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BIPV market and stakeholder analysis and needs

Project report

R2M, Onyx Solar, Flisom, BEAR-iD, Acciona

October 2016

Summary

This document is associated to the task "T1.1: Market and stakeholder analysis and needs" within "WP1: Business case definition" of the PVSITES project.

It presents a market and stakeholder analysis of the BIPV and related technologies within the scope of the PVSITES project.

In chapter 2, a top down analysis of the BIPV market is presented, starting from the global situation, then on the European market and finally a focus on the target countries. Chapter 3 illustrates the BIPV market segmentation, synergies among technologies and constructive elements, and key market drivers and challenges. Finally, chapter 4 conducts a stakeholder analysis divided in primary and secondary stakeholders according to the power and interest in the BIPV technology.

Acknowledgements

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The present report was prepared by PVSITES project partner R2M, with additional contributions from Onyx Solar, Flisom, BEAR-iD and Acciona. The report was originally submitted to the European Commission as Project Deliverable D1.1 in October 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

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1 EXECUTIVE SUMMARY

1.1 Description of the deliverable content and purpose

Building-integrated Photovoltaics (BIPV) is an expanding market supported by many factors including the increasingly demanding legislation related to building energy performance, especially within the European Union and the increased sustainability mindset of companies and citizens. However, there are also barriers and limitations that have caused the BIPV forecasted growth to be overestimates. These include strict requirements in terms of design flexibility, aesthetics, durability, cost, performances, grid integration, compliance with standards and operation & maintenance.

This deliverable provides a characterisation of the current BIPV markets and trends as well as expectations and challenges from key stakeholders. The current report aims to characterise the market status, trends, drivers and barriers as well as stakeholder needs and influence. It starts from the global figures of BIPV, analyses the EU in greater detail and finally focuses on the 4 target countries. This document also analyses the market and stakeholders involved in BIPV related industries and solutions. This process will support the refinement of strategic R&D direction, taking into account market conditions, competitors and expected trends. Additionally, this information ensures the delivery of values and pain relievers needed by the relevant actors. It elucidates their roles, desired pain relievers and expected benefits. This critical information will also be vital when defining exploitation and commercialisation strategies for the developed solutions. To support the information gathered during the work, a stakeholder survey was developed within the consortium and distributed at ad hoc events such as EUPVSEC, IEA PVPS Task 15 on BIPV and others. Detailed information regarding the questionnaire can be found in annex A. The answers were used in different sections of the document to, e.g., assess drivers and barriers, market sector relevance or stakeholder wishes.

1.2 Relation with other activities in the project

The market and stakeholder analysis is part of WP1 (Business case definition) and specifically of T1.1 (Market and stakeholders analysis and needs). Although T1.1 ends with this deliverable, the information contained in it with be used throughout the project and periodically updated with new data, projections and events. The information summarized in this document is fundamental for the refinement of the overall aims and specific R&D technical objectives (WP3-7). This will ensure readiness of market entry while at the same time advising on the development routes to increase the strengths and limiting the weaknesses. Table 1.1 depicts the main links of this deliverable to other activities (work packages, tasks, deliverables, etc.) within the PVSITES project. The table should be considered along with the current document for further understanding the deliverable contents and purpose.

Table 1.1 Relation between current deliverable and other activities in the project

Project activity	Relation with current deliverable
WP1 (T1.5, T1.6, T1.7, T1.8)	This deliverable sets the basis over which these tasks are going to be built. In particular, understanding the current market situation helps to develop the business models (T1.6) and identifying the risks for potential investments
WP3-7	This document provides a specific analysis of the market drivers and trends that are being taken into account for products design and developing.
WP8	This deliverable specifies the BIPV framework (Market and Actors) which increase the knowledge about the PVSites project demo-sites for the implementation activities.

1.3 Abbreviation list

- **a-Si:** Amorphus-Silicon
- **BAPV:** Building Attached Photovoltaics
- **BIPV:** Building Integrated Photovoltaics
- **CdTe:** Cadmium telluride
- **CIGS:** Copper indium gallium selenide
- **c-Si:** crystalline Silicon
- **CSR:** Corporative Social Responsibility
- **ENISA:** Spanish National Innovation Company
- **EPBD:** Energy Performance of Building directive
- **EPFL:** École polytechnique fédérale de Lausanne
- **ETHZ:** Swiss Federal Institute of Technology in Zurich
- **FiT:** Feed in Tariff
- **GBC:** Green Building Council
- **GDP:** Gross Domestic Product
- **GW:** Gigawatts
- **HSLU:** Lucerne University of Applied Sciences and Arts
- **m-Si:** Mono crystalline silicon
- **NZEB:** Near zero energy buildings
- **OPV:** Organic Photovoltaic
- **PV:** Photovoltaics
- **PVSITES:** (Project) Building-integrated photovoltaic technologies and systems for large-scale market deployment.
- **ROI:** Return On Investment
- **SUPSI:** University of Applied Sciences and Arts of Italian Switzerland
- **WAPV:** Wall Attached PV
- **ZHAW:** Zurich University of Applied Sciences

2 BIPV MARKET ASSESSMENT

2.1 Global market sizes and trends

For several decades, building integrated photovoltaics (BIPVs) have experienced a considerable growth. But this technology, which transforms a building's envelope into a solar power plant, has remained a niche market since its development in the late 1970s. Spurred by the decrease in PV installed price, a 50% reduction in the last 10 years as shown in Figure 2.1, global PV installations have risen by a factor of ten [1][2]. However, of the approximate 200 gigawatts (GW) of PV worldwide installed capacity, BIPV accounts for only about 5 GW (Figure 2.2). This situation is expected to change in the future.

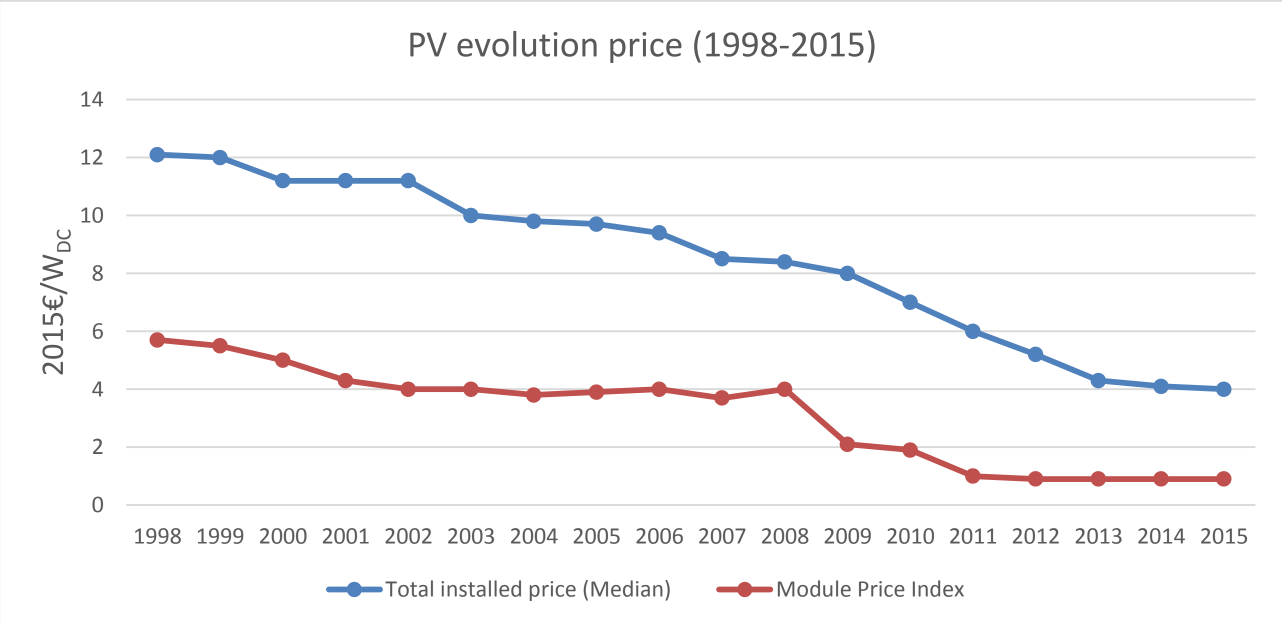


Figure 2.1 PV price evolution [3]

The requirement for BIPV, which replaces and upgrades standard exterior building elements with new ones incorporating photovoltaics, seems poised to take off. Reports, such as a 2015 report by Technavio [4], predict that global BIPV sales will triple by 2019. **growing at a Compound Annual Growth Rate (CAGR) of 18.7% from 2013 to 2019.** The most important factor driving this growth is a trend toward "truly integrated PV materials" include BIPV shingles and tiles that can be substituted for conventional roofing products and have built-in electrical connections. Currently the BIPV market holds a market share of around 2% of the overall PV market. The "BIPV Technologies and Markets: 2015-2022" report from n-tech Research [5] forecasts there will be about 13% BIPV penetration by 2022. Figure 2.2 shows the current and forecasted BIPV penetration within the PV market for the period 2014-2021.

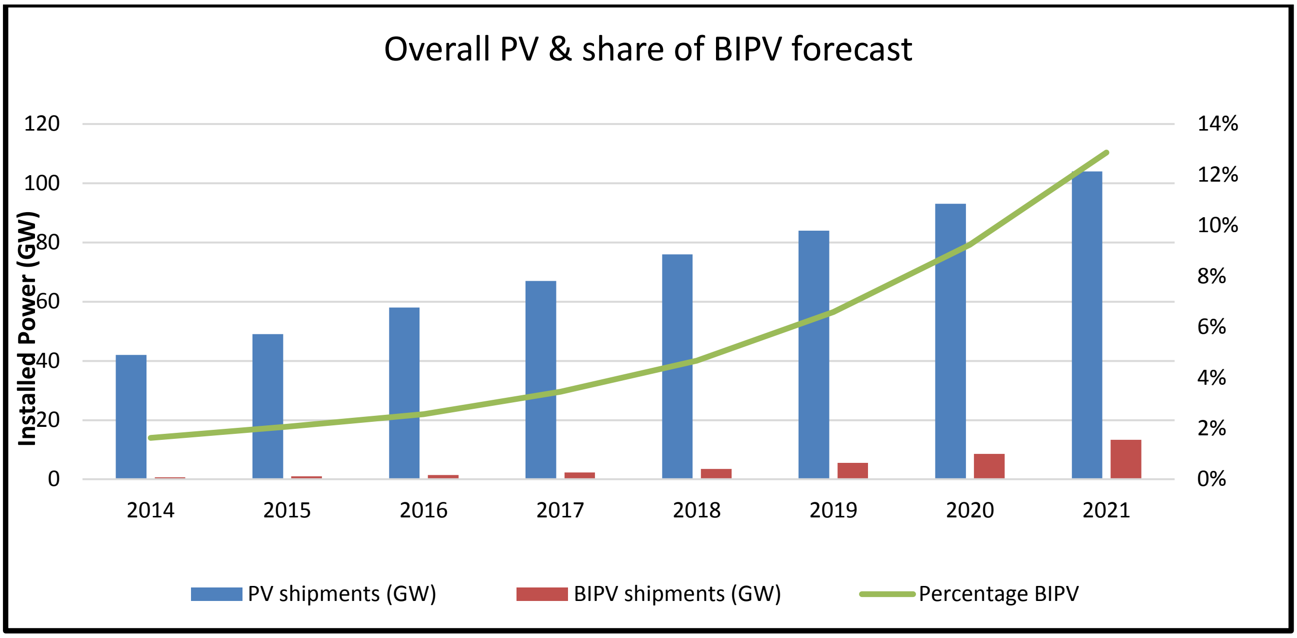


Figure 2.2 Overall PV & BIPV forecast [5]

The BIPV market share by region is shown in Figure 2.3. The most evolved BIPV market regions are Europe and the USA which combined currently account for around 70% of the worldwide market share. Investments in the following years are expected to exponentially grow in these regions. For other regions like China and Japan the increase of investments will be slower but they will still represent attractive markets.

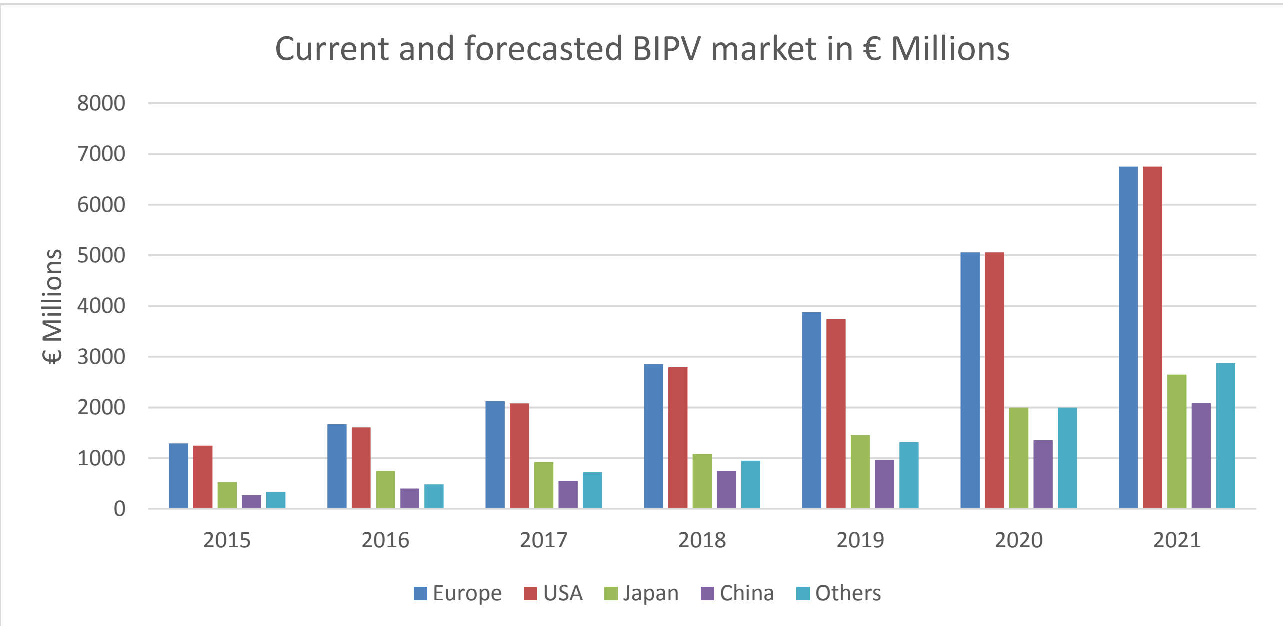


Figure 2.3 Current and forecasted BIPV market by region in € million [6] [5]

As we will explain later, there are 3 main applications for BIPV: roofing, walling and glass. In Figure 2.4 the BIPV roofing market is shown. For 2020, around 3.5B€ will be invested in BIPV roofing solutions in each Europe and USA, with a total worldwide BIPV annual investment exceeding 10B€. This is mainly due to favorable regulatory and incentive schemes that can be found in these regions.

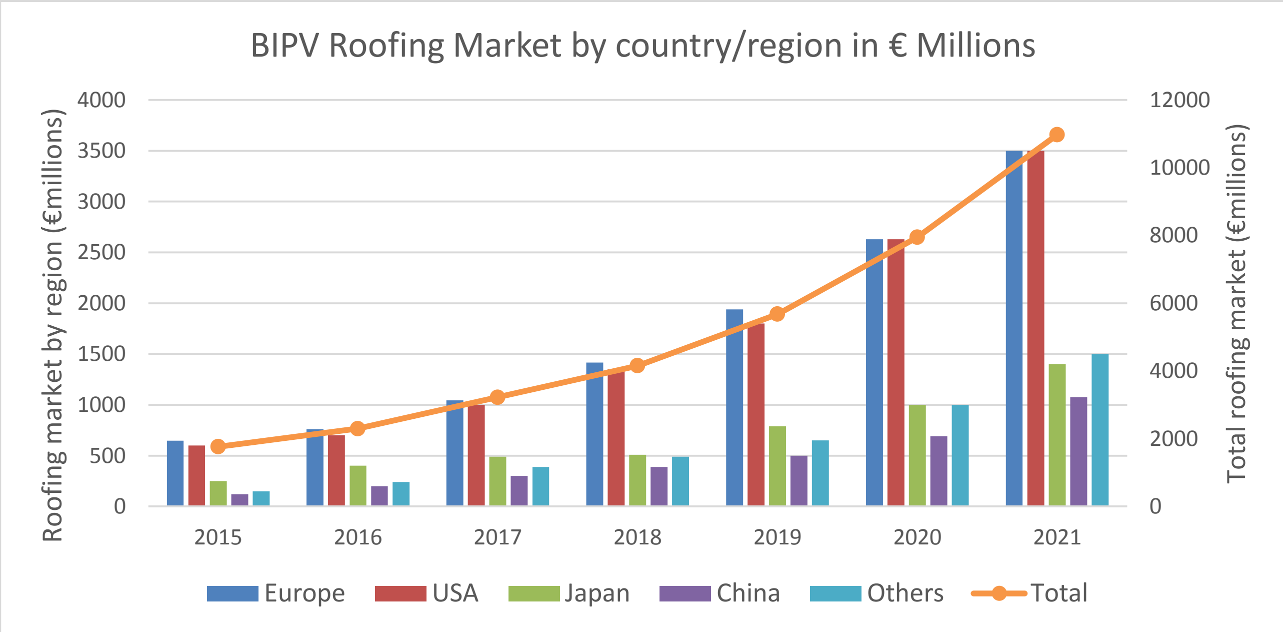


Figure 2.4 BIPV roofing market by country/region in € millions [6]

According to the n-teach market report *BIPV glass markets: 2015-2022* [7], the total worldwide demand for BIPV glass will increase from €1B in 2015 to €6.3B in 2022 (Figure 2.5). Europe will still be the largest market and will remain so through most of the forecast period 2015-2021. This is due to European enthusiasm for sustainable architecture, costly electricity and a preponderance of prestige buildings upon which BIPV glass still relies.

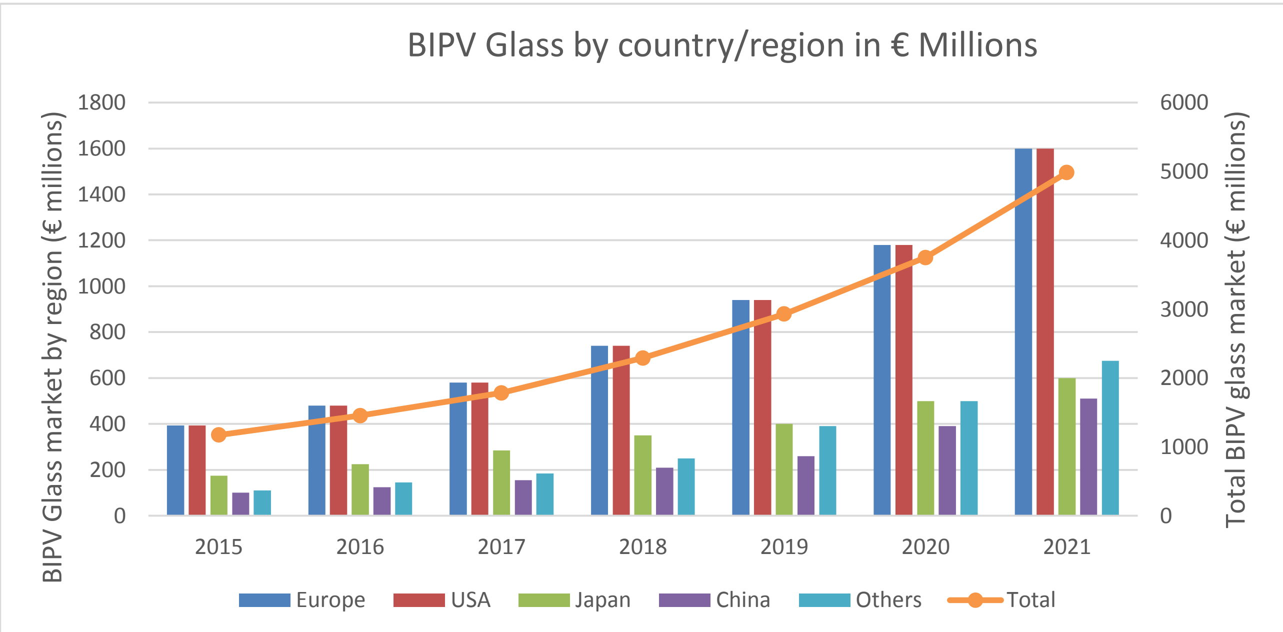


Figure 2.5. BIPV Glass market by Country/Region in € Millions [6]

Figure 2.6 shows the current and future figures of the BIPV walling market by regions. In agreement with the other BIPV markets, Europe and the USA are and will be the regions leading the market.

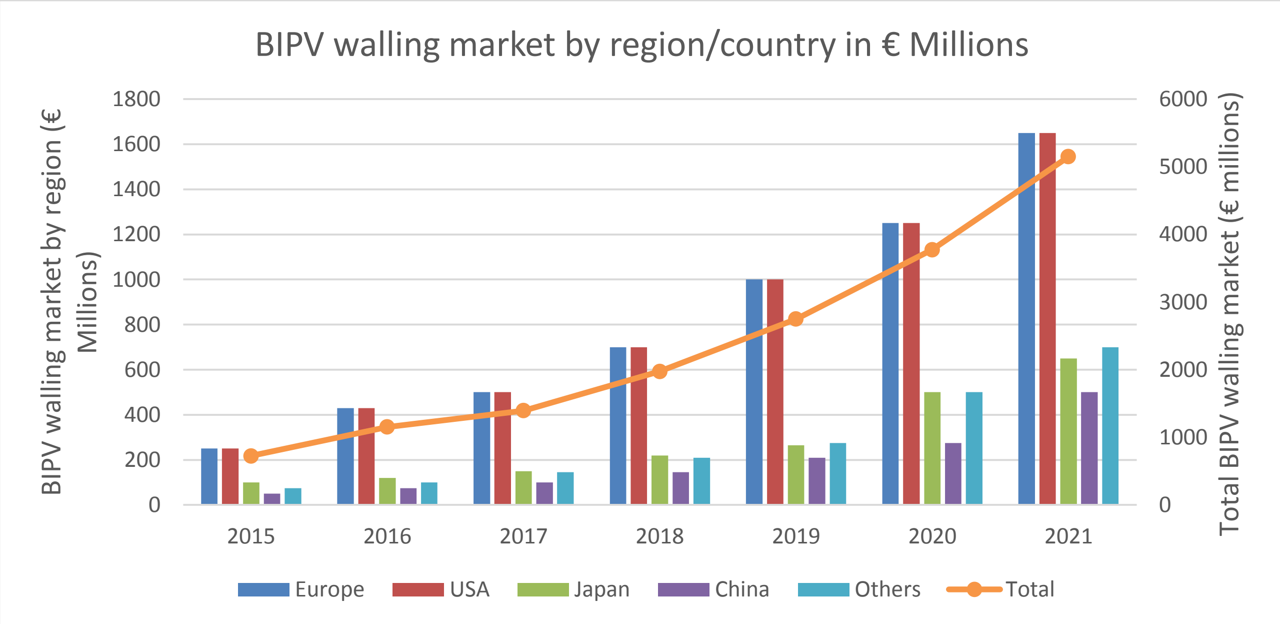


Figure 2.6 BIPV Walling market by region [6]

2.2 European Market Analysis

Annual cumulated European installed capacity of BIPV is projected to exceed 11 GW by 2020, driven by the increasing focus on renewable energy and the green building movement in the construction sector. Europe represents the leading worldwide market region. Adoption of BIPV systems in the region is benefiting from the greater customer willingness to adopt green practices as a result of voluntary environmental stewardship, incentives and stringent building energy efficiency regulations. Figure 2.7 shows the European BIPV market forecast [5]. Exponential growth is expected for the following years; this predicted growth is much more conservative in comparison to previous reports that overestimated the value of the BIPV market, A series of primary demands from the stakeholders which have not been properly addressed by the BIPV value chain are the main cause for this deviation. These key requirements are mainly related to the flexibility in design and aesthetics considerations, lack of tools integrating PV and building performance, demonstration of long-term reliability of the technology, compliance with legal regulations, smart interaction with the grid and, of course, cost effectiveness. In Europe, as in the rest of the world, the BIPV non-glass roofing applications have the largest share (around 50%) of the market and this trend is expected to continue.

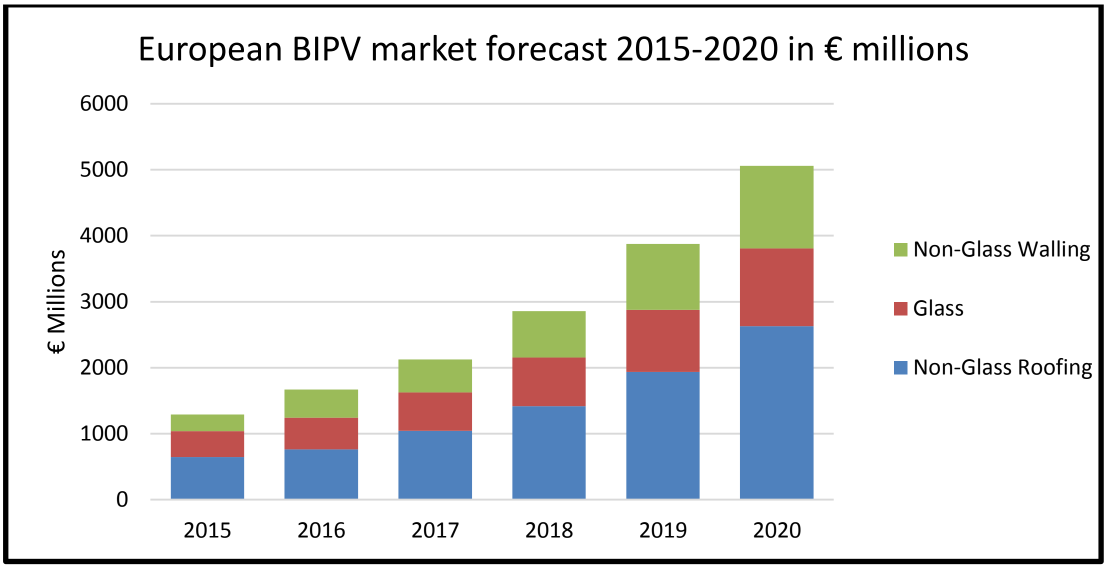


Figure 2.7 European BIPV market forecast 2015-2020 annually about 1,400TWh

In order to have a major impact in the future development of buildings in Europe it is essential to put in place favourable conditions across Europe that will support a wide deployment of BIPV applications. From 2012 onwards, all Member States adopted the recently approved Energy Performance of Building Directive (EPBD) establishing that by 2020, all new building will need to be Nearly Zero Energy Buildings, therefore producing most of their energy needs on-site or nearby. Solar photovoltaics will be a key technology enabling such an ambitious and crucial objective to be reached. In addition, in the few countries proposing explicit support for BIPV, this support can be sometimes quite generous, especially at a time when support for Building Adapted PV (BAPV) systems is rapidly being phased out. In countries such as France, Switzerland and Austria, and in smaller markets such as Lithuania and Croatia, higher feed-in tariffs (FITs) for BIPV systems are currently available and were established with the specific goal of promoting structural integration of PV systems in the built environment. Some other examples are shown in Table 2.1; investment grants or tax credits are often available in addition to the FiTs.

Table 2.1 Various support schemes overview targeting BIPV in European countries

Country	Type of Support
Austria	Investment Subsidy
Czech Republic	Investment Subsidy
Denmark	Investment Subsidy
France	FiT and Investment Subsidy
Italy	Investment Subsidy
Slovenia	Investment Subsidy
Spain	Investment Subsidy
Switzerland	FiT

In France for example, guaranteed FITs are today the main support measure for the development of PV. The tariffs are revised quarterly and guaranteed for a period of 20 years. Back in early 2013, the pricing schedule was simplified by reducing the number of tariff categories from 5 to 3. In addition, a tariff bonus of either 5 % or 10 % was applied, if the installed PV modules were manufactured in the European Economic Area. While tax credit was suppressed by the end of 2013, the tariff bonus was not cancelled until March 2014

For BIPV systems up to 9 kW, the tariff decreased by 7,9 % and in the last quarter of 2014 reached 0,291 EUR/kWh and now stands at 0,2655 EUR/Kwh, while all other technologies in this range only receive 0.06 EUR/kWh. Tariffs for simplified building-integrated systems up to 100 kW, suffered a 20 % reduction and now stand at 0,130 EUR/kWh.

Recent trends in the construction sector clearly show the development of the BIPVs and their steady growth within the building envelop market in Western Europe. Large building surfaces, up to 1611 million m^2 annually of both rooftops and facades in industrial and residential buildings, remain available for solar electricity generation. This significant number defines the upper limit of the European building envelop market suitable for BIPV. In this analysis both retrofitted or newly built surfaces are taken into account, and only a small portion of them is currently used for PV installations. The largest sub-market of these is the roof surfaces sector and that was estimated on an annual basis to be at 1080 million m^2 in 2014 (Figure 2.8). Of these, the main roofing typologies are tile (41%) and bituminous (29%).

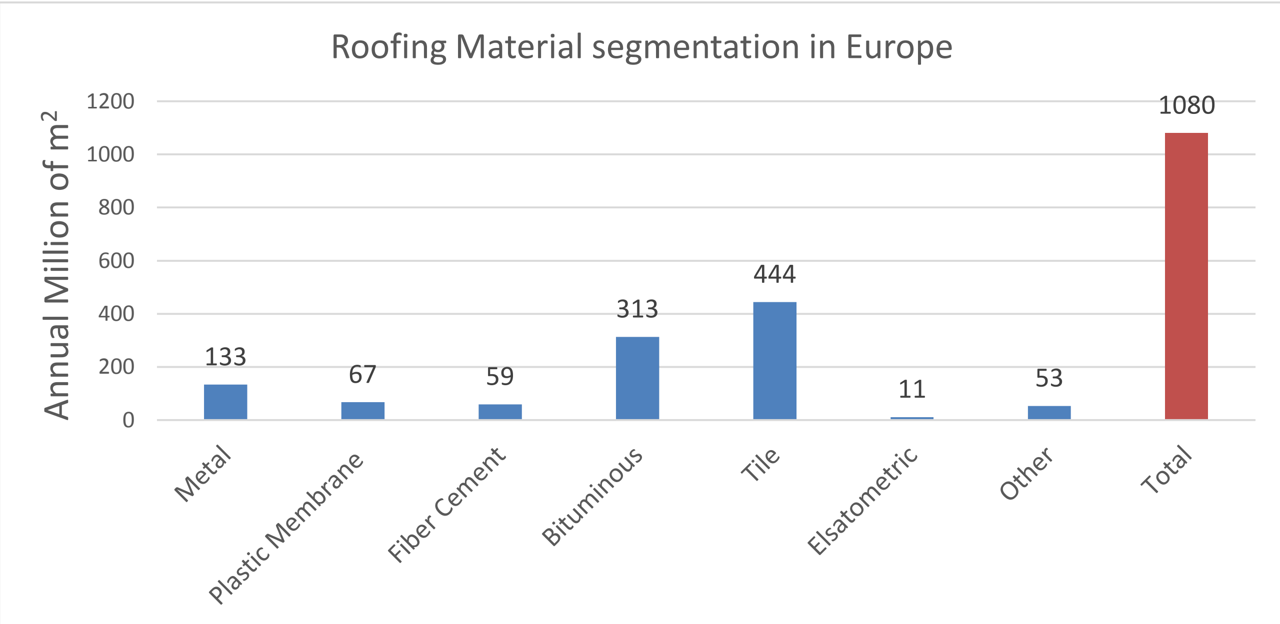


Figure 2.8 Overview of roofing material segmentation in Europe in 2014 [8]

All the main current conventional roofing segments (metal roofing, plastic membrane roofing, bituminous roofing and tile roofing) could potentially be replaced by BIPV solutions, especially in all those cases in which BAPVs are afterwards installed. BIPV roofing solutions would increase the deployment of photovoltaics and simplify the PV installation process, guaranteeing benefits both in terms of reduction of construction costs and energy savings.

The annual cladding/facade market in Europe in 2014 was estimated at 531 Million m^2 (Figure 2.9). However, BIPV development in this market segment faces more constraints and limits. BIPV cladding solutions are currently less competitive than the conventional ones in terms of aesthetic attraction, prices, energy production and efficiency.

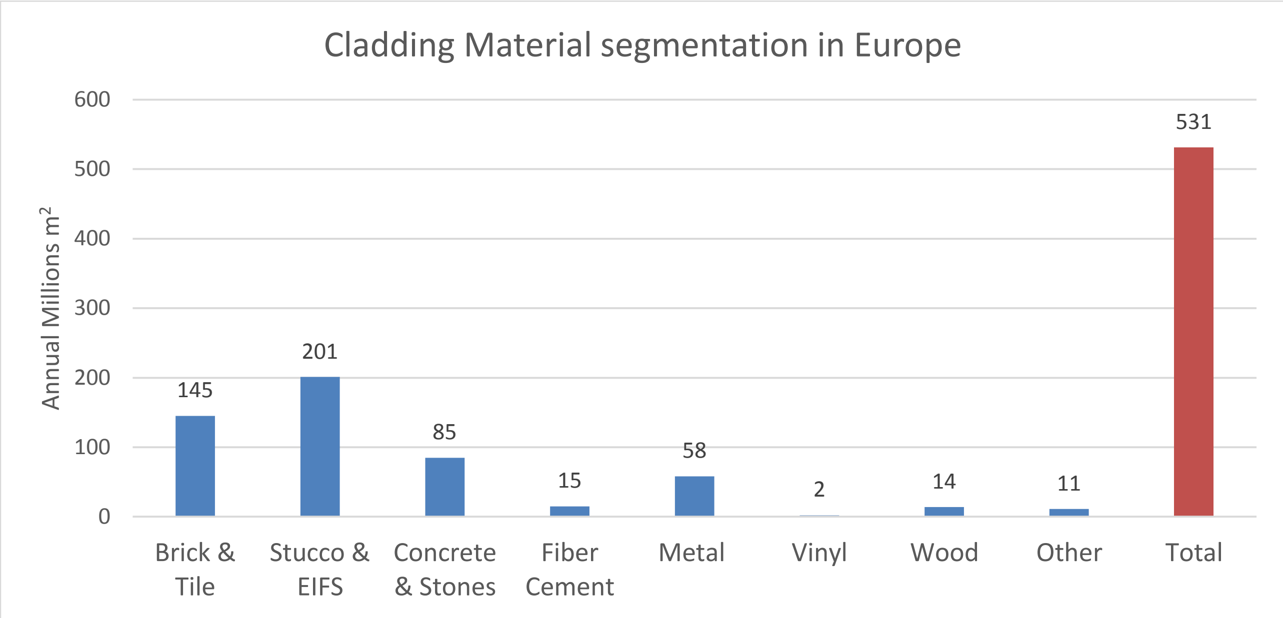


Figure 2.9 Overview of cladding material segmentation in Europe in 2014 [9]

BIPV Price in Europe

The BIPV Status Report 2015 by SUPSI-SEAC [10] developed a price analysis of roofing and façade materials in which the costs (€/m²) are separated into conventional materials and PV systems (both BAPV as well as three types of BIPV product groups). Figure 2.10 shows a significant price range for the different conventional roofing materials. The cheaper solution, with a price around 45€/m^2, are the concrete tiles. More expensive solutions like slates or thatch roofing oscillate between 90€ and 130€/m^2.The PV products were all priced roughly 200 €/m^2 higher than the conventional roofing materials. The BAPV system price varied between 225 and 250 €/m² higher. For the in-roof mounting system the price varies between 350 €/m² and almost 400 €/m². For the BIPV tiles the price varied between 375 and 475 €/m². For the 'full roof solution' category, the price ranged from 250 €/m² to almost 475 €/m².

Figure 2.11 displays the price survey (€/m²) for façades, comparing conventional façade systems with some BIPV solutions. Conventional façade technologies include fibrocement, brick-ceramic, metal, stone, wood, window and curtain walls. Prices range all the way from 30-50 €/m^2 for a low cost fibre-cement façade (similar to a traditional plaster) to 1.100 €/m^2 for a special curtain wall (e.g. self-lighted, interactive façade, etc.). The price of the systems varied from 130 €/m^2 for a thin film PV cold façade (with a really simple sub-structures and a low efficiency solar technology) to 750 €/m^2 for a high end PV solar shading system. This indicates the following important conclusion: for façades a very interesting price point has been obtained, as BIPV systems are comparable in price with conventional façade materials. Low cost BIPV façade strengthens the promise of BIPV because these applications are cost-wise suitable as a substitute for the conventional façade solutions. [10]

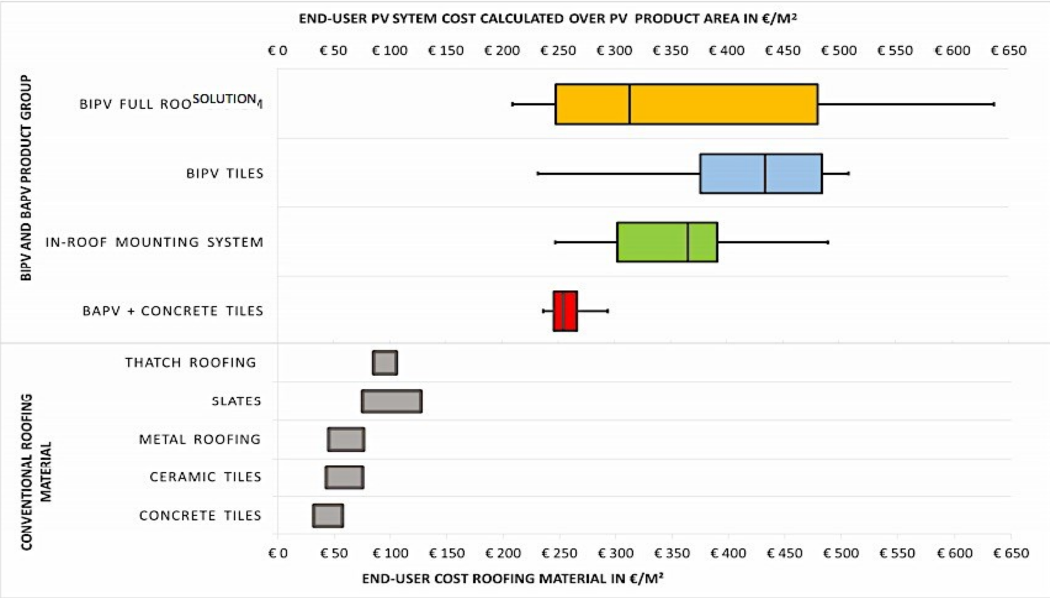


Figure 2.10 A benchmark of the conducted price survey, comparing conventional roofing materials with BAPV and BIPV roofing solutions. The price is defined as the end-user price and measured in €/m². [11]

The pricing analysis shows good potential for BIPV applications. Clearly, BIPV products are higher priced than the conventional products but this price increase is offset by the revenues/savings from electricity generated on site. In cases of partial installations, BIPV products are generally more expensive (by approximately 200 €/m^2) than conventional roof products.

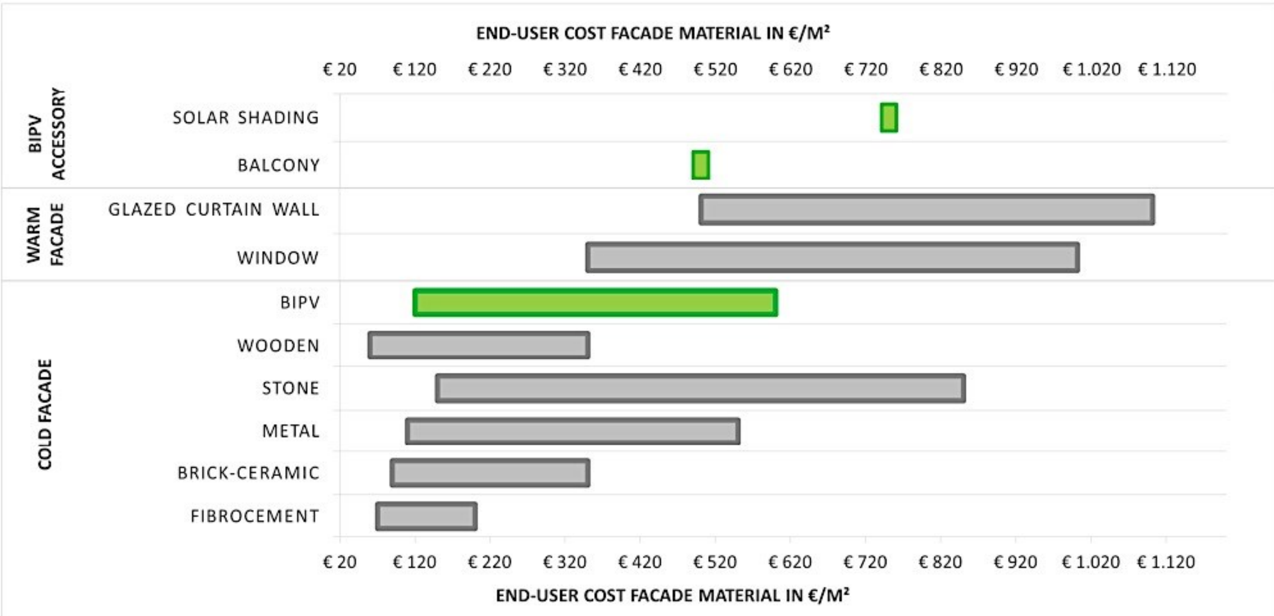


Figure 2.11 A benchmark of the conducted price survey, comparing conventional façade materials with BIPV façade solutions. the price is defined as the end-user price and measured in €/m² [11]

BIPV market and pricing policies are being defined in order to face the competition of conventional materials. This is the case for BIPV facades which already have prices that are very similar to conventional facade materials. Future trends will be presumably characterized by the possibility of getting PV systems free of charge by choosing BIPV products instead of the conventional ones at a similar price

2.3 Targeted Countries Market Analysis

Within the PVSITES project, buildings located in Spain, France, Switzerland and Belgium are going to be used for demonstration activities; additionally, a greater presence of partners and a desire for exploitation/commercialization is typically present in these countries. For these reasons, this market analysis examines the situation of the above-mentioned markets.

Specific information regarding the BIPV market is limited, particularly in Spain and Belgium, and therefore to evaluate the current situation and market trends the following sections use the correlation of the construction and the PV market that are the main drivers of BIPV technology.

The information provided is:

- PV/BIPV installed capacity and investments in 2015
- Feed in Tariff and incentives for PV/BIPV
- Construction market growth rate (New and retrofit)
- % of the Gross Domestic Product (GDP) of the country

These parameters are good indicators for forecasting the BIPV market.

2.3.1 Spain

The PV power installed annually and cumulative capacity in Spain [12] is shown in Figure 2.12. The cumulative installed capacity is around 4GW by 2015. The highlights are: the boom of 2008, almost 3 GW installed, due to favorable political/economic directives; the sharp reduction in 2009 due to unfavorable regulatory modifications; the stop in new installations since 2012.

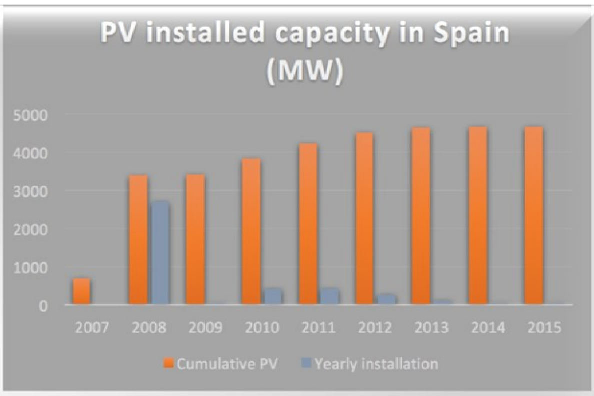
In 2015, only 49 MW were installed and 70M€ were invested; the cause was the new country directives that removed any incentives of the PV market. The regression of the photovoltaic sector reached such a point that while 51 GW of PV energy were installed worldwide in 2015 (including in neighboring countries: 4 GW in the UK, 1.4 GW in Germany and 1.1 GW France); in Spain only 49 MW were added to the existing capacity. Currently, there is no specific data regarding the BIPV power capacity installed in Spain, but some indications point towards it being less than 1% [13].

Last year a fee for the consumption of electrical energy generated by solar panels was established for grid-connected PV installations higher than 10kWp. Thus, this new law requires self-consumption PV system owners to pay a 'sun tax' on energy produced and self-consumed, in addition to the usual grid fees for electricity consumption. Furthermore, storage systems reducing the power capacity required from the grid are subjected to an additional fee. As a result, Return On Investment of the new self-consumption PV installations has been increased.

Despite the current situation, a recent market report [14] points to Spain as one of the markets with highest growth in the next five years. This study predicts a recovery in the sector, which will facilitate the installation of 2.1 GW and the creation of 5,500 new jobs by 2020. Therefore, according to this report, Spain will be one of the key markets in the upswing of PV energy in Europe. Also, the construction sector is growing at a good pace (i.e., 3.6% in 2016) so providing new surfaces where BIPV could be integrated. The reasons for that growth are varied (e.g., low interest rates, improvements on medium household incomes, European recovery plan investments) but they are also exposed to some risks.

Construction sector rates are expected to grow to 3.7% in 2016, 4% in 2017, and 3.5% during 2018 driven mainly by the increase of new projects in the residential sector. However, political instability and the pressure to reduce the public deficit are serious risks affecting the civil engineering markets. This is particularly true for public investments, with a reduction of 6.9% in 2016 and an expected reduction of 0.1% in 2017. For 2018, light growth rates of 2.8% are predicted. This sector is important to follow, as some of the new developments can become clients for BIPV solutions.

PV power installed in Spain in 2015		
Type of installation	Size	Installed capacity in 2015 (MW)
BAPV	Residential (<30kW)	49
	Commercial	0
	Industrial (>250kW)	0
BIPV	Residential (<30kW)	n.d.
	Commercial	n.d.
	Industrial (>250kW)	n.d.
	Total	**49**



Investments in PV installations in 2015	70 million €

Construction Market	
Year	Growth rate (%)
2015	2,6
2016	3,6
Sector share in the national economy (%)	0,3

Feed-in-Tariff		
PV system size	BAPV FiT	BIPV FiT
≤ 30 kW	no	no
≤ 100 kW	no	no

Figure 2.12 Summary of the indicators of the PV and construction market in Spain

The Spanish Government has an open program 2013-2016 [16] for the “Retrofitting of building and urban renovation”, that can help up to a total of 35% total eligible costs with a limit of 11,000 €/retrofitted dwelling. Total budget of such program is 418 M€, and the grants are managed by the Regional Governments. With different possibilities, it is mainly focused on improving accessibility, structural damages and energy efficiency. As an interesting measure, we can mention that the Spanish Building Code forces to cover part of the electrical demand with Photovoltaics for some new big tertiary buildings (Malls, Hospitals, Workshops, >5000m^2 useful surface), which could be an opportunity for BIPV application.

2.3.2 Switzerland

Switzerland installed 330 MW of PV in 2015 [17], of which approximately 18% being BIPV in residential installations and 7% in commercial (Figure 2.13). This high percentage of BIPV in Switzerland is not mainly driven from high BIPV incentives, but from a high acceptance of well-designed BIPV solutions among architects and building owners. As building regulations in Switzerland are less stringent than in the EU, architects experiment more with BIPV products. The PV installed capacity has been growing steadily over the last 10 years with approximately 200-400 MW installed per year for the last 5 years.

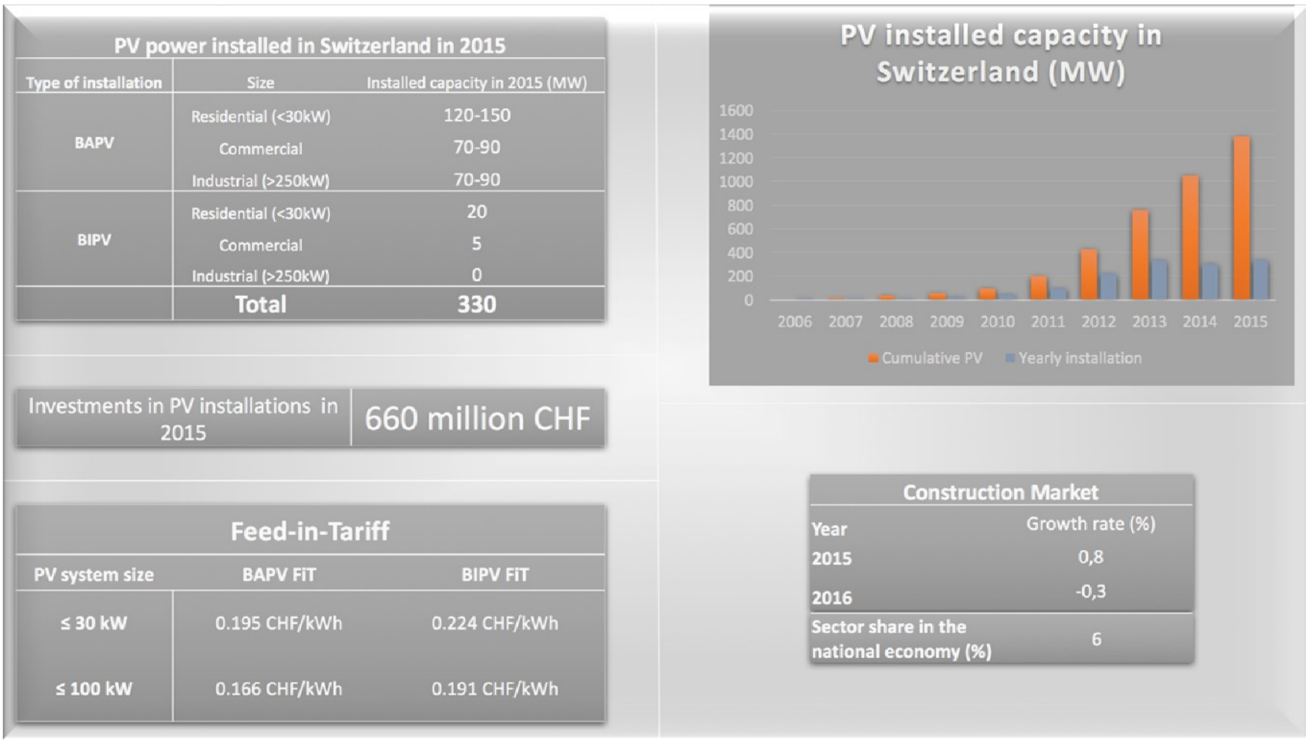


Figure 2.13 Summary of the indicators of the PV and construction market in Switzerland

Currently the BIPV incentive is 15% higher compared to a non-integrated solar installation and is payed for installations up to 100 kW. The incentive is constantly adapted to market prices and paid as a one-time payment for small installations between 2-10kW (max. 30% of investment cost of a reference installation). For installations between 10-30 kW, the incentive can be paid per unit of energy generation or as a one-time fee based on the cost model of a reference installation. The construction sector contributes about 6% to the GDP of Switzerland and employs 327,000 employees [15]. However, its growth has slowed in recent years.

2.3.3 France

The grid-connected PV power installed in France in 2015 (metropolitan France and overseas department/regions) was estimated at 887 MW [19] compared to 951 MW in 2014, and 651 MW in 2013 (Figure 2.14). Grid-connected distributed applications, which are mainly building-integrated systems, reached 294 MW and centralized ground-mounted systems 593 MW.

