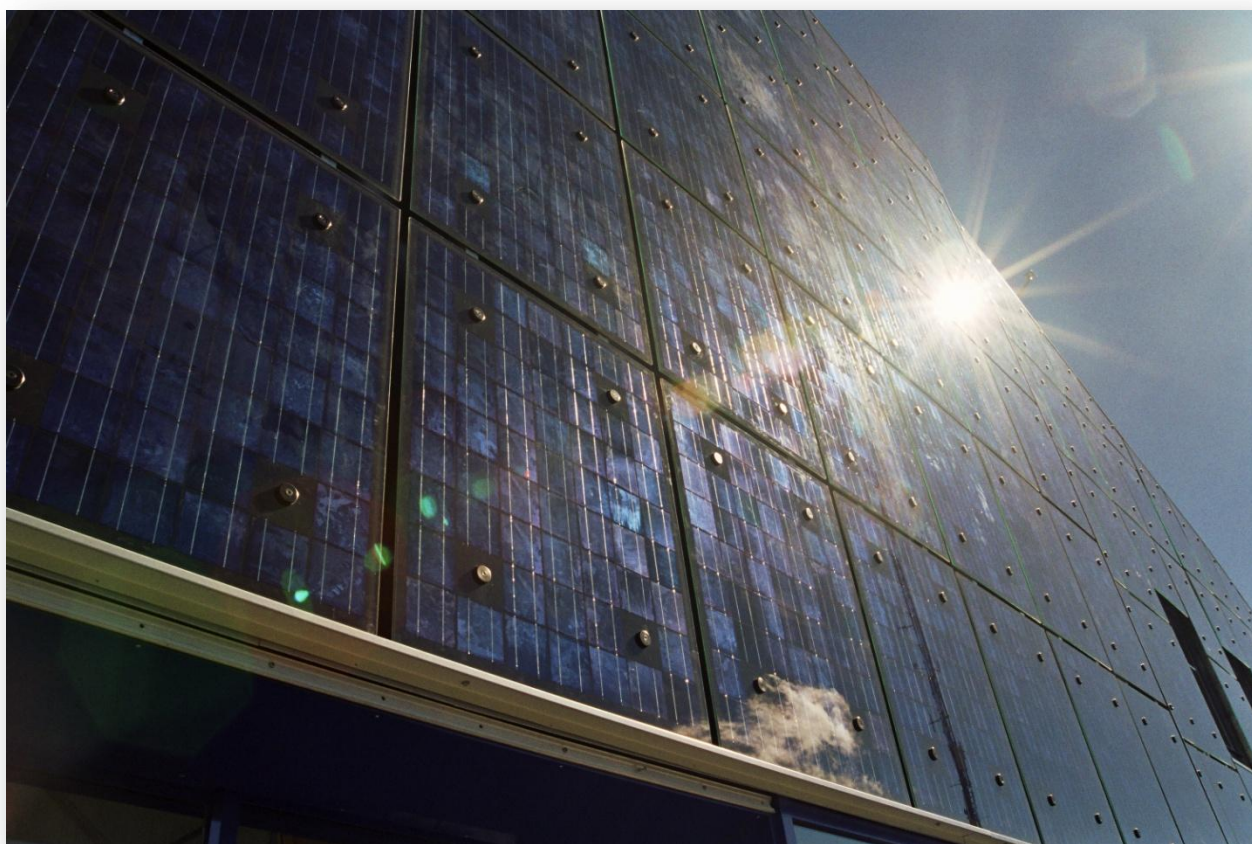


# **BUILDING INTEGRATED PHOTOVOLTAICS:**

## ***AN OVERVIEW OF THE EXISTING PRODUCTS AND THEIR FIELDS OF APPLICATION***



**Report prepared in the framework of the European funded  
project SUNRISE**

Strengthening the European Photovoltaic Sector  
by Cooperation with important Stakeholders





## Table of contents

<b>1. Introduction to the Sunrise Project .....</b>	<b>4</b>
<b>2. Definition of BIPV .....</b>	<b>6</b>
<b>2.1. What is BIPV? .....</b>	<b>6</b>
<b>2.1.1. BIPV as a multifunctional building element .....</b>	<b>6</b>
<b>2.1.2. Different levels of PV building integration .....</b>	<b>8</b>
<b>2.2. BIPV market penetration .....</b>	<b>11</b>
<b>2.3. The legal BIPV definition .....</b>	<b>13</b>
<b>3. BIPV Products overview .....</b>	<b>15</b>
<b>3.1. Classification of BIPV products and their applications .....</b>	<b>15</b>
<b>3.1.1. Standard in-roof Systems .....</b>	<b>16</b>
<b>3.1.2. Semi-transparent Solutions (glass/glass modules) .....</b>	<b>17</b>
<b>3.1.3. Cladding Systems .....</b>	<b>21</b>
<b>3.1.4. Solar Tiles and Shingles .....</b>	<b>23</b>
<b>3.1.5. Flexible Laminates .....</b>	<b>24</b>
<b>3.2. Distribution of BIPV products in the market .....</b>	<b>26</b>
<b>4. Comparison between different BIPV products and cell technologies .....</b>	<b>29</b>
<b>4.1. Comparison between BIPV products .....</b>	<b>29</b>
<b>4.2. BIPV opportunities with different technologies .....</b>	<b>30</b>
<b>4.2.1. Opportunities for Crystalline Silicon PV Suppliers .....</b>	<b>30</b>
<b>4.2.2. Opportunities for Thin-Film PV Suppliers .....</b>	<b>31</b>
<b>4.2.3. Opportunities for 3<sup>rd</sup> generation technologies (Organic PV, Dye Sensitive solar cells) .....</b>	<b>32</b>
<b>4.3. The price of BIPV .....</b>	<b>34</b>
<b>4.3.1. PV Integration in Roofs .....</b>	<b>34</b>
<b>4.3.2. PV integration in Facades .....</b>	<b>35</b>
<b>4.3.3. Future prices .....</b>	<b>36</b>
<b>5. Conclusions .....</b>	<b>36</b>
<b>6. References .....</b>	<b>39</b>

## 1. Introduction to the Sunrise Project

SUNRISE is a Co-ordination Action type project financed within the 6<sup>th</sup> Framework Programme. The main aim of the SUNRISE project is to support the key objective to reduce costs of PV systems by achieving further growth to compete in the liberalised energy market of the future. The co-operation with important stakeholders and networking with the European PV industry needs will lead to cost reduction as a direct result of stimulating market demand. With the anticipated reduced levels of subsidies, the manufacture of PV systems needs to be more cost-effective if the PV industry wants to be competitive with conventional energy production. Therefore, the SUNRISE project delivers the basis for ensuring a cost-effective supply of PV products by improving interaction and production processes within the European PV industry and through involving all relevant stakeholders, in particular those in the construction sector, utilities, planners and architects.

Work Package 1 “PV Diffusion in the Building Sector” aims to improve the cooperation with and uptake of BIPV in the building sector. The main target group of this work package are architects, planners and PV module manufacturers. On one hand, architects (and also construction

companies) need to be convinced that PV systems are a reasonable alternative or complementary competitive solution in satisfying energy needs in comparison with other solutions. On the other hand, PV module manufacturers and the building sector have to collaborate in developing new products – not only for roof-top installations but for building-integrated PV modules that not only generate electricity but also replace other traditional construction materials (e.g. sun-breakers, roof tiles, and glass panes). All energy related features of buildings, e.g. energy consumption characteristics, play an increasing role in the sustainability and life cycle costs of buildings. Therefore a PV system can contribute significant added value to buildings in terms of value and image.

**The main objectives of Work Package 1** are:

- To identify the barriers that militate against the integration of PV in buildings
- The transition from Wp to Wh to help architects in the calculation of KWh / year produced by the PV modules integrated into buildings
- Draft proposal for standardisation and regulation for PV modules to be integrated in buildings in order to match

the standards and regulations applicable in the construction sector.

The Work Package includes awareness raising events in particular a Campaign for BIPV, targeted at the interfaces between stakeholders potentially interested in introducing BIPV products and additional workshops aimed at raising the awareness of architects and builders in order to encourage them to integrate PV and Renewable Energy Technologies in their designs. Information on the SUNRISE project will be presented during the major European events arranged across the building and construction sector to ensure that architects and builders become increasingly aware of the added value and advantages offered by BIPV.

