This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement Nº 691768

European regulatory framework for BIPV

Project report

ACCIONA, NOBATEK, CEA

July 2016

Document summary

This document is the deliverable associated to the task "T1.2: Regulatory framework" within "WP1: Business case definition" of the PVSITES project.

A detailed analysis of the current regulatory framework potentially affecting the project expected impacts is performed: functional requirements for the standardization of BIPV products and systems, and construction needs and barriers; financial and supporting schemes commonly used in PV sector; and suitable business models for a new scenario given by the PV and electricity market evolution in recent years and the grid-parity achievement in the most advanced and privileged countries and markets.

Self-consumption business models, the most suitable for BIPV technologies, particularly in the residential sector, are assessed in detail; and some useful recommendations are provided in order to improve regulatory frameworks and advance towards a more sustainable energy global model.

Acknowledgements

The work described in this publication has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement Nº 691768.

The present report was mainly prepared by PVSITES project partner ACCIONA, with additional contributions from NOBATEK and CEA. The report was originally submitted to the European Commission as Project Deliverable D1.2 in July 2016, and revised in September 2016.

Disclaimer

About the PVSITES project

PVSITES is an international collaboration co-funded by the European Union under the Horizon 2020 Research and Innovation program. It originated from the realisation that although building-integrated photovoltaics (BIPV) should have a major role to play in the ongoing transition towards nearly zero energy buildings (nZEBs) in Europe, the technology in new constructions has not yet happened. The cause of this limited deployment can be summarised as a mismatch between the BIPV products on offer and prevailing market demands and regulations.

The main objective of the PVSITES project is therefore to drive BIPV technology to a large market deployment by demonstrating an ambitious portfolio of building integrated solar technologies and systems, giving a forceful, reliable answer to the market requirements identified by the industrial members of the consortium in their day-to-day activity.

Coordinated by project partner Tecnalia, the PVSITES consortium started work in January 2016 and will be active for 3.5 years, until June 2019. This document is part of a series of public reports summarising the consortium's activities and findings, available for download on the project's website at www.pvsites.eu.

The PVSITES consortium:

Tecnalia Research & Innovation	**CTCV**	**FormatD2**
Onyx Solar	**Flisom**	**Vilogia**
BEAR-iD	**Cricursa**	**R2M Solution Research to Market**
Nobatek	**CEA**	**CADCAMation**
Film Optics	**Acciona Infraestructuras**	**WIP - Renewable Energies**

Contents

Tables

Figures

1 EXECUTIVE SUMMARY

1.1 Description of the deliverable content and purpose

The regulatory framework affecting the development, implementation and commercialization of building integrated photovoltaic (BIPV) products included in PVSITES project is analyzed in this document, in order to advance in the achievement of the general and specific objectives set out in the project. These goals can be summarized in the following subjects, which constitute in turn the structure of the document:

- Procedures for the standardization of construction products and possible barriers in those countries where demo-systems will be implemented: Belgium, France, Spain and Switzerland (demo-countries).
- Financial and business models, support and incentive schemes for photovoltaics. Analysis of the grid-parity evolution and assessment the self-consumption opportunities in the demo-countries, in the demo-countries.

In the first part of the document (Chapter 2), the general procedures for the standardization of construction products are analyzed according to the current legislation about the declaration of performance required for obtaining the CE marking, necessary to commercialize any product in the EU. Additionally, possible barriers encountered will be gathered and analyzed in order to develop mechanisms for overcoming them. In this regard, the following items will be explored:

- General procedure to obtain the CE marking: clarification of basic concepts and mechanisms of the EU legislation for the standardization of construction products, such as Basic Requirements (BR), Harmonized Standards (HS), European Assessment Document (EAD), European Technical Assessment (ETA), Declaration of Performance and CE marking.
- Functional requirements for standardization: identification of construction, photovoltaic and passive energy requirements of PVSITES products. Detection of needs and barriers of the related harmonized standards and European Technical Guidelines (ETG) useful to obtain the European technical assessment and the CE marking.
- Roadmap for the standardization of PVSITES products: analysis of the more suitable procedure to get the standardization of products and the CE marking, and identification of the common potential requirements and needs aimed at the future elaboration of a new specific harmonized standard, or an appropriated European assessment document, for BIPV products.
- Construction needs and barriers for implementing the PVSITES demo-systems: detection of specific needs and barriers in the national building codes of the countries where the demo-buildings are placed; specifically focused on the arquitecture requirements to fulfil by the demo-systems in their respective locations.

This section analyzes the standardization procedure of BIPV products identifying some common potential requirements and needs aimed to the future elaboration of a new harmonized standard, or a European assessment document, specifically focused on PVSITES products. A deeper and more detailed analysis will be carried out in T1.3, including the main current legislative standards in place, needed standardization and testing activities aimed to the market introduction of the innovative products.

As a conclusion, it will be seen that the difficulty of standardization for a BIPV product comes from its double energy-construction functionally, with specific application, implementation and architectural result. In order to move towards standardization, PVSITES products have to be industrialized, and this could run counter to a good architectural integration. Each construction project can have specificities and BIPV products need some flexibility to take into account these specificities. The full integration of PV demands a complex and tight interlocking of all stakeholders, including those responsible for products and product development, marketing, planners, developers, architects and installers. Such a holistic approach requires a multitude of building codes to meet with electro-technical codes in order to provide access to the electricity grid.

The second part of the deliverable (Chapters 3 and 4) includes the study of the main financial schemes, business models and supporting mechanisms for photovoltaics in a selection of European countries, such as feed-in-tariff, net-metering, subsidies, energy certificates, etc., and other support mechanisms launched by public authorities and bodies to promote PV:

- General description of the most common financial schemes.
- Analysis of the business models and supporting mechanisms options.
- Analysis of the current PV regulatory framework in terms of business in the demo-countries.

The analysis is especially focused further in the opportunities to implement the self-consumption business models in the demo-countries, motivated by the grid-parity happening and the current status of legislation, now at day not fully developed or with difficulty in doing, in some strategic countries. Grid parity exists when the levelized cost of the PV electricity matches with the net electricity price, in such a way that PV projects can be economically viable without needing financial supports and under certain conditions.

The complete analysis of these matters consists in:

- Definition and useful concepts related to the levelized cost of electricity, retail electricity prices and grid-parity situation.
- Analysis of the grid-parity evolution for photovoltaics in the demo-countries and assessment of the financial viability of the BIPV projects in a new economic framework, where grid-parity has been nearly or completely achieved, in contrast to the use of retail electricity.
- Detection of self-consumption opportunities, barriers found and suggestions of changes in the national or regional regulations in the countries studied, often still maintaining old supporting schemes.

The analysis of the business models opportunities, especially self-consumption schemes, will be significantly relevant in turn to define the specifications of the energy conversion and management systems and decide the installation, or not, of electrical storage in order to optimize the economic benefits of the BIPV implementation. This and other subjects will be deeply and specifically treated in the rest of the WP1 tasks.

It will be seen, as a conclusion, that both challenges: grid-parity achievement and regulatory framework reforms are essential in order to boost PV self-consumption for residential and other critical sectors. The transition towards a more sustainable global and local energy model, based on distributed energy generation and in-site consumption is mandatory for the compliance of the environmental objectives of this century. Net-metering and Net-billing schemes are the most suitable to implement self-consumption business models; and the use of storage and management systems, the establishment of favorable grid-connection technical and economical requirements, the reasonably retail electricity prices maintenance and, above all, the fair compensation of excess electricity are the best measure which must be put in practice in order to achieve these targets.

1.2 Relation with other activities in the project

Table 1 depicts the main links of this deliverable to other activities (work packages, tasks, deliverables, etc.) within PVSITES project. The table should be considered along with the current document for further understanding of the deliverable contents and purpose.

Project activity	Relation with current deliverable
D1.3	Deliverable 1.2 provides the general roadmap for the standardization of BIPV products, focusing on EU directives and compliance with CE marking requirements. Deliverable 1.3 provides the detailed implementation of this framework, by establishing specific testing sequences for each of the products to be developed within PVSITES project.
WP2, WP3, WP4, WP8	Beyond EU directives, the document provides a specific analysis of the legal framework affecting BIPV implementations for each of the countries where PVSITES demonstration activities will take place. These considerations are being taken into account both at product design and demonstration definition levels.
WP6 and WP8	The analysis of the business models opportunities from chapters 3 and 4, especially self-consumption schemes, will be significantly relevant in order to design the energy conversion and management systems and decide on the installation, or not, of electrical storage in the demonstration buildings in order to optimize the economic benefits of the BIPV implementations. The document content is focused on the countries where the demonstration installations will be executed.

Table 1: Relation between current deliverable and other activities in the project

1.3 Abbreviation list

- **AVCP:** Assessment and Verification of Constancy of Performance.
- **BAPV:** Building Attached Photovoltaics.
- **BIPV:** Building Integrated Photovoltaics.
- **BoS:** Balance of system.
- **BR:** Basic Requirements.
- **CAPEX:** Capital costs of PV systems.
- **CE marking:** Conformité Européenne (European conformity) marking.
- **CEN:** European Committee for Standardization.
- **CENELEC:** European Commission for Electrotechnical Standardization.
- **CPD:** Construction Products council Directive 89/106/EEC.
- **CPR:** Construction Products Regulation (EU) No 305/2011.
- **DoP:** Declaration of Performance.
- **DP:** Declaration of Performance.
- **DSO:** Distributor System Operator.
- **EA:** Euro area.
- **EAD:** European Assessment Document.
- **EEA:** European Economic Area.
- **EOTA**: European Organization of Technical Assessment.
- **EPBD**: Energy Performance of Buildings Directive.
- **ESO:** European Standardization Organizations.
- **ETA:** European Technical Assessment.
- **ETAG:** European Technical Approval Guideline.
- **ETSI:** European Telecommunications Standards Institute.
- **EU or EU-28:** European Union.
- **FiT:** Feed in Tariff.
- **FPC:** Factory Production Control.
- **hES:** Harmonized European standard.
- **IEC:** International Electrotechnical Commission.
- **ISO:** International Organization for Standardization.
- **LCOE:** Levelized Cost of Electricity.
- **NANDO:** New Approach Notified and Designated Organizations.
- **NSB:** National Standardization Body.
- **OJEU:** Official Journal of the European Union.
- **PGC:** Power Generation Companies.
- **PV:** Photovoltaics.

- **PV-GAP**: PV Global Approval Program.
- **PVSITES:** (Project) Building-integrated photovoltaic technologies and systems for large-scale market deployment.
- **REACH:** Registration, Evaluation, Authorization and Restriction of Chemicals.
- **RES**: Renewable Energy Sources.
- **SME:** small and medium-sized enterprise.
- **TAB:** Technical Assessment Body.
- **TOU**: Time of Use metering.

2 PROCEDURES FOR THE REGULATION OF BIPV PRODUCTS AND POSSIBLE BARRIERS

2.1 General procedure to obtain the CE marking

Not all products must bear the CE marking. Only those product categories subject to specific directives that provide clauses for the CE marking are required to be CE marked. Currently, there are around twenty technical harmonization directives providing for the affixing of "CE" marking relating to a huge range of products. For PVSITES BIPV products, the specific directives are:

- Construction Products Regulation EU No 305/2011[1]: lays down harmonized rules for the marketing of construction products in European Union. To be used as construction products and obtain CE marking, PVSITES products have to comply with this directive.
- Low Voltage Directive 2006/95/EC [2] ensures that electrical equipment within certain voltage limits provides a high level of protection for European citizens, and benefits fully from the Single Market [3]. The directive prescribes the CE-marking for inventers and PV modules which comply with the harmonized standard EN 61730: “Photovoltaic module safety qualification” (more details in 2.2.1).
- Electronic Electromagnetic Compatibility Directive 2014/30/EU: ensures that electrical and electronic equipment does not generate, or is not affected by, electromagnetic disturbance [3]. The directive prescribes CE-marking for PV inverters, requiring that the products do not cause any unacceptable disturbances and their function is not impaired by other equipment.

2.1.1 Construction Product Regulation

The Construction Products Regulation [1] entered into full force on the 1st of July 2013 and allows comparisons of performance of products from different manufacturers in different countries providing a common technical language.

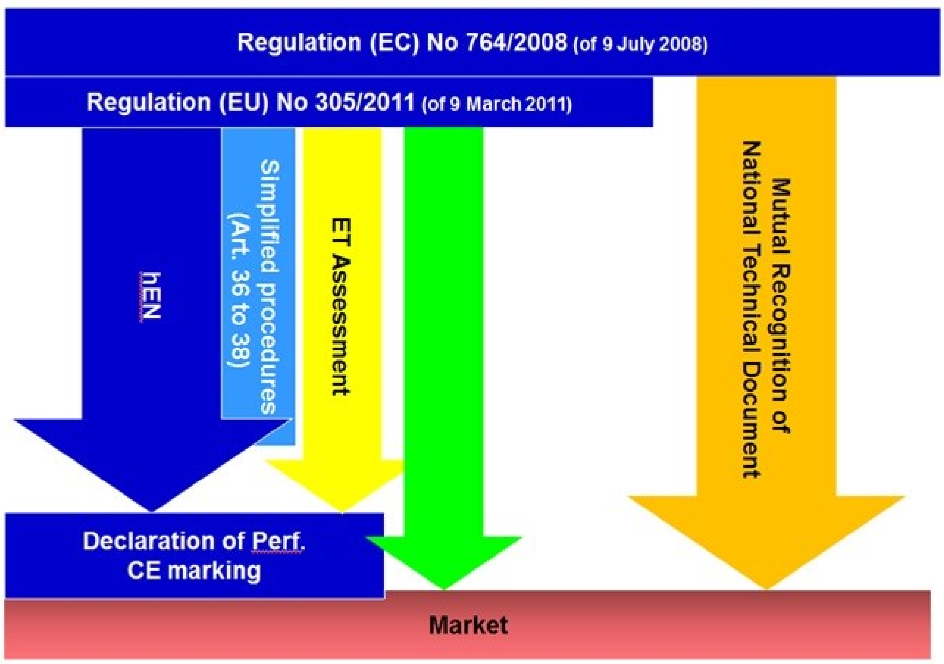


Figure 1: Different ways to EU marketing [5]

Under the CPR, a Declaration of Performance (DoP)[1] must be drawn up for each construction product placed or made available on the market that is covered by a harmonized European standard (hES) or European Technical Assessment (ETA) and must be made available to all purchasers.

To know if the CE marking of a product is compulsory, the first step is to consult the Official Journal of the European Union [4] and search for the last update of the publication of titles and references of harmonized standards (the part 2.2.3 present the harmonised standards applicable to BIPV products). In case a harmonized standard exists, the CE marking is mandatory in order to guarantee the performance of the product covered by this standard, taking into account the provisions related to the intended use. Harmonized European standards create a common technical language used by all actors in the construction sector to [5]:

- Define requirements (regulatory authorities in EU countries);
- Declare the product's performance (manufacturers);
- Verify compliance with requirements and demands (design engineers, contractors).

Standardization results from voluntary cooperation between industry, businesses, public authorities, and other stakeholders. Manufacturers can develop additional officially document called "appropriate technical documentation» to simplify the assessment of the product. They can share the test results of the product obtained by the other manufacturers. Micro-enterprises can also use simplified procedure for products covered by a harmonized standard. All the simplified procedures are explained and detailed from article 36 to article 38 of CPR [1].

When the product is not in the scope of any harmonized standard, manufacturer can voluntarily CE mark his product. But he has to check first if it is covered by one of the existing European Assessment Documents (EAD) on the website of the European Commission [3] in the area called NANDO (New Approach Notified and Designated Organizations). The EAD permits to elaborate the European Technical Assessment (ETA), which covers the product and its intended uses[2].

The ETA is the way to obtain the CE marking in those products which are not covered or not fully covered by a harmonized European standard, and it will allow to manufacturers and importers to make the declaration of performance of their products. The ETA and the consequent CE marking facilitate the marketing of non-standardized innovative products on European market. It contains the following information:

- General information on the manufacturer and the product type.
- Description of the product and its intended use.
- Performances of the product and references to the methods used for its assessment.
- Assessment and Verification of Constancy of Performance systems (AVCP) applied Technical details necessary for the implementation of the AVCP [2.1.2]

CE marking does not mean that a product was made in the European Economic Area (EEA), but states that the product is assessed before being placed on the market. It means the product satisfies the legislative requirements to be sold there. It means that the manufacturer has checked that the product complies with all relevant essential requirements.

---

[1] *The Declaration of Performance (DoP) under the CPR replaces the Declaration of Conformity (DoC) under the CPD.*

[2] *Formerly, European Technical Approval Guidelines (ETA Guidelines or ETAGs) were elaborated in order to evaluate the specific characteristics/requirements of a construction product or a family of construction products. ETAGs were used as basis for European Technical Approvals (ETAs). As of 1st of July 2013 no new ETAGs will be developed. ETAGs remain valid and can be used as EADs according to Construction Products Regulation (CPR) for issuing European Technical Assessments (ETAs). The list of ETAG's (used as EAD's) as of June 2013 is shown in EOTA website [*

For products that are not subject to EU harmonization, mutual recognition ensures market access. The principle of mutual recognition stems from Regulation (EC) No 764/2008 [10]. It defines the rights and obligations for public authorities and enterprises that wish to market their products in another EU country.

To conclude, the CE marking is required for many products for different reasons:

- It shows that the manufacturer has checked that these products meet EU safety, health or environmental requirements.
- It constitutes an indicator of a product's compliance with EU legislation.
- It allows the free movement of products within the European market.

2.1.2 Assessment and Verification of Constancy of Performance (AVCP)

The manufacturer is responsible for assessing product performance and putting in place factory production control. The Assessment and Verification of Constancy of Performance (AVCP) is a harmonized system defining how to assess products and control the constancy of the assessment results. This system safeguards the reliability and accuracy of the Declaration of Performance.

Five different systems are in place for construction products in the CPR. They range from large-scale third party involvement to self-declaration and monitoring by the manufacturer. The European Commission establishes which systems are applicable for:

- A construction product;
- A family of construction products;
- An essential characteristic.

There are different CE Marking systems in which responsibilities of the fabricant and Notified bodies differ. Figure 2 below gives an overview of the responsibilities of the involved actors as a function of each system.

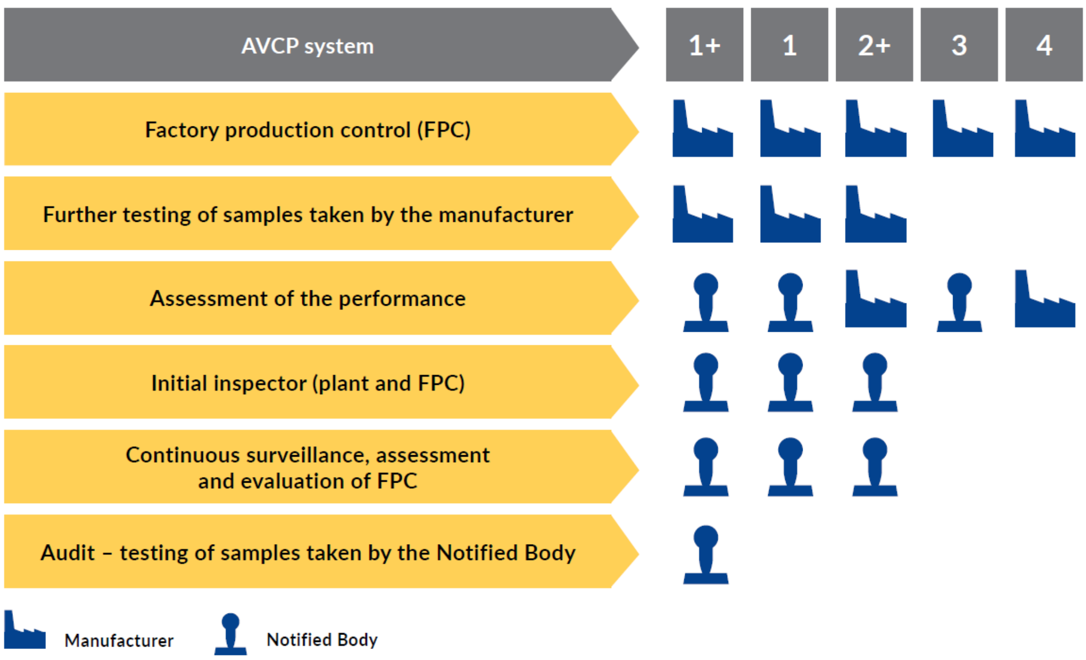


Figure 2: Assessment and verification of constancy of performance systems (AVCP systems) [6]

The assessment of the product is done by defining the value of a list of characteristics called essential characteristics. The full list is in the annex ZA of the harmonized standards and in the EAD. The list includes the AVCP system for each essential characteristic. If all characteristics come under AVCP system 4, manufacturers will not need to contract a Notified Body. When they are covered by system 3 product has to be tested by a Notified Body (in this case a notified laboratory) that can be different for each essential characteristic. If they are under system 1, 1+ or 2+ the Notified Body will collaborate during the assessment and will do some tasks in manufacturing plant so the best option is usually to contract only one Notified Body to carry out all the tasks. More details about all these subjects may be looked up in Regulation (EU) 305/2011, Annex V [1].

Once the assessment is finished manufacturers have to assign a code to the product. The name of this code is "unique identification code of the product type" and it is linked to the sort of manufactured product and to the performance of its essential characteristics. For a new product is essential to assign a new unique ID-code to it. If the performance of a product changes, the code must be changed.

2.1.3 Declaration of Performance and CE marking

Once fulfilled the assessment and verification of constancy of performance, Declaration of Performance and CE marking can be elaborated and used.

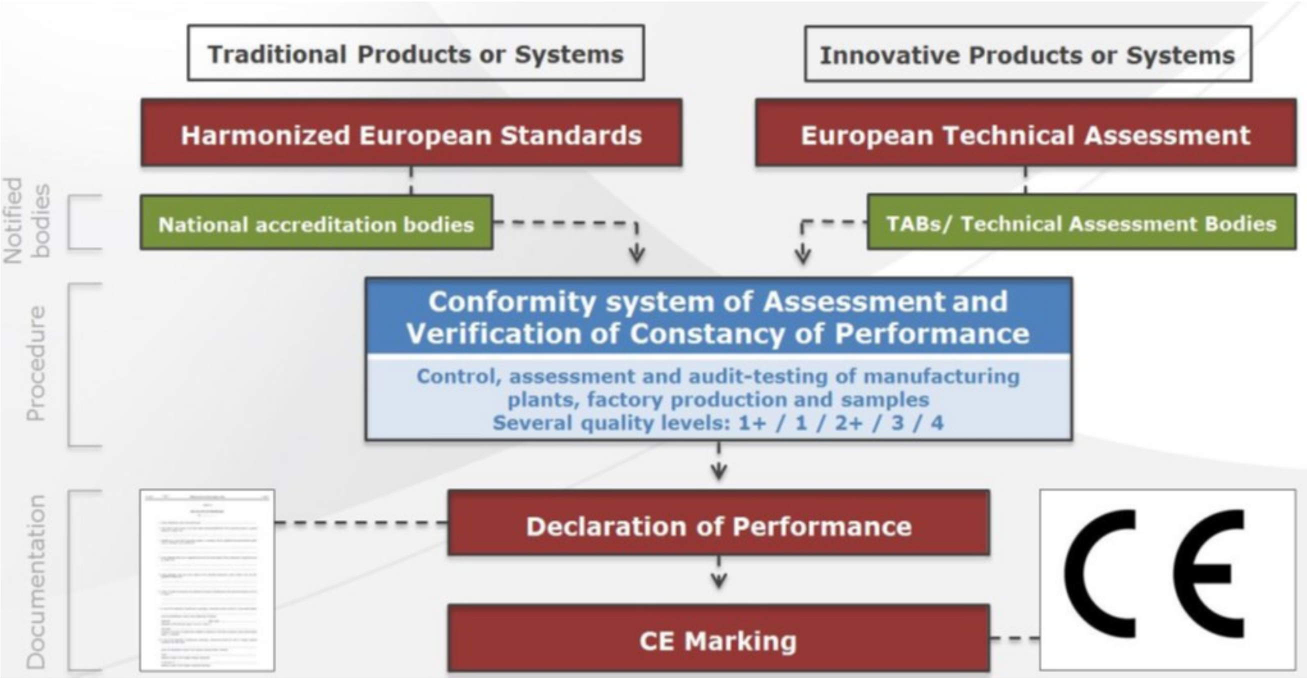


Figure 3: Assessment and verification of constancy performance, declaration of performance and CE marking [7]

Construction products in conformity with a hES must (except in the cases described in Article 5 of the CPR [1]) have a CE marking affixed to the product or issued with the accompanying documentation. It is also possible for innovative product and system to voluntarily affix the CE marking when it is not covered, or not fully covered, by a hES. This needs to be done if the product conforms to an ETA issued by a Technical Assessment Body (TAB).

A DoP must be drawn up for each construction product (for which European technical specifications have been determined) that is placed or made available on the market, and must be made available to all purchasers, whether they are distributors, construction companies or non-professional consumers.

This includes, among other, the following information: reference of the product-type; intended use or uses for the construction product; system(s) of assessment and verification of constancy of performance of the product; reference number and date of issue of the harmonized standard or the European Technical Assessment which has been used for the assessment of each essential characteristic; list of essential characteristics; etc. To sell a product in other countries of the EU, it is important to translate the DoP to all the languages required by the Member States where the product is going to be sold.

If a declaration of performance has not been drawn up, the CE marking should not be affixed. The CE marking indicates that the manufacturer has taken responsibility for the performance of the product as stated in the DoP and can be the only marking that attests the conformity of the product with the CPR and EU legislative requirements.

The CE-marked product can therefore cross national borders more easily, and compliance with national legislations, such as building codes, can be conveniently demonstrated based on the declared values.

2.2 Establishment of functional requirements for standardization

2.2.1 Existing standards for PV products

A standard is a norm that all interested parties have agreed upon, such as the size of a golf ball, the width of a railway track, or the way a solar PV installation should perform. Given that photovoltaic modules are to be inserted into buildings, they must satisfy both the standards on the electrical characteristics of photovoltaic modules and those on buildings.

PV module standards	Building standards
IEC International Electrotechnical Commission	**ISO** International Organization for Standardization
CENELEC European Commission for Electrotechnical Standardization	**CEN** European Committee for Standardization

Table 2: Commissions and Organizations for PV module standards and building standards

The International Electrotechnical Commission (IEC) [9] is the leading global organization that develops and publishes consensus-based International Standards for electric and electronic products, systems and services, collectively known as electro-technology. The committee with responsibility for photovoltaics within the IEC is technical committee TC82: Solar Photovoltaic Energy Systems. The results of IEC's work are published as IEC standards.

Different European norms deal with the homologation of photovoltaic modules. Three standards have to be considered in here:

- IEC 61215: "Crystalline silicon terrestrial photovoltaic (PV) Modules - Design qualification and type approval" referred to the crystalline silicon PV modules that are not subjected to an intense sunlight.
- IEC 61646: "Thin-film terrestrial photovoltaic (PV) modules - Design qualification and type approval "defines the qualification of the conception and the homologation related to the PV

modules realized by using thin layers. This standard must be applied to flat plate equipment that is not treated by IEC 61215.

- IEC 61730/EN 61730 “Photovoltaic (PV) module safety qualification” has been issued to further examinations about the PV modules safety against electrical shock hazard, fire hazard, mechanical and structural safety. An important scope of this standard is to provide the fundamental guidelines for the certification of the PV modules construction presented for the security approval obtained by means of the tests defined by IEC 61215 standard.

The international standards IEC 61215 and IEC 61646 include the examination of all parameters, which are responsible for the ageing of PV modules and describe the various qualification tests on the basis of the artificial load of the materials. A new version of IEC 61215, integrating both standards is actually under development.

EN 61730 international standard is realized in order to respect the same sequence of tests already defined for IEC 61215 and IEC 61646. Thus, the same sampling procedure can be used to evaluate the performances and the security conditions of the PV modules. The main goal of this standard is to define the fundamental needs for different application classes of PV modules but it is not able to cover all national and regional construction codes.

To obtain a suitable certification of the product (for TUV or CERTISOLIS), it is essential that EN 61215/61646 (qualification) and EN61730 (safety) standards requirements are met. This point is further developed in deliverable D1.3.

These three existing standards are from the IEC and cover only PV modules, and the measurement of their performance. The lifecycle of the PV elements will be strongly dependent on their conception and mainly on the environmental conditions in which these elements will work. To implement on building, BIPV modules have also to follow some building requirements.

From the beginning of 2016, EN 50583 (“Photovoltaics in buildings”) sets out the requirements for photovoltaic components used in the building envelope. The first part of this standard applies to photovoltaic modules and the second one applies to photovoltaic systems that are integrated into buildings with the photovoltaic modules used as construction products.

EN 50583 focuses on the properties of photovoltaic modules and systems relevant to essential building requirements as specified in the European Construction Product Regulation CPR 89/106/EEC, and the applicable electro-technical requirements as stated in the Low Voltage Directive 2006/95/EC / or CENELEC standards.

For some specific applications for PVSITES BIPV products, national standards or regulations for building works may apply in individual countries, which are not explicitly referenced in EN 50583. This subject is discussed in 2.4.

Concerning electric installations, the framework of the laws, norms, directives and provisions is quite complex and articulated and depends on the country. It can be shared substantially in two main different directions that are interesting for the development of the PV technology:

- Laws/provisions/norms related to the link between the PV system and the electric public network.
- Security conditions that characterize installation of the PV systems and their utilization.

For example, in France, the design and the implementation of photovoltaic installations are well defined by a standard, well-known by electricians: the norm NF C 15 100. This standard fixes the conditions that must be necessarily met for the electric installation in France and they are regularly renewed in order to consider all innovations and all needs. This standard also specifies that photovoltaic installations are integrated and treated in the Guide UTE C15-712 and UTE C 15 400.

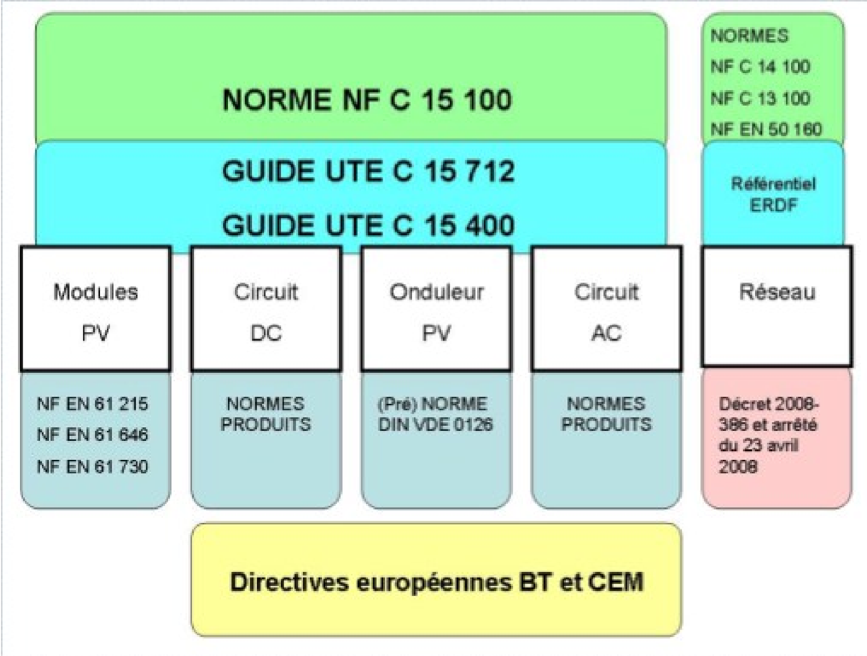


Figure 4: Example of French regulatory framework organisation[3]

Several national or regional PV standards developed over the years have not been incorporated into the IEC system or differ slightly from existing IEC standards. These standards can be very valuable, given the general lack of PV standards. National and regional standards have limitations in a global economy. A general harmonization in EU members is essential to develop BIPV products on European market.

2.2.2 Photovoltaic Product Testing and Quality Assurance

Across Europe, many different testing laboratories for PV modules, PV components and PV systems exist. Some of them are presented below:

- TÜV Rheinland - The work of TÜV is animated by the conviction that social and industrial development cannot be achieved without technical progress. TÜV Rheinland's PV laboratory is accredited in compliance with the ISO/IEC 17025 norm and listed as a certification test laboratory by the worldwide certification system of the IECEE in the photovoltaics category. TÜV Rheinland can support manufacturers and service providers by testing the quality of their PV modules, PV components, and PV systems. For PVSITES project, TÜV tests sequence is considered as basis for PV modules standard tests (more details about this subject may be looked up in D1.3).
- ELIOSYS (Belgium) ELIOSYS offers the services of a cutting-edge laboratory to companies interested in product characterization relative to environmental constraints. ELIOSYS provides accredited ISO 17025 services in order to carry out tests, controls, as well as

[3] *http://www.photovoltaique.info/-Normes-guides-et-securite-.html*

certifications. These services follow the IEC 61215, IEC 61646, IEC 61730, and IEC 61853 standards or respect customer's particular specifications. ELIOSYS provides the photovoltaic sector with its solar simulators, its climatic chambers, and all its test benches. This whole machinery meets the features specific to the photovoltaics, namely precision, rapidity/reactivity, and flexibility.

- CERTISOLIS (France) CERTISOLIS is a testing laboratory and a certification body for photovoltaic modules. It provides for conducting tests on photovoltaic modules and components in order to certify their intrinsic performance according to international standards IEC 61215, IEC 61646, and IEC 61730.The Certisolis MPV label not only guarantees the modules conformity with applicable Standards, but also indicates that the modules annually undergo a quality audit on their design and manufacture. Certisolis is accredited by COFRAC (French National Accreditation Body).

- Fraunhofer Institute for Solar Energy Systems (ISE) -(Germany) at present, Fraunhofer ISE has four accredited testing units: the Test Centre for Solar Thermal Systems, the Thermal-Optical Measurement Laboratory, the Test Centre for Photovoltaics and the ISE Calibration Laboratory CalLab. Further service units include a test facility for compact heating and ventilation units, a laboratory for quality control of phase change materials (PCM) and a battery testing laboratory. With Fraunhofer TestLab PV Modules, a path-breaking facility for the solar sector was established and accredited according to ISO/IEC 17025. Their TestLab Solar Façades permit to test, advice and research for building project.

- CENER - (Spain) the CENER laboratories are authorised to perform certification tests under international standards of reference. This service is available for the different technological areas. CENER works in all stages of a PV cell manufacturing process, from the study of initial materials, through all different production steps until the final device characterization. The action capacities of the Photovoltaic Solar Energy Department in the photovoltaic systems area start with component assessment (modules and inverters) and end with the design, execution and optimisation of the final photovoltaic installation.

- AT4 wireless- (Spain) AT4 wireless works closely with the photovoltaic industry with the aim of guaranteeing the quality and safety of photovoltaic modules and components launched to the market. AT4 wireless is a Photovoltaic Test Laboratory offering Testing and Certification Services according to IEC and UL standards. Its lab. is accredited by ENAC (Spanish National Accreditation Body) according to the ISO/IEC 17025 requirements.

- Intertek (United Kingdom) test and certify Building-Integrated Photovoltaic (BIPV) Modules through its expertise and network of testing laboratories for both solar, building products, and energy systems. Interlek have several accreditations, affiliations and recognitions throughout Europe according to the ISO/IEC 17025 requirements.

- SUPSI-Swiss PV Module Test Centre – (Switzerland) ISAAC has over twenty years of experience in PV module testing and since 2001 an ISO 17025 accreditation for performance measurements of PV modules.

- SGS– (Switzerland) Photovoltaic (PV) module certification from SGS – PV module testing and certification to ensure that your modules comply with international standards including IEC 61215, IEC 61646, IEC 61730-1/2, ISO 9000, ISO 14001

- European Solar Test Installation (ESTI) - Located in Ispra (Italy), the Institute for Environment and Sustainability (IES) is one of the institutes that constitute the Joint Research Centre of the European Commission. In line with the JRC mission, the aim of IES is to provide scientific and technical support to European Union strategies for the protection of the environment contributing to a sustainable development. ESTI's maintains an ISO-17025 compliant laboratory management system and is accredited for the calibration of photovoltaic devices.

2.2.3 Existing harmonized technical specification applicable to BIPV

Generally, one or several building functions are realized by BIPV modules, like weather protection, thermal insulation, noise protection, etc., provided that conventional building product can be omitted. BIPV elements can be used to build roofs, facades, overhead glazing, balustrades, semitransparent windows or skylights. For these products, there are harmonized European standards and European Technical Approval Guidelines (ETAG), which can serve as the basis for constructing the regulatory framework of PVSITES BIPV products. Indeed, these documents contain all the information required for the CE-marking of such products.

EUROPEAN HARMINIZED STANDARDS (hES)	
EN 13830	**Curtain walling - Product standard** For the purposes of this standard, curtain walling is defined as an external vertical building enclosure produced by framing elements mainly of metal, timber or plastic, which are connected together and anchored to the supporting structure of the building, thereby providing all the normal functions of an external wall but without contributing to the load bearing characteristics of the building structure. This standard applies to curtain walling ranging from a vertical position to 15° from the vertical, onto the building face. This covers fire performance, weather tightness, wind loading, other applied loads, impact and thermal transmittance.
EN 14449	**Glass in building - Laminated glass and laminated safety glass - Evaluation of conformity/Product standard** It covers factory production control as well as the process of evaluation of conformity of laminated glass and laminated safety glass for use in buildings.
EN 1279-5+A2	**Glass in building - Insulating glass units - Part 5 : evaluation of conformity** It contains the requirements, the factory production control and initial type testing of insulating glass units for use in buildings.
EUROPEAN TECHNICAL APPROVAL GUIDELINES (ETAG)	
ETAG 002	**Structural Sealant Glazing Systems** Part 1: Supported and Unsupported Systems Part 2 : Coated Aluminum Systems Part 3 : Systems incorporating profiles with thermal barrier This guideline relates to Structural Sealant Glazing Kits (SSGK) for use as facades and roofs, or parts thereof, with glazing at any angle between vertical and 7° above horizontal.
ETAG 034	**ETAG of kits for external wall claddings** Part 1- Ventilated cladding kits comprising cladding components and associated fixings Part 2- Cladding kits comprising cladding components, associated fixings, sub-frame and possible insulation layer This ETAG sets out : - the performance requirements for cladding kits - the verification methods used to examine the various aspects of performance, - the assessment criteria used to judge the performance for the intended use - the presumed conditions for the design and execution

Table 3: Main existing hES and ETAG applicable to BIPV

2.2.4 BIPV products general requirements

PV systems are generally considered to be building-integrated, if the PV modules replace a building component providing a function as defined for example in the European Construction Product Regulation CPR 305/2011. If the integrated PV module is dismounted, it has to be replaced by an adequate building component able to satisfy the same technological requirements. A BIPV module/system can be used in the building envelope to provide (one or several functions):

- Mechanical rigidity or structural integrity;
- Weather Protection : rain snow, wind, hail;
- Energy saving, as shading, natural light, thermal insulation;
- Fire Protection;
- Noise protection;
- Separation between the interior and the exterior environments;
- Safety, shelter or security.

For successful integration, the above mentioned characteristics must all be coherent with the overall building design logic. To achieve quality in the architectural integration of PV systems some requirements need to be fulfilled. The global integration quality depends on module several characteristics such as:

- Field size and position of PV or collector systems;
- Materials and surface texture;
- Color of the cells for PV systems and absorbers for solar collectors;
- Shape, weight and size of the modules;
- Type of jointing;
- Multifunctional elements.

As Electrical Components, BIPV modules are subject to electrical applicable requirements set out in the Low Voltage Directive 2006/95/EC/ [2] or CENELEC standards.

REQUIREMENTS	DESCRIPTION
Protection against hazards arising from the electrical equipment	Measures of a technical nature should be prescribed in order to ensure: - that persons and domestic animals are adequately protected against the danger of physical injury or other harm which might be caused by direct or indirect contact; - that temperatures, arcs or radiation which would cause a danger, are not produced; - that persons, domestic animals and property are adequately protected against non-electrical dangers caused by the electrical equipment which are revealed by experience; - that the insulation must be suitable for foreseeable conditions
Protection against hazards which may be caused by external influences on the electrical equipment	Technical measures are to be laid down in order to ensure: - that the electrical equipment meets the expected mechanical requirements in such a way that persons, domestic animals and property are not endangered; - that the electrical equipment shall be resistant to non-mechanical

	influences in expected environmental conditions, in such a way that persons, domestic animals and property are not endangered; - that the electrical equipment shall not endanger persons, domestic animals and property in foreseeable conditions of overload

Table 4: Main requirements defined in the Low Voltage Directive 2006/95/EC [2]

From a functional point of view, a BIPV product is able to fully replace a building component. In this perspective, it is important to understand the role of BIPV in satisfying the basic requirements for construction works set out in European Constructions Products Directive CPR 305/2011 [1]

REQUIREMENTS	DESCRIPTION
Mechanical resistance and stability	The construction works must be designed and built in such a way that the loadings that are liable to act on them during their constructions and use will not lead to any of the following: - collapse of the whole or part of the work; - major deformations to an inadmissible degree; - damage to other parts of the construction works or to fittings or installed equipment as a result of major deformation of the load-bearing construction; - damage by an event to an extent disproportionate to the original cause.
Safety in case of fire	The construction works must be designed and built in such a way that in the event of an outbreak of fire: - the load-bearing capacity of the construction can be assumed for a specific period of time; - the generation and spread of fire and smoke within the construction works are limited; - the spread of fire to neighboring construction works is limited; - occupants can leave the construction works or be rescued by other means; - the safety of rescue teams is taken into consideration.
Hygiene, health and the environment	The construction works must be designed and built in such a way that they will, throughout their life cycle, not be a threat to the hygiene or health and safety of workers, occupants or neighbors, nor have an exceedingly high impact, over their entire life cycle, on the environmental quality or on the climate during their construction, use and demolition, in particular as a result of any of the following: - the giving-off of toxic gas; - the emissions of dangerous substances, volatile organic compounds, greenhouse gases or dangerous particles into indoor or outdoor air; - the emission of dangerous radiation; - the release of dangerous substances into ground water, marine waters, surface waters or soil; - the release of dangerous substances into drinking water or substances which have an otherwise negative impact on drinking water; - faulty discharge of waste water, emission of flue gases or faulty disposal of solid or liquid waste; - dampness in parts of the construction works or on surfaces within the construction works.
Safety and accessibility in use	The construction works must be designed and built in such a way that they do not present unacceptable risks of accidents or damage in service or in operation such as slipping, falling, collision, burns, electrocution, injury from explosion and burglaries. In particular, construction works must be designed and built taking into consideration accessibility and use for

	disabled persons.
Protection against noise,	The construction works must be designed and built in such a way that noise perceived by the occupants or people nearby is kept to a level that will not threaten their health and will allow them to sleep, rest and work in satisfactory conditions
Energy economy and heat retention	The construction works and their heating, cooling, lighting and ventilation installations must be designed and built in such a way that the amount of energy they require in use shall be low, when account is taken of the occupants and of the climatic conditions of the location. Construction works must also be energy-efficient, using as little energy as possible during their construction and dismantling
Sustainable use of natural resources	The construction works must be designed, built and demolished in such a way that the use of natural resources is sustainable and in particular ensure the following: - reuse or recyclability of the construction works, their materials and parts after demolition; - durability of the construction works; - use of environmentally compatible raw and secondary materials in the construction works

Table 5: Requirements defined in CPR 305/2011 [1]

The PVSITES products must comply with the basic requirements for construction works which constitute the basis for the elaboration of standardization directives and harmonized technical specifications.

However, besides these important requirements on BIPV modules, two further preconditions must be fulfilled for the application of photovoltaics in buildings. On the one hand the BIPV module must be of high quality in order to ensure an operation as intended. On the other hand, the BIPV module must be attractive and aesthetical from a visual point of view.

2.3 Roadmap for the standardization of PVSITES products

Actually there is not specific reference or standards for BIPV system. It is often difficult to translate the multifunctionality of BIPV in clear building requirement, making it very complicated to obtain CE marking.

For PVSITES products, existing different application requirements depending on whether BIPV module containing, or not, glass panes. When containing one or several glass panes, BIPV product should be in accordance with respective harmonized products standards applicable to glass in construction (referred in 2.2.3). These standards and other standards specifying test methods and requirements are detailed and analyzed in D1.3.

Harmonized standards were conceived with the intention of removing the technical barriers in the building field and stimulate the commercialization and use of construction products within the European Union. The common IEC certification depending on Low Voltage directive covers BIPV products but to implement on buildings, products have also to comply with Construction Product Regulation. An adapted certification could consequently cover these needs. The preferred route for PVSITES products to comply with existing harmonized standards or create a new hES wherever possible. But if standards cannot be produced or foreseen within a reasonable period of time, if a product deviates substantially from a standard or if the product is a new or innovative, such as certain PVSITES product, then the product may be the subject of an ETA.

The purpose of the harmonized technical specification for a product is to cover all the performance characteristics required by Regulations in any Member State. In this way, manufacturers can be sure that the test methods and methods of results declaration will be the same for any Member State. These tests sequences are described for each BIPV PVSITES products in D1.3. Each product must be developed in order to comply with this testing plan but also to be architecturally integrated to the building. Indeed, for the application of photovoltaics in buildings, the quality and visual appearance are of major significance and important decision factors of building owners and architects.

To conclude, certification is for PVSITES products which have a high TRL and the final module design must be complete. Further requirements concerning PV modules depend on the type of assembly and several characteristics (size, material, texture, color). These requirements have to be fulfilled for the global performance and architectural integration of the BIPV system. An ETA or hES is restricted to the specification of the product. Stipulations regarding usage are not included and are the responsibility of the respective EU member's state in which the project is being realized. For specific application of PVSITES products, other national evaluations (e.g ATec for France or DAU in Spain) can allow to implement the product on buildings. These evaluations can also provide an initial feedback of innovative technology in order to improve the product before going to a future standardization.

2.4 Construction needs and barriers for implementing demo-systems

2.4.1 General considerations

CE marking concerns only the product and not its implementation into construction work even if it indicates essential requirements. BIPV has enabled the implementation of PV, not only as a technical device but also as a building component. Despite a variety of interesting products providing by manufacturers, the adoption and application of BIPV by the building sector is relatively slow.

Sometimes zoning regulations regarding colors, building shape, and building codes, will also have an impact on the selection of the different kind of BIPV modules to use depending on several characteristics (color, size, texture ...). The integrated nature of applied architectural BIPV installations requires the combined efforts of a number of different building trades and jurisdictions.

BIPV as a building element should fulfil the requirements of the EC directives. Due to its nature, BIPV, as building element, can be regarded as an electronic device and as a building product. The relevant EC directives for PV in buildings are therefore:

- Low Voltage Directive (LVD, 2006/95/EC);
- Electromagnetic Compatibility Directive (EMCD, 2004/108/EC);
- Construction Products Directive (CPD, 89/106/EEC);
- Energy Performance of Buildings Directive (EPBD, 2002/91/EC);
- Energy Efficiency Directive (EED –2012/27/EU).

The three first, as explained in 2.1 prescribes the CE marking for PV components (modules and inventers) and define general requirements

The European building sector is responsible for about 40% of the total primary energy consumption. To reduce this share the European Commission (EC) has introduced the Energy Performance of Buildings Directive and more recently the Energy Efficiency Directive. These directives must be technology neutral. For instance, they can promote RES against conventional sources, but they cannot promote PV against wind or biomass, and even less BIPV against another RES technology. These frameworks require Member States to develop energy performance requirements for new buildings, a system of energy performance certificates for all buildings and policy that support actions to reach the goals like building only 'Nearly Zero Energy Buildings (NZEB)' by 2020 and realizing an almost carbon neutral building stock by 2050.

The European Directive on Energy Performance of Buildings 2002/91/EC (EPBD), favoring renewable energy systems especially in new buildings with a useful area larger than 1.000 m², is being transposed in all countries. However, in most national building directives, BIPV is not explicitly promoted, since policy-makers are not always aware of BIPV as a potential technology to use. Any kind of promoting has to be achieved indirectly, by adding for instance specific requirements/conditions only achievable with PV/BIPV.

One of the strongest barriers to BIPV market proliferation is the difficulty to undertake a really integrative approach from the first stages of design, merging energy, BIPV and building requirements. In most EU countries, a patchwork of political initiatives, building codes and national approaches make it difficult to promote BIPV. Formal buildings permits are compulsory, administrative requirements are high and in many cases inappropriate. Building regulations in all countries are neutral regarding their impact on the installation of PV systems, covering such topics as structural safety and insulation levels. In Europe, there are various examples for solar obligations, mainly on a municipal basis. These regulations go beyond the requirements of the EPBD and make PV obligatory in specific types of buildings.

Legal and technical requirements constitute the necessary data that partners have to take into account for the development of BIPV system and their implementation on demo-system. Works have been carried out on four prior countries: France, Spain, Belgium and Switzerland. Different levels of building regulations have been studied which can have a potential influence on BIPV products requirements.

In this context, work has been mainly focus on gathering together the legal requirements that prevails in each country. The work included in this deliverable will be provided as input data to avoid possible regulatory barriers.

2.4.2 Construction needs and barriers in Belgium

Belgian building codes and regulations

The Belgian system of building regulations and control differs widely from other European countries. Belgium consists of three independent administrative regions: Wallonia, Brussels and Flanders.

In Belgium, there are legislation and some provisions that relate to construction. The regulatory system is based on the Civil Code.

TEXT	REQUIREMENTS
Civil Code	The Civil Law in Belgium governs the laws and regulation of the Civil Code. The current Civil Code in Belgium is based on the French Civil Code developed in 1804, named Napoleonic Code, which is based on the principles of private property, the freedom of contract and biding contract.
Brussels Town Planning Code (Code Bruxellois de l'Aménagement du Territoire - CoBAT)	In the Brussels-Capital Region, the Brussels Town Planning Code lays down the following instruments and administrative procedures the Regional Urban Planning Regulation (Règlement Régional d'Urbanisme - RRU). The urbanism laws regarding building integration of solar modules are contained in the Government Decree of 13 November 2008. This Decree establishes the conditions that a solar installation must comply with in order to avoid the need of urbanism permission or the

	involvement of a government employee, the local authorities, the royal commission for monuments, or an architect. The permission is not needed if "the solar modules are not visible from the public space or located in roofs, parallel to the roof slope, not exceeding a 30 cm height or exceeding roof limits. Every type of roof is included."
Walloon code for town and country planning, urbanism, heritage and Energy (Code Wallon de l'aménagement du territoire, de l'urbanisme, du patrimoine et de l'énergie)	According to the Walloon code for town and country planning, urbanism, heritage and Energy, the installation of photovoltaic solar modules does not need a urbanism permission (Art. 262, paragraph 2), no matter their shape, surface or thickness. This is only valid if the installation, - Does not imply non-fulfilment of other legal requirements (sector plans, local urbanism legislations, etc.) - Is not located on a protected building - Does not need actions or works under the conditions of urbanism permissions
Flemish Code for Environmental Planning	Provides for a mixed system involving a duty to obtain a permit, a duty to notify, and certain exemptions. The exemption from planning permission for the placement of photovoltaic modules (except in certain protected areas or areas with special requirements) is thus contained in the Exemptions decree.
Energy performance and thermal regulation	For new buildings, the overall insulation level of buildings should be at least K45, in accordance with standard NBN-B 62-301.The aim is to achieve energy consumption levels for heating or cooling of 15 kWh/m²/year or less. Belgium standards related to Energy performance is divided as follows: - Thermal Insulation - Lighting and visual comfort - Heating and cooling - Ventilation and air quality - CE mark and technical approvals The energy performance certificate (EPC) imposes the calculation of primary energy consumption: E or Ew levels. Buildings are not just energy consumers; they can also act as energy generators by means of photovoltaic systems and other technologies. In the EPC calculation, the energy generated by means of photovoltaic systems will be deducted from the energy consumption of the building for heating, cooling, hot water, etc…
Fire regulation	In Belgium, there are three levels with competence to establish regulations concerning fire security : - The federal authority is competent to establish the Basic Standards, which fix the minimum conditions that each building category must fulfil independently of its location. - Regions and Communities are competent to regulate particular aspects of security, complementing or adapting the federal legislation, improving the demands in terms of security (never reducing them). - Municipalities are responsible to enact regulations concerning fire prevention. The board of the Mayor and aldermen may attach conditions to building permits or environmental. The mayor is in charge of controlling the current legislation (Basic rules).
Acoustic regulation	Protection against noise essential requirement is regulated in Belgium through European standards for test and calculation methods and Belgian standards defining performance levels. For example, Noise levels may not exceed the maximum laid down in standard NBN S0l-401, category 4

Table 6: Main Belgian regulatory requirements and building codes

In Belgium, the fulfillment of mechanical resistance and stability, safety in the case of fire and safety in use requirements rely on the Eurocodes, contains harmonized evaluation methods for the different characteristics considered. Particular performance levels are stated by national authorities (or regional/local). In the Belgian case, performance levels are added to the Eurocodes by means of an “Annexe National- ANB” (National Annex).

In Belgium it is relevant to mention six interested parties: the owner, the architect, the building constructors, the local authorities, the insurance companies and the technical control bodies. The owner have the choice or not to do a technical control. If the owner wants to be insured, the insurance company can require a technical control office in order to carry out technical supervision of the works. Often, reporting to the local authority before the work starts is enough and the building permit is not required. Actually, building permit is not required to put PV modules on the roof and therefore as BIPV roof.

Specific requirement for integrated PV installations [12]

In Belgium only architects of the National Council of the Order of Architects can draw the building plans that have to be submitted to obtain the building permit [1]. The only construction partner legally obliged to insure for damage of the decennial liability is the architect. As regards the insurance and construction regulatory system, Belgium can be described as a voluntary insured based system. There are three main insurance policies: the policy all site risk or ABR (Albright Bishop Rowley), decennial insurance and professional liability policy. The main purpose of the technical control activities in this country is the standardization of risks in order to get insurance companies to cover builders' liability over a ten year guarantee period. Therefore the control bureau has to be renowned for their reliability by the insurance company.[4]

In addition to the local regulation and the few national laws and building ordinances, there are the following national “rules for good workmanship” and there are also documents made by institutions with a normalizing activity. These “documents with a normative character” do not connect directly to the working of the NBN (Belgian Normalization Institute). These are for example [2]:

- NBN standards, the Belgian standards issued by the Belgian Normalization Institute (NBN).
- PTV’s: Technical Prescriptions (Prescriptions Techniques). These are ‘normative’ documents drafted by a qualified technical institute, In order to get the Benor mark the product must comply with the NBN standards and the PTV's.
- The Belgian Building Research Institute (WTCB) is established by law and financed by building contractors and public research funds. The WTCB conducts research into construction and the components used in building. Their publications are seen as "rules for good workmanship"
- The ‘STS’ (Spécifications Techniques unifiées – unified technical specifications), published by the Federal governmental office DGV;
- The technical approvals (ATG) of the BUtgb (Belgian Union for the technical approval in construction);
- Technical reports (TV, Technische voorlichtingsnota’s): TV’s are guidance documents, primarily intended for contractors, but used by everyone in the Belgian construction sector as good practice documents even used in court to judge workmanship of contractors.

In Belgium, to put PV in building, no specific profession is required, except an electrician which can do electrical modification. The PV system is installed in accordance with the technical regulations

RGIE (Règlement général sur les installations électriques), best practices and the contents of the contractual signed offer. For the moment no specific qualifications are required. Only some voluntary quality labels are available (Quest for quality, PVQual).

The acceptance of the installation needs to be done by a recognised control authority (eg. AIB-Vinçotte, BTV ...). For implement a BIPV on roof, consult a roofer can be useful, the module being the main waterproofing element for the roofing the BIPV.

2.4.3 Construction needs and barriers in France

French building codes and regulations

The French system of building regulations is complex. The French regulatory system is a hybrid system with a shared of public mandatory regulation, with national application, and an important part of market requirements through certifications and Technical approvals.

The rulings and regulations for construction are combined in the Codes. The Code of Construction and Housing[5] (Code de la Construction et de l'Habitation) and the Urban planning Code (Code de l'Urbanisme) are the most important ones for building regulations.

At the same level of the Code of Construction and Housing, one can find the Environmental Code, the Energy Code and the Consumer Code.

TEXT	REQUIREMENTS
Code of Construction and Housing	Comprise legislative articles and regulatory articles. It define the requirements in the field of safety, accessibility, acoustics and thermal insulation, and leaves the other performances to technical standards of a contractual nature.This code refers to main general regulatory texts for: - Energy control - Fire safety - Acoustic - Health - Seismic and structural - New EU Construction Products Regulation - Reach
Urban planning code	Including in French law legislative and regulatory provisions for town planning law. In France, the planning rules are codified in the town planning ode (Code de l'urbanisme). A 'Certificat d'Urbanisme (CDU) is required to get the right for building on land in a specific area. The CDU is not a building permit, but it is an 'approval in principal'. An architect is compulsory for applying the building permit for buildings larger than 170m². The building permit mostly deals with planning and architectural issues, based on an outline design of the architect. The contractor makes the detailed construction drawings. The project developer ("maître d'ouvrage") is responsible for conformity to the technical requirements of the Housing and Building code.
Consumer Code	Include the legal provisions relating to the consumer law, which is a subset of the business law. Identify the risks relating to use of the product and implement measures to prevent them. Compliance with this obligation may be presumed on the basis of standards or test protocols.
Insurance Code	Guarantee of product performances during for at least 10 years. Obligatory insurance of decennial guarantee implies a technical verification of the

[5] http://www.legifrance.gouv.fr/affichCode.do?cidTexte=LEGITEXT000006074096 French building code and occupancy code

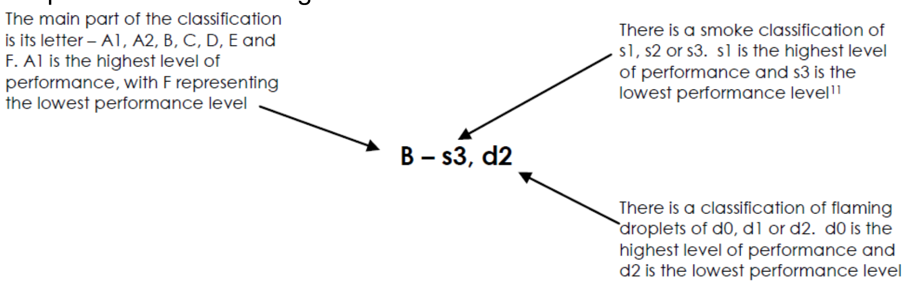
	conformity of the works with technical standards by a controller contracted by the insurance company
Energy Code and RT2012	Official French legal code collecting various provisions relating to energy law. Since they were first introduced in 1975, the French Thermal Regulation (RT) has been developed and strengthened several times. The new RT 2012 thermal regulations aim to limit energy consumption in new residential and commercial buildings. It corresponds to the application of a part of the commitments defined under the Grenelle 2 environment forum concerning better management of our energy consumption. In actual thermal regulation RT2012, as a result the code includes mandatory renewable energy requirements (for individual house): solar thermal collectors, offered renewable energy is at least 5 kWh/m² in primary energy, thermodynamic water heaters, micro-cogeneration boiler. The next thermal regulation is scheduled for 2020 and should generalize energy-plus building (BEPOS[6]).
Fire regulation	Many decrees and the Code of Construction and Housing describe the fire regulation. Fire behaviour is judged on two criteria : - Fire reaction : represents the capability of a material to inflame and therefore o contribute to the development of a fire - Fire resistance: means the property of a material or assembly in a building to withstand fire or give protection from it. The NF EN 13501 February 2013 provides a harmonized procedure for the classification of reaction to fire of construction products, including products incorporated within building elements like BIPV. 
Acoustic regulation	Code of Construction and Housing describe the fire regulation. Many decrees gives minimal acoustic characteristic depending on building type. To follow different French regulation requirements, different class levels in terms of : - Airborne sound insulation global between rooms-DnT,A - Façade sound insulation- DnT,A,tr - Impact sound insulation between rooms L'nT,w - Service equipment noise global - LnAT in dB(A)

Table 7: Main French regulatory requirements and building codes

Many regulations require implementing orders to be made to set levels of requirements. There are quite a number of ministerial decrees that have the same force as laws.
If you want to build near a protected building in France, or within a conservation area, you are subject to stronger planning controls. The most relevant of the French legislation concerning the protection of heritage and its relationship with modern architecture, such as BIPV, is that dealing

[6] *The energy-plus building is a passive building (BEPAS) that exceeds its energy needs through renewable energy production like PV systems*

with the surroundings of listed buildings. When a building is located within the field of vision of a 'classé' or 'inscrit' building, a buiding permit cannot be granted without the prior agreement of the architectural review board (Architecte des Bâtiments de France).

There is also a number of local regulations, applicable in the field of urban local planning, that have also to be met (the local plan, the legal maximum density [of constructions], coefficient of land use, floor space ...). Thus if by their location, their architecture, their size or their outside appearance, buildings or works might interfere with the character or the interest of neighbouring areas, sites or natural or urban landscapes, or the protection of monumental perspectives, the building permit can be refused or be subject to strict conditions.

In France, there is no specific national policy to encourage the use of Renewable Energy Sources (RES) in the urban planning process. In response to this lack of national policy, some local authorities have implanted local policies. For instance, Greater Lyon, drew up on a voluntary basis a local policy to enforce the Rational Use of Energy and the use of RES in new buildings.

Specific requirement for integrated PV installations

The French market of photovoltaic installations could be shared in two different kinds of PV system:

- PV elements that are simply placed generally on the roof but that are not integrated in the structure;
- BIPV elements that are integrated in the buildings and that have not only a PV function but also architectural and structural function.

For the first category of PV elements, a two years warranty is only necessary while the second one is involved in ten years warranty ("garantie décennale"). This warranty is key in the market regulation system. For traditional products, the insurers involved in construction require compliance with products standards and DTU - *Document Technique Unifié* (compliance and implementation). For non-traditional products, such as PVSITES products, insurances require guarantees on products. The CE marking, based on harmonized standards or ETA, is not enough in most cases. Obtaining an ATEX (Technical Experimental Assessment), ATEC (Technical Assessment), ETN (Enquête de Technique Nouvelle) or Pass Innovation will be necessary for the French market.

Professional associations and administrative authorities have developed a range of recommendations and quality labels to promote products and service quality. Qualit'EnR is a certified association specialized in the qualification of renewable energy businesses. The Qualit'EnR/QualiPV label comes in two versions: QualiPV Elec for electricians and QualiPV Bât for roofers. Once accepted by the public authorities and ADEME, these quality labels display the acronym RGE (*Reconnu garant de l'environnement*). From the 1st of July 2014, homeowners wishing to benefit from a public subsidy have had to call on qualified professionals who carry the RGE quality label and comply with the mandatory ten-year liability requirements.

In 2008, CSTB (Scientific and Technical Centre for Construction) set up a technical assessment procedure to ensure that photovoltaic products and processes used on a building would pose minimal accident risk and would be covered by basic insurance contracts. Photovoltaic Technical Assessments (ATec PV) are renewable, modifiable and readily available. They are awarded for a maximum period of 3 years. CSTB's '*Pass Innovation Vert*' is an optional step before starting the Technical assessment procedure. It is valid for a maximum period of 2 years.

The following table represents the framework of norms and provisions that are related to the PV elements integrated in the buildings.

The structurally integrated PV elements must still respect the norms already presented:

- NF C 15 100 and the technical requirements that are specified by the GUIDE UTE C 15-712-1/2;

- NF EN 61215 or NF EN 61646 (it depends if the product is realised by crystalline silicon PV modules or thin layers).

Règles de mise en œuvre des installations intégrées au bâtiment			**Textes Réglementaires, DTU, Normes et Règles de calcul**
Aptitude à l'emploi des capteurs			NFC 57-100, 101, 102, 103 CEI 61215, 61646
Sécurité des capteurs dans l'ouvrage	Stabilité	*Neige, Vent, Séisme, Actions combinées, Corrosion*	NV 65 DTU P06-002 CB 71 DTU P21-701 CM 66 DTU P22-701 AL DTU P22-702 PS 89 NF P06-014 ISO 7599
		Hygrothermique	Variation dimensionnelle sous l'effet de la température Référence à l'expérience ou calculs
		Charges d'exploitation, Entretien maintenance	NF P06-001 DTU 95.1 NF P95-201
	Sécurité des travailleurs et des personnes		Décret 65-48 du 8 Janvier 1965 Décret 88-1056 du 14 Nov. 1988 Décret 75-848 du 26 Août 1975
	Risques électriques		NF C15-100
	Feu		Sécurité contre l'incendie : JO n° 1477, 1536, 1540, 1603
	Chocs accidentels		NF P01-012 (assimilation aux garde-corps)
	Effraction Explosion		Sauf prescriptions particulières
Habitabilité de l'ouvrage	Etanchéité air-eau		Référence à un classement homologué ou à des essais DTU 33, 39, 40, 43
	Confort hygrothermique		Th-U, Th-C, Th-E RT2000
	Confort acoustique		NF S31-010 NF S31-057
	Aspect		NF P24-351
	Salubrité		Matériaux non nocifs, stabilité physico-chimique
Durabilité de l'ouvrage	Entretien maintenance		Notice fournie par le fabricant DTU 33, 39, 40, 43
	Chocs accidentels		NF P08-302
	Hygrothermique		Référence à un classement homologué ou à des essais

Table 8: French framework related to PV elements integrated in buildings[7]

[7] http://www.developpement-durable.gouv.fr/IMG/pdf/166-ReglementationPVIntegreBati-CSTB.pdf

It is necessary to respect the provisions related to the mechanical behaviour of all mounting devices (fixing clips, rail, screw, etc). These mechanical checks must be also performed in relation to all steps of the entire process framework. For example, the bolts pull-out test must be carried out in accordance with the provisions presented by the norm NF P 30 313. These calculations on the mechanical strength must consider the climatic conditions that characterise the geographic position of the PV installations.

About the durability, the structurally integrated PV elements must present also suitable waterproofness and airtightness and technical provisions that must be respected for the maintenance. The technical requirements related to these aspects are presented in the following unified technical documents:

- Unified technical documents: 33: lightweight facades;
- Unified technical documents: 39: glaziery and mirror trade;

The norm NF P08-302 Annexe A contains the provisions related to the resistance against accidentals shocks and corresponding tests on the glass protection (garde-corps). The norm NF P01-012 is related to the definition of the dimension for the protection (garde-corps).

The seismic behaviour must be also treated and in this case it is necessary to respect the following provisions: “Arrêté” of the 22 October 2010 that is renewed with the “Arrêté” of the 19 July 2011.

2.4.4 Construction needs and barriers in Spain

Spanish building codes and regulations

The Spanish regulatory system has national laws and it is supplemented by regulations and controls in Autonomous Communities.

The Spanish building regulation is highly codified and centred on the CTE[8] (Technical building code). The Spanish Technical Building Code specifies the requirements in Spain for the design, construction, use, maintenance and conservation of buildings. Compliance with this code foments building quality, guarantees the health and safety of occupants and protects the surrounding environment. It is a detailed set of documents with different sections:

- Part 1: sets out the basic requirements in performance terms; an initial specification of requirements. The safety requirements are the following: structural safety; fire safety and building use safety. The habitability requirements include: hygiene; noise protection; and energy economy;
- Part 2: is in a volume series (Documentos Básicos – DB) related to each of the basic requirements. These DB volumes contain verification procedures, technical rules and examples of deemed to satisfy solutions.

The Spanish Technical Building Code requires that a certain percentage of energy consumption comes from renewable energy sources, particularly thermal and photovoltaic solar energy. For this reason, it states that it is necessary to install systems for solar energy collection and transformation into electrical energy by means of photovoltaic processes for personal use or for the electricity grid.

[8] http://www.codigotecnico.org/ingles/introduction/

This is obligatory for certain buildings, such as hypermarkets, with a surface area greater than 5000 m2, hotels with more than 100 rooms, etc.[9]

TEXT	REQUIREMENTS
Law on Building Ordinances **Law 38/1999 of 5 November (LOE), and modifications.**	Establishment of the basic requirements to be met by buildings to ensure the safety of people, the welfare of society and environmental protection.
Technical Building Code **(Código Técnico de la Edificación - CTE)** **Real Decreto RD 314/2006 Approved on 17th March 2006 (BOE 28-03-2006) and modifications.**	It is the regulatory framework that establishes the requirements to be met by buildings in relation to the basic requirements of safety and habitability established by the LOE. One of the basic requirements of the CTE is energy saving and its objective is to achieve a rational use of the energy necessary for the use of the buildings, reducing consumption and achieving that the origin of part of the same is from renewable sources of energy. A part of the energy demand requirements, the “DB HE5 Minimum photovoltaics contribution of electrical energy” of the Spanish CTE introduces the obligation to supply a certain quantity of the electrical power by photovoltaics technologies.
Energy performance: **Royal Decree RD 235/2013**	Approving the basic procedure for the certification of the energy performance of buildings. Spanish transposition of the Directive 2010/31/UE, related to the establishment of the technical and administrative conditions for the certification of energy efficiency in buildings, and the methodology for calculating the energy efficiency rating.
Regulation of Thermal Installations in Buildings (RITE)	As a transposition of Directive 2002/91/EC, in 2007 the Spanish government enacted the Reglamento de Instalaciones Termicas en los Edificios [Regulation of Thermal Installations in Buildings]. According to this regulation, thermal installations should be designed, implemented, maintained and used so as to achieve a significant reduction of conventional energy consumption and, consequently, a parallel reduction of greenhouse gas emissions and other atmospheric pollutants
Fire regulation	The CTE Establish rules and procedures to enable compliance basic safety requirements in case of fire. The Basic Document DB SI of the Spanish CTE contains the applicable directives of security in construction in case of fire.
Acoustic regulation	The CTE Establish rules and procedures to enable compliance the basic requirements of protection against noise. Others laws and decrees describe acoustic regulation.

Table 9: Main Spanish regulatory requirements and building codes

The national government provides the overarching legislation and technical regulations, but most Autonomous Communities have legislation dealing with housing habitability conditions and these usually include some sustainability requirements, such as gray water recycling, minimum sun exposure requirements, and others.

For example, in the case of Madrid’s AC, the Energy Plan 2004-2012 aims at doubling the energy contribution from Renewable Energy Sources and a 10% reduction of CO2 emissions. Amongst the actions foreseen related to Photovoltaics, the promotion of PV systems in domestic and services sectors, and the support of municipal bylaws are mentioned. In September 2005, there were more

[9] http://energyprofessionalsymposium.com/?p=8213

than 30 municipal bylaws concerning solar technologies, most of them only dealing with Solar thermal. The region of Catalonia is by far the most active in this field, followed by Madrid and Valencia.[10]

Specific requirement for integrated PV installations

In Spain, CE marking is the first "certification" asked and it is enough in most cases.

For construction product, three equivalent options exist to provide verified information:

- DAU (Document of Assessment for fitness of Use)
- DIT (Documento de Idoneidad Técnica)
- TC (Technical Conformity Report)

The DAU, Document of Assessment for fitness of Use, is the statement of a favourable opinion on the performances of an innovative product or system regarding its intended uses and defined constructive solutions, within the field of building and civil engineering construction.

A DAU assesses the fitness for the intended use of a constructive solution on the basis of objective levels or required limit values for building works and on functional requirements established case by case.

For new products and non-traditional construction, this type of information is strongly "recommended" by insurances companies.

2.4.5 Construction needs and barriers in Switzerland

European Union (EU) regulations do not directly apply to Switzerland, as the country is not a member of the EU. However, Switzerland maintains extensive co-operative relations with the EU, including those related to the harmonization of environmental legislation.

Building in Switzerland is regulated in detail in federal laws as well as in the laws and ordinances of the Cantons. Since Switzerland is a federal state comprised of 26 Cantons, there are 26 different Building Laws.

TEXT	REQUIREMENTS
Swiss Civil Code of 1907	It is the codified law ruling in Switzerland and regulating relationship between individuals. It contains rules that apply to the abatement of nuisances such as water or air pollution, as well as noise.
Swiss federal Land Use Planning Law	Stipulates the ground rules for all planning on all levels, namely the economic use of land in general and the use of agricultural land in particular.
Energy performance and thermal regulation	Under the existing law, there are no national targets or legal requirements for increasing the use of renewable energy, but some cantons have set regional targets The Federal Council has proposed the Energy Strategy 2050, with the aim of restructuring the Swiss energy system and withdrawing from nuclear energy. Minergie® is the Swiss energy label launched in 1998. It is a private organisation owned by the non- profit Minergie® Association and sets benchmarks and tools to combine energy efficiency in building with improved comfort. Minergie® is a registered trademark and a labelling system. It is not just about accrediting energy efficient buildings.

[10] http://www.pvupscale.org/IMG/pdf/The_Spanish_planning_process.pdf

Table 10: Main Swiss regulatory requirements and building codes

Building permits are usually obtained from the local authority where the construction work is to be performed. The local authority coordinates with the authorities of the Canton and all other instances involved in issuing the building permit. Buildings, structures and their surroundings have to be designed in such a manner that they, each for themselves and in combination with each other as a whole, give a favorable or pleasing impression. In particular, special attention has to be paid to buildings and land under cultural heritage protection or nature conservation areas.[11]

The Swiss Federal Office of Energy introduced various incentives to promote solar technology with special attention to the integration in buildings. It has published a directive (03/04/2014) defining the criteria for feed-in remuneration of Building Integrated Photovoltaic installations.

[11] http://www.building-law.ch/building-procedure

3 BUSINESS MODELS, SUPPORTING MECHANISMS AND FINANTIAL SCHEMES FOR PV

This chapter focuses on different financial mechanisms and supports that can be adopted by PV investors, owners and consumers linked to a specific business model. Regulatory framework of those countries where PVSITES demo-systems will be installed has been analysed in detail.

3.1 Business models and supporting mechanisms for PV

Support schemes were defined for photovoltaics, since it is considered as a clean energy source suitable for decentralized energy supply and which can contribute to climate change protection.

In order to promote installation of BIPV products, public authorities in different countries launch financial support mechanisms and requirements varying according to defined criteria. In the same way, several private financial mechanisms are also available to potential investors, consumers and other stakeholders. Business model finally adopted by a PV system owner will be closely bound up with these financing options.

Self-consumption business models have been given a special treatment in this section, since they are the most suitable to be adopted in order to take advantage of the grid-parity happening in some EU regions.

3.1.1 Business models based on public supporting mechanisms and energy policy requirements to promote PV

- **Feed-in tariff:** it is a supporting mechanism by which power generated by renewable energy technologies is paid at different price than retail electricity, generally according with the typically cost of generation of each technology. In the case of photovoltaics this price has been normally higher than retail electricity price, in order to promote the implementation of PV systems. It has been, traditionally, the main and more supporting model used by governments to boost renewable energies. Feed-in-Tariff (FiT) supports are being progressively withdrawn, driven by the grid-parity happening, in those regions and markets where a favorable regulation framework is being developed in order to implement self-consumption models.
- **Capital subsidies:** supporting mechanism aiming to provide direct financial subsidies in order to tackle the up-cost barrier, either for specific equipment or total installed PV system cost.
- **Income tax credits:** allow some or all expenses associated with PV installation to be deducted from taxable income streams. These fiscal advantages can relieve the economic pressure on small producers/investors in order to improve the economic viability of the projects.
- **Sustainable building requirements:** including requirements on new building developments (residential and commercial) and also in some cases on properties for sale, where the PV may be included as one option for reducing the building's energy foot print or may be specifically mandated as an inclusion in the building development.
- **Renewable portfolio standards (RPS):** is a mandated requirement by which electricity supply companies are obliged to produce a portion of their electricity from renewable energies. This scheme is not exactly a financial or supporting mechanism addressed to owners/consumers of a PV system, but just a policy measure to promote presence of renewable sources in the energy national and global system.

3.1.2 Business models based on private supporting mechanisms

- **Investment funds for PV:** share offerings in private PV investment funds plus other schemes that focus on wealth creation and business success using PV as a vehicle to achieve these ends.
- **ESCO/EPC:** reduces upfront capital investment paid off by the increased revenues associated with the produced electricity, throughout the intervention of an energy saving company which get involved in the project financing and managing.
- **Commercial bank activities:** including activities such as preferential home mortgage terms for houses including PV systems and preferential green loans for the installation of PV systems.
- **Green electricity schemes:** allows customers to purchase green electricity based on renewable energy sources from the electricity utility business, usually at a premium price. PV-specific green electricity schemes are specifically adopted for photovoltaics. These schemes are voluntary adopted by consumers generally driven by an environmental awareness.

3.1.3 Self-consumption business models

With the grid-parity advancing and in order to facilitate the implementation of the self-consumption schemes some innovative business models have been emerging during the last few years. The most widespread business models within a self-consumption scheme are the following:

- **Pure self-consumption with constraints:** this model is typical of those countries or regions in which a self-consumption regulatory framework has not yet been implemented or is on track to be developed. Grid connection of self-consumption systems are allowed in these cases, usually with some fees or taxes (i.e. as a contribution to the network maintenance). Sometimes, there are constraints to include electric storage systems in a self-consumption installation connected to the grid. The consumer can get energy from the grid at the retail price, if necessary, but there is no compensation for the excess electricity fed into the grid. These circumstances, extra fees/taxes and no remuneration for the surplus, make difficult to amortize the investment. Thus, efforts addressed to reduce system size, to improve the demand management or include suitably sized storage systems are necessary in order to reduce the PV energy generation cost in comparison with the retail electricity price. This is the case of Spain, where a high and unjustified “sun tax” has been stablished for PV self-consumption systems.
- **Pure self-consumption with a FiT:** this model is characteristic of those countries or regions with a transitory state on energy policies, where grid-parity has not yet been achieved. Self-consumption is allowed, in such a way that prosumer can benefit from bill reductions, but old support mechanisms, such as feed-in-tariff, still apply. In this regard, prosumers can get energy from the grid at the retail price and, additionally, could sell the excess electricity energy to the grid at a predefined advantageous tariff which facilitates the economic viability of the projects. Regulation has to clearly stablish, for this purpose, the specific conditions for metering the energy import-export balance. A similar model is currently in place in Germany.
- **Net-billing:** in those places and markets where grid-parity has already happened, self-consumption without governmental support is possible under a favorable regulatory framework. One of these regulatory frameworks, net-billing, contemplates a compensation for the excess electricity and considers both energy flows between the PV system and the grid. This mechanism might establish different prices for the energy consumed from the grid and the excess electricity injected into the grid; the latter being lower than the electricity retail price. Finally, costs associated to both flows are netted, at the end of the period stablished by contract, and a single invoice is issued. Regulation has to clearly stablish, for this purpose, the specific conditions for metering the energy import-export balance.

- **Net-metering:** as in the previous case, net-metering business model compensates the excess energy fed into the grid; but, in this one, this compensation is not lower but equal to the electricity retail price. As a counterpart, some taxes might usually charge for the grid availability and maintenance. If grid-parity has not yet been achieved, policy-makers can still maintain additional supports or define a specific one in order to make possible the economic viability of the systems and boost, consequently, the implementation of a more sustainable energy model.
- **Self-consumption with premium:** in the same vein of the last observation, there are certain measures that can be included, as part of a self-consumption scenario, in those cases for which grid-parity is still not a reality and the PV LCOE is higher than the retail price. Several mechanisms to be put in place might consist in receiving an additional payment for on-site self-consumption, or obtaining a compensation for the excess exported electricity at a higher price than retail electricity, as in a FiT model. In the other hand, certain tariff models such as Time-of-Use (ToU), whereby electricity prices are set for a specific time period on an advance or forward basis, could be beneficial for the self-prosumer, who has control over the energy management of its system.

Some of these conclusions are gathered in the table below:

		Production based: classical "FiT" - style. No self-consumption	Self-consumption with constraints	Self-consumption + FiT	Net-billing	Net-metering	Self-consumption + Premium
1	Right to self-consume	Not Allowed	Yes	Yes	Yes	Yes	Yes
2	Revenues from self-consumed PV	N/A	Savings on the electricity bill	Savings on the electricity bill	Netting of production revenues and consumption costs	Savings on the electricity bill	Savings on the electricity bill
	Additional revenues on self-consumed PV	N/A	No	No	No	No	Premium
3	Charges to finance T&D cost	N/A	Yes	No	No	No	No
4	Revenues from excess electricity	N/A	Zero	< retail price	<= retail price	= retail price	> retail price
5	Maximum timeframe for compensation	N/A	Real-time	Real-time	Long period	Long period	Real time

Table 11: Range of business models from the perspective of the prosumer [28]

3.2 Public initiatives to promote BIPV in Europe

At European level various public initiatives are proposed in order to promote BIPV.

The European Union has set out plans for a new energy strategy based on a more secure, sustainable and low-carbon economy. It has aimed to achieve at least 27% share of renewables by 2030 in order to encourage private investment in infrastructure and low carbon technologies. [19]

Photovoltaics are expected to make a significant contribution to realizing this goal, as being the renewable energy technology with the largest scope for cost reduction and efficiency gains.

3.2.1 Public initiatives of the European Industrial Initiative on solar energy

In order to achieve the goals of the European energy and climate change policy, the development and deployment of low carbon energy technologies are necessary while continuing to rely on conventional energy technologies (see the Commission Communication An Energy Policy for Europe COM (2007 1) and the Second Strategic European Energy Review COM (2008 0781)).

Europe Union has validated the European Strategic Energy Technology Plan (SET-Plan) as a vehicle to accelerate the development and large scale deployment of low carbon technologies that draws upon the current R&D activities and achievements in Europe. It proposes a new innovation model based on a collective approach to research, development and demonstration planning and implementation with a focus on large scale programs.

The implementation of the SET-Plan has started and is currently working towards the establishment of large scale programs such as the European Industrial Initiatives (EIIs) aiming at the rapid development of key energy technologies at the European level. Six priority technologies have already been identified as the focal points of the first EIIs: wind, solar, electricity grids, bioenergy, carbon capture and storage and sustainable nuclear fission. [31]

Concerning photovoltaics, the EII aims to establish photovoltaics as a clean, competitive and sustainable energy technology providing up to 12% of European electricity demand by 2020. Among all actions, EII proposes a program for the development and demonstration of Building-Integrated PV (BIPV). Aesthetics and suitability are the challenges that relate to both the appearance and functionality of the module and its support structure. Advanced BIPV modules need to be developed which are multifunctional, self-cleaning and serve as construction elements. In order to support the large-scale deployment in typical urban environments and small decentralized communities demonstration projects ("Solar Cities") will be promoted. (See figure 6).

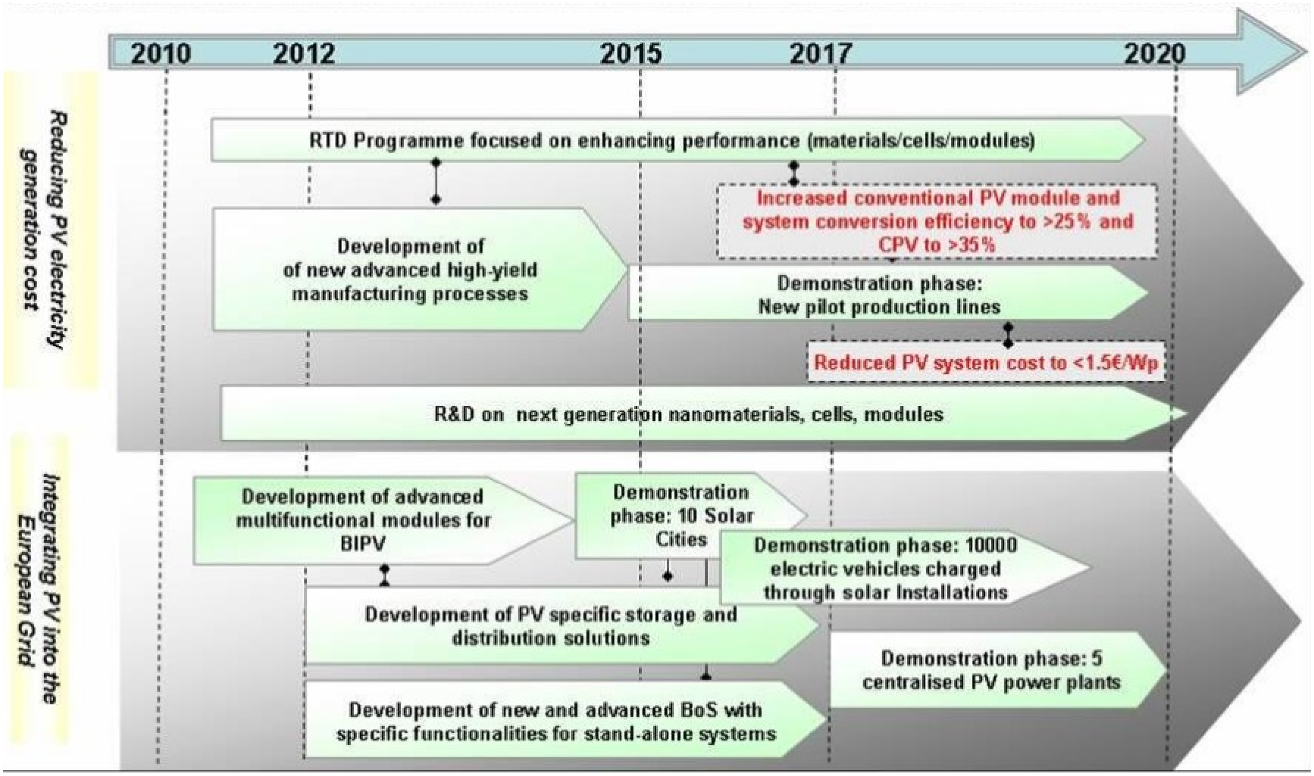


Figure 5: SEII for photovoltaic action plan

3.2.2 Strategic targets for Photovoltaic energy

In 2015, an initiative has been proposed by European Commission in order to modify EPBD (Energy Performance of Buildings Directive 2010/31/EU), RED (Renewable Energy Directive) and EED (Energy Efficiency Directive) regulations at the end of 2016. EPBD revision, especially, could be the mean to unlock the potential of BIPV market through: [32]

- Definition of obligations on building renovation targets and roadmaps;

- Consideration of energy consumption at various building and products life cycle stages;

- Enhancement of energy efficiency and use of renewable energy in buildings, with specific obligations for nearly zero-energy buildings (NZEB) to become the standard for new buildings after 2020, recommending that the very low amount of energy that NZEB consume comes primarily from renewable sources (NZEB).

- Comparison of energy performance of construction products and impact on building energy efficiency.

In January 2016 [33], an agreement was reached between various European actors (representatives of the European Commission services, representatives of the EU Member States, Iceland, Norway, Turkey and Switzerland, (i.e. the SET-Plan Steering Group) and representatives of the SET-Plan stakeholders most directly involved in PV) in order to maintain global leadership of Europe in the PV sector and reduce the Levelized Cost of Electricity (LCOE) of PV. (See SET-Plan - Declaration on Strategic Targets in the context of an Initiative for Global Leadership in Photovoltaics (PV)). Among actions, these targets will be achieved by making mass realization of "(near) Zero Energy Buildings". This will be possible by integrating PV into building envelope (BIPV) through establishment of structural collaborative innovation efforts between the PV sector and key sectors from the building industry. The aim will be to *develop BIPV elements, which at least include thermal insulation and water protection, to entirely replace roofs or facades and reduce their additional cost by 50% by 2020, and by 75% by 2030 compared to end-2015 levels, including flexibility in the production process* (see BIPV detailed targets in Table 12).

		BIPV's main applications		
		Roof integration	Façade integration	
			Semi-transparent	opaque
Additional cost (Euros/sq.m)	today (end 2015)	Some 80-120 (roof-integrated modules) 130-200 (tiles, membranes)	150-350	130-250
	2020	50% reduction with regards to end 2015		
	2030	75% reduction with regards to end 2015		

Table 12: BIPV detailed targets

Moreover, SolarPowerEurope is leading an action to draft several specific proposals for amendments towards definition of minimum share of renewable energy sources (RES) on-site generation as part of minimum energy performance requirements. [34]

The objective is to *position active buildings envelopes and on-site renewable generation including BIPV as prerequisite to reach Nearly Zero Energy buildings by 2020*. This target could be achieved by setting:

- *Obligations for Member State to set targets for RES onsite generation in view of reaching the NZEB objectives which are also included in their national plans.*

- *Minimum RES share in new and existing buildings.*

3.3 PV business models and financial mechanisms in Belgium

Belgium financial mechanism varies according to the region (Flanders, Wallonia and the Brussels region) and is submitted to various reforms. [13]

Table below summarizes the financial support measures in Belgium.

Support scheme	Wallonia and the Brussels region	Flanders
Feed-in tariff	No	No
Capital subsidies	No	No
Green electricity schemes	Green certificates	Green certificates
PV-specific green electricity schemes	No	No
Renewable portfolio standards (RPS)	No	No
PV requirement in RPS	No	No
Investment funds for PV	No	No
Income tax credits	Fiscal incentives applied at federal level to businesses and professionals. The Federal government allows a 13.5% reduction on the total taxable annual income.	Fiscal incentives applied at federal level to businesses and professionals. The Federal government allows a 13.5% reduction on the total taxable annual income.
Prosumers' incentives (self-consumption, net-metering, net-billing…)	Net-metering / Self-consumption	Net-metering / Self-consumption
Commercial bank activities e.g. green mortgages promoting PV	No	Beneficial credit terms
Activities of electricity utility businesses	No	No
Sustainable building requirements	No	No

Table 13: Financial support measures in Belgium

The benefits of these support schemes are described in subsections 3.4.1 and 3.4.2.

3.3.1 Case of Wallonia and the Brussels regions

For PV installations up to 10kW

For PV systems up to 10kW, a scheme called "Qualiwatt scheme" is applied and includes net metering and premium measures.

In this scheme, the solar PV installation (complying with some quality requirements) owner realizes net metering and receives annually a payment from its distribution system operator during the first 5 years of operation of its installation. Payment levels for future systems are defined by the Wallonian Energy Regulator (CWaPE) and depend on the relevant distribution system operator.

Payment levels are calculated so as to guarantee that the solar PV plant owner amortizes the investment within 8 years and makes 5% return on the investment.

For PV installations above 10kW

Green certificates remunerate the produced solar PV electricity. For this kind of PV installations, green certificates and self-consumption are applied.

More precisely, the installation owners are remunerated by green certificates for the PV electricity produced, no matter whether it is injected into the grid or self-consumed. Moreover, the electricity to be injected into the grid can be sold to a supplier at a negotiable but low rate. Or, it can be directly used, reducing thus owners' electricity bills. Neither grid fees nor taxes need to be paid on the self-consumed power. Green certificates are bought for a period of 10 years. The minimum price is set at 65€/certificate. The number of certificates/MWh is reevaluated biannually. A ceiling of 2.5 green certificates / MWh has been set for projects developed after 01/01/2015.

This scheme is interesting, particularly for BIPV systems.

3.3.2 Case of Flanders region

For PV installations up to 10kW

In this configuration, net metering scheme is available but is different from Walloon and Brussels mechanism. This scheme is designed to ensure a 5% internal rate of return but it is limited to total annual electricity consumption.

Indeed, in order to improve the match between solar PV system size and PV system owner consumption level, the exceeding electricity produced is injected into grid without any remuneration. A grid fee, varying according to the local grid operator, must be paid.

For PV installations above 10kW

For these PV installations, green certificates and self- consumption are applied but with requirements different from Walloon and Brussels. PV installation owners sell green certificates to grid operators for the produced electricity injected into grid or self-consumed.

This system is designed to provide PV investors with a 5% internal rate of return. PV system owners must sign a contract with a supplier in order to sell him the electricity injected into the grid at a negotiable rate of about 85% of the year-ahead wholesale electricity market price. The self-consumed electricity is not exposed to the payment of any fee or tax. Green certificates are bought for a 15-year period. The minimum price is set at 93€/certificate. The number of certificates/MWh is reevaluated biannually (1 green certificate per MWh of electricity produced).

For this kind of installations, beneficial credit terms also exist and consist in specific local green loans for a maximum 10.000 Euros at from 0% (low income citizens) to 2% (all citizens) interest rate.

3.4 PV business models and financial mechanisms in France

The PV financial mechanisms in France have evolved since the definition of feed in tariffs of 2011. Indeed, there are actually depending on the PV installation power. They consist in:

- Feed-in tariffs applied to PV systems mounted on building with power lower than 100kWp;
- Public tender for PV systems mounted on building or ground-mounted photovoltaic power plants with power higher than 100kWp.
- Task incentives only for solar photovoltaic/thermal installations (PV/T).
- Tenders for self-consumption.

These financial mechanisms are specific to France and are different in other countries.

3.4.1 Feed-in tariffs specificities

In France, a distinction is made between BIPV systems according to their contribution to the water tightness of building roof in order to allocate feed-in tariffs. A BIPV system is said fully integrated (noted IAB) if only PV modules ensure the sealing of the roof (the dismounting of PV modules makes the building unsuitable for use or affects the sealing function) and are 2 cm maximum over the roof plane. BIPV products in which PV modules replace existing construction elements (without ensuring sealing function) and are parallel to the roof plane are said partially integrated (ISB). For vertical BIPV systems, the difference depends on the envelope technical function (enclosed and covered). [14]

Integration configuration	From the 1st of January to 31st of March 2016	From the 1st of April to 30th of June 2016	Trimestral reduction
Fully integration (IAB) [0-9kW]	25,01 c€/kWh	24,63 c€/kWh	-1,5%
Partial integration (ISB) [0-36kW]	13,82 c€/kWh	13,27 c€/kWh	-4%
ISB [36-100kW]	13,13 c€/kWh	12,61 c€/kWh	-4%

Table 14: Feed-in tariffs in France from January 2016 to June 2016. [16]

Since 2011, a trimestral decrease of the feed-in tariffs is applied. Depending at first on the kind of building (residential, commercial, industrial…) and on the peak power installed, the new tariffs proposed by French authorities, early 2013, consider mainly the peak power of the installation.

In April 2016, the French Energy regulation comity presented new values of feed-in tariffs for the second trimester of 2016 [15]. More precisely, feed-in tariffs decrease of 1.5% for IAB installations and of 4% for ISB installations. (See table 14).

3.4.2 Tax incentives for solar PVT installations

Since January 2014, tax credit for PV installation was cancelled. Nevertheless, a tax credit of 30% exists for PV/T installations in 2016 with a maximum amount of 1200Euros. [17]

3.4.3 Public tenders

This PV financial mechanism consist in submitting proposal of PV installations fulfilling specifications defined by Authorities in collaboration with actors of PV sector and including particularly environmental requirements. [24]

3.4.4 Tenders and self-consumption

This new support scheme consists in a tender dedicated to self-consumption based on authorities' specifications to be published before summer 2016. [18]

This tender is deliberately focused on commercial and large office buildings sectors, for a best correlation between production and consumption, in case of installation or not of energy storage systems.

It will permit an initial selection of 50 MW of projects from 100 to 500 kWp with an additional valuation of the electricity self-consumed in order to encourage this kind of installation. The aim of this tender, instead of encouraging the excessive consumption or production at any cost, is to achieve a relevant balance in the valuation of energy (in kWh) produced. In order to facilitate self-consumption and its implementation, the specifications will be greatly simplified.

Finally, it has to be noted the appointment of the winners of the tender concerning photovoltaic combined with energy storage system in insular zones (French overseas territories) also for a power of 50MW.

3.5 PV business models and financial mechanisms in Spain

In Spain, following a renewables moratorium (RDL 1/2012) and considering the current financial situation, all economic incentives and administrative and funding systems for photovoltaic installations have been suspended by the Spanish government for an undetermined duration. Nevertheless, already registered installations will not be retroactively affected by this decision. Replacing feed-in tariffs, a legislation allows small generators of up to 100 kW to connect to the grid and receive the market price for any electricity they feed in. [20] [22] [23]

Support scheme	Application in Spain
Feed-in tariffs (gross / net?)	No
Capital subsidies for equipment or total cost	Yes / 24/2013 Power Sector Act finishes with feed in tariffs and swift to direct complement to ensure return on investment at a fix price.
PV-specific green electricity schemes	No
Renewable portfolio standards (RPS)	No
PV requirement in RPS	No
Investment funds for PV	No
Income tax credits	Yes
Prosumers' incentives (self-consumption, net-metering, net-billing…)	Self-consumption
Commercial bank activities e.g. green mortgages promoting PV	No
Activities of electricity utility businesses	No
Sustainable building requirements	No

Table 15: Financial support measures in Spain

The PV financial mechanisms in Spain are mainly based on three legislations:

- The Royal Decree 413/2014 of June 6 2014 regulating the activity of generation from renewable sources,

- The Ministerial Order IET/1045/2014 (the Parameters Order) regulating the remuneration parameters for standard installations, applicable to electricity production facilities based on renewable energy, cogeneration and waste.
- And a Law (Law 24/2013 4).

In the new Spanish regulation (24/2013 Power Sector Act), a shift from remunerating production (kWh) to remunerating installed capacity is established as the element to support renewals technologies. It only permits very restrictive self-supply with PV technology.

In October 2015, a royal decree (Royal Decree 900/2015) is published on self-consumption.

All consumers under any of the self-consumption modalities (except in the case of isolated facilities, the Canary Islands, Baleares Islands, Ceuta and Melilla) have to be registered in the "Registry for Electrical Energy Self-Consumption".

This regulation sets up two self-consumption modalities:

- Type 1 or supply with self-consumption: consumer with a contracted power up to 100 kW, owning one or more generation facilities within its internal network, not registered as production facility.
- Type 2 or production with self-consumption: consumer associated to one or more production facilities of the same owner and connected within its network (connected through direct lines; or sharing connection infrastructures). The combined power of the production facilities must be equal or less to the consumer contracted power. There is no limit regarding the installed capacity of this type of facilities which have to be registered. Owners of PV systems up to 100 kW have to register to donate their extra electricity production. Nevertheless, they receive no compensation. For installations over 100 kW, owners can get revenues for excess electricity by selling electricity on the wholesale market or through an intermediary for the excess power they generate. Moreover, they must be the owner of the contract with the electricity company, while community ownership is prohibited for all sizes of self-consumption systems.

The new law requires self-consumption PV system owners to pay the usual grid fees for electricity consumption in Spain, if their installation is higher than 10kW plus a 'sun tax' on energy produced and consumed.

According to the Royal Decree, electrical energy storage devices may be installed within the self-consumption facilities falling under its scope. But, it implies an additional tax.

3.6 PV business models and financial mechanisms in Switzerland

The feed-in tariff scheme for Renewable energies still has strong support from the Swiss parliament and administration.

- The feed-in tariff scheme has an extra category for BIPV systems with a tariff slightly higher than for "normal" roof mounted systems (BAPV).
- Since 2014, new installations below 10kWp can't apply for the feed-in tariff scheme anymore which was replaced by direct subsidies and the possibility of self-consumption.
- In April 2014, a new direct subsidy scheme on a federal level has been introduced concerning systems from 2 to 30kWp DC.
- Self-consumption is allowed for all systems since January 2014. Almost all rural and inhabited areas are grid-connected. PV generation and consumption from grid are compensated in real-time. The excess electricity produced is bought by utilities at price lower than electricity price. No additional grid fee has to be paid by owners for the moment.

Support scheme	Application in Switzerland
Feed-in tariff	Yes, but with cap, huge waiting list Self-consumption
Capital subsidies	Since April 1st 2014, No cap Max 30kWp DC
Green electricity schemes	Some utilities
PV-specific green electricity schemes	A lot of the DSOs offer green electricity schemes including a share of PV
Renewable portfolio standards (RPS)	No
PV requirement in RPS	No
Investment funds for PV	No
Income tax credits	Yes, especially for residential systems
Prosumers' incentives (self-consumption, net-metering, net-billing…)	Self-consumption since 1.1.2014
Commercial bank activities e.g. green mortgages promoting PV	Some
Activities of electricity utility businesses	Some utilities engage in installation and distribution of PV
Sustainable building requirements	Green Building Codes require PV

Table 16: Financial support measures in Switzerland

- Green Building codes require the installation of PV production facilities.

- Many Distribution System Operators offer green electricity schemes including a share of PV.

- Some local utilities have specific green electricity schemes by allowing full net-metering or by defining higher tariffs for excess electricity production than the minimum price fixed by law.

3.7 Conclusions

This analysis of PV financial has shown that common support schemes (such as feed-in tariff, tenders…) could be found in different European countries but have national or regional application conditions depending on Authorities.

Thus, in the framework of the PVSITES project, the choice of technologies for the development and demonstration of the 14 products should be led by these specificities, in particular concerning inverters, kind of grid integration (grid connection, self-consumption…) to be applied for demonstration.

The results presented here are based on a state of art performed in 2016 at the Month (6) of PVSITES project. They could change all along the project. Thus, all along the project and in particular prior to the design of demonstrators, a short update of this information would be necessary.

4 ASSESSMENT OF GRID-PARITY EVOLUTION AND CURRENT SELF-CONSUMPTION OPPORTUNITIES

This chapter studies the proximity to grid-parity needed to achieve the economic viability of PV self-consumption systems and the currently existing regulatory in those European countries chosen for PVSITES demonstrations.

Opportunities for implementing successfully self-consumption business models for BIPV are analyzed. In this regards, once detected possible barriers, some recommendations will be provided in order to improve regulations, depending of the case.

The gradual change towards a new global energy model experienced in recent years has been translated into a continuing decrease of the PV systems costs. Reciprocally, costs reduction of photovoltaics is motivating the implementation of PV technologies in all sectors of human activity. This trend has been increasingly accentuated, in such a way that the perspective of a grid-parity scenario for photovoltaics, where generated energy costs are similar to the net electricity price, is already a reality in many places in the world. A specific analysis of the grid parity evolution in those countries where demo-systems be implemented is necessary.

4.1 Capital costs of PV systems (CAPEX)

One of the main factors involved in the grid-parity assessment is the installed cost of the PV systems. In conjunction with the specific PV regulatory framework, it will be used to calculate the final cost of PV energy, needed to carry out the comparison with the retail price. The installed cost of a PV system constitutes the concept of *Capital cost*, which is determinated by the *PV module price* and the *Balance of System (BoS) costs*.

4.1.1 PV module price and potential saving of BIPV systems as building elements

PV module price has greatly decreased during the last years motivated by the growing demand and the emergence and development of ever-cheaper new PV technologies and manufacturing processes, as shown in Figure 6. Currently PV module price is around 75% lower than their levels at the end of 2009 [24]. The economy of scale and the technological improvements have reduced the price of the crystalline silicone modules to values between 0,48 €/W-0,63 €/W for modules from Southeast Asia and Japan, respectively, in May 2016. More details in Table 16 [31].

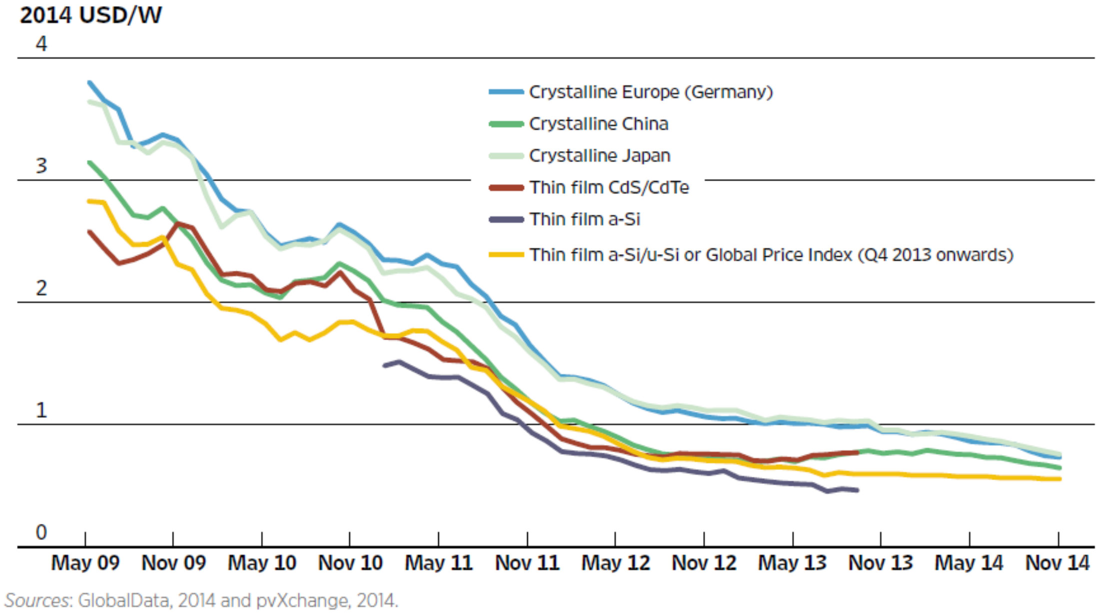


Figure 6: Average monthly solar PV module prices by technology and manufacturing country sold in Europe, 2009 to 2014 [24]

Price trends May 2016

Module type, origin	€ / Wp		Trend since 2016-04		Trend since 2016-01
Crystalline modules					
Germany, Europe	0.56		- 1.8%		- 5.1%
Japan, Korea	0.63		- 1.6%		- 4.5%
China	0.54		- 1.8%		- 3.6%
Southeast Asia, Taiwan	0.48		0.0%		0.0%

Table 17: PV price trends May 2016, Solar Server [31]

In the other hand, it is necessary to extend the concept of a PV module/system to a BIPV module/system, which has building functionalities further than photovoltaics.

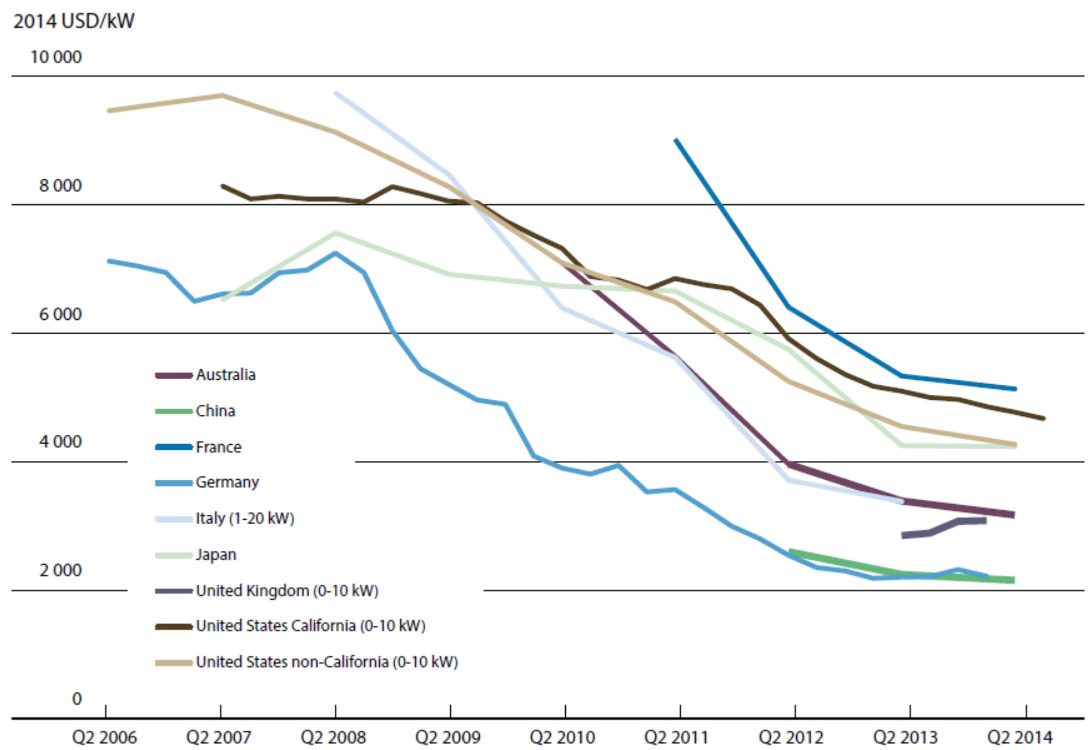
Since BIPV are becoming more and more common for residential applications, some considerations should be taken into account in order of estimate the capital costs of a BIPV systems according to their special particularities: implementation of BIPV systems can significantly reduce the building costs of the envelop components (roofs, façades, closings, etc.), due to the fact that some traditional construction elements and mounting components could be substituted or eliminated by the BIPV ones, which can partially or totally present similar constructive features in themselves. In this regard, the cost of the *original* building components replaced by BIPV elements should be discounted from the CAPEX; in this way, a more adjusted estimation of the LCOE and grid-parity assessment could be made.

4.1.2 Balance of System costs (BoS)

The BoS costs include the electrical equipment (inverters, transformer, wiring, batteries, electrical components, etc.), the mounting structures and anchoring systems and the soft implementation costs (system design, installation and grid connection works, project management and development, customer acquisition, permitting, insurances, financing costs, etc.).

Due to the fact that the price of the PV modules has considerably decreased the specific importance of the BoS costs (particularly the soft costs) in the resultant capital cost has significantly increased. In this scenario, the need to revise the regulatory framework acquires a special relevance, in order to reduce BoS costs and contribute to the reaching grid-parity.

Considering the modules' price and the BoS costs, total installed costs can be calculated. This has experienced a high reduction in accordance with the decrease of both concepts. Market trends are different in this regard, depending of the final application (residential, industrial, commercial or utilities sectors).



Source: IRENA Renewable Cost Database; CPUC, 2014; GSE, 2014; IEA PVPS, 2014; and Photon Consulting, 2014.
Note: Annual data for Australia, China, and Italy; quarterly data for the remaining countries.

Figure 7: Average total installed cost of residential solar PV systems by country, 2006 to 2014 [24]

Here, residential sector has been taken as a reference, because it is considered more significant and interesting from the business point of view. As an example, it can be seen in the Figure 8 how the total installed cost of a residential PV system in Germany has passed from 5,40 €/W in 2006 to approximately 1,70 €/W in the 2014, with a reduction average rate about 0,46 €/W per year. Note, furthermore, differences appreciated between countries within the same market environment (such as France or Italy, members of the EU); a clear symptom of the importance of an appropriated regulation, such as the German one, which traditionally promotes photovoltaics from many years ago through favorable awareness and financial policies, reducing in this way administrative barriers and BoS costs.

Summarizing, the total installed costs of utility-scale PV systems have fallen by 29% to 65% between 2010 and 2014, depending on the region.

4.2 PV levelized cost of electricity (LCOE) and retail electricity price

In order to compare the PV generation price with the retail electricity prices (or wholesale market prices) the LCOE for solar PV projects has to be estimated. The LCOE, measured in [€/kWh], is the present value of the unit-cost of the electrical energy generated by a specific system over its lifetime. It includes not only the installed cost but also operating costs during its entire useful time: initial investment, operations and maintenance, cost of the energy auxiliary system (if exists), financing costs, etc.

There are some factors, regarding the energy balance of the PV systems, under a self-consumption scheme which can significantly influence the estimated fair LCOE value. A well-conceived self-consumption system could include not only power generation units but also electrical storage and intelligent operational and management systems.

4.2.1 Improving factors of self-consumption and economic viability ratios

Although it has not been considered for the grid-parity assessment, there are several factors which could increase the self-consumption ratio and facilitate the economic viability of the projects:

- Electric storage: using of batteries generally increases the BoS costs of the PV systems, because of their high prices and costs of maintenance and periodical replacing, and entails additional obligatory taxes with the current regulatory frameworks; but, if they are suitably sized and managed, according with the production and consumption profiles and considering possible advantages offered by the tariff system adopted, they could increase the energy autonomy of the building and positively contribute to the system financing. Casuistry can vary a lot in this regard; thus, a detailed and specific study of the electric storage convenience, in conjunction with the rest of the system components, is absolutely necessary in each case.
- Electrical vehicles: besides a demand unit, batteries of the electrical vehicles may also be used as energy storage system; in such a way that, if no compensation measure exists for the excess electricity stored energy could be used by the vehicle itself or the rest of the demand charges in the short or medium term. In this regard, electrical vehicles could be considered as a conventional storage systems.
- Management systems: the soul of any PV self-consumption installation is, in either case, the management system. The more complex are the system and, the tariff model and applicable regulation, the more important is the role of the energy management control. Advanced management systems would be needed in order to efficiently control the energy flows between the solar field, the batteries, the network and the demand charges. The proper control of energy flows is an essential matter to optimize every system components and will have an immediate influence on the financial cash-flows. Thus, the appropriate choice and operation of the management control can mean the difference between an energy efficient and economically viable system and a non-profitable investment.

4.2.2 PV levelized cost of electricity estimation

As said above, the high reduction of the total installed cost significantly influences the value of the LCOE. Additionally, the available irradiation in a certain location and the system efficiency have an important weight in the final result, in such a way that a high performance and well optimized system located in a suitable place (with high solar resources) will provide a great deal of energy. This fact would further reduce the LCOE. Thus, systems installed in different places but covered by a similar regulatory framework will not, necessarily, achieve the grid-parity which makes economically advisable a PV system instead the use of grid electricity. Additional factors as those mentioned in the previous section could also influence in the final LCOE value and the grid-parity achievement.

As a first approximation, the simplified formula for calculating the LCOE for a generic PV system is:

LCOE = total costs over lifetime / total energy generated over lifetime

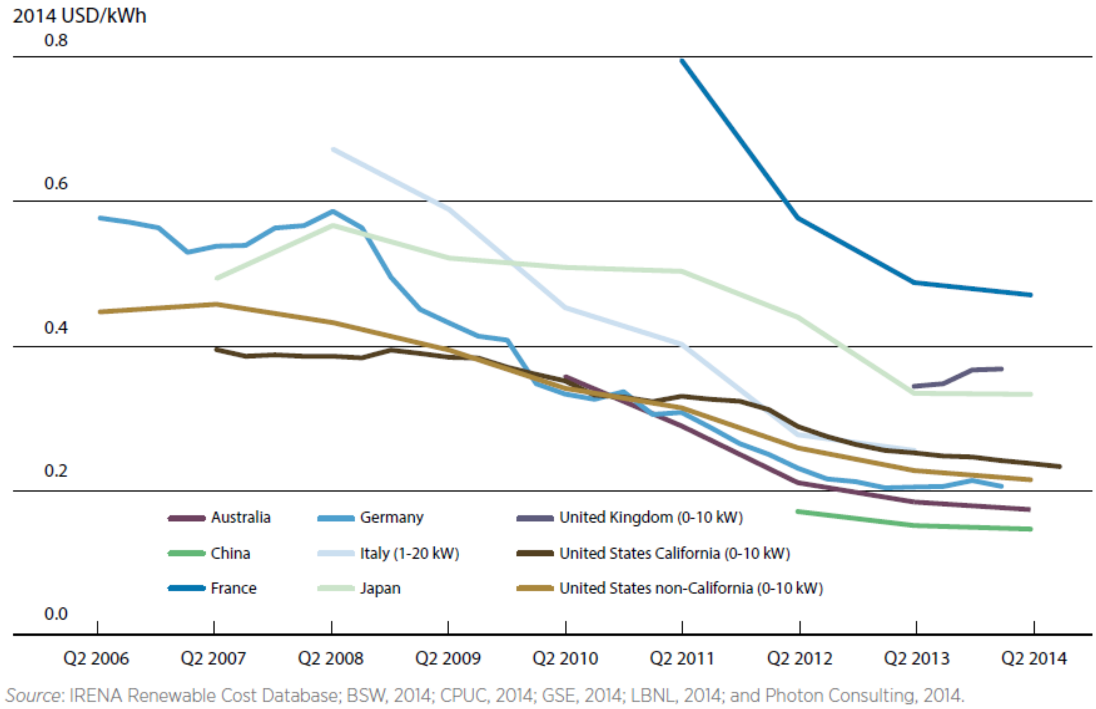
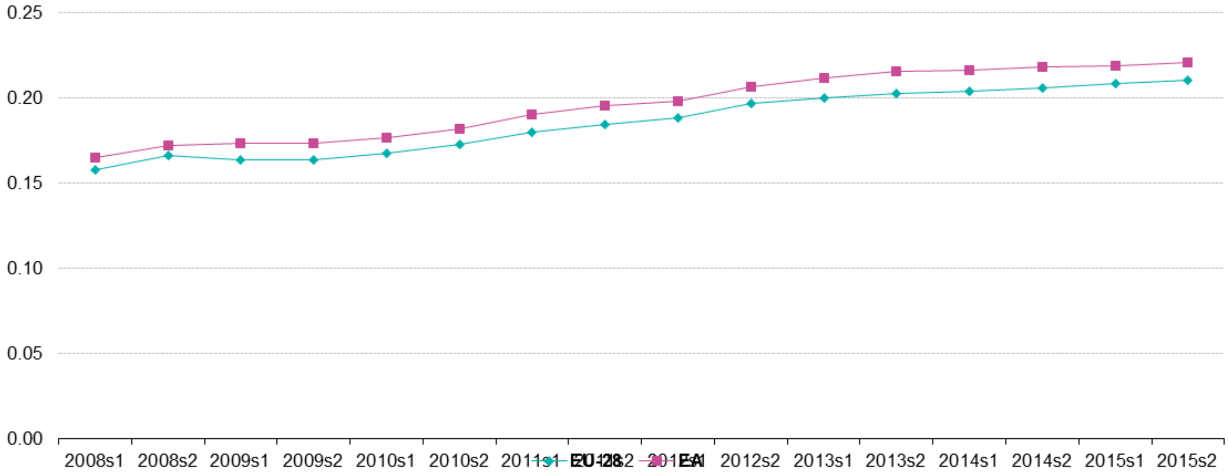


Figure 8: Levelized Cost of Electricity (LCOE) of residential PV systems by country, 2006-2014 [24]

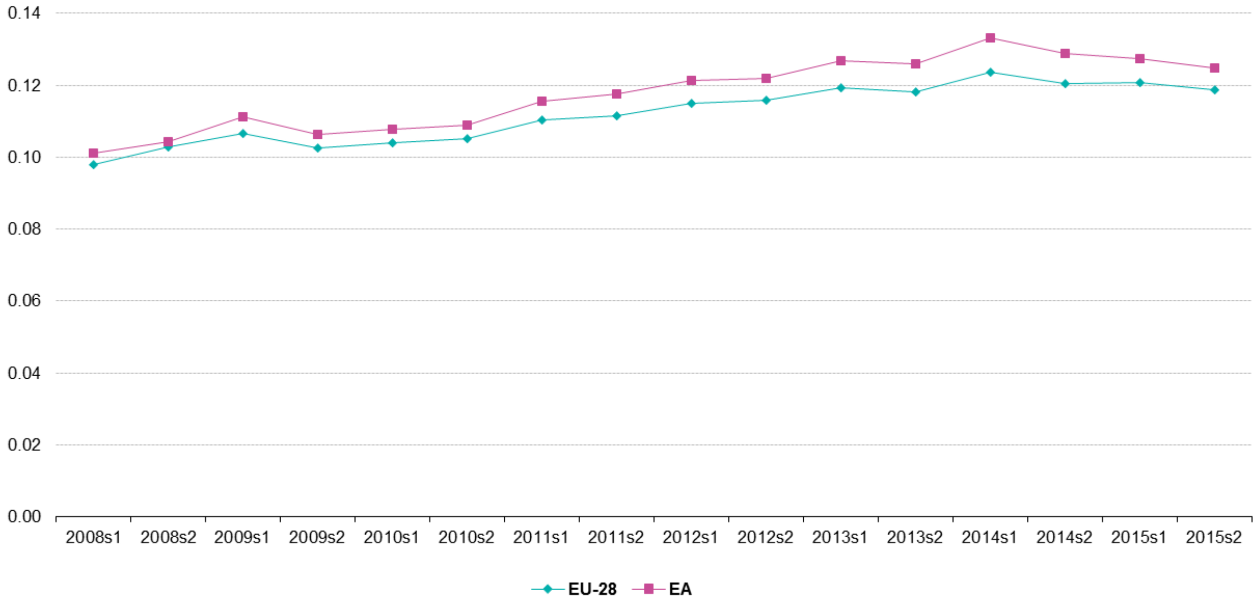
As shown in the graph of Figure 9, the unit-cost of the electricity generated by photovoltaics technologies has been drastically reduced following the trends experienced by modules and BoS, even in countries with medium-low solar resources. In Germany, a generation cost of residential PV systems was about 0,16 €/kWh in the second trimester of 2014; only five year before it was more than double. The average LCOE of utility-scale solar PV has fallen by half during the last four years.

4.2.3 Retail electricity prices

On the other hand, electricity prices from the grid have also experienced changes during the last years. Contrary to the PV costs, electricity prices have been rising in Europe up to 2014. This trend continues for the residential sector, despite of the current decreasing of the fossil fuel price; but not for industrial sector, which is decreasing from the first semester of 2014. Below graphs show both trends for the EU-28 and the Euro Area (EA), and the next table the retail prices per country in the second semester of 2015.



Source: Eurostat (online data code: nrg_pc_204)



Source: Eurostat (online data code: nrg_pc_205)

Figure 9: Evolution of EU-28 and EA electricity prices (€/kWh) for household and industrial consumers, respectively [32]

	Basic price	Other taxes and levies (excl. VAT)	VAT	All taxes and levies in %
	in EUR per kWh			
Belgium	0.184	0.022	0.029	21.7
Bulgaria	0.080	0.000	0.016	16.6
Czech Republic	0.106	0.001	0.023	18.3
Denmark	0.094	0.149	0.061	69.1
Germany	0.143	0.105	0.047	51.6
Estonia	0.095	0.013	0.021	26.3
Ireland	0.199	0.017	0.029	18.9
Greece	0.123	0.034	0.020	30.7
Spain	0.186	0.009	0.041	21.4
France	0.111	0.032	0.025	33.9
Croatia	0.100	0.005	0.026	23.6
Italy	0.148	0.073	0.022	39.1
Cyprus	0.146	0.009	0.028	20.4
Latvia	0.110	0.027	0.029	33.6
Lithuania	0.086	0.016	0.022	30.6
Luxembourg	0.133	0.031	0.013	24.7
Hungary	0.090	0.000	0.024	21.2
Malta	0.121	0.000	0.006	4.7
Netherlands	0.123	0.029	0.032	33.0
Austria	0.124	0.041	0.033	37.5
Poland	0.111	0.005	0.027	22.1
Portugal	0.115	0.071	0.043	49.5
Romania	0.094	0.013	0.026	28.9
Slovenia	0.113	0.021	0.029	31.0
Slovakia	0.123	0.003	0.025	18.8
Finland	0.101	0.023	0.030	34.1
Sweden	0.120	0.030	0.038	35.9
United Kingdom	0.208	0.000	0.010	4.8
Iceland	0.100	0.002	0.025	21.1
Liechtenstein	0.158	0.009	0.013	12.5
Norway	0.099	0.015	0.029	30.7
Montenegro	0.087	0.000	0.012	11.9
FYR of Macedonia	0.071	0.000	0.013	15.3
Albania	0.068	0.000	0.014	16.7
Serbia	0.050	0.004	0.011	22.6
Turkey	0.097	0.006	0.019	20.5
Kosovo*	0.048	0.006	0.007	21.3
Bosnia and Herzegovina	0.071	0.000	0.012	14.5
Moldova	0.088	0.000	0.000	0.0

*This designation is without prejudice to positions on status, and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo Declaration of Independence.

Table 18: Electricity share of taxes and levies paid by household consumers, 2015 semester [32]

The comparison between the LCOE and the electricity price coming from the public grid will be the key criteria to assess the current situation of the grid-parity condition. When the PV generation costs over the system's lifetime equals and falls below the electricity cost, under certain market, energy resources and regulatory framework conditions, the economic viability and convenience of the PV project is guaranteed. In some cases, classic or adapted supporting measures are still needed to achieve or promote grid-parity happening.

It should be noted that high quantity and diversity of network electricity tariffs throughout Europe, the eventual changes of these tariff systems and the future evolution of fossil fuel prices introduce a high degree of uncertainty in the grid-parity situation assessment. Nevertheless, this does not prevent from drawing conclusions about the general trends and, overall, the suitable policies needed to definitively push for the extensive implementation of photovoltaics in Europe.

4.3 Grid-parity for photovoltaics

As advanced in the previous section, grid parity exists when the LCOE of the PV electricity matches with the net electricity price. Since solar resources, retail tariffs and energy policies are not the same everywhere, even within the same countries, grid-parity is being unevenly reached depending of these and other factors. Grid-parity constitutes a key condition to undertake PV projects, under a self-consumption model, with high guaranties of being competitive with the retail electricity prices in the long term. In this scenario, no government subsid or feed-in-tariff support would be necessary anymore.

If an electrical storage system (batteries) is used, in the chosen self-consumption modality in order to increase the system autonomy, LCOE generally gets worse because the CAPEX increases in the absence of incentives and without considering the existence of ToU tariffs. Consequently, grid-parity could be more difficult to reach. Nevertheless, this conclusion should be treated with caution, just as a simple generalization, because the results could be highly unequal depending of the case. In this regard, the suitable energy management would have a significant relevance.

In the same way, the existence of a well-conceived net-metering regulation supporting the self-consumption system, through which the network assumes the energy surplus and provides extra electricity during the consumption peaks, contributes to the grid-parity achieving; because the system does not need to be oversized or completed with additional equipment to cover the total demand profile.

The figure below graphically shows the moment in which grid-parity is achieved for a typical case in Germany (two variations, with or without batteries).

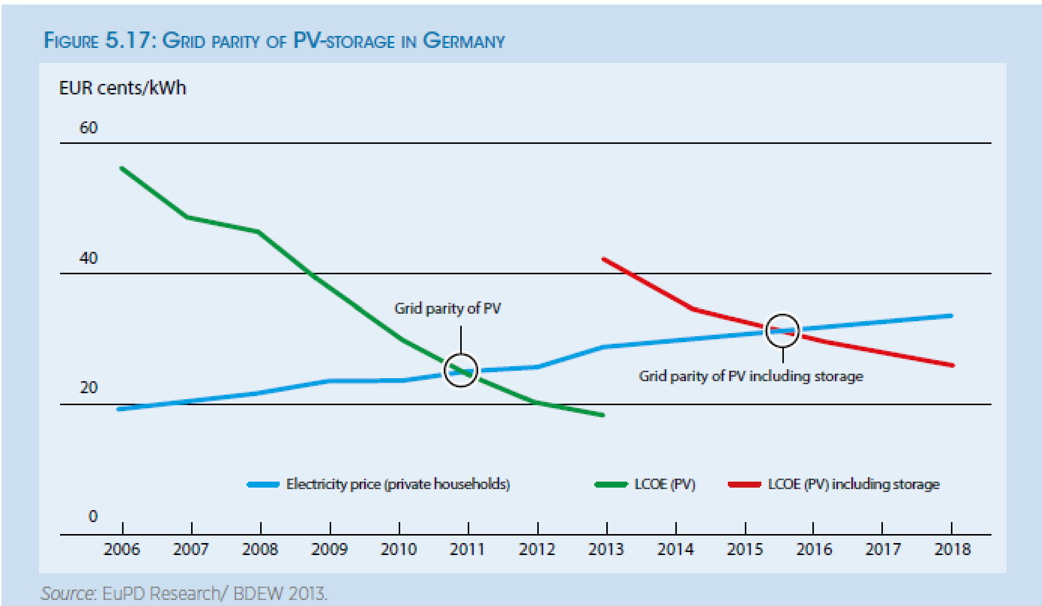


Figure 10: PV-Storage grid-parity of a typical residential system in Germany [26]

Next figure shows the foreseen evolution of PV grid-parity happening from 2012 to 2020, calculated in the PVPARITY project, co-financed by the Intelligent Energy Europe programme of the European Commission. Recently updated data confirm up to now the trend foreseen by this study.

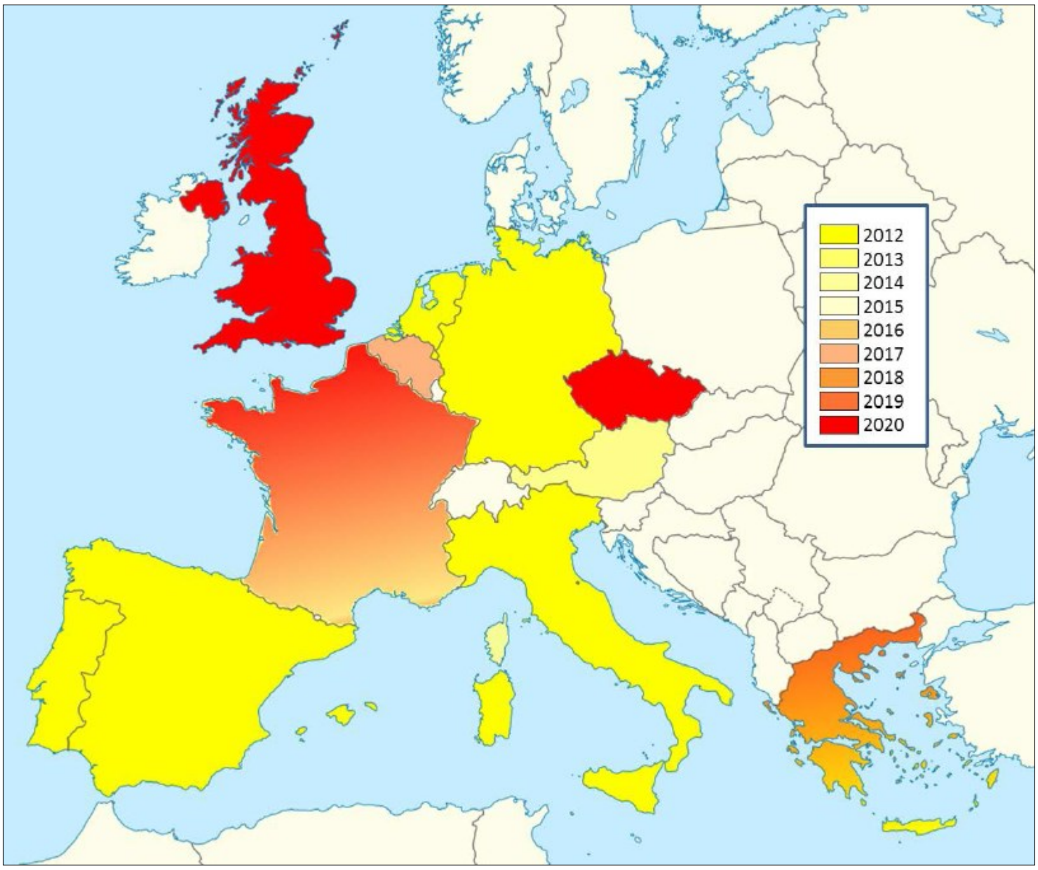


Figure 11: Overview of the foreseen achieving of PV Grid Parity in some European countries, 2013 [30]

The analysis showed in the next section is based on real data from local PV installers and existing retail electricity tariffs, in order to compare LCOE of PV systems and grid energy prices. It does not consider financing mechanisms and administrative barriers.

The photovoltaic LCOE, which computes the PV-generated energy cost over its lifetime including initial investment, O&M actions, gradual loss of performance, useful lifetime, etc., has been calculated from average prices estimated for the chosen countries & cities. Retail electricity prices has been taken from the current tariffs (a maximum of three modalities), in these countries & cities, at the costumer's disposal for residential buildings.

This analysis detects the achieving or proximity of the grid-parity scenario in the case studies, assesses whether current regulation helps or hinders its arrival and concludes which are the most favourable regulatory frameworks needed to promote the competitive implementation of PV self-consumption systems.

Although the graphic representations are related to Building Attached Photovoltaics (BAPV) for residential sector, Building Integrated Photovoltaics (BIPV) systems are also considered in the analysis of the regulatory support to PV self-consumption and to draw some conclusions about each particular case. In principal, installation prices of BIPV systems are higher than BAPV, but these costs would be greatly reduced considering that fewer constructive elements to install are needed in a BIPV case: it should not be forgotten that BIPV elements/systems are constructive and energy multifunctional units. BIPV have an extra constructive advantage over BAPV because of the substitution of the *original* building elements/systems directly impact on the building costs, reducing the total cost of the project. In the other hand, BIPV passive energy features (apart of active PV power generation) also can bring energy saving influencing the total energy balance of the building, with the correspondent economical saving. All these considerations might move the grid-parity point for a BIPV system compared to an *equivalent* BAPV installation. It is impossible to provide a general conclusion in this regard; a specific analysis would be necessary for each particular case.

4.4 PV levelized cost of electricity (LCOE) and retail electricity price

In this section is carried out a specific assessment for self-consumption opportunities from the LCOE-grid parity approach and considering the current regulatory framework, detailed in Chapter 3, of those countries chosen for demonstrating PVSITES products.

4.4.1 Assessment of self-consumption opportunities in Belgium

As shown in Figures 12 and 13, for the residential sector, grid-parity happened on 2013 in Flanders, and on 2014 in Wallonia, where higher BoS costs led to an slight increase of LCOE compared to the Flemish case. The same study (PVPARITY project) expects, in both regions, that grid-parity will be achieved for 90% of cases in 2017.

Summarizing the information provided in Chapter 3, the current PV regulatory framework in Belgium is the following:

- The Belgian regulation contemplates the self-consumption model for PV systems across the country, with slight differences depending of the region (Brussels, Flanders and Wallonia) and the system size; thus, system owners can benefit from saving on the electricity bill.
- Excess electricity can be remunerated based on a net-metering scheme, as energy credits at the retail electricity price, for being used during one year on the generation site for residential systems.
- Only in Flanders, for residential applications up to 10 kW, there are capacity based fees and taxes addressed in order to partially, or totally, finance grid (transmission and distribution) costs and other related concepts.
- Additionally, self-consumption residential systems are also supported by means of Time of Use Metering (TOU) tariffs and green certificates for PV producers, currently fading away.
- Greatest financial benefits exist for commercial and industrial sectors (systems above 10 kW) for which related to the gird fees and tariff are eliminated.

Conclusions:

- PV self-consumption schemes and net-metering policies are currently advanced in Belgium, not only for commercial and industrial sectors but also for residential consumers, with a foreseen increase of BIPV implementation under an enabling regulatory framework. But some measures mentioned below could reverse this trend.
- Despite the favorable regulation, PV market has significantly decreased because of the progressive retreat of green certificates, measure negatively perceived by potential producers and consumers.

- Furthermore, recently implemented capacity-based grid fees might dissuade new investors.

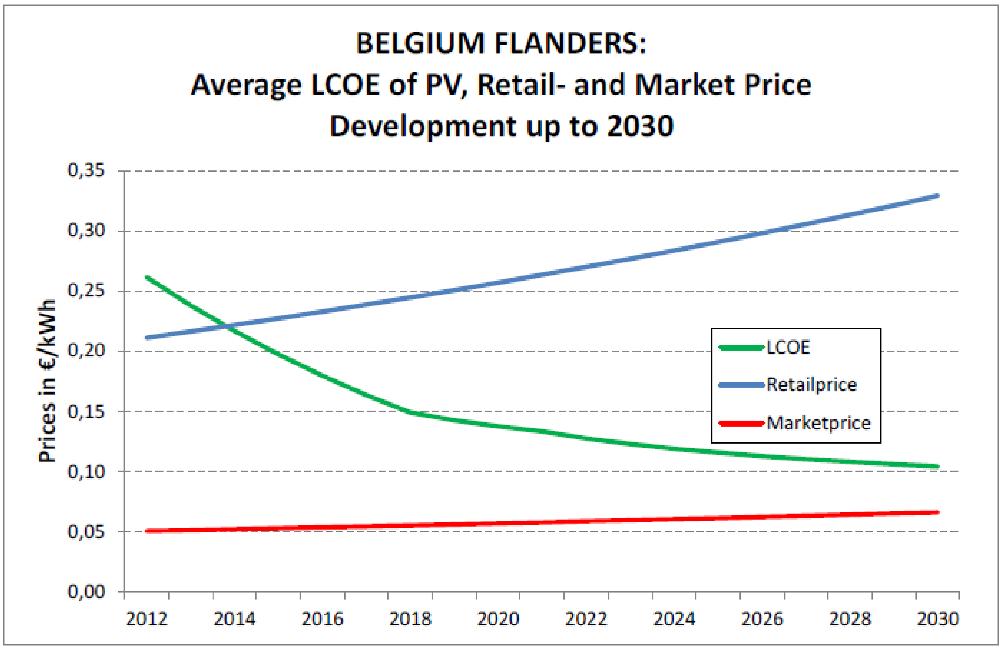


Figure 12: Grid-parity evolution for PV systems in Flanders, Belgium [30]

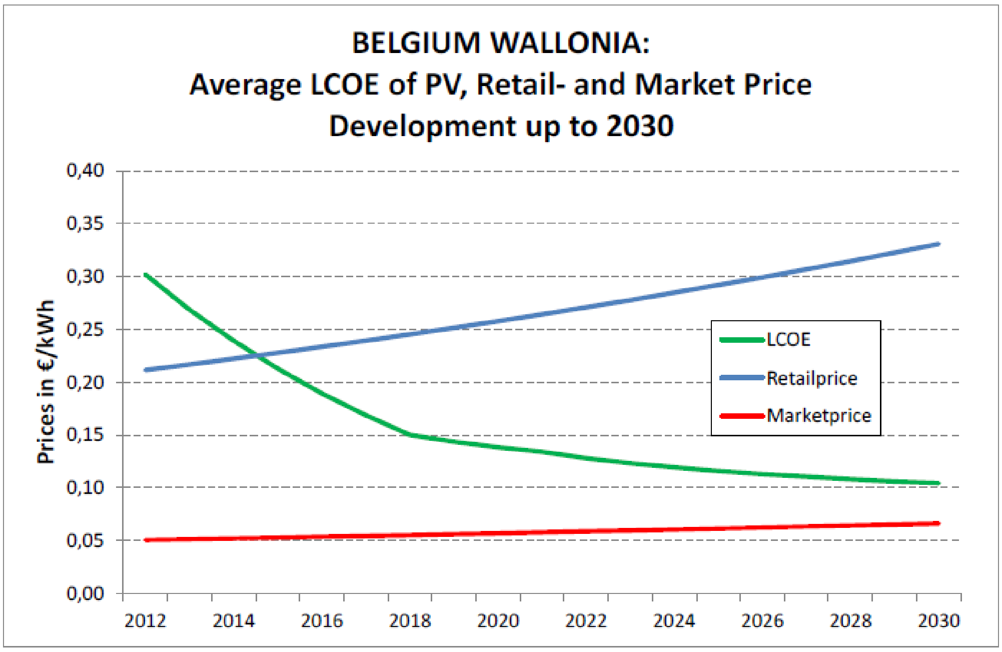


Figure 13: Grid-parity evolution for PV systems in Wallonia, Belgium [30]

4.4.2 Assessment of self-consumption opportunities in France

As shown in the figures below, currently situation in France highly depends on the system costs differences and the solar resource availability.

The average decreasing of the LCOE has been around 13% per year, between 2009 and 2014, for BAPV systems. In the other hand, grid electricity tariffs have annually increased 4,9% as average in the same period. Both trends have made possible the grid-parity in favorable locations and markets: in Paris, where the installed costs are high and the average irradiance has a moderate value, grid parity has not yet been achieved. Nevertheless, in Marseille, where both trends are contrary, grid parity has recently happened for standard and low coverage tariffs, although distance between LCOE and net electricity price is still small.

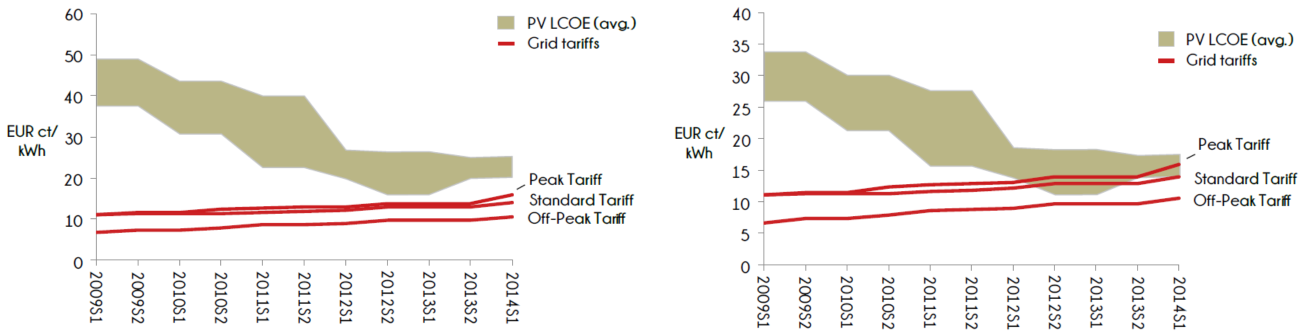


Figure 14: Grid-parity evolution for PV systems in Paris and Marseille (France) [26]

The current PV regulatory framework in France is summarized in:

- Self-consumption is allowed in France, but BIPV systems cannot compete with the retail price of electricity at the moment.
- Due to retail electricity price is lower than LCOE for BIPV systems, such projects adopt a model based on feed-in tariff instead of self-consumption. Thus, public supporting is still necessary if economic viability is intended.
- France has a Feed in Tariff (FiT) program for small PV systems which pays for the excess electricity fed into de the grid. These compensations are significantly higher for BIPV than for BAPV, in order to extend and boost the BIPV implementation. Although grid-parity has been already achieved for BAPV systems in locations such as Marseille, BIPV FiTs are still over the grid electricity price.
- In the other hand, there are also several benefits that can be applied to BIPV projects: tax credits of 11% to cover equipment, and reduced VAT of 10% to cover equipment and installations costs for systems below 3 kWp.
- Since it is expected that FiTs and other incentives will be reduced or eliminated in a short or mid-term, policy makers and market should adapt prices in order to gain competitiveness, particularly BoS costs.
- The sustained rise in the price of grid electricity price might facilitate the path to change.

As a conclusion:

- Debate on self-consumption regulation is currently on-going in France. A more suitable regulatory framework is imperative for the BIPV market boost. In this regard, remunerations for PV self-consumption systems through tailored incentives are being proposed.
- Additionally, a clear and favorable net-metering regulation would be needed, as well as a good estimation of the energy excess during the design phase, particularly for residential consumers.

4.4.3 Assessment of self-consumption opportunities in Spain

As shown in the figures below, grid-parity has been reached not only in the Canary Islands, with high irradiance ratios, but also in the whole continental territory.

The high PV LCOE decreased, as an annual average, around 5,5% in the last few years up to 2014. This, together with the increase of retail electricity price has favored the grid-parity happening until the end of 2012.

Nevertheless, this trend has reversed from 2013: evolution of energy price and changes in the distribution of the billed charges (power contracted charges, the fixed component, have been increased in comparison with energy consume charges, which have become cheaper) have resulted in a reduction of the retail electricity price and, consequently in the move away from the grid-parity convergence.

Since, economic viability of PV self-consumption systems is not possible in most cases, due to the “Sun tax” and other restrictions, and too risky in viable cases, because of the energy policy uncertainty and the lack of legal certainty in energy business, some measures are being implemented in order to free inject excess electricity to the grid, such as the use of PV inverters with power control, which reduces output power during overproduction periods.

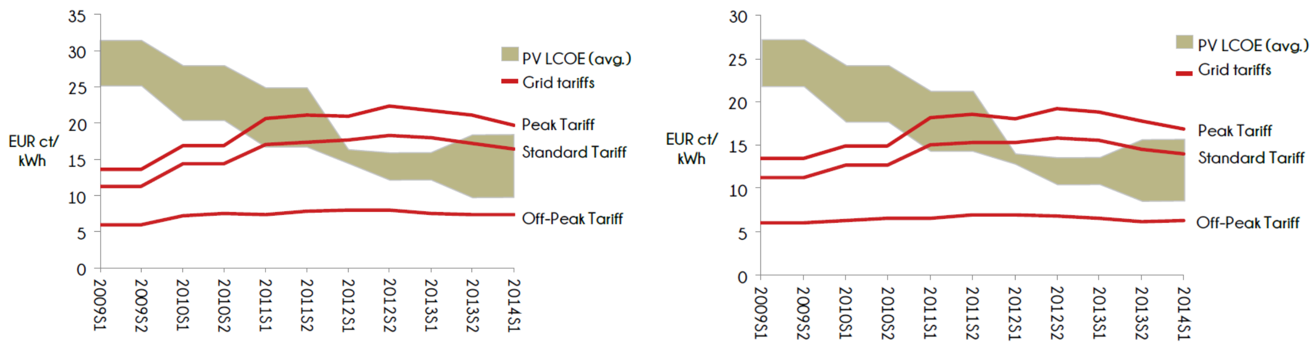


Figure 15: Grid-parity evolution for PV systems in Madrid and Las Palmas (Spain) [26]

The current Spanish regulation allows self-consumption systems, but severe mandatory measure boosted by Power Generation Companies (PGC) totally disincentive PV implementation by potential consumers and stakeholders. As explained before, legal conditions of the complicated Spanish regulatory framework are:

- PV self-consumption systems size cannot exceed the maximum power contracted.
- Regulations are different depending of the system size:

  Type 1: it is allowed for consumption systems up to 100 kW. Prosumers have saving on the electricity bill, but no compensation for excess PV electricity injected into the grid.

  Type 2: it is mandatory for consumption systems above 100 kW. Prosumers have saving on the electricity bill and excess PV electricity can be sold on the wholesale market directly or through an intermediary. Two taxes must be paid: a specific grid tax of 0.5 EUR/MWh and 7% tax on the electricity produced.
- An additional fee has been imposed, by the Spanish government, as a “grid backup toll” per energy unit (kWh) consumed for PV self-consumption systems above 10 kW. This new fee has generated great controversies between consumers, industrial sector and PV associations on one

side and the policy makers and power generation companies on the other, and is commonly so-called “Sun tax”.

- PV self-consumptions systems with battery storage have further an additional tax, if it is used for peak-shaving and the consumed peak power is greater than contracted power.
- Installation of two meters, at least, is mandatory to measure energy came from and injected to the grid, depending of the connection type. These energy meters and associated protections must be located the closest to the connection point, which could be unaffordable in the case of high power consumption installations. Furthermore, strict requirements are imposed by the Distributor System Operator (DSO) to stablish grid connection.
- There is neither a feed-in tariff nor a net-metering scheme for self-consumption installations on site. Excess energy only can be sold on the wholesale market, as mentioned above for systems larger than 100 kW.

As a conclusion:

- Self-consumption in Spain could be a more than viable reality in a short time if the regulatory framework be revised in its favour. High solar resource has led the grid-parity happening, but current legislation and energy policy impede the boosting of the PV sector and the extended implementation of BIPV system by consumers and companies.
- A just and objective net-metering scheme is absolutely necessary in the Spanish regulation to facilitate the amortisation of the investment, through the compensation of the excess electricity injected into the grid.

4.4.4 Assessment of self-consumption opportunities in Switzerland

Updated data or good previsions have not been found for Switzerland, but is expected that the trend be similar to the countries of its environment. We can consider in this regards that grid parity have been already achieved or is in progress, since some local policy measures are being already implemented in order to promote self-consumption.

The current situation of the Swiss regulatory framework is listed below:

- PV self-consumption systems are allowed in Switzerland for every kind of systems from 2014, while regulation is not stablished yet for multi-family housing.
- The excess generated energy is remunerated, regardless of the PV system size, through a FiT scheme in real time; being the selling price lower that the variable price of the DSO minus around 8%.
- This lower remuneration is partly compensated by the absence of charges to finance transport and distribution grid costs; in such a way, that only energy costs are remunerated. So far, every grid costs are charged on retail electricity price; thus, the DSO could pressure the government to include some taxes to the self-consumption system owner. Debate is ongoing regarding the grid costs financing, but no change has happen, up until now.
- A full net-metering scheme or FiT compensations higher than mentioned above have been chosen by some local governments.
- In the other hand, there are direct subsidies for systems up to 30 kWp, from FiT fund.

5 CONCLUSIONS

This document has mainly analysed the regulatory frameworks regarding standardization of BIPV products and possible business models, particularly self-consumption schemes, to be adopted for PV projects.

As a conclusion, some considerations and measures to overcome regulations barriers for BIPV products and systems and financial and regulatory barriers for self-consumers are provided.

5.1 Overcoming regulations barriers for BIPV products and systems

As a conclusion to the analysis of the standardization and implementation barriers, it follows that BIPV must satisfy both photovoltaic modules standards and requirements related to the functionality of PV products on building as any construction products.

At product scale, several standards from the IEC exist and are essential to obtain a suitable certification. BIPV as electrical components and construction products, are subject to electrical applicable requirements set out in the Low Voltage Directive 2006/95/EC and construction works requirements set out in European Constructions Products Regulation CPR 305/2011. BIPV are PV components that replace the look and function of a primary building material. Depending on the specific context, BIPV system has to satisfy basic requirements for building component such as mechanical resistance and stability, safety in case of fire, hygiene and health of people, safety and accessibility in use, protection against noise as well as energy economy and sustainable use of natural resources.

In the field of traditional products, evaluation process is linked to the satisfaction of the harmonized standards. This harmonized standard specifies the certification process, tests, rank in order to attest the performances of the products and their durability. Certain BIPV containing glass panes can access to the certification if they comply with harmonized products standards applicable to glass in construction. To obtain CE marking for a specific BIPV product, it is possible to create a European technical agreement (ETA) or elaborate a harmonized standard. For that, tests requirements which are not defined in existing BIPV standard have to be explained in order to cover all the performance characteristics required by regulations in any Member State. This part is detailed in deliverable D1.3 For BIPV modules CE marking facilitates market access and allows the free movement of products within Europe. It also allows the manufacturer to prove that his product comply with EU legislation and with EU safety, health or environmental requirements. Other certification processes or national agreement such an ATEC (Technical Assessment) in France can also allow to market PVSITE products in the country of use.

Others barriers can appear, at building scale. The product, with its specific functionalities and applications, have to respect technical and aesthetical requirements and should be cost effective to be competitive with the other existing products on the market.

As building element, BIPV should fulfil the requirement of the European Commission (EC) directives such as Energy Performance of Buildings Directive and more Energy Efficiency Directive. These directives promote the use of RES especially in new construction in order to obtain ‘Nearly Zero Energy Buildings (NZEB)’ by 2020 and almost carbon neutral building stock by 2050. Even if BIPV is not explicitly, encouraged by these directives, certain local authorities, such as Madrid’s AC in Spain or Greater Lyon in France enforce the use of RES in new buildings.

Even if some applications with their requirements are explicitly referenced in EN 50583, BIPV products must also obey the specific standards and specifications in the country of use. Depending on the country of origin, insurance applications, town planning rules (zoning regulation regarding colors, building shape…) or national building codes (fire, acoustic, thermal…) must also be met.

Finally, the difficulty of standardization for BIPV is that we should consider both BIPV modules characteristics (color, shape, size ...) and building integration with specific application, implementation and architectural result. To move towards standardization, PVSITES products have to be industrialized, which could run counter to a good architectural integration. Each construction project can have specificities and BIPV products need some flexibility to take into account these specificities. The full integration of PV demands a complex and tight interlocking of all stakeholders, including those responsible for products and product development, marketing, planners, developers, architects and installers. Such a holistic approach requires a multitude of building codes to meet with electro-technical codes in order to provide access to the electricity grid.

5.2 Overcoming financial and regulatory barriers for self-consumers

As a conclusion to the analysis of the financial and regulatory barriers, it follows that a suitable regulatory framework is needed to ensure the economic viability of BIPV projects.

Grid-parity happening ensures the PV systems competitiveness with the network electricity. The instantaneous coverage of 100% electricity demand would constitute the ideal case, particularly for residential sector. Nevertheless, this scenario does not correspond to a real case, because in order to get 100% of the instantaneous electricity demand PV system would be necessarily oversized. This measure would greatly increase the LCOE value, making it worse (more €/kWh); therefore, our PV system would move away from grid-parity. Other measures for increasing self-consumption ratio, for instance the Demand Management (DMS) or the use Electrical Vehicles (EV), could be implemented, but they have not been considered in this report.

In a real case not all the generated energy could be consumed in site, or not all the demand could be satisfied at real time. It is possible that total annual production would be cover, and even excess, the total electricity demand; but matching instantaneously the demand profile of the consumer would be highly unlikely. In this regards, certain mechanisms to enable the electricity consumption from the grid during periods of high demand or low generation, and the excess electricity injection to the grid during periods of low demand or high generation, become indispensable.

Different measures are being proposed and applied in order to resolve this issue, according to the main needs of a potential self-consumer:

- To have chances of getting compensation for the excess electricity injected to the grid.
- To have access to grid electricity at reasonable prices, when necessary.
- To fulfill reasonable grid connection requirements, in technical and economic terms.
- To be free of taxes and fees not justifiable or unrelated to a private activity.

These measures basically should consist of promoting fair, equitable and consistent regulations and policies according with the interests of consumers, PV industrial sector and PGCs involved, and on compliance with environmental protection targets:

- Policy-makers must promote, facilitate and reduce soft costs in order to decrease BoS costs and, consequently, PV LCOE. Promoting low installation prices, facilitating customer acquisition and reducing administrative barriers and permitting cost are some of the favorable policies which might be implemented. This measures, jointly with the gradual lowering of PV modules and the electricity tariffs rising, would help to the grid-parity happening.
- National and local governments should also promote regulatory mechanisms for self-consumers to receive some compensation for the excess electricity fed into the grid. In this regards, “selling” mechanisms, such as net-billing and net-metering, should be preferable opposed to “supporting”

mechanisms, such as FiT. The more self-sufficient are PV systems and less dependent on public assistance, the more economically viable and competitive will be against retail electricity prices.

- Compensation schemes, net-billing and net-metering, clearly are the most suitable strategies oriented at a global energy distribution model, through the expansion of the self-consumption concept. They can be articulated in two different ways: monetary compensation, by means of a net-billing scheme, and energy compensation under a net-metering scheme. Both of them can be effective, although periods of validity of the monetary or energy credits given to the PV producer must be enough long to be remunerated without any problem (at least, one year).
- The main factors which might hamper the above mentioned compensation mechanisms are the commercial interests of the Power Generation Companies (PGCs) and the technical, administrative and economic conditions required by the Distribution System Operators (DSOs). In some extreme cases, such as the Spanish one, these factors can reverse the current and natural trend to a grid-parity scenario, needed for the extensive and definitive implementation of BIPV systems for residential and other sectors.
- National, regional and local policy authorities also should take into account possible differences between the economic viability of the same PV system placed in different location under a common BIPV regulatory framework. The variety of solar resource, installing costs, retail electricity price, local requirements and fees, etc. can generate a wide range of cases with different results related to the grid-parity proximity. A responsible policy and regulation must be consider this circumstance, and create plans aimed to balance self-consumption opportunities for potential consumers by means of regional or local regulation to compensate or reduce such differences.

As a conclusion: both challenges, the grid-parity achievement and the adaptation of the regulatory framework, are essential in order to boost self-consumption for residential and other sectors. The transition towards a more sustainable global and local energy model, based on the distributed energy generation and in-site consumption is mandatory for the compliance of the environmental objectives of this century. Self-consumption, promoted by important market and policy changes and the involvement of all the actors participating, is the key factor to achieve these targets.

5.3 General considerations

A more detailed and specific assessment of all the subjects treated in the Task 1.2, particularizing for PVSITES technologies and developments, will be carried out in the next tasks included in the WP1.

General bases for the standardization of products and possible barriers have been established in this deliverable. Some measures needed to facilitate the standardization of BIPV products have been pointed out. Task 1.3 will go deeper into these topics.

Grid-parity situation and current regulatory framework, concerning different modalities of financing, supporting and self-consumption business models for PV systems, have been provided and assessed. This information will be useful for choosing the more suitable business model in the cases studied. Specific solutions for PVSITES demo-systems will be suggested in the Task 1.6. In addition, some progress needed for boosting self-consumption through a more favourable regulation have been pointed out.

The identification of the exploitable results and the assessment of the marketing opportunities of the PVSITES innovative products will be evaluated in Tasks 1.4 and Task 1.7, based on the features of the developed technologies and items and results extracted from the previous task, among which is the “Task 1.2.Regulatory Framework”.

6 REFERENCES

[1] Construction Products Regulation, Regulation (EU) No 305/2011 of the European parliament and the council of 9 March 2011, Official Journal of the European Union, available at

http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011R0305&from=EN

[2] Directive 2006/95/EC of the European parliament and the council of 12 December 2006, Official Journal of the European Union,

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:374:0010:0019:EN:PDF

[3] European commission website:

http://ec.europa.eu

[4] Official Journal of the European Union (OJEU),

http://eur-lex.europa.eu/oj/direct-access.html

[5] European Organisation for Technical Assessment (EOTA) website:

http://www.eota.eu/

[6] "CE marking of construction product, step by step", European Commission:

http://ec.europa.eu/growth/tools-databases/newsroom/cf/itemdetail.cfm?item_id=8419&lang=es

[7] Deliverable D2.2 "EU regulations and legislation for PV construction components. ETFE particularities", ETFE –MFM project, December 2013:

http://www.etfe-mfm.eu/

[8] Tobe Nwaogu (Project Manager),Sophie Upson ,Scott Marshall, Yvette Le Crom ,Henk Vermande, "Analysis of the implementation Construction Products Regulation", Luxembourg: Publications Office of the European Union, 2015:

http://ec.europa.eu/ipg/basics/management/day_to_day/opoce/index_en.htm

[9] International Standards and Conformity Assessment for all electrical, electronic and related technologies,

http://www.iec.ch/dyn/www/f?p=103:22:0::::FSP_ORG_ID,FSP_LANG_ID:1276,25

[10] Regulation (EC) No 764/2008 of the European parliament and the council of 9 July 2008, Official Journal of the European Union, available at

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:218:0021:0029:en:PDF

[11] Deman, J., Civil Engineering. Master Dissertation, "Technical control of building projects in the EU", Instituto Superior Técnico Lisboa Portugal:

https://fenix.tecnico.ulisboa.pt/downloadFile/395145628798/Extended%20abstract%20Jonas.pdf

[12] Thomas De Decker, "Building Control Systems and Technical Control Activities in Belgium, Germany and The United Kingdom", Dissertation to obtain the Master Science Degree in Civil Engineering, July 2013.

https://fenix.tecnico.ulisboa.pt/downloadFile/395145789552/Dissertation_DeDecker.pdf

[13] Solar Power Europe, 2015:

http://www.solarpowereurope.org/home/

[14] CEIAB, 2013:

http://www.ceiab-pv.fr/servlet/KBaseShow?sort=-1&cid=24035&m=3&catid=24595

[15] Actu-environnement website, 2016:

http://www.actu-environnement.com/ae/news/deliberation-CRE-tarifs-achat-photovoltaique-second-trimestre-2016-26698.php4

[16] Developpement durable, 2016:

http://www.developpement-durable.gouv.fr/Quels-sont-les-tarifs-d-achats.html

[17] Les énergies renouvelables, 2016:
http://www.les-energies-renouvelables.eu/conseils/photovoltaique/credit-dimpot-aides-financieres-projet-installation-photovoltaique/

[18] Actu-environnement, 2016:

http://www.actu-environnement.com/ae/news/cahier-charges-appel-offres-autoconsommation-26830.php4

[19] Setis, 2016:

https://setis.ec.europa.eu/sites/default/files/reports/Perspectives%20on%20future%20large-scale%20manufacturing%20of%20PV%20in%20Europe.pdf

[20] IEA, 2014, "National Survey Report of PV Power Applications in Spain 2014":

http://www.iea-pvps.org/index.php?id=93&no_cache=1&tx_damfrontend_pi1%5BshowUid%5D=740&tx_damfrontend_pi1%5BbackPid%5D=93

[21] SEIA, 2016:

http://www.seia.org/policy/distributed-solar/net-metering

[22] PV Magazine, 2016:

http://www.pv-magazine.com/services/solar-incentives-and-fits/feed-in-tariffs-for-various-countries/#spain#ixzz490AnDz00

[23] Ministère de l'Environnement, de l'Énergie et de la Mer:

http://www.developpement-durable.gouv.fr/Quels-sont-les-tarifs-d-achats.html

[24] "Renewable Power Generation Cots in 2014". IRENA, International Renewable Energy Agency:

http://www.irena.org/documentdownloads/publications/irena_re_power_costs_2014_report.pdf

[26] "CREARA PV Grid-Parity Monitor in the Residential, Commercial and Utility Sectors". 2015:

http://www.leonardo-energy.org/sites/leonardo-energy/files/documents-and-links/pv_grid_parity_monitor_-_residential_sector_-_issue_3.pdf

[27] "Pulse, March 2016". GTM Research PV:

https://www.greentechmedia.com/research/report/pv-pulse

[28] "Review and analysis of PV self-consumption policies. T1-28:2016". International Energy Agency (IEA)

http://iea-pvps.org/index.php?id=353

[29] "Executive Summary of the Interview Report on PV Financing Schemes". PVFINANCING Project, European Union's Horizon 2020 research and innovation.

http://www.pv-financing.eu/wp-content/uploads/2015/12/D3.4_Interview_Report_on_Financing_Schemes_Executive-Summary.pdf

[30] "Realistic roadmap to PV grid parity for all target countries". PVPARITY.

http://www.pvparity.eu/results/pv-competitiveness/

[31] Solar Server. Global solar industry website.

http://www.solarserver.com/service/pvx-spot-market-price-index-solar-pv-modules.html

[32] Eurostat Statistics, 2016.

http://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_price_statistics#Further_Eurostat_information