Compared to 2014 figures, there has been a 7% decrease in power and a 35% decrease in the number of installations, the downward trend being particularly marked for low power installations. In France in 2015, 68% of the annual PV installed volume is supplied by systems over 250 kW, and systems up to 9 kW represent 10% of power and 86% of the total number of installations. The average power of all installations increased from 19 kW in 2013 to 35 kW in 2014 and 51 kW in 2015 indicating an increase in the size of the installations.

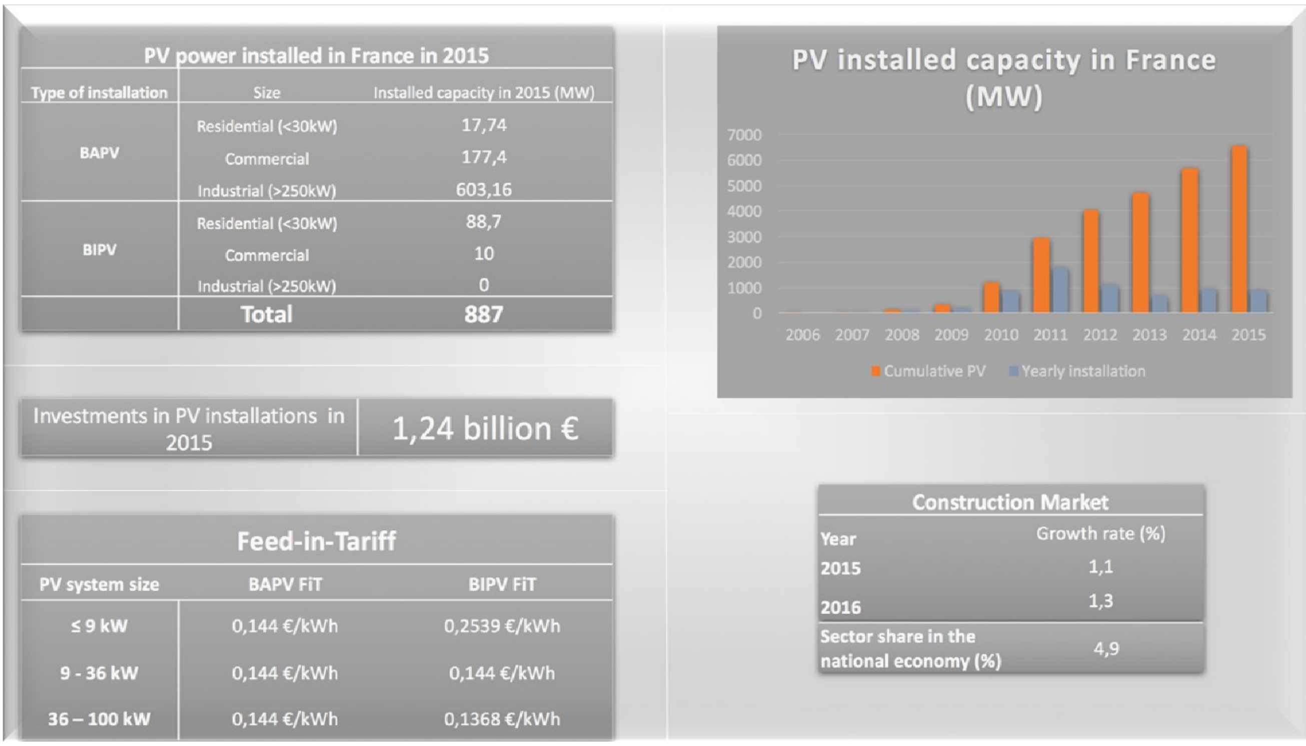


Figure 2.14 Summary of the indicators of the PV and construction market in France [18]

The construction sector accounts for 4.9% of French GDP, with 540,000 companies employing about 1.5 million people [18]. New residential construction output decreased by 3.9% in volume in 2015, with the number of new housing developments remaining low. In the non-residential subsector public construction decreased 18%, while the private segment recorded a 6.6% decline.

In 2016, construction output is expected to rebound by 2.5%, with residential construction activity expected to grow 5.5%, helped by government support for new buildings and retrofit (e.g. tax exemptions and reductions for real estate investors and first-time buyers and VAT reduction for finishing) and increasing loans for real estate acquisitions by private households. That said, non-residential construction activity is expected to remain subdued, especially in the public construction segment. Public works will likely continue to suffer from reduced investments: The government has reduced funds allocated to local authorities by nearly 12B€ from 2015 to 2017 (approx. 4B€ per year) as part of an overall cost cutting program of 50B€ over three years to tackle the public deficit. Maintenance, renovation and repair are expected to increase by 0.4%.

2.3.4 Belgium

The information regarding the PV and the construction market in Belgium is summarized in Figure 2.15 [20]. Until 2015, the total PV installed capacity is 3.300 MW and since 2011 the yearly PV installation has decreased. The power installed in 2015 was low, 91.3 MW, compared to the 1000 MW installed in 2011. This collapse of the Belgian PV market has been mainly attributed to the cutbacks in government support over recent years in each of the 3 Belgian regions. As a result, home/buildings owners have been cautious, refraining from investing in PV on a large scale in recent years. Currently each region has a different regulatory scheme incentivizing PV installations. In Brussels and Wallonia direct subsidies are offered on a yearly basis and depending on the size of the installation. Further information regarding the regulatory framework can be found in Deliverable 1.2.

Regarding BIPV, there is no specific data about the current installed capacity. It is excepted that EU regulations, mainly on nearly zero energy buildings, will drive the BIPV market in the big cities.

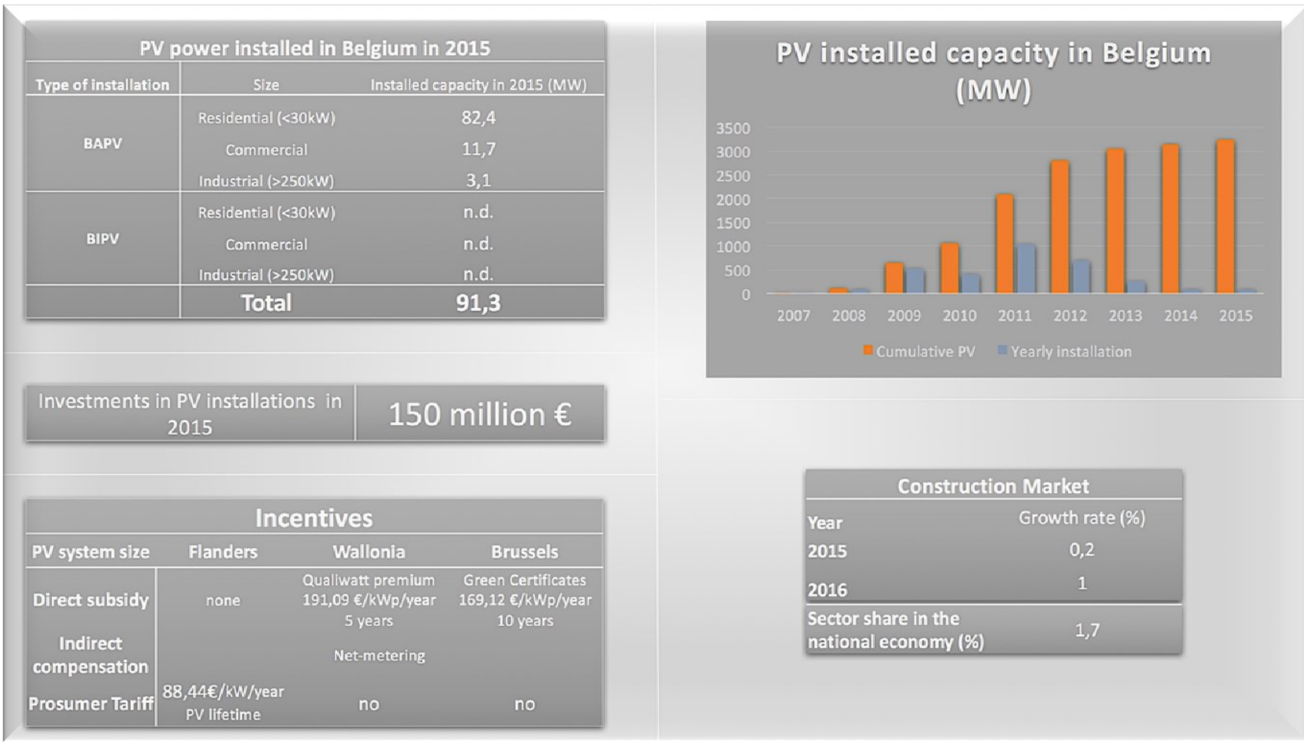


Figure 2.15 Summary of the indicators of the PV and construction market in Belgium

The construction sector growth is expected to remain subdued in 2016 [18], with low public construction investment. Belgian construction businesses suffer from high labor costs, especially when compared to construction businesses from Eastern Europe that are active in Belgium. Construction output is expected to grow by just about 1% in 2016.

3 BIPV MARKET SEGMENTATION

BIPV market can be subdivided in three main sub-markets: glass, non-glass roofing and non-glass walling. Figure 3.1 presents the BIPV sub-market categories and further details on applications and products.

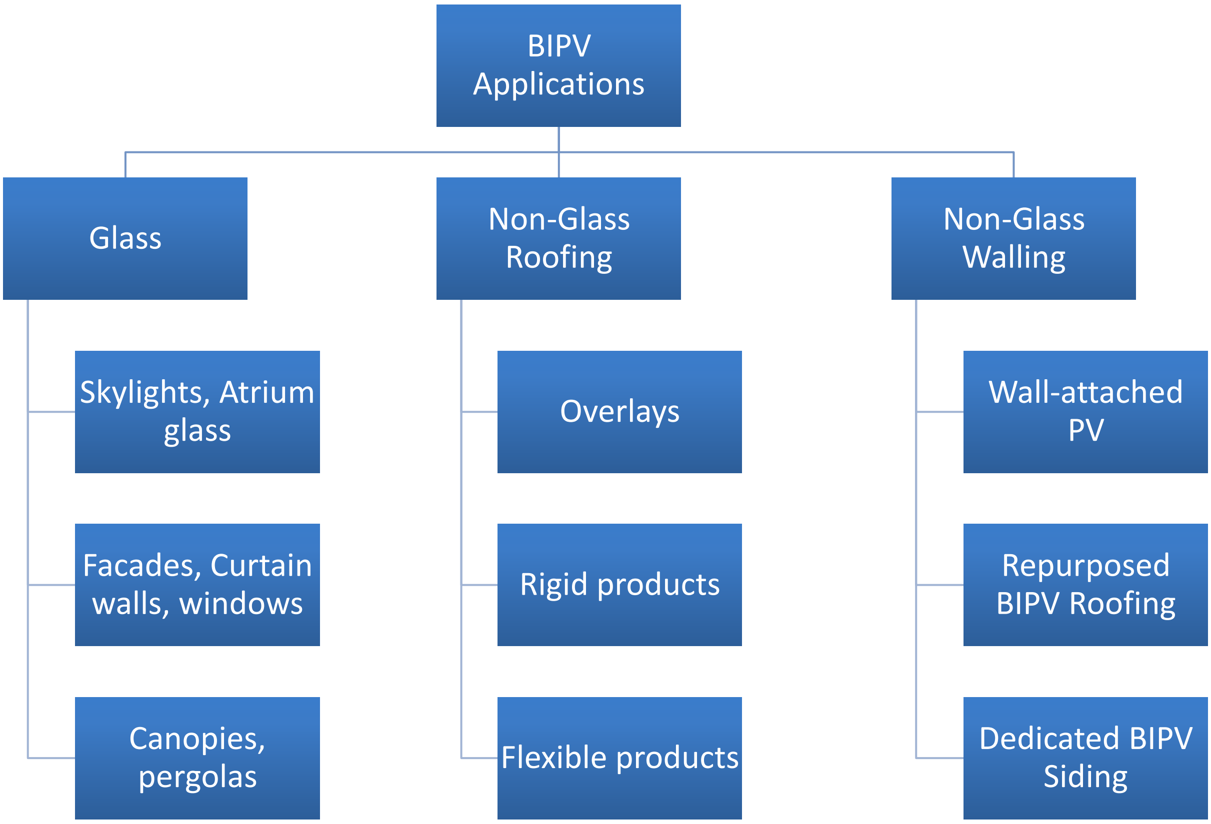


Figure 3.1 BIPV Market applications [6]

The summary of the BIPV market share by product is shown in Figure 3.2 . Currently around 50% of the worldwide BIPV market is associated with non-glass roofing products and it is expected to lead the shipments in the following years. Non-glass walling products will increase its share, reaching and exceeding glass products in a couple of years.

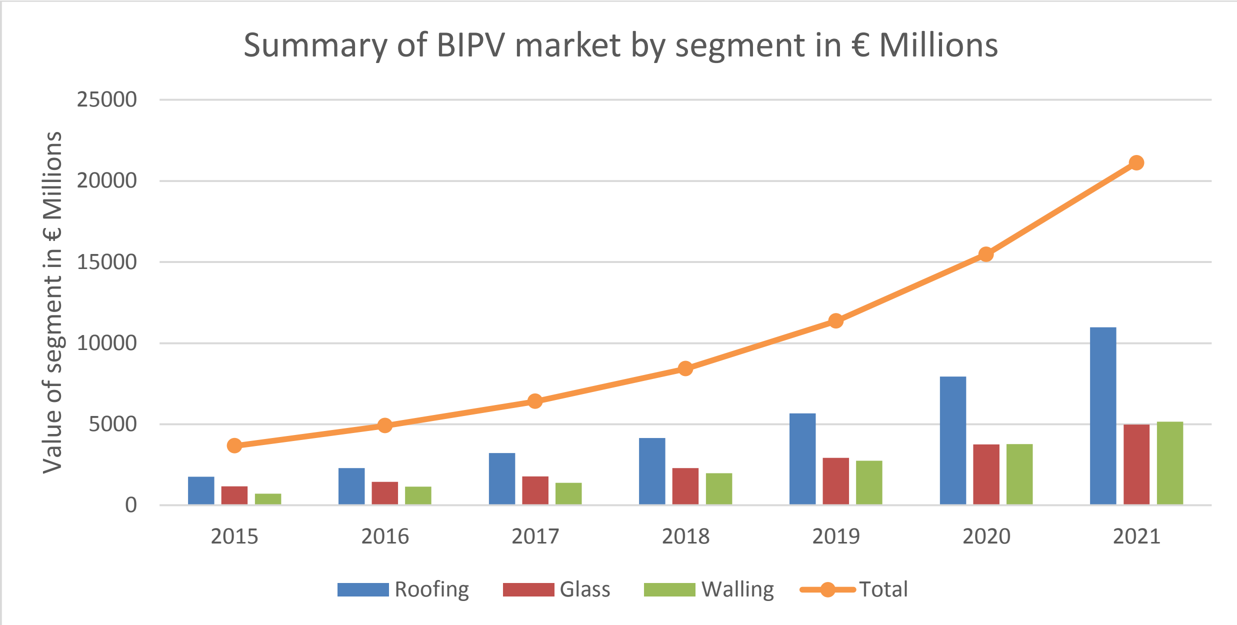


Figure 3.2 Summary of BIPV technologies market shares [6]

PVITES survey assessed the relevance of the BIPV technologies (see Annex A for questionnaire script and response data); the main results (presented in Figure 3.3) indicate that façade elements, followed by continuous facade, are considered the most relevant technologies according to the respondent experts.

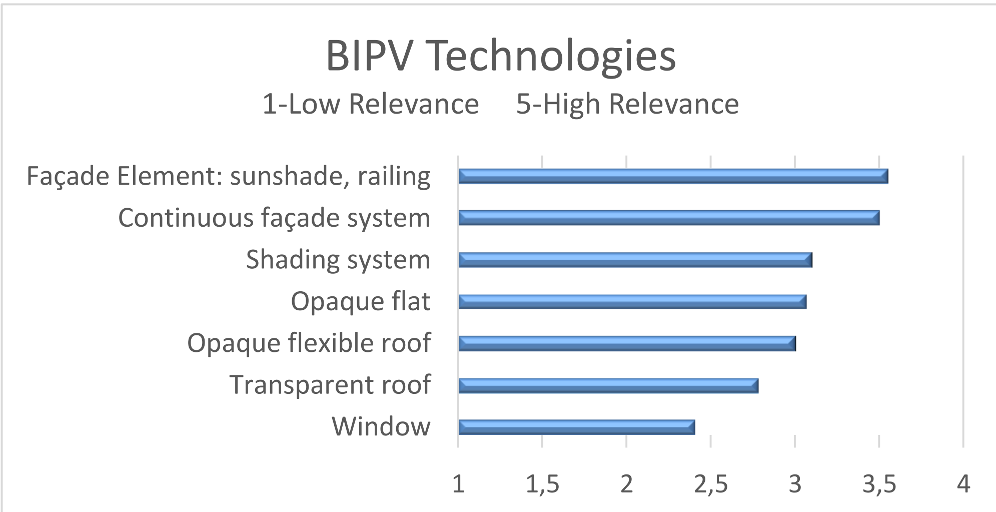


Figure 3.3 Relevance of BIPV technologies results of PVsites Survey

3.1 Synergies among technologies and constructive elements

In general, BIPV products can be seamlessly integrated into the building envelop, following the building contours. Synergies between PV and buildings are leveraged in various dimensions:

- Create value by integration and customization.
- Integration of combined functionalities in one product changes the product/solar application economics.
- Potential for cost reduction of an integrated product below the cost of a solar module plus a building product.
- A BIPV product can potentially become smart if additional functions like e.g. thermal functions are added.
- Simplified transport to installation site as there is only one pre-fabricated integrated solution.
- Avoidance of additional mounting substructure for solar substrates.
- Simplification of installation process and saving of installation labour time.

CIGS thin film technology offers a wide range of possibilities when integrated in a building element for PV integration. Like other thin-film options it offers flexibility, low weight and low-cost manufacturing, while its efficiency has quite a higher potential ceiling, potentially as high as mono crystalline silicon (m-Si). However, it still has challenges, most notably improving efficiency and lifetimes by using better encapsulation. Based on the analysis of the BIPV market share by product segment (Figure 3.2), Table 3.1 evaluates the potential of the most common BIPV technologies in replacing/complementing constructive elements.

Table 3.1: Potential of the most common BIPV technologies in replacing/complementing constructive elements (source: Nanomarkets report BIPV Market Analysis and Forecast 2014-2021)

Applications	Benefits	Opportunities
	Non-Glass BIPV	
Roofing systems	PV tiles used on roofing weigh less than cement tiles. Flexible materials even extend the lifetime of a roof. All these features appeal to prestige buildings and Net Zero Energy Buildings.	Roofs are the biggest market for the non-glass BIPV and should remain so in the near future.
Walls	These find application in multi-story buildings, especially Net Zero Energy Buildings, where roof area is limited.	Though Wall Attached PV (WAPV) dominates the market now, dedicated BIPV sidings should lead the market in the near future.
	BIPV Glass	
Skylights	These stimulate architectural design of light and shadow and multifunctionality.	At present, skylights constitute the biggest market for BIPV glass. On-going projects indicate they still contribute a significant portion of the revenue.
Façades	BIPV glass in different colours allow the architect to come up with innovative glass façades for buildings.	Possibly the biggest market for BIPV glass in the near future.
Atrium and canopies	Ideal for applications where the bulding´s rooftop area is limited or shading obstructions limit solar radiation.	This is a smaller market and should remain so in the near future.

3.2 Competence Analysis

As pointed out in previous sections, the range of BIPV solutions is broad and the market is not very transparent, as there are many solution providers with niche products leaving and entering BIPV markets. For this reason, it is difficult to directly compare competitors and market offering.

Table 3.2 shows a summarized description and analysis of some of the main players, mainly for glass/glass solutions. More detailed information about BIPV component manufacturers can be found in section 0.

Table 3.2 Brief Description of European BIPV main players

COMPANY	DESCRIPTION
ISSOL	This Belgium Company has developed outstanding BIPV large scale projects, mainly in France. They are focused in c-Si (crystalline silicon technology) and the majority of their solutions could be considered BAPV “Building Applied Photovoltaics” instead of BIPV.
ERTEX	This Austrian Company is specialized in customized BIPV solutions. They have carried out outstanding projects with a rich variety of colors and shapes trying to get fully adapted to the client needs. This strategy leads to a rich variety of projects however limiting the scale and extended use of their solutions. Their market is focused in Austria and Germany.
ENERGY GLASS	This BIPV Company is a subsidiary of a large conventional glazing company. They focus on the development of large format and high-resistance BIPV glass using c-Si technology. Most of their projects were carried out in Italy.
SUNOVATION	This young German company counts on the support of two large enterprises - Mage and Krall Group ensuring financial stability. They currently only produce c-Si glazing solutions that are limited in dimensions. They do offer in small scale projects with customized added value solutions including triangular shapes, cool bend curve glass, LED-PV integrated solutions and urban mobility products.
HELIATEK	Heliatek is a spin-off coming from the University of Dresden, Germany, focusing in the development of BIPV solutions based on third Generation Organic PV materials (OPV). Although their product is not ready for the market yet, showing significant delays in production from their original plans, they are an interesting alternative since OPV could satisfy highly demanded products in terms of shapes, flexibility and rich variety of colours.
ONYX SOLAR	ONYX is a Spanish technology-driven company founded in 2009 that manufacture cutting-edge BIPV products based on thin film and crystalline silicon technologies to be used in multiple buildings and urban furniture solutions. In addition to their office and production in Spain, ONYX has a commercial office in New York and more than 55 distributors and accredited professionals worldwide. Due to its excellent performance in the BIPV sector it began to attract the interest of many investors such as José Manuel Entrecanales (FJME), the FIDES Group and the Spanish National Innovation Company (ENISA).
FLISOM	Flisom, founded in 2005, is a spin-off company of the Swiss Federal Institute of Technology Zurich (ETHZ), currently completing its first pilot line to manufacture flexible and light-weight solar modules based on a roll-to-roll, co-evaporation CIGS semiconductor deposition process. As of 2015, Flisom has over 50 employees. Flisom’s expertise is notable in the field of thin film deposition on polyimide and masters all deposition stages, laser scribing stages, back-end stages and testing at various production stages.

It is important to highlight that only Heliatek is developing a flexible product capable of being integrated into curved surfaces. However, it is not a product that is ready to market as it is based on non-consolidated technologies (i.e., OPV) that has still to overcome important stability limitations to be a long-lasting solution when integrated into buildings. On the other hand, the traditional focus for distributed energy applications including PV in buildings has been put on BAPV. BAPV can be considered a substitute for BIPV in some cases and therefore it is still competing against BIPV in some aspects and type of constructions such as residential, commercial and industrial buildings where market reports [7, 12] forecast that BAPV will continue to hold a substantial share of the solar market for many years to come. The weak points of BAPV in comparison with BIPV are mainly that BAPV requires an additional investment within the building budget and their aesthetical aspects do not fulfill the requirements of most of the building stakeholders leading to poor acceptability. The factors that still play in favor of BAPV is the ease in installation and the possibility of being physically better positioned than BIPV.

3.3 Key Market Drivers and Challenges

Currently BIPV represents around 2% of the PV market. However, BIPV should not only be considered as a part of the PV market, as other sectors (i.e., constructive elements) also have a high influence on its deployment. The results of the survey regarding the main market drivers are shown in Figure 3.4.

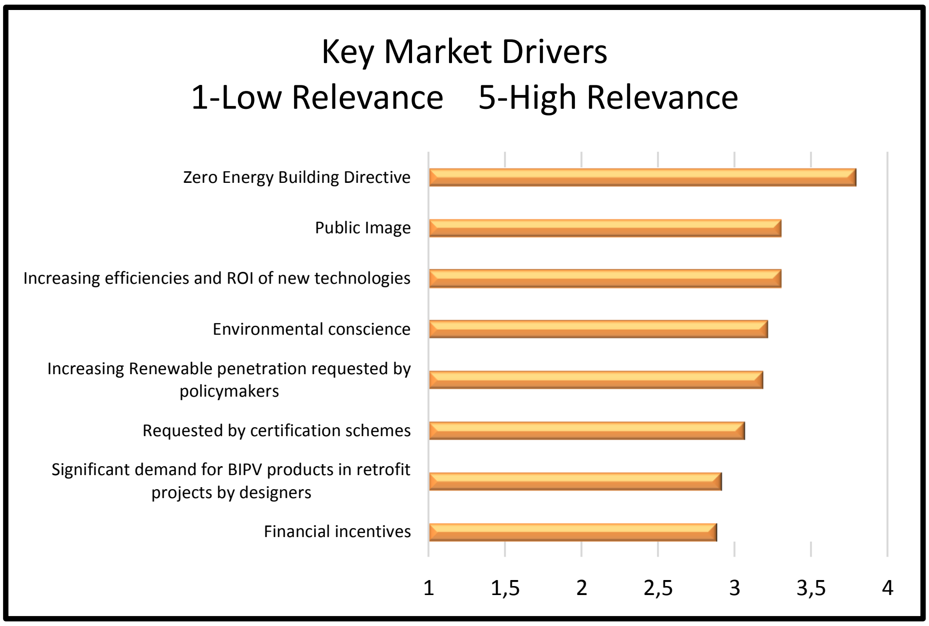


Figure 3.4 BIPV key market drivers results from PVsites Survey

Some of the most important market drivers for BIPV are:

- Increased demand for **near zero-energy buildings** and emerging BIPV technologies and solutions capable of adapting to the needs of these ambitious buildings. These types of buildings are supported by the EPBD Directive, which is promoting the diffusion of low/zero energy buildings, therefore fostering the integration of Renewable energy technologies on-site or nearby the buildings.
- The **public image** of companies is becoming more important every year and therefore they are interesting in investing their capital in showing an eco-friendly image to their current and potential clients.

- The fact that new technologies are constantly increasing the gene**ration efficiency is rapidly improving the return on the investments** in BIPV. In addition, these new technologies are more flexible and have better aesthetics which facilitates their integration in the planning phase.
- In developed countries the mature **social environmental conscience** is a continuous force pushing politics and policymakers in finding new and better ways to incentivise green technologies
- Other markets drivers, which according to the PVSITES survey have a lower weight in pushing BIPV, are the Certification schemes (e.g., LEED, BREEAM), the request of BIPV products by developers and the current incentives which need improvements to further drive the BIPV market

In spite of this favorable framework, it is a fact that estimates of BIPV market growth have been subsequently overestimated in the past few years. A series of demands from the stakeholders which have not been properly addressed by the BIPV value chain and the price drop of regular PV, making it a more profitable business, with lower RoI than BIPV. are the cause for this deviation. These key requirements are mainly related to the flexibility in design, aesthetics considerations and lower costs. Results of the survey regarding main BIPV challenges are shown in Figure 3.5.

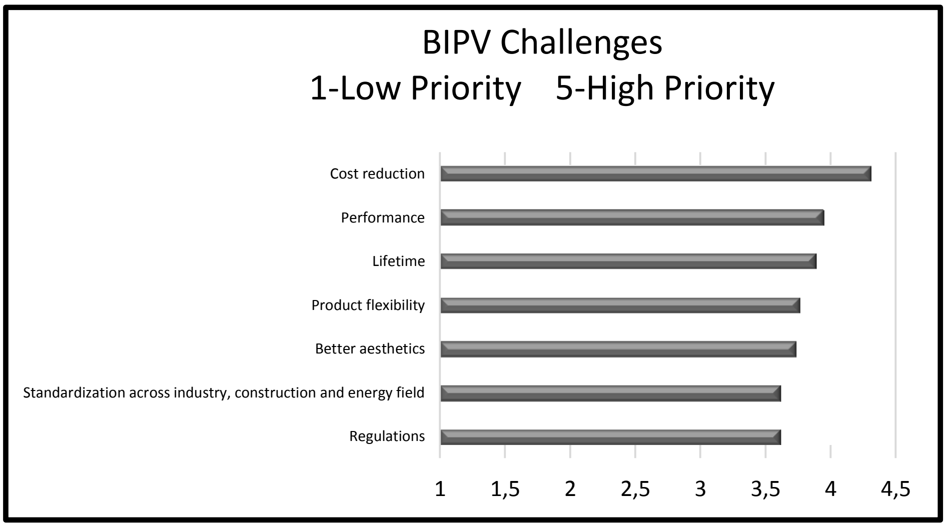


Figure 3.5 BIPV challenges results from PVSites survey

Challenges to be overcome include:

- BIPV has to achieve **cost competitiveness** for large deployment in the construction sector. Thanks to standardization, BIPV products will be cheaper and with similar prices to conventional building products.
- There is a constant need to improve the **efficiency and lifetime** of the BIPV products to reduce the RoI and generate higher revenues during the life span of the products.
- Translating BIPV value into a message that resonates with costumers will rely more heavily on its unique **aesthetics and design** considerations: color, transparency, flexibility, different form-factors, and even being indistinguishable from conventional construction materials like architectural glass.
- **Regulations** and better **incentives** are needed to support the BIPV growth and ensure better confidence among the stakeholders.

4 STAKEHOLDER ANALYSIS

Analysing stakeholders is crucial for projects to understand the relevant actors' needs, desires and potential barriers to a specific implementation, development or change. By assessing the needs of each category, proactive steps can be taken to ensure affected/affecting actors work synergistically with the goals of the project and do not undermine its success. If we are capable of identifying and delivering benefits consequential to the engagement in BIPV market for the most relevant stakeholders, the probabilities of success and large-scale deployments will exponentially increase.

This stakeholder analysis uses a common Power/Interest approach [21] which divides the stakeholders into 2 groups (primary and secondary stakeholder) are presented in Figure 4.1. The main difference between primary and secondary stakeholders is that BIPV market success depends strictly on the involvement and cooperation of the first ones. Primary stakeholders may show more or less interest on BIPV but they have higher influence and power than the secondary stakeholders and their aversion could lead to project failure. However, although BIPV could be successful with low involvement of investors, maintenance companies, occupants or grid operators (secondary stakeholders), if they are involved in an early stage using the strategies listed in Table 4.1, for group 3 and 4, the final solutions will be more complete and further business opportunities may arise. High power, high interest stakeholders are key players. Low power and low interest stakeholders are least important. Depending on the classification of the different stakeholders, different engagement strategies should be implemented.

Table 4.1 Classification of different stakeholder types with associated strategies for engagement

Level of importance	Category & classification	Strategy to maximise their engagement
Primary Stakeholders	1. **Key players:** High Influence & High Interest	• Key players focus effort on this group • Engage and consult regularly • Involve in governance
	2. **Meet their needs:** High Influence & Less Interest	• Engage and consult in their interest area • Try to increase level of interest • Aim to move into key players
Secondary Stakeholders	3. **Show consideration**: Less Influence & High Interest	• Make use of interest through involvement in low risk areas • Keep informed and consult on interest area • Potential supporter
	4. **Least important**: Low Influence & Low Interest	• Inform via general communications: Newsletter, website, etc. • Aim to move into group 3

Often the process of identifying stakeholders will result in a long list of individuals and groups. After identifying the long list of actors, these are condensed into the main relevant categories. Subsequently, each of them is assigned to a class, according to Figure 4.1. [21]

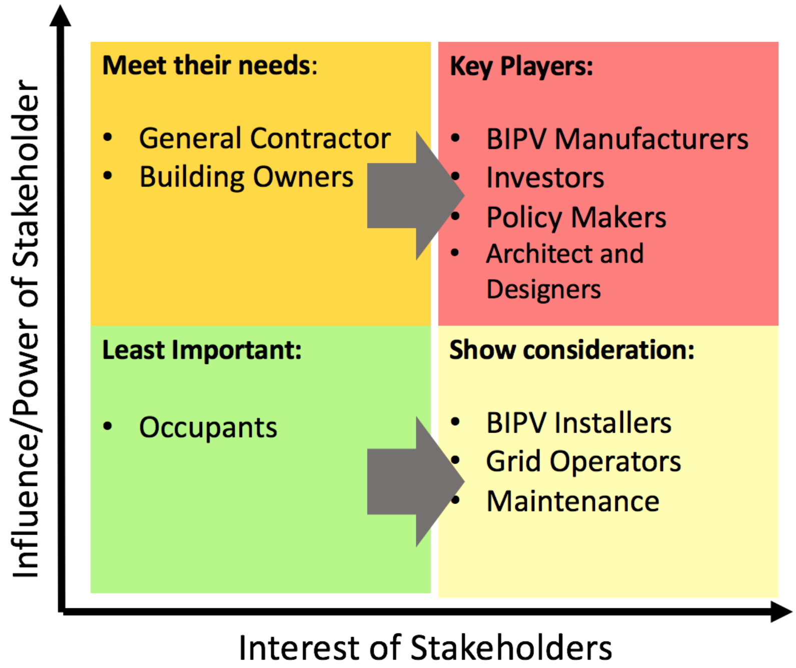


Figure 4.1 Classification of different relevant stakeholders in the power vs. interest chart

4.1 Primary Stakeholders

Primary stakeholders are those that have high influence and power with respect to BIPV technology. They include BIPV manufacturers, Architects/designers, Building Owners, General contractors, Policymakers and Investors. Table 4.2 summarises the relevance, needs and benefits for each primary stakeholder that is then discussed in further detail in the remaining of chapter 3.1.

Table 4.2 List of main stakeholders with associated relevance, needs and challenges, and benefits for them with respect to BIPV

Actor	Relevance	Needs and challenges	Benefits
BIPV component manufacturers	Main investors on production, R&D of BIPV technology to meet market demands for technical, liability and economic aspects.	Meeting design and building specifications High customization requirement for project based business.	Direct sale of products.
Investors	Financing the different market sectors involved.	Risk reduction Evolving legislations Liability Ownership of BIPV elements in case of financing the cost Increasing competitive environment	Return of investments Extended investments portfolio

Architect and Designers	One of the most important actors since define the design features. If the architect is aware of the possibilities/limitations and is willing to design a building with BIPV exploiting aesthetic features BIPV can be integrated.	Knowledge to optimally design. The most cost effective are standard products. The aesthetics, of the products is very important.	Building green (including BIPV) can be profitable for the architect to get more clients and reputation.
Building Owner	Building owner is one of the key stakeholders that must be convinced that BIPV technologies are suitable for a variety of reasons and are worth the investments.	Convince the group of investors that BIPV worth the extra investment and some of the associated extra efforts in exchange for remuneration and image.	Energy bill reduction Enhanced public image Increased property value. Tax reduction, other type of incentives
General Contractors	General contractors are in the middle of the chain through the end users of the buildings. Influence on the effective perception of these products. Responsible of the practical incorporation of the BIPV in the building to be constructed	Create internal policies flexible supporting higher RoI periods and higher risks.	Increase of market. Reduction of cost of the construction process. Improve Social Cooperative Responsability
Policymakers	Policy enablers Providing a favourable and stable BIPV regulatory environment	Creating innovative incentives and schemes balancing the needs of several sectors and lobbies	Increasing renewable energy penetration and decarbonisation. Economy and industry support.

4.1.1 BIPV component manufacturers

The Swiss BIPV Competence Centre of SUPSI published one of the most complete overviews of European BIPV component manufacturers in 2015 [11]. This detailed overview features more than 107 manufacturers in Europe, but has to be read with care as every year competitors leave or enter the BIPV market place. BIPV manufacturers so far could not be separated from general PV markets and are continuously benchmarked with BAPV system prices. This leads to continuous disappearance of good BIPV products from the market due to the price pressure of conventional BAPV systems. On the other hand, new innovative BIPV manufacturers with unique concepts are continuously entering markets. The market is relatively opaque due to the complexity of building & design requirements in the various European countries and a mostly regional-focused market access for many BIPV component manufacturers. Table 4.3 summarizes the different types of manufacturers, their benefits and challenges and finally the relevance to the BIPV sector.

Table 4.3 BIPV manufacturers Benefits and Challenges

Type of BIPV component manufacturer	Benefits / Motivation	Challenges for BIPV manufacturer	Relevance for BIPV sector
Standard glass module BIPV manufacturer	Looking for premium sales channels for standard products	Meeting design and building specifications	Medium/High
Customized glass BIPV manufacturer	Specialized in customized BIPV solutions on project base	High customization requirement Project based business	Medium/High
Technology developer of PV production technology	Looking for differentiated markets which value specific product attributes like lightweight, aesthetic etc.	Development of complex production technologies Competition with low cost provider	Medium
Single or slate manufacturer	Innovative products based on existing components like c-si cells, roof shingles etc.	Product certifications & norms	Medium
Mounting structure supplier	Developing innovative ways of mounting, e.g. in-roof systems for standard panels	Fulfil design and roof requirements	Medium
Traditional roofing supplier	Value added products	Integration of PV in existing product offering	High

4.1.2 Investors

Investors are relevant to the development of the BIPV market because they are financing the different market sectors involved. Different types of investors are interested in investing into BIPV product & solution sectors. A few of the main sources of cash for BIPV companies are listed below:

Table 4.4 BIPV Investors Benefits and Challenges

Type of investor	Benefits	Challenges for Investor	Relevance for BIPV sector
Building component manufacturer	Innovative products to offer to the market	Differentiation of existing product portfolio in an increasing competitive environment	high
ESCOs	Revenues from selling the produced electricity Leasing the BIPV installation and collecting part of the revenues	The higher RoI can scare investors. Creation of bundle services to the BIPV electricity generation. Ownership of the BIPV constructive element.	Medium/High
Industrial supplier of materials / half products for BIPV products	Downstream integration that has direct advantage to the diffusion of BIPV	Meet BIPV requirement specifications	Average
Oil & Power companies	Diversifying portfolio	Move to a low-carbon world	Average
Banks	Loans and investment financial benefits	Predictable returns	Low
Personal investors	Sustainability	Investment in line with personal ideas / values	High, especially in first years

4.1.3 Architect and Designers

The architect makes many design decisions. These decisions can be in favor of or can be against the application of BIPV. If the architect is aware of the possibilities/impossibilities and he is willing to design a building with BIPV, already in an early stage of the design process, BIPV is introduced and problems can be solved or avoided. Some architects are not aware of the application of BIPV. So the design they make is probably not the optimal design for the application of BIPV. A BIPV engineer/consultant that steps in later has to convince the architect to make changes in the design. In general, this is not a very efficient process and in many cases it will be impossible to make big changes. Therefore, the engineer/consultant has to accept a less optimal solution. Therefor the role of the architect as almost the first player in the field is very important.

Benefits

The benefits are indirect. Green building (including BIPV) can be profitable for the architect to get more clients. But as regulation is changing rapidly (NZEB buildings within 5 years) this benefit is only temporary as all architects will have to gain this knowledge. However, being on top of the game can have a competitive advantage.

In general, the architect will not get paid for extra work or get a consultancy fee for the application of BIPV. It is an integrated building product and part of the general scope of work. To make it special and to try to get extra payment for this work is counter-productive. It will keep BIPV in a special position and less attractive for clients to accept.

Challenges

As regulation is changing (more energy-efficiency, NZEB, etc) architects will focus more on green design and especially energy-efficient design. The NZEB regulation promotes the use of renewable energy. Of all the different renewable energy sources, solar energy and geothermal (aquifer and heat pumps) are the most common in buildings. As heat pumps are mainly an engineering solution, it falls mainly on the engineer responsibility. The architect is often responsible for the aesthetics and solar energy has implications on it. The application of solar energy can be as passive solar energy (focus on floor plan and facade design), thermal solar energy (focus on integration in roof and facade) or photo-voltaic solar energy (focus on integration in roof and facade). This means he should design with the requirements for solar energy integration. In general, the architect will be challenged to find a well-designed solution that enhance the look of the building and will not settle for a simple frame with modules on the roof (BAPV).

The main challenge is to design with PV- modules or elements in a way that it is, or looks like, an integrated element of the whole building. As a matter of fact it does not really matter if this is BIPV or BAPV. The main challenges for the architects to deal with PV-solar in the design will be:

a. How to design in an optimum way (good output). For that reason, software is needed to do the analysis and to support to make the right design decisions.

b. The most cost effective are standard products. This will challenge the designer as they are less flexible then tailor-made solutions.

c. The look, the aesthetics, of the products is very important. The architect will look for texture, color and pattern (the pattern is mostly formed by the mounting system).

In D2.4 “Formulation of architectural and aesthetical requirements for the BIPV building elements to be demonstrated within the project” we can find detailed information about architectural design and aesthetics.

4.1.4 Building Owners

The building owners have the power to decide whether to follow a sustainable approach for their buildings or not within a certain regulatory framework. Once the sustainable approach is selected, the next decision is to select which green technologies will be installed. Therefore, the building owner is one of the key stakeholders that must be informed/convinced with the fact that BIPV technologies are the most suitable for the project and that the benefits are worth the investments. If he/she will also occupy the buildings, the building owner will also cope or benefit with the design decisions.

Benefits

The main benefit for the building owner is related to the energy bill reduction, if he pays the bills, as a consequence of the self-consumed energy and the energy exported to the grid. Other benefits are:

1. Enhanced public sustainable image.
2. Increased property value and associated applicable rents.
3. Tax reduction, other type of incentives (Depending on the country)

Challenges

The main challenge for building owners is to convince the group of investors that BIPV worth the extra investment. The extra costs represented by the installation of BIPV is a particular factor which make investor hesitate. In addition to the costs, the added complexity is another factor that building owners see as a challenge. In many cases, the rejection to the BIPV installation comes from an lack of expertise and fear about the complex and uncertain outlook. This issue can be summarized in the fact that currently there is a lack of a simple business models for BIPV technologies that facilitate the vision to the stakeholders.

4.1.5 General contractors

General contractors are in charge of the construction site actions and decisions, therefore they must have a deep knowledge on the last technologies and construction elements that are used for construction. Big general contractors have the power to push the success of the new constructions elements, as the BIPV can be considered.

Benefits

The main benefit for the general contractors is to reach greater market share by differentiation of their BIPV developments from conventional developments, through the improvement of their energy behavior characteristics. The final product increases their value and even more so, if this differentiation can be certificated by any of the existing environmental building certifications (LEED, Breeam, etc.). This mainly increases the general contractors potential market, as nowadays many promotors are more and more interested in including sustainability in their developments.

Other benefits include, the potential of reducing costs and time during the construction phase. Also, the accreditation of the project as “green”, can make some planning permission processes easier, and may also make the project eligible for some tax allowances and other incentives, that result in an economic optimization of the project. If the contractor is involved in the exploitation of the assets during their installed life they would also benefit from the lower operating costs.

Finally, the improvement of general contract corporate image (CSR Corporative Social Responsibility) Green technology has become a way of improving public image, and for good reason: people want to know that businesses are committed to good environmental practices; and have enough knowledge and practice in implementing BIPV solutions. PVSITES products can contribute to that commitment

Challenges

The possible increase in the investment (CAPEX), can be compensated through time (reduced OPEX) but requires internal policies flexible to longer return of investment periods and higher risks. In this sense the promotors and/or investors of the project should be have common vision.

Small companies can achieve easier than the bigger ones the specialization as 'BIPV implementer', because usually their production is more focused in a specific construction area, for example, green single familiar housing. They can search for special market niches.

4.1.6 Policymakers

The penetration of BIPV varies substantially across Europe reflecting national conditions and triggered by different sets of policies, programmes and implementation schemes. Although policy in Europe is under the same overarching schemes, national policymakers have a primary role in providing a favourable and stable environment for the different stakeholders involved. They would need to push via incentives or mandatory regulations general contractors, private/public parties and other stakeholders into proposing and increasing the share of renewable, and in particular BIPV, into urban areas.

Benefits

A large deployment of BIPV products represents a positive step toward a widespread renewable energy penetration in the big urban areas generating a favorable environment for new smart cities in Europe and therefore reduction in CO_2 emissions as well as fostering the green economy.

Challenges

The main challenge for policy makers is to develop innovative incentives and regulations in order to find the balance between pushing the BIPV penetration without making the technology incentive dependent. This will allow a long term evolution of BIPV in the PV and construction market. In addition, policymakers need to design regulations taking into account the needs of different actors and lobbies.

4.2 Secondary stakeholders

Secondary stakeholders are those who, although they do not have great power/interest in BIPV, still play a role and influence the success of BIPV. Additionally, some secondary stakeholders could move toward becoming a primary stakeholder in future developments or in specific situations/contexts.The first step in dealing with secondary stakeholders is identifying everyone who might fall into this group and as a second step starting to reach out to them with relevant information. This lets secondary stakeholders know that the project recognises they have a stake in it and cares about them. Projects that work with, rather than against, their secondary stakeholders tend to accumulate goodwill and cooperation for expansion and other necessary business activities. The following sections describe the relevance, needs and challenges and main benefits of the secondary stakeholders that were identified.

Table 4.5 List of secondary stakeholders with associated relevance, needs and challenges, and benefits for them with respect to BIPV

Actor	Relevance	Needs and challenges	Benefits
BIPV Installers	Companies specialized in façade/roof building installations as well as curtain wall/skylight The electrical installation is usually conducted by PV installers or regular electrical installers.	Dealing with the electrical particularities of BIPV installations.	Installation Fee
Maintenance	Efficient and effective running of buildings and their energy systems Ensure reliability of the system	Skills /knowledge gap in relation to the BIPV maintenance Need for training and knowledge transfer	Financial benefits related to additional services Financial incentives that indirectly can be captured by the maintenance company Companies with their own maintenance can reduce costs
Occupants	Occupants awareness drive the technology	Get occupants involved by giving them on-going, clear information about the building, the environmental impact and the benefits.	Bill reduction. Social acceptance and environmental consciousness.
Grid Operators	Enabling the distributed PV integration to network in an efficient manner and maintaining the security and reliability in the grid	Ensure balancing and reliability of BIPV generation variability.	Reduction of congestion points due to self-consumed energy in the buildings, reduction of losses and improvement of CO_2 footprint.

4.2.1 BIPV Installers

Depending on the characteristics of the BIPV project, there are several possibilities for BIPV installers. Most common BIPV installers are companies specialized in façade/roof building installations as well as curtain wall/skylight structural system manufacturers for BIPV glass installations. The electrical installation is usually taken over by PV installers or regular electrical installers. Due to the evolution of the BIPV market in the last years, BIPV installers exclusively specializing in custom turnkey design and installation of building integrated photovoltaics have gained greater importance. Table 4.6 summarizes the different types of installers, their benefits and challenges and finally the relevance to the BIPV sector.

Table 4.6 BIPV Installers Benefits and Challenges

Type of installer	Benefits	Challenges for Installers	Relevance for BIPV sector
General contractors	Turnkey projects, cost reduction.	Construction contractors who are not electrical contractors are not properly licensed to install PV in certain projects so there has to be a specialized subcontractor with a high level of dependence of initial designs and related works within the building to ensure the quality of final results.	High
Façade/roof installers	Specialization, including innovative products in their portfolio. Patentability of new potential structural systems and solutions for BIPV.	Dealing with electrical installations in façades and roofs. Sometimes, regulation permits this kind of installers to place only the BIPV modules but all electrical work, including wiring installation, terminations, etc., must be completed by electrical and/or PV installers. To avoid this, some façade/roof installers are also specializing in BIPV products and installations.	Medium
Electrical installers/ PV installers	Specialization and additional expertise for clients.	Dealing with the electrical particularities of PV/BIPV installations.	Medium
BIPV installers	Turnkey projects, cost reduction, specialization.	Adapt BIPV to initial architectural designs optimizing electrical output and passive properties.	Medium

4.2.2 Maintenance

Buildings need maintenance, some buildings more than others. Facility managers will have a scheme to plan future maintenance activities and to control the maintenance budget. This does not usually include the window cleaning. Depending on the type of installation, window cleaning can also be applied to PV cleaning. It is probably more cost effective to use existing services then start a new service (like PV cleaning). As inverters have a shorter life-time then PV modules, it is important to have a budget for replacement (between 10-15 years life-time). The PV modules have a reasonably long life-time of over 25 years. Yearly or 2-yearly inspection maybe needed. As most commercial buildings will have a make-over after 25 years, the PV modules can be part of this make-over. In cases in which the PV is coupled with batteries, its maintenance must also be taken into account.   A simple monitoring system with at least weekly output can be used to check if there are big changes in the output. This can be the indicator of failure and promote further investigations.

Benefits

The benefits of maintenance are obvious. Cleaning the modules, especially in a dusty urban environment (traffic, micro dust) increases the output. The difference in output between clean and dusty modules is around 4 - 5%. The constant and correct maintenance of the equipment can avoid or differ repairs and increase the lifespan.

Challenges

Maintenance is not a special service but part of an on-going practice. The responsibility is on the Facilities Manager. However, smaller buildings or private buildings (small office, workspace, shop or residential) may lack the maintenance planning that is standard in bigger buildings. So here is a possibility to set up a special service. This can be a BIPV Maintenance service that has contracts with small building owners and can do this for a fixed contract price. Comparable with yearly maintenance on a heating system or a car.

4.2.3 Occupants

The occupant is probably less important as he will use the building after the BIPV system is designed and installed. For commercial buildings, it is known that occupants are often not aware of the ‘green’ status of the building or the application of BIPV. It is important to give attention to this aspect. Occupants that are familiar with the ‘green’ issues of the building will be influenced by it as well. In the case where the owner is the occupant, this will be slightly different. The decisions are made by the owner, (in his role as owner and as occupant) and in the role as occupant he will have to discuss the application of PV with the other occupants.

This is especially true in the residential and commercial market where there are tenants and occupants. They rent a house/office including the BIPV system. In this case there will be the issue of investment versus profits. The owner makes the investment but the occupant has the financial advantage of a lower energy bill unless the bills are included in the rent. In some cases the investor will directly benefit from the revenues correlated with produced electricity since it is their way to recover the initial investment.

Benefits

The occupant benefits from a ‘green’ and less energy-consuming building. Depending on the financial structure the occupant also has financial benefits. In general, the role of the occupant will not be very important regarding BIPV, unless they are willing to pay higher price with a building equipped with BIPV therefore supporting the demand for such constructions. However, organizations social and environmental goals are increasing. If this is the case, the occupant will be interested in paying more for a green office.

Challenges

The main challenge is to get occupants involved by giving them on-going, clear information about the building, the environmental impact and their benefits (financial and quality of living).

4.2.4 Grid operators

Grid operators play an important role in enabling the distributed PV integration. They are responsible for the operation of the network in an efficient manner and in maintaining the security and reliability of the network. In many EU countries the evolution of the traditional grid toward smart grids has begun, although operators are facing challenges.

Benefits

The main benefits for the grid operators of increasing the penetration of renewables, in particular PV/BIPV, are the reduction of congestion points due to self-consumed energy in the buildings, reduction of losses and CO2 foot print. Additionally, since the penetration will occur since it is demanded by citizens and pushed by regulators, if they are part of the process they can set up specifications and requirements for this integration.

Challenges

The variability in the electricity production can be a significant challenge for grid operators who must be adept at filling-in when PV output drops and then reducing grid support as PV output picks up after clouds have passed. With an increase of PV distributed, some segments of the grid could require reinforcement and the DSO must be forced to disperse the injected electricity if no costumer needs it. A somewhat related challenge is referred to as the “cloud edge effect.” Consider how the edge of a cloud with the sun behind it seems especially bright. That phenomenon acts like a lens which concentrates insolation (light and other radiation from the sun), leading to a temporarily increases in the amount of insolation reaching the PV modules by as much as 25%, for a few to many seconds. Depending on how the PV system is designed, this cloud edge effect can cause short duration increases of power output that may have to be offset or managed.

5 CONCLUSIONS

This deliverable summary the current status and forecast of relevant BIPV markets, its drivers, trends and market segmentation with respect to applications and competitors. Additionally, we characterized the role, needs/challenges and benefits of different important actors. Key conclusions highlighted in the document are:

- In the past years, the penetration of the BIPV has been overestimated by analysts. One of the main reason why the estimations failed was the **price drop of regular PV**, making it a more profitable business, with lower RoI than BIPV.
- Although past estimations failed, it is expected that the global **BIPV market will grow** in the following years. This growth will be more conservative in the period 2016-2018 and it will likely increase faster in the following years. It must be noted that within the PV market, the BIPV technologies will remain a niche market with **no more than 8% of the total PV shipments by 2020**, reaching 5 GW by 2020.
- **Europe is foreseen as the BIPV market leader** along with the USA with approximately 3.5B€ invested in each. Regulations toward near zero energy buildings, better incentives schemes and citizen consciousness are the main drivers for the optimistic forecast for the BIPV economy in Europe.
- Among the targeted countries, **France and Switzerland are in a better position** for a faster and higher penetration of BIPV. The specific FiTs for integrated PV along with a higher social awareness regarding environmental issues increase the opportunities for investments in BIPV. On the other hand, **Spain is facing a deep crisis** in the solar renewable energy field which led to almost zero PV installations in the past years. It is expected to have a slow recovery in the future, although this is highly dependent on the political and economic stability. Finally, Belgium has a similar but less drastic situation than Spain, In the past 3 years annual installed capacity decreased and there are no specific benefits for BIPV.
- The BIPV market can be divided into three sub-markets: glass, roofing and walling. The non-glass roofing market is currently the biggest one and it will continue to lead the market in the future reaching 10B€ in 2021. Therefore, this market is/will be the most attractive almost doubling the investments in the other two by 2020.
- The stakeholder analysis has shown the need for an integration/collaboration between actors to reduce complexity and costs in the value chain. Contractors, architects and BIPV manufacturers are the main stakeholders and a close collaboration between them will exploit their synergy bringing benefits to the rest of the actors involved in the BIPV market.

In order to continue supporting the market penetration of BIPV, the following aspects will continue gaining importance:

- BIPV must be considered as a constructive element generating electricity, therefore combining both functions of constructive element and energy harvesting technology
- Clear message to the construction (designers and owners) and Real Estate Sectors regarding the benefits and possible business models to capture the complete value of BIPV and overcome some barriers.
- To understand the BIPV “green value” for the different stakeholders and the channels to communicate with them.
- Reliability, liability, performance, aesthetics, costs, maintenance and flexibility will continue to be critical element in order to ensure support from the different actors involved in the decision process and operation.

6 REFERENCES

[1] EPIA, “Global Market Outlook for Photovoltaics 2014-2018,” 2014.

[2] SSE, “Global Market Outlook for Solar Power 2015-2019,” 2014.

[3] SPV Market Research, “Solar PV market research,” 2014.

[4] Technavio, a U.K, “Global building integrated photovoltaic (bipv) market 2015-2019,” 2015.

[5] n-tech Research, “BIPV Technologies and Markets: 2015-2022,” 2015.

[6] Nanomarkets , “Nanomarkets report BIPV Market Analysis and Forecast 2014-2021,” 2015.

[7] n-tech Research, “BIPV glass markets: 2015-2022,” 2015.

[8] European Parliament, “Energy Performance of Buildings Directive (2010/31/EU),” Brussels, 2010.

[9] The Freedonia Group, Inc., “World Roofing,” 2016.

[10] The Freedonia Group, Inc., “World Cladding,” 2015.

[11] SUPSI-SEAC , “BIPV Status Report 2015,” 2015.

[12] U. E. F. José Donoso and Pedro Palencia, “National Survey Report of PV Power Applications in Spain 2014,” PVPS, 2014.

[13] Union Fotovoltaica Española, “La energía fotovoltaica una alternativa real,” 2015.

[14] Ernst & Young, “Renewable energy country attractiveness index,” 2015.

[15] Euroconstruct, “Country Report 2015,” 2015.

[16] Minister of development, Spanish goverment, “Plan estatal de fomento del alquiler de viviendas, la rehabilitación edificatoria, y la regeneración y renovación urbanas, 2013-2016,” 2012.

[17] International Energy Agency, Photovoltaic Power System Programme, “National Survey Report of PV Power Applications in Switzerland 2015,” 2016.

[18] Atradius, “market monitor Focus on construction performance and outlook,” 2016.

[19] International Energy Agency, Photovoltaic Power System Programme, “National Survey Report of PV Power Applications in France 2015,” 2016.

[20] International Energy Agency, Photovoltaic Power System Programme, “National Survey Report of PV Power Applications in Belgium 2015,” 2016.

[21] A. Mendelow, “Stakeholder Mapping’,” Proceedings of the 2nd International Conference on Information Systems, Cambridge, MA., 1991.

ANNEX A “Market and Stakeholder Survey”

PURPOSE AND BACKGROUND

The survey was conducted by Dr. Federico Noris and MSc Juan Manuel Espeche from R2M Solution as part of the PVSITES project, financed by the European Community grant n. 691768.

The objective of PVSITES project is 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.

The goal of this survey is to help the consortium to identify the BIPV market perspectives, including its trends, key drivers and challenges from the point of view of the different stakeholders.

DISTRIBUTION CHANNELS

Distributed among the following selected channels and conferences:

Online:

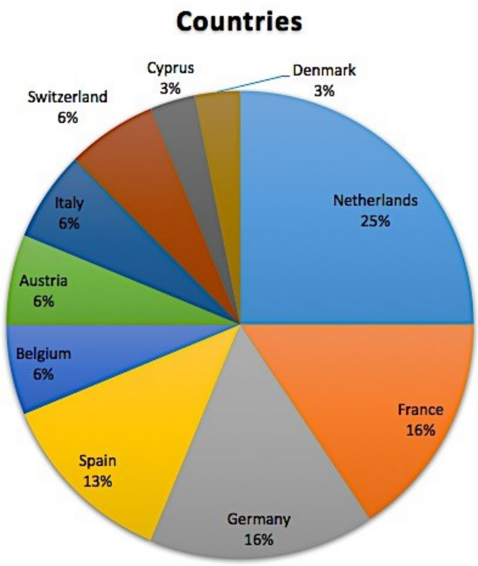
- *Advisory board of PVSITES*
- *GeoSmartCity project consortium*
- *CityGML Energy ADE Workshop participants*
- *'La recherche en Architecture' (French alliance for applied research in architecture schools) members*
- *Dem4BIPV project consortium*
- *ETIP PV working group on BIPV*
- *IEA PVPS Task 15 on BIPV*
- *Spanish Photovoltaic Platform (Fotoplat) website*
- *Architects' Council of Europe (ACE) members*
- *Norske Arkitekters Landsforbund (NAL) members*
- *'Ordre des Architectes - Conseil Francophone et Germanophone' Belgian Architects's Association Council*

Events:

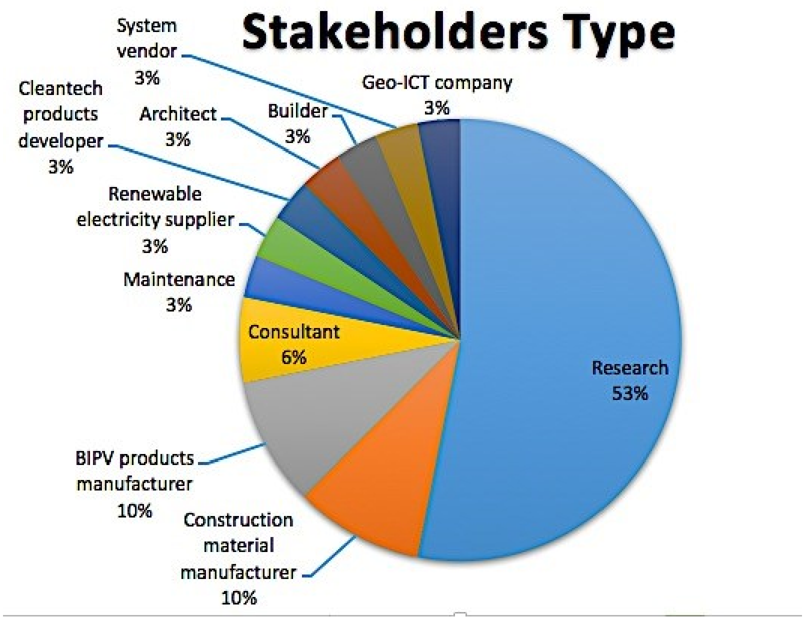
- *EUPVSEC Conference in Munich*
- *Intersolar exhibition in Munich*
- EU PV Clusters in Barcelona

QUESTIONNAIRE AND RESULTS:

A. For which country could you provide feedback on BIPV Market:



B. Which of the following stakeholder categories do describe best yourself - or your organization?



1. ***In its latest new report, industry analyst firm N-tech Research predicts the total market for building-integrated solar photovoltaic (BIPV) systems will grow from about €3 billion in 2015 to over €9 billion in 2019, and surge to €26 billion by 2022, as more truly "integrated" BIPV products emerge that are monolithically integrated and multifunctional.***

Please indicate your level of agreement:

Strongly Disagree: 1

Strongly Agree: 5

Level of Agreement:	**3,15**

2. ***The SET Plan and Energy Union both refer to the importance of energy efficiency and integration of renewable energies, and BIPV is an excellent option in this direction.***

Strongly Disagree: 1

Strongly Agree: 5

Level of Agreement:	**4,27**

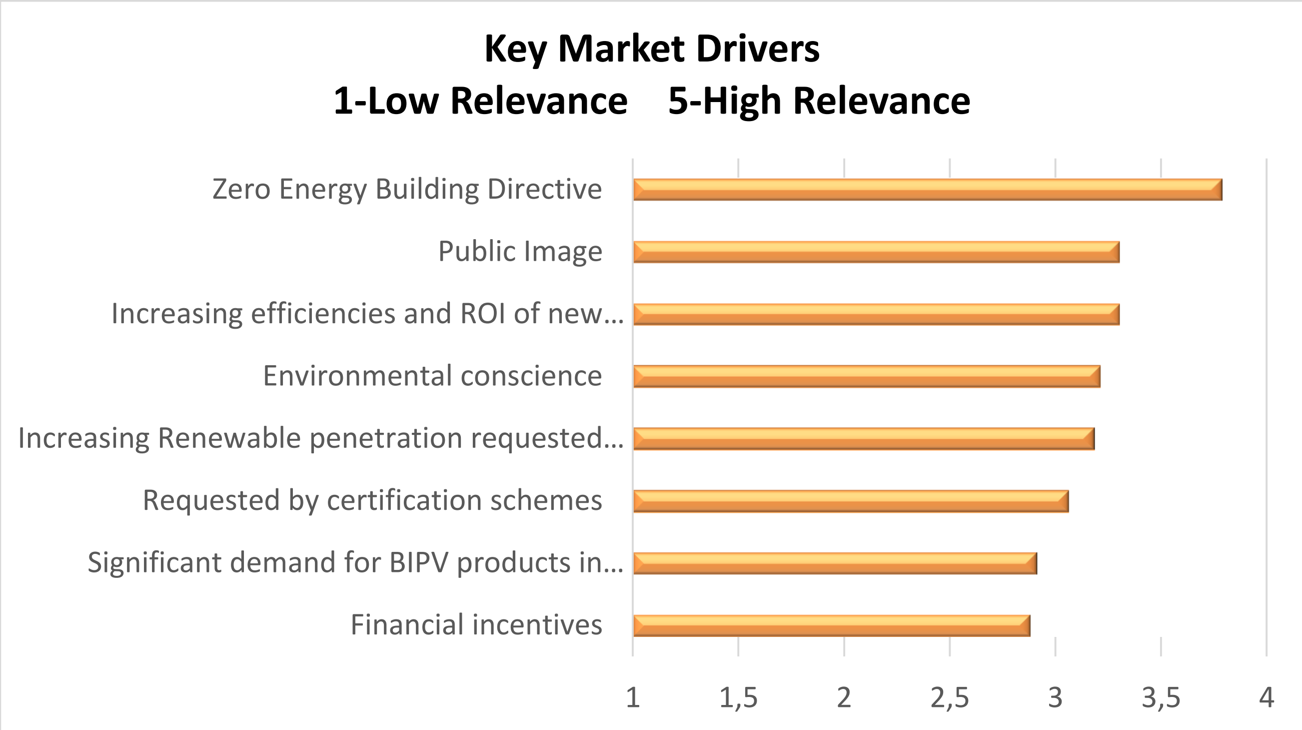
3. ***Regarding BIPV European perspectives, Europe will become a key player, new companies will arise and R&D investments will keep growing.***

Strongly Disagree: 1

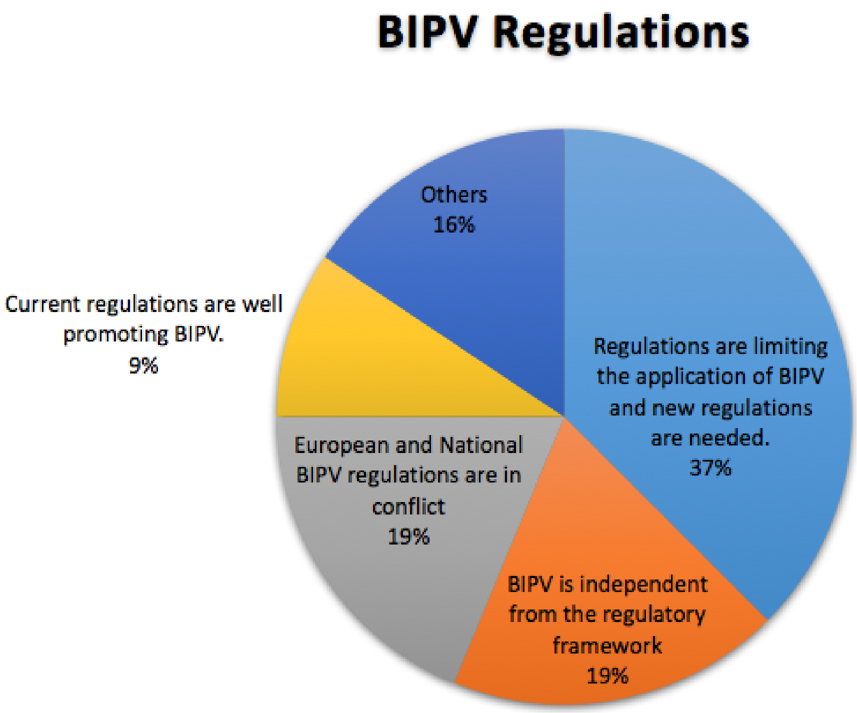
Strongly Agree: 5

Level of Agreement:	**3,36**

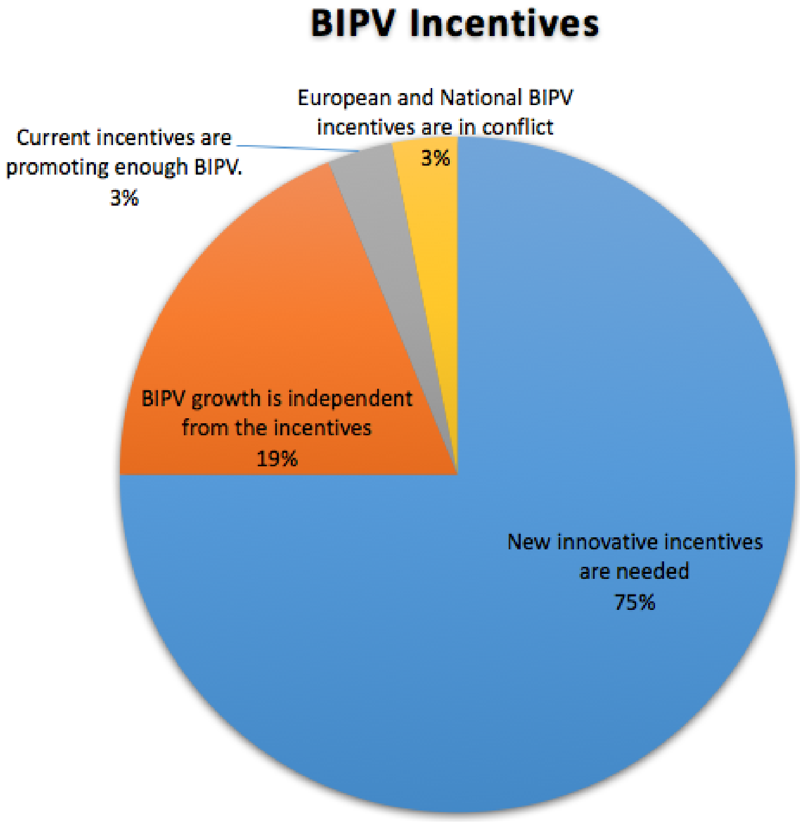
4. *Please rank in terms of priority the BIPV key market drivers in your country.*



5. *Regarding BIPV regulations in your country, where regulations mean the national legislation on construction industry, building standards, etc.*



6. ***Regarding BIPV incentives in your country, where incentives mean financial schemes such as FIT; TAX Reduction, etc.***



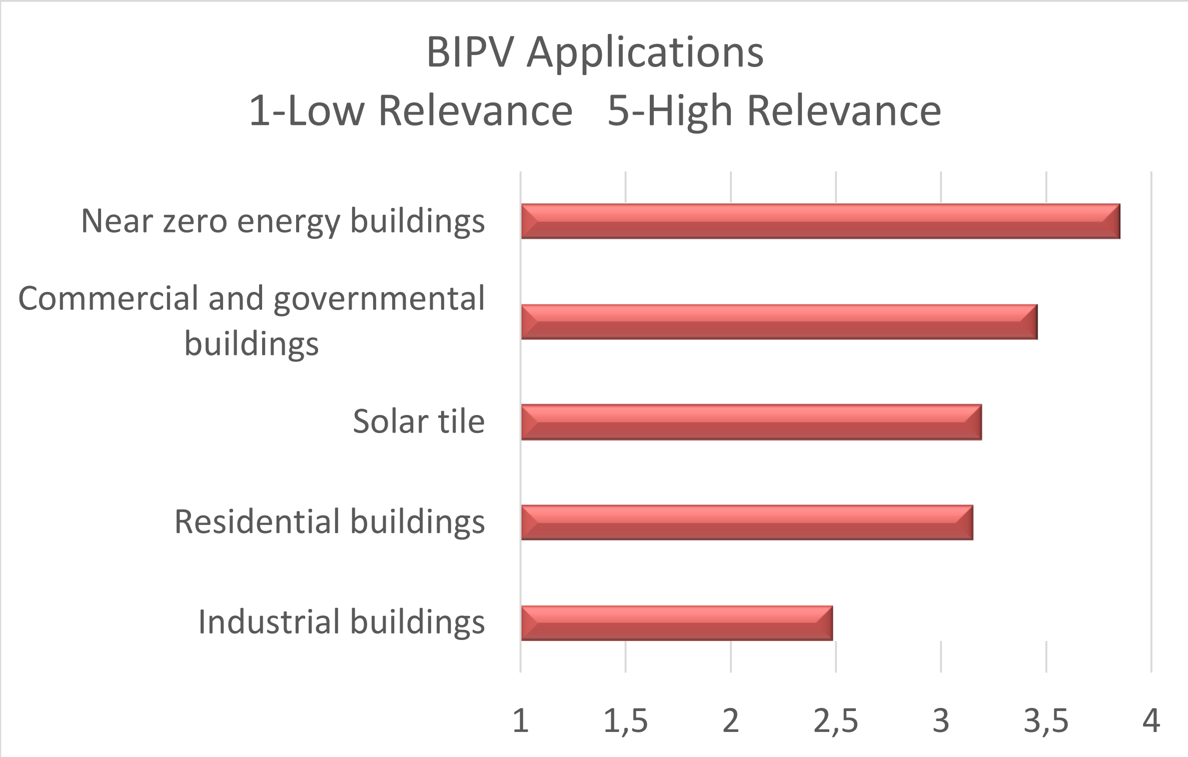
7. ***BIPV could rapidly find an economic justification per se, in the absence of any financial support scheme.***

Strongly Disagree: 1

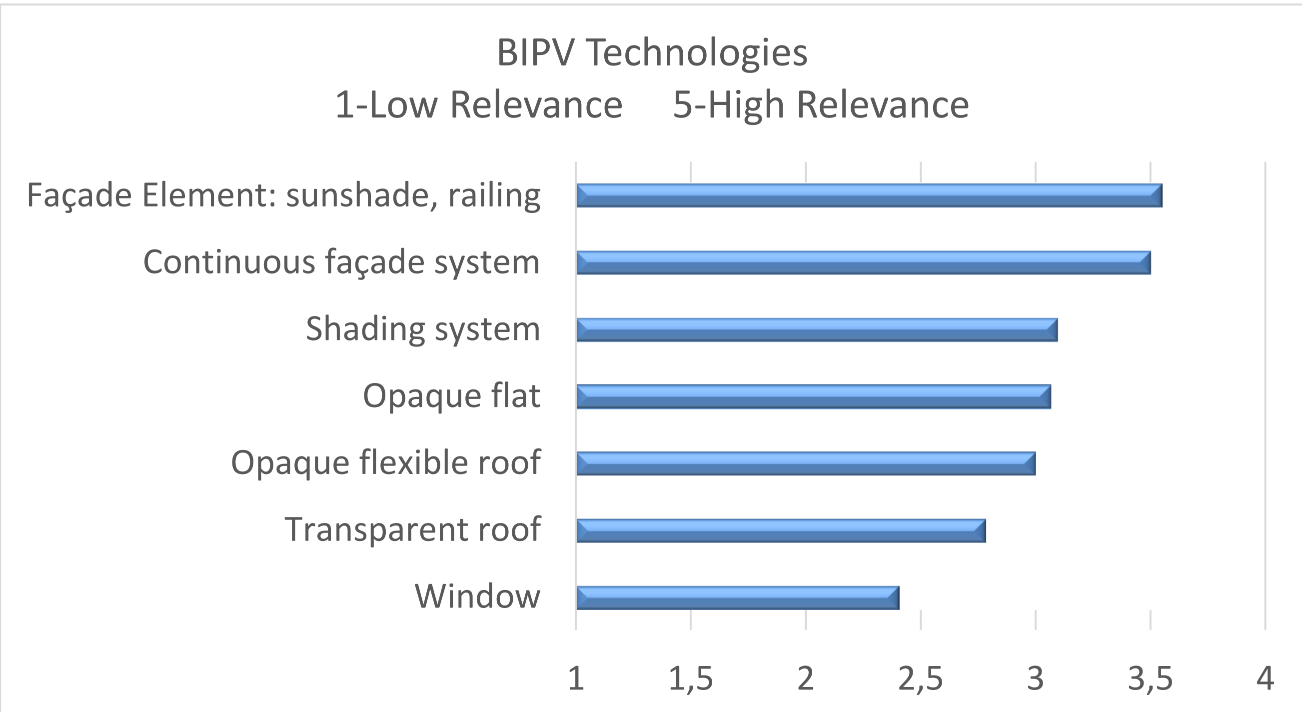
Strongly Agree: 5

Level of Agreement:	**3,21**

8. ***Please rank in terms of relevance the BIPV applications in your country.***



9. ***Please rank in terms of relevance the BIPV technologies.***



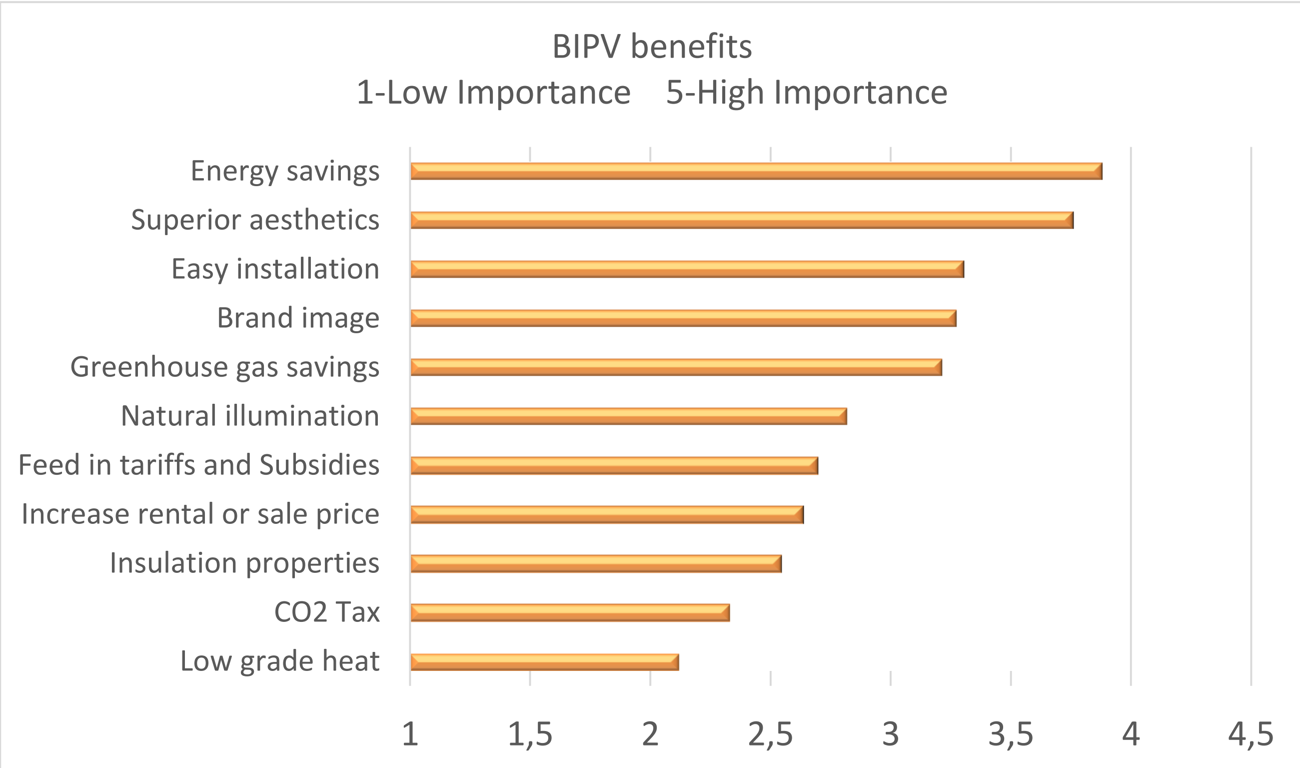
10. Further development of BIPV will require the definition of new "business models" regarding the operations and financing of the projects.

Strongly Disagree: 1

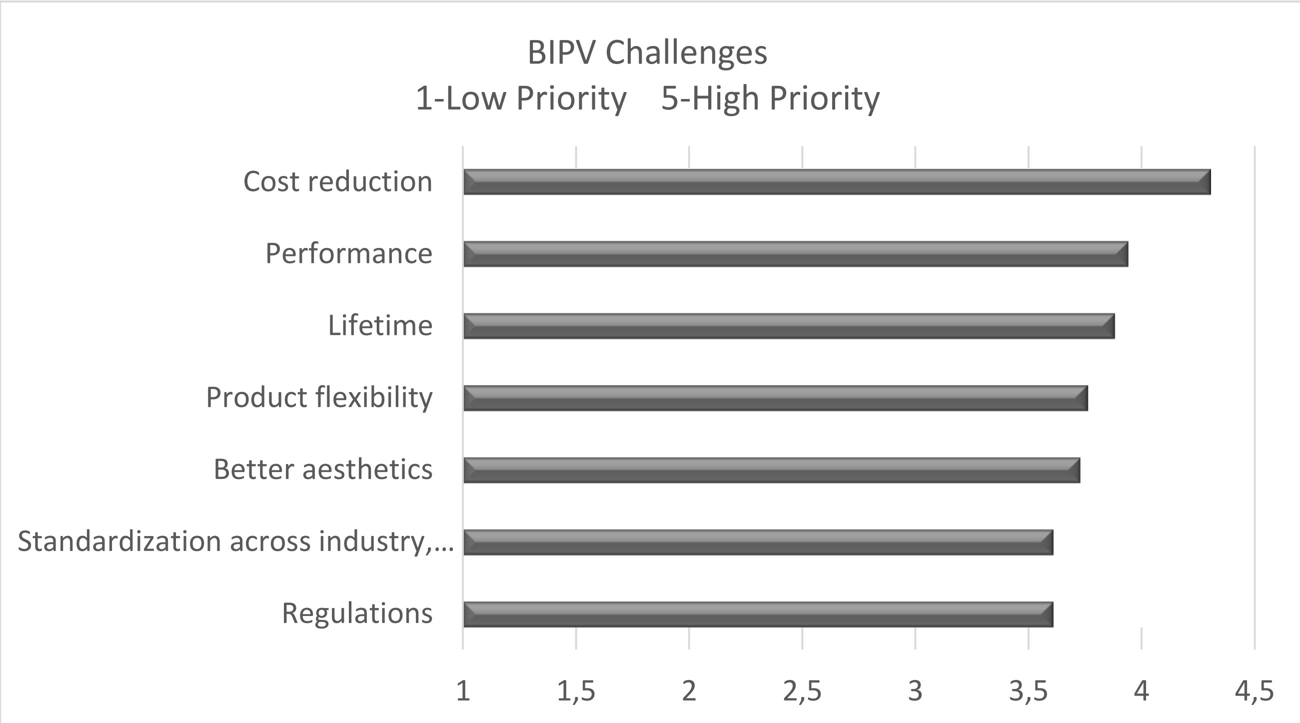
Strongly Agree: 5

Level of Agreement:	**4,09**

11. Please rank in terms of importance the benefits of BIPV in your field and profession.



12. ***Please rank in terms of priority the challenges of BIPV in your field and profession.***



13. ***Most architects remain unfamiliar with PV, which they often see as an additional source of complexity, of project risk and an additional architectural constraint. By what means and with which tools do you see BIPV becoming for architects a usual construction technique, such as super isolating glass or HVAC.***

1. Availability of easy to understand specific product performance information. 2. Independent understandable ranking or comparison of products. Without deep understanding of (BI)PV technology. 3. Easy availability of product specific technical drawings/details. 4. Extensive product libraries and calculation tools for use in regular used BIM software.	With CAD tool which guide Architects to find adapted PV solutions
Education at University stage. Lack of a big company (and related marketing) that sells BIPV solutions	There should be good design cases available, BIPV producers have to look at their product as a component integrated in the building with other materials, and deliver examples of these solutions.
We need to include architects in BIPV product development, and bring BIPV to building schools	Reduce complexity of mounting systems and electrical connection systems; increase flexibility in colors, shapes and forms
Increase in awareness and education. Innovative products which are also nice aesthetically.	1st: availability of many different BIPV solutions from building element industry. 2nd: education and promotion of these products
Not a question of tools: BIPV has to be as easy to install, needs a long term guarantee and requires more awareness from architects and builders (a very conservative industry)	Training, communication, incentives and laws
Providing very flexible products in terms of design, aesthetics, colors, shapes...	Education and awareness -raising
Regulations for compulsory use of BIPV products in newly built houses for energy saving	Develop specific components for and adapted to building construction
Neutral energy building regulations. Familiarization of architects with new BIPV products.	Architects should be consulted by an BIPV engineer for design and organization.
Architects do not use PV enough since it does not offer the flexibility in size and shape they need. As soon there are more variants in standard sizes (such as now is the case for other building materials), architects will start looking for these products. In general architects just simply use google-search to find products they need, but showing products in an construction market is also very useful. Some people suggest that PV products should be included in BIM-files if you want the PV to be used as a standard construction material.	The combination of functionality (e.g. insulation, electricity supply) gives benefits on the one hand side but additional complexity for the different planners. While facade planners take normally care about the Windows and facades a BIPV facade requires to get Involvement from other planners e.g. electrical and HVAC. This is against traditional planning processes and requires more alignment and interaction. So it's not the architect Problem but a building planning Problem.

14. ***Can you please explain the main challenges that have limited the applications of BIPV with respect to your field and in general. Any suggestions for how to overcome them.***

There is not enough collaboration between the construction industry and PV industry with regard to the product application. BIPV is just 'a' building product for the construction industry. Application should be simplified and better match with the normal construction system.	Urban planning regulations and economic incentives
Cost. No suggestions	Apart from standard Si-cell based modules, aesthetically appealing and technically "easy to handle" BIPV systems have to enter the market
Cost	BIPV should be like a building element (on demand, flexible size and color). More investment in manufacturing techniques for building products that allow to build in the PV functionality. Government could give incentives to the building industry (not to PV industry) to develop such products, because building industry is not familiar with 'technological development'
Customer´s investment capacity to be solved through new business models	Cost, aesthetics
Lack of sufficient awareness of the benefits. Culture. Nonexistent incentive schemes to encourage investments.	Regulation and costs
Lack of industrial development	All leakage problems and durability solution suggested in R13
Cost, reliability, products are not standardized and not aesthetic enough	Complex DMU with lack of understanding of BIPV: overcome by training/marketing
Aesthetics, complexity, myths.	- PV panel cost, but this cost are decreasing structurally - Reluctance of architects and project master, it may be exceeded by regulation - Global PV brand image was degraded by the French PV policy since 2010, this sector must be more supported by French policy and European policy - French thermic regulation must impose PV in building

High cost of BIPV products, lack of incentives, lack of regulations, lack of awareness by customers	Integrated process
No obligation and no state incitation	We require BIPV panels with an electronic MPPT concept on panel level and easy stringing. Currently the cost of installation with BIPV as a system (not on panel Level) is more difficult than conventional PV panels.
Awareness, the price, complex design process.	Price difference between standard PV and BIPV caused on lower market share.
The costs	Prices, design, support from the government
Cost and regulation. Cost will be reduced through R&D, mostly. Improvements in regulation will be needed from the nation's government.	BIPV vs. Standard solar module (price)
I am currently working in the field of research and innovation management, but I have a background in architecture and building Physics. What I noticed is that the main challenges are: too high TCO for current BIPV systems, unawareness of key decision makers (house owners, architects and even installers) about what products are available, uncertainty about life-span. Costs are a big thing: working closely together with people in the construction world (that are already used to making roofs and facades) helps to optimize BIPV design. Currently you often see that BIPV products are designed and developed from a PV point of view, instead of optimizing the products based on a construction point of view. Unawareness about the products is also a big challenge: the question is: how did this awareness grow for BAPV systems? And can we learn from that? Apparently the most effective way to grow awareness amongst house owners is to show them examples ('when my neighbor has it, I want it too!)	costs factors