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INNOVATIVE MODEL OF PRODUCT CERTIFICATION WITHIN THE ENERGY DEREGULATED MARKET.
EXAMPLE OF APPLICATION TO A SMART ENERGY AREA IN THE SECTOR OF LOCAL TRANSPORT SERVICE

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Introduction

Scenario

Certification services are widely expanding with the growing request of process and product validation on the part of the organizations, organized communities, municipalities, institutions, as well as production and services companies.

Certification is required in order to safeguard markets, mainly users, buyers and consumers during purchase of products and services, and of performances.

More and more interesting is the growth potential of certification services in the field of energy, where, owing to the well-known developments following Kyoto Protocol, the production market and services appear to be widely expanding, following the liberalization of energy market, a growing diffusion of the renewable power sources, the development of IC technologies, the aim at energy savings and efficiency, the worldwide strategic target of environmental sustainability.

Target

This study deals with the problem of certification applied to the institutions, energy processes and products, starting from the cultural and applicative platform of certifications already existing, consolidated and approved both at institutional and market levels, such as those referred to products (CE, IMQ, etc) and to organizational standard (ISO) as well as to the security and interoperability in the field of railway transportation (TSI).

The study aims to investigate the possibility to extend at the system and to systematize the different certification activities that could be already considered as 'emerging' within the evolution of processes and products following the development in the electric power field.

With reference to future applications of smart engineering to the various sectors of production and use of the energy product-service, the present work aims to verify the practical feasibility of a "voluntary product certification program", proposed at system level, for the energy sector. The approach consists of defining a template for a generalized certification procedure to be used in a flexible way in function of the large variety of types of product and in an evolutionary way, depending on the technological development and on the benchmarks derived from a deregulated energy market. Its flexibility involves many and various parameters such as complexity of the configuration, in terms of number of elements and types of distributed energy resources (DERs) and renewable energy sources (RESs).

Method

To develop the certification model, for an operative management of all aspects connected to the complexity of the energy product, reference was made to some analogies with the railway certification, referring specifically to the Technical Specifications for Interoperability standards.

State and trends of certification's market models was firstly systematized, starting from the definition and classification of the different types and sectors of application. Among the latter, the field of energy was mainly investigated. Later, the evolutions of energy market and pertaining technologies were considered, in order to define a targeted certification and qualification of techniques and products.

The approach used in this study is strongly influenced by the identification of the criticalities introduced by technological innovations, services and mechanisms of commercial transactions, introduced into energy market and upon which is based the need to guarantee the measurements and estimates of consumptions, data and operating results about technological systems, production potentials, power efficiency, reliability, forecast and uncertainty parameters, environmental impacts, costs and economic evaluations.

According to the growth trend of the sector, an innovative certification of energy product was proposed, flexible if compared to the peculiar targets of the product qualification, in accordance with the type, complexity and innovation of the planning methods and technologies considered. This study was aimed to the identification and implementation of a certification scheme related to the market of energy services, which could emerge from the re-organization and development on the physical, managerial, infrastructural and environmental context of future cities. Smart cities are characterized by new urban concepts deriving from a constant growth of residential areas, and respective energy requirement, from the evolution of energy services models, following the application of paradigms as Smart Grids and micro grids, as well as from the development of electrical power systems integrated with ICT. Among the different fields of application of future certification models linked to the energy sector, special reference was made to the field of electrified public local transport. In this context, let us mention three areas of interest of the parallel development of drivers such as: *city*, *energy market*, and *smart technologies*.

In this context, the field of local public transportation, based on eco-sustainable electrified techniques, may potentially represent a segment for future requests of an energy certification. In this view, urban and regional public transport appears to be particularly significant since, at present, their organizational and technological structure is less programmed than railway long-distance transportation (such as high speed railway transport). For this reason it was considered relevant for this study, since it open to a new proposals of standards and regulations, for the current development in markets of energy and certification.

Case study

Case study has been set up with reference to eco-sustainable electrified mass transit systems which represent a basic resource for supporting the sustainable development of future cities, in a scenario of innovation based mainly on rationalization processes of planning and design - at a systemic level – of all types of energy resources.

Focusing on innovation related to the implementation of smart grid concepts into the urban context, the case study proposes a systemization of principles for an energy efficiency management based on a new approach of Global Energy Efficiency (GEE). This new paradigm enhances the traditional definition and application of energy efficiency (EE) by simply connecting the applicative platform of smart methodologies and technologies to the potential wider energy efficiency objectives of users' area, at the system level, pursued by optimizing the use of all their available primary and infrastructural energy resources, and maximizing the economic benefits of both energy providers and consumers. The GEE approach is "customized" to the metropolitan assets for mass transport services within the urban context. The interest of dealing with such a type of infrastructure derives from several factors, such as centrality, extension, dispersion, electrical powering and consumptions, structuring and organization of service. Given the intrinsic systemic approach, the model provides strong and flexible capability of supporting the EE management in planning and decision-making problems with smart and dynamic transactions, addressing participation in the future electricity market. Therefore, it is very suitable for GEE in a smart city environment.

Moreover, on the basis of the developed optimal power flow model, a complete management of power flow and energy dispatching can be scheduled and implemented, according to the ordinary operation of the components of a Smart User Grid, accepting their possible variations over the time related to compatible technical procedures. In particular, a variety of tasks can be considered, such as Demand Response Program (DRP) management, load leveling and shifting, ancillary services supporting Distribution System Operator's ordinary operation, electricity market transactions, or at fulfilling emergency requirements.

The choice of the Case study was made with a twofold view: firstly the Case Study can be clearly included in the class of most complex and advanced future energy systems or areas, consisting of a very heterogeneous and largely distributed energy area centered on a urban mass transit system; secondly also the model of intelligent energy management tool for its operation was featured and developed to highlight the feasibility and significance of the proposed new scheme of energy product certificate.

Demonstration

This thesis reports some demonstrative cases to give evidence to the smart proprieties of the model and the potentiality of the energy smart system, that was chosen as an ideal pattern of complex and flexible energy area, particularly suitable to be an objective of the proposed certification scheme. In the demonstrative applications the operator's operational strategy aims to gain maximum profit by best coordinating of the available energy resources, within the limits deriving from the activities both of the SUG, representing the users, and the DSO, representing the Distribution Network (DN).In the last part of the thesis, an exemplification of the new procedure for Voluntary Product Certification Program (VPCP) was performed, considering the energy area represented by the referential case study.

Contents

This thesis consists of 8 chapters, as follows.

In the first chapter, an overview of certification and accreditation is presented. Then, the state of the art of the certification is explained in the second ones, giving particular attention to the energy sector, on which the present work is centered. The third and fourth chapters consist in a dissertation of the recent evolution of power systems physical structure and technologies, as well as on the certification services needs within the energy market. The proposal of a new energy Voluntary Product Certification Program is presented in the chapter 5. The case study and pertaining applications is explained in the chapter 6 and 7, they are related to a metro- funicular transportation system and its neighborhood. Finally, in chapter 8 the model proposed in chapter 5 is implemented in the Energy Area defined in the case study.

Chapter 1: Certification

Definitions

Conceptually and roughly, certification means a written evidence of the compliance of material or immaterial “objects” with prefixed requirements, where the guarantee depends on technical, economic or regulatory requirements.

According to the current technical definition, “certification” indicates the formal procedure by which an accredited or authorized person or agency assesses and verifies (and attests by a written certificate) the attributes, characteristics, quality, qualification, or status of individuals or organizations, products, goods or services, procedures or processes, or events or situations, in accordance with established requirements or standards.

The need arises when a product, a process, a performance or a system requires to be assessed in the presence of regulatory requirements, for example for the acquisition of additional market shares or of a better relationship with the stakeholders.

Certification guarantees the compliance with the specifications for safety, quality, performance and reliability in conformity with the National, European and International standards taken as a reference, in which each subtends different rigorous procedures.

The UNI EN ISO 9000:2005 defines: *product* as "result of a process”; *process* as "set of interrelated or interacting activities which transforms inputs into outputs"; *requirement* as “need or expectation that is stated”, generally implied or obligatory; *procedure* as “specified way to carry out an activity or a process”.[1]

According to the International Organization for Standardization (ISO), *Standards* are “documented agreements containing technical specifications or other precise criteria to be used consistently as rules, guidelines or definitions, to ensure that materials, products, processes and services are fit for their purpose”.

Product standards are specifications and criteria for the characteristics of products, while process standards are criteria for the method of manufacturing.

Classifications

Various classifications could be made about certification depending on the:

1) Object of evaluation: organization system, product, process, management system, environment;
2) Mandatory nature: expected or optional certification;
3) Procedural scope application;
4) Legal framework: Standardized procedure or Prescriptive;
5) Jurisdictions.

Consequently, the certification can be:

Related to point 1- Object of evaluation

Depending on the types, certification assures that a system, product/service, process, person complies with pre-set requirements. Below are some of the definitions object of interest.

Product certification finds, of course, the suitability of a product or service to the applicable requirements.

System certification specifically regards the ability of an organization to structure and to manage its activities in conformity with reference standards, in order to meet the customer needs.

Process certification confirms the compliance of technical specification of a process to the applicable requirements. Process standards could be further divided into management system standards and performance standards.

Personnel certification ensures that the professional figures possess, maintain and continuously improve the necessary competence, where "competence" indicates the demonstrated ability to apply knowledge, skills and attributes to conduct assigned functions.

ISO 9001 gives a particular attention to it, because compliance with the requirements can be directly or indirectly influenced by personnel. Specifically, section 6.2.1 includes that "the staff that carries out activities that affect compliance with the requirements of the product must be competent and appropriate about education, training-training, skill, and experience.[2]

Environmental certification is a form of environmental regulation and development where a company can voluntarily choose to comply with predefined processes or objectives set forth by the certification service. This is seen as a form of corporate social responsibility allowing companies to address their obligation to minimize the harmful impacts to the environment by voluntarily following a set of externally set and measured objectives.

Related to point 2 – mandatory nature

Let us mention:

- Mandatory certification refers to the Community directives that provide the minimum requirements for the safety of workers and consumers and for environmental protection;
- Regulated certification refers to the national or Community regulations (for example: food products DOP/IGP/STG);
- Voluntary certification: a free membership to the certification.

Related to point 3 – Procedural scope application

An evaluation of the first part consists in a conformity assessment performed by the same organization that provides the subject of the evaluation, for example a product, as a self-declaration.

A verification of the second part consists in a conformity assessment performed by the users.

A third-party verification is done by a party with no direct interest in the economic relationship between supplier and buyer. It requires the intervention of an independent and impartial body to obtain a reliable, credible and internationally recognized certification. An internal control is a first-party verification. A second part evaluation is performed by a person or an organization who has an interest from user to the object of the evaluation, for example when a buyer verifies if the supplier adheres to the standard.

Related to point 4 -Legal framework: Standardized procedure or Prescriptive;
A certification consists, in substance, of a process based on inspections and testing aimed to the confirmation of certain characteristics (e.g.. technical specifications for a product) according to a prefixed program of V&V. Such a program is composed by standardized or prescriptive procedures, i.e. procedure based on standards and prescriptions, inset in a legal framework.

Related to point 5 - Jurisdictions;
All certification activities are framed in strictly established jurisdiction areas clearly recognized by the market, where are clearly positioned certification users, Notified Bodies, Accreditation Organisms, certification Authorities.

The certification may be considered as an extremely useful marketing tool, because through it the organizations can:

- Communicate the quality of the products offered, strengthening the confidence of the consumer (customer loyalty);
- Open out to an additional market share;
- Ensure compliance with the declared characteristics;
- May achieve a differentiation from competitors;
- Equip itself (be equipped) with a tool for an effective communication and management.

In this view have an increasing role the voluntary certification programs, which anyway must be recognized by Certification Authorities and issued by accredited Notified Bodies.

Accreditation

Accreditation "is given by the national accreditation body certifying that a conformity assessment body satisfies the criteria established by harmonized standards and, where appropriate, any other supplementary requirements including those defined in the relevant sector programs, for conducting specific conformity assessment activities" [3] .

Accreditation certifies the quality of the work of a certification and inspection body or of a testing and calibration laboratory, assessing the conformity of its management system and its competences against internationally recognized requirements and standards, including all legal obligations.

Accreditation is thus a guarantee of:

- *Impartiality:* representation of all interested parties within the body or laboratory;
- *Independence:* assessors and committees releasing the certification or report guarantee their absence of conflict of interests with the organization to be certified;
- *Correct behavior:* European standards disallow offers of consultancy either directly or through associated organizations;
- *Competence:* accreditation certifies primarily that those performing the assessment are culturally, technically and professionally qualified.

Accreditation regards all sectors of production and service which are of daily concern to users because every type of activity subjected to evaluation, for example, construction, energy, environment, transportation, health and education.

The accreditation is a complex process that**:**

- Promotes the improvement of the offer of certification through the enhancement of regulations, also making use of funds from the standardization bodies UNI (the Italian National Unification body) and CEI (the Italian Electrotechnical Committee) for matters concerning the connection between laws and voluntary standardization;
- Studies new accreditation schemes and develops guidelines for the harmonized evaluation of reference standards in order to meet the growing and diverse socio-economic demands of the country;
- Helps to promote the request for quality which, in an increasingly aware population, continues to rise;
- Contributes to the creation of trust in society.

Accreditation is a service undertaken in the public interest so that business users, final consumers and authorities can have trust, right through to the final link in the production and distribution chain, in the quality and safety of the goods and services available in an increasingly globalized market.

Reciprocal trust between producer and purchaser of goods, between supplier and user of a service, is a conquest for the efficiency of contemporary market functions, both public and private, national and international.
According to the n.443Ministerial Decree the Italian accreditation body is *Accredia*, a member of the *European Accreditation*.
Accredia was created by the merger of *Sinal* (Sistema nazionale per l'accreditamento dei laboratori di prova) and *Sincert* (Sistema Nazionale per l'Accreditamento degli Organismi di Certificazione e Ispezione) and the contribution of *SIT* (Servizio di Taratura in Italia) - *INRIM* (Istituto Nazionale di Ricerca Metrologica), *Enea* (Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile) and *ISS* (Istituto Superiore di Sanità), as a recognized non-profit-distributing association.[4]
The National Body is responsible for accreditation in compliance with the international standards of the series ISO 17000 and of the guides and the harmonized series of European norms EN 45000.
The family UNI CEI EN ISO IEC 17000 is the legal framework essential to the accreditation bodies, for the bodies of product certification, management systems, personnel, inspection and for the testing and calibration laboratories since explicit requirements of professionalism and competence that agencies and laboratories must meet.
The EN 45000 series cover accreditation for different types of conformity assessment bodies:

– certification bodies;
– testing laboratories;
– inspection bodies;
– accreditation bodies.

Basically they assess the organization and management of the body rather than the technical requirements relating to the operation of the body.
Accredia evaluates the technical competence and professional integrity of conformity evaluation operators (laboratories and bodies), evaluating compliance with mandatory regulations and voluntary norms in order to ensure the value and credibility of the attestations they release.
Its activities are divisible into four main departments represented in figure 1.

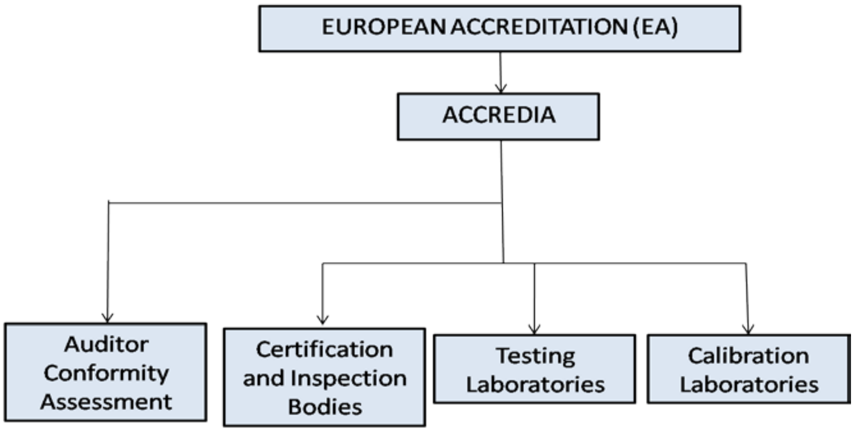

Figure 1 - Accredia activities

The accreditation guarantees that testing, inspection and certifications respect the most stringent international requirements. The certification indicates the compliance of a process, system, product, event, or skill to the specific standards. The certificate is a form of communication between seller and buyer, the label is a form of communication with the end consumer. For an effective communication the system must be transparent, information on the content and the organization behind the label should be accessible and should be not cause any misunderstanding.

Certification Body

The primary purpose of the certification body is to operate and manage the certification program, including the certification of manufacturers' products. It can be an existing certification body, a new body created by a PV trade association, or a new body organized by a PV industry segment.

For legal reasons, the certification body should be incorporated. It should be governed by a board of directors

that includes persons dealing, for example, with industry participants such as manufacturers, the public sector, and PV technical representatives. The functions of the body are handled by committees of persons from these same interests. An executive director manages the certification program on a day-to-day basis and interfaces with the operational committees as an ex officio member.

A committee on test methods and standards is responsible for adopting test procedures needed for certification.

In this capacity it maintains official liaisons with the domestic committees active in PV standards development and maintenance. It must continuously update the test procedures to conform to the relevant standards, as well as additional requirements as they arise.

The laboratory committee adopts, develops, and modifies the testing laboratory accreditation requirements.

It reviews, and accepts or rejects, assessment reports submitted by laboratory assessors or the accreditation body. From these reports, it selects one or more laboratories based on need, full or partial capability versus needs, testing fees, and ability to meet scheduling requirements.
The committee develops and maintains a between-assessment surveillance and reviews the program for accredited laboratories.
A product certification and rating committee reviews and evaluates results of qualification and electrical performance tests submitted by the laboratory. After evaluating any discrepancies and requesting any needed additional information, it renders a decision on the suitability of an applicant's product for certification. If the product is deemed suitable, it requests the executive director to issue a license to allow the manufacturer to use the certification mark or label.
Several other committees handle functions such as manufacturers quality-system and licensing compliance, and auditing and financial concerns. An appeals board handles appeals of test and audit results, technical disputes involving test laboratories, disputes between participants and the certification body, complaints from participants or users about other certified product, and complaints about misuse of certification labeling.

ISO standards

The International Organization for Standardization is a voluntary, independent, non-governmental organization, the members of which are the standards organization of the member countries out of the total countries in the world. It is the world's largest developer of voluntary international standards and facilitates world trade by providing common standards between nations. Nearly twenty thousand standards have been set covering everything from manufactured products and technology to food safety, agriculture and healthcare.
Use of the standards ensures that products and services are safe, reliable and of good quality. The standards help businesses increase productivity while minimizing errors and waste. By enabling products from different markets to be directly compared, they facilitate companies in entering new markets and assist in the development of global trade on a fair basis. The standards also serve to safeguard consumers and the end-users of products and services, ensuring that certified products conform to the minimum standards set internationally.

ISO's members are recognized authorities on standards, each one representing one country. Members meet annually at a General Assembly to discuss ISO's strategic objectives. The organization is coordinated by a Central Secretariat based in Geneva.

A Council with a rotating membership of 20 member bodies provides guidance and governance, including setting the Central Secretariat's annual budget. The Technical Management Board is responsible for over 250 technical committees, who develop the ISO standards.

ISO has formed joint committees with the International Electrotechnical Commission(IEC) to develop standards and terminology in the areas of electrical, electronic and related technologies.

ISO/IEC JTC 1 is the committee on Information technology. Joint Technical Committee 1 (JTC 1) was created in 1987 to "develop, maintain, promote and facilitate IT standards". ISO/IEC JTC 2 is the Joint Project Committee for Energy efficiency and renewable energy sources, created in 2009 for the purpose of "standardization in the field of energy efficiency and renewable energy sources".

ISO has three membership categories:

- Member bodies are national bodies considered the most representative standards body in each country. These are the only members of ISO that have voting rights;
- Correspondent members are countries that do not have their own standards organization. These members are informed about ISO's work, but do not participate in standards promulgation;
- Subscriber members are countries with small economies. They pay reduced membership fees, but can follow the development of standards.

Participating members are called "P" members, as opposed to observing members, who are called "O" members

ISO's main products are international standards. ISO also publishes technical reports, technical specifications, publicly available specifications, technical corrigenda, and guides

International standards are designated using the format ISO/IEC/Title/ number of the standard/optional part number/ year published.

Technical reports are issued when a technical committee or subcommittee has collected data of a different kind from that normally published as an International Standard, such as references and explanations. The naming conventions for these are about the same as for standards.

Technical specifications may be produced when "the subject in question is still under development or where for any other reason there is the future but not immediate possibility of an agreement to publish an International Standard". A publicly available specification is usually "an intermediate specification, published prior to the development of a full International Standard, or, in IEC may be a 'dual logo' publication published in collaboration with an external organization". By convention, both types of specification are named in a manner similar to the organization's technical reports.ISO also sometimes issues "technical corrigenda". These are amendments made to existing standards due to minor technical flaws, usability improvements, or limited-applicability extensions. They are generally issued with the expectation that the affected standard will be updated or withdrawn at its next scheduled review.

ISO guides are meta-standards covering "matters related to international standardization". They are named using the format "ISO/IEC Guide/date/ Title. (For example: ISO/IEC Guide 2:2004 Standardization and related activities — General vocabulary).

Most popular standards are [5]:

ISO 9000 - Quality management - Make sure your products and services meet customers' needs with this family of standards.

ISO 14000 - Environmental management - Improve your environmental performance with this family of standards.

ISO 3166 - Country codes - Avoid confusion when referring to countries and their subdivisions with this standard.

ISO 22000 - Food safety management - Inspire confidence in your food products with this family of standards.

ISO 26000 - Social responsibility - Help your organization to operate in a socially responsible way with this standard.

ISO 50001 - Energy management - Make energy savings and help make your organization more efficient with this standard.

ISO 31000 - Risk management - Manage risks that could be negative for your company’s performance with this standard.

ISO 4217 - Currency codes - Avoid confusion when referring to world currencies with this standard.

ISO 639 - Language codes - Describe languages in an internationally accepted way with this standard.

ISO 20121 - Sustainable events - Manage the social, economic and environmental impacts of your event with this standard.

ISO 27001 - Information security - Ensure your organization's information is secure with this family of standards.

CHAPTER 2:STATE OF THE ART IN CERTIFICATION

Certifications for the market

For decades certification has been developed as an instrument for promoting sustainable management of many aspects of modern life. ISO was the most important initiative worldwide. In the recent time a strong need of commercial guarantees arose from the globalized market, especially in the emerging development economies and countries. Nowadays, some challenges arise from the predictable development of the certification service in some sectors, despite of the spectacular growth trend of their related services demand. Among them, reasons for this disparity are: weak market demand for certified products in global markets; wide gaps between existing management standards and certification requirements; weak implementation of national legislation, policies and programs in many countries; insufficient capacity to implement sustainable management at the unit level and to develop standards and delivery mechanisms; and the high direct and indirect costs of obtaining certification. Despite these challenges and constraints, many countries remain interested in pursuing certification. Among the most emerging sectors, nowadays energy and environment are coming out to dominate the certification need arising from the respective markets, and joint those similarly important for human life, more or less traditional, related to safety, health, security and transport.

In this section, according to the definitions and classification exposed in the previous chapter, a summarized survey of most popular certification types and mechanisms is made. This survey corresponds to a short state of the art of certification services, limited to those which are more or less directly related to the aspects of certification of products or services , specifically addressing technological guarantees anyhow possibly required by the markets. In particular product certification and energy certifications are handled.

Product Certification

Product certification or product qualification is the process of certifying that a certain product has passed tests of performance and quality assurance, and meets qualification criteria stipulated in contracts, regulations, or specifications(typically called "certification schemes" in the product certification industry).

Most product certification bodies (or product certifiers) are accredited to ISO/IEC Guide 65:1996,an international standard for ensuring competence in those organizations performing product certifications. The organizations which perform this accreditation are called Accreditation Bodies, and they themselves are assessed by international peers against the ISO 17011 standard. Accreditation bodies which participate in the International Accreditation Forum (IAF) Multilateral Agreement (MLA)also ensure that these accredited Product Certifiers meet additional requirements set forth in "IAF GD5:2006 - IAF Guidance on the Application of ISO/IEC Guide 65:1996".

Examples of some certification schemes include the Safety Equipment Institute for protective headgear, the U.S. Federal Communications Commission(FCC) Telecommunication Certification Body (TCB) program for radio communication devices, the U.S. Environmental Protection Agency Energy Star program, the International Commission on the Rules for the Approval of Electrical Equipment Product Safety Certification Body Scheme (IEECE CB Scheme), and the Greenguard Environmental Institute Indoor Air Quality program. Certification schemes are typically written to include both the performance test methods that the product must be tested to, as well as the criteria which the product must meet to become Certified.

<u>Voluntary Product Certification</u>

A Voluntary Product Certification can make reference to recognized standards developed by ISO (International Standard Organization) or accredited by Notified Bodies as TPS (Technical Product Specification).
TPS is a public document which describes the most significant characteristics of products, the performed testing and used analytic methods.
In all cases the certification includes the quality assurance evaluation, the production process monitoring and product samples testing. Samples are valued on the basis of the parameters of product specifications and the risk admissible levels for both consumers and producers.

<u>Product Certification process</u>

A product can be verified to comply with a specification or stamped with a specification number. This does not, by itself, indicate that the item is fit for any particular use. The person or group of persons who own the certification scheme (i.e., engineers, trade unions, building code writers, government, industry, etc.) have the responsibility to consider the choice of available specifications, choose the correct ones, set qualification limits, and enforce compliance with those limits. The end users of the product have the responsibility to use the item correctly. Products must be used in accordance with their listing for certification to be effective.
Product certification is often required in sensitive industry and marketplace areas where a failure could have serious consequences, such as negatively effecting the health and welfare of person using that product.
The process for a product certification is generally summed up in four steps:

- Application (including testing of the product);
- Evaluation (does the test data indicate that the product meets qualification criteria);
- Decision (does a second review of the product application concur with the Evaluation);
- Surveillance (does the product in the marketplace continue to meet qualification criteria).

In many instances, prior to applying for certification, a product supplier will send a product to the testing laboratory (some certification schemes require the product to be sent out for testing by the product certifier instead). When the product to be certified is received at the testing laboratory, it is tested in accordance with the laboratory's internal procedures and with the methods listed in the test standards specified by the certification scheme. The resulting data are collected by testing laboratories and then forwarded either back to the manufacturer, or directly to the product certifier.

The product certifier then reviews the product supplier's application information, including the testing data. If the certifier's evaluation concludes that the test data show that the product meets all required criteria as listed in the certification scheme, and the decision maker(s) of the product certifier concur with the evaluation, then the product is deemed "certified" and is listed in a directory which the Product certifier is required to keep.ISO Guide 65 requires that the final decision to grant or not grant certification be made only by a person or group of persons not involved in the evaluation of the product.

Products often need periodic recertification, also known as surveillance. This requirement is typically identified within the certification scheme of concern. Certification bodies may require product suppliers to perform some sort of surveillance activity, such as pulling sample products from the marketplace for testing, in order to maintain their "listed" or "certified" status. Other examples of Surveillance activities include surprise audits of the manufacturing plant, supervision of the manufacturing and/or testing process, or a simple paperwork submittal from the supplier to the product certifier to ensure that the certified product has not changed. Other causes for recertification may include complaints issued against the product's functionality which would require removal from the marketplace, and expiration of the original certification. These lists of examples are by no means all inclusive.

Some certification schemes, or the product certifiers which operate those Schemes, may require that the product supplier operate a Quality Management System registered to ISO 9000, or that the testing be performed by a laboratory accredited to ISO 17025.The decision to set these requirements is most often made by the person or group which owns the Certification Scheme.

CE mark

The CE mark certifies that a product has been evaluated and meets the EU requirements in the field of safety, health and environmental protection. It is mandatory for products that are made both inside and outside the EU and are commercialized within its territory.

In creating the European single market, the European Union (EU) has put in place specific safety legislation for certain categories of products on the market.

Under this legislation, manufacturers must declare that their products are safe. This declaration includes affixing the CE marking on the product. Importers have to verify that the manufacturer has undertaken the steps necessary to fulfill the declaration while distributors must act with due care and be able to identify and withdraw products that are unsafe. It is important to know that the CE marking does not indicate that products have been approved as safe by the European Union or by another authority nor it indicates the

origin of a product. Manufacturers shall evaluate the possible risks and make tests on a sample. Once they have done this, they must affix the CE marking on the product.
For certain products that present inherently higher risks, such as gas boilers or chainsaws, safety cannot be checked by the manufacturer alone. In such cases, an independent body, appointed by national authorities, has to perform the safety check. Only once this is done can the manufacturer affix CE marking on the product.
The responsibility to declare conformity with all requirements rests solely with producer, once it has obtained the CE mark the manufacturer may be required to provide distributors and/or importers with the supporting documentation.

There are a series of steps outlined below for CE mark approval, depending upon the product and risk level presented:

1. Determine the directives to be applied to the product;
2. Choose the conformity assessment procedure from the options (modules) mentioned in the specific directive;
3. Check if the product must be tested by an independent national authority;
4. Test the product;
5. Prepare a technical dossier to prove the product's conformity to the technical requirements;
6. Affix the CE mark and draw up a declaration of conformity.

There are several modules available for the Conformity Assessment Procedures as listed below:

- Module A: internal production control;
- Module Aa: intervention of a Notified Body;
- Module B: CE type-examination;
- Module C: conformity to type;
- Module D: production quality assurance;
- Module E: product quality assurance;
- Module F: product verification;
- Module G: unit verification;
- Module H: full quality assurance.

To classify the level of risk manufacturer shall refer to a chart called "Conformity Assessment Procedures" that includes all of the acceptable options.[6]

System Certification

The system certification shall certify, specifically, the ability of an organization to structure and to manage its activities in conformity with the reference standard, with the main goal to meet the customer needs. In this context the topic of certifying a Management System is expanded, starting from its definition.

A Management System is the framework of processes and procedures used to ensure that an organization can fulfill all tasks required to achieve its objectives. For instance, an environmental management system enables organizations to improve their environmental performance through a process of continuous improvement, while an occupational health and safety management system (OHSMS) enables an organization to control its occupational health and safety risks and to improve its performance.

Examples of Management System reference standards, among others, are:

- UNI EN ISO 9001:2015 – Quality Management System _Requirements;
- UNI EN ISO 14001:2004 – Environmental Management System _Requirements;
- UNI EN ISO 50001:2011– Energy Management System _Requirements with guidance for use;
- UNI CEI ISO IEC 27001:2014 – Information technologies - Techniques for safety - Management systems for information security _Requirements;
- UNI EN ISO 22000:2005– Food safety management systems.

Integrated management systems certification

The certification of integrated management systems (quality, environment and safety) attests that organizations are equipped with an integrated business management system that enables them to deal synergistically with mandatory requirements and demands of the market.

The ISO 9001, 14001, 50001, ISO/IEC 27001, SA8000 and the specification OHSAS 18001 are respectively the references for the quality, environmental management, energy management, information security, social responsibility and the safety of the workers.

The presence in the company of an integrated project allows to simultaneously realize the improvement in:

- Organization Performance;
- Environmental responsibilities;
- Energy management;
- Management of health and the risks;
- Customer satisfaction.

The integration is a function of the business choice take as reference two or more of the above-mentioned standards. In certain cases only one of the systems above mentioned is applied, to meet personal needs or market demands. In the following paragraph the Energy Management System will be presented.

An example of product and service certification: Railway certification

The railway sector is characterized by a strong transnational connotations therefore all those investments promoting interoperability and intermodality are fundamental.

The Directive 08/57/CE has as its purpose the definition of procedures to be met in order to achieve the conditions necessary to ensure the interoperability of the trans-European rail system.

The Interoperability is defined as the capability to operate on any stretch of the network without any difference, going through the different systems on the EU's railways. To this end, subsystems and rail components should be subject to a procedure of a CE verification, subject to conditions of the Technical Specifications for Interoperability (TSI).

In Italy, the legislation has been transposed by the D. Lgs. 191/2010, it provides on a component or a subsystem of the railway system the verification of the Interoperability must be carried out with reference to the TSI.

The European and National legislative frame is represented in Table 1**:**

Scope	TENs	Type	TSI	Status	Decision/Reg	Date	Document	Comments
Transverse	On	Structural	Control, Command and Signalling	TSI	2012/88/EU	25/01/2012	Decision	Applicable from 23/08/12 (NB repeals Dec 2006/679/EC and Dec 2006/860/EC)
Transverse	On	Structural	Control, Command and Signalling	Amendment	2012/696/EU	10/11/2012	Decision	Standards or other documents referenced in Regulation 1299/2014
Transverse	On & Off	Structural	Control, Command and Signalling	Amendment	2015/14/EU	07/01/2015	Decision	Applicable from 01/07/15 (NB amends Decision 2012/88/EU)
Merged (HS & CR)	On & Off	Structural	Energy	TSI	Reg 1301/2014	12/12/2014	TSI	Applicable from 01/01/15 (NB repeals Dec 2008/284/EC and Dec 2011/274/EU)
Merged (HS & CR)	On & Off	Structural	Infrastructure	TSI	Reg 1299/2014	12/12/2014	TSI	Repeals Decisions 2006/679/EC & 2006/860/EC (applicable from 23/08/12)
Conventional	On	Operational	Operation and Traffic Management	Amendment	2012/464/EC	14/08/2012	Decision	Applic. from 22/07/12 (NB repeals and replaces Annex III to Regulation 454/11)
Transverse	On	Operational	Operation and Traffic Management	TSI	2012/757/EU	15/12/2012	Decision	Applic. from 01/01/14 (NB amends Dec 2011/314/EU rep by Dec2012/757/EU)
Transverse	On	Operational	Operation and Traffic Management	Amendment	2012/757/EU	15/12/2012	Decision	Applicable from 01/01/13 (NB amends Decision 2012/88/EU)
Transverse	On	Operational	Operation and Traffic Management	Amendment	2013/710/EU	02/12/2013	Decision	Applic. from 01/01/14 (NB repeals Decision 2008/231/EC and Dec2011/314/EU)
Transverse	On & Off	Structural	Persons with ReducedMobility	TSI	Reg 1300/2014	12/12/2014	TSI	Applicable from 01/01/15 (repeals Decision 2006/861/EC)
High Speed	On	Structural	Rolling Stock	TSI	2008/232/EC	26/03/2008	TSI	Applicable from 01/01/14 (NB amends Decision 2012/756/EU)
High Speed	On	Structural	Rolling Stock	ApplStandards	N/A	N/A	Appl Stand	Applicable from 01/01/14 (NB amends Regulation 321/2013)
High Speed	On	Structural	Rolling Stock	Amendment	Reg 1302/2014	12/12/2014	Regulation	Applicable from 07/12/13 (NB amends Regulation 454/2011)
Conventional	On	Structural	Rolling Stock (Freight Wagons)	TSI	Reg 321/2013	13/03/2013	TSI	Applicable from 01/01/14 (NB amends Decision 2012/757/EU)
Conventional	On	Structural	Rolling Stock (Freight Wagons)	Amendment	Reg 1236/2013	02/12/2013	Regulation	Applicable from 01/01/15
Merged (HS & CR)	On & Off	Structural	Rolling Stock (Locom& Pass Carriages)	TSI	Reg 1302/2014	12/12/2014	TSI	Applicable from 01/01/15 (NB repeals Decision 2008/217/EU and Dec 2011/275/EU)
Conventional	On & Off	Transverse	Rolling Stock (Noise)	TSI	Reg 1304/2014	12/12/2014	TSI	Applicable from 01/01/15 (NB repeals Decision 2008/164/EC)
Transverse	On & Off	Transverse	Safety in RailwayTunnels	TSI	Reg 1303/2014	12/12/2014	TSI	Applicable from 01/01/15 (NB repeals Decision 2008/163/EC)
Transverse	On & Off	Operational	Telematic Applications for Freight	TSI	Reg 1305/2014	12/12/2014	TSI	Applicable from 01/01/15 (NB repeals Decision 2011/291/EU)
Transverse	On	Operational	Telematic Applications for Passengers	TSI	Reg 454/2011	05/05/2011	Regulation	Applicable from 01/01/15 (NB repeals Regulation 62/2006/EC)
Transverse	On	Operational	Telematic Applications for Passengers	Amendment	Reg 665/2012	21/07/2012	Regulation	Applicable from 01/01/15 (NB repeals Decision 2011/229/EU)
Transverse	On	Operational	Telematic Applications for Passengers	Amendment	Reg 1273/2013	06/12/2013	Regulation	Applicable from 08/12/13 (NB amends Regulation 454/2100)
ConformAssess	On				2010/713/EU	04/12/2010	Decision	Applicable from 01/01/15 (NB amends Decision 2008/232/EC)

Table 1The European and National legislative frame

According to the Decision 661/2010 / EU of the Union guidelines for the development of trans-European transport network, the rail trans-European system is divided into:

– Trans-European high-speed system;
– European conventional rail system.

The rail system is composed of:

- Structural subsystems: infrastructure , Power, Control - Command and Signaling, Rolling Stock;
- Functional subsystems: operation and traffic management, maintenance, telematics applications for passenger and freight.

Where each subsystem applies one or more TSI and it incorporates the components for the Interoperability.

The Certification of Interoperability involves the following subsystems railway:

- Signaling On-board;
- Rolling Stock;
- Energy;
- Infrastructure;
- Service (Maintenance);
- Noise, operations management and traffic, accessibility for people with disabilities.

For the certification of interoperability, the Notified Body begins its activities in design and continues throughout the construction period and until the entry into service of the subsystem.

The verification procedure can be aimed to the activation of a new railway or the adaptation of an existing with technical specifications dependent on the "intended use".

The methodology of attestation CE is structured in the following steps:

- Evaluation of the implementation of Quality Management System by the supplier of the specific component, (check requirements);
- Evaluation of the manufacturer's documentation;
- Presence in Laboratory Tests Test Witnessing;
- Audit of Quality requirements;
- Audit of technical requirements;
- Exam service/maintenance documentation;
- Audit Report and emission of any technical notes;
- Preparation of the reports of final evaluation;
- Preparation of the technical dossiers for the verification for the component/subsystem;
- Emission of the CE certificates in accordance with the forms provided and in accordance with the guidelines.

The process of CE verification of a subsystem is intended to check the compliance of the subsystem with the requirements of the relevant TSI and possibly the National Technical Standards applicable.

The CE verification of a subsystem is conducted by a Notified Body and is carried out according to certain procedures established by Council Decision 2010/713 / EU.

The CE verification affects both the design phase, in which it conducts the examination of project, and the construction, assembly and final test, in which they are acquired evidence to demonstrate compliance of the project.

At the conclusion of the CE verification the Notified Body issues a "CE Certificate" that shows the results of the audit with information on requirements and application conditions for the operational management of the subsystem in operation conditions. On the basis of the certificate of EC verification of the notified the Contracting Authority issues a "Declaration of CE verification" of the subsystem.

Energy certification: the frame

The following are the major types of energy certification of interest for this study:

- Certification of management systems, energy and environmental, as: ISO 14001 or EMAS or ISO 50001;
- Certification of product / process: Energy Star , LEED , The Planet Mark;
- Certification of energy performance: when specifically concerns the buildings;
- Certification of personnel: is about qualifications and experience of staff for energy management systems and energy / environmental audits.

In the following paragraphs will be developed those of major interest for this study.

The Energy Management System ISO 50001

The UNI EN ISO 50001:2011 standard specifies requirements for establishing, implementing, maintaining and improving an Energy Management System (EnMS), that is a set of interrelated or interacting elements to establish an energy policy and its objectives, as well as the processes and procedures to achieve those objectives (from the ISO 50001). The ISO 50001 has been designed to be used independently but it can be aligned or integrated with other management systems. It is applicable to any organization wishing to ensure that it conforms to its stated energy policy and to demonstrate this to others.[7]

The standard is divided into four sections :

a. Purpose and scope;
b. Normative References;
c. Terms and definitions;
d. Requirements of the Energy Management System (EnMS).

The general requirements of a EnMS consists that the organization shall:

a) Establish, document, implement, maintain and improve an EnMS in accordance with the requirements of this International Standard;

b) Define and document the scope and boundaries of its EnMS;
c) Determine how it will meet the requirements of this International Standard in order to achieve continual improvement of its energy performance and of its EnMS.

The energy policy shall state the organization's commitment to achieving an improvement of performances. Top management shall define the energy policy and ensure that it:

a) Is appropriate to the nature and scale of the organization's energy use and consumption;
b) Includes a commitment to continual improvement in energy performance;
c) Includes a commitment to ensure the availability of information and of necessary resources to achieve objectives and targets;
d) Includes a commitment to comply with applicable legal requirements and other requirements to which the organization subscribes related to its energy use, consumption and efficiency;
e) Provides the framework for setting and reviewing energy objectives and targets;
f) Supports the purchase of energy-efficient products and services, and design for energy performance improvement;
g) Is documented and communicated at all levels within the organization;
h) Is regularly reviewed, and updated as necessary.

Its focus is on the performance of the organization on the energy performance in the specific and above requires that energy efficiency is considered all along the distribution chain of the organization, down to the suppliers.

It applies to all variables affecting energy performance that can be monitored and influenced by the organization. It does not prescribe specific performance criteria with respect to energy.

The organization shall establish, implement and maintain a documentation to describe the core elements of the EnMS and their interaction.

The EnMS documentation shall include the:

- Scope and boundaries of the EnMS;
- Energy policy;
- Energy objectives, targets, and action plans.

The organization shall ensure that the key factors that determine energy performance are monitored, measured and analyzed at planned intervals, keeping safe recording the results. Therefore, depending on the specific organization an energy measurement plan shall be defined and implemented.

The implementation process of an EnMS consists in:

- Identifying the most significant energy aspects of the organization;
- Analyzing and assess their criticality and weaknesses;
- Defining the operational choices and act on the basis of the objectives identified (PLAN);
- Realizing the measures identified (DO);

– Evaluating the efficiency of these measures and analyze any new weaknesses (CHECK);
– Putting in place as planned by defining new goals (ACT).

In Figure 2 an energy planning process diagram extracted from the UNI EN ISO 50001:2011 is shown.

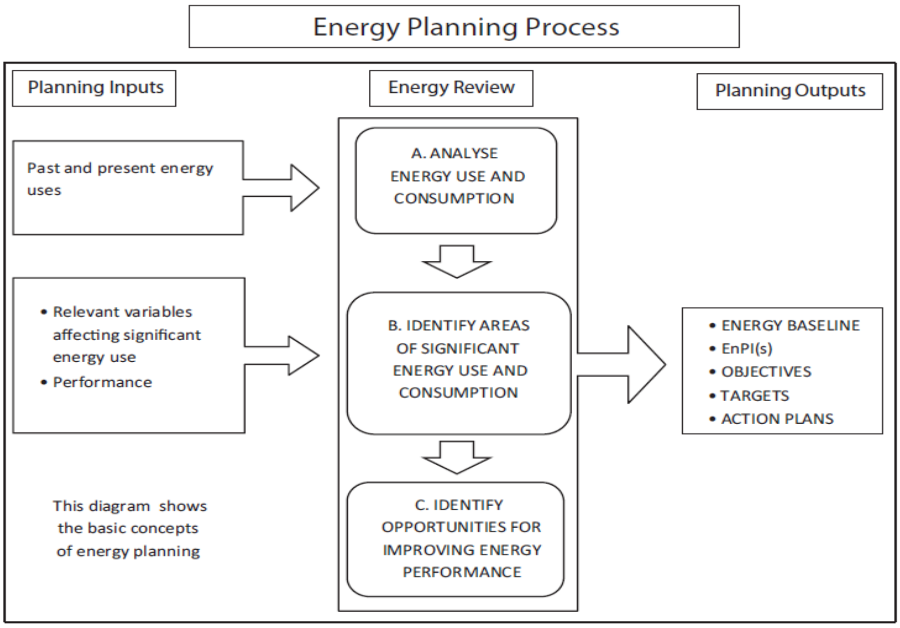

Figure 2 Energy planning process diagram (from the UNI EN ISO 50001:2011)

The main benefits of its implementation consist in:

– Having a systemic approach to the definition of energy objectives and identifying the right tools to achieve them;
– Identifying opportunities for improvement (also in energy efficiency);
– Ensuring compliance with all statutory and regulatory requirements;
– Reducing costs related to energy consumption;
– Achieving competitive advantages.

Energy Star certification

The *Energy star* is a U.S. Environmental Protection Agency (EPA) voluntary program that helps businesses and individuals save money and protect climate through results on energy efficiency.
It was established by EPA in 1992. It directs the administrator to "conduct a basic engineering research and technology program to develop, evaluate, and demonstrate non–regulatory strategies and technologies for reducing air pollution." In 2005, Congress enacted the Energy Policy Act. Section 131 of the Act amends Section 324 (42 USC 6294) of the Energy Policy and Conservation Act "established at the Department of Energy and the Environmental Protection Agency a voluntary program to identify and

promote energy efficient products and buildings in order to: reduce energy consumption, improve energy security, reduce pollution through voluntary labeling about products and buildings that meet the highest energy efficiency standards."

Under EPA's leadership, American consumers, businesses, and organizations have made investments in energy efficiency that are transforming the market for efficient products and practices, creating jobs, and stimulating the economy. Now in its 23rd year, the Energy Star program has boosted the adoption of energy efficient products, practices, and services through valuable partnerships, objective measurement tools, and consumer education. The Energy Star blue label on appliances, electronics, light bulbs, and other products means that it will save energy and money during operation, without any sacrifices in performance.

Among others, commercial buildings and industrial plants can earn EPA's *Energy Star*, where buildings and plants, if certified, use less energy, are less expensive to operate, and cause fewer greenhouse gas emissions than their peers. Starting with the first Energy Star certified building in 1999, tens of thousands of buildings and plants across America have already earned EPA's *Energy Star* for superior energy performance. Currently, there is a Portfolio Manager, a free online tool, for measuring and tracking of energy use, water use and greenhouse gas emissions for commercial buildings, while Industrial plants can use other tools, called Energy Performance Indicators.

Both tools calculate a 1 – 100 *Energy Star* score. Facilities that score a 75 or higher are eligible to apply for *Energy Star* certification. Before facilities can earn the *Energy Star*, a professional engineer or registered architect must verify that the information contained within the certification application is accurate.

Through *Energy Star Portfolio Manager*, the EPA's online tool, more than 150 different metrics can be assessed that give insights about the performances. It's useful to compare a property's energy performance to similar properties nationwide. It takes into account the experiences of the first period of program implementation, and contains new demanding and innovative energy efficiency criteria. *Energy Star* is part of the Community strategy to better manage energy demand, contribute to security of energy supply and mitigate climate change. [8]

The benefits of obtaining the *Energy Star* certification are:

- Have lower operating cost;
- Be more marketable;
- Contribute fewer greenhouse gas emissions to the environment;
- Increase asset value;
- Increase the credibility and visibility of the brand;
- Achieve the green building certification: *Energy Star* is the program for certifying energy-efficient buildings because this certification ensures that the building uses less energy and leaves a smaller carbon footprint;

– Show the proven results to the stakeholders about financial performance plus environmental performance.

Leadership in Energy and Environmental Design (LEED)

Nowadays, the earth's natural resources are being depleted at a growing rate and the construction industry is being compelled to look at alternatives to traditional construction materials and styles.

LEED is Leadership in Energy and Environmental Design (LEED), a third-party certification program. It is a nationally accepted organization for design, operation and construction of high performance green buildings. This ensures the buildings are environmentally compatible, provide a healthy work environment and are profitable. To LEED New Construction buildings are awarded points for sustainability for things like, among others, energy-efficient lighting, low-flow plumbing fixtures and collection of water. Therefore, Recycled construction materials and energy efficient appliances impact on the point rating system. LEED New Construction certification and Energy Star ratings seem to be the future of construction projects. It's important to build energy efficient buildings, healthy for their occupants and that they not harm the environment.

The LEED prerequisites are:

- Lower operating costs and increase asset value;
- Reduce waste sent to landfills;
- Conserve energy and water;
- Be healthier and safer for occupants;
- Reduce harmful greenhouse gas emissions;
- Qualify for tax rebates, zoning allowances and other incentives in hundreds of cities.

The 2009 version of LEED was structured of three major areas: harmonization between rating systems, credit weightings, and regionalization. One of the most important changes with LEED 2009 was the introduction of a new credit weighting system based, in part, on user requirements and changing market conditions. Consequently, greater emphasis was placed on those strategies that yield greater benefits in the areas of energy efficiency and CO2 reduction. Another change with LEED 2009 was the addition of regional priority credits, which awards additional points based on the achievement of credits pertaining to specific regional environmental issues. As a result of this restructuring, the total number of possible LEED base points was increased from 69 to 100 when using the standard categories, with a maximum of 110 points being possible if regional priority and innovation bonus points are included.

As of 2011, LEED was comprised of nine separate rating systems, each focusing on a different aspect of the built environment. Those rating systems was grouped under seven different reference guides, as below.

The LEED rating system offers four certification levels for new construction -- Certified, Silver, Gold and Platinum -- that correspond to the number of credits accrued in five green design categories: sustainable sites, water efficiency, energy and atmosphere, materials and resources and indoor environmental quality. LEED standards cover new commercial construction and major renovation projects, interiors projects and existing building operations. Standards are under development to cover commercial "core & shell" construction, new home construction and neighborhood developments.

Before the design phase it's necessary to decide to what level of LEED certification aim for and settle on a firm overall budget, set a clear and adequate budget. Higher levels of LEED certification, such as Platinum, do require additional expenditure and should be budgeted for accordingly. [9]

The LEED New Construction buildings:

– Have higher occupancy than non-certified ones;
– Are Rented them for a higher amount per square feet than non-certified ones;
– Have a market demand higher than not certified ones;
– Allow to take advantage of a growing number of state and local government incentives.

Green Building Design and Construction Reference Guide		**Credits**
LEED for New Construction and Major Renovation	It focuses typically on commercial buildings and may include multi-story residential complexes that are either newly constructed or undergoing major renovation (which may include major alterations to the building envelope, the HVAC system or renovation of interior spaces).	• MR Credit 6: Rapidly Renewable Materials • MR Credit 7: Certified Wood • IEQ Credit 4: Low Emitting Materials
LEED for Schools	Similar to the non-school version of New Construction, LEED for Schools also addresses issues unique to academic spaces including acoustics, air quality, and master planning.	• MR Credit 6: Rapidly Renewable Materials • MR Credit 7: Certified Wood • IEQ Credit 4.4: Low Emitting Materials – Composite Wood
LEED for Core & Shell	Also similar to New Construction, Core & Shell addresses only the base building components, including HVAC, structure and envelope. This system may also be used by developers and owners of multi-tenant buildings in conjunction with Commercial Interiors, thereby allowing further green development of the interior	• MR Credit 6: Certified Wood • IEQ Credit 4.4: Low Emitting Materials – Composite Wood and Agrifiber Products
Building Design and Construction Reference Guide: Healthcare Supplement		
LEED for Healthcare	It addresses the unique demands of healthcare within the context of New Construction and focuses on care facilities, offices, and education and research centers.	• MR Credit 3: Sustainably Sourced Materials and Products • MR Credit 5: Furniture and Medical Furnishings
Building Operations & Maintenance Reference Guide		
LEED for Existing Buildings	Applicable to existing buildings not undergoing major renovations and focuses predominately on issues pertaining to building operation and maintenance, which includes purchasing guidelines, waste management, air quality and green cleaning processes and procedures.	• MR Credit 1: Sustainable Purchasing – Ongoing Consumables • MR Credit 2.2: Sustainable Purchasing – Furniture • MR Credit 3: Sustainable Purchasing – Facility Alterations and Additions • IEQ Credit 3.3: Green Cleaning – Purchase of Sustainable Cleaning Products and Materials

Homes Reference Guide		
LEED for Homes	It focuses on residential construction and looks at many of the same areas as New Construction.	MR Credit 2.2: Environmentally Preferable Products
Interior Design and Construction Reference Guide		
LEED for Commercial Interiors	Looks at interiors in the context of tenant owned or leased spaces within a larger building, such as office, retail or institutional buildings. This system is designed to work with Core & Shell.	• MR Credit 6: Rapidly Renewable Materials • MR Credit 7: Certified Wood • IEQ Credit 4.4: Low Emitting Materials – Composite Wood and Agrifiber Products
LEED for Retail Reference Guide		
LEED for Retail	Designed to address a wide range of retail-specific issues in two different areas, which are 1) New Construction & Major Renovation, and 2) Commercial Interiors. The Retail versions of these are similar to their respective non-retail versions, but incorporate a variety of issues such as multi-tenant retail complexes, retail furnishings, and spatial occupancy in a retail setting.	• MR Credit 6: Rapidly Renewable Materials • MR Credit 7: Certified Wood • IEQ Credit 4: Low Emitting Materials (IEQ Credit 4.4 in CI)
Neighborhood Development Reference Guide		
EED for Neighborhood Development	Looks at green neighborhood development integrating principles of New Urbanism, smart growth, and green infrastructure.	

Table 2 Estimation criterion for LEED

Italcertifer's activities

Italcertifer SpA arose from requirements introduced by the European Union on the implementation of the principle of free movement of goods and people within the European Union (EU), which is a large and growing community of states spread across a road and rail network connecting every corner of its territory.

The absence of obstacles and boundaries strongly affects on the vitality of the transport network, which must allow millions of people and goods to move about safely. An exchange without limits, from which emerged the need of railways "without borders". To achieve this goal, then, the interoperability of the European railway network is fundamental.

To develop a trans-European rail system interoperable, the EU has issued over the past 15 years directives for both the high-speed network that for the conventional network, then transposed by the Italian State with appropriate Legislative Decrees.

These decrees identify basically <u>three macro-processes</u>:

1. The realization: conducted by manufacturers, infrastructure managers, railway companies;
2. The certification: carried out by the Notified Bodies and Independent Verifiers of Security;
3. Authorization of commissioning, made from the ANSF (Railway Safety National Agency).

All the actors which contribute to provide interoperability must require the certification of components and subsystems to obtain the permission to put them onto the railway market and for commissioning.

The interoperability of the trans-European rail system is ensured by respect the Technical Specifications for Interoperability (TSI), that prescribe the requirements for components and subsystems interoperable.

As part of the implementation process, the Notified Bodies operate for checks and certification.

In order to meet these demands "Italcertifer S. C. s.p.a." (the Italian Institute of Research and Railway Certification) is born in 2001, whose original members were *RFI*, *Trenitalia*, *polytechnic of Milan* and the *University of Florence, Pisa and Naples*.

Italcertifer carries out its certification activities and evaluation of products and subsystems, starting from the design stage, through documentary analysis and simulations prototypes, also carried out with the help of virtual reality techniques, continuing the construction phase and testing and final checks.

In order to carry out all necessary checks Italcertifer also uses their own laboratories, accredited by the competent authority and placed in a structure independent from the process of evaluation and certification, in addition, it uses those of University institutes affiliated and those external, which operate in accordance with the rules of the railway sector national and European with credited proofs or qualified by Italcertifer. All laboratories are divided into specialist areas of expertise as required by the Legislative Decrees.

Italcertifer represents today a center of excellence in the field of certification and inspection not only in the field of rail transport.

Italcertifer is qualified for the transport sector and meets all the requirements of certification in the field of European rail and offers support the organizations working, among others, in the national and international railway sector.

Following the needs of a market and an economy that is increasingly complex and internationalized Italcertifer is able to provide high value added services capable of giving a competitive advantage in different industrial sectors.

The selection of verification and certification carried out by *Italcertifer* are:

Inspections

Inspections and evaluations for railway safety

Issued by the ministry of infrastructure and transport according to the Decision 57 /2008/CE transposed by the Legislative Decree 191, October 08, 2010. Approved to issue certificates of conformity and suitability for the use of interoperable components indicated by the various technical specifications TSI Approved to issue the certificate of CE verification for all railway subsystems.

Inspections and evaluations for the rail transport

Issued by the national agency for the safety of railways according to Directive 2008/57/EC adopted by Legislative Decree 162, August 10, 2007.

Approved to issue evaluation reports interim and final for all of the subsystems by rail for the purposes of ensuring the safety of exercise.

Inspections and tests for the purposes of validation of civil projects and industrial

Accredited by Accredia according to the UNI CEI EN 45011. Approved to issue certificates of conformity of all products /services/processes that may find application in the various rail subsystems.

Inspections and evaluations different sectors

Accredited by Accredia according to UNI CEI EN ISO/IEC 17020 type "a".

Approved to issue of inspection reports on all the products/ equipment/ subsystems/ services/ processes that find application in various subsystems. Approved to issue of verification reports of projects for the purposes of relevant validation in accordance with Legislative Decree 163/2006 art. 112 on public contract.

Certifications

Interoperable rail components certification of compliance

Issued by the ministry of infrastructure and transport according to the Decision 57 /2008/CE transposed by the Legislative Decree 191,October 08, 2010. Approved to issue certificates of conformity and suitability for the use of interoperable components indicated by the various technical specifications TSI.

Approved to issue the certificate of CE verification for all railway subsystems.

Certification of CE verification of subsystems by rail for the high speed and conventional

Issued by the national agency for the safety of railways according to directive 2008/57/EC adopted by Legislative Decree 162, August 10, 2007.

Approved to issue evaluation reports interim and final for all of the subsystems by rail for the purposes of ensuring the safety of exercise.

Certification compliance' products, services and processes with applications in the transport service on rail

Accredited by Accredia according to the UNI CEI EN 45011. Approved to issue certificates of conformity of all products /services/processes that may find application in the various rail subsystems.

Compliance certification of management systems and skills

Accredited by Accredia according to UNI CEI EN ISO/IEC 17020 type "a".

Approved to issue of inspection reports on all the products/ equipment/ subsystems/ services/ processes that find application in various subsystems. Approved to issue of verification reports of projects for the purposes of relevant validation in accordance with legislative decree 163/2006 art. 112 on public contract.

This procedure apply to the certification of products using in rail systems, interoperable and not, trans-European high-speed and conventional, with particular reference to:

1. conformity assessment of products in rail and metropolitan application;
2. evaluation of conformity or suitability for the components interoperability;
3. "EC" verification of conformity of the subsystems .

The certification procedure includes the following activities:

Certification request;

- Planning of the evaluation procedure;
- Documents verification;
- Verification of the activities on the field;
- Surveys;
- Action planning view (written by the customer);
- Certificate release;
- Audit planning for checking.

An example of possible Third Party Product Certification Programs for PV plant components

There are three options that are used for product certification programs: certification body assessment (option l), independent assessment (option 2), and testing laboratory certification (option 3). In option 1, a certification body assesses the test laboratory(s) as well as certifies products.

Option 2 is similar to option 1, except that the test laboratory assessment is performed by an independent assessment agency. The assessment agency uses the requirements of the certification body to perform laboratory assessments. For option 3, a single test laboratory also certifies product. The criteria for model PV certification program recommends using independent assessment. This option frees the certification body from the additional burden of laboratory assessment, and is advantageous for liability reasons.

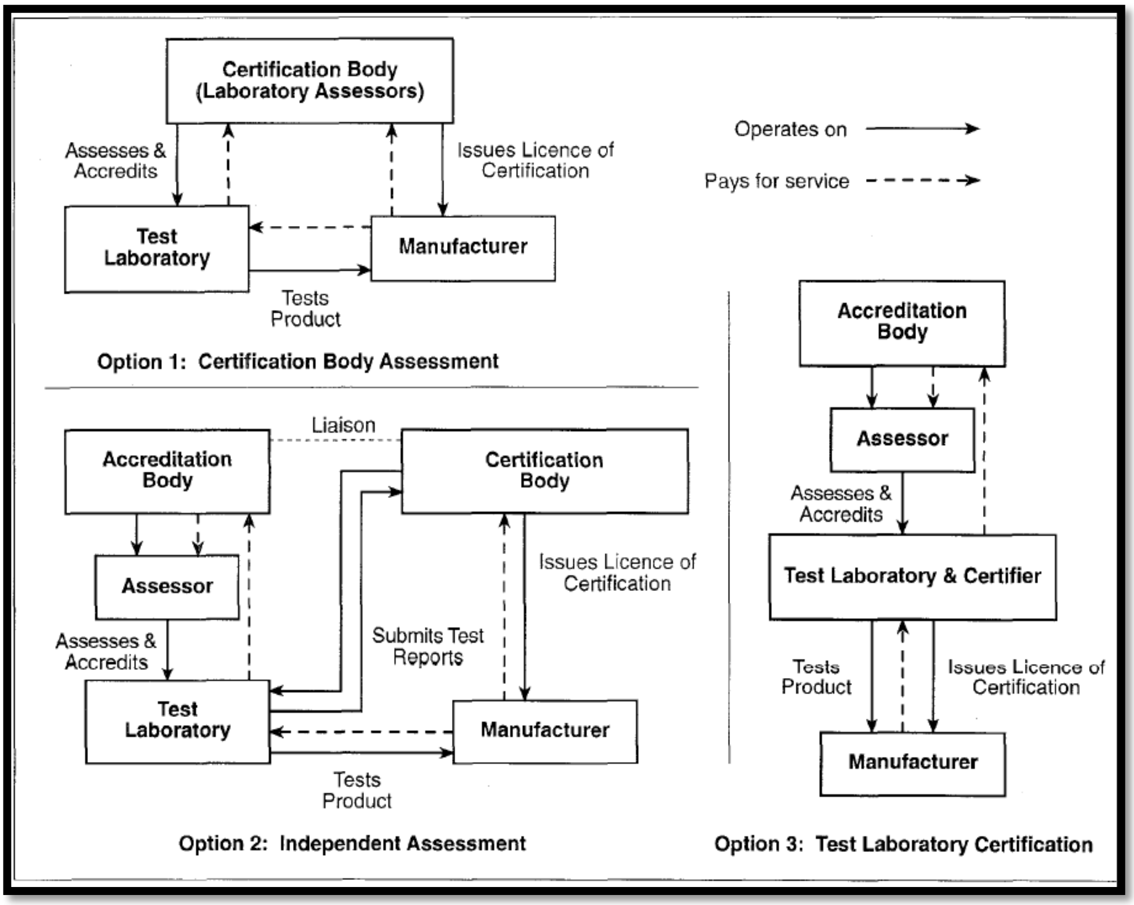

Figure 3

Testing Laboratory Options

Several laboratory options are also available for product testing in a certification program: single full-service laboratory, multiple full-service laboratories, and multiple partial-service laboratories. There are advantages and drawbacks for each of these.

A single full-service laboratory is the easiest to accredit and monitor, and systematic errors are not randomized among multiple laboratories. On the other hand, it is noncompetitive and thus testing costs are higher, and the single laboratory can become technically complacent.

Having multiple full-service laboratories available solves the non-competition disadvantage, but increases the complexity needed for administration of the certification program. Also, all errors are randomized among laboratories, which may result in differences. Testing costs may actually be higher for this option because the testing volume, which may be limited, is distributed among the multiple laboratories.

The multiple partial-service laboratories option may actually be required in the initial stages of a certification program if no single laboratory has the ability to perform all the certification testing. Its major drawback is the need to transport test samples between the participating laboratories, which increases costs and risks in-transit damage and loss.

Because of the present lack of third-party testing services in the PV industry, it was not possible to recommend one of these options at the present time. This question will have to be answered after the certification program is initiated. [10]

CHAPTER 3 – EVOLUTION OF TECHNOLOGY AND SERVICES

Evolution of power systems physical Structure

Modern civilization depends heavily on energy extracted from burning fossil fuels, which results in the release of greenhouse gases (carbon dioxide, methane, nitrous oxide) to the atmosphere causing global climate change. Electricity accounts for about 24% of greenhouse gas emissions now, but electricity consumption is expected to grow from 18 trillion KWh in 2006 to 32 trillion KWh in 2030, a 77% increase. This means that 4800 GW of new electricity generation plants must be added, more than half of which will be from developing countries [11].

A drastic reduction of global carbon emissions cannot be reached without a significant contribution from the electricity sector. A fundamental transformation in the electricity generating, delivering and utilizing must take place, and "decarbonizing" the power sector is necessary.
Basic actions to face these challenges are:

- Carbon Capture and Storage, if feasible and safe;
- Reduce energy use;
- Improve energy efficiency;
- Develop and expand low carbon energy sources;
- Major contributions from solar renewable sources;
- Energy economic policies;
- Political and financial support.

Power markets worldwide have been monopolistic for the most part of the 20th century, but in the recent years a significant restructuring process has occurred. In fact, since the 1980s, the trend in many countries has been to reshape the traditional regulated power industry in a more open way, supporting an encouraging competition and increasing its efficiency. Starting from the World War II the electricity market was subject to an increasing evolution for the occurrence of various events, as: the energetic crisis of the 70s, demographic development, climatic changes and advancement of Information and Communication Technologies (ICT).
Several structures for deregulated energy markets have been proposed over the years in different countries. Among these, the *power pool* has been the most successful one. In such a market, producers compete for serving the consumers' demand, each one aiming to maximize its own profits by means of strategic bidding in the *power pool*. Hence, in deregulated electricity markets, more freedom is left to the players. In fact, price results from the intersection between supply and demand as it typically happens in a competitive market. A characteristic of energy markets consists in the high entry barriers, i.e. conspicuous investments and longtime are needed for new actors. As a consequence, the deregulation process may

lead to an oligopolistic situation where few big players can manipulate the market through strategic bidding.

In Italy in 1999, according to the *Bersani* Decree (DLgs 79/1999), liberalization of the electricity market happened, involving production and distribution sectors, leaving out transmission that is still a monopolistic system, under the jurisdiction of the State.

Figure 4 depicts the role of ICT in the liberalized electricity market according to a generalized international scheme [12]

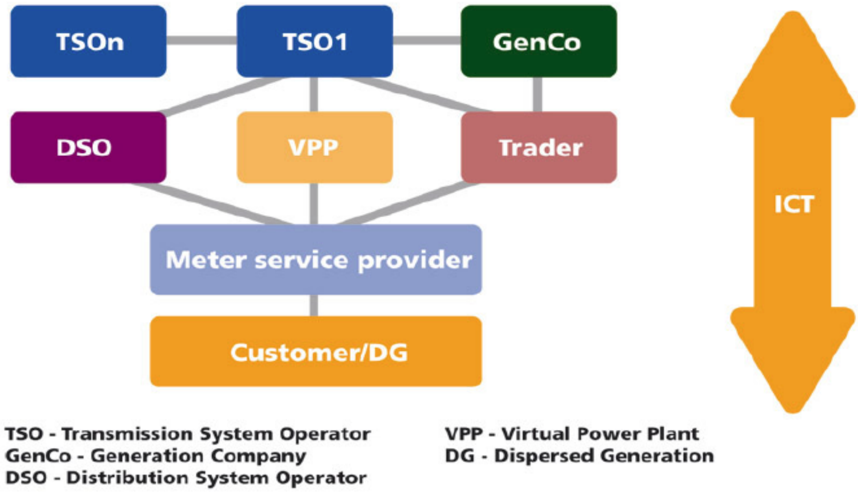

Figure 4 **ICTs in liberalized electricity market**

The Italian Market of electricity

The Italian Electricity Market arises from Legislative Decree no. 79 of 16 March 1999 (Legislative Decree 79/99), which transposed the European Directive on the internal market in electricity (96/92/EC) into the national legislation.

As in other international experiences, the creation of a market responds to two specific requirements:

- Promoting competition in electricity generation, sale and purchase, under criteria of neutrality, transparency and objectivity, through the creation of a marketplace;
- Ensuring the economic management of an adequate availability of ancillary services.

The Electricity Market consists of the Spot Electricity Market (MPE), of the Platform for physical delivery of financial contracts concluded on IDEX (CDE) and of the Forward Electricity Market (MTE)(Figure5) [13]

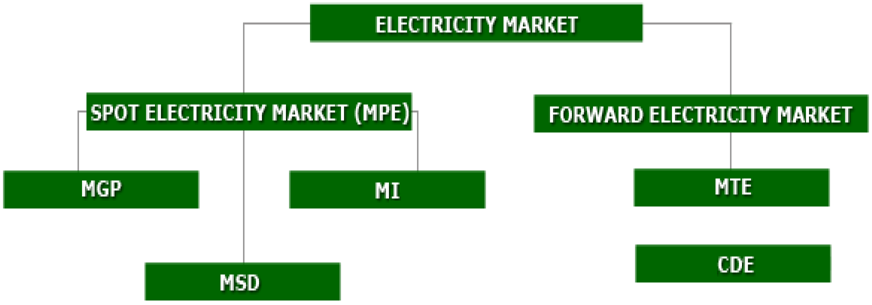

Figure 5 - Italian market of electricity

The Spot Electricity Market

The Spot Electricity Market (MPE) consists of:

a) Day-Ahead Market - MGP (energy market);
b) Intra-Day Market - MI (energy market);
c) Ancillary Services Market- MSD.

The Day-Ahead Market (MGP)hosts most of the electricity sale and purchase transactions.

- In the MGP, hourly energy blocks are traded for the next day;
- Participants submit offers/bids where they specify the quantity and the minimum/maximum price at which they are willing to sell/purchase;
- The MGP sitting opens at 8 a.m. of the ninth day before the day of delivery and closes at 12 p.m. of the day before the day of delivery. The results of the MGP are made known within 12.55 p.m. of the day before the day of delivery;
- Bids/offers are accepted after the closure of the market sitting based on the economic merit-order criterion and taking into account transmission capacity limits between zones. Therefore, the MGP is an auction market and not a continuous-trading market;
- All the supply offers and the demand bids pertaining both to pumping units and consuming units belonging to foreign virtual zones that are accepted in the MGP are valued at the marginal clearing price of the zone to which they belong. This price is determined, for each hour, by the intersection of the demand and supply curves and is differentiated from zone to zone when transmission capacity limits are saturated;
- The accepted demand bids pertaining to consuming units belonging to Italian geographical zones are valued at the “National Single Price” (PUN – Prezzo Unico Nazionale); this price is equal to the average of the prices of geographical zones, weighted by the quantities purchased in these zones;
- GME acts as a central counterparty.

The Intra-Day Market (MI) allows Market Participants to modify the schedules defined in the MGP by submitting additional supply offers or demand bids. Supply offers and demand bids are selected under the same criterion as the one described for the MGP.

▪ Unlike in the MGP, accepted demand bids are valued at the zonal price.

▪ GME acts as a central counterparty.

The Ancillary Services Market (MSD)is the venue where Terna S.p.A. (the Transmission System Operator of Italy) procures the resources that it requires for managing and monitoring the system relief of intra-zonal congestions, creation of energy reserve, real-time balancing. In the MSD, Terna acts as a central counterparty and accepted offers are remunerated at the price offered (pay-as-bid).

The MSD consists of a scheduling substage (ex-ante MSD) and Balancing Market (MB). The ex-ante MSD and MB take place in multiple sessions, as provided in the dispatching rules.

The MB takes place in different sessions, during which Terna selects bids/offers in correspondence of the hours on which the related MB session takes place. In the MB, Terna accepts energy demand bids and supply offers in order to provide its service of secondary control and to balance energy injections and withdrawals into/from the grid in real time.

The Forward Electricity Market

The Forward Electricity Market (energy market) is the venue where forward electricity contracts with delivery and withdrawal obligation are traded.

These are its main characteristics:

- All Electricity Market Participants are automatically admitted to the MTE;
- Trading in the MTE takes place on a continuous basis;
- In the MTE, the tradable contracts are of the following types: Base-Load and Peak-Load, with monthly, quarterly and yearly delivery periods. The contracts with quarterly and yearly delivery periods are regulated by the "cascading" mechanism;
- Market Participants submit orders where they specify the type and period of delivery of the contracts, the number of contracts and the price at which they are willing to purchase/sell.
- After the trading period, the contracts with monthly delivery are registered as corresponding transactions onto the PCE, after the adequacy verifications that are referred to in the PCE Rules.
- Also OTC contracts may be registered in the MTE.
- GME acts as a central counterparty.

The electricity grid

Until a few years ago, power system was characterized by large production plants managed by a unique company. Power flew in the grid, from producers to users (unidirectional flow).

Modern electric grid is a complex system divided for convenience, into several subsystems: generation, transmission, substation, distribution, and consumption (Figures6-7).

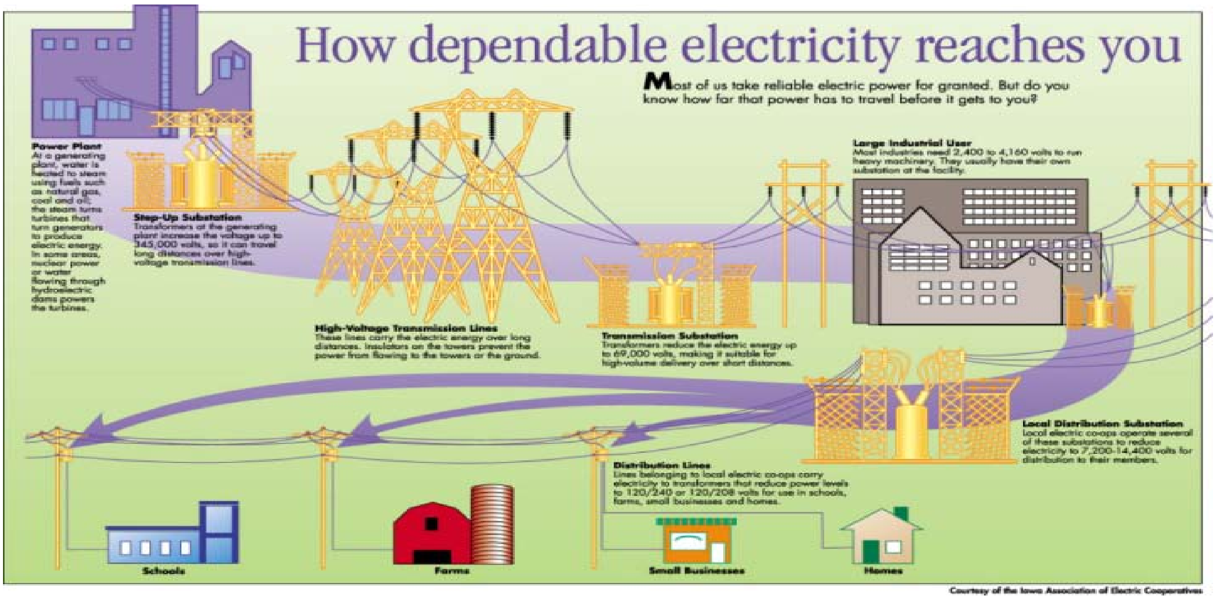

Figure 6Typical electricity grid [http://www.absolutepowertc.com/blog/]

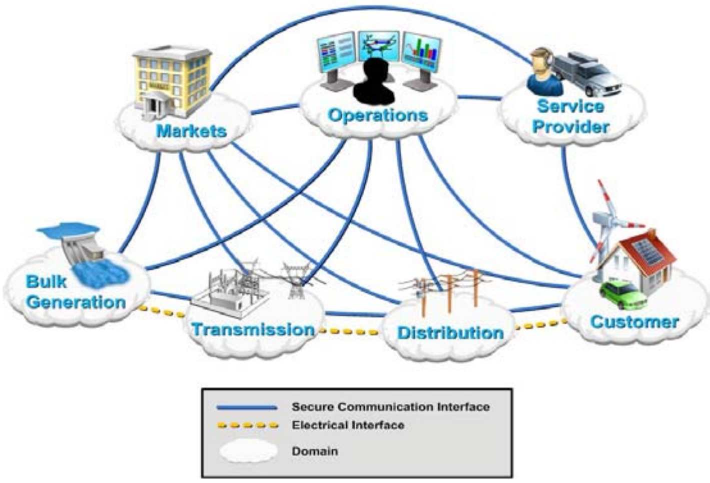

Figure 7Smart Grid and Dynamic Power Management –[Dave Hardin]

A typical power system consists of a few hundred generators interconnected by a transmission network serving several hundred (transmission/distribution) substations. From a substation downward, the distribution network has a simple topology and connects to a large number of consumer loads, along its path in a substantially treelike structure with feeders (trunks), laterals (branches), and loads (leaves).

The grid was built when generation was concentrated in a small number of large generators and load demand was to be met anywhere anytime. It was designed for generators whose outputs were controllable, with load that were passive.

The feature target will be to obtain a dynamic grid with several aims, such as: reduction of losses, power balancing, reduction of voltage drops and increase of reliability. Thus, system security, operation safety, environmental protection, power quality, cost of supply and energy efficiency need to be examined in new ways in response to changing requirements in the liberalized market environment above mentioned.

The Main innovative technological challenges consists in the equipment for a bidirectional communication among the different areas for their interactions.

As far as technical and structural aspects, the transformation of electrical systems was characterized as follows:

- Unbundling of management and operative systems activities at generation, transmission and distribution levels, verified following the liberalization of production, distribution and sale;
- Diffusion of the distributed generation downstream the transmission involves the distribution grid «active»;
- Inlet of various control architectures necessary for the energy dispatching in the different electric areas;
- Introduction of smart technologies for compensation/adjustment, regulation and control;
- Evolution of the energy demand due to the changing in habits and to the introduction of new loads (for example Electrical Vehicles - EVs).

The existing grid is neither built nor designed for the presence of variable renewable sources generation and interactive demand response. Both integration of Distributed Generation (DG) and Renewable Energy Sources (RES), both demand side integration (DSI) and energy storage technologies turn out to be necessary to obtain a technologically advanced grid. High penetration of renewable generation and demand response have imposed an immense challenge to the operation of the electric grid.

Distributed Energy Resources (DERs) are sources generated or stored by a variety of small grid-connected devices. DER systems are decentralized, modular and more flexible technologies, that are located close to the load they serve, albeit having capacities of only 10megawatts(MW) or less. DER systems typically use renewable energy sources, including small hydro, biomass, biogas, solar power, wind power, geothermal power and play an increasingly important role for the electric power distribution system. Distributed generation and storage enable collection of energy from many sources and may lower environmental impacts and improve security of supply.

The rate of adoption of these sources (RES - DER) will be driven faster as the economic and environmental benefits improve(Figure 8).

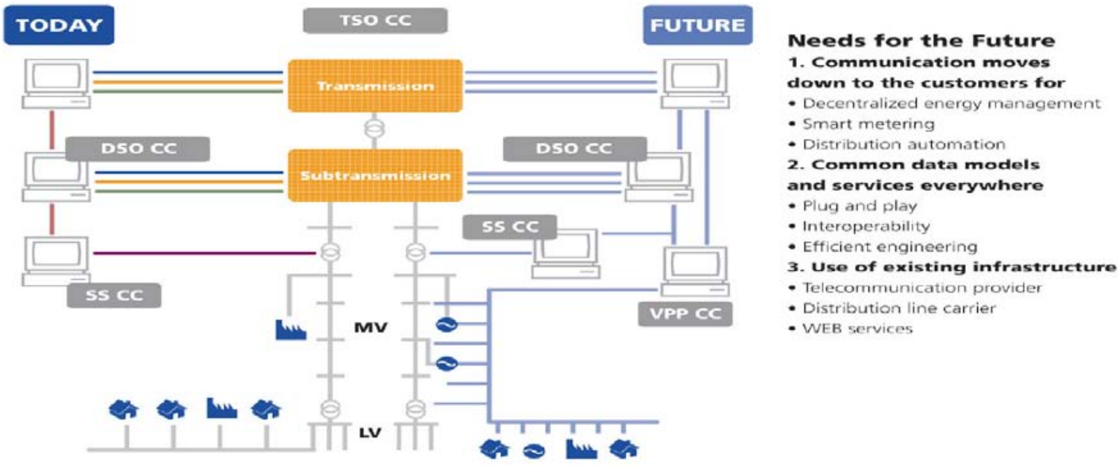

Figure 8 Market schemes

Smart Grid

According to the *European Technology Platform*, a *Smart Grid* is an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that assume both roles – in order to efficiently deliver sustainable, economic and secure electricity supplies.

Smart Grid systems consist of digitally based sensing and communications, control technologies and field devices that function to coordinate multiple electric grid processes. A grid more intelligent than traditional ones, includes the application of information technology systems to handle new data and permits utilities to more effectively and dynamically manage grid operations. The information provided by smart grid systems also enables customers to make informed choices about the way they manage energy use.

The modernization of electricity networks is obtainable through the application of innovative and intelligent products, services and technologies to provide greater monitoring, automation, control, co-ordination of the transmission, distribution and generation (including distributed generation).

Major aims consist in increasing energy and cost efficiency, sustainability, energy security and the benefit and empowerment of customers and society.

Smart Grid Components

A smart grid is comprised of an increasingly extensive array of functionalities, capabilities and achievements. Some of key components include control, automation, protection, sensing, monitoring, demand response management and energy efficiency, and supporting infrastructure, as reported in the following list:

1. *Control, Automation and Protection:*

- FLISR (Fault Location, Isolation and Service Restoration);
- DLR (Dynamic Line Rating) allowing the increase of available transfer capability of transmission circuits;

- Advanced Relays;
- Advanced Voltage Management (e.g. VVO (Volt/Var optimization): implementation of FLISR. VVO enables users to improve the efficiency and reliability of distribution systems, reducing demand and environmental impact;
- Power Factor Correction;
- Fuse Savers;
- Advanced SCADA;
- Dynamic Rating;
- Load Transfer and Line Loading Analyses.

2. *Demand Response Management and Energy Efficiency:*

- Dynamic, Critical Peak Rebate and advanced Time of Use pricing;
- HEMS (Home Energy Management Systems) / Smart Home / Home Automation;
- Consumption Feedback (e.g. In Home Displays);
- Advanced Frequency Control of Residential and Commercial Appliances.

3. *Additional Supporting Infrastructure*

- Wireless and other Advanced Communications;
- Electric Vehicles and Electric Vehicle Charging;
- Distributed Generation;
- RAPS (Remote Area Power Supplies);
- Advanced Field Crew Management;
- Energy Storage;
- Cyber Security and Data Protection.

4. *Sensing and Monitoring*

- Advanced network status monitoring: what is connected to it, its capacity, its balance and stability, weaknesses and failures (including outages);
- Smart Meters: they record consumption of electric energy and communicate that information at least daily back to the utility for monitoring and billing. They enable two-way communication between meters and central system.

Deployment in power system sections

The following sections provide an overview of deployment in four key technological areas - Advanced Metering Infrastructure, transmission, distribution and customer systems.

Major areas of developments considered are the following:

- Smart metering: it implies getting metering data from all possible measurement points including end of the feeder over communications in order to maintain proper distribution voltage level for all consumers. This includes deploying voltage regulators, capacitor banks, switches, and other devices in the distribution network;

- Advances in communication: they imply real-time communication between the consumer, the network, and the generation station, so the utility can balance load demand in both directions. Advanced communications are also needed for manual or automatic reconfiguration of the network in case some components of the network are experiencing failures or deficiencies;
- Advanced protective relays and other control devices with enhanced communications and algorithms capabilities: to automatically detect, isolate, and reconfigure the grid to maintain uninterruptable power supply;
- Fast deployment of renewable energy sources in the distribution network: Wind power, solar power, hydro power units will increase their capacity and output. Energy storage systems will be deployed to help system to meet peak demand and offload system generators.

Advanced Metering Infrastructure (AMI)

AMI encompasses smart meters, the communication networks that transmit measurement data to the utility at regular intervals (hourly or shorter), and the utility office management systems (such as meter data management systems) that receive, store, and process the meter data.

AMI requires significant investment, and adoption barriers remain for utilities. Concerns about meters safety, costs and consumer privacy protections are being addressed, and enhanced consumer education is necessary.

The following terms are used when smart metering is discussed: Automated Meter Reading (AMR), Advanced Meter Management (AMM), and Automated/Advanced Metering Infrastructure (AMI).

Smart meters enable hourly based meter reading and communication with the utilities. AMR technology enables remote reading on an hourly basis. This makes it possible for the billing to be based on real time consumption and therefore use of hourly tariffs. Remote reading can be done for example via power line communication (PLC) and/or GSM/GPRS connection. AMM is a variation of AMR that includes also two-way communication which enables more sophisticated functions, such as demand response.

AMI refers to overall system, that measures remotely read and analyzes the consumption. Different meters, such as electricity, gas, heat, and water meters can be added to the AMI. The system can also remotely manage measured data and send commands with two way communication. The most significant advantages, which smart metering can offer for microgrid operation, are communication link and demand response.

AMI enables a wide range operational and efficiency improvements to reduce costs, including:

- Improved outage management from meters that alert utilities when customers lose power;
- Improved voltage management from meters that convey voltage levels along a distribution circuit;
- Measurement of two-way power flows for customers who have installed on-site generation;
- Improved billing and customer support operations.

Transmission System Upgrades

Transmission system modernization includes the application of digitally based equipment to monitor and control local operations within high-voltage substations and wide-area operations across the transmission grid. Synchrophasor technology, which uses devices called Phasor Measurement Units (PMUs) to measure the instantaneous voltage, current, and frequency at substations, is being deployed to enhance wide-area monitoring and control of the transmission system. Sophisticated software applications allow grid operators to identify growing system instabilities, detect frequency and voltage oscillations, and see when the system exceeds acceptable operating limits before they jeopardize grid stability. Additionally, synchrophasor data enable improved coordination and control of generators, including renewable resources (e.g., wind power plants), as they interact with the transmission grid.

Utilities are already using synchrophasor data to improve the engineering models that simulate and explain how individual power plants and large system interconnections perform. Engineers design and operate the grid using mathematical models that predict how a power plant or other transmission assets will operate under various normal and abnormal conditions, and use these models to set grid operating limits and manage real-time operations and contingencies. These models are intended to prevent the high costs of potential power plant damage or large regional blackouts.

Distribution System Upgrades

The main function of an active distribution network is to efficiently link power generation with consumer demands, allowing to decide how to best operate in real-time. Power flow assessment, voltage control and protection require cost-competitive technologies and new communication systems where information and communication technology (ICT) play a key role.

Distribution level is now experiencing an evolution because it needs to be more “smart”, in order to:

- Facilitate access of distributed generation on a high share, from renewable energy sources (RESs);
- Enable local energy demand management, interacting with end-users through smart metering systems;
- Benefit from technologies already applied in transmission grids, such as dynamic control techniques, so as to offer a higher overall level of power security, quality and reliability.

Distribution grids are being transformed from passive to active networks, so decision-making and control are distributed, and power flows bidirectional.

Grid modernization at the distribution level includes the deployment of sensor, communication and control technologies that permit highly responsive and efficient grid operations.

Smart distribution technologies enable new capabilities to automatically locate and isolate faults, using automated feeder switches and reclosers, to dynamically optimize voltage and reactive power levels, and monitor health of assets to effectively guide the maintenance and replacement of equipment.

In addition, utilities are beginning to upgrade and integrate their computer systems for managing distribution grid operations including meter operations and customer support, outage management, automated operations within substations and distribution circuits, and asset management. The impetus for advancing and integrating distribution management systems comes from the significant inflow of new data from field devices, such as smart meters and sensors on equipment and lines that provide utilities with enhanced understanding of grid status and new capabilities for planning and operations.

Distribution automation technologies can enhance reliability and resilience while improving operational efficiencies.

Customer-Based Systems

Advanced technologies can provide customers with detailed information and greater control over energy usage when coupled with residential customer technologies—including programmable communicating thermostats, web portals, and in-home displays—and business and industrial technologies that include building or facility energy management systems. Customer-based systems enable and support demand response and time-based rate programs that promote more efficient customer energy use.

Giving feedback to customers about their energy usage encourages consumers to adjust their consumption based on price. This results in reductions in peak or overall electricity use. Time-based rate programs are growing but still reach only a small fraction of total applications. Deploying AMI with customer-based systems and time-based rates can reduce electricity demand during peak periods to improve asset utilization and defer new capacity needs.

Advancement of smart grid technologies

Progress in smart grid deployment is being made in many areas:

- Advanced metering infrastructure (AMI);
- Customer-based technologies, such as programmable communicating thermostats for residential customers and building energy management systems for commercial and industrial customers, work with smart meters to make energy usage data accessible and useful to customers;
- The integration of sensing, communications, and control technologies with field devices in distribution systems is improving reliability and efficiency;
- The deployment of advanced sensors and high-speed communications networks on transmission systems is advancing the ability to monitor and control operations at high-voltage substations and across the transmission grid.

The integration of these technologies and practices will require both a faster-acting and a more flexible grid, as well as new business and regulatory approaches. There will be a need to maintain reliability, especially as consumers and third-parties become more involved in the management and generation of electricity. Also, long-term investment strategies will be needed to effectively balance competing demands for reliable, efficient, secure, and affordable electricity delivery.

Main differences of smart grid and traditional grid are presented in Table 3.

	Traditionaldistributiongrid		Smartgrid	
	LV	MV	LV	MV
Communicatio	None	Some	Sometwo-way	Two-way
Production	None	Centralized	DG	DG+centralized
	Blackout	Reconnections+	Islanding+adapt	Self-
	Manual	Manual+Semi-	Manual+Semi-	Self-healing
Powerflow	One-way	One-way	Two-way	Two-way
Monitoring	None	Lowlevel	Lowlevel	Highlevel
Relays	None	Somedigital	Somedigital	Digital

Table 3 - **Main differences between traditional grid and Smart Grid.**

As can be seen from the table above, the development is expected to happen in several functionalities. Smart grid can be seen as much more flexible than traditional distribution grid. In addition to two-way power flow, the most eye-catching changes are the characteristics of monitoring, communication, and self-healing.

Distributed energy resources

Distributed energy resources (DER) are important parts of future smart grids. DER unit can be either an energy production unit or an active load. Distributed production units are the base of microgrids. Nowadays the role of renewable energy sources is growing because of the targets to decrease of CO2 emissions and use of fossil fuels. Traditionally, power levels of renewable energy units are significantly lower than in traditional coal or gas plants.

Distributed energy resources can be divided into separate categories according to the nature of the energy resource. Intermitted renewable production includes wind power and solar power. Wave energy has intermittent nature too. Typical for intermitted production is variability of output power which sets some challenges for the system operation and power balance. Thermal driven production and hydro power are more constant and the output power can be adjusted according to the needs. Energy storages include rotating masses, such as flywheels, and storages, such as batteries or fuel cells.

Intermittent renewable production

Wind and solar power are examples of intermittent renewable production. These two production types are also the most popular in small scale electricity production. From the producer's point of view, they may become more interesting because investment price has decreased independently from financial support offered by governments. The greatest challenges related to wind or solar productions regard the variation of output power and lack of control capability that resources have. The variation causes that other power sources or loads need to compensate the variation of intermittent production. Consider that total amount of intermitted power is increasing because the power levels of production units are increasing and the amount of production units is increasing. Thus, intermittent renewable resources seem to be discussed even more.

Solar power

Solar energy is a primary energy source that generates many other energy sources, such as wind. Electricity can also be produced directly from sun radiation with photo voltaic (PV) modules. Another option to use solar power is to collect the energy as heat and then produce electricity from the heat with traditional steam turbine system. This kind of collector system is adapted in some large scale test plants. PV modules are more common in small scale usage and there are several different photovoltaic technologies in the market. Operation of PV module is based on PN-connection between semiconductors that convert the solar energy into direct current (DC). As the intensity of the sun radiation increases, the current increases but effect to the voltage level is small. In other words, PV panel is a current source where the voltage remains almost unchanged but the current varies according to sun radiation. The controllability of the solar power is limited because of its nature, although the DC to AC conversion enables some adjustability of the AC output power.

PV modules are common in private customer electricity production solutions. The most common ones are crystalline silicon modules that represent about 85% of global annual module sales. Thin films have 15% market share. Thin films are new solar cells that consist of thin layers of PV material. Weakness of the thin films is their lower conversion efficiency which usually means that larger area is needed to achieve the same power levels as with crystalline silicon PV modules. [14].

Solar power in Italy has been increasing rapidly in recent years. Installed photovoltaic nameplate capacity has increased nearly 15-fold from 2009 to 2013 and 2013's year-end capacity of 17,928 MW ranks third in the world. Solar power accounted for 7% of the electricity generated in Italy during 2013, a share that's expected to double by 2030.

As of December 2013, the installed capacity is approaching 18 MW (see next figure), with a production so important that several gas turbine power plants currently operate at half their potential during the day. The sector provides employment to about 100,000 people, especially in design and installation.

Wind power

In Italy, installed wind capacity reached 8,554 MW in 2013, with the addition of 434 MW net capacity during the year (a decrease of 66% in new installations with respect to 2012). This decrease is mainly due to the enforcement of the new supporting schemes of renewable energy systems (RES), in which the incentive access is constrained by established annual quotas, which involve a severe limitation for new installations compared with previous years.

Incentive tariffs depend on plant size and characteristics as well (i.e., land-based or offshore plant).

In 2013, 221 new turbines were deployed, reaching a total of 6,391 installed wind turbines. Wind electricity generation increased from 13.1 TWh in 2012 to 14.9 TWh (12%) in 2013, corresponding to about 4.7% of total electricity demand on the Italian system.

Issues affecting wind energy growth include the new support scheme mentioned above and permitting procedures, which still represent a bottleneck for new wind energy projects. With acknowledgement by the regions of the national guidelines issued in 2010 is expected to overcome this obstacle.
Another critical issue has been wind production curtailments ordered by the transmission system operator (TSO). The noteworthy efforts made by the TSO TERNA to upgrade the grid in order to match RES-production dispatching needs have resulted in a significant decrease in wind production curtailments, from 5.5% in 2010 to about 1% in 2012 and less than 1% in 2013. Moreover, the regulatory authority AEEG has provided for curtailed production to be estimated and wind park owners indemnified.
Consider that most of the large turbines installed in 2013 were supplied by foreign manufacturers. The market for small wind turbines is growing, reaching about 20 MW of overall installed capacity (estimated value).
Because of the lack of a coordinated national research program, wind energy R, D&D activities have been carried out by different entities, mainly CNR (National Research Council) and ENEA (the first and second national research institutions respectively), RSE (Research on the Electric System), Universities and other companies. [15]

Situazione impianti al 31/12/2013		Produttori	Autoproduttori	Italia
Impianti idroelettrici				
Impianti	n.	3.187	70	3.257
Potenza efficiente lorda	MW	22.260,2	122,7	22.382,9
Potenza efficiente netta	MW	21.890,5	118,8	22.009,3
Producibilità media annua	GWh	55.454,3	615,3	56.069,6
Impianti termoelettrici (*)				
Impianti	n.	3.434 *(34)*	637	4.071
Sezioni	n.	4.501 *(35)*	908	5.409
Potenza efficiente lorda	MW	74.903,5 *(773,0)*	4.370,4	79.273,8
Potenza efficiente netta	MW	71.595,7 *(729,0)*	4.182,9	75.778,6
Impianti eolici				
Impianti	n.	1.385	1	1.386
Potenza efficiente lorda	MW	8.560,8	0,0	8.560,8
Impianti fotovoltaici				
Impianti	n.	579.524	-	579.524
Potenza efficiente lorda	MW	18.420,3	-	18.420,3

Energia richiesta			
Energia richiesta Italia	GWh	318.475,1	
Deficit (-) Superi (+) della produzione rispetto alla richiesta	GWh	-42.137,6	(-13,2%)

Deficit 1973 = -879,0 Deficit 2013 = -42.137,6

Figure 9 Mix of production plants in Italy - 2013 [Terna]

Combined heat and power (CHP)

CHP production is common in large heat kettles that burn fossil fuels and also peat, wastes, or biofuels. Sort of new things in CHP production are micro turbines. Micro turbines are small gas or steam turbines that can be used for distributed energy production. The turbines work with heat that can be produced with multiple energy sources, such as wood chips, other biomass fuels, wastes or natural gas. Heated steam or burned gas rotates the turbine and then the turbine rotates power generator which generates electricity. Electricity production creates also some waste heat because the system has a quite low efficiency.

Therefore, combined heat and power production is recommended and usually applied at least in larger units. With combined heat and power production, the total efficiency can be improved. Efficiency in electricity production is usually about 25% but in CHP system the overall efficiency can be over 80%. [16]

Energy Storage

Batteries

Batteries are made of stacked cells where-in chemical energy is converted to electrical energy and vice versa. The desired battery voltage as well as current levels are obtained by electrically connecting the cells in series and parallel. Batteries are rated in terms of their energy and power capacities. For most of the battery types, the power and energy capacities are not independent and are fixed during the battery design. Some of the other important features of a battery are efficiency, life span (stated in terms of number of cycles), operating temperature, depth of discharge (batteries are generally not discharged completely and depth of discharge refers to the extent to which they are discharged), self-discharge (some batteries cannot retain their electrical capacity when stored in a shelf and self-discharge represents the rate of discharge) and energy density. Currently, significant development is going on in the battery technology. Different types of batteries are being developed of which some are available commercially while some are still in the experimental stage. The batteries used in power system applications so far are deep cycle batteries (similar to the ones used in Electric vehicles) with energy capacity ranging from 17 to 40MWh and having efficiencies of about70–80%. Of the various battery technologies, some seem to be more suitable (have been used) for power system applications and these have been discussed briefly below [17]:

1. Lead acid: each cell of a lead-acid battery comprises a positive electrode of lead dioxide and a negative electrode of sponge lead, separated by a micro-porous material and immersed in an aqueous sulfuric acid electrolyte (contained in a plastic case);
2. Sodium sulphur (NaS): aNaS battery consists of molten sulfur at the positive electrode and molten sodium at the negative electrode separated by a solid beta alumina ceramic electrolyte. The electrolyte allows only the positive sodium ions to go through it and combine with the sulfur to form sodium polysulfides. During discharge, positive sodium ions flow through the electrolyte and electrons flow in the external circuit of the battery producing about 2V. The battery is kept at about 300 ◦C to allow this process;
3. Lithium ion (Li ion): the cathode in these batteries is a lithiated metal oxide and the anode is made of graphitic carbon with a layer structure. The electrolyte is made up of lithium salts dissolved in organic carbonates. When the battery is being charged, the lithium atoms in the cathode become ions and migrate through the electrolyte toward the carbon anode where the combine with external

electrons and are deposited between carbon layers as lithium atoms. This process is reversed during discharge;

4. Metal air: the anodes in these batteries are commonly available metals with high energy density like aluminum or zinc that release electrons when oxidized. The cathodes or air electrodes are often made of a porous carbon structure or a metal mesh covered with proper catalysts. The electrolytes are often a good hydroxide(OH–) ion conductor such as potassium hydroxide (KOH). The electrolyte may be in liquid form or a solid polymer membrane saturated with KOH;
5. Flow batteries: this type of battery consists of two electrolyte reservoirs from which the electrolytes are circulated (by pumps) through an electrochemical cell comprising a cathode, an anode and a membrane separator. The chemical energy is converted to electricity in the electrochemical cell, when the two electrolytes flow through. Both the electrolytes are stored separately in large storage tanks outside the electrochemical cell. The size of the tanks and the amount of electrolytes determines the energy density of these batteries. However, the power density in flow-batteries depends on the rates of the electrode reactions occurring at the anode and cathode. Flow batteries are often called redox flow batteries, based on the redox (reduction–oxidation) reaction between the two electrolytes in the system.

Nowadays, prices of batteries are still too high for many purposes but if significantly lower costs can be achieved, it might be reasonable to use batteries as energy storage, not only in microgrid operation but also in utility network operation. If batteries with reasonable costs and good features can be achieved, the use of battery storages will probably increase exponentially.

Penetration of electrical vehicles (EVs) is totally dependent on the development in battery technology. Energy density and power density as well as the lifespan are critical issues in the battery technology. Inexpensive battery technology can enable the implementation of EVs. In addition, storage systems can be connected to the distribution system to smooth the power variations and enhance the power quality. This would be useful also for microgrids because energy storages could enable easier island operation and reduce the disadvantages caused by the intermittent energy production.

Supercapacitors

Supercapacitors are energy storages that can provide high peak power but only for a short time. Supercapacitors have ten times higher power density than batteries and supercapacitors are also lighter than batteries. Both discharging and charging processes are fast. Supercapacitors cannot be used for a long periods of time as energy sources because of their low energy density. Instead, they can be used for short duration energy releases to improve for instance voltage quality. Supercapacitors can also compensate switching transients and voltage sags. Some studies have even proposed control principles that use supercapacitors as dynamic voltage restorers to improve the power quality. One interesting use for supercapacitors could be next to the distributed generation units because supercapacitors could improve fault ride through capability of distributed generation. This kind of features that enable flexibility and better stability are more than welcome also in microgrid operation. However, all additional components come with a price and therefore costs and benefits need to be carefully considered before implementation. [18]

Fuel cells

Fuel cells are energy storages where basic components are anode, cathode, and electrolyte. In fuel cells, electricity is produced based on electrochemical reactions. The difference between batteries and fuel cells is that in fuel cells the power level is determined by the fuel cell and the amount of energy by the fuel storage and fuel itself. The vision is to use hydrogen as fuel for fuel cells. Hydrogen can be manufactured from water with electrolysis. Hydrogen is clean fuel and the only reaction product is water. The total emissions of hydrogen fuel cells depend on how the electricity, which is used in electrolysis, is produced. If electricity is produced with fossil fuels, the emissions are remarkable but if electricity is produced with renewable energy resource, hydropower or nuclear power, the emissions are small. Today, fuel cells are expensive and the lifespan is short. Fuel cells work best with steady power because current spikes shorten the life time of the cells. Fuel cells are interesting topic but so far any breakthrough is not expected. If the breakthrough happens, the most remarkable change from the electricity grid point of view would probably be the increasing amount of fuel cell powered electric cars. From microgrid point of view, fuel cells have similar positive effects as batteries but the costs are too high for implementation. [16]

Other distributed energy resources

In addition to energy storages and wind and solar power, there are also many other distributed energy resources. If traditional hydropower is forgotten, the number of these other DER units is limited in the today's network. In future, the role of other distributed energy resources, such as wave energy, electrical vehicles or fuel cells might be much bigger than today. Therefore, also following energy resources should be considered when future grids and microgrid operation are planned.

Demand response

Demand response refers to the management of customer consumption of electricity in response to supply conditions. A demand response that utilizes economic incentives (e.g., real-time pricing), coupled with technology innovation (e.g., communication networks), could be employed to induce optimal response from consumers to adjust their demands to improve the efficiency of electricity utilization, hence achieving the dual goals of reducing carbon emission and optimizing asset utilization.

As the term describes, demand response means that electricity demand responses to the control signal by changing the consumption. The control signal of demand response (DR) can be high wholesale electricity price or high power fluctuation in the network. The idea of demand response is to avoid peak prices and to even out loading variation. With more even consumption profile, more energy can be distributed through the same network. Demand response can be used for power balancing purposes so that the loads response to the power fluctuation. In microgrids, where low inertia is usual, demand response can be essential part of power balance. With active customer behavior, less important loads can support the power balance by responding to changes of voltage or frequency level. Demand response can be important, especially if the power production is based on intermittent power production. Reason for this is that demand response increases adjustability and by that way helps to maintain the power balance. Technical development of demand response is almost ready but business models and customer awareness still need some work. [19]

Microgrids

The realization of active networks requires the implementation of radically new system concepts. Among others, at the demand side, Microgrid paradigm was introduced.

Microgrid projects are driven by factors that can be very different case by case.

Some key drivers include:

- Need for electrification in remote locations and developing countries;
- Customer need for more reliable, resilient, and sustainable service;
- Grid security and survivability concerns;
- Utility needs for grid optimization, investment deferral, congestion relief, and ancillary services;
- Demand for lower-cost energy supplies than are locally available (especially at remote sites, such as islands, military or mineral/resource installations, and isolated communities relying on expensive, high-polluting fuels);
- Environmental, efficiency, and renewable energy benefits.

The organization of microgrids is based on the control capabilities over the network operation offered by the increasing penetration of distributed generators including microgenerators, such as microturbines, fuel cells and photovoltaic (PV) arrays, together with storage devices, such as flywheels, energy capacitors and batteries and controllable (flexible) loads (e.g. electric vehicles), at the distribution level. These control capabilities allow distribution networks, mostly interconnected to the upstream distribution network, to also operate when isolated from the main grid, in case of faults or other external disturbances or disasters, thus increasing the quality of supply. Overall, the implementation of control is the key feature that distinguishes microgrids from distribution networks with distributed generation.

Microgrids combine local energy assets, resources, and technologies forming a whole system that's designed to satisfy the host's requirements -- which can include factors as basic as electrification, and as complex as integrating variable DERs in a balanced net-zero system.

DERs and technologies available to make microgrids work: gas or diesel cogeneration / CHP; fuel cells and microturbines; photovoltaic (PV) modules; Wind, biomass, small hydro generators; storage capacity; energy management and automation systems.

From the customer's point of view, microgrids provide both thermal and electricity needs, and, in addition, enhance local reliability, reduce emissions, improve power quality by supporting voltage and reducing voltage dips, and potentially lower costs of energy supply. Naturally, user must have both structural and technological prerequisites operational counterparts and compatible with technological standards of automation, information and communication of the latter in order to interact with the Smart Grid.

Advanced communications capabilities equip customers with tools to exploit real-time electricity pricing, incentive-based load reduction signals, or emergency load reduction signals. In addition, smart grid can also allow the customers to save energy and sell them, for instance, by enabling distribution generation resources like residential solar panel, some small participator like individual homes and small business are allowed to sell their saved energy to neighbors or back to grid. The same will hold true for larger commercial businesses that have renewable or back-up power systems that can provide power for a price during peak demand events, typically in the summer when air condition units place a strain on the grid.

From the grid operator's point of view, a microgrid can be regarded as a controlled entity within the power system that can be operated as a single aggregated load or generator and, given attractive remuneration, also as a small source of power or ancillary services supporting the network. Thus, a microgrid is essentially an aggregation concept with participation of both supply-side and demand-side resources in distribution grids. Based on the synergy of local load and local microsource generation, a microgrid could provide a large variety of economic, technical, environmental and social benefits to different stakeholders.

In comparison with peer microsource aggregation methods, a microgrid offers maximum flexibility in terms of ownership constitution, allows for global optimization of power system efficiency and appears as the best solution for motivating end-consumers via a common interest platform.

Key economic potential for installing microgeneration at customer premises lies in the opportunity to locally utilize the waste heat from conversion of primary fuel to electricity.

There has been significant progress in developing small, kW-scale, combined heat and power (CHP) applications. These systems have been expected to play a very significant role in the microgrids of colder climate countries. On the other hand, PV systems are anticipated to become increasingly popular in countries with sunnier climates. The application of micro- CHP and PV potentially increases the overall efficiency of utilizing primary energy sources and consequently provides substantial environmental gains regarding carbon emissions, which is another critically important benefit in view of the world's efforts to combat climate change.

From the utility point of view, application of microsources can potentially reduce the demand for distribution and transmission facilities. Clearly, distributed generation located close to loads can reduce power flows in transmission and distribution circuits with two important effects: loss-reduction and the ability to potentially substitute for network assets.

Furthermore, the presence of generation close to demand could increase service quality seen by end customers. Microgrids can provide network support in times of stress by relieving congestion and aiding restoration after faults.[20]

Microgrid management

Microgrid management is needed to achieve the expected functionalities, such as transition between on-grid and off-grid modes, synchronization, control of power balance and blackstart. As reported in Laaksonen (2011) [21], a microgrid management system (MMS) is needed to control the Low Voltage (LV) microgrid system as entity. In MV studies, these kinds of exclusive models are not created. Therefore, both MMS based and self-sufficient management strategies can be recommended. However, intelligence of MMS is mainly software based which increases formability.

The intelligence of management can be centralized or distributed. There are some pros and cons in both alternatives.

Distributed management and control strategy has advantage in reliability, because lost of one part does not affect remarkably to other parts. On the other hand, centralized control might need less modification in existing devices, because most of the devices are only supporting the operation. This is significant advantage when microgrids are implemented into existing distribution system. Also, need of communication might be an issue because it has impact on system costs and reliability. Distributed control usually needs more communication than centralized one. Reliability and cost of communication are the main challenges in communication based management.

Power balance and control

Power balance is traditionally achieved by controlling the power production and in extreme conditions by controlling the loads. In transmission system, control of active power has impact on system frequency and control of reactive power has impact on local voltage level. In microgrid, the system and inertia are much smaller and the frequency needs to be controlled locally. Therefore, fast control methods are needed to avoid fluctuation in frequency or voltage. Most of the distributed energy sources are not planned for this kind of control.

As in protection or power generation, also in control, the question to begin with is whether the control is centralized or distributed. Two main control strategies are P/Q control and V/f control. P/Q control is a control strategy where frequency and voltage level are determined elsewhere in the grid and the P/Q controlled unit adjusts its output power. In other words, P/Q controlled unit can be seen as voltage source where current and angle are controlled. In V/f control, the controlled unit can be seen as voltage source where magnitude and frequency can be adjusted. [22]

Control of distributed generation

Control capability of DGs is important especially in microgrid operation. In grid connected mode, distributed generators can be seen as support units that support voltage control by adjusting their output power. In addition, distributed generators reduce grid losses because the power can be produced locally. However, reactive power transmission might be needed which increases losses. In microgrid operation, at least one DER unit needs to be the grid forming unit that sets the frequency and voltage level. In practice, the grid forming unit is the largest unit in the terms of capacity. Controllability is an important criterion when suitable main unit is chosen.

The amount of needed spinning reserve in microgrid operation was studied in [23]. Spinning reserve is unused capacity of power production that is already synchronized with the grid and can be taken into use within given short period of time. Estimation of sufficient reserve depends on specific microgrid operation. In addition to economics and reliability, mix of different sources and use of intermittent DG units introduce significant uncertainty into planning. Excessive capacity of the network is the easiest way to solve the problem of uncertainty in system planning but it increases costs.

Control of the distributed generator depends of the generation type and machinery.

Therefore, control strategies need to be flexible and suitable for different generation types.

Demand side management

Demand side management is mentioned to be a part of microgrid power balance system for instance in Schawaegerl& al. (2009)and in Laaksonen (2011) [21][24]. In microgrids, the amount of controllable production is more limited than in traditional networks because of larger share of intermittent production. If the production cannot be controlled well enough, it is logical that also the demand side is controlled to secure power balance. All loads cannot be controlled and therefore they need to be categorized. Critical loads are not disconnected, however dispatchable loads can be disconnected when needed.

Dispatchable loads can be shiftable or interruptible. Shiftable load means that the load can be shifted to some other time of the day. Interruptible load can refer to day-time lighting, standby devices etc. However, this kind of load categorization and demand side management is not realistic yet.

Demand response and demand side management are differentiated through differences in control strategy. In demand response, the loads are controlled with signals that come from aggregator and are based on price. In demand side management, loads can be directly controlled by the system operator or local measurements. When the customer's smart household system receive demand response signal, it can reduce the consumption. Also, the term virtual power plant (VPP) is used for this kind of operation. Both demand side management and demand response include high potential if customers get interested. However, they are not yet available. Economic issues as well as lack of customer's interest are the main limitations of demand side management implementation. The fact that demand side management is not yet realistic to implement means that power balance need to be achieved with other options in the near future microgrid pilots. [24]

Challenges related to product certification needs -

The importance of quality assurance and performance accreditation for the deregulated energy market is strictly related to the very remarkable hi-tech level of technologies, design, construction and operation methods, required for the wide range of typologies of energy products – at the levels of components and more or less large and complex systems - of interest for all kinds of market operators. The complexity of challenges introduced in the electricity distribution network following the market deregulation, mainly due to the distributed generation from renewable sources and smart technologies related to the new intelligent models of user grids energy management based on market oriented or security oriented operation strategies, was highlighted.

Technically speaking, all problems of secure operation in every section of a power system put down to solve a stable balance of energy supply and demand. In distribution networks and in users' grids secure operation is obtained maintaining the power system in perfect equilibrium sufficiently faraway from the security boundaries. Such boundaries are the limits prefixed for stability and steady state operation of the power systems that every component can function within the security coefficients designed in terms of frequency, voltage and current at every instant. For example, for a microgrid (MG), this result can be obtained by ensuring in every state and environment to mantain the following equality at every instant:

$$P_{Gr}(t) + \sum_{n=1}^{N} P_{G_n}(t) + \sum_{k=1}^{K} P_{S_k}(t) + \sum_{j=1}^{J} P_{DS_j}(t) = \sum_{m=1}^{M} P_{L_m}(t) + \sum_{ht}^{H} P_{RL_h}(t) \qquad (1)$$

where:

P_{Gr} is the grid power sypply. It's "> 0" if the MG operates grid-connected or "= 0" if the MG operates islanded;

P_{G_n} is the n-th generic local generator;

P_{L_m} is the m-th generic passive load;

P_{RL_h} is the generic h-th regulated load;

P_{S_k} is the k-th generic storage device, which is positive, negative, zero depending on if charged, discharged, or inactive, respectively, within the considered time interval;

P_{DS_j} can simulate positive contribution of regenerative loads, as vehicles with regerative system on board or grounded, or Vehicle-To-Grid (V2G) systems, if present.

Traditional methodologies for electrical power systems studies arrange variously equation (1) in modeling addressed to security and stability analyses in steady-state and transient conditions. In this case, equation (1) can help to put in major evidence deterministic qualitative and quantitative contributions of the element participating to the overall balancing, and also in evaluating their uncertainty.

Considering a distribution network of the next future, the increasing of power and the enlarging of area extention of distribution networks could heavily influence issues for planning and management of microgrids. In particular, two challenges besides those above described could become much more critical for MG and consequently for the grid, precisely the effective control of major fluctuating generation and proper management of MGs in presence of very etherogeneous and dispersed energy resources within MG's area. The quantitative enhancing of those two factor influences the issue of balancing and control of energy resources involved in the technical and economic management of the MG.

While in large power system the most unpredictable event as a major threat for unbalance is loads variation , in MGs this risk is more controllable, because consumers and respective loads are identified and in some way programmable and manageable. Adaptative control as well as even a strategy of load sharing or shadding can be easily arranged if needed.

However, the risk of internal power fluctuations deriving from unexpected variations or even loss of local generation is higher in comparison to large power systems and is further increased by the occurring of transient conditions deriving from manouvres of intentional or non intentional islanding as well as of power quality issues. This problem is basic for MG's realibility and performance as well as, consequently, for costs and thus for the feasibility of its real implementation.

Beside the control of transients behaviour of MGs deriving from islanding manouvres from grid-connected to grid-tied conditions and vice-versa, which have been widely studied also experimentally, the fluctuations of the parameters of generation in (1) remain a big problem addressed to ensure the istantaneous energy balance during MG operation, through the control of all its electric parameters. The probability of the occurrence of power and voltage fluctuations and the difficulties of their control, mitigation and protection against mainly depend on the presence of local generation, particularly if derived from renewable sources. If fluctuations are considered as the scheduling of local generation for Unit Commitment purpose for programming the MG's duty, they actually make uncertain the forecast covering of demand.

It is well known, in fact, that renewable technologies such as wind, wave, solar and even some CHP, are naturally subjected to fluctuation of the generated electric energy so that their producibility is not predictable as for more traditional generation technologies, and, on the other hand, during operation the output of the generators is intermittent and do not fit expected power quality performances. Increasing levels of such unpredictable and intermittent renewable generation on the system would increase the costs of balancing the MG system and managing system frequency. Fluctuations of the generation have great probability to occur also during operation, because of unpredictable very short term variations. It is the case of irregular wind, as well as in case of shadowing derived from clouds movement. In addition, other unpredictability and intermittency factors derive from active loads which candidate themselves to participate to the balance of MGs as generation resources. Among them relevant are the V2G systems and regenerative sources, which, on the other hand, in proper ways can contribute significantly to the energy management economy of the MG. A particular case is the impact of pulsed power loads. In many types of MGs pulsed power loads can be significant interesting. Storage charge and recharge stations acts cause rapid intermittency.

The composition of the MG feeders is not easy because of the quantity and the non-homogeneity of distributed generation units. Thus, all these challenges become harder if the MG increases its largeness and complexity, as a results of the topological and operative extension of serviced areas, in correlation with major power and dispersion of DERs and loads which have direct involvement with both issues of power security and participation to market. As a matter of fact, power increase of generation and load units entails major issues concerning the circuit dynamics as a response to voltage profiles and active and reactive current values, depending also on the lines constants in each of MG sections.

With reference to the general physical and service configuration of MG or multi-MG, the architecture and the overall electrical features are essential for insuring electricity service. The major challenges for implementing MGs in this view are related to the deepening of analyses about the response of concretely configurated MGs, in terms of reliability and producibility performances to fluctuation contingencies. Major studies have to be carried out on topic as intermittency or variations phenomena occurred for the change of internal and/or external operating conditions, first of all those deriving from impredictable and sudden changes in wind and solar irradiation during the day, as well as disturbances lead by power electronics regulation and controls (included load sharing and shadding addressed to security issues or provision of ancillary service to market). For this aim, general backgrounds on Power Quality cause and effect for distributed generation within SG could be pertinent to MG's issue and should be transferred to the MG dimensions in order to develop studies and experimentation both in laboratories and on the field. A framework of results from simulations and experimental data for control design put into a right scale of MG's issues and to intermittency time response would be expected.

The mitigation and control of intermittency of generation and loads can be highly helped by a proper strategy of aggregation and programmed coordination of all MG's energy resources. From the intermittency management functional, the security and economic benefits can be obtained. The intermittent generator could result complementary for covering electrical loads, and results could be further improved introducing collaborative techniques between generation and loads into control strategy.

Against all the aforesaid different challenges for ensuring balancing to MG, storage devices can be essential. For this reason, the literature has largely reported about the advancement of storage devices in awide range of applications. Recently, typical supercapacitors-based applications for MG dynamic compensation have been proposed. Storage systems can provide balancing service, performing peak-shaving of power adsorbed by the connected feeder and, as a consequence, reducing power required from the network, the current circulating in the line and losses in there. Decreasing the current demand in the network, storage devices contribute to improve network stability and reliability. From the economic point of view, their contribute in reducing supply currents relieves the dimensioning of lines. Furthermore, they can provide ancillary services to the grid, including voltage control, reactive support, frequency control and power quality compensation. A rapid evolution in storage devices technology is ongoing, being differently oriented to application depending on directions of energy dynamics and capacity performance increasing. Dynamic performances, characterized essentially by discharge rate, address systematization of three fields of applications for supporting energy services in MGs, related to supercapacitor, flywheel and batteries types.Increasing attempts in research to study and develop applications of storage systems addressed to ancillary services and integration of renewable generation systems are mainly expected over the next years, concerning batteries, super capacitors, regenerative fuel cells, compressed air, flywheels, SMES, etc.).

The application of BES technologies is an issue that needs to be addressed differently in grid-connected and isolated systems, as it differently relates to the reliability and security aspects of the systems. In fact, the potential and role of the BES is strictly determined by its size, and the battery sizing must be done in connection with the system security, so that:

- in a grid-connected mode, the limit to BES sizing is determined with respect to the amount of critical load.
- in an isolated systems, the sizing must rather be put in relation to the total load aggregation.

In isolated systems, renewable energy sources (RESs) are not complementary components, but instead they are fundamental. Here, two possible battery use solutions could be considered: 1) use as a stand-alone resource of electricity generation/absorption; 2) use as a support resource integrated with some RES in order to make it controllable and dispatchable.

The aforesaid comprehensive – although not fully exhaustive – survey of challenges possibly arising from a given and anyhow composed energy system-product , could be a practical reference for a risk analyses procedure fitting the a security performance accreditation framework.

As a purely indicative summary of some main challenges related to the necessity of accrediting technologies and performances of energy component and/or systems for both management and operation duties the following items are to be taken in evidence with reference to the further presentation contents:

- measurement and acquisition of electrical and related physical parameters as well as energy consumption by means with technology (Advanced Metering Infrastructure (AMI);
- predictability and productivity control of Renewable Energy Resources (RES);
- management and control of energy exchange or injection related to the use of Energy Storage System (ESS) and Flexible AC Transmission System (FACTS) technology;
- smart Energy Management Systems (EMS) implemented by a Supervisory Control And Data Acquisition (SCADA) technology;
- smart Load Control Management for marked oriented scheduling and operation of users' grids;
- smart Load and RES Control Management either for security oriented operation of users' grids or for stability control ancillary services according to Automatic Generation Control (AGC) paradigms;
- intelligent Real Time state control systems.

The Energy product certification

Market condition

For twenty years about, certification services are spreading due to an increasing demand of organized market entities – especially production or services companies –interested to accredite their products and processes.

Such certifications serve to guarantee markets, in particular buyers, sellers and users during the trading steps of products and services, or commissioner of projects, documental outputs, realizations, or, more generally, performances' delivery.

The expansion potential of product energy certification demand is a great focus of interest for a decade at least. Free electricity market mechanisms, the preferential exploitation of renewable energy sources, ICT developments, established targets of energy efficiency and saving at a global level, the general institution of environmental sustainability policies worldwide are the most propulsive drivers.

Energy products as possible product certification objects

Will respect to the state of the art, from the vision line of the product certification for the energy market, the energy product may regard:

1. Technological product at the component or apparatus level, related to the application fields of energy generation, transmission, distribution consumption;
2. Technological product at level of system or plant, generally related to applications in a distribution-consumption area (microgrid) or simple consumption;
3. Technological product at level of energy area, composed by a set of system or plants, generally related to territorial applications of distribution-consumption systems, provided with distributed power generation sources;
4. Conformity of performance to technological or technical requirements and specification addressing energy efficiency or technical standards.

Currently, only certification of types 1 and 4 are already offered within the energy market (building certification, protocols for White Certificates).

UNI CEI EN ISO 50001:2011, although is a certification for energy management systems, it clearly requires improvements of energy efficiency. However, its certificate calls for the existence and the real operation of instruments working for energy efficiency, but does not address the "how" and "how much" of their technical contents, then the certification of the related actions doesn't deal with accreditation of technological objects or technical processes. This is for its generalist character.

As for the next future, because of the trend of request of component and systems based on advanced or innovative technologies, a heavy demand in certification of products and processes quality and performances is highly expected. This counts specially toward the hi-tech products and systems based on

ICT and power electronics technologies involved in intelligent operation programs,. All these products must be proved within the energy market with reference to requirements such as: production quality, technological quality (materials, processes, design, construction, testing) environmental quality, energy quality, maintenance quality, lifecycle, security and safety)

The attractiveness of the certification offered is determined by the commercial value of the product at the moment of the offer presentation till to the commissioner. This value depends on both the economic and patrimonial values of the product.

In order to evaluate the real perspectives of product certification within the market, it is necessary to individuate the potential physical objects (named “product” generally in the following) which will be considered worth being certificated, either for obligation or for commercial accreditation.

A possible criterion for classifying energy products could be the following:

1. Technological products in the sector at the component or subsystem level;
2. Energy systems and processes;
3. Energy services;
4. Energy areas;
5. Documents in the energy and environmental sectors;
6. Investments in the energy and environmental sectors;
7. Due Diligence of ESCo.

Exemplificative lists (non-exhaustive) of technological products, at the component and subsystems level, possibly composing the large variety of typologies of Renewable Energy Sources and Distributed Energy Resources are presented in Tables 4,5,6,7. These items should be the individual object to be included in the context of V&V (Validation and Verification) envisioned within the established certification program. Each item should be verified and individually certificated according to appropriate procedures of technological audit.

RESs’&DERs’ Components	**DERs’ Components**
RES components	*Loads*
Solar panel and sensors	Appliances, motors, lighting systems, etc.
Aerogenerator	*Network components*
Gas turbines, steam generator	Switchboards, Cables, cabling, Ground system, etc.
Diesel generators	Power factor compensation, Control device, etc.
Hydroturbines	Converter, Transformer, FACTS, etc.
Boiler, heat-pump	Load control systems, others
others	*Data acquisition and processing*
Storage components	Measurementinstruments, Sensors
Batteries	Data acquisitiondevices
Flywheels	Computers
Supercapacitors	
others	

Table 4

RES subsystems	Subsystems and Areas
Photovoltaic	HV-MV Station and MV-LV substation
Thermo-solar	Storage Systems
Wind power	EV- PowerRecharge Station
Off-shore windpower	Lightingsystems
BiogassThermoelectric	ResidentialPower center
BiogassCogeneration	Industrial Power center
Hydroelectric	InfrastructuralPower center
Biogass CHCP	Industrial Motor control
Others	Infrastructural Motor control
	SCADA systems
	ICT systems
	Measurementsystems
	Hw+Swsystems
	Others

Table 5

Networked energy systems/processes	Energy service packs
Microgrid	High energy efficiency plants provision and installation
Hybrid Microgrid	Renewing and improvement of buildings and industry
User grid	Energy plants operation and maintenance
Others	Plants and structures energy management
	Electricity and heat provision
	Others

Table 6

Energy Areas	Documents
Buildings and residential parks	Projects, data processing
Service structures and urban areas	Energy generation scheduling
Commercial centers and tertiary districts	Operation planning
Industries and industry areas	Energy contracting
Ports	Energy Policy Analyses
Infrastructures (galleries, highways, etc)	Others
Railway stations	**Investments**
Airports	Energy Efficiencyinterventions
EV recharging stations	New power generation plants
Public lighting systems	Energy revamping interventions
Sports facilities	Energy saving by recovering
Others	Others

Table 7

Chapter 5 – Proposal of a new energy Voluntary Product Certification Program

Generality on the VPCP model

The first part of the thesis has highlighted that quality organization or management system certifications cannot guarantee requirements declared for product certifications, which should be related specifically to the individual products or functional systems. This is the reason that for products in general and for hi-tech products in particular voluntary certification are remarkably spreading. Only in specific sectors, such as railways, aerospace, etc.) product certification finds organic and comprehensive standard platforms related to mandatory regulations, suitable to be directly framed within the third-party certification logics.

In this section a proposal of a possible scheme of Voluntary Product Certification Program (VPCP) for a generic Energy Product/System is presented, as a result of the preceding methodological developments.

The new certification program of energy product proposes a very flexible verification structure, capable to use a basic procedural path usable for technological certification of components, as well as for complete technological areas or complex systems anyhow extended and composed.

The particularity in respect to other existing technological certification models (e.g. the railway certification model implemented according to ITS -Interoperability Technological Standards) is that, in the case of energy products, there are no basic standard references. It means that the certification program includes an analysis of the case and the selection of a package of specific standards tailored to the overall object of the certification request. This package must be defined before managing the procedure implementation case by case.

The VPCP procedure starts logically by considering the most complex case of a certificate addressing a large and complex system, i.e. an energy area system as a whole, but, more generally, the certification can be limited to a subsystem or a component, as parts of the entire system without any problem.

Some preliminary explanations could be useful.

VPCP Definition

The VPCP model is based on the project of a voluntary third-party certification of product for accreditation of energy products in terms of technological and reliability performances with reference to technical specifications and service (energy production capacity, energy efficiency and lifecycle.). VPCP differs from Voluntary Certification Program (VCP) which refers to the combined certification programs consisting of certificates suitably gathered to gain a general level of accreditation pursued by a company as a whole. Instead, VPCP refers to a voluntary model of certification which can be open to be tailored to the specific product by a procedure which arranges a customized standard and recommendation framework fitting the accreditation needs.

VPCP certification objective

VPCP aims to certificate technological and/or energy performances of an energy product, as to say to accredit the compliance of technical, reliability and quality specifications of the product, and related processes with reference to a verification scheme suitably organized according to a set of standard, recommendations and good practices, as well as to contractual references. The performances of products and processes can regard in particular total and partial energy efficiency parameters at the component, subsystem and system levels.

VPCP applicant

The certification applicant is the jurisdictional entity that in that moment is interested to get hold of certification. Typically, such entity should be either the owner (for example to get white certificate for energy efficiency, or to sell the system) or the manufacturer (to sell the system, or demonstrate the granted technical specifications or/and energy performance).

VPCP Object

In the most general case the VPCP refers to the accreditation of technological and/or energy performances of an energy area or energy system, which represents the more complex case.

Dealing with an energy area the VPCP joins or includes ISO certificates. Then, VPCP can positively join other certificates, pursuing the following VCP (Voluntary Certification Program):

- ISO 9001 – General Quality Certificate as an organization;
- ISO 14001 - Environmental Certificate as an organization;
- ISO 50001 – Energy Efficiency Certificate as an organized energy system;
- VPCP – Voluntary Certification Program of Product of technological quality product and Efficiency Energy Performer System.

The VPCP methodology has arisen from a conceptual platform built-up by preceding studies, as a result of gathering and systematizing several sources referred to quality assurance and technical procedures drawn out from other engineering areas.

Specific references have been made to technological and verification standards developed and currently used by Italcertifer S.p.A., member of the Italian National Certification Body and Notified Body specialized in Railways Product Certification.

The certification model is supposed to be developed by an autonomous and independent body (Notified Body - NB), according to standards and best practices of the electricity/energy market according to the interests of operators and customers as well as in a wider vision of safeguarding property, territory sustainability and the environment in general. The NB undertakes classification, certification, and other verification and consultancy services relating to quality of energy products and their application in their all possible forms of technical units and installations, technological standards, physical objects, devices, systems, services, structured areas, documents, as well as productive industries or services processes, as earlier defined.

Definitions

A list of definition is accordingly reported [25].

Client: NB's contractual partner.

Manufacturer: any juridical entity (contractor, builder or seller) of the technological system or component to be accredited, in the market or compelled to issue the compliance certificate.

Certificate Applicant: could be the contracting subject, the purchaser, the manufacturer or any public or private entity commissioning design and/or construction, restructuring or renewing of a energy system, subsystem or component. The entity can be the manufacturer, an owner, an operator or an Authority appointed to put on use an energy project.

Certification: Procedural action by the NB, providing written assurance that adequate confidence is provided that a duly identified product is demonstrably in conformity with the specific standard and other normative documents, according to in force and applicable standards and previously formally stated contractually.

Certification Basic Platform: Requirements for the system's specifications, operating conditions, performance targets and reliability targets. The basis to which the system will be assessed during certification.

Certification Customized Platform: set of requirements and conditions described by technical specifications contracted for the VCP's issuance.

Declaration of Conformity: is a document which says that the product meets the requirements of the EU directive(s) which apply to it. A properly issued Declaration of Conformity is always issued by the product's manufacturer (or by the person responsible for selling the product in Europe) and never by a test house or Notified Body.

Conceptually feasible: A technology at an early stage of development is considered conceptually feasible if the main challenges have been identified and judged to be resolvable by use of sound engineering practice. Although a technology has been stated conceptually feasible, there are still activities necessary to be executed in order to prove that the technology is fit for service. Consequently, there will be the possibility that the technology, contrary to expectations, will not be stated fit for service.

Failure: Termination of the ability of an item to perform the required (specified) function.

Fit for service: A technology is considered fit for service when the failure modes that have been identified through the systematic process outlined in this OSS have been properly addressed, and the supporting evidence substantiates that the technology fulfils all stated functional requirements and meets the stated reliability target.

Although a technology has been stated fit for service, the technology has not necessarily an in-service record that eliminates the possibility for failures due to unidentified or misjudged failure modes. Consequently, there will be a possibility that the technology, contrary to expectations, will fail in-service.

New technology: Technology that is not proven. This implies that the application of proven technology in a new environment or an unproven technology in a known environment, are both new technology. The degree of new technology will be classified in categories to be used as input to risk assessment.

Prototype: An original type that serves as a model for later models, and allows for testing and improvement of the design.

Proven technology: In the field, proven technology has a documented track record for a defined environment. Such documentation shall provide confidence in the technology from practical operations, with respect to the ability of the technology to meet the specified requirements.

Risk: The qualitative or quantitative likelihood of an accident or unplanned event to occur, considered in conjunction with the potential consequences of such a failure. In quantitative terms, risk is the quantified probability of a defined failure mode multiplied by its quantified consequences.

Risk reduction measures: Those measures taken to reduce the risks to the operation of the technology and to the health and safety of personnel associated with it or in its vicinity by:

— reduction in the probability of failure

— mitigation of the consequences of failure.

Surveillance: The process of inspecting tests, calibrations or other activities to assure that the necessary quality is maintained. Once the device is in operation, reviews carried out to assure that operation is within safety limits, and is maintained within limiting conditions.

Technology qualification: A confirmation by examination and provision of evidence that the new technology meets the specified requirements for the intended use. Hence, qualification is a documented set of activities to prove that the technology is fit for service.

Verification: An examination to confirm that an activity, a product or a service is in accordance with specified requirements.

General Scheme of the VPCP model

Basic procedures arise from the progressive steps of the VPCP process. Firstly, the general approach allows to frame any subject to get certification within a perimeter including the set of available energy resources. Such perimeter can be generally and systemically definable as an "energy area".

The certification object may concern either the whole system inside the energy area or a part of this, inclusive of all related internal energy resources.

On the other hand, like any other product certification procedure for complex technological systems, the VPCP model applied to energy areas must be managed at the levels of subsystem or component. Then, the definition of the object of certification for the energy areas can be obtained only transforming the entire heterogeneous and complex system in a set of energy subsystems or components, each of them classified or classifiable as individual certification objects.

The procedure to complete the first step of certification objects identification is represented in Figure 10.

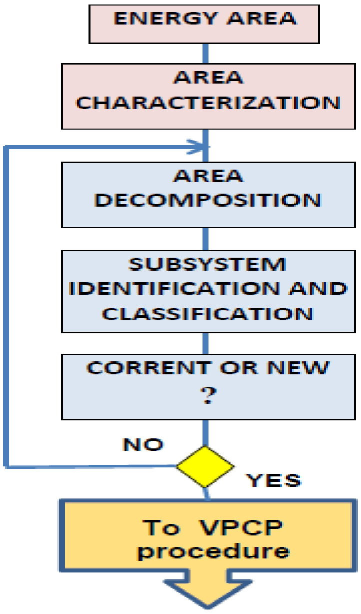

Figure 10 Procedure

The subsystems' analyses related to each area's subsystems or components permit the identification of the entire system through the classification of the subsystem and components, then of the individual objects to be certificated. If a subsystem seems hard to be classified, it is necessary to go on to a further decomposition. Each object identified through the classification procedure can be identified as either "current" or "new", depending on the technological innovation and existence of standard references for the items of concern.

The above described first step is very important for the certification of energy product at issue. The reason is that each energy area/system is in all different from the other, then a certification program should necessarily be implemented through the first step, that is a very specialized audit, on which the correct framework of the main certification procedure strictly depends. For example, the choice related to the identification as "current" or as "new" typologies and technologies of innovative components and subsystems can be a specific evaluation task. This choice should be formally supported by conclusions of an ad-hoc Evaluation Report.

System Identification

In this case, the entire energy area is to be considered, and the comprehensive definition and characterization of services, technological components and related processes allow to classify the overall technological system, to be certified component by component selected and classified according to the list of energy products' categories.

This identification allows to enter standards, specification databases and testing procedures related to the energy products' class of concern. For this purpose:

1) The energy area has to be declared and identified in terms of property, jurisdiction, physical composition and by lists of assets, departments, structural and infrastructural components.
2) Juridical references and data, organizational and functional diagrams must be gathered and formally evaluated
3) Technical documents and graphics has to be gathered, examined, in order to extract all data needed to draw a complete description of the context of interest. All resulting data must be validated to be assumed as reference for further evaluations and conclusions.

Document survey should be completed by place and asset inspections for the exhaustive identification of the system of concern.

Decomposition

Having considered the SUG, the overall technological system should be properly decomposed in parts (subsystems and components), making possible and easy the further steps of Characterization and Classification.

The expected result should have homogeneous and definable arrays of subsystems, suitable to be evaluated from all the aspects of possible concern.

Characterization

This step deals with the characterization of overall system and it is aimed to classify the parts gathered from the system decomposition. The characterization addresses in particular the analysis of the part in order to evaluated factors of both presence, influence and relevance of innovation, related to technologies, components and their possible aggregation into subsystems.

Classification - Current/New Technologies

Classification represents the result of characterization in terms of 1) typologies and 2) grade of innovation. The latter is basic for selecting the next procedure which has to be chosen between consolidated or new technology. Such two procedures are basically different as described in the following.

The systemic approach used for classification addresses the need to manage systems or subsystems already experienced but in some way modified or technologically updated. In this case, a previous analysis has to be carried out in order to decide either or not the modification to be made is relevant and in which rate.

In general, the approach for identifying and assessing the innovation grade is systemic and multi -criteria. Parameters used to perform the assessment can be different and generally depend on energy resource classes. The evaluation must be performed at the level of detail necessary to separate proven from new technology as parts of the subject subsystems, and may be arranged together with known as well as unproven technologies. The classification can imply the identification of new technical uncertainties and new technical challenges.

New technologies will be subject to qualification process before being admitted to certification procedure. Qualified new technologies and proven technology will be subject to traditional certification.

Chapter 6–The Case Study

Rationale of the case Study

The purpose of the case Study is to demonstrate the full feasibility of the VCP proposal. The “energy area” aim of the research is centered on an urban belt involved by the track of a light mass transit ropeway system.

In the area of regional and urban mass transit systems there are two conditions basic for the implementation of intelligent energy areas. Transportation systems are distributed within the territory, although in a scaled way. Then such systems are intrinsically featured to capture energy resources in the surrounding, if suitable to be aggregated to the local electrical system managed by the transportation system power supply operator.

In the case of urban metro system equipped with an its own internal distribution electrical system, the energy resources captured and integrated into the power supply system make up an Energy Hub, intended as an energy resources collector, in general composed of energy resources of RES and DER types.

Such an area presents many of the requirements demanded for demonstration:

- Completeness;
- Complexity;
- Intelligence;
- GEE **-** Global Energy Efficiency benchmark.

Its completeness is due to the fact that it includes all types of energy resources referred to the standard configuration of multi-microgrid and more generally of user grids, anyhow large and complex.

The complexity is firstly due to its completeness, secondly to the twofold objective to be managed by the SUG (Smart User Grid) operator for pursuing optimal operation, addressing both security and participation in the electricity market.

Intelligence derives from the smart technologies which were assumed both as applied to individual components of the user grid and as technological standard for operation.

Global Energy Efficiency (GEE) is the benchmark used to define and configure the energy system of the considered “Energy Area”, as described in the next paragraph.

GEE Global Energy Efficiency paradigm

“*Energy efficiency*” (EE) corresponds to reduce the amount of energy request to provide products and services. The effort for improving energy efficiency is pursued, because reducing energy use could result in costs saving to consumers, especially if energy saving offsets the additional costs for implementing more efficient technologies. Focusing the energy management on the processes of energy conversion in a global form leads to consider the energy system as an Energy Hub, capable to cluster, to control and optimally manage all involved resources.

The need to face the environmental challenges has led to enhance the traditional concept of the EE management, which by now introduces renewable energy as another pillar of sustainable energy policy. This enhancement was an evolutionary change both for the advances of ICTs in power systems, both for the implementation of the Smart Grid (SG) and Microgrid (MG) paradigms. Other drivers of this evolutionary development were the technological and operational integration as well as the unification of the commercial commitment, put in evidence by Energy Hub concept. The extensive use of EE and SG paradigms leads to a collaborative action of the available energy resources which have to be exploited by proper tools for technical control and operational management, in order to minimize cost or maximize economic revenues.

Acting systemically on every energy component (or subsystem) of the whole system, with the aim of achieving the "*global*" efficiency, the EE management approach can upgrade structural and organizational models. In this respect, this paper proposes the new paradigm of GEE.

Global energy efficiency for a metro system

Electrified transportation systems and related infrastructure are enhancing for the progressive expansion of mobility service demand as well as for the extraordinary technological evolution. Nowadays, High speed long-distance railways and highly automated urban mass-transit systems offer effective and market-competitive solutions for sustainable mobility worldwide.

In this case study, the potential of the GEE approach is "customized" for the metropolitan assets for mass transportation services which constitute an infrastructural core within wider urban context.

Typical structures of future mass transit systems for the smart city are not easy to establish, in particular when it comes to underground metro systems. Long lasting realizations associated to a variety of dynamic factors in the urban contexts cause the systematic diversity of each solution from others.

Therefore, in future cities, systematization and standardization are both objectives to be pursued.

The evolution of modern metro systems aims to achieve more effective and efficient features. The interest of dealing with type of infrastructure derives from several factors, as: centrality, extension, dispersion, electrical powering and consumptions, service structuring and organization.

In light of this, the GEE can ideally find application in the case-study of mass transit metro-system, viewed as an EH configured according to the features of a MG interfaced to the a smart Distribution Network (DN).

GEE concept for Energy Areas

The globalization of the contents related to the new concept of Global Energy Efficiency offers the advantage of accelerating the implementation of different methods, models and architectures, proposed up to now for over fifteen years by researchers and technicians, both of academic and industrial areas, which have still difficulty in being systematized under the prompting of market globalization and liberalization processes. The GEE also includes the traditional energy efficiency, mainly based on simple energy saving, where the energy management target is pursued through strategy of consumption reduction, without a structural energetic policy.

The case study is addressed to an energy areas, as a general Energy Hub, containing various energy resources, such as Distributed Energy Resources and Renewable Energy Sources besides loads and other local generation systems. Energy areas can be identified generally as User Grid or Smart User Grid (SUG) if provided with intelligent technologies.

Then, GEE well fits with SUG configuration, if it includes energy resources for local generation, typically from renewable energy sources, energy storage controlled systems and controllable or regenerative load facilities. Such energy distributed resources allow to increase the potential of electricity to be made available for maximizing economic benefits ,which are to be redistributed among all the components of the energetic system. SUG’s management tools have requisites of interactivity, real time programming and dynamic operation, being implemented on smart architectures and controllable technologies. In a SUG the energy management is performed by a remote centralized control system supported by interactive SW optimization tools which aim to get the optimal control of energy system’s technical and economic sensitive parameters.

Within this technological context, GEE paradigm allows to manage the energy resources made available to capture the opportunities offered by the deregulated electricity market, which can remarkably facilitate the payback of energy efficiency investments.

Figure 11 describes the basic methodology for extracting and identifying an electrical smart user grid (SUG) from the physical context of an urban area, anyhow extended and composed.

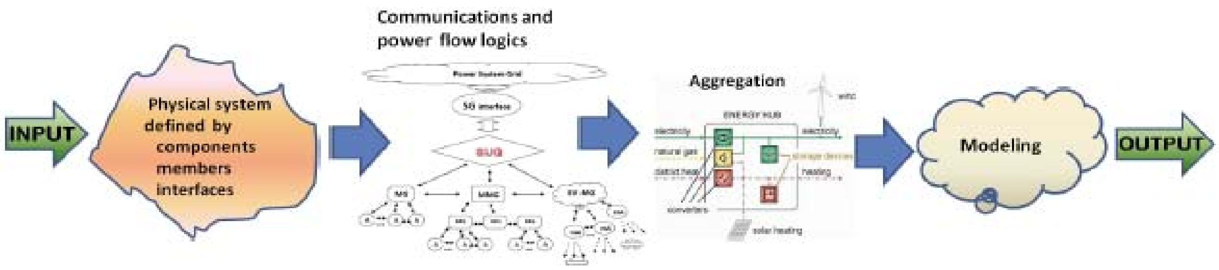

Figure 11 Methodology of identification of an electrical Smart User Grid

According to the management logics, a SUG's aggregator is required to interface the DSO as the coordinator of energy Agents singularly identifiable as participant members. Typically an Energy Service Company (ESCo) might have the position of SUG's administrator in the market. According to its basic paradigms, the SUG operates as a large and complex microgrid arranged to participate in the electricity market composed by the following members:

- a photovoltaic energy independent provider which sells energy at the PV market price (RES market);
- a wind power provider which sells energy at the WP market price;
- a CHP producer which sells the energy at the market price;
- an EV's service operator which buys energy from the grid;
- various Metro-system and external energy user areas properly organized also as buyers at the grid energy prices.

The SUG computes all the energies at this price disconnected from system administrator benefits.

At GEE first level, loads profiles are predetermined basing on the daily activity and power schedule starting from energy requests of each agent. Prices are different for each of SUG members and they depend on the limits for connection and contracts of Maximum Power Delivery (MPD).

At GEE second level, the SUG activates with some of its members a Demand Response Program (DRP), which makes available a range of demand decreasing, allowing a load management program. In this case, prices are considered depending on Time of Use criterion (TOU).

Advanced DRP procedures are based on Dynamic Pricing (DP) theoretically established on Real Time in the perspective of application of AMI and pervasive ICT technologies, according to the expected implementation of Smart Grid paradigms. In this case study Demand Response Program (DRP) procedures are based on the possibility of programming one hour ahead, which enables the SUG to perform an hourly optimal strategy.

Simulations are carried out assigning hourly profile of prices inversely linearly depending from the total power, on varying of prices and power span.

The modeling can be made more sensitive to the dynamic price (RTP - Real Time Price) in order to permit the SUG to maximize benefits basing on local resources available. In such a perspective, it is necessary to: know the dynamic pricing program, fixed by the Distribution System Operator (DSO), perform proper simulations and present the "offer", starting from the obtained results, in less than one hour.

At GEE third level, SUG offers ancillary service basing on agreements regarding pre-established peak load reduction, useful for stabilizing or regulating basic power system parameters during operation. The price of this reduction can be related to the tariff value.

Case Study description

The electrical system

The basic new idea is to apply the concept of Global Energy Efficiency (GEE) to a modern electrified metro system by making the supply system intelligent in order to optimize the electric and energy parameters involved in the global strategy of GEE conceivable for the case of concern, which means the maximization of full operational efficiency management.

Firstly the case study of concern must be defined and the metro-system choice be properly identified as an electricity Smart User Grid (SUG). The feature of the selected transportation system is assumed as being a funicular-line servicing a hilly neighborhood of a modern city.

Figure 12 shows the power distribution scheme of the considered system.

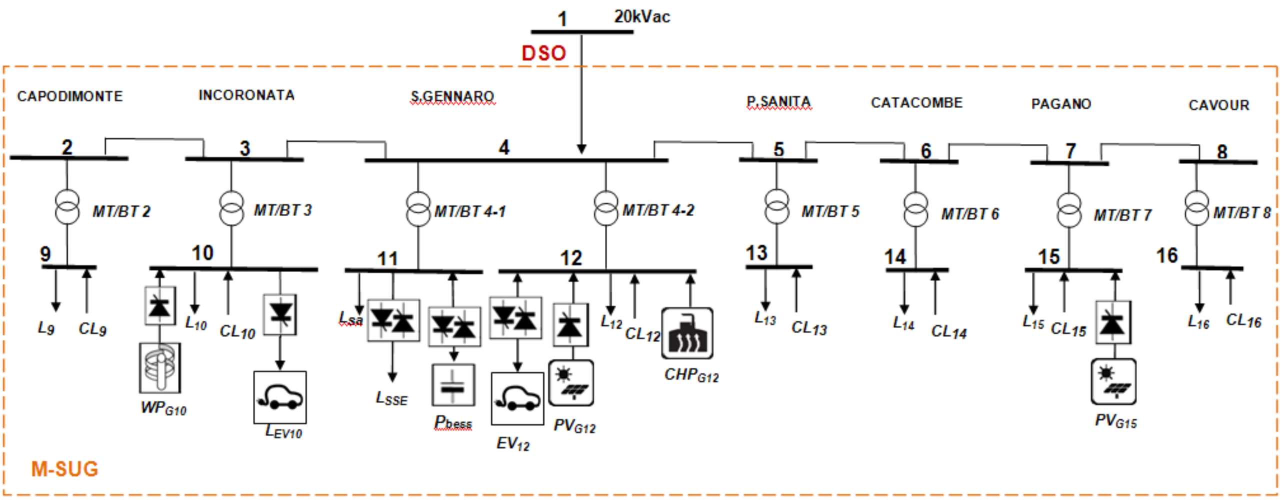

Figure 12– Basic power distribution system of the Case Study

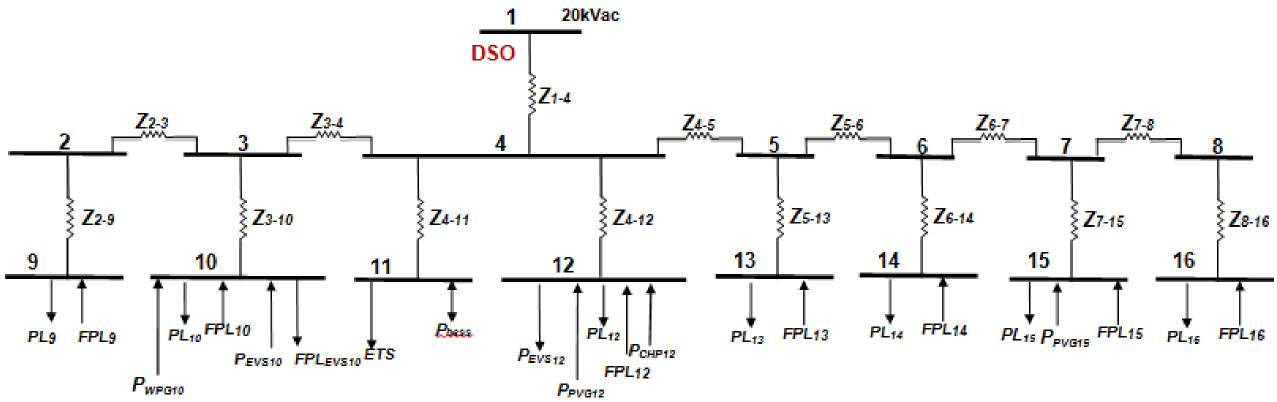

Figure 13–Electrical model scheme of the concerned system

Scheme's Symbols

DSO	Distribution System Operator
M − SUG	Metro Smart User Grid
LTSS	Traction Substation
L1, L2, L3, L4, L5	Load areas in AC (Alternate Current)
EV − PL	EV (Electric vehicle) Parking Lot charging station facility
EV − DC	EV (Electric vehicle) Distributed Charging Station facilities
PVG	PhotoVoltaic Generation
CHPG	Combined Heat & Power Generation
WPG	Wind Power Generation
ESS	Energy Storage System

In the scheme of Figure 12 all the energy resources included in the energy metro-system area (M-SUG) are represented. In Figure 13 the electrical model of the M-SUG is shown.

According to the paradigm of GEE, Metro-Smart User Grid (M-SUG) is a complex user grid that gathers various energy resources, including the supply for an electrified urban transportation system, light or heavy, as a typical metro system.

The particularity of such a SUG is the association of the traction service power supply to a variety of other energy resources, organized within a complex electric plant, including every devices and facilities needed to provide metro area service with electricity traction energy supply and general services. In the context of future smart cities, we suppose that the metro area service includes a multiplicity of other consumers modeled by a Thevenin equivalent. The latter is managed by the DSO with a NILM (Non Intrusive Load Management), possibly operated through a VPP (Virtual Power Plant) approach, and is characterized by its hourly or instant equivalent load. In this study it is referred to with the acronym DUG (Distributed User Grid).

The M-SUG includes three types of members;

- local generation entities (basically from renewable primary resources and classifiable as RES (Renewable Energy Resources) , committed to cover part of the SUG's consumption, saving costs for the energy to buy;
- SUG members unavailable for exploiting DRP advantages, as regards Security and Safety Loads;
- The remaining SUG members up for managing DRP in their energy provisions related to the productions in their respective activity areas, in this case structurally EVS and FPL and possibly ETS.

In general, the introduction of RESs poses some practical questions related to the whole strategy of energy management of the involved area. For example, it is interesting to evaluate parametrically the incidence of these RES' production in both general and singular terms of economic management of the M-SUG's energy strategy, because the local energy covering can have a different economic effect on the individual SUG's members, whether engaged in DRP or not. Moreover, it is interesting to evaluate the incidence on SUG's economy of investments in DERs' plants and also the benefit loss due to unpredicted lack of natural renewable energy in one day.

The scheme of Figure 12 depicts the system and its components.

A connection (primary substation 150-132/20 kV 50 Hz) is managed *intelligently* by a Distribution System Operator (DSO) which provides with energy the M-SUG. This resource represents an equivalent energy generation resource at the SUG system interface with the main Distribution System (DS), at the point of common coupling (PCC). From this point a MV feeder laid along the metro line which, through a system of MV/LV substations located by the stations, supplies all metro-system consumers including generation and load external energy resources participating in the M-SUG GEE management program.

The LV M-SUG system includes:

- traction load (bus 11)
- biomass/biogas cogeneration power plant (CHP, bus 12)
- non-dispatchable generation (N-DG) micro wind power plant (WP, bus 10).
- N-DG roof-top photovoltaic plant (PV, busses 12,15)
- controllable AC loads (CL, busses 9-16)
- electric vehicles (D-EV, busses 10,12)
- critical loads (L, busses 9-16)
- battery energy storage (BS, bus 12)

Management program

The case study addresses a general procedure of optimal energy management, which contains the following resources and paradigms:

- Controllable loads (load Shedding, Load Sharing, Load Shifting);
- Load Leveling, Peak Shaving;
- Demand Response;
- Dynamic pricing;
- Uncertainty of RES' production forecast;
- Uncertainty of battery costs (lifecycle, reliability, certification, etc.), fuels and electricity market prices
- Incidence of penalty factors in revenues from load management energy.

The optimization strategy is specifically highlighted by the following assumptions:

a) DSO has benefits from the DRP market mechanism. The tariff based on dynamic pricing encourages SUG members to participate to DRP and make available a negotiable part for decreasing of consumption scheduled at peak hours;

b) PV and WP energy producers are interested in selling the energy at the maximum price, depending on their organization and own plants. They have fixed price, estimated as an average price on statistic bases, agreed with the SUG Operator;
c) Consumer's flexibility for DRP consists of the possibility of cutting a reasoned rate of the demand peak during peak hours, when dynamic price is higher. The cutting rate is determined by out-line evaluation depending on various productive, economic and organizational elements;
d) Considering the strategy of participation in DRP mechanisms assumed by the flexible SUG's consumers, the SUG's members are available to manage DRP pursue to get maximum benefits from participation in the SUG consortium, but would estimate possible chance loss in productivity, related to their respective activities and economies.

The Case study addresses simulations market oriented, then it is a-priori assumed that the M-SUG system operates within security boundaries, thanks to real time control of regulation and conversion units added to DER and RES generation components as well as to controllable loads. Indicatively, controlled operation aims to:

- Adapt the electrical parameters to the output connecting bus;
- Stabilize such electrical parameters to the rated references;
- Operate local primary regulation by activating self-control automated procedure.

Modeling of M-SUG's DERs and RESs

As explained in the description of the assumed methodological platform of the method, referred in particular to the GEE paradigm, the electrical system representing the DSO-connected SUG is to be viewed as an Energy Hub, whose model for PF and OPF analyses is a single-line wiring diagram where all generation and load energy resources are represented by their reactive and active power injections with related signs, while batteries are represented as generators or loads according to the resultant energy flow of discharge or charge in the time span considered (1 hour in these applications) , respectively.
The M-SUG system has been modeled in a very general way, in order to be able to perform a variety of simulations both operation-oriented and market-oriented. The applications developed for this work aim to demonstrate a pattern of future intelligent energy area of possible typical concern for the new proposed certification program, which is the central scope of this study. For this reason, applications are limited to some cases related to the demonstrative scope, but anyway they are very explanatory for highlighting the flexibility and robustness of the model.
The model can represent the reactive components, even if in some cases, when the focus is on active power dispatch, under the assumption that all converters (DERs' interfaces) are working at unity power factor, the effects of reactive power may be not represented. In this case study reactive power is considered.
Energy resources affected by uncertainty can be modeled in a probabilistic way according to proper off-

line data processing.
Modeling similarly deals with identification issues as for bounds and constraints variation limits. In particular, as follows:

Local RESs' - wind and solar power

The variability of power outputs is primarily related to wind speed profile for wind power (WP) and to solar radiance profile for photovoltaic (PV) [26]. Hourly forecasts of these profiles over 24 hours was extracted from applications obtained by Monte Carlo simulation (MCS), generating a large number of scenarios around defined mean and variance. In these applications a scenario Reduction (SR) [27] technique was employed to eliminate the scenarios with very low probability and aggregate close scenarios.

Such elaborations were not reported in the thesis, not being considered significant for the scope of the work.

Battery energy storage

The BES operation can be constrained by the limits in storage capacity, as well as in charge/discharge rates through binary variables to account for the BES charge/discharge cycles. Such modeling has not taken into account in the application, not being included in the scope of the work.

Critical and controllable loads

Hourly (24-h) stochastic scenarios are modeled referring to typical profiles of residential and commercial loads, with deviations based on a normal probability distribution function.

Operating constraints of the controllable generation CHP units and controllable EV-loads

The applications of Case Study implementation consider CHP power generation and EV charging loads as sensitive variables for the OPF objective function. The constraints in CHP power production and controllable EV-loads are defined by proper "contracted bands" (limits) of possible variation of the controllable demand. These bands are set up by agreement between M-SUG operator and customers. Moreover, the model takes into account the rate of deviation of the production or the loads from the respective rated values within the limits of the contracted bands due to the influence of prices, which are assumed functionally related to the variability of power flow respectively related to CHP generation and to EV charging load. Both functional relations of power and loads respectively to price are assumed linear.

The OPF modeling

The proposed OPF model is suitable for addressing different energy management aspects, as previously discussed. Different stages of analysis can be considered, related to time horizon and to the definition of the problem variables. With reference to short term horizons (day, week, month), the tool can perform operation, operational planning and short-term management simulations. Such is the case of this paper, where a daily time horizon is considered for scheduling and operation analyses. For longer horizons (one quarter of year and over) the application of the tool can be extended to investment or resource planning analyses, or scenario analyses, such as reliability assessment and risk analysis

The following model formulation refers to the M-SUG structure of Figure 13. The proposed model is implemented by nonlinear program in MATLAB environment, the objective of which is to determine the optimal strategy of scheduling and operation of the controllable M-SUG resources at the minimum cost, in order to ensure the continuity of energy supplies relative to possibly critical demand.

Explicitly referring to the system composition of Figure 13, the model can be formulated as described below.

Legend

P_{rate}	rated Power
PL_n	active Power Load at bus n
PL_{nr}	reactive power Load at bus n
FPL_n	flexible Active Power Load at bus n
P_{PVG_n}	current power from PV generation at bus n
P_{CHP_n}	current power from CHP generation at bus n
P_{WPG_n}	current power from wind generation at bus n
P_{EVS_n}	active power load from Electric Vehicle Service
$P_{EVS_{rn}}$	reactive Power Load from Electric Vehicle Service
P_{ETS_t}	power for Traction supply at time t
L_{sa}	traction system auxiliary load
$P_{grid,t}$	current active power from the grid at time t
$Q_{grid,t}$	current reactive power from the grid at time t
$c_{grid\_TPL,t}$	TPL unitary cost of electricity from grid at hour (time)t
$c_{grid,t}$	unitary cost of electricity from grid at hour (time)t
$c_{grid\_comm,t}$	commercial unitary cost of electricity from grid at hour (time)t
CR_{PVG}	unitary cost of PV production at time t
c_{EVS}	unitary electricity costs of EV-service at time t
c_{ETS}	unitary electricity costs of traction supply at time t
c_{WPG}	unitary cost of WP production at time t
c_{FPL}	unitary electricity costs of controllable loads at time t
CR_{chp12}	price of P_{CHP12} energy unaffected by any penalty factor
CR_{evs10}	price of P_{EVS10} energy unaffected by any penalty factor

Equations

Objective function

$$\min \sum_{t=1}^{24} \left[Cu_{grid_{i,t}} \cdot \frac{P_{grid,t}}{Pgrid_{rate}} + Cu_{chp12,t} \cdot \frac{P_{chp12,t}}{Pchp_{rate}} + Cu_{FPLevs10,t} \cdot \frac{FPL_{evs10,t}}{PEVS_{rate}} + Cu_{FPL,t} \cdot \frac{FPL_{,t}}{PFPL_{rate}} \right]$$

Subject to:

Equality constraints:

$$P_{gi} - P_{Li} - P_i = 0 \quad i = 1, \dots, n$$
$$Q_{gi} - Q_{Li} - Q_i = 0 \quad i = 1, \dots, n$$
$$V_1 = 1.05 \quad \textit{Slack Bus}$$
$$\theta_1 = 0 \quad \textit{Slack Bus}$$

where:

$$P_i = V_i \cdot \sum_{j=1}^{n} V_j \cdot [G_{i,j} \cdot \cos(\delta_i - \delta_j) + B_{i,j} \cdot \sin(\delta_i - \delta_j)]$$
$$Q_i = V_i \cdot \sum_{j=1}^{n} V_j \cdot [G_{i,j} \cdot \sin(\delta_i - \delta_j) - B_{i,j} \cdot \cos(\delta_i - \delta_j)]$$

Disequality constraints:

$$P_{grid} > 0$$
$$V_{imin} \leq V_i \leq V_{iMax} \quad \forall\, i = 1, \dots, n$$
$$K_{pchp12} \cdot P_{rate\_CHP12} \leq P_{chp12} \leq P_{rate\_CHP12}$$
$$0 \leq FPL_{evs10} \leq (1 - K_{pevs10}) \cdot P_{rate_{evs10}}$$
$$0 \leq FPL \quad \leq alfa\ P_{rate}$$

Chapter 7 Applications

Application's data

The distributed energy resources are represented by injections of power generated or absorbed considered statically by their average values in the unit interval considered (in this case 1 hour) .
The following dependent variables are considered sensitive to the optimization problem:
- Local CHP fueled by biogas fuel (node 12);
- Loads controllable ordinary (9,10,12,13,14,15,16 node);
- Loads for the programs of charging electric vehicles (node 10).

The respective values are calculated starting from the respective reference profiles (nominal , dependent on the operation program), plus the respective ranges, dependent on the flexible exercise program established by the Manager of the microgrid (M-SUG's Agent).
All other resources of generation and load are identified through their profiles assigned in accordance with their operation programs.

Renewable generation

Renewable generations are present in the following nodes:

- Node 10: wind turbine of 20 kW(Pwpg10);
- Node 12: photovoltaic plant of 220 kW(Ppvg12);
- Node 15: 70 kW photovoltaic system (Ppvg15).

Daily profiles of power generation are considered as "known". In Figure 14, the generation curves of the renewable profiles are presented for each node above indicated.

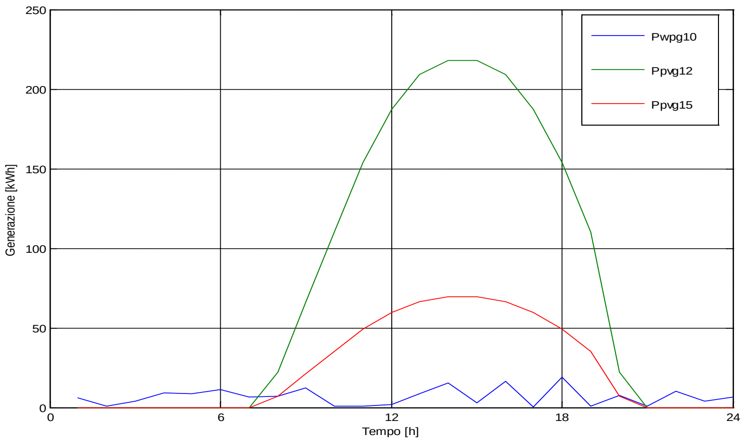

Figure 14 Renewable profiles

Nodal Loads

The absorption hourly profiles were derived from real cases of metro station / funiculars and relative utilities and service facilities.

Following figures show the graphs relating to the absorption profiles of active and reactive hourly powers. For each of them, a degree of controllability has been defined, in order to consider them as sensitive variables in the optimal power flow.

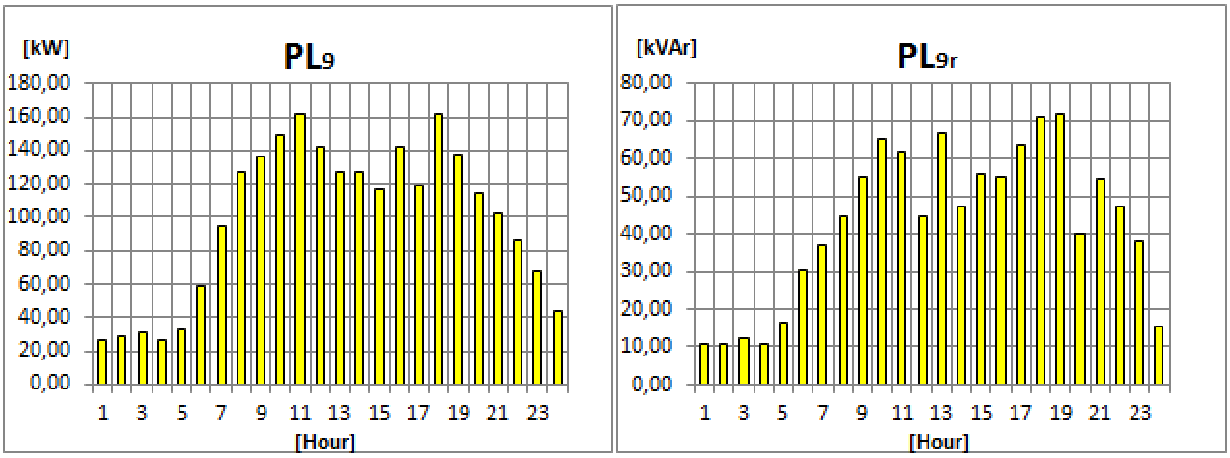

Figure 15 - Active and Reactive Power at Node 9 – [165 kW]

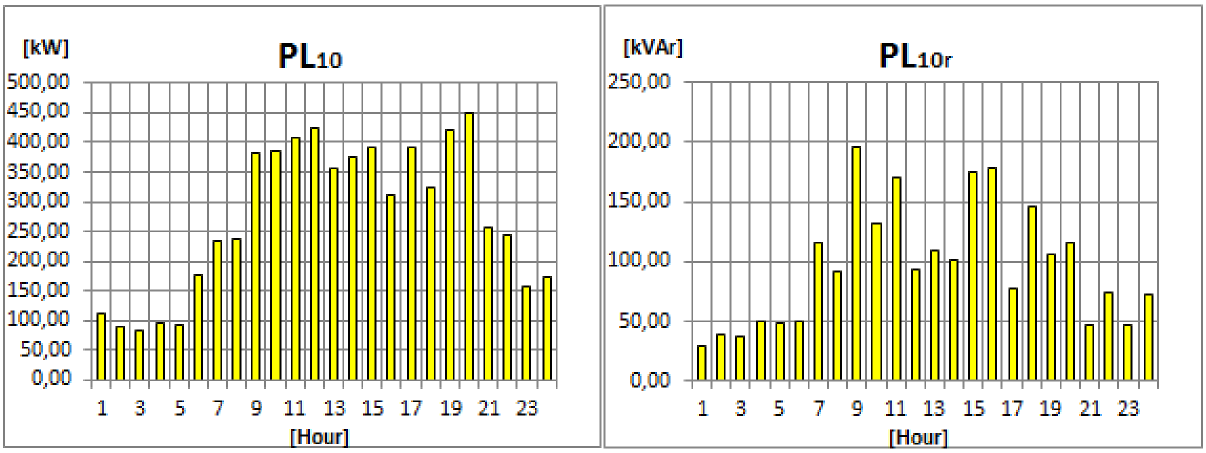

Figure 16 - Node 10 – [525 kW]

The traction system is considered connected at node 11. In Figure 17 the active and reactive power adsorptions are presented (P_{ETS} and P_{ETSr} respectively). Reactive load is due to the system of AC/DC conversion, assuming the presence of a diode three-phase bridge group.

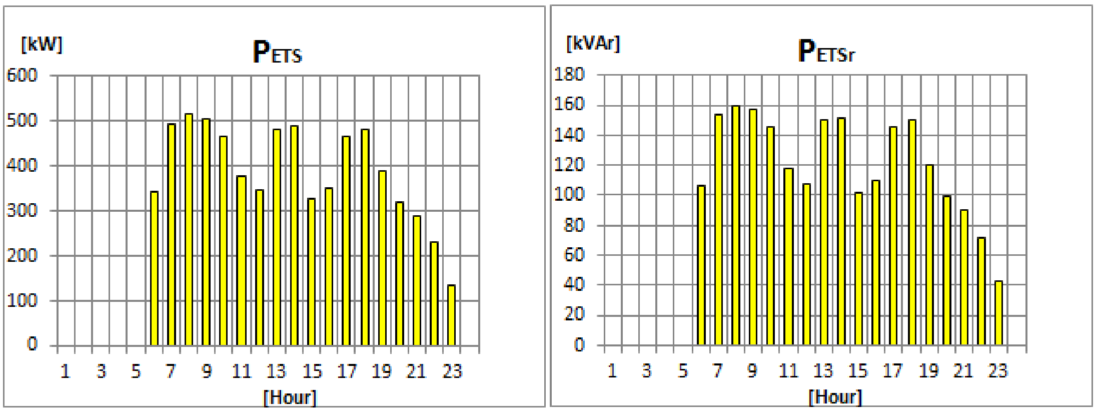

Figure 17 - Node 11 – [400 kW]

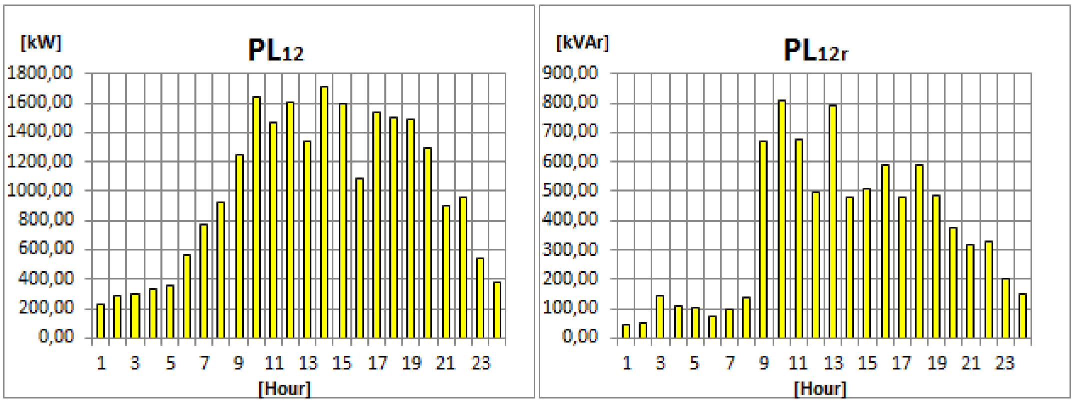

Figure 18 - Node 12 – [1900 kW]

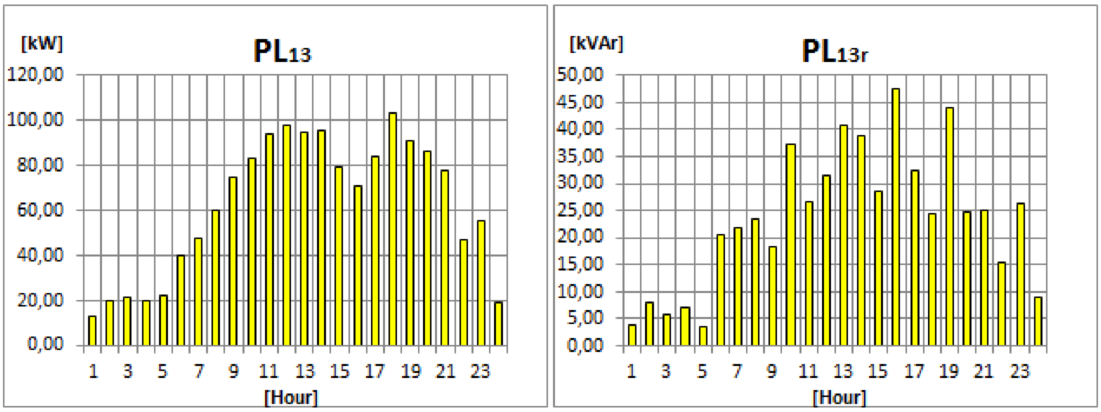

Figure 19 -Node 13 – [120 kW]

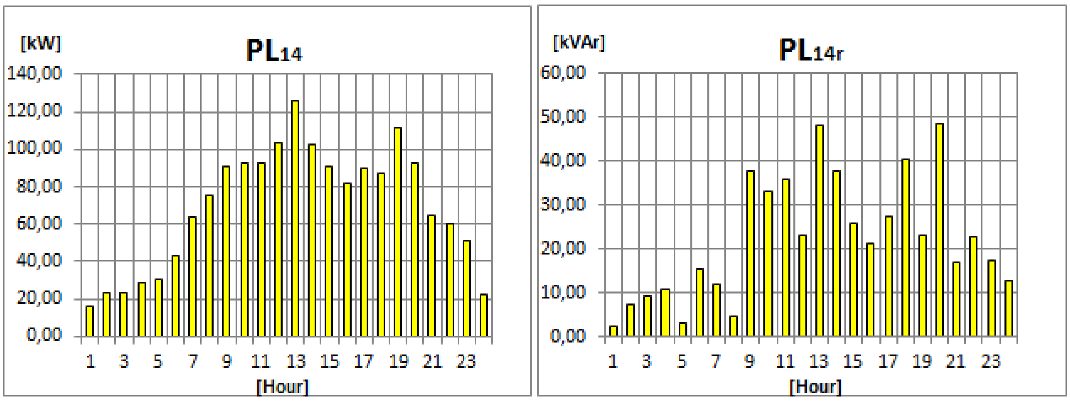

Figure 20 - Node 14 – [130 kW]

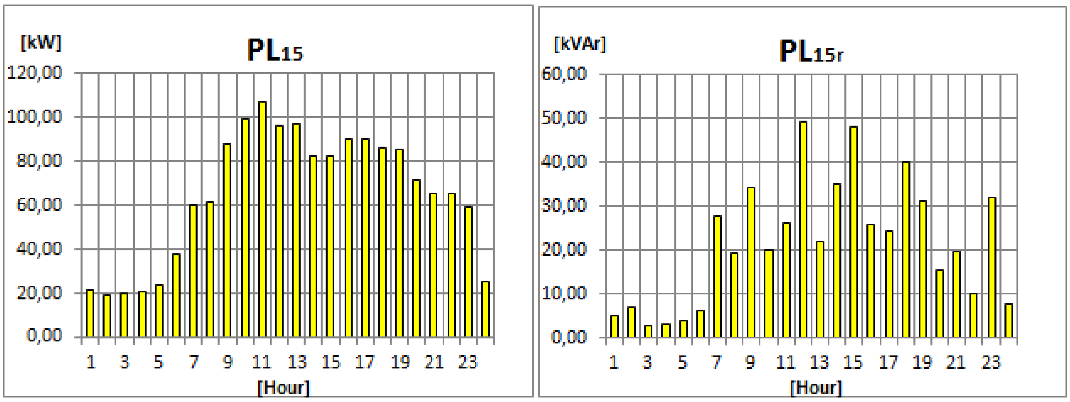

Figure 21 - Node 15 – [120 kW]

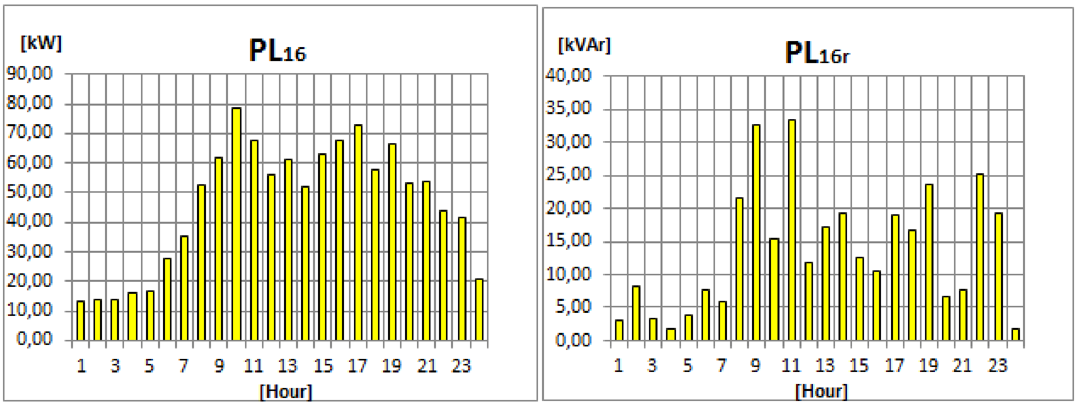

Figure 22 - Node 16 – [80 kW]

In Figure 23 hourly consumptions for electric services to stations of the Metro system are presented.

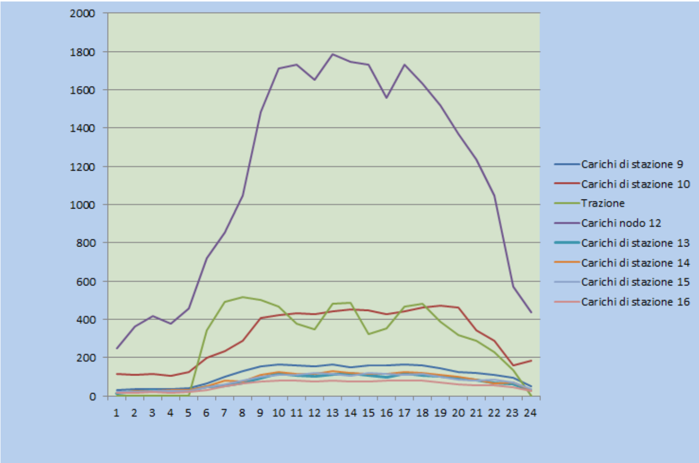

Figure 23–Loads serving Metro stations from 9 to 16 nodes

Prices were given in input to the algorithm by choosing values deriving from an European survey. The values were grouped in three different time slots (I,II,III), where the time slot II comprises the greater values, because it includes peak hours.

In next table, the unitary values are presented, specifically, those for residential users and programmable loads of the transportation system, respectively.

Time slot	**Time**	**Price for residential loads**	**Price for FPL TPL**
	h	**euro/MWh**	**euro/MWh**
I	1	90	87
	2	88	79
	3	92	93
	4	87	79
	5	86	84
II	6	137	117
	7	157	113
	8	160	108
	9	140	118
	10	144	113
	11	160	124
	12	159	130
	13	155	120
	14	141	126
	15	137	132
	16	140	117
	17	161	114
	18	162	124
III	19	98	77
	20	99	83
	21	88	76
	22	86	72
	23	89	86
	24	96	86

Table 8

CRCHP [euro/MWh]	CREVS 10 [euro/MWh]
120	100

Table 9

C_{RCHP} is the cost value for rated power production..

C_{REVS} is the cost value for rated absorption.

Application Scenarios

The following scenarios were considered for simulations:

First Scenario

In this case, substantially, snapshots of the microgrid are taken in the absence of any participation in the Demand Response Program. The M-SUG performs an economic dispatching starting from local generations and demand of electricity. This case represents the reference scenario in respect to which other alternative Energy Management strategies could be comparatively evaluated.

Second scenario

Snapshots of the M-SUG are carried out considering various participation levels of individual controllable loads actively involved in the DRP. The M-SUG agent performs optimal energy dispatching with the aim of minimizing costs resulting from local generation and electricity consumption, considering as sensitive variables among possible participations of SUG members in DRPEV controllable loads and CHP generation sharing.

Electrical energy absorption from the grid is limited according to a prefixed value (Constraint of maximum absorption from the grid: PGRID<2,1 MW).

Third scenario

The same application based on 2nd scenario was repeated modifying the constraint of maximum absorption from the grid increasing the limit to PGRID<2,5 MW.

Different values of upper bound for grid absorption allow to analyze different strategies of Demand Response participation, where different values of objective function ensue.

Generation sharing involves Combined Heat and Power (CHP) generation at node 12, by shaping the absorption amount of this local generation for which the MSUG opts. Main purpose is to buy reducing generation purchased.

Load sharing involves electrical vehicles at node 10, and programmable amount of the loads of the urban transport system, distributed from node 9 to node 16, which include no traction loads.

Participation in Demand Response program is guided by different pricing policies implemented by MSUG, in accordance with the prices imposed by the DSO, with the main purpose in minimizing its own costs.

Results

1st Scenario – Without Load Leveling

In Figure 24, generated and absorbed power profiles resulting from the application of the algorithm are given, in solid and dashed lines respectively. Electric generation comprises supply from the grid (Pgrid), the CHP plant (Pchp12) and the programmable amount of electrical vehicles and loads of the transportation system not directly connected with the traction service (FPLevs10 and FPLtot), in dotted lines.

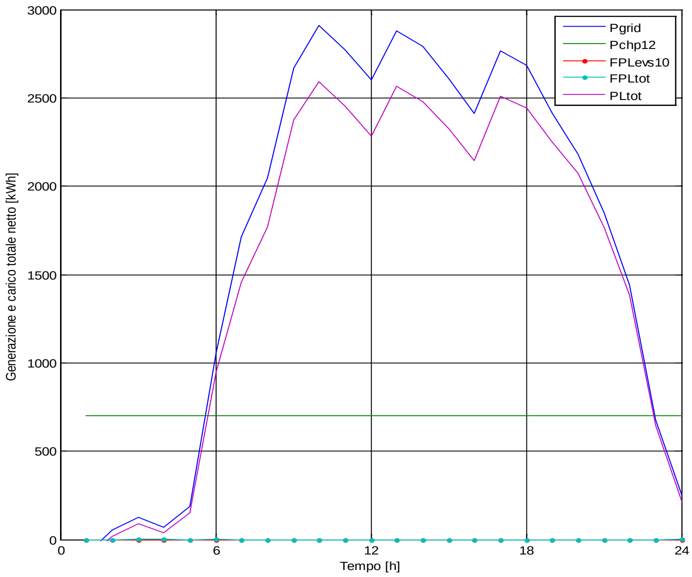

Figure 24 – Local generations and loads

In the absence of any participation in Demand Response Program, as expected, CHP gives a steady contribution to generation, instead programmable loads don't give up any amount of its load.

Figure 25 shows the unitary costs of energy in nodes 10 and 12, which are sensitive in the objective function as a result of simulations.

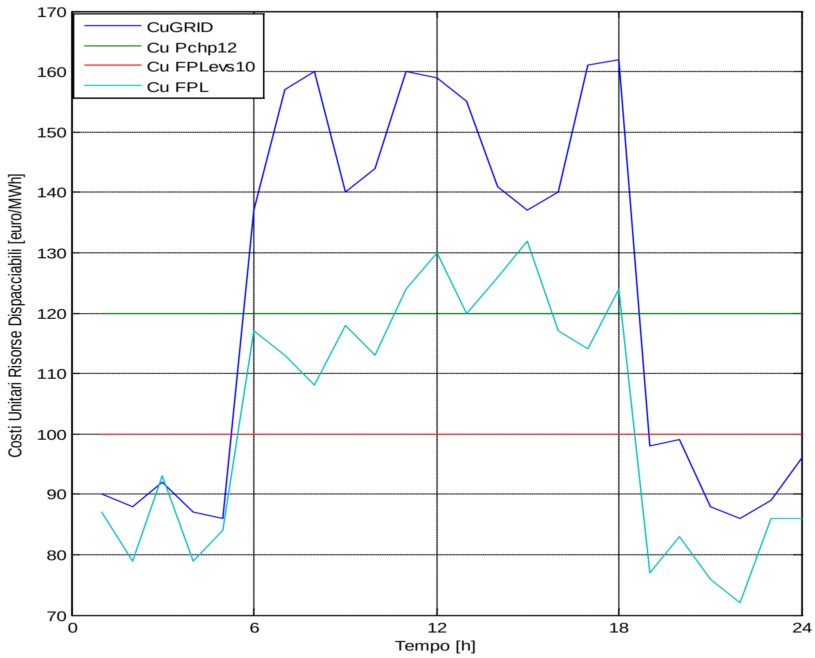

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Figure 25 – Unitary Costs

Figure 26 shows that, as expected, load reduction is not present.

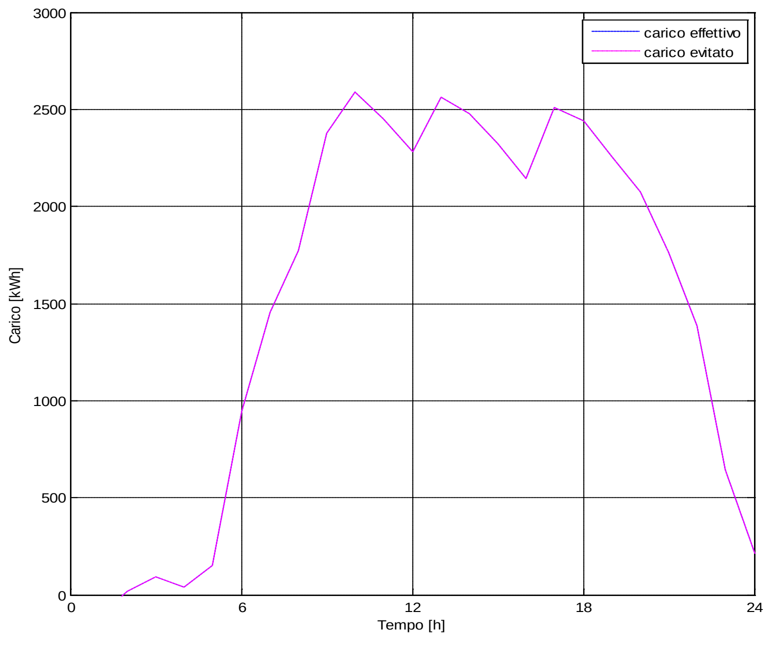

Figure 26 – Effective Load and spare ones

Electric generation includes supply from grid - Pgrid, RES (renewable energy sources) - CHP, WP and PV - and DER (programmable amount of electrical vehicles and station loads - FPLevs10 and FPLtot). Distributed Resources doesn't give any contribution, in accordance with hypothesis (Figure 27).

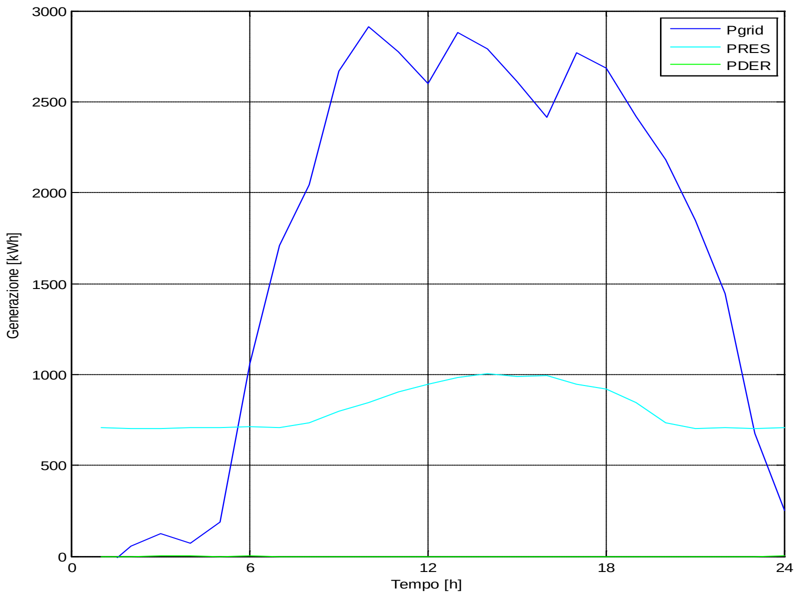

Figure 27 – Mix of production: production from RES, DER and Grid.

Figure28 shows voltage drops resulting from the application of algorithm.

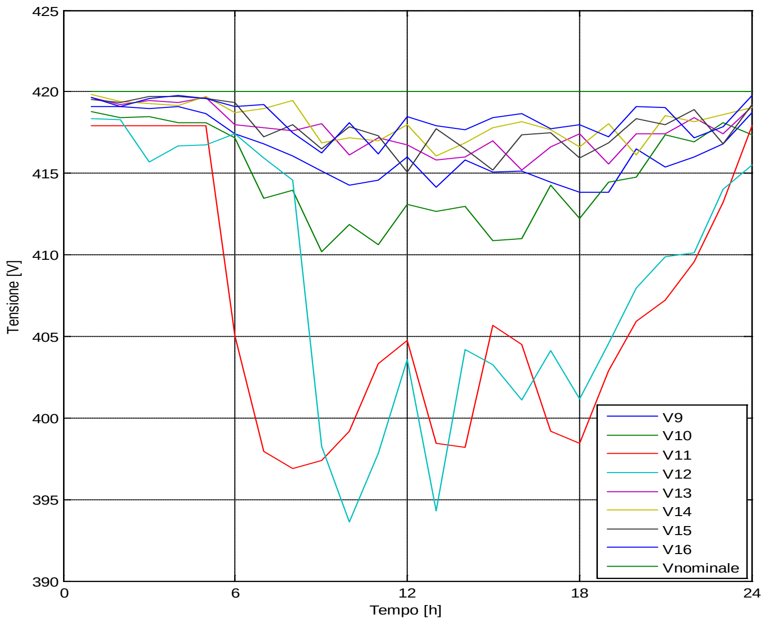

Figure 28 – Nodal Voltage Drops

Most drops are at nodes 11 and 12, evidently, where there are major loads.

2nd scenario – Load Leveling –Pgrid< 2.1 MW

In Figure 29 generated and absorbed power profiles resulting from the application of the algorithm are given, in solid and dashed lines respectively. Electric generation comprises supply from the grid (Pgrid), the CHP plant (Pchp12) and the programmable amount of electrical vehicles and loads of the transportation system not directly connected with the traction service (FPLevs10 and FPLtot), in dotted lines.

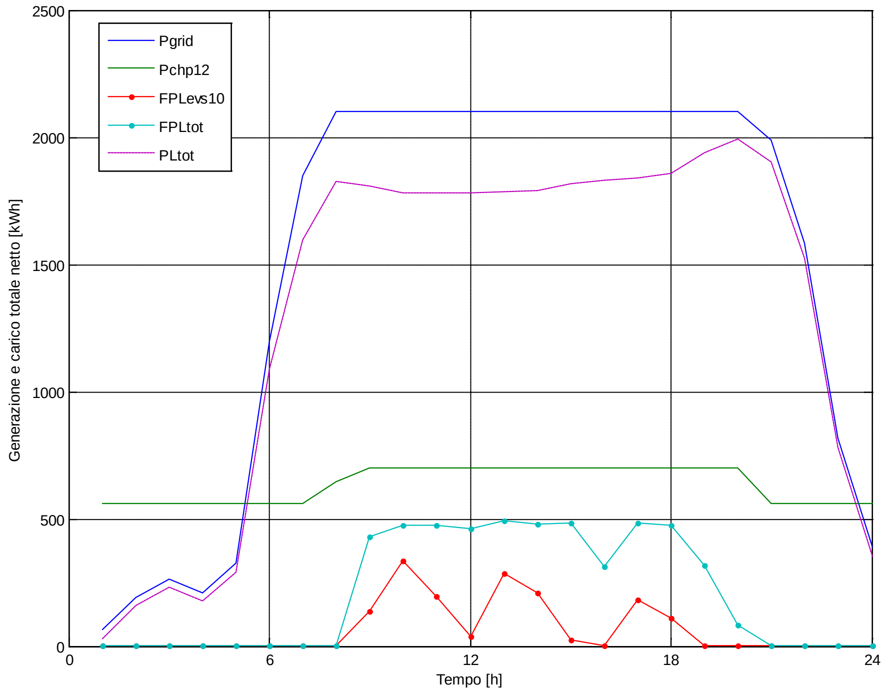

Figure 29 – **Global load and Generation**

In accordance with the hypothesis, CHP generation varies its contribution, while programmable loads give up an amount of demand.

In Figure 30 the curves of unitary costs sensitive to objective function are presented.

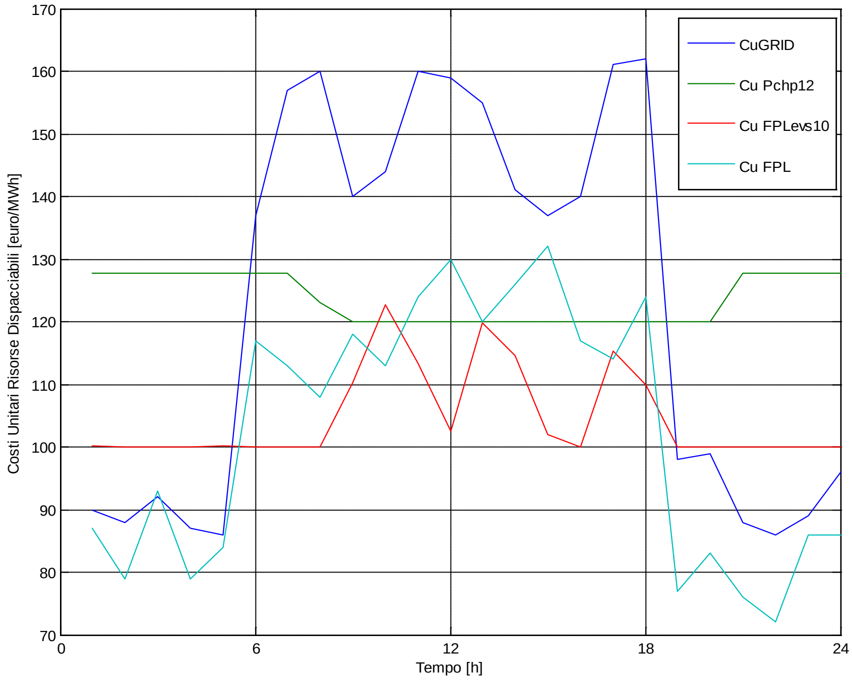

Figure 30 –Unitary Costs

Figure 31 depicts the load reduction depending on the participation in DRP, highlighted by the well visible difference between the achieved effective and spare loads.

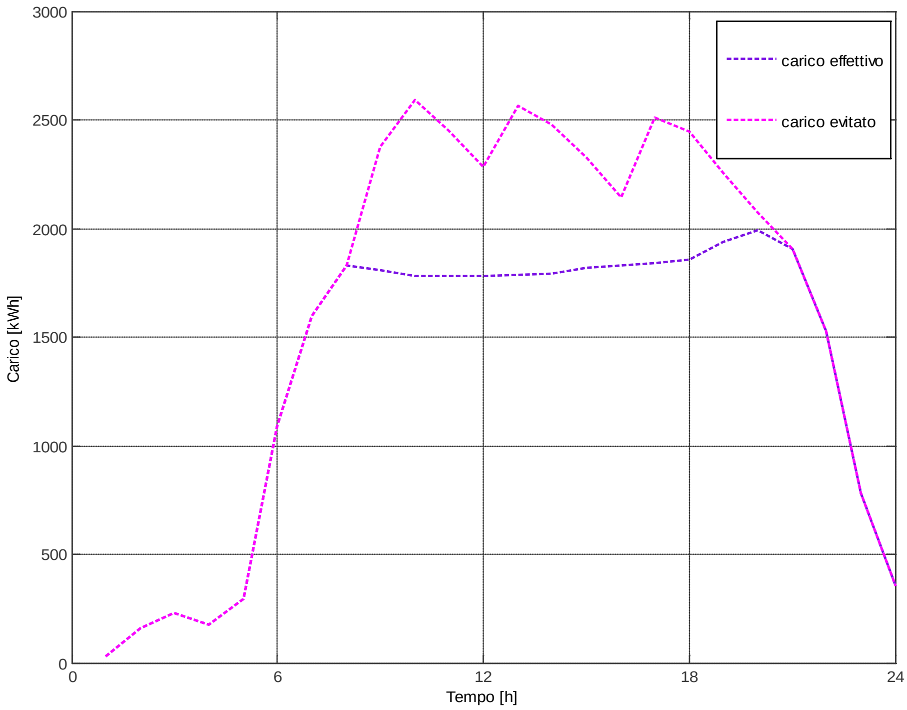

Figure 31 – Effective Load and spare ones

Figure 32 represents the electric energy generation, which comprises supply from grid - Pgrid- , RES (renewable energy sources) including CHP, WP and PV.DERs (programmable loads consisting of electrical vehicles and station loads - FPLevs10 and FPLtot)give a load sharing contribution to local production.

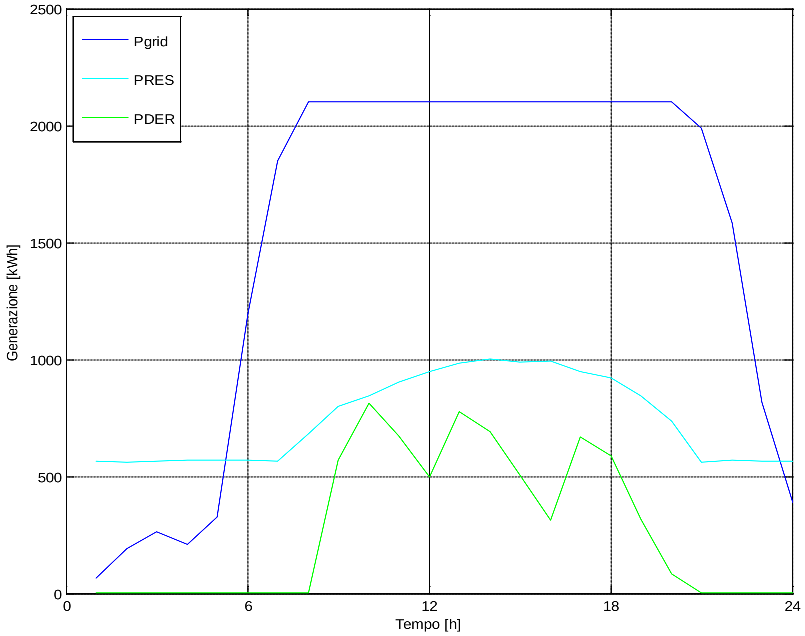

Figure 32 – Mix of production

Figure 33 shows voltage drops resulting from the application. Most drops are at nodes 11 and 12, evidently, where there are major loads.

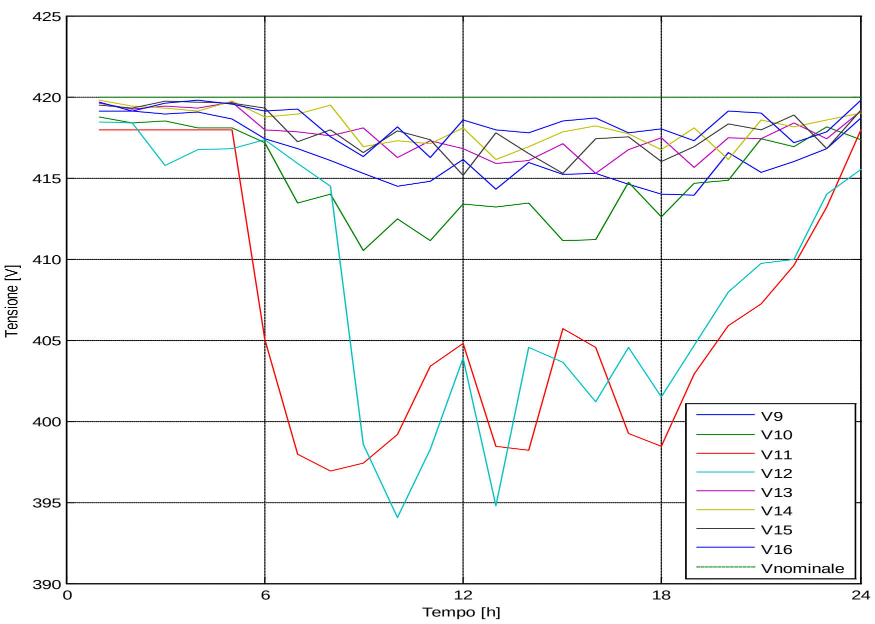

Figure 33 – Voltage drops

3rd scenario – Load Leveling - Pgrid< 2.5 MW

In Figure 34 generated and absorbed power profiles resulting from the application are shown, in solid and dashed lines respectively. Electric generation comprises supply from the grid (Pgrid), the CHP plant (Pchp12) and the programmable amount of electrical vehicles and loads of the transportation system not directly connected with the traction service (FPLevs10 and FPLtot), in dotted lines.

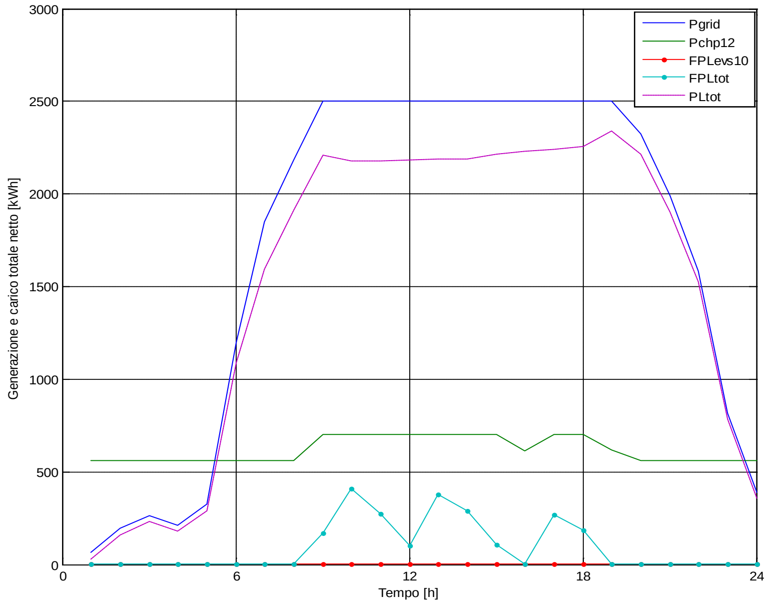

Figure 34 –Power adsorbed from the grid, local production and global load

Participating in DRP, the CHP producer does not generate a constant contribution whose variation is related also to the price policy on the load sharing rate made available. Correspondingly, the variation of demand of programmable loads is visible.

Figure 35 shows the unitary costs of energy in nodes 10 and 12, which are sensitive in the objective function

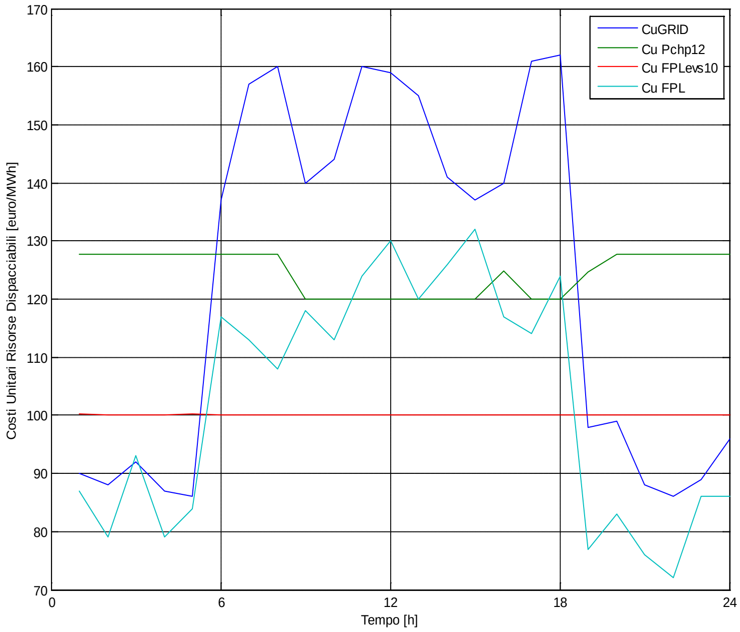

Figure 35 – Unitary Costs

Figure 36 shows the difference between the achieved effective and spare loads derived from the load sharing of controllable loads.

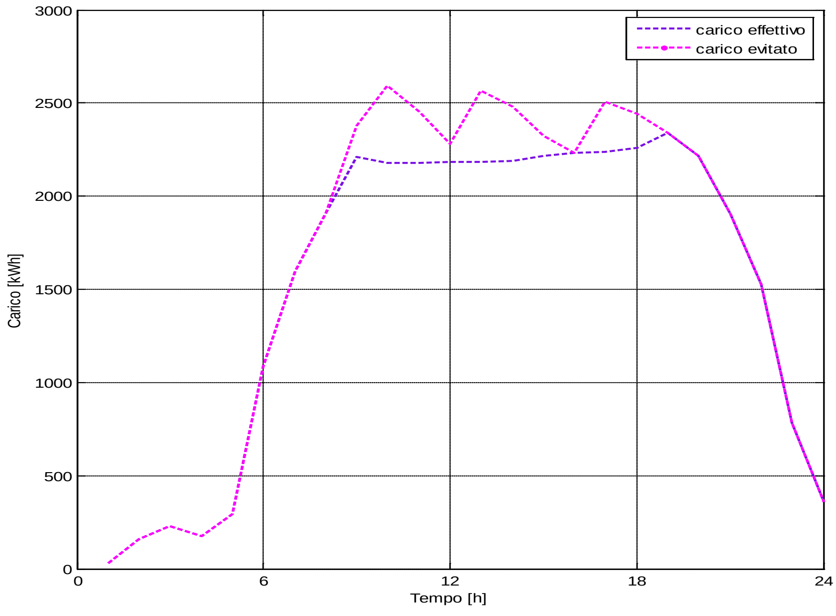

Figure 36 – Effective Load and spare ones

Figure 37 shows the mix of electricity generation in the 3rd scenario.

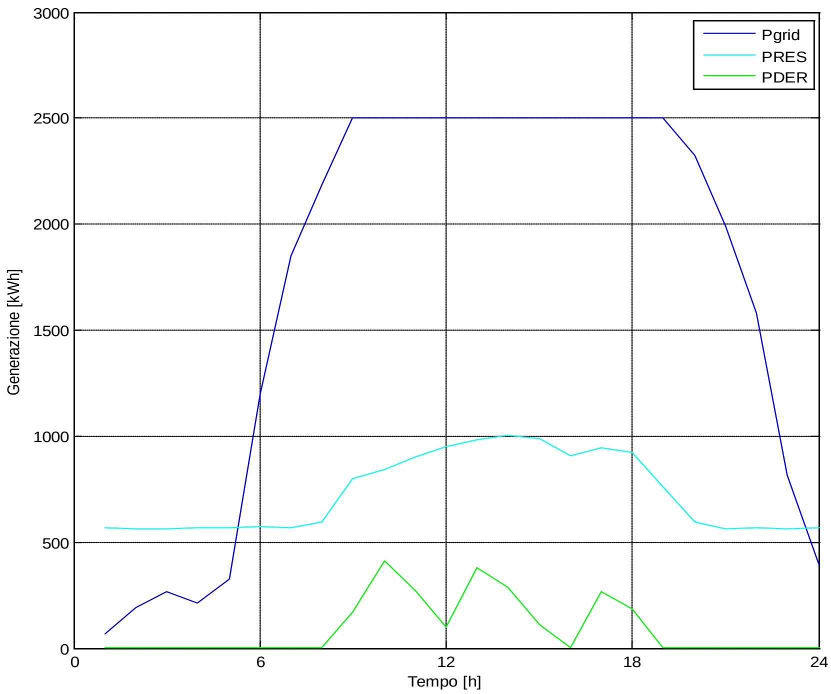

Figure 37 – Mix of the electricity generation

Figure 38 shows voltage drops resulting from the 3rd scenario application. The most remarkable voltage drop is observed at nodes 11 and 12, as expected.

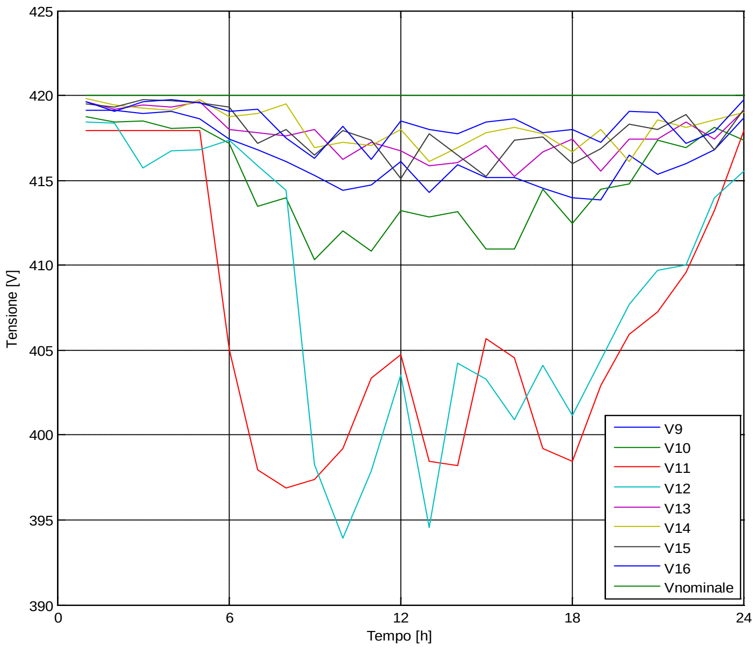

Figure 38 – Voltage drops

Comments on Applications

As above explained, the first scenario represents the absence of any participation in DRP program for each agent of the microgrid. In this case, global costs for the MSUG's Agent (A-MSUG) are equal to 3450 euro for a day (typical day corresponding to that studied). The global consumptions are equal to 36877 kWh, calculated by the proposed algorithm. No-one contribution of the DER to the generation is certainly present, and CHP gives a steady contribution to generation, as expected.

If the Distribution System Operator leads the M-SUG Agent to reduce its total consumption, for the reasons above described, the A-MSUG has to implement the other strategies (as planed) in order to avoid a penalty, fixed by the DSO.

In accordance with hypothesis, in the second scenario CHP gives to generation a not steady contribution and programmable loads give up an amount of its demand.

In the third ones, CHP producer gives to generation a not steady contribution that is different from the above observed, in dependence of the unitary hourly cost (price policy is different), and programmable loads give up an amount of its request, that is different from the 2nd case, depending on electricity hourly prices.

For evaluating the overall performance of the microgrid for each scenario a table of indexes is defined (in Tables 10-11). In order to identify the indexes, the following variables are considered:

1. Global operational costs of the MSUG;
2. Global consumption;
3. DER generation;
4. CHP generation;
5. Power Losses;
6. Differences between the total effective consumption and total avoided;
7. Voltage drops;
8. Local production: sum of production from RESs (PV-WP-CHP) and DERs;
9. Rate of the difference between consumptions and costs, calculated for each strategy (energy saving/cost saving).

This variables allow to calculate the following indexes, respectively:

1. Cost saving;
2. Energy saving;
3. DER's weight: as a contribution to the local production;
4. CHP's weight: as a contribution to the local production;
5. Sum of the Power Losses;
6. Economic Losses: in correspondence of any participation in the DRP;
7. Maximum voltage drop: at node i for time h;
8. Autonomy degree of the MSUG from the grid adsorption;

9. Performance index: based on the efficiency of each strategy.

These indexes allow to compare the strategies, for example, in term of:

- Eventual reduction both in operational costs and electricity consumptions (indexes 1 - 2);
- Effective advantage of each different RESs and DERs integrations (3 - 4);
- Sum of the power losses expected (5);
- Benefits deriving from the different Demand Response Programs (6);
- At which node and at what time the maximum value of voltage drop is obtained (7);
- Autonomy degree of the microgrid from the grid (8).

Finally, in order to establish what is the best strategy a performance index is calculated by comparing the efficiencies of each strategies (index 9). The latest index is calculated as the rate of the difference between consumptions and costs calculated for each strategy (energy saving/cost saving).

Drivers	1st scenario	2nd scenario	3rd scenario	Index
MSUG's Costs	Fval (1)	Fval (2)	Fval (3)	**Cost saving**
Global consumption	PLtot (1)	PLtot (2)	PLtot (3)	**Energy saving**
DER's contribution (medium)	$\frac{P_{DER}}{GEN\ tot}$	$\frac{P_{DER}}{GEN\ tot}$	$\frac{P_{DER}}{GEN\ tot}$	**DER's weight in the global production**
Contribution of CHP (medium)	$\frac{P_{CHP}}{GEN\ tot}$	$\frac{P_{CHP}}{GEN\ tot}$	$\frac{P_{CHP}}{GEN\ tot}$	**CHP's weight in the global production**
Power Losses (TOT)	GENtot - PLtot	GENtot - PLtot	GENtot - PLtot	**Power Losses**
With and without participation in DR	PLtot eff - PLtot avd	PLtot eff – Pltot avd	PLtot eff - Pltot avd	**Economic losses**
Voltage drop at node 12 (max)	ΔV	ΔV	ΔV	**Voltage drop**
Local production	$1\text{-}\frac{P_{GRID}}{GEN\ tot}$	$1\text{-}\frac{P_{GRID}}{GEN\ tot}$	$1-\frac{P_{GRID}}{GEN\ tot}$	**MSUG's autonomy from the Grid adsorption**
ΔConsumptions/ ΔCosts of the MSUG	Comparative term for the other scenarios	$\frac{PLtot(1)-PLtot(2)}{\Delta\ Costi\ MSUG}$	$\frac{PLtot(1)-PLtot(3)}{\Delta\ Costi\ MSUG}$	**Efficency of the strategies**

Table10 – Table of Indexes

Drivers	1st scenario	2nd scenario	3rd scenario	Index
MSUG's Costs [euro]	3450+penalty	6800	5400	**Cost saving**
Global consumptions [kWh]	36877	31977	36680	**Energy saving**
DER's contribution (medium) [%]	0	7	2	**DER 's weight in the global production**
Contribution of CHP (medium) [%]	40	34	34	**CHP's weight in the global production**
Power Losses TOT [kWh]	4213	4210	4212	**Power Losses**
With and without participation in DR [euro]	-	6800-(3450 + penalty)	5400-(3450+penalty)	**Economic losses**
Medium voltage drop (max) at node 12 – (h=10)	26,41	25,95	26,08	**Voltage drop**
Local production [kWh]	43,70	45,16	39,63	**MSUG's autonomy from the Grid adsorption**
ΔConsumptions/ ΔCosts of the MSUG	Comparative term for the other scenarios	1,46	0,10	**Efficiency of the strategies**

Table 11 Results

A total cost reduction is obtained by implementing the third scenario, instead the minimum value of the global consumptions is obtained in correspondence of the second one (for the third scenario the achieved energy savings are smaller than those in the second scenario). For the 2^{nd} scenario the performance index results greater than 1 (because energy saving > cost saving), instead for the 3^{rd} the performance index results less than 1 (because energy saving < cost saving). Therefore MSUG's Agent could choose to apply the third scenario if its objective consists in minimizing the global consumptions, rather than could choose the second ones to maximize the performance index of the strategies.

Reducing MSUG's dependency on the grid requires a combination of different measures that can be defined from knowledge of the autonomy degree of the microgrid, measuring the 8^{th} index. In this case study, the greater autonomy is in correspondence of the second scenario, as expected.

Chapter 8 - VPCP model implementation Energy Area of Case Study

Basic procedures of VCP certification

Basic procedures arise from the progressive steps of the VPCP process applied to the features of the specific Energy Area.

Firstly, the general approach described in Chapter 5 allows to frame any subject to get certification within a perimeter, including the set of available energy resources. Such perimeter can be generally and systemically definable as an “energy area”.

The certification object may concern either the whole system inside the energy area or a part of this, inclusive of all related internal energy resources. Then, in general the VPCP object’s identification can be considered derived from a decomposition of the whole system in parts or modules, according to the schematization shown in Figure 39, where the example is referred to the Case Study developed in Chapter 5.

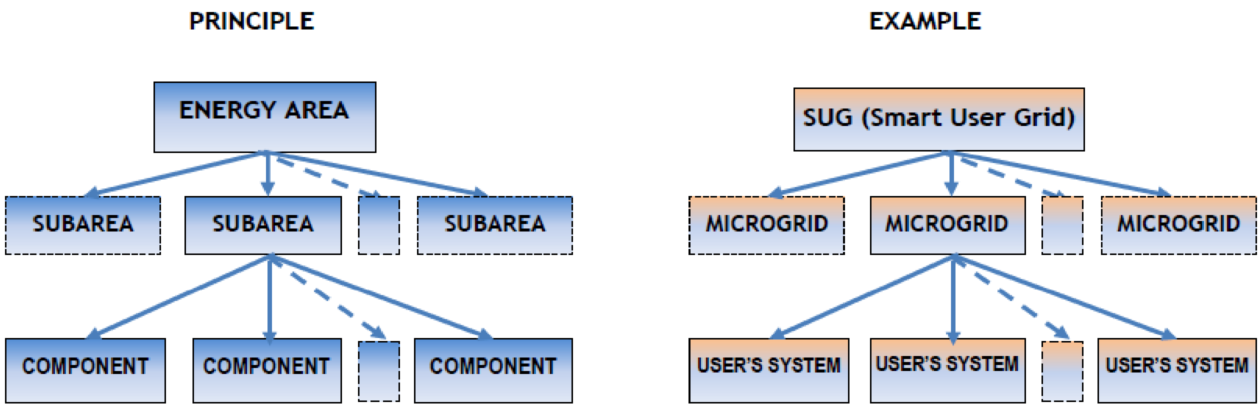

Figure 39 - Definition of energy area and extraction of the certification subject

On the other hand, like any other product certification procedure for complex technological systems, the VPCP model applied to energy areas must be managed at the levels of subsystem or component. Then, the definition of the object of certification for the energy areas can be obtained only transforming the entire heterogeneous and complex system in a set of energy subsystems or components, each of them classified or classifiable as individual certification objects.

The procedure to complete the first step of certification objects identification is referred to Figure 10 of Chapter 5 and related descriptions.

As mentioned in Chapter 5, the analyses related to each area’s subsystems or components permits to identify the entire system through the classification of each subsystem and components, then of the individual objects in order to be certificated. If a subsystem seems hard to be classified, it is necessary to go on to a further decomposition. Each object identified through the classification procedure can be identified as either “current” or “new”, in dependence on the level of technological innovation and the existing standard references for the items of concern.

In the case in study the energy area is identified in terms of property, jurisdiction, physical composition and by lists of assets, departments, structural and infrastructural components.

Juridical references and data, organizational and functional diagrams can be supposed at disposal, as well as technical documents and graphics related to the system. The data of interest can be gathered and examined for a complete description of the context of interest, its modeling and further parameter identification, if required.

Having considered the SUG, the overall technological system is decomposed in subsystems and components and then classified and characterized, not only as for technical specifications but also regarding the operation modes and duty programs.

Classification is basic for determining of type and innovation of technologies. It is important in this step to take into account the available standards of possible references related to technologies to be verified.

Structure of VPCP certification

The basic generalized scheme of the VCP process for Energy products is shown in Figure 40.

The process consists of three steps:

1. Procedural step aimed to build-up a basic platform of verification, structuring the VCP through a program of Verification and Validation (V&V) procedures oriented to the achievement of the certificate, considering the complexity of the energy system, its individual subsystems, the specific typologies of technologies implemented. The deliverable is the design of basic platform, addressing the certification case, consisting of the definitive program of surveying approach including methods and planning of both V&V actions and related lists of specific procedures to be implemented for the case;
2. Technical step which, starting from the previous deliverables, firstly implements individual procedures of V&V and testing survey according to typology and features of the concerned energy system or product, for all the subsystems. The deliverable aims to the customization of the basic platform which provides the list of standard requirements of practical application of VCP for this case. Such material is drawn from a detailed development of general procedures performed by a program suitable for the criticality's identification and risk's analyses.

Then, the standard requirements are completed with a comprehensive recognition of applicable recommended practices related to specific technologies, particularly specialized according to parameters such as system complexity, innovation levels, subsystems hi-tech ranking, etc. The final deliverable is a complete and exhaustive multi-level procedure which is organized in an unique template of VCP.

The basic structure proposed for the certification model consists of the following types of documents:

— *Service Specifications.* Procedural requirements.

— *Standards.* Technical requirements.

— *Recommended Practices.* Guidelines for applying procedures and technical standards.

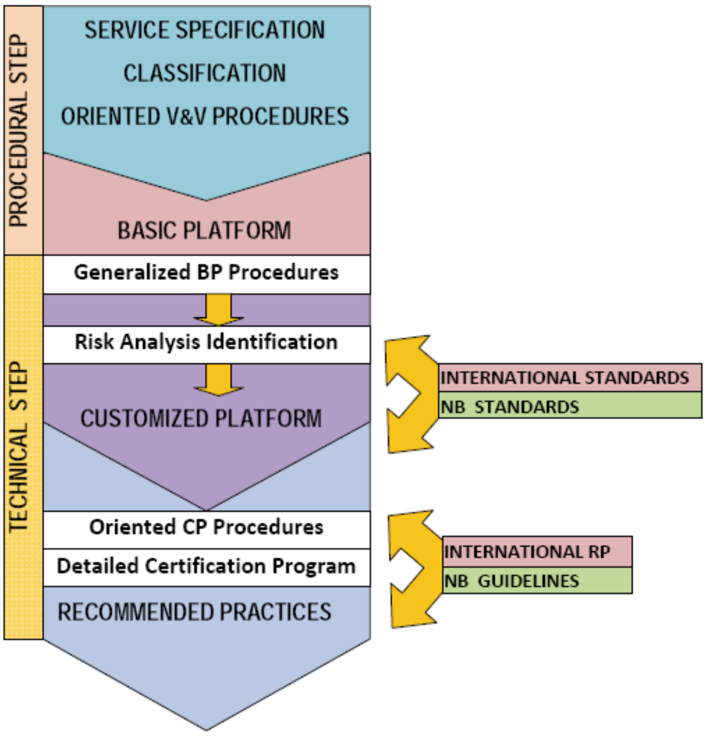

Figure 40 - ***BP - Basic Platform - CP - Customized Platform -NB - Notified Body - RP - Recommended Practice***

In the Case Study, the whole SUG is considered as the certification object, and in such an assumption the first step of analysis and characterization of the subject starts, in order to carry out the Basic Platform Development, as shown in Figure 40 and described in the followings.

Qualification process for new technology

The procedure of the "Qualification of a New Technology" specifies the philosophies, principles and methods to be used in the qualification process, as well as it is applied in the context of energy areas. At each step of the process, certain documentation is needed for the process traceability.

The first objective of the qualification procedure is to ensure that the technology functions are reliable within specified limits. The pursued approach provides a rational qualification process, by focusing on a balanced use of parameters as reliability, performances and costs. Practically, the adopted certification scheme assumes the qualification based on previously specified performance limits, boundary conditions and interfacing requirements. Then, the qualification process is centered on reliability parameters, considered strictly dependent on the costs strategy. The reliability goals specified for the certification should be based on the system business plan. These goals should be clearly specified in the certification basis.

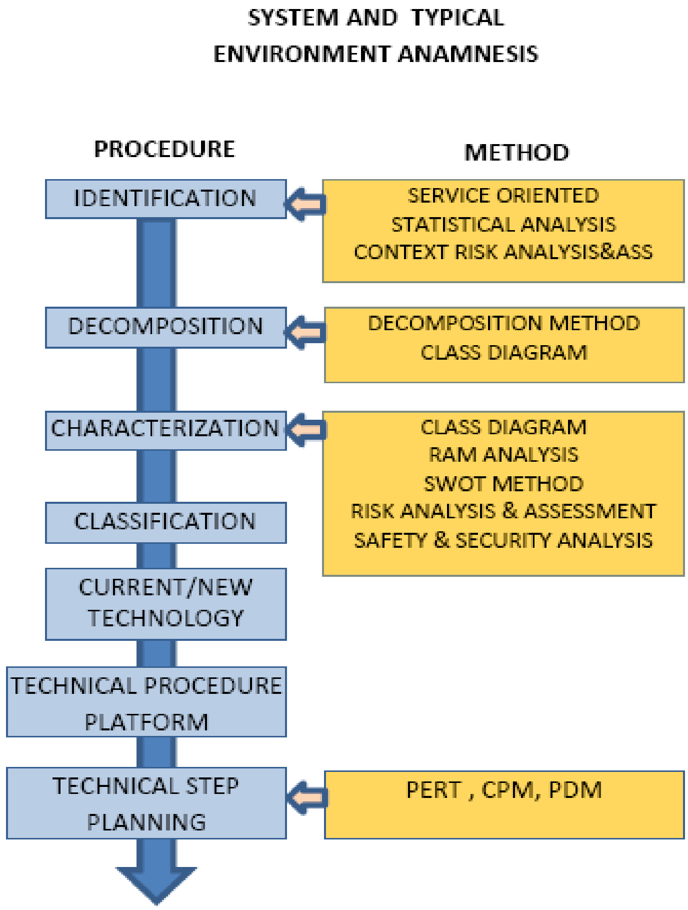

Figure 41- Basic Platform development

The process is led according to an overall plan for the qualification, customized to the specific technologies. Such a process is continuous and needs being renewed after each step, using the available knowledge on the status of the qualification.

It comprises the following main activities, for each part of the system (components, subsystems) and of the whole system:

- Develop a comprehensive report of each part, classifying and identifying the concerned technology in terms of 1)typology, 2)general mission 3) particular functional, 4) safety and 5) environmental targets, 6) degree of novelty and 7) Technology Transfer, 8) grade of uncertainty significance.
- Establish an exhaustive V&V procedure aligned to the technological mission, after defining the functionality and limiting operating parameters for the new technology.
- Assess the influence of factors such as maintenance, condition monitoring and possible concept modifications in order to reduce the risk.

- Plan and execute reliability data collection. The data is used to analyze the risk of not meeting the specifications through experience, numerical analysis and tests.
- Analyze the reliability of the new technology, and thereby the risk of the failure modes related to the functional requirements of the new technology.

These logical steps in the qualification process are combined and visualized in groups in Figure 42. The results from one step are the input to the next step.

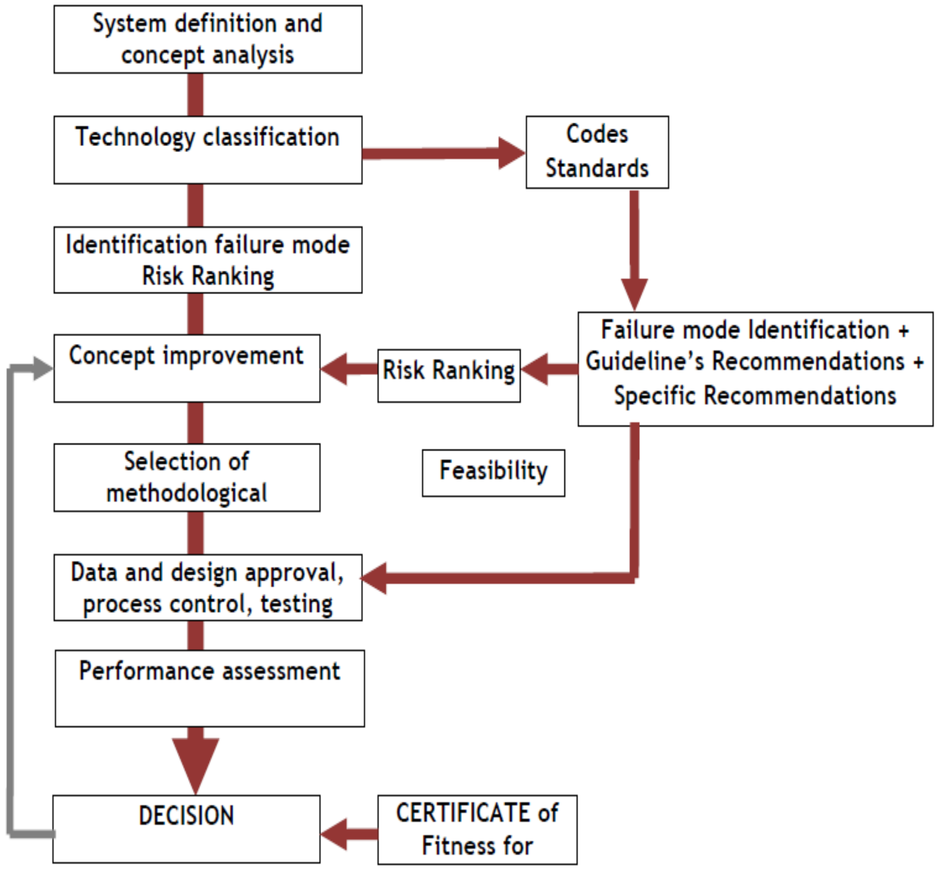

Figure 42

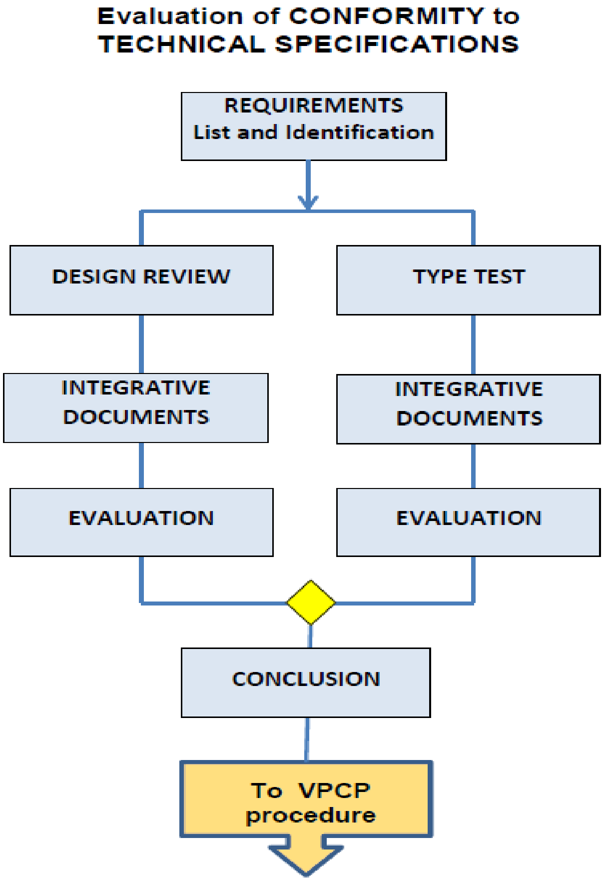

Figure 43

Deliverables and documents

Documents

The final conclusion for the certification will be documented by a specific agreed deliverable . The deliverables indicate the incremental nature of the certification process with each stage contributing to the next step. The deliverables provide for the gradual increase in detail and scope from the concept stage through to certification of a fully developed product. Typically these deliverables will be issued as follows.

Reports

—*Feasibility evaluation*. The document states that, at the time of assessment, the new technology is considered conceptually feasible and suited for further development and qualification, according to the specific recommendation;

— *Design validation* The conclusion of the design assessment process, on the basis of the formal and informal intermediate registered or gathered material, should be documented by a Statement of Design Assessment;

— *Product Conformity* for Components and Assemblies. Such documents are certificates issued by the NB regarding different components including design appraisal, manufacturing surveillance and factory acceptance testing;

— *Survey Conclusion statement*- Reports issued by NB surveyor addressing the issues related to surveillance activity that may cover different stages such as manufacturing, testing, commissioning and installation.

Certificates

After design and experimentation assessments, on the basis of the exploitation of the progressive and final V&V procedures, certification documents can be issued.

In order to account for the different stages in the development of the device the NB may issue the following certificates supported by survey reports:

Prototype Certificate

Certificate issued to enable testing of prototypes and is based on design evaluation. This certificate implies that all the certification steps up to the issue of this certificate were successfully carried out (statement of feasibility, design assessment, fitness for purpose and manufacturing surveillance) for the specified location/conditions.

The location of the device is stated on the certificate and the period of validity is limited up to a fixed time (e.g. 2-3 years). The issue of the Prototype Certificate is based on successful evaluation by NB of:

— prototype design, including installation procedures

— prototype fabrication surveillance

— installation surveillance

— final acceptance/commissioning inspection

— periodic inspection.

During the prototype design evaluation, matters with no safety implication within the period of validity can be considered at a higher level with the use of simplified methods (sufficient to demonstrate that the risk of significant damage to structure and equipment is minimized), pending operational data from the prototype and any resulting design changes. Those issues will be assessed based on existing knowledge and with uncertainties to be clarified, under controlled circumstances, during the prototype test stage.

Conditioned Type Certificate

The Conditioned Type Certificate is issued to allow for 0-series production as well as to allow for outstanding matters with no safety implication. The Conditioned Type Certificate is based on full certification scope with the exception that outstanding matters are allowed. The outstanding matters are however limited to:

— matters with no safety implication within the period of validity (maximum 1 year)

— matters related to the finalization of manuals and quality control procedures

— matters related to the finalization of inspections regarding the implementation of the design-related requirements in production and installation.

Type Certificate

The Type Certificate is issued for production model with no outstanding issues (validity of 5 years subject to annual endorsement).

Project Certificate

These documents/certificates will make reference to the standards, regulations and other specifications which have formed the basis of the certification, and will be backed up by a traceable record, documenting the information considered and the considerations made in arriving at the final status of the verification work.

Declaration of Conformity EU

The Declaration of Conformity EU needs to be signed by someone who has the power to make binding commitments on behalf of the manufacturer, but for the Declaration to be truly meaningful the signatory should also be someone who has the authority to commit the resources required to ensure that the CE marking process is properly completed. Each directive has slightly different requirements for the content of its Declaration but some features are common to all, as the following:

- Name/address of manufacturer (and of responsible person where applicable);
- Model and/or serial number of equipment;
- List of relevant directives;
- List of standards used, with dates + amendments;
- Declaration statement;
- Name and position of person signing;
- Signature;
- Date.

If a Notified Body is required to be involved in the CE marking process (e.g. for product type approval or quality system assessment), their details should appear on the Declaration.

All documents are characterized and headed through all characteristics of location, site and environmental conditions. Also variability factors are considered, including the connections to power grid and ICT interfaces.

For new technologies, qualification and testing of new technology will be documented separately.

In the contract typology of the object to be certified, as well as aim, rationale, objective and expected service requirements should be clearly reported.

All these aspects should be carefully examined before starting the certification process in order to get adequate data and information for defining and identifying all requisites of the system and its context.

Evaluation of reliability

The qualification process can be run throughout the whole development of the new technology, or be started at any time in the development. Appropriate methodologies depending on the certification object should be defined. Generally the reference platform for reliability evaluation is based on multi-criteria method, based on calibrated combination of experimental and operation data, testing and RAM analyses.

Testing

The analytical approach should be supported and complemented by results obtained from testing to handle the uncertainties in the technologies of concern.

Testing program consists of testing activity carried out along design, prototyping and production processes, but can be integrated by supplementary activities by laboratory or pre and post installation tests.

Typical testing regards basic tests, such as testing of material properties and degradation mechanisms, as well as operational tests, where components or subsystems are tested in operational condition.

The prototype/pilot is important, it represents the prove of possible activation of the products or systems and can ensure that all aspects of a complex system have been taken into account.

Conclusions

In the next future, following the trend of deregulated energy market developments, driven by the unstoppable technological progress of energy products and services, a heavy demand of voluntary certification shall undoubtedly arise, in order to guarantee quality and technical specifications of products and related processes, by procedure much more complete than CE Mark mandatory for single devices and elementary components. In fact, the needs of certification will regard products and related technical specifications with proven requirements, such as: origin, productive quality, technological quality (materials, design, construction, technological transfer, manufacturing, testing, etc.), environmental quality, energy and power quality, durability, safety and security.

The variability of smart configurations and control logics will necessarily require a customized of product certifications, based on operative procedures and Technical Operative Instructions tailored on the cases of interest.

After a systematization of certification services and related state of the art, a description of the recent evolution of the energy deregulated market guided by the technological development has been made. In this context a new paradigm of Global Energy Efficiency is presented. It introduces the concept of the global energy management strategy based on providing an intelligent management tool, giving suitable flexible specifications to the management model. A procedure for implementing an optimal EE management based on a flexible logic architecture is proposed, integrating highly automated distributed resources, according to concepts of systemic EE for urban transport systems.

The proposal is technologically advanced and addresses systemic innovations in the field of electrified urban transport systems. Some evolutions in power supply standards should be required along with high quality design and realization. Nevertheless, remarkable advantages would be ensured:

- Use of complex and hardly applicable logic tools for optimal EE management. Availability of consolidated automation and control technologies to build up the new technical proposal;
- Easiness to perform assessments through indices associated with EE parameters.

Then, a general third part new voluntary certification program is developed for the energy sector, it is named VEPCP(Voluntary Energy Product Certification Program) and aims to ensure the expected requirements of quality, technical specifications of energy products and processes related to component, subsystems, systems and technical areas, anyhow complex. A case study has been properly set up for exemplifying the feasibility of VEPCP and its suitability to address the following goals:

- Demonstrating the necessity of the accreditation, with its economic value of market, about the technological reliability and efficiency performances of the management system;
- Illustrating the typical process and contents of a possible proposal of a voluntary certification model, for the accrediting of the energy efficiency performances of a 3th-level energy product, according to the classification proposed, employing the GEE paradigm.

Case study deals with a complex system, whose real performance in terms of energy efficiency are strictly dependent on the technological quality, reliability and measurements accreditation. As a consequence of such complexity, the economic appraisal of the concerned EE certification should be suitably valued by the market.

Beyond this target, the choice of the Case Study gave the possibility to propose an innovative approach to carry out a flexible simulation tool capable to perform optimal energy management of both operation-oriented and market –oriented practical applications related to anyhow extended and composed smart user grids. On the basis of such a pattern, the Case Study performed the experimental implementation of the new certification method, thanks to its very heterogeneous and largely distributed energy area centered on the urban metro-funicular system, as well as to the intelligent energy management tool needed for its operation. For these prerogatives the application was featured and developed to specifically highlight the feasibility and significance of the proposed new scheme of energy product certificate.

VEPCP is a certification program which can be defined as vertical, because it matches the scheme of the ISO 50001:2011 standard.

Because of the huge variety of energy product and processes and the high rate of innovation of devices and of energetic and environmental projects, the implementation of the new certification platform is neither easy nor fast. One of the major challenge is that energy products are often highly innovative, then their certification programs cannot have a complete standard to use as reference.

To contrast a possible lacking of reference standards, also partially, a certification procedure must be replaced with Specific Technical Disciplinaries (STD), depending on the specific certification proposal.

Each STD is built up on the basis of technical references and procedures, derived from best practices, practical experiences and consolidated engineering doctrines.

Given the intrinsic systemic approach, the model provides a strong and flexible capability of supporting the EE management in planning and decision-making problems with smart and dynamic transactions, addressing participation in the future electricity market. Therefore, it is very suitable for the GEE in a smart city environment.

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