## Report Objective

This report aims to give a general overview of the type of building integrated PV products commercially available. One of the objectives is to show the different levels of building integration which results into certain advantages and drawbacks. Understanding the definition of what is considered BIPV and what is not will be fundamental for project developers applying for special premium tariffs in those countries where these mechanisms exist and be rewarded by the added effort and cost of integrating PV modules to the building envelop.

Finally, the authors of the report provide a comparison of the different existing products and their potential applications, a comparison between PV technologies and some indications on estimated product prices.

## 2. Definition of BIPV

### 2.1. What is BIPV?

Essentially, Building Integrated Photovoltaics (BIPV) refers to photovoltaic cells and modules which can be integrated into the building envelope as part of the building structure, and therefore can replace conventional building materials, rather than being installed afterwards. Rather than sticking out like a sore thumb, BIPV modules can be naturally blended into the design of the building. The beauty of BIPV lies in the name: it can be used in any external building surface.

Together with the evolvement of the integration of modules in the architecture, the new BIPV products are able to fully replace some building components - the construction parts of the building envelope (roofing, facade cladding, glass surfaces), devices, sun protection (sunscreens), architectural elements and accessories "(porches, balconies, railings, etc.) or for instance, elements of visual and acoustic shielding. Within the BIPV definition, also plants integrated in urban and transport structures (independent shelters, shelters for vehicles, sports or play, bus stops, etc.) are considered.

This definition excludes therefore building "independent" installations such as modules mounted on roofs or supports attached to other parts of the building that do not assume any other function in addition to electricity generation. The later types of installations are known as BAPV (building adapted/applied PV).

#### 2.1.1. BIPV as a multifunctional building element

BIPV is a multifunctional technology. Besides of being a source of electricity, several other purposes can be achieved, such as weather protection, thermal insulation, noise protection or modulation of daylight. For instance, they can be used to regulate the intake of daylight to a building by powering an automatic sun-blind, operate an engine driven ventilation opening or even as emergency lighting. Furthermore, they act as a public demonstration of a building owner's green ecological and future-oriented image.



The following is a non-exhaustive list of the functions that PV modules can perform beside the fundamental production of electricity:

- Noise protection (up to 25 db sound dumping is possible)
- Thermal insulation (heating as well as cooling), improving the efficiency of cells by cooling through rear ventilation, isolation function is possible as well.
- Visual cover/ refraction (one-way mirroring visual cover)
- Electromagnetic shielding (can be used as Faraday cage but also as repeating antennas)
- Aesthetic quality (integration in buildings as a design element)
- Safety (safety glass function is possible)
- Weatherproof (waterproof and windproof façade or roof of a building)
- Sun protection/ shadowing (degree of shadowing is eligible through positioning and degree of transparency)



Figure 1. Multiple functions of PV modules. Source: Multielement project

### 2.1.2. Different levels of PV building integration

PV modules can be applied into the building envelope in several forms. Depending on their level of integration and on the functionalities they can perform, they are classified into:

**BAPV (Building Adopted/ Applied Photovoltaics)** refers to concepts where the photovoltaic systems are mounted on top of the building existing structure and therefore do not add any additional value beside thus of producing electricity. BAPV is normally added to the building after the process of construction is finished.



Figure 2. BAPV installation. The Modules are installed on top of the existing roof

**BIPV (Building Integrated Photovoltaics)** on the other hand, signifies that photovoltaic elements have been present in the project from the very beginning – are a part of a holistic design. Thus, for the BIPV, solar

modules have the role of a building element in addition to the function of producing electricity. The large variety and different characteristics of the available BIPV products makes it possible for them to fully replace many of the building components, mainly in façades and roofs.



Figure 3. BIPV installation. The Modules are seamlessly integrated as part of the roof

The Building envelope guarantees a border between the controlled inner building environment and the outer climate. It has to provide a stable air-quality, preventing the uncontrolled air mass exchange and enabling the appropriate functioning and efficiency of the air-conditioning systems. Moreover it is bound to be waterproof and fulfil the priority of ensuring the comfortable inner-climate with the possibly least energy expense. Thus, facades and roofs takes over a regulation and control functions in relation to the daylight, ventilation, energy, safety, demarcation and privacy protection, etc. When the Photovoltaic Modules are to be integrated in the building envelope, all



these elements need to be considered during the design phase in order to obtain the most suitable product. Additionally, other requirements (from the aesthetics as well as from the pure construction point of view) are to be met. Those are for instance:

- colour, appearance, size
- weather-tightness
- wind and snow load
- resistance and maintenance
- safety in the construction and utilization phases (fire, electricity and mechanical safety)
- costs
- weight and materials used

**BIPV Fastening Systems** refers to those systems which allow the building integration of the most PV modules currently available on the market (standards modules often without frame). While being able to fulfill the need of the building envelope, they present one of the most competitive solution since they can be produced at large scale in the factory thus reducing its cost. Their installation can also be easier since most PV installers will be familiarized with their mechanical and electrical characteristics. This type of solution is mostly applied into pitch roofs and external building walls as cladding element since they are completely opaque.

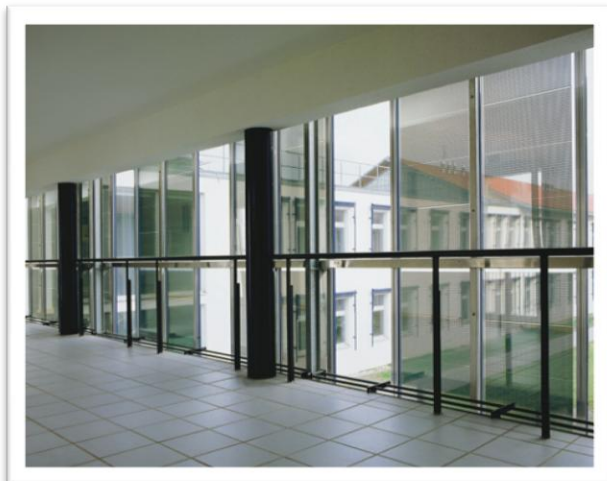


Figure4. BIPV installation. Semi-transparent facade based on Thin Film technology (Schott Solar)



Figure 5. Fastened BIPV system on a pitch roof. This system allows a simple and quick assembly of the modules. It is a system meant for aslope roofs and requires an impermeable roof covering that has to end in the eave (Schüco)

**Other BIPV systems:** Besides the uses of PV in residential, commercial and industrial building, there are number of urban and transport structures where PV can be seamlessly integrated. This could include independent shelters, shelters for vehicles, sports or play, bus stops, parking meters, sounds barriers and many other solutions.



Figure 6. Car Shelter based on thin film technology. In the future, these elements will be used for the charging of electrical vehicles (First Solar)



Figure 7. The 500kWp sound-barrier with ceramic based PV modules installed next to the Munich airport (Isofoton)

## 2.2. BIPV market penetration

In 2009 the total volume of PV installations reached 5.6 GW in Europe and 7.2 GW worldwide. Cumulative installed PV capacity is about 16 GW in Europe and about 23 GW worldwide. BIPV still only makes up a relatively small part of this, besides the fact that the concept already exists for many years. The main reason for this slow deployment is that BIPV installations are still more expensive than conventional PV installations. Therefore, targeted support for BIPV is needed in order to trigger market growth. Such targeted BIPV support should provide higher revenue per kWh generate to compensate the higher product cost as well as the higher installation cost. Market growth will consequently increase production volumes stimulating the

production of more cost-competitive products, which will again trigger further market growth.

The year 2009 was definitely not the most successful year for BIPV companies. Due to the economic downturn that affected not only the PV industry but specially the construction sector, BIPV has known severe difficulties. However, the PV market recovered quickly thanks to the larger than expected German and Italian markets and the quick developments in smaller markets such as Belgium and the Czech Republic. The PV industry decided to continue emphasizing BAPV and ground-mounted installations and the path of BIPV was somehow left aside.

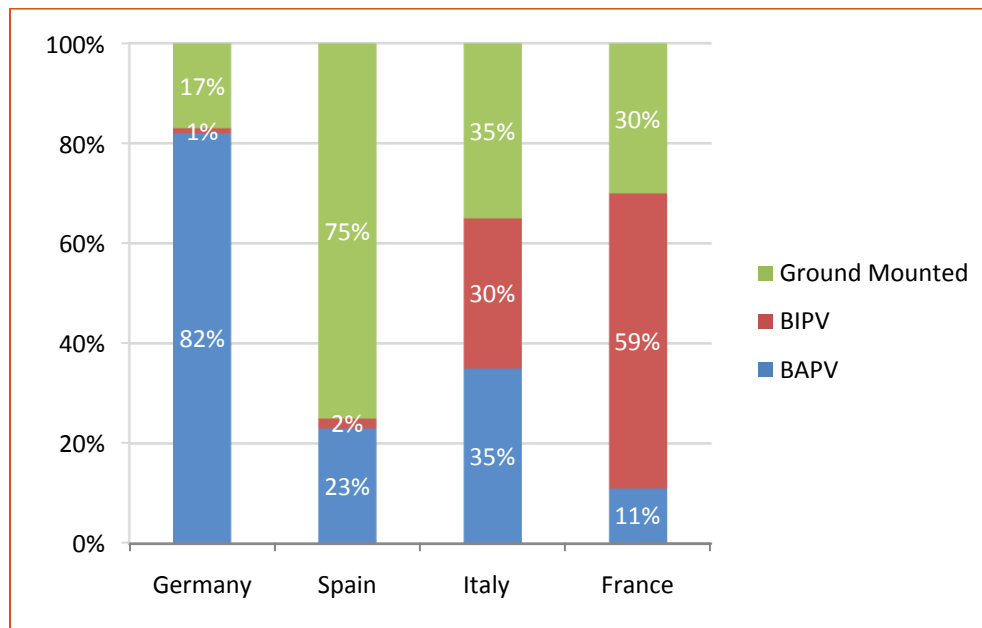


Figure 8. Market segmentation for the four key European markets in 2009.  
Source: EuPD Research.

In Europe, it is estimated that in 2009 about 400 MW (about 7%) were building integrated (BIPV) installations. Figure 8 shows the market segmentation for the four key European PV markets in 2009. It indicates clearly that the share of BIPV differs significantly between the countries.

In Germany (the largest worldwide market), while over 80% of the market is based on roof-top application, just 1% of the installations in 2009 were fully integrated into the building environment (see figure 8). Also in Spain, where ground-mounted installations always have been very popular, BIPV only accounts for 2% of the 2009 market. Most of these relatively scarce BIPV installations are present in commercial and public buildings.

In some other countries, the benefits of BIPV (its multi-functionality, its appealing aesthetics and its ability to be a building product in its own right which transforms an

inert roof/facade surface to be an unobtrusive active energy generator) have been acknowledged. In these countries, the BIPV market has been rapidly growing thanks to specific targeted BIPV support mechanisms. This is the case in Italy and France, where the share of BIPV in 2009 was about 30 and 60% respectively (see figure 8).

All countries in Europe that have a special support mechanism for BIPV (this can be a special FiT or a tax incentive, investment subsidies, etc...) are the following: Austria, Czech Republic, Denmark, France, Italy, Slovenia, Switzerland and Spain (see table 1 for an overview of the types of support schemes available in different countries in Europe). In all the other European countries, there are no specific incentives for BIPV. However, in some countries, special requirements for newly built buildings take into account the potential of PV (and BIPV); an example is the “Building Planning requirements” in the UK.

Country	Type of Support
<b>Austria</b>	Investment subsidy
<b>Czech Republic</b>	Investment subsidy
<b>Denmark</b>	Investment subsidy
<b>France</b>	FiT and investment subsidy
<b>Italy</b>	FiT and investment subsidy
<b>Slovenia</b>	FiT
<b>Spain</b>	Investment subsidy
<b>Switzerland</b>	FiT

Table 1. Overview of the types of support schemes that target BIPV differently in European countries. Source: EPIA, DENA



While about 7% of the total installations in 2009 in Europe were BIPV systems, the share of BIPV worldwide is estimated to be even smaller; about 5% of the 2009 installations. In 2009, Japan and the US (the two biggest markets outside Europe) accounted for almost 1 GW of installations in 2009. Moreover, almost 19% of the cumulative installed capacity worldwide has been installed in these countries.

In the US, most of the installations are BAPV and ground-mounted systems; and the latest are expected to grow rapidly in the following years since electricity utilities are driving the demand. BIPV only accounts for a small market share of the total PV installations; there is no specific tailored FiT or other policy support for BIPV at the moment.

The Japanese on the contrary have been working on BIPV since the beginning of the 1990s and since 1998 they are performing

field tests for different products. Most of the PV installations in Japan are BAPV ones, because there is a lack of space for the installation of large ground-mounted systems and because subsidy-support in the past was focused on residential market. Nowadays, Japan offers a Fit (established in 2009) that treats all PV in residential applications (<10kWp) in the same way, regardless of their integration level.

Also in other markets outside Europe, the development of BIPV is being promoted. Examples are Malaysia, South-Korea, China and Canada. In most of these countries, there is some form of targeted support or, at least, clear development targets for PV in buildings exist. However, as the line between BIPV and BAPV is sometimes fuzzy, it is very important to agree on a common definition for BIPV to avoid different perception of the concept worldwide, as explained in the following chapter 2.3. The legal BIPV definition.

## 2.3. The legal BIPV definition

In section 2.1, a general description of what can be considered BIPV is given. This definition helps the reader to understand better the terms used by the PV sector and to realized the several levels of integration

that can be achieved. However, in those countries where a targeted BIPV support mechanism exists, the legal definition made by the government and administration is the one which matters. BIPV products need to

comply with the definition if they are to get the BIPV special tariff (higher revenue). The definition is very important in France and Italy where the BIPV tariff is attractive and the market are large enough. The definition will influence some PV manufacturers as they try to develop products that, while falling under the BIPV legal definition, they present a competitive approach (standardized products manufactured at large scale). This is exactly the concept that “BIPV fastening products”, as well as “standard-in-roof systems” (see section 3) try to reflect.

**The legal definitions of BIPV for France and Italy can be found in Annex 1 and 2 respectively.**



### 3. BIPV Products overview

#### 3.1. Classification of BIPV products and their applications

Based on the function, the materials used and its mechanical characteristics, BIPV products can be classified in five **main categories**:

- Standard in-roof systems
- Semitransparent systems (glass/glass modules)
- Cladding systems
- Solar tiles and shingles
- Flexible laminates

Each of the above mentioned categories has a specific market to be addressed, although they all involve the same types of technologies, namely c-Si and thin film (excluding the flexible laminates, where only the thin film technology is widely applied).

Within those categories different types of **applications** are addressed, the main being:

- Pitched roofs
- Flat roofs
- External Building Walls
- (Semi-) transparent facades
- Skylights
- Shading systems

This is a very general division. One has to note that there exists a great deal of projects and buildings requiring tailor made products, which are being developed only for single client/design and thus a simple classification is not easy.

Type of application \ Type of product	Pitched Roofs	Flat Roofs	External Building Walls	Semi-Transparent Façades	Skylights	Shading Systems
Standard in-roof systems	✓					
Semitransparent systems (glass/glass modules)				✓	✓	✓
Cladding systems			✓			
Tiles and shingles	✓					
Flexible laminates		✓				

Table 2. Overview of BIPV solutions and their fields of application

### 3.1.1. Standard in-roof Systems

Standard in-roof systems are the simplest and most common approach to BIPV taken by the crystalline silicon PV industry by just modifying existing panel designs and mounting systems to make them thinner, more uniform, and flush-mountable on top of existing roofing or siding. Some purists would not consider products produced like this—and applied over conventional building materials—to be true BIPV products, however this is debatable. In any case, they represent an important approach to building integration that is still going strong. And this approach also makes sense from the manufacturer's perspective because minimal retooling and redesign is needed and these flat panels are well-suited to the crystalline silicon industry.

As the products do not differ significantly from the conventional panels, they represent low risk investment, guaranteeing similar conditions to the customers.

#### Pitched Roofs

The main application for this type of solutions is pitched roofs as they can easily be fixed on top of them. Their installation can be easier than many other BIPV solutions since most PV installers will be familiarized with their mechanical and electrical characteristics and there is no need to hide cables, for instance. These solutions require an impermeable roof covering that has to end in the eave.



Figure 9. Roof-mounted solar power system. Source: Daviddarling.



Figure 10. Oryon. Waterproofing system using standard laminated PV modules allowing an esthetical integration and optimal performance. Source: Solstis

### 3.1.2. Semi-transparent Solutions (glass/glass modules)

Although glass/glass based modules are currently still not enough transparent to let in enough sunlight where it is the most needed, they are integrated where only some sunlight penetration is required, being added mainly for aesthetical reasons rather than structural. They are also commonly used to provide sun/wind protection to building surfaces and interiors. The market sectors where these types of BIPV are commonly used are skylights, semi-

transparent facades, curtain walls and shading structures (canopies, atrium roofing). The amount of light desired to go through the designed structures can be customized by dimensioning and adjusting the number and spacing of cells in the case of crystalline silicon technology or by modifying the manufacturing process in the case of thin-film. In both cases the more transparent the module, the lower the energy efficiency.

These products are used usually for commercial and prestigious buildings, designed to provide a great deal of natural



lightning by using large areas of semi-transparent window-like areas. High visibility of those projects/constructions guarantees wide opportunities for BIPV suppliers.

Within this group we can distinguish applications such as:

### Skylights

These structures are usually one of the most interesting places to apply PV. They combine the advantage of light diffusion in

the building while providing an unobstructed surface for the installation of PV modules. In this type of application, PV elements provide both electricity and light to the building. Modules and support structures used for this type of application are similar to those used in semi-transparent glass façades. The structures are able to produce interesting light hallway walks and floors and can stimulate architectural design of light and shadow.



Figure 11. Greenhouse in Munich. Source: Design-BuildSolar.

A greenhouse renovation project undertaken by SAPA Solar. The installation was financed by the city of Munich. Some glass was substituted by solar see-through panels, however since direct solar rays are harmful for some of the tropical plants in the greenhouse, modules with 35% transparency were also integrated in the roof.

### (Semi-) transparent façades

Glass PV laminates can be applied to windows providing a semi-transparent façade. The transparency is normally achieved using either of the following methods:

- a) The PV cell can be so thin or laser grooved that it is possible to see through. This will provide a filtered vision to the outside. Semitransparent **thin-film modules** are especially appropriate for this application (see figure 12).

- b) **Crystalline solar cells** on the laminate are spaced so that partial light filters through the PV module and illuminates the room. Light effects from these panels lead to an ever changing pattern of shades in the building itself. The rooms remain shaded, yet not constrained. Adding layers of glass to the base unit of a semitransparent PV glass module can offer thermal and acoustic insulation, for example (see figure 13).



Figure 12. BIPV Project - OLV hospital Aalst, Belgium. Source: Design-BuildSolar.

The eye-shaped curtain wall of the hospital hall has a 500 m<sup>2</sup> surface area and over 18,000 polycrystalline cells that produce 31,122 kWh a year. A self-cleaning facade surface with a draining system that rinses away any settled dust was installed. The photovoltaic cells were incorporated in between two plates of safety glass. These pre-assembled modules – which are 120x240 cm in size – are connected by aluminium frame sections with built-in thermal breaks and integrated.



Figure 13. Semi-transparent facade based on Thin Film technology (Source : Schott Solar )

### Shading systems

There is a growing need for carefully designed shading systems due to an increase in the use of large window openings and curtain walls in today's architecture. PV modules of different shapes can be used as shading elements above windows or as part of an overhead glazing structure. Since many buildings already provide some sort of structure to shade windows, the use of PV shades should not involve any additional load for the building structure. The exploitation of synergy effects reduces the total costs of such installations and creates added value to the PV as well as to the building and its

shading system. PV shading systems may also use one-way trackers to tilt the PV array for maximum power while providing a variable degree of shading.





Figure 14. Council's 'Customer First Centre', Romag BIPV PowerGlaz application, Hackney, UK. Source: Design-BuildSolar.

One of the more recent Romag BIPV installations is in the London Borough of Hackney, UK, where PowerGlaz covers the glazed roof of the local Council's 'Customer First Centre'. The project involves approximately 600 panels, most of which are insulated glass units. Ninety-six are PowerGlaz BIPV modules and additionally, in areas of 'shading', PowerGlaz 'dummy' modules were installed. All the PowerGlaz BIPV and non-PV panels meet demanding performance specifications for 'solar shading' and insulation.

In the case of the PowerGlaz modules the mono-crystalline PV cells were strategically spaced to meet the solar shading requirement.

### 3.1.3. Cladding Systems

Solar panels can be integrated into building walls as a conventional cladding element. The creation of a "cladding void" helps to, firstly, regulate the internal temperatures of the building by minimising solar gain in the summer and, secondly, by encouraging a 'thermal stack effect' which helps to draw air through the building spaces. This helps to minimising the year-round energy demand of the building, to keep the PV modules operating at their highest efficiency and so maximises the contribution of the PV to the building's energy requirements.

This application therefore minimises the building's overall energy demand to further reduce overhead energy cost (see figure 15).

To obtain good ventilation behind the modules is important so that the PV system can work at full efficiency; if this is not possible, the performance will be reduced but the system will continue to work (approx. 10% loss of performance).

In many cases, standard modules (frame or frameless) are used for such application although the use of tailored made modules

is sometimes requested in order to match the facade specifications. Glass PV laminates, replacing conventional cladding material, are basically the same as tinted

glass. They provide long-lasting weather protection and can be tailor-made to any size, shape, pattern and colour.

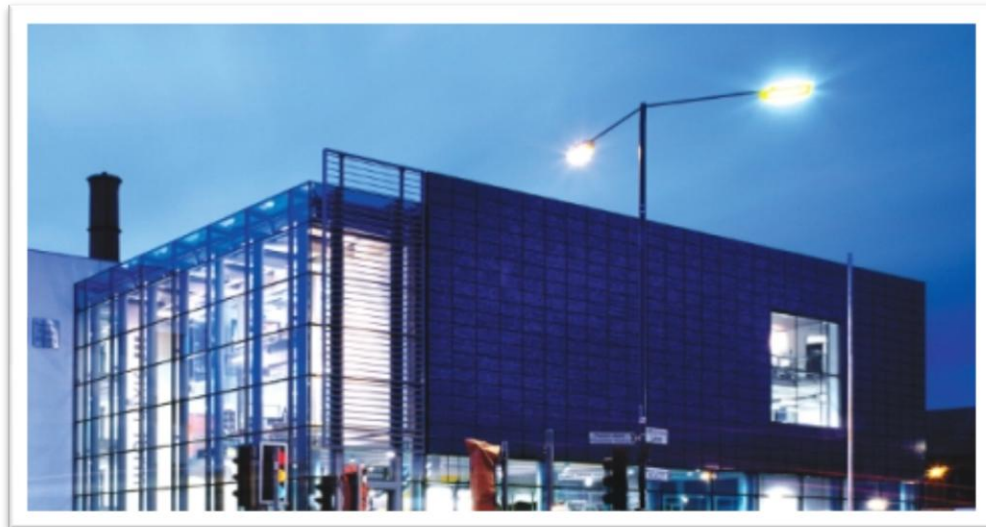


Figure 15. Manchester College of Arts and Technology. Source: Design-buildSolar.

Manchester College of Arts and Technology have incorporated visionary design and building innovation in their North Manchester Sixth Form Centre and Library in the Harpurhey area of the city. The south facade of the building is clad in a monolithic array of solar PV modules. Taking advantage of the building's flat roof, rows of PV modules crown the building providing further clean energy. A total of 482 80W polycrystalline modules are used in the cladding design with a further 178 165W modules providing the roof top power system.



Figure 16. Living Tomorrow Brussels, Belgium. Source: Design-buildSolar.

For the exterior of the Living Tomorrow entrance, Elegance 52 GF, curtain wall using Sapa Building Systems was specified with PV integrated glazing.

### 3.1.4. Solar Tiles and Shingles

The currently available on the market products of this category include i) tiles, designed to interlace with conventional roofing tiles or cladding materials; ii) larger tiles that serve as entire roof or wall portions themselves; and iii) thin, flush-mounted panels that overlay conventional roofing or siding but specifically designed for that purpose.

Many proprietary roof-integrated BIPV systems are available, since the design of a PV tile/shingle has to adapt to regional/local roofing methods and building. Therefore the

market for one particular BIPV roofing system may not be applicable to a wide range of countries.

Products such as flexible PV roofing shingles and analogically rigid PV tiles enable reasonably and cost effectively allocating expenses between power production and design/architecture.

The main category of applications where PV tiles and shingles are used are **pitched roofs**. In this type of application the most common solutions are photovoltaic roof tiles with mono- or polycrystalline solar cells used together with the classical roof tiles.



Figure 17. Sunslates. Compatible with large Swiss Eternit slate. Source: Solsticeenergy

A PV tile/shingle roof should be very well ventilated. The sub-construction consists of a batten system, which should be at least 50 mm high to guarantee the ventilation. