distribution. Integrated management of communicative network and electric power will also allow to discriminate the supply of energy and the prices associated thereto, for example on the basis of the zone.[57].

- The fundamental element is the intelligence available to the intelligent grid, in fact through cutting-edge devices in the latter manages to optimize all the steps related to the electricity from generation to distribution and in the case considered, recharging of the vehicles. By connecting the communicative network with the distribution and transmission it is possible to understand for example when an accumulator is low and act accordingly, recharging this.

- Advanced Metering Infrastructure or AMI, this system already analyzed previously plays a primary role also in this case, in fact with the transmission of the data it is possible to manage the problems, the demand for energy and hence the quantity supplied not only in real time, also allows to make provision in such a way as to best manage not only the accumulator considered but also and especially the whole system.

- Always for an efficient energy management, i.e. its supply and demand management, are important management systems of the load it uses the demand response ; thanks to these it is possible to modify the energetic load acting on the thermostats and air-conditioners.

- An automated deployment allows not only a reliable management and elastic electricity but also the possibility to plan the future supply that affects not only the individual but the overall demand, for example going to expand its capacity of the network.

- Being able to know and even predict demand of energy and being even able to geo-locate its consumption, is considerably easier to integrate multiple sources of energy to the production network, in fact the renewable energy being not always reliable, without the use of these innovative instruments of calculation cannot be considered as single source.

[57] Silver Spring Networks, 2013

2.2.5. Renewable energy sources integration with EVs

As we mentioned before, the increase in penetration of renewable energy sources (RES) into the electric power system is quite appealing. The existing power grid suffers from unpredictable and intermittent supply of the electricity from these sources especially wind and PV solar energies. The electric power production from these RES can be very high (more than the power demand) or very low (less than the power demand) depending on the available energy sources, i.e. wind speed and sun radiation[58].

In short, these RES are variable with time, non-dispensable with limited control and have low capacity credit especially on the power system planning.

Most of the studies revealed that the integration of wind energy conversion systems (WECS) and PV solar systems into the electric power grid is pretty mature and practically viable.

[59]The EVs can absorb the surplus power generated by the RES through different charging schemes or can deliver power to the grid in the low power generation scenarios and level the grid operations through the V2G schemes. To this end, the EVs will be acting like energy buffer for the grid regulations and ancillary services. A possible solution to maintain energy security can be achieved by integrating the distributed RES (PV solar and wind in this study) and adopting EVs with capability to deliver the V2G services.

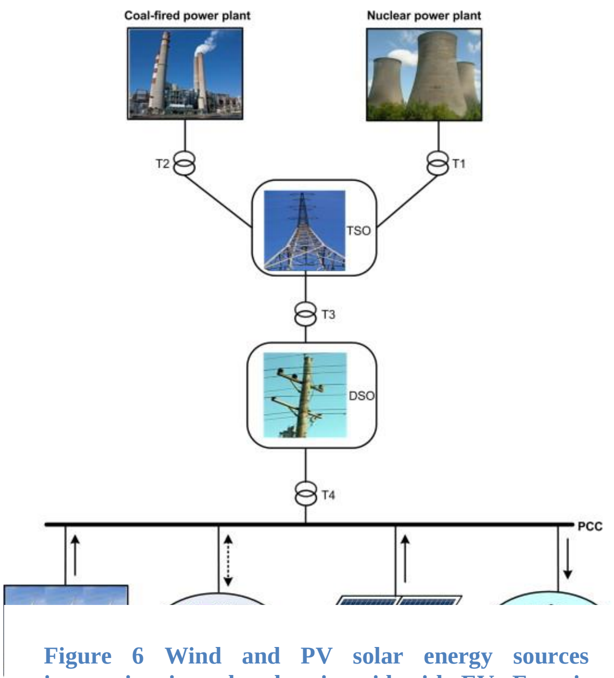

Figure 6 Wind and PV solar energy sources integration into the electric grid with EV, Francis Mwasilu, Jackson John Justo, Eun-Kyung Kim, Ton Duc Do, Jin-Woo Jung, 2013

Fig.6 illustrates the integration of wind and PV solar energy sources into the power grid with EVs. The electric vehicles are aggregated at the charging station located at public area or office and can be used to suppress power fluctuations from these RES in the V2G mode.

ıng Kim, Ton Duc Do, Jin-Woo Jung, 2013

ıng Kim, Ton Duc Do, Jin-Woo Jung, 2013

2.3. FEASIBILITY OF V2G SYSTEM AND NOTABLE PROJECTS

The interaction of electric vehicles with an electric grid is an attractive research area which has drawn attention to a number of people in the academia, industrial, public and private research institutes. Numerous smart grid and V2G technologies necessary to integrate electric vehicles into the smart grid in an efficient manner are yet under development stages. Research activities and pilot projects initiatives are already in place to escalate the V2G concept into reality.

2.3.1. University of Delaware no

There is a group of researchers at the US University of Delaware, led by Dr. Kempton, Advani and Prasad that is involved in researching V2G technology as well as its performance when used on the grid, in addition to the technical research, the team has worked with Dr. Meryl Gardner, a Marketing professor in the Alfred Lerner College of Business and Economic at the University of Delaware, to develop marketing strategies for both consumer and corporate fleet adoption, as we mentioned at chapter’s beginning.

The University of Delaware’s platform for integrating vehicle-to-grid (V2G) technology is now operating in Denmark, creating a new V2G hub outside the United States that is poised to expand widely with commercial products.

Ten electric cars and 10 V2G charging stations are now providing commercial V2Gservices in Frederiksberg, Denmark, according to Willett Kempton, professor in the School of Marine Science and Policy in UD’s College of Earth, Ocean, and Environment and research director of the University’s Center for Carbon-Free Power Integration.

The project is a collaborative effort between Nuvve, which is licensing UD-developed technology, Nissan, Enel, Danish Technical University, and the Danish grid operator, Energinet.dk.

“This is a low-cost way to provide electricity storage for the electric grid, making large-scale renewable energy more practical,” explained Kempton.

To deploy renewable energy at large scale, low-cost storage is needed. Instead of buying batteries just for this purpose, the vehicle-to-grid concept is to use batteries in electric vehicles when they are parked. It’s an idea much discussed and debated, but only now being implemented by multiple industrial companies.

The first deployment of this type was done by a joint venture between NRG and UD in the United States, which launched the world's first revenue-generating vehicle-to-grid project on UD's Science, Technology and Advanced Research (STAR) Campus in early 2013.

"Locally in Delaware, we provide storage used for the service of balancing power on the PJM grid, and they pay us at the end of each month for the amount of balancing power that we provided. We are now doing the same thing in Denmark, although the technical requirements and rules are somewhat different," said Kempton.

Partners:

Nissan is providing the cars for the Denmark effort, Enel is the maker and distributor of the V2G charging stations, and Frederiksberg Forsyning is the local fleet operator who purchased and is operating the cars. Nuvve, a startup company, licensed the V2G control and grid integration platform for use in Europe through UD's Office of Economic Innovation and Partnerships. Besides being the first in Europe, this development is significant because all of the participating companies are prepared to expand widely, with commercial products.

"This is not just an experiment or trial," said Kempton.

Kempton and colleagues have been working in Denmark for four years with Danish Technical University, as well as the Danish grid operator to prepare the technical and regulatory basis of the project. The initiative required that specialized charging stations be developed for use in Europe and included significant enhancements to ensure that the V2G technology integrates seamlessly with Denmark's electric power grid.

The electricity stored in the vehicles' batteries is controlled and aggregated by a centralized server. UD's Grid Integrated Vehicle computer software links multiple vehicles together, allowing them collectively to be viewed as a single "power plant." It's a complicated task that requires a lot of qualification and testing to local standards and regulations, provided by Nuvve, to officially identify, certify and register the aggregator and charging stations.

On the technology side, UD postdoctoral researcher Stijn Vandael adapted the GIV software so that it would interface properly with the Danish grid operator to ensure that the V2G-enabled vehicles qualify and correctly report what they are doing, so that their owners can be paid for the power service.

2.3.2. Technology

2.3.2.1. Full V2G Concept

The Vehicle System grid (V2G) allows the use of an electric vehicle and once parked in appropriate points of the city or in their garage, on the basis of the properties or less of the vehicle it is possible to charge its battery thanks to accumulators, alternatively if the latter discharge would happen to the contrary and if necessary, once transferred, the energy will be transferred through the network at the points where there is a shortage. This particular mechanism operates as already explained without any operator intervention, but thanks to sophisticated data transmission systems that send orders to the various managers of energy. In addition to make an example of the capacity of this system, the Smart Grid is able to accelerate or less the charging process based on the needs of the system. In a system that includes V2G-enabled electric vehicles, the power still begins at the generator and travels to the vehicle. Moreover, such vehicles can constitute a storage resource of comparable capacity to traditional generators.

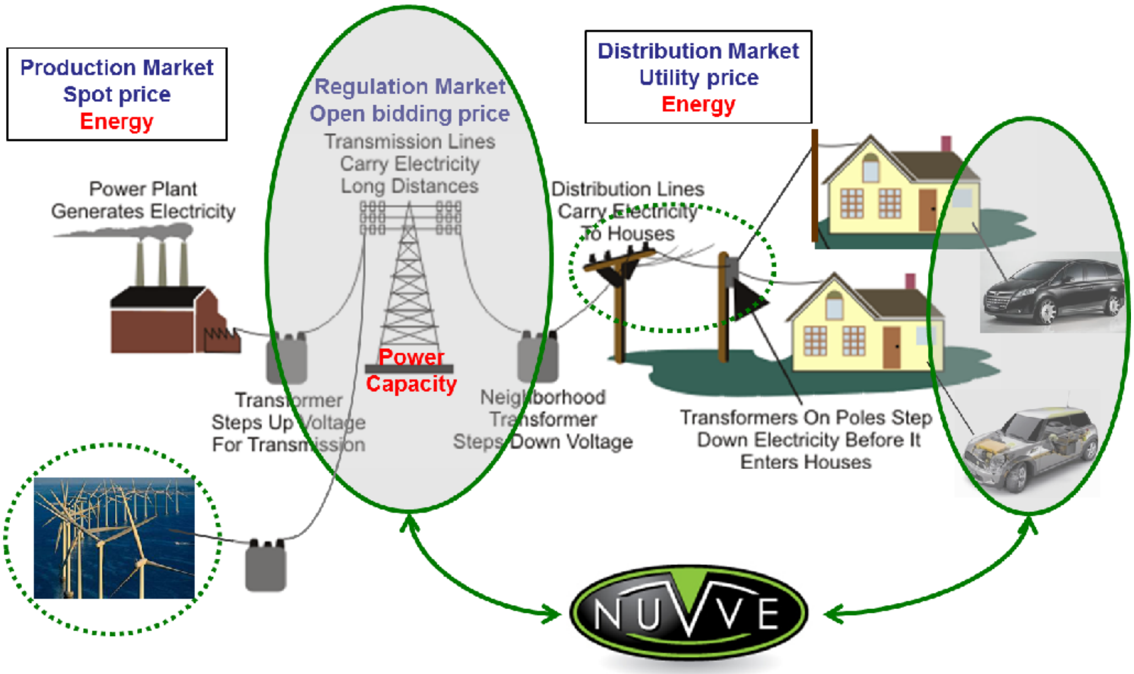

Figure 7 How EV system works[60]

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[60] http://nuvve.com/

2.3.2.2. How does it works?

“In some parts of the world, as in the U.S. the equilibrium between demand and offer of energy is guaranteed by huge generators which act on the basis of the fluctuation of both sides. Some vehicles are fitted with the system V2G and are under the supervision of the IRP server, which constantly monitors the status of deficit or surplus of energy in the various areas in order to adjust the flow and therefore the power. In addition to the owners of intelligent machines this innovative technique of management is also a source of revenue and thus not only an advantage in terms of convenience and efficiency. On the basis of short-term testing by the Danish grid operator in July 2016, Poilasne estimates that on an annual basis of revenues for car would be approximately $1,445 (Euro 1,300) per year."[61]

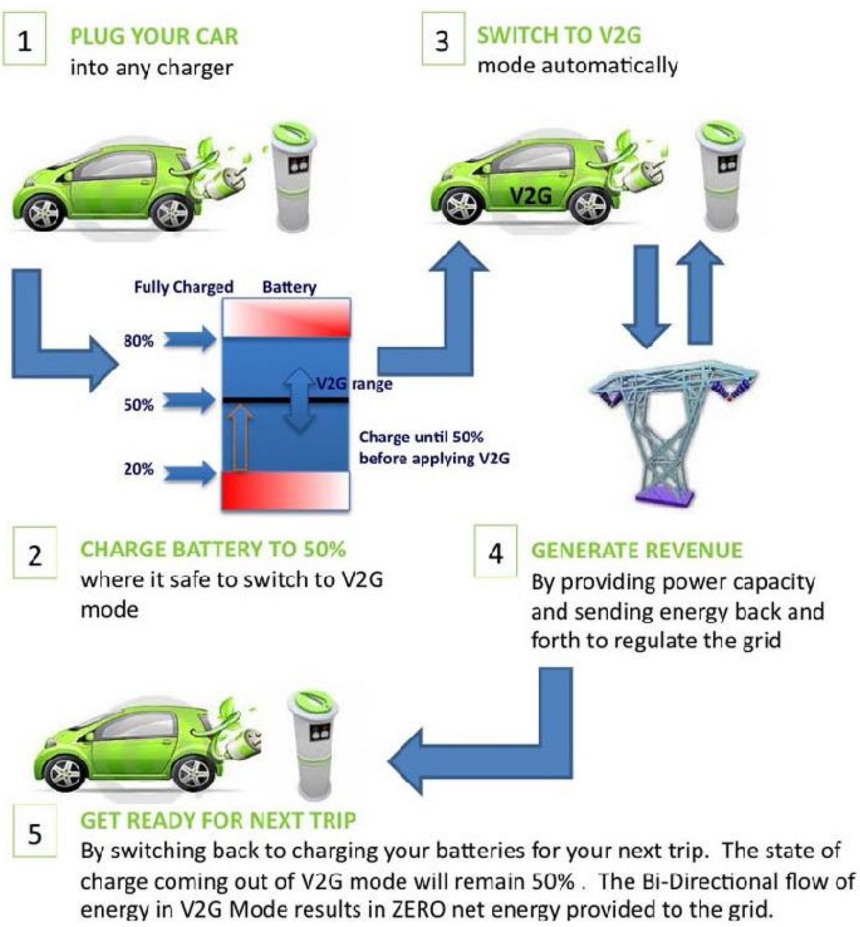

Figure 8 EV operation, http nuvve.com/://

2.3.3. Value Proposition

Nuvve Smart Grid V2G brings value to many players:

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[61] http://nuvve.com/

-Car OEM: lowers the cost of EV ownership, accelerates deployment of EVs, access to high value inforation

-Car Owener: household energy efficiency, emergency backup, mobile power (camping), corporate cash through participation in V2G

-TSO/ISO/DSO: lower cost of A/S (Ancillary Serices), regulation, reverse capacity, T&D upgrade deferral, peak shaving (corporations)

-Society: more renewables, less emission, more jobs, healthier climate

-Market benefits are presented in the figure below.

Figura 9 Market benefits
[62]

2.3.3.1. How Nuvve is commercializing the UD licensed technology in Europe

According to its vision Nuvve believes in a better world where the energy used for transportation and the electric energy are directly connected through our Grid Integrated Platform to support both high level of renewable energy and larger numbers of electric vehicles. According to Gregory Poilasne, CEO and co-founder of Nuvve, the Denmark operation is just one example of how Nuvve is commercializing the UD licensed technology in Europe.

2.4. PROJECTS STARTED

[62] http://nuvve.com/

Nuvve has started launching its commercial projects:

-2011: First Demo on China Light Electric Network in Hong Kong

-2012: test project between University of Delaware and PJM.

-2013: participation in a research project in Denmark with DTU University (NIKOLA)

-2015: Aggregation of approximately 19,000 car chargers in the Netherlands, in collaboration with The New Motion, to provide auxiliary services for TenneT NL.

-2016: In collaboration with Enel and Nissan, installing charging stations and V2G vehicles. This initial fleet of 44 vehicles will provide frequency adjustment for the Danish TSO (Energinet.dk)

In the next paragraph, we will focus on Nissan and Enel V2G project.

2.4.1. Nissan and Enel V2G trial project

In May 2016, Nissan and Enel power company announced a collaborative V2G trial project in the United Kingdom, first ever carried out in the country. The trial will work by installing and connecting one hundred V2G units at locations agreed by private and fleet owners of the Nissan LEAF and e-NV200 electric van. By giving Nissan electric vehicle owners the ability to plug their vehicles into the V2G system, owners will have the flexibility and power to sell stored energy from their vehicle battery back to the National Grid. Not only will Nissan electric vehicle owners be able to play an active role in grid stability, providing an alternate source of income, but it will revolutionize how energy is supplied to the grid. Once scaled up, the V2G technology can become a game-changer for owners of Nissan EV in the UK as they become fully fledged and active participants in the UK energy market.

This announcement follows the signing of the Nissan-Enel V2G partnership agreement in Paris in December 2015 during the 21st UN Conference on Climate Change (COP21) and the subsequent kick-off, in January 2016, of the installation of 40 V2G units in Denmark.

Smart energy management is one of the biggest challenges any nation faces for the future which is why this trial is so critical in assessing the feasibility of using variable, more flexible energy sources. Moreover, there will be an increasing number of EVs on the roads across Europe in the future and it is vital that V2G technology is rolled out to ensure the grid can satisfy the demands made upon it for increased energy.

The installation of V2G will encourage the integration of non-programmable renewable energy flows into the grid and will help the spread of electric mobility in the country, benefitting the energy sector and the environment, while also having a positive impact on electric owners wallets.

Industry projections show that by 2050 there might be twice as many cars on the road as there is today - a staggering 2.4 billion. Delivering and managing that growth in a way that is sustainable for the world, requires smart thinking.

Nissan, as the pioneer of electric vehicles, alongside Enel, a worldwide leader in smart grid technology and advanced energy metering, have been looking at ways to use electric vehicles beyond traditional mobility. Nissan electric vehicles will be used for more than just getting from A-to-B. They will turn into clean mobile energy units whose unused power can be sent back to the grid to power homes, offices, schools and hospitals. Currently if all 18,000 Nissan electric vehicles in the UK were connected to the energy network, they would generate the equivalent output of a 180 MW power plant. If that was scaled up in a future where all the vehicles on UK roads are electric, vehicle-to-grid technology could generate a virtual power plant of up to 370 GW. This energy capacity would be enough to power the UK, Germany and France[63].

V2G technology allows electric vehicles to be fully integrated into the electricity grid and will help to improve grid capability to handle renewable power, making renewable sources even more widely integrated and affordable. V2G charging infrastructure developed by Enel gives private EV owners and businesses with large EV fleets the opportunity to create mobile energy hubs by integrating their vehicles into the grid. The system works by allowing Nissan EV owners to connect to the grid to charge at low-demand, cheap tariff periods, with an option to then use the electricity stored in the vehicles

[63] Nissan and Enel launch groundbreaking vehicle-to-grid project in the UK, May 10, 2016

battery at home and at work when costs are higher, or even feed back to the grid which could generate additional revenue for the EV owner. Thus talking about integration, innovation and cooperation ,is fundamental taking into account the role covered by Europe and its legislation and certainly by the entire regular section that affects each state.

3. Smart Grid in Europe's environment and the Italian Energy Market

The Smart Grid of the European Technology Platform (comprising several European stakeholders, including the scientific community) defines the Smart Grid as: "An electrical network that can intelligently integrate the actions of all users connected thereto - generators, consumers and prosumers, for an efficient, safe and sustainable delivery of electricity supply”[64]

In this chapter two main argument will be faced and developed, the European Community's role in respect of Smart Grid and liberalization of the Italian energy market. Also the principals projects that have forecasted cooperation among Europeans countries will be analyzed paying particular attention for pros and cons associated to them.

3.1. EUROPEAN ORIENTATION ABOUT SMART GRID

Now that it is clear the concept of Smart Grid and are clear to its many shades, now is the time to deal with this topic in practice. The energy consumption in the world are destined to grow continually and dramatically, especially if placed in relation with the traditional electric network which is obviously antiquated for the fulfilment of the current needs, in fact it is envisaged that the consumptions are going to increase at an annual rate equal to 1.4% for the next 15 years.

For these reasons as for those inherent to the depletion of fossil fuels and to the environmental problems caused by these it is necessary a turn as regards both the electrical structure both the approach adopted in relation to the electric system and the production of electricity. The Joint Research Centre(JRC)of European Commission has detected as may be observed by its reports that, “459 smart grid projects are developed in 47countries as of 2014. The discriminating criterion for including a smart grid project in the JRC's database is the involvement of at least one partner from the European Union; this brought to the total number of 47 countries featured in that study. 211 of the mare R&D(Research

[64] Debora Stefani, 2016, “ Smart Grids: L'esperienza ENEL Distribuzione”, Workshop PER Bologna

and Development)projects with a total budget of around €830 million. The rest of them include demonstration and deployment projects with a total budget of around €2320 million. More than 50% of all projects are situated in seven countries: Denmark, Germany , Italy, Austria, United Kingdom, France and Spain. France, UK, Germany, Spain and Italy are the leading investors in smart grid projects. Denmark is the country most actively involved in R&D projects, supporting a large number of small-scale projects. Denmark is also the country that spends the most on smart grid projects per capita and per kWh consumed. According to the mentioned reports, project budgets have been rising steadily. The investment share for the projects with budgets bigger than €20 million grew from less than 30% in 2006 to about 60% in 2012. In 2006, projects with budgets below €20 million accounted for more than half % of the total investment. In 2012, this share shrank to less than 40%, in favor of large and very large scale projects, which now represent the bulk of investments in smart grid projects. This implies that the smart grid technology has reached a mature stage and investors do not see it any more as something risky. The mentioned reports include around 170 projects (51%R&D) carried out by multinational consortia. Analysis of the countries involved in these projects provides an interesting representation of the relations between smart grid players in different European Union countries. Organizations from France, Spain and Germany are the most active in multinational projects. Italy and the UK also have a high number of collaboration links, particularly with Spain, France and Germany. A second group of countries following these leading countries includes Denmark, the Netherlands, Belgium, Sweden, Austria, Finland and Portugal, which have high levels of collaboration mainly with countries in the first group or among them. Universities, research centers, consultancies and distribution system operators are the best represented in all smart grid projects. They are followed by manufacturers, engineering services, contractors, operators and companies focused on IT technologies that collaborate and support projects financing threm and providing strategical devices. A part from these, many notable smart grid projects in Europe were concluded in 2011and 2012, for example the Model City of Mannheim and RegModhHarz in Germany, Edison in Denmark or Energy Demand Project in United Kingdom."[65]

Returning to the definition of Smart Grid, this implies a multiplicity of interpretations regarding what means an "Intelligent" electrical system and what are the solutions and technologies of which the "Smart Grid" is made of. Despite the lack of a shared vision on these points there is a broad convergence between researchers and operators of the sector on the fact that the transition to the

[65] Ilhami Colak, Seref Sagiroglu , Gianluca Fulli, Mehmet Yesilbudak, Catalin-Felix Covrig, 2015

paradigm Smart Grid is now inevitable. In this path of progressive diffusion of the Paradigm Smart Grid are different actors to play a relevant role: firstly the legislator considered the nature still heavily regulated by the electric system, especially in Italy and industrial operators who will be called on to identify business models and partnerships in order to seize the opportunities that the regulatory evolution and the development of enabling technologies will offer them.[66]

Now get ahead with a brief focus on the implementation of Smart Grid in the world, especially on Smart Meter and Italian influence.

Many electricity companies in the world have already started projects which concern the installation of meters of intelligent energy distribution networks. It is expected that by 2016, 600 million smart meters have been installed throughout the world, of which 130 million in Europe. The following are some of the projects abroad of Italian matrix[67].

3.1.1. Within Europe

-Spain: The country of greater development in terms of Smart Metering within Europe will be Spain, starting with the purchase of the utility Endesa by Enel. The Group is planning the installation of 13 million electronic counters, which will be telegestiti. In this project the Enel Group will leverage the experience gained during the development of the project Telegestore.

-Sweden: Sweden was the second country in the world, i.e. after Italy, to install Smart Meters in the totality of the users. This means have replaced over 1 million counters throughout the country. The other Nordic countries such as Norway and Finland are also working seriously on the replacement of the counters[68].

3.1.2. Outside of Europe

-North America - The United States: As regards to the Smart Metering, have initiated projects in different states. The state of progress of projects depends on the region, given that in some counties as Marin County the Smart Metering was forbidden not only to slice the health of users but also to invade

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[66] Energy & Strategy Group, 2012

[67] Tesi di Gustavo Barbera, 2012

[68] Tesi di Gustavo Barbera, 2012

the privacy of their own. By 2016, there will be over 80 million smart meters installed in North America.

-Asia - South Korea: In this country in the year 2010, have launched a major project with respect to Smart Grids. Have decided to play of experimental tests on the island of Jeju, situated to the south of the country. These tests will eventually by 2013. The project concerns the research and development on five different areas: systems for intelligent power, energy efficiency in buildings, electric cars, use of renewable energy sources and the creation of new energy services. To meet the challenge, investors have created an important consortium which are part SK Telecom, SK Energy, Samsung and many others.

-South America - Brazil: In this continent, Brazil was the first country to invest in research and development in the context of the Smart Metering. The main objective of the country is to replace approximately 63 million counters within 2021. In fact, Brazil is considered one of the most interesting markets at world level in terms of Smart Grids and Smart Metering. For example, the firm Electropaulo AES has invested in projects in the field of intelligent networks to San Pablo. Have launched a project for the provision of electronic counters for the city of Rio de Janeiro and one of the major goals set is to reduce the losses associated with the theft of energy[69].

3.2. KNOWLEDGE SHARING

Smart Grid's architecture requires a high level of resources, in fact only through a strict cooperation among the developed countries is possible improve the current electric system, but what indeed is fundamental share is knowledge, the rarest and the most complex resource to obtain. In respect of it a lot of association were born, yearly events created, all places where humankind share what has discovered and learn each one by the others.

Follow some examples.

3.2.1.The Association METERS AND MORE

This non-profit association was created by Enel and Endesa, which belongs to the Enel Group. The objective of meters and more is to make accessible the communication protocol used by Endesa in the

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[69] Tesi di Gustavo Barbera, 2012

remote management system that you are deploying in Spain. This protocol is different from the one used by Enel in Italy, given that has been improved according to the experience gained by the Italian firm during the project Telegestore. Accordingly, the European utilities can take advantage of the experience not only Italian but also Spanish, and use the communication protocol as a reference standard in the architecture of the Smart Metering. Since 2010 the association has had the support of companies are very important for the development of Smart Grids as IBM, Siemens, ST Microelectronics, CESI, etc. The evolution and new applications of meters and more will be evaluated and certified by a body chosen by the same association to perform this task[70].

3.2.2. IEEE ISGT (Innovative Smart Grid Technologies)

Is a yearly conference or rather a platform sponsored by the IEEE Power & Energy Society (PES) to promote discussions among participants from electric utilities, industries and academia on the innovations in progress concerning smart grid technologies and applications. The Conference includes keynotes, plenary sessions, panel discussions, presentations and tutorials. Researchers and practitioners are invited to submit their contributions. In 2017 will take place the eighth edition of this event[71].

3.2.3. European Utility Week

Has been decided to exploit European Utility Week definition to describe itself because has considered of primarily valence to explain correctly and briefly what represents this international platform for discover and learn how the world is changing and in which way. “It is a smart utility community, allowing visitors to meet with experts from utilities, network operators, vendors, consultants, startups and system integrators covering the entire smart energy value chain. At this event employers are passionate about fulfilling our role to help the smart energy industry drive efficiencies in meeting sustainable development goals. Inclusion and partnerships are key and therefore European Utility Week serves as an annual meeting point for the community and is attended by 12,000 international visitors from all levels of the utility value chain from technology giants to startups and from senior-level experts to young talent. It focus on regional and global developments in Grid Optimisation, Renewables, Energy Storage, Smart Metering, Smart Cities, Smart Homes, Energy Services &

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[70] Tesi di Gustavo Barbera, 2012

[71] IEEE, 2017

Efficiency, Energy Trading, Intelligent Buildings, Data Management, Analytics and IoT, Cyber Security, Smart Gas and Smart Water"[72].

3.3. INTERNATIONAL PROJECTS FOR THE DEVELOPMENT OF THE SMAR GRIDS

At European level there are numerous projects characterized by the objective of promoting the development of Smart Grids. In these projects were involved as anticipated many institutional actors, as for example distributors of electricity, centers of research, universities and also industrial firms. Of course Enel, the Italian company leader in the field of Smart Metering, plays an essential role in the activities carried out in these projects[73].

Follow the most important projects.

3.3.1. The project ADDRESS

ADDRESS comes from the English "Active Distribution network with full integration of demand and distributed energy resources". Of course the aim of the project is to participate in the electricity market users of low voltage and therefore that they become an actor active network. This is a revolutionary idea for an electricity market from the conservative nature, this concept is called "Active Application".

The main objectives are:

-Try to remove the barriers that currently exist in the development of this new concept of active application.

-Identify an open architecture for real-time communications that an intelligent network requires.

-Clearly identify what are the benefits for the different actors of the electric Mercat.

The project lasted 4 years, was born in 2008, financed for more than 50 % from the European Community, in fact on a total budget of 16 million Euros, the EC funded 9 million Euro. In addition to

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[72] European Utility Week Website, 2017

[73] Tesi di Gustavo Barbera, 2012

this, is coordinated by Enel and participate 25 partners, 4 of which are companies of the transmission and distribution of energy, 10 universities and research centers, 2 energy suppliers, 6 manufacturing industries and 3 are suppliers of telecommunications services. These partners belong to 11 European countries and are:

-Belgium: VITO, Electrolux.

-Finland: VTT.

-France: EDF-SA, Landys & Gyr.

-Germany:Consentec.

-Italy:Enel Distribuzione , Enel Produzione, Alcatel Italia, University of Cassino, University of Siena.

-Holland: KEMA, Philips.

-United Kingdom: University of Manchester, EDF En, RLtec.

-Romania: Dobrogea.

-Spain: Iberdrola, Universidad Pontificia Comillas, Ericsson Esp, Labein , Ziv.

-Sweden: Vattenfall.

-Switzerland: ABB, Current Technologies Extn.

Moreover thanks to energy generation systems, for example through the installation of photovoltaic panels, there will be the so-called Energy Box. This will work together to counter intelligent and will be able to manage not only the consumption of the user through the connection to home appliances, but also the energy input into the network by the same user in accordance with the requests of the system.

In the system is present there is the innovative figure of the aggregator, which represents a mediator between the user and the electrical system. This actor is able to offer new services to the electrical system and at the same time encourages users to become part of the market. This is new private companies that offer this service to connect to active users with the system, allowing for both actors to obtain particular advantages on the market of electricity[74].

3.3.2. The project EDSO

EDSO is also from the English "European Distribution System Operator" and is one of the main actors of the EEGI (European Electricity Grid Initiative). Are part of the project to the most important European firms distributing energy, among these we find the Enel. The aim of this project is to renew the distribution networks communities in the light of the new concept of Smart Grids[75].

Below is going to be presented GRID4EU project, main features and a special focus on Italian role and results.

3.3.3. GRID4EU

As a response to a call for projects from the European Commission, GRID4EU is a Large-Scale demonstration of Advanced Smart Grid Solutions with the possibility of a Replication and Scalability Potential for EUROPE and it has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement n°268206. The project was led by six electricity Distribution System Operators from Germany, Sweden, Spain, Italy, Czech Republic and France but it was realized in close partnership with a consortium that gathered 27 partners, included a set of major electricity retailers, manufacturers and research organizations. GRID4EU consisted of six Demonstrators, which were tested over a period of 51 months in six different European countries. The project strived at fostering complementarities between these Demonstrators, promoting transversal research and sharing results between the different partners as well as with the wider Smart Grids community[76].

3.3.3.1. Who are the leading partners and which objectives they have

-"Sweden, Vattenfall: Development of a monitoring system of low voltage network based on AMI infrastructure and intelligent equipment in secondary substations.

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[74] Tesi di Gustavo Barbera, 2012

[75] Tesi di Gustavo Barbera, 2012

[76] GRID4EU PROJECT, 2016

-Germany, RWE: Improvement of surveillance and advanced control of medium voltage grid based on an Autonomous Switching System.

-Italy, Enel Distribuzione: Implementation of an advanced control system to increase hosting capacity and maximize the integration of distributed renewable energy sources in the medium voltage network.

-Czech Republic, CEZ Distribuce: Automation of low voltage and medium voltage grid, including the monitoring of influence of EV on distribution network and power quality measurement, and islanding operation.

-Spain, Iberdrola Distribucion: Enhancement of MV and LV networks automation and awareness of customers about their consumption and the network situation.

-France, ERDF: Optimization of PV integration and reduction of the peak load into the low voltage grid, by using PV and load forecasts, flexible loads, electric storage, islanding and active customer participation.

-ERDF is the Coordinator of the project, while Enel Distribuzione is the Technical Director and Iberdrola Distribucion the Chairman of the General Assembly."[77]

3.3.3.2. The main objectives dealt in the project

The main tasks designed to be achieved with the project are:

-Give a new aspect to the MV and LV network to make it automatic and thus to manage better the huge number of DER and the increasing energy demand; to reduce energy wastes and elevate quality of the service due to innovative devices for detecting information about consumers' behavior.

-The integration and the optimization of all the DERs.

-The improvement of devices able to control, forecast and manage flux of energy allowing also its accumulation for future uses.

-The evaluation of blackout islanding.[78].

[77] GRID4EU PROJECT, 2016

3.3.3.3. Key Points

To improve the capacity of the shelter it is thought to control more the on load tap changer through the secondary stations HV/MV, even if it brings the results it should be remembered that OLTC acts only on the limitations of voltage but not on those of power, for this reason imbalances associated to the second hypothesis, the action of the OLTC would not produce any result thus obliged the handler to introduce zanders to check feeders.

In all cases it appears that it is necessary the use of circuit breakers because the standard general does not allows switches classics of ancillary cabins to switch several times in short periods.

The most unfavorable scenarios and consequences are:

-“Long overhead lines in rural areas.

-Large DG units concentrated at the end of feeders.

-Indeed, grid storage tested at MV level in the Italian Demonstrator and at LV level in the French Demonstrators is, when correctly sized, able to contribute effectively to voltage regulation and grid power flow control and thus increase network hosting capacity. Moreover, this tool turns out to be easy-to-use and programmable but too expensive when it is used only for distribution service.

- Beyond the willingness to decrease the bill, the opportunities to act in favor of the environment and to contribute to improving the security of supply turned out to be major drivers.

- The enhanced observability of the LV grid, enabled in the Swedish and Spanish Demonstrators, is the first step towards grid automation. Indeed, a large number of events and alarms arriving at the dispatching center makes the implementation of smart solutions necessary to associate them to the cause of problem.

-The planning phase is a very important stage, in fact during its operation is possible the reduction of network losses but the total amount depends on the available resources.

-A project like GRID4EU needed huge coordination efforts, in fact it included 30 Technical Committee meetings took place within the 4 years of the project. Most of them were physical meetings because

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[78] GRID4EU PROJECT, 2016

were more efficient and effective compared to the virtual meetings. The great effort implemented during the first year of the project in order to have the same tools, to model processes and describe the implemented solutions in a similar way, allowed people from different Demonstrators to speak a common language, improving and sharing the knowledge."[79]

3.3.3.4. Italian Demonstrator

The project foresees a relevance role played by Enel, in fact it has the task to verify a unique solution at HV/MV substation level for controlling the OLTC (On Load Tap Changer) of the HV/MV transformer, third-party controllable generators (DERs) and an EESS (Electric Energy Storage System) using an IP communication for the acquirement of information through protocol IEC 61850, wireless and wire-based networks.

To improve the HV/MV substation is necessary:

-To Increase Voltage Control and Power Flow Control.

-To Improve the assessment of the current and the future status of the network through algorithms.

-To Give the possibility to the Ancillary Services to enable MV Network operation.

-To Integrate the distribution of every source of energy, renewable or not through the MV network, includes the use of a storage system.

-To Find the way to optimize the management and the credibility of the units of generation, also to avoid unexpected islanding.[80].

3.3.3.4.1. How the system works

"The system can be divided into three parts: the measurement devices, the computational algorithms and the controllable resources. The firsts are acquired and the commands are sent to the field, through the Remote Terminal Unit (RTU) called TPT2020; the core of the second is where the algorithms run and is placed in the HV/MV substation.

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[79] GRID4EU PROJECT, 2016

[80] GRID4EU PROJECT, 2016

The control system relies on three different controllable resources, communicating via IEC 61850 protocol:

-HV/MV transformer’s OLTC: interfaced through the integrated transformer protection panel (DV7500), which receives the bus-bar voltage set point and translates it for the load tap changer;

-MV generators: interfaced through the energy regulation interface (IRE), which receives the reactive power set points and delivers them to generators’ inverters.

-Electric Energy Storage System: interfaced through its own RTU which receives the active and reactive power set points. In addition, the EESS can be connected to different MV feeders and the control system can identify the optimal connection. for achieving different goals.

All these elements do not receive only commands, but also send a complete set of information.

Regarding the installations, in the HV/MV substation, it has been installed the Substation Control System which is the brain and the integrated transformer protection panel which integrates the protection relays of the HV/ MV transformer along with interfacing the on load tap changers (OLTC).

The MV generators have been equipped with the energy regulation interface that is the interface system between the DSO Control System and the MV generators, with the aim to implement reactive power control and to enable active power control.

The IRE device fulfils the following main requirements:

-Implementation of Energy Regulation Interface functions.

-Collection of measures from generation plant’s inverters.

-Delivery of set-point commands to generation plant’s inverters.

Generators’ reactive power set points are calculated by the voltage regulator and sent to the MV generation plant. Locally, these signals are received by IRE which delivers them to plants’ inverters via the data loggers.

Another fundamental part of the system is the LTE (Long Term Evolution) wireless communication infrastructure, which has been implemented for connecting the HV/MV & MV/LV substations, the generators and the EESS with the control system.

The evolutions have not only interested the field equipment, but also the grid Operation Control Centre, which is placed in Bologna and where the operators manage - 24 hour a day - the MV grid. The main evolutions of the Control Centre are related to the development of the HMI interfaces:

-Interface for generation forecast data and network state estimation results.

- Interface for MV generation plants monitoring and controlling.

-Interface for storage system monitoring and controlling.

The core system SW implementing the calculation algorithms is the Network Calculation Algorithm System (NCAS). It is designed to be open and modular and the main components are represented by:

-Network manager.

-Topological processor.

-Plug-in algorithm manager.

-Load/generation profiles manager.

The Grid Voltage Regulation (VR) algorithm is an optimization algorithm that uses the real-time network state and forecasted data as input.

The anti-islanding algorithm aim is to disconnect the grid from all the generators that are connected to a MV grid portion that is no longer energized from the main power network for example due to faults or maintenance work, avoiding through a loop control an unsafe and uncontrolled islanding operation.

The EESS has been installed closed to the MV/LV substation called Dispatching and it has the following features:

-Apparent power: 1 MVA

-Energy capacity: 1 MWh

-System efficiency: 86%

-Number of cycles: 2000

It is composed of 5 independent battery subsystems (nominal capability 213 kWh), themselves composed of a sub-set of Li-Ion batteries managed by a Battery Management System (BMS) and a power conversion system (DC-AC). In case one subsystem breaks down, the other ones will continue to work. In parallel the EESS reduces the nominal capability and signals the degraded operation. The objective is to study a new centralized/decentralized solution for voltage regulation and increase of the network hosting capacity. The EESS is connected to the MV network with a remote controlled circuit breaker and also it has a LV connection for the auxiliary services and UPS. The Energy Storage System is remotely controlled by the DSO's network control center. There are two control loops: the external control loop assigns reference set points while the internal control loop is in charge to apply the control action to track the reference set values. The information interface between the EESS and the DSO's Remote Terminal Unit is compliant with the IEC 61850 international standard. The communication architecture is based on the Client/ Server model. The EESS interface assumes the server role while, on the DSO side, there is a Remote Terminal Unit that plays the client role being remotely connected with the remote control center that hosts the DSO's SCADA."[81]

Integration, collaboration, connection and communication are all concepts at the base of standards', procedures' and devices' harmonization promulgated by EU and simultaneously at the base of Smart Grid System. To understand correctly how countries are succeeding to realize SMS is necessary know Europe's normative about it and how it has been stimulating the process of cooperation and liberalization of the electric market during the last decade to guarantee to consumers an efficient system of production, transmission and distribution.

3.4. LIBERALIZATION OF THE ITALIAN ENERGY MARKET AND EU INFLUENCE

The liberalization of the electricity sector and the implementation of an internal market in electricity not only create the regulatory conditions for a more efficient system, a smart one, but also a significant increase in international trade of electricity. This increase together with the factors already mentioned highlights some shortcomings which, on different borders, characterize today the interconnection capacity between networks; these deficiencies become the main limit to the achievement of a genuine internal market in electricity, which will require therefore development interventions in the transport

[81] GRID4EU PROJECT, 2016

capacity between the Member States. It is also essential that the available capacity is managed and allocated to the various operators in a transparent and non-discriminatory manner, in order to ensure the orderly development of international transactions in conditions of equal competitive among the various stakeholders. In addition to the warranty of predefined procedures and transparent access to the national transmission grid and the interconnection between the different Member States, the development of the internal energy market requires a structure of charges for access to and use of transport networks which does not penalize international transactions with respect to trade in electricity within the Member States.

Follows a brief excursus on the process of liberalization of the Italian electricity market that is accompanied by the adoption of Community legislation for the opening of the market and a correct use of energy by stressing the importance of that renewable.

The awareness of the shortcomings both regulations that in organizational and in the management of the energy sector terms have started in the first years 90' the complex process of liberalization of the electricity sector in Italy. Since then the compartment has been completely revolutionized through a process in which liberalization and regulation have represented tools not alternative, but complementary. The electricity sector is, in fact, a typical example of the "paradox of liberalization", whereas interventions pro-competitive have provided even more space for adjustment, both economic and technical, time to ensure continuity in the provision of the service, to protect end-users and to reach the target of environmental policy. In order to be able to better interpret the real extent of the choices of the national legislator, it is appropriate to provide in a preliminary a simplified diagram of the various activities in which can be broken down the spinneret of the electrical sector:

-The activities of generation and import of electricity;

-The exchange activity wholesale market for electricity;

-The placing of the energy exchanged in the national transmission grid thanks to which takes place also the activity of dispatching;

-Local distribution networks connected to national ones;

-Pick up and measurement of the energy sold to the final consumer (both industrial and domestic) [82].

3.4.1. The main regulatory interventions

Law n.9/1991 - Rules for the implementation of the new national energy plan: institutional aspects, hydroelectric power plants and power lines, hydrocarbons and geothermal energy, autoproduction and tax provisions

-The first signs of opening up of the electricity sector are found in this law that reduces the constraints laid down by the law of nationalization of 1962 that weighed on the auto-producers and encourages the production of electrical energy from renewable and similar sources (the so-called "Program CIP 6"), allowing the entry of private player in the step of generation of electricity.

D.l. n. 333/1992 - Urgent measures for the restructuring of public finances

-The decree is crucial for the privatization of "right" of ENEL that the Amato government transforms into a joint stock company, by assigning the entire shareholding to the Ministry of Treasury, so as to allow the subsequent privatization of "fact" that began in 1999. The new company will be allocated, by way of concession, all activities previously reserved ex lege to the entity.

Law 481/95 - rules for competition and the adjustment of public utility services. The institution of regulatory utilities

-The law is propaedeutic to the whole process of liberalization, as establishing the Authority for Electricity and Gas (AEEG), an independent body that has the task, by means of activities for the adjustment and control, to protect the interests of consumers and to promote competition, efficiency and the diffusion of electric services, with qualitative levels adequate.

Legislative Decree n. 79/1999 - Implementation of Directive 96/92/EC concerning common rules for the internal market in electricity

-The substantial liberalization of the Italian electricity sector finds its roots in Directive 96/92/EC of 19 December 1996 'laying down common rules for the internal market in electricity" that identifies a set of alternatives available to the Member States to open to the competitive dynamics of the individual dies

[82] LUISS WebSite, 2017

national electricity. The directive is implemented in Italy only a few years later with the d.lgs. 79/99 (better known as "Bersani decree").

Among the main novelties introduced by the "Bersani decree" is possible can include:

1-The liberalization of the activities of generation, final sale and interchange with abroad;

2-The regulation of access to the network for transmission via suitably rates established by the AEEG;

3-The separation of ownership and management of the network, with the expectation of the management of the dispatching and for cross-border interconnection to the National Transmission Grid Operator (GRTN), leaving property, development, operating and maintenance in head to Terna (company of the ENEL group);

4-The institution of the GME (GME, Manager of energy markets by 2009) which has the task to regulate and manage the market (power exchange) by means of a system of rods;

5-The creation of society Single Buyer (AU) who buys electricity on the market (mainly in the bag Electric) on behalf of the so-called captive customers;

6-The expectation of the distribution in territorial granting unique for each municipality;

7-The "controlled liberalization" of final sales, identifying the so-called eligible customers, or allowed to choose their electricity supplier (on the free market or on the basis of bilateral trading), and captive customers, or supplied by the distributor of its geographical area of competence with electricity purchased wholesale by the AU.

Important are the interventions of nature expressly pro-competitive environment which aim to reduce the market power of the incumbent:

1-The imposition of a ceiling for the activities of generation and imports attributable to a single operator (50%);

2-The obligation to dispose of production capacity (15GW in total) imposed to the ENEL;

3-The obligation of legal separation for the activities of production, transmission, distribution and sales to eligible customers;

4-The simplification of legislation aimed at simplifying the authorisation procedures for the construction of new power plants.

On the environmental plan, the "Bersani decree" aims to fill the gap left by the "Program CIP 6", providing new incentives for the production of electrical energy from renewable sources. In particular, is introduced the system of "green certificates", by providing the obligation for each producer to enter in the network a share of green energy calculated as percentage is fixed with respect to the total entered. An incentive mechanism that proves ineffective for photovoltaic plants, whose production costs are so high as not to ensure a reasonable return on investment, even in the presence of the possibility to participate in the exchange of "green certificates".

Law n. 290/2003 - Conversion to law, with amendments, of the decree-law of 29 August 2003, n. 239 laying down urgent provisions for the safety of the national electric system and for the recovery of power to electrical energy. Delegation to the government on the matter of compensation of the production capacity of electricity and expropriation for public utility

-The separation between ownership and management of the transmission network is modified with this rule, which attaches both functions to TERNA, preventing the control of the company (listed on the Stock Exchange) from any producer of electrical energy (the majority shareholder from 2005 becomes the Cassa Depositi e Prestiti, while each producer may not hold more than 5 % of the capital). Following the reunification of the two functions from the ashes of the GRTN is born the Handler Electrical Services (GSE, Manager of Energy Services from 2009), controlled at 100% by the Ministry of the economy and parent at 100% of the AU and GME, with the task of stimulating the production of electricity from renewable sources and assimilated.

Law n. 239/2004 - Reorganization of the energy sector, as well as delegated to the government for the reorganization of the provisions in force concerning energy

-A subsequent thrust to the liberalization process is provided by Directive 03/54/EC of 26 June 2003, implemented in Italy with the law 239/04 (the so-called "Marzano law"), which has the main merit to allow all users to obtain supplies on the free market in electricity. In fact, starting from 1 July 2007 each customer is defined suitable and can choose their own seller who will then transfer part of their profits to the distributor holder of territorial concession. Users who do not intend to make use of this opportunity are included in the so-called market of greater protection, stocked with the energy acquired by the AU, or in the market to safeguard, which includes users of large and medium size excluded from greater protection, but that does not in any case make recourse to the free market.

D.lgs. n. 387/2003 - Implementation of Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market

-In order to stimulate the pv production, the d.lgs. 387/2003 implementing the Community Directive 2001/77/EC for renewable sources of energy, by establishing the system of "Conto Energia" that provides an additional payment with respect to the price of energy per kWh produced by photovoltaic. This mechanism, made operational for the first time with the Ministerial Decree of 28 July 2005 of the Ministry of Productive Activities and arrived at its fourth edition ("energy account 2011-2016"), favors the spread of a very large number of photovoltaic plants. On the one hand, the increase in the number of these plants has the effect of enhancing environmental sustainability and the independence of the national energy system (it is estimated that in 2011 the installed power of the plants to renewable sources of non-conventional has exceeded the 120GW), on the other hand, however, generates new challenges for both conventional producers, called to deal with production of energy into bands of peak at marginal cost is practically zero and with excesses of availability than peak (peak hours are also those wherein the photovoltaic ensures greater production), both for the managers of the activities of transmission, dispatching and distribution, due to the multiplication of the number of entry points of the energy in the network and of the greatest difficulties encountered in Management of discontinuous sources (wind and photovoltaic). Are not to be neglected, finally, the substantial costs arising from the financing of incentives for the development of renewable sources of energy, and in particular from the cover of the "conto energia", affecting significantly on the final price of energy[83].

3.4.2. The regulatory measures more recent

D.lgs. n. 93/2011 - Implementation of Directive 2009/72/EC, 2009/73/EC and 2008/92/EC concerning common rules for the internal market in electricity, natural gas and to a Community procedure to improve the transparency of prices to the final consumer of industrial gas and electricity, and repeal of Directives 2003/53/EC and 2003/55/EC

-The decree aims at increasing the security of supply and competition in the internal market in electricity and gas. Among the most important innovations is the introduction of a national energy

[83] LUISS WebSite, 2017

policy, entrusting to this regard both the activity of address, both regulatory activities to the Ministry of Economic Development, which must develop scenarios decennial of development of energy markets. Also network managers are directly involved in the national energy strategy and are called to develop ten-year plans for the development of the network. The improvement and modernisation of the network is not left exclusively to the autonomous choices of handlers, but must necessarily be framed in the light of the requirements of the energy system the national and European. For electricity is confirmed then the proprietary separation between production, sale, and management of the transmission network. Is, in particular, ban for TERNA to exercise any activity of producing, supply or management, even temporary, of production facilities.

D.lgs. n. 28/2011 - Implementation of Directive 2009/28/EC on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC

-This measure has translated into concrete measures the strategies laid down in the plan of action for the achievement of a national market share of 17 % of the production of electricity from renewable sources by the year 2020. The decree aims on the one hand to the rationalization and harmonization of incentive systems of production from renewable sources, on the other hand to an increase in the quality of the energi. Provision is also made for the simplification of authorisation procedures connected with the development of the electricity networks that are indispensable for the exploitation of renewable sources. The measure also acts on the monitoring of the progress made with respect to the objectives of the national action plan and on the dissemination of information. There is also provided the progressive cessation of the mechanism of the stimulation of the "green certificates". Finally, are fixed limits with regard to the installation of photovoltaic systems on agricultural land.

Law n.96/2010 - Provisions for the fulfilment of obligations arising from membership of Italy to the European Communities - Community Law 2009

Article 17 delegates the government to start a reorganization of incentive systems in force for renewable sources of energy, so as to guarantee the achievement of the objectives of the EU Package 20-20-20. There is also an increase in cross-border trade in electricity, taking into account in the new infrastructure construction of production and transport of their relevance for the internal market in electricity and of their consistency with the objectives of energy policy at both national and Community level.

Legislative Decree n.105/2010 - Urgent measures in the field of energy

-The decree provides for the establishment at the AU of a computer system that allows the management of information flows relating to the electricity and gas markets, through the creation of a data bank for identifying the final customers. It is further contemplated that the AEEG defines rules aimed to prevent the so-called virtual saturation of the electrical network, preventing the reservation of network capacity for those plants sources whose realization does not take place in the defined times.

D.l. n.78/2009 - crisis measures, as well as extension of deadlines and the Italian participation in international missions

-Are lightened the authorization procedures for the implementation of infrastructure investments in the electricity sector. The Council of Ministers has the task of identifying the infrastructural interventions relating to the production, transmission and distribution of electrical energy for which there are special reasons of urgency and to appoint, for each of them, an extraordinary commissioner responsible for the implementation phase.

Law n.99/2009 - Provisions for development and the internationalization of enterprises as well as energy

-In order to promote the development of interconnection with foreign countries and to reduce the cost of energy, prefigures, for some operators selected by TERNA, the possibility of financing new import infrastructures, benefiting from an exemption period (20 years) of access by third parties on the ability of transport so installed. The rule also intervenes on the discipline of CIP/6 and extends the powers of the AEEG at all stages of the chain of production, including those liberalized, strengthening the protection of consumers and users. The law also has the reform of the system of "green certificates", transferring the obligation to purchase from the producer of energy to the seller of the same.

Decree of the Ministry Economic Development 29 April 2009 - Addresses and directives for the reform of the electricity market rules

-Introduces a systematic reform of the electricity market, acting specifically on the Ancillary Services Market and establishing an intraday market of energy that replaces the so-called adjustment market. The intraday market takes place between the closing of the market of the day before and the opening of the Ancillary Services Market. It is also the reform of the determination of the price of the energy in the market of the day before. The change is however subject to a detailed study of the process of the formation of prices in force.

Regime di maggior tutela D.l. 18/6/2007 e D.lgs. n. 93/11 Tariffe elettriche previste dal D.lgs. n. 102/14[84].

3.5. THE MAIN ACTORS OF THE CURRENT ITALIAN ENERGY MARKET

The figures that dominate the Italian energy scene are ten:

- As regards the producers must remember that nobody can hold a market share higher than 50%, are often private companies that sell to wholesalers or directly to consumers.

- Importers, they too rarely public entities, are those which possess an infrastructure such as to allow the inflow from abroad.

- The transmission is instead an exception, it is in fact a national monopoly chaired for the 98% by Terna, regulated by the AEEG.

- The market is very fragmented as regards the distribution, in fact if they occupy 140 bodies of various sizes, usually each deals with a specific geographic area. The most important of these is the Enel distribution with a market share of over 80%. The most important local operators are A2A, ACEA, IRIS, Deval, HERA.

- Wholesalers cover instead have the role to purchase energy producers and resell to consumers.

- The Authority for Electricity and Gas (AEEG), is the regulator and decides the tariffs and any parameters associated with them. Furthermore it is also responsible for licensing, competition and the proper functioning of the market.

[84] LUISS WebSite, 2017

- The manager of the energy market (GME) deals with the management of the electricity market as regards the equipment of supplies and the related fee, shipments and the rights of issuing shares.

- The Single Buyer (AU) has the task of safeguarding end users who do not have access to the free market, in fact sells these consumers purchased energy to wholesale prices established by the AEEG, through the networks of the distributors of the area.

- The Manager of Energy Services (GSE) deals with the development of renewable energy sources and the promotion of an efficient energy management through policies of incentives. In addition these guidelines to GME, the AU and the RSE.

- Research on the energy system (RSE), the latter is responsible for research and development projects of general interest. [85].

As transpires from this chapter, Italy is deeply affected by Smart Grids question, the legislation has not only received European rules in its order but it has also developed and improved the discipline about it. Moreover a lot of the projects analyzed, have concerned as currently happen, one of the most important and profitable Italian reality, the Enel's Group.

4. The key role of the Enel Group and its projects in Italy

In this chapter the key role covered by the Enel Group will be explained, starting from an introduction to the reality of Enel, getting ahead with the presentation of the main project leads by the Group and ending with a special treatment of the ones applied in Italy.

4.1. INTRODUCTION TO ENEL

Enel (National Institute Electric Energy) was created by the Italian Government in 1962, after the privatization in 1992 became a joint stock company. Listed on the Milan Stock Exchange since 1999, Enel is one of the Italian companies with the highest number of shareholders, between retail and institutional investors, the largest shareholder of Enel is the Ministry of Economy and Finance that

[85] Ricerca Sistema Energetico (RSE), 2013

holds 23.6% of the shares, 22.4% are individual investors while 54% is held by institutional investors, in fact thanks to the Code of Ethics, Sustainability Report, the policy of respect for the environment and the adoption of international best practices in the area of transparency and Corporate Governance, between the shareholders of Enel are the major international investment funds, insurance companies, pension funds and ethical funds. In addition to Enel, other Group companies are quoted on the main world stock markets.

With 62,000 employees work in 31 countries on 4 continents, produces energy through a net installed capacity of about 83 GW and distributes electricity and gas on a network of approximately 2.1 million km. With over 65 million users in the world, has the largest customer base compared to its competitors in Europe and is among the principal electricity companies in Europe in terms of installed capacity and reported EBITDA of 15.3 billion euro. In 2016 Enel has produced a total of about 262 TWh of electricity, has deployed on their networks 426 TWh and has sold 263 TWh. Posted revenues of 70.6 billion euros, has also sold 10,6 billion m3 of gas.

Manages approximately 36 GW of installed capacity from water plants, wind, geothermal, solar, biomass and cogeneration in Europe, the Americas, Asia and Africa. Between companies operating in the sector of renewable energy at world level, Enel has the highest level of technological diversification.

It was the first company in the world to replace traditional electromechanical counters, present in Italy, with smart meters: the modern electronic counters which allow the reading of consumption in real time and the remote management of contracts. An innovative system of measurement that is indispensable for the development of intelligent networks, smart cities and of electric mobility.

Figure 10 shows the logo of Enel, which has become a "Registered trademark" throughout the world. In addition, the slogan that their use is "Energy that listens to you"[86][87].

[86] Enel Website, 2016

[87] Gustavo Barbera, 2012

Figure 10 Logo of Enel[88]

4.2. THE ENEL GROUP

Currently, the Enel Group is present in 40 countries on 4 continents. As regards the activities of the Group in Europe, the success more relevant is certainly represented by the purchase of Endesa, the most important company in the Spanish electricity referred Enel owned 92% of share capital reduced to 70.14% in 2014. By exploiting this partnership has decided to implement in Spain a telemetry system and remote management similar to that developed in Italy, the project named Cervantes, thanks to the know-how obtained with previous projects will allow the reading and the management of more than 13 million users. Moreover Enel Green Power operates plants for the generation of energy from renewable sources in Spain and Portugal and is also presents in France, Slovakia, Romania and Russia. In the American continent , the Group is active in North America and Latin America, where he plants for the generation of renewable energy.

The Enel Group is composed of a set of companies operating in different sectors of the electricity. The following are major:

-Enel Energia: Is the leading company in the free market, sells energy at prices which are not regulated by the Authority. It is the leader in the market of energy and offers services for businesses and for families.

-Enel Distribuzione: Is the company that performs the task of distributing electricity. Manages more than one million kilometers of power lines in the Italian territory. Despite refills 86 percent of users in different regions of Italy there are also small distributors of electricity. This is usually of undertakings belonging to the municipalities that are involved in the provision of different public services such as electricity distribution, distribution of gas, water, the collection and treatment of waste and other

[88] Gustavo Barbera, 2012

environmental services. For this reason it is called multiservice companies, or multi-utility(an example is HERA in Emilia Romagna).

-Enel Green Power: It deals with the development and the generation of energy from renewable sources, i.e. wind, solar, hydro and geothermal energy.

-Enel Produzione: Deals to produce and deliver electricity to the market of the wholesale market. The objective is to seize the opportunities that the free market offers.

-Enel Sun: Is the Group company that is in charge of public lighting in cities through the use of technology and innovative products in such a way as to reach a rational use of energy[89].

The next step will be to explain the role played by Enel in the reality of Smart Grids, since in fact its valence in this context was relevant from the outset.

4.3. MAIN PROJECTS

4.3.1. The Project Telegestore

4.3.1.1. Introduction to the project

The project was initiated by Enel toward the end of the nineties and is linked to the process of liberalization of the electricity market occurred in Italy during the last decade and the first creation and implementation of a Smart Grid System in its primordial state. It is a network that connects over 30 million users of electrical energy and at the time was considered to be the most extensive network of bidirectional communication. The heart of the project is the new electronic counter of energy drawn from Enel, in other words a counter that in addition to measuring the energy drawn by the user is able to receive and transmit data between the customer and the operator.

In Figure 11 is possible see a photograph of the counter.

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[89] Gustavo Barbera, 2012

Figure 11 Single phase energy meter used in the Telegestore Project[90]

This project allows the operator not only to measure but also to the ability to remotely manage the totality of energy consumed by 32 million Italian users. On the other hand, this system allows consumers to know their consumption in real time, which becomes an energy saving, thanks to a more aware of energy. Therefore, the project represents an advantage for Enel, for consumers and for the same electrical system. One of the most important innovations that presents the project is that of the use of the low tension network as a means of transport for the data exchange. The total investment of the project was more than 2.1 million euros. Moreover, the project has allowed to Enel to save on many operations for example in terms of readings of the traditional counters, failure to billing and user management[91].

4.3.1.2. The architecture of the system

The functioning of the system as it is designed is based on three key elements:

-The electronic meter that in addition to measure the flow and the consumption of energy, manages to establish a bidirectional communication between the user and the central system.

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[90] Gustavo Barbera, 2012

[91] Gustavo Barbera, 2012

-The concentrator device that collects data that are transmitted from a set of counters and sends them to the central system. It is installed in a secondary substation.

-The central system, i.e. a data acquisition system and system management.

Any user in low voltage has an electronic counter, which sends and receives data from and to the concentrator through its network of low voltage used to deliver the energy users. In order to establish this communication between counter and concentrator, it uses the so-called "Distribution Line Carrier" (DLC), or system to "conveyed wave". Once the data coming from the counters of the district arrive to the Concentrator, the signal is converted to a radio frequency signal, which is transmitted to the central system via the cellular telephone network GSM/GPRS. Of course, the latter is an electromagnetic wave high frequency that propagates via air[92].

4.3.1.3. Communication systems

Communications between counters and concentrators - conveyed wave

As anticipated, communication between counters and concentrator occurs through the low tension network itself, using a system of conveyed wave. Firstly, is necessary remember that the low tension network has been designed and built to deliver electricity to users even if inside the project is also used as a means for exchanging data. In this sense, the European standard CENELEC EN 50065 regulates the use of the frequency range from 3 kHz to 148.5 kHz, which is used for the transmission of data. According to what is established by the standard, the frequency range is divided into four sections. The standard establishes not only the frequency bands, but also the maximum output level permissions for each band. The signal then must be transmitted using the band reserved for the operators of the distribution networks, i.e. between 3 and 95 kHz. As regards the modulation technique used, it was decided to use the system BFSK (the acronym stands for the phrase in English Binary Frequency Shift Keying). This system is of a numeric type or digital, therefore the modulating signal assumes only two possible values (0 and 1). The modulating signal shifts the frequency of the carrier from one to the other of two predetermined values, one to represent a zero and other defined to represent a one. In the particular case of the Telegestore project it was decided to use two frequencies, the primary at 86 kHz and the secondary to 75 kHz. Use the second, when the first is disturbed. As regards the speed of transmission, it is located between 2400 and 3200 bps (bits per second).

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[92] Gustavo Barbera, 2012

As regards the behavior of the low tension network as a means of communications, you must consider both its attenuation in both the existing noise. The latter is particularly important and complex because the noise level at any time depends on the permanent connection and disconnection of the loads connected to the distribution network[93].

Communication between concentrators and the central system

In this respect, it was decided to use the cellular phone network, since it guarantees an important capillarity all over the Italian territory in fact in the last decade the use of the mobile phone has become indispensable and then the networks have grown considerably. There are two standards that are used in cellular telephony: GSM (acronym for Global System for Mobile Communications), known as 2G technology, and GPRS (General Packet Radio Service), i.e. 2.5G technology. The introduction of GSM in the context of cellular telephony, through a transmission of the digital type, has led to the following benefits:

-Greater throughput.

-New services such as SMS and data transmission. Clearly this innovation has been indispensable in order to make possible the exchange of data in the field of the Telegestore Project.

-Greater safety in the transmission.

The frequency band used depends on every continent. In the particular case of Europe, the bands used are around 900 MHz and 1800 MHz. For the first band you are using the band ranging from 890 MHz to 915 MHz for uplink transmissions, while the band ranging from 935 MHz to 960 MHz is used for the downlink transmissions. After these bands were widened from 25 MHz to 35 MHz, giving rise to the so-called EGSM (extended GSM). The more modern versions use a similar system but with two bands from 75 MHz around 1800 MHz.

As regards the architecture of the GSM system, it is constituted by three subsystems interconnected:

-MSS (Mobil Station Subsystem): Is composed by me (Mobil Equipment), in other words the mobile phone, and the Subscriber Identity Module (SIM), which identifies the subscriber to the service and contains a certain number of data.

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[93] Gustavo Barbera, 2012

-BSS (Base Station Subsystem): It is composed from the BTS (Base Transceiver Station) that takes care to establish contact with the GSM terminal and the BSC (Base Station Controller) that interacts with the cellular network via the interface to and with the other BTS in the area.

This last is the intelligence of the radio subsystem.

-NSS (Network and Switching Subsystem): Works as a communication node for a particular zone. Among other things it is composed from the MSC (Mobile Switching Center), which is the point of interface between the GSM network and the terrestrial network Public Switched Telephone Network (PSTN).

One next development of GSM is the GPRS, which is also used inside the Telegestore Project. This technology has introduced the packet switching and the possibility of Internet access, given that it was the first system designed specifically to provide data transfers by some changes of hardware and software to the GSM system. In fact, both systems are able to coexist[94].

Below is a brief summary of the three essential elements of the system.

4.3.1.4. The Counters

With regard to the certification of the counters were executed tests very stringent to ensure a correct operation, both in terms of accuracy and safety. These carry out the measurement of the active energy in accordance with the IEC61036 (Class 1), while that realize the extent of the reactive energy in accordance with the IEC61268 (Class 2). The tests were carried out at the premises of production, as determined by the IEC standards and of course, they have obtained the CE marking required by the European market. As regards energy consumption, is to consider that electrical losses due to the Joule effect of new counters are negligible with respect to those of the electro-mechanical counters. Furthermore the electronic counters are equipped with a device capable of signaling the attempts of the opening of the box, in order to reduce the number of cases of fraud which occur daily on the low tension network.

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[94] Gustavo Barbera, 2012

The single-phase power meter:

Consumers are able to download from the site of Enel a clear document that describes the counter monophase from a technical point of view and explains how you should use. The most important characteristics of the single-phase power meter are:

-The liquid crystal display placed at the center of the counter thanks to which customers are able to read the power consumed in real time. Next to the display instead, there is a button that allows you to view the data in a sequential manner.

-Power control made possible by a device that is located at the center of the bottom. This allows the user to consume for unlimited time a power up to 10% above that engaged at contract level. If the power drawn reaches 30 percent above the engaged, the device for the control of supply snaps within 4 minutes.

-Rates biorarie, indeed as explained previously, the rules of the Italian electricity market allow customers to choose the biorarie rates. Therefore, the counters used must be able to distinguish the energy price according to the hours in which takes place the consumption. These counters allow to distinguish up to three times.

-The bidirectionality in fact for those customers who behave as prosumers, you must install a counter capable of distinguishing the energy picked up by the user from that entered into the network. Of course, new counters are able to make this distinction. They are also able to determine if the reactive energy is inductive or capacitive. Therefore, these counters measure the energy on the four quadrants.

-Monitoring of parameters related to the quality of the electricity service, in fact another important characteristic of the electronic counters is to be able to monitor the electric quantities related to the quality of the electricity service and geographically distinguish them without having to invest in measurement campaigns. For example, they are able to measure the number and length of outages that occur in the totality of the users. In addition to the interruptions, the counters are able to measure the effective value of the supply voltage as established by CEI EN 50160. In this sense, the tool calculates the percentage of the effective values of the voltage, mediated in 10 minutes, compressed in the range a 10% / -15%, over a period of one week.

-The counter also provides additional information such as the number of customer, the maximum power of the current invoicing period and that the previous period, and the date and time at the time of viewing.

The three-phase power meter:

In those systems where it requires a supply of three-phase power, you must install a counter able to measure and manage power in this mode. In the same way as the single-phase power meter, 3 Phase Meter designed by Enel manages to do everything described above about the 1 Phase one. The main differences are related to the electrical powers which they are able to manage. In fact, there are three different models according to the power managed:

- GET Model2A: For systems with power up to 16.5 kW.

- GET Model3A: For systems with power between 16,5 kW and 33 kW.

- GET Model4S: for plants with a power exceeding 30 kW.

These counters are to insertion semi-direct given that connect to the electric network by means of transformers for the current measurement. Also in this case customers can download the user manual from the site of Enel[95].

4.3.1.5. The concentrator

According to the architecture of the project, upstream of the counters is the so-called concentrator, which is installed in the cab on the secondary side of the low voltage. This name clearly is due to its function within the system, i.e. that of concentrate or collect data that are sent by all the counters that are located toward the valley on the low tension network, then send it to the central system. According to the planning of the network, typically a transformer provides energy to about 80 users, therefore, this represents the number of counters that a concentrator should manage. After a little from the start of the project had already been installed over 350,000 concentrators throughout Italy.

The main operations that must perform are the following:

-Check the condition of the electrical connections.

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[95] Gustavo Barbera, 2012

-Query in a cyclic manner all the counters that are supplied by the transformer MT/BT in order to collect any diagnostics.

-Collect the data sent by the counters for the purpose of billing.

-Synchronize the clocks of the counters.

-Route data traveling from the central system toward the counters to carry out the contractual changes, activations and deaths.

-Periodically update the software of the counters.

From a functional point of view, the Concentrator is constituted by a computer and communication modules while since the communication with the central system via the telephone network GSM/GPR, in addition to an antenna is installed inside the device a module that makes possible this communication.

The activation, indeed the assessment of the level of the signal existing in the area in which the concentrator will be installed, is performed by a technician via the computer as it happens for the counters[96].

4.3.1.6. The central system

It is a system able to collect the data sent from the concentrators and to manage the overall system efficiently and reliably.

This system commonly called AMM, acronym for Automatic Meter Management consists of three subsystems:

-System commercial information.

-Central Management System.

-Interface system for communication.

Via an intranet, employees who work at the operational center, are able to access the system[97].

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[96] Gustavo Barbera, 2012

4.1.3.7. The advantages that the project offers

For the operator the main advantages are:

-Through remote management is no longer necessary to go to the homes of consumers for the management of its customers because any management can be performed by the office.

-Has improved the relationship with its customers, through the use of custom fares.

-Has improved commercial quality because the project has made possible the reduction in response times to customers.

-All bills are calculated on the actual readings of the counters.

-Allows to have a more precise control and effective fraud and theft of energy.

-Allows you to invest in a more effective way, since the system provides precise data on the needs of the network.

Advantages for the system:

-Ability to manage demand in a way more exact, i.e. starting from the measurement of the real consumption.

-Reduction of electrical losses thanks to a lower consumption of the counters.

-The greater efficiency of the overall system implies a lower need for generation and then brings benefits not only economic but also environmental.

Advantages for Users:

-Possibility to visualize in real time the consumption of all appliances. As a result, consumers are able to manage their consumption in a more reasonable.

-Now all the bills are based on real consumption of customers and not on estimates.

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[97] Gustavo Barbera, 2012

-Thanks to the greater reliability of the system, users receive an improved quality of service.

-Possibility to make changes under contract without the need to contact the office of the firm.

-There is no need to receive visits by personnel of the distribution company to carry out the counter readings or contractual changes.

The project just presented has represented a turning point in the field of energy, has opened the door to many new ideas for research that bunches have changes to the lives of all and that it will bring as many in the future. Closely linked to the Telegestore project there is the project "Smart Info", essential to emphasize one of the main goals imposed by Smart Grids, i.e. make consumers aware[98].

4.3.2. Project "Enel Smart Info"

The first aim of this project is to provide customers with a tool that increase the awareness of their energy consumption and is based on the installation of a device that allows to visualize the respective data on one screen. This device will play a very important role, since it should be able to interact effectively with a network of "smart" household appliances within the home. In addition this device must also interact with the power distribution network.

Figure 12 Schematizes the technology used both inside and outside the house.

[98] Gustavo Barbera, 2012

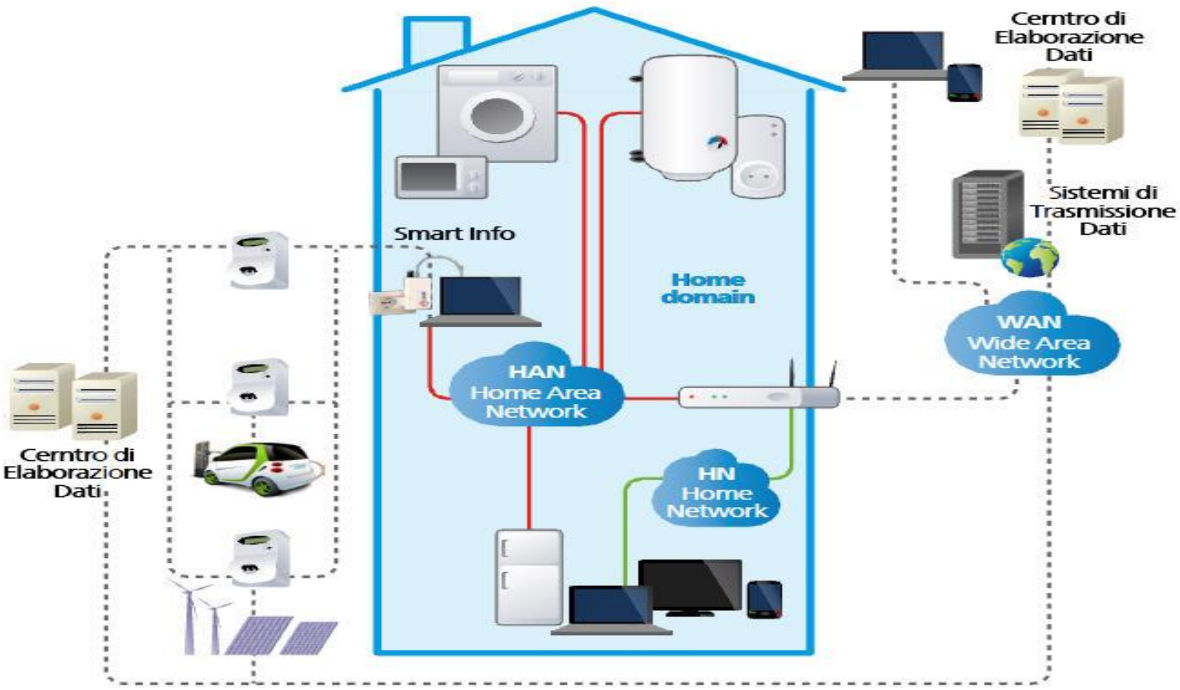

Figure 12 The architecture of "Smart Info"[99]

The "Smart Info", which represents the heart of the architecture, is flanked on one side by the electric network with its electronic counters, and on the other the appliances present in the house. According to Enel the use in mass of Smart Info in Europe will allow the electrical system d save between 2 % and 7 % of energy, while allowing a reduction in the peak demand between 3 % and 8 %.

The system is composed of two separate blocks:

The first or the basic one, you can plug it into any electrical socket in the home. This block is able to establish a wireless communication with the meter installed in the same house, is also fitted with a USB connector through which is able to interact with the second block; the second block can be a dedicated display or can be installed on your computer the Smart software Info Manager then to connect with the Smart Info. Using the Smart Info users are able to view more easily data on their consumption, for example the instantaneous power, graphs of historical consumption, have access to administrative data relating to the supply contract or receive alarm signals in case of overshoot of the contractual power[100].

[99] Gustavo Barbera, 2012

[100] Gustavo Barbera, 2012

4.3.3. Project "ENERGY@HOME"

This is another revolutionary project that involved together with ENEL, the telephone company Telecom Italia and the manufacturers of household appliances Indesit and Electrolux. A key aspect is the introduction of domotics inside houses in order to improve the comfort and energy efficiency and to encourage a more flexible. The most important objective of this project is to define a communication platform indoor open and accessible to all as a tool for the development of new energy services. The aim is precisely to be able to provide a network of communication inside the house, i.e. a Home Area Network (HAM), which connect all the existing appliances via the communication protocol ZigBee wireless. As regards the architecture of ENERGY@HOME, the heart is precisely the Smart Info described above in fact represents the bond between the energy meter and the HAM. The other actors of the system are:

-Smart appliances in addition to fulfilling its function will also provide the consumer information with regard to energy consumption. Also adapt their behavior to the state of the entire system due to their interaction with the network.

-Smart sockets, which will be able to turn on/off the traditional apparatuses or "not intelligent", such as lighting systems, according to the orders received.

-User interface that on one side allows the user to view the data that arrive from the Smart Info and on the other hand, through the connection with the HAM allows you to configure the system. The technical challenge is to allow users to make these changes through a Wide Area Network (WAN).

-Home Gateway: The task of this device is to constrain the HAN with the WAN in order to coordinate the overall system[101].

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[101] Gustavo Barbera, 2012

Figure 13 schematically illustrates this architecture in which can be seen the Smart Info as a link between the counter and the home network.

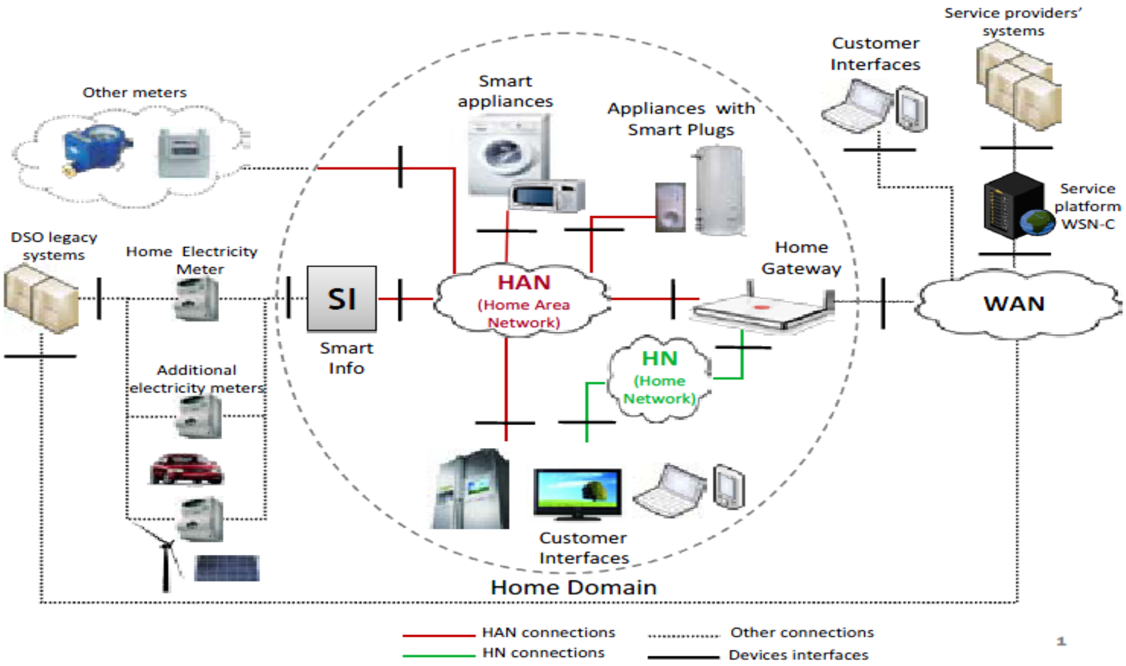

Figure 13 The Architecture of E@H[102]

In addition to these projects, there are many others that have been made in specific areas of Italy, among the many, the most interesting will be analyzed briefly.

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[102] Gustavo Barbera, 2012

4.4. ENEL SMART GRIDS MAIN PROJECTS DEVELOPED IN ITALY

In the figure n. 14 are summarized the Enel Smart Grids main project developed in Italy.

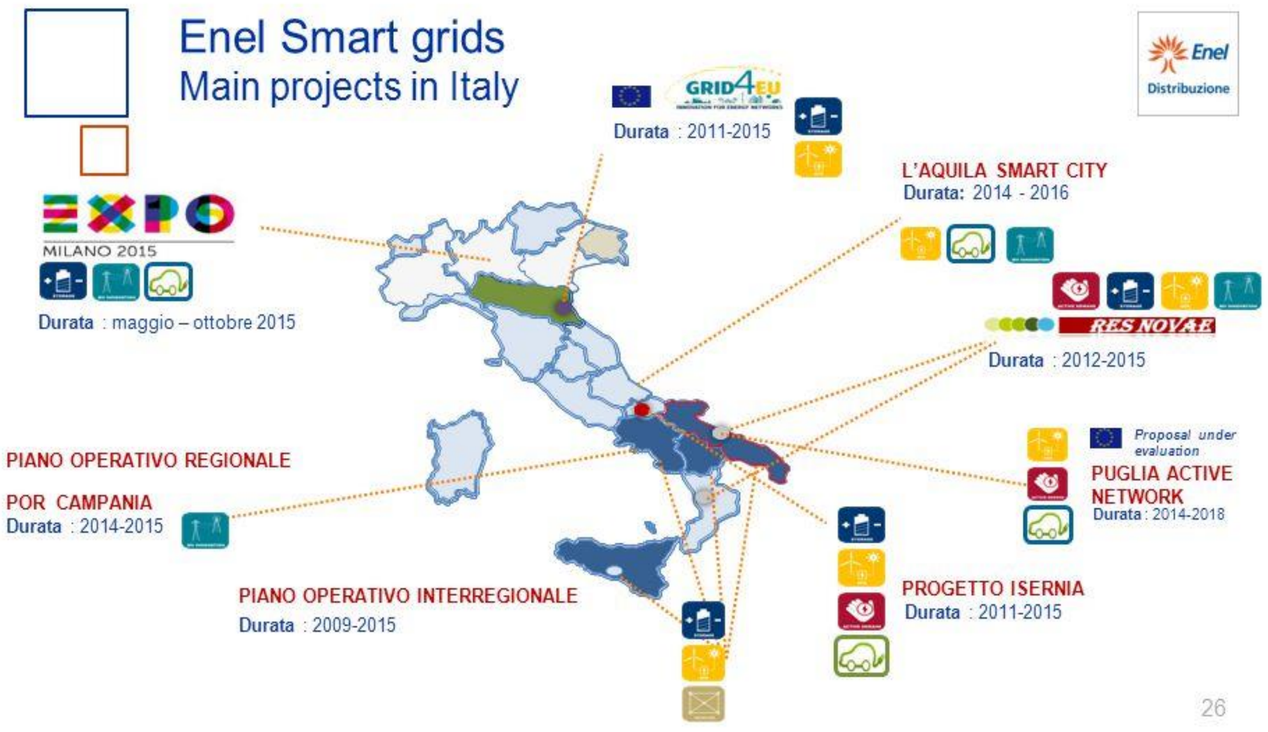

Figure 14 Projects of SG led by ENEL[103]

4.4.1. Project Isernia

The Project Isernia, presented by Enel Distribuzione on 10 November 2010 within the framework of pilot projects smart grid Resolution ARG/elt No. 39/10 and admitted to the incentive treatment on 8 February 2011 with Resolution ARG/elt No. 12/11, represents a demonstration in the field of Smart Grid and proposes the experimentation of a series of components, systems and techniques for the management of the network "Active", for a subsequent diffusion throughout the national territory. Particular attention is paid to the standardization and unification of the components as well as the

103 https://www.google.it/search?q=progetti+smart+grid+enel++in+italia&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjqutSAjpjUAhVE6xoKHfsRAgkQ_AUIBygC&biw=1517&bih=654#imgrc=At1U-sRgUvDBtM:

minimization of the cost. The project involves investments to be realized on the primary substation (CP), CARPINONE (IS) - Green Bar and on the network from it fed, as well as on the telecontrol system (SCADA) of Campobasso which leads the CP in question, involving users active and passive connected thereto.

In concrete terms, the project foresees the following interventions:

-Installation of a control system, in order to overcome the problems that the Distributed Generation (GD) can create on the distribution network, based on a communication infrastructure that, on the one hand has a high capacity of transport of information (broadband) and on the other hand has latency very reduced. This network, in addition to connecting to the control systems the cabins of the distributor, must also connect installations GD.

-Introduction of a fleet of electric vehicles used by the teams Enel; the charging columns will be supported by a photovoltaic system, integrated in the canopies of a suitable parking.

-Experimentation of an electrical energy accumulation system (Storage) connected to the medium-voltage grid.

-Experimentation on a population of about 8,000 domestic customers and/or small commercial a device called a Smart Info that, connected to a normal socket of the house, offers in domestic data managed by the electronic counter. The objective is to ensure that the information is likely to contribute to the efficiency and the integration of production from renewable sources.

The functionality developed in the course of the project are:

-Search trunk failure fast and antiislanding Telescatto.

-Innovative adjustment of voltage MT and increase of the hosting capacity.

-Forecasting injections of GD in the perspective of a local dispatching, and to provide differentiated Data (GD, load) to transmission network manager (TSO).

-Multifunctional storage, charging station and electric vehicles.

-Device Enel Smart Info for utilities BT.

The communication network to support the project Isernia, based on a topology "hub&spoke", creates paths logical communications between peripheral systems (CS-CS and CPCS) and between the peripheral equipment and operating center authority. The requirements in terms of crossing times of the network to be part of the information necessary for the proper functioning of services Smart Grids are particularly challenging and led to the choice of solutions characterized by capacity for high bandwidth and low transmission delays. The connection of the primary substation of Carpinone to the control center of Campobasso occurs through the digital channel number broadband (operator Wind). The connection between the CP Carpinone and CSAT Carovilli and between the CP Carpinone and manufacturer "Enel Green Power - Central Carpino" takes place via fiber optic ADSS. The connection of the secondary cabins and of the remaining active users is via wireless network provided by a public provider[104].

4.4.2. Project Puglia Active Network

It is a project of Enel Distribuzione, realized with the support of the European Union and the Ministry of the environment and protection of the territory and the sea, that involve interventions extended to the whole of the electrical network of the region to improve efficiency and performance and enable municipalities, businesses and consumers to innovative management of the distribution of electric energy in smart key. Give greater impetus to the development of renewables, distributed generation, energy efficiency and to electric mobility: are the goals of the pan that provides, among other things, improving interventions in 8,000 cabins for the distribution and installation of new stations for the rapid charging of electric vehicles that have already begun to spread in some urban centers with particular emphasis in the chief town of Bari.

Puglia is the national champion of clean energy: With an installed power of more than 5,000 MW of renewables is the Italian region with the largest production of "green" energy able to satisfy the energy requirements annual 3 million and 400 thousand households. This virtuous characteristic stems from the widespread presence throughout the regional territory of small and large energy producers to zero emissions: development in the years of the green sources has in fact made the Puglia the ideal context to give life to the pan and develop so fully the new paradigm of energy distribution according to the model of the smart grid.

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[104] Enel, 2013

The intelligent network of pan will travel the entire region and will be able to manage the electrical service with greater flexibility by integrating the energy generated from renewable plants distributed over the whole regional territory and ensuring a constant balance between demand and supply of electricity. Interventions on over 8000 transformation cabins will allow Enel to integrate into the distribution system a modern wireless communication network always active that will connect the network in medium voltage to a central control system. This evolution, in addition to make more reliable and secure network, will allow the system to carry not only electricity but also information and data to know in real time the evolution of consumption. This is innovations that will have an important impact on the environment resulting in lower emissions of carbon dioxide and that will limit the need to build new cabins and power lines, thereby avoiding subtract new spaces to the territory and make new excavations.

The PAN also provides a strong acceleration on the diffusion of electric mobility in the region since the smart grid lays the foundations to allow citizens to travel to zero emissions over the whole territory of Puglia. The project includes the installation throughout the region about 150 new locations of second generation multistandard and that will be added to the 42 charging stations already exist and will reload times much more rapid and simultaneous charging of more vehicles. Will be so connected to the main regional arteries and will be made possible integration with other projects of sustainable mobility in the developing world as draft ESF/Siemens and Project Bari Smart City/Car Sharing ACI[105].

4.4.3. E-mobility Italy

With this project, Smart, the youngest and most innovative brand of the Daimler Group and Enel, have launched one of the largest world projects for electric mobility in the city of Rome, Pisa and Milan, three cities that best fitted and fit the different Italian styles of life. It was an unprecedented integrated model designed to make possible the diffusion and the efficient use of electric vehicles through the deployment of innovative charging technologies and the development of infrastructure tailored to customers able to offer services safe and smart.

Key points of the project:

-Over 100 cars provided and maintained by the Daimler Group

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[105] Enel, 2016

-At least 400 points of intelligent charging guaranteed by Enel network together with a central control system.

-Technologies for feeding and innovative infrastructure.

-The beginning of the trial in 2010.

The energy provision of electric cars will be certified RECS (Renewable Energy Certificate System) an international system that involves 25 European countries, set up to finance the development of renewable energy sources such as water, sun, wind and heat of the earth. Already at the time 1.3 million customers had subscribed to this kind of offer available from Enel Energia on the free market. Thanks to this new system has been made possible a substantial reduction of all emissions of carbon dioxide (CO_2), benzene, sulfur dioxide, oxides of nitrogen and particulate.

Also noteworthy are the cost savings, theme that is at the heart of consumers: with an electric car, 10 euro enough to travel on average 280 km, against the 120 km of a car with petrol. Charging infrastructure have been operating through the technology of 32 million electronic counters described before, all managed by Enel.

The infrastructure have allowed users motorists to know the position of the points of free charging, a similar technology was already used for Enel’s employees that in the morning received directly into the car service the information necessary to perform the service and maintenance activities on the distribution network throughout Italy. Moreover the project was planned to involve the smart for two electric drive with electric motor to 'zero emissions'.

The Project e-mobility Italy meet the specific competence and the considerable experience of two large industrial groups, with the aim of creating a sustainable mobility and environmentally friendly in urban contexts. The initiative is a good example of the achievements reached in the field of the protection of the environment and the climate when energy suppliers and automotive industry unite[106].

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[106] Enel, 2008

4.4.4. EXPO 2015 AND FUTURE EXPECTATIONS

The Milan Expo is also under the energy profile, an authentic smart city in full exercise. Thanks to Enel, leader in the energy sector, it was possible to ensure to the international event a smart grid, an innovative system of public lighting entirely in LED and much more. Systems at the vanguard have been installed for the management and control of the smart grid, plants for accumulation of electrical energy, then infrastructure charging of electric vehicles, all for a flexible and balanced structure adapted to a changing world.

In addition to the system for the Expo area, Enel - in partnership with Siemens - offers participating countries three different packages of services (Basic, Advanced and optional), ranging from the monitoring and control of the electrical loads to the artistic lighting. This incredible offer conveys in a single urban model the pursuit of the objectives of environmental protection, energy efficiency and economic viability. The numbers of the contribution of Enel to the Expo are in fact impressive: 75 MW of installed power for a million KWh of daily consumption estimated. More or less as a small town by 100,000 inhabitants. And yet: 100 medium-voltage substations for the delivery of electricity to the individual pavilions, as many points of charging for electric vehicles, 30 on the perimeter of the area and 70 outside. Then 8,500 light points of the led, Archilede, dedicated to the illumination of the exhibition area between Cardo, Decuman and internal roads, with a saving of approximately 280thousand kWh, 7,250 apparatuses of urban furniture, a storage for optimization local energy flows (270 kw), a management and control center operating 24 hours a day (set in Via Berruto Lambrate) and a show room intended for visitors. A forest virtual media and that is just the tip of a commitment extremely deep that allows every days of "turn on" the Expo. Many, inter alia, the challenges in the management of the energy flow of the incredible site of Rho. The consumption peaks on all: from air conditioners to cookers activated at certain times and certain days of the week with the influx of visitors. A flow that is controlled through a ring of controllers connected in optical fiber to dodge in real time any failures and blackouts. Each pavilion has inter alia to provision of a system of "energy management" dedicated to monitor and control consumption and energy requirements, to optimize the energy consumption and integrate the plants from renewable sources with the systems of accumulation.

Fascinating was the possibility given to visitors to understand in full the whole mechanism of this Smart City in miniature, in fact these was given permission to visit both the control center because the entire system so as to understand the whole process of generation from renewable sources, management and distribution of energy, up to recharging of the accumulators for the electrical machine that they could use to visit the park. Fundamental aspect was the communicative one, it also explained in an exhaustive way and not only, in fact it was also possible to see it in action thanks to various interactive display which could access the tourists. To remember the partnership of Enel with Siemens, the most important of the companies in terms of involvement.

The involvement of Enel with Expo 2015 underlined its critical role in the energetic field as stated on the one hand by Paolo Andrea Colombo, Enel Group Chairman:

"Our partnership with Expo 2015 is a source of great pride for Enel, reaffirming the role played by our company in the process of growth and development of our nation, a role that Enel has played throughout its long history and with which we are marking our fiftieth birthday celebration later this year and also on which we look back with pride at our past achievements, spurring us on to think even more deeply about our energy future and inspiring us to take a long-term view and provide effective responses to the challenges of competitiveness, environmental sustainability and technological development. The Universal Exposition is the perfect place for our vision for the future to become a reality. This is why Enel wants to make the most of this partnership with Expo 2015, because it gives us the opportunity to tell all the millions of visitors to the exhibition all about the new electric era which, thanks to our newest technologies, is our contribution to the planet and all its inhabitants".

And on the other by Giuseppe Sala, Managing Director of Expo 2015 SpA:

"We are delighted to have Enel as our Smart Energy Partner for Expo Milano 2015. Having the support and collaboration of Italy's largest electricity company makes us very proud. Enel's presence means that we now have four of the world's leading companies as our partners. This means that our plan to create a smart city which is both high-tech and eco-friendly is not only up and running but is seen by the business world as a great opportunity. Thanks to the smart grid and public lighting system to be installed by Enel, the Milan Universal Exposition will prove to be the ideal place for trialling new low environmental-impact lighting systems. This is perfectly in line with one of the challenges launched by the Milan Expo 2015 theme. 'Feeding the Planet, Energy for Life' is not merely an invitation to arrive at a more equal distribution of food resources in the world, rather it provides an incentive to promote more sustainable food, environmental and urban planning development models, with the goal of ensuring a better quality of life and greater wellbeing for all" [107].

[107] Enel, 2012

As can be seen from the data reported, the innovativeness of the Group is unquestionable in fact does not end with the completion of the last nominated projects but continues to be revived, an example is the memorandum initialled by Enel s.p.a.on 14 January 2017 with the Dubai Electricity and Water Authority (DEWA), a Dubai's public company provider of infrastructural services. According to the memorandum, which has a duration of three years and may be extended by agreement between the parties, the two companies will aim to build relationships of partnership, to facilitate the achievement of common strategic objectives, the exchange of information, experience and studies in the areas of work identified by the MoU, between which the analysis of key performance indicators in the management of the smart grid as well as in digitization and security of networks.

The Parties will cooperate in research in the areas of work of the MoU and will share the know-how of Enel in deployment automation, integration of renewable energies, smart meters and smart city, with particular reference to the role played by Enel in the context of the Expo 2015 in Milan, as well as the experience of DEWA in the field of smart grid.

The Parties will consider further opportunities for cooperation in network technologies for Expo 2020 Dubai, given the experience of Enel in realizing ad Expo 2015 A smart city electric entirely and considered that DEWA contributes to the development of network infrastructures and related technologies for Expo 2020 in Dubai[108].

Furthermore Enel and the Italian government have agreed a new action plan to bring broadband connection and 30 Mbps Internet access to the entire country by 2020. ENEL will take advantage of its existing infrastructure to bring optical fiber grid to the majority of Italian households. For this purpose, a new organization, Enel Open Fiber, will have responsibility for realizing this plan[109].

There are other leading electrical utilities in Italy include Edison, A2A, Eni, Iren, Acea, Hera, Dolomiti Energia, Ascopiave and Acsm-Agam, all of them are fostering introduction of Smart Grids with several projects, for example the one that endorsed Acea that foresaw the provision on Rome network of apparatuses of monitoring able to detect in real time information relating to the operation of the network and apparatuses of telecontrol appropriately coordinated in order to improve both the

[108] Enel Website, 2017

[109] Marta Abbà, 2017

continuity that the quality of the electricity service and increase the energy efficiency of the network itself while minimizing losses techniques[110]. Moreover also Terna has a role in the Italian SG reality in fact on January 31, 2012 presented the Development Plan of the National Electricity Transmission Grid for 2012-2021 which includes investments in over 7 billion euro to increase the efficiency for the electricity system and reduce CO2 emissions[111].

What appears clearly is the emblematic role covered by Enel within the energetic environment and especially in the Italian one, innovativeness and creativeness are features on the day order for the Group and their demonstrations belonged both to the past such as to the future. Surely Enel will accompany Italy in its future development and will always represent one of the flag companies facing such European challenges as the globalization ones.

5. The effort of LUISS to redefine its shape

In this chapter is going to be developed an hypothetic plan that forecasts the application of some of the main concepts found by facing the Smart Grid System, to LUISS reality, particularly the headquarter located in Viale Romania. There are two macro-categories of reasons why I have chosen it:

- The former includes theoretical aspects that characterized the University;
- The latter includes practical aspects that represent necessary conditions for Smart Grid application.

Gets ahead a detailed analysis of both.

In respect of practical reasons why has been chosen LUISS as application for the study case, let's start talking about the liquid availability or the financial basin from which it can draws, in fact the budget of 2015 shows a profit equal to almost 2 million euros. This feature provides it the ability to invest and improve the service offered and not only, also to extend them through the creation of new venues and new educational offerings or entertainment. In this way it was possible to work in the context of a future realization, thus providing an additional incentive to engage in maximum in designing the idea

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110 Autorità per l'energia elettrica, il gas ed il sistema idrico, Acea Distribuzione s.p.a., 2010

111 Marta Abbà, 2017

that in the future it could really change things, achieve energy savings, ensure users greater awareness of consumption, such employees as students, improve and elevate higher again the name of the LUISS university.

A fundamental element which should be considered is the nation in which this institution throws the roots, Italy, in fact in the same Italian tradition have always found space characters of creativity, innovation and ingeniousness, Enel, treated in previous chapters, is an example, as explained has launched the first projects signed Smart Grid and has still been promoting much more, covering always sensible roles.

Another fundamental technique reason, which makes the LUISS suitable for application of the Smart Grid is the presence of a system of car-sharing for the fact that is based on the use of electric machines.

Moreover the university did not allow an indiscriminate application of the Smart Grid System, in fact it would have been necessary to take into consideration a city or at least a geographical area, for this reason only certain elements were suitable to be studied in the case in question. In the previous chapters were only submitted cases placeable in opposite categories on a dimensional scale, such as city and houses, reason for which was taken inspiration partly from both and partially by any, attempted to give innovative connotations to a study innovative for itself.

Having said that, the main ideas that will be addressed are:

- Application of the Smart Meter.

- Application of the Smart Info.

- A mechanism for gathering, to connect all the electrical appliances in LUISS.

- Photovoltaic Thermodynamic Panels to guarantee energy self-sufficiency.

- Transformation of the car-sharing system into a profit center.

- Gymnasium as a source of energy.

5.1. INTRODUCTION TO LUISS GUIDO CARLI

LUISS Guido Carli, acronym of Free International University of Social studies, was founded in 1966 in Rom, before the transformation had been an Roman institution known as “Pro Deo University”. In ancient time such as today It has been emblem of innovativeness, in fact this orientation was given in 1974 by a group of entrepreneurs led by Umberto Agnelli that decided to invest human and financial resources in an innovative educational project aimed at executives. To continue on this way in 1978, Guido Carli, President of Confindustria, an Italian industrial association, became president of the young School and established new requirements to be admitted to best fit the needs of the marketplace. In 1982 the Department of Law was added to the Department of Economics and Political Science, in 1994 the University was renamed of Guido Carli and in 1997 LUISS Management s.p.a. was established for all market-directed educational activities. Time by time LUISS has affirmed itself in any fields as a dreadful competitor, thanks to its faculty and students it has always searched better results and more difficult challenges to face.

5.2. SMART METER

Smart Meter was selected as the first item to be presented given the relevance of its rationale, in fact the first problem when we talk about energy consumption is that of awareness. Most people do not know or at least did not know the true extent of their own consumption, people rely on the number that appears in the bills next to the words " Total To Pay", the metro to distinguish an overspending by an acceptable is given by a comparison with the bills passed or at the most with those who we believe have consumption "similar” to those personal. With this tool, now present in many homes and Italian companies it is possible to understand not only the consumption in real time but also isolate all sources of cost, thus having the possibility of being able to act on the most relevant and achieve significant savings. It may seem commonplace as discourse, but it is not at all, in fact the one that may seem apparently an easy source of savings, for example, keep for many years the old washing machine had as a wedding gift because still function, could prove to be a substantial source of cost compared to the consumption and the purchase prices of new washing machine, but as they say in Italy: ignorance you pay.

5.3. SMART INFO AND THE CONNECTION GATHERING DEVICES

The smart info, already analyzed in previous chapters as one of the Enel excellences recognized at international level, is another essential instrument for the achievement of two of the main objectives set for this investigation, the full awareness of energy consumption and the ability to manage them. Given the complexity of the last goal mentioned it is necessary to take a step forward and anticipate another of the key concepts of this thesis, i.e. the establishment of a connection between all the electrical appliances owned. As has already been explained the functions of the device "smart info" as to those of the system of gathering, is going to be exposed their joint application to the case under examination. At the LUISS the use of these systems together with the Smart Meter would allow to know the energy consumption, in fact through this digital interface all consumers might understand both their consumption as well as the overall structure in a simple and quick manner. For the realization of this objective it would be sufficient to install in any computer the software in question, but could also be a god idea creating a section of the App Luiss dedicated to consumption in such a way as to increase exponentially the basin of users. By connecting all the electronic equipment and these with the smart info, it would then be possible to manage power in real time but not only, in fact it would also be possible to program it. Clearly not everyone should have control of the mechanisms for switching on and off all devices since in a situation like that, reckless actions might be accomplished. To solve this problem and to restrict the discretion of some, would be sufficient to set an algorithm such as to preclude some persons the full freedom of action. For example always linking to the App., students to use it must enter in their account, consequently could be attributed freedom more accounts by teachers and used as regards energy management of their respective offices. In this world there would be a centralized management of consumptions, but this would be accompanied by another system for managing highly decentralized that would guarantee in the immediate, cost savings, for example the air conditioners in summer or heating in the winter or even computers, in fact who better than the owner of the Office would be able to manage the operation of the objects indicated above.

5.4. GYMNASIUM AS A SOURCE OF ENERGY

The idea is to provide students with the opportunity to carry out physical activities behind a consideration. The system is composed of 4 actors, students, cyclette, accumulators and the LUISS university. The first will have the task of producing electricity with the movement through the exercise bike, energy once produced will be channeled in the accumulators of electrical machines for which serve as supply boats. In exchange for this service the LUISS, compensate willing students with voucher consumable in the cafeteria located inside the complex. The benefits of the application of this mechanism would be many:

- LUISS in first place would have a further source of energy and secondly would pay the service with another service offered by the same then theoretically without additional costs.

- Students will have the opportunity to download the voltage accumulated with the study without departing from the University and could dine for free again without departing from its own study desks.

5.5. THERMO-PHOTOVOLTAIC PANELS

The innovations in the field of energy are the order of the day, this datum is not so surprising in fact given the energy dependency of which all are slaves would be strange to the contrary. The "why", has already been explained several times, energy, is an economic asset that is available to an extent less than that requested and given the current sources will always less and at prices ever higher. From to highlight is the role played by the technology in the process that leads to the development of innovation, may in fact be one of its components necessary or even itself may be the innovation. Prepare the necessary condition to ensure the energy self-sufficiency at LUISS is the objective of this second part of the chapter the objective secondary instead, which is included in the primary is to ensure to the system of car-sharing the electricity that it needs to function in such a way as to transform into a real business this service. Today everyone that wants to exploit this service has to pay a price, thus LUISS earns that money but must pay the company which had furnished electricity, in this way is possible to achieve a little profit, but if would be able to produce autonomously the energy necessary to the cars operation, the car-sharing service could become a center of profit, in fact without ulterior costs the money gave by the consumers would be at whole profits. Moreover the energy accumulator used by the car to refill their battery might be used as explained in this thesis, to store the surplus of energy produced by the renewable sources and transmit it to the machines, in this way when the car come back to the charger station if LUISS needs energy it may absorb it from the chargers. The self-sufficiency must be satisfied on two fronts, the first one is purely electrical, the second relates to the heating, hot water and so forth. The renewable solution at problem has been found in the solar energy. Until a short time ago the two categories of needs were to be met separately because the efficiency of the photovoltaic panel is directly proportional to the light absorbed but inversely to the heat to which are subjected the cells, on the contrary the efficiency of thermal panels is proportional to the heat absorbed, consequences was unable to integrate in the same panel the two functions. Today there are the panels thermo-photovoltaic that thanks to the new technologies are able to simultaneously optimize both output and hence to provide in a single solution electricity and heat saving space and money.

Get ahead with a brief explanation about how the thermo-photovoltaic panels work.

To begin with, it may be useful to observe figure n.15, in fact the concepts explained are complex and visual feedback could facilitate understanding.

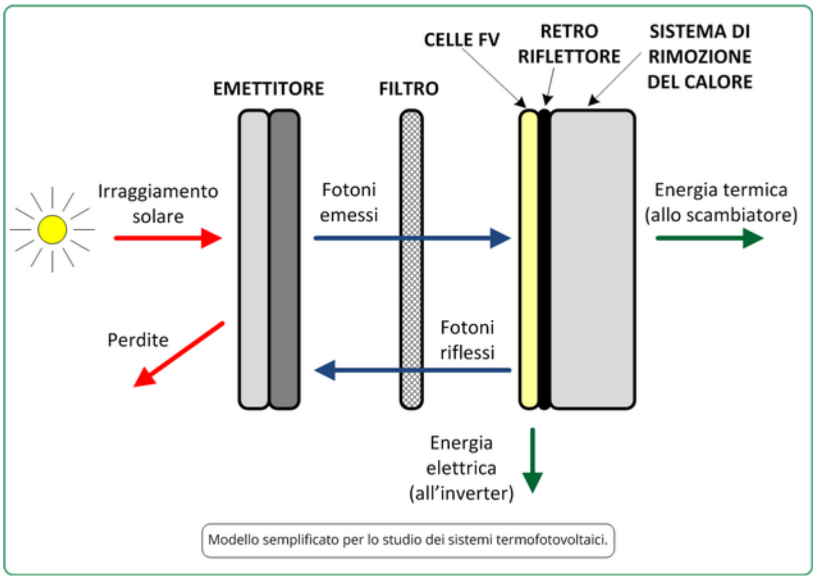

Figure 15 Simplified architecture of a Thermo-Photovoltaic panel[112]

The main actors are:

-The emitter that is the apparatus able to receive thermal energy (heat) from the source (in this case it is the solar radiation) and to transmit it to the sections immediately following, on the basis of its own working temperature and to its optical properties. There are different types of emitter, among which may include those with a gray body and one selective, which are the two most commonly used in the current state of technology. The first provides a transmission capacity and total absorption similar to the one ideal associable to a black body; the second goes remembered its peculiarities, already guessed from the name, it alludes to the charge carriers excited present in the cells, which can move selectively precisely to the contacts in the current circuit outside.

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[112] http://www.bottegaenergia.com/termofotovoltaico.html

-A filter that allows you to control the flow of energy output from the emitter toward the photovoltaic cells immediately following. This is an optical filter which, in the case of systems thermo-photovoltaic, in order to function correctly must be characterized by a low coefficient of absorption and a high coefficient of transmission in the frequency range in which the energy of the photons is greater than the gap of the photovoltaic cells and by a high reflection coefficient outside this range. Filter types commonly used are those of interferential, plasma, resonant and plasma-interferential.

- The photovoltaic cells that in the current state it seems that the cells used does not have characteristics so much different from the ones used in conventional modules, such as to be considered as "dedicated" to thermo-photovoltaic systems. In most cases the producers prefer to use photovoltaic cells in monocrystalline silicon. However the photovoltaic cell is where takes place the conversion of solar radiation into a current of electrons. These devices are constituted by a thin wafer of semiconductor material, very often silicon, suitably treated. Such treatment is characterized by different chemical processes, by inserting in the crystalline structure of silicon impurities, i.e. atoms of boron and phosphor, it generates an electric field and also make available the charges necessary for the formation of the electrical current. This occurs when the cell, whose two sides are connected to a user, is exposed to the light. The energy that you can then exploit or the conversion efficiency depends on the characteristics of the material of which the cell is formed , from the temperature to which it is subjected, from its area and the intensity of the radiation.

-The rear reflector that is installed in the lower part of the photovoltaic cells and serves to improve the electrical efficiency of the system. Are surfaces characterized by an high reflection coefficient, which refer to the emitter, the photons not absorbed by the photovoltaic cells.

-A system of heat removal that is the one by which the heat is removed from the cells (improving the efficiency of operation) and used, usually by means of a heat exchanger, i.e. a heat carrier fluid consisting of water and glycol, in the transfer of thermal energy.

Based on this model, it is possible to represent the following expression for the overall energy efficiency:

$$\eta = 1 - \frac{QE + QS + QF + QC}{QIN} = \eta EL \cdot \eta T \cdot \eta 0$$

Figura 16 The formula of the overall energy efficiency [113]

in which appears the following terms:

QIN: thermal power total incident on the manifold, date from solar radiation multiplied by the opening of the surface of the manifold itself

QE: losses of thermal power due to the emitter

QS: losses of thermal power between the components of the system

QF: losses of thermal power due to the filter

QC: losses of thermal power due to the photovoltaic cells

ηEL: electric efficiency of the system

ηT: thermal efficiency of the system

ηO : optical efficiency of the system

To keep in mind is that the model presented and the expression obtained for the overall efficiency provide approximations and not exact figures.

Taking into account a thermo-photovoltaic panel furnished by the Fototherm S.P.A. , a specialized firm in the solar energy field, the series AL 275 module monocrystalline of 1,58 m^2 and a nominal power of around 275 Wp, it represents the maximum instantaneous power. The model FT260AL has a instantaneous power equal to 260 Wp respects of the production of electricity and 960 W of nominal thermic power respects of the heating for the price of 800 euro; According to these data, assumed that the roof of the LUISS University is approximately 200 square meters it would be possible to install almost 127 panels for a total power of peak equal to 34925 W, 16510 W/m^2 and a total price of

[113] http://www.bottegaenergia.com/termofotovoltaico.html

almost 102.000 euro without considering the tax deduction equal to 65%; consulting any specialized sites seems that for an investment like the one hypothesized the Pay Back Period would be around 8 years and considering the incomes that might provide the system integrated with the car-sharing one, i think that would be also briefer the time necessary to recuperate money invested.

Conclusion

Thanks to this thesis, which I consider an investigation, I have realized that I had never considered how many energetic factors are able to influence each day of my life as well as that of anyone. I have used the term investigation because by developing the topic of Smart Grid, I have had the opportunity to know what will be the worldwide electrical system in the coming years. Globalization with all its facets touches every aspect of our living, even if it brings with itself negative consequences too, here I preferred to focus on the positive ones since the revolution of the electric system is just one of these. I do believe that this inevitable change is pushed by two willings that run parallel toward the same direction, the future. The first one is represented by the attempt to eliminate any constraint of geographical nature, while the second one of anthropological nature, concerns the general tendency of being part of a Community. We begin to analyze the first concept, the world is one, the human race is one, but resources are always less with respect to the population that is in continuous growth. Our ancestors have expanded their territory to know what there was around them, in order to search for their needs, but once they reached a territory already controlled by others, they were forced either to fight or to cooperate. Even if sometimes the war is chosen in order to get new resources, time by time the second alternative is wholly shared as the best one. As a matter of fact in the past the resources of a specific zone were limited, nowdays the lack of resources involves the worldwide population. An asset could be present in abundance in a place while in another one could not be enough and vice versa, for this reason population had been forced to lead exchanges and to organize a society. Efficiency, integration and cooperation are probably the three words that may better explain the logic underlying the Smart Grid. In the broadest sense of globalization, we could say that the first is a product of the second; in fact was not perhaps thanks to the sharing of knowledge, resources and technologies among the various countries that had become possible the beginning of the Smart Grid implementation process? By quoting into question one of the first true economists, David Ricardo, I would like to recall the theory of comparative costs and benefits associated with international trade. Without economic and institutional constraints or limitations linked to the conflicts of interest, we can produce any product in the best possible way by drawing from the "warehouse" of every country to obtain the necessary parts. There are no absolute advantages in the capability to producing goods autonomously if they are of poor quality. For everything there is a place *ad hoc* for its development, by making it with minimal cost and maximum yield, in a word the best achievable version of the product. When we come to technology the concept of globalization has to be extended to the opportunity of sharing ideas and knowledge, in fact innovations need a lot of much time to be developed otherwise if we should do everything individually it would take decades to reach even the most insignificant result. The Smart Grid is entirely composed by highly technological devices, it is an innovation since its beginning when the idea was conceived up to outstanding goals achieved. Also in this case the results would not be achievable without the cooperation. Awareness of energy consumption, of the meaning of the bill, of how our actions may change the common trends. Such achievement constitutes the first result that has to be reached because you rarely deeply know something if you are not interested in. With Smart Meter and Smart Info, it becomes possible to fully understand the output of our own actions, thus by sharing the same vision we can get concrete results. Renewable energy sources offer always more yields and in a short time will reach high standard efficiency; to give a meaning to these developments it is necessary to change mentality and understand that fossil fuels will ruin the world in which we live and not only. Just by looking the daily news is possible to see with our own eyes the consequences of a society that works with energy sources that cause wars, death and barbaric social behavior. This is about to finish, fossil fuels are going to end. If we want to continue to make progress, to survive, to pursue the dream of an ever better future, we must believe in innovation, break the chains imposed by the lobbies and smash through any barrier placed to limit the spread of knowledge and the society welfare.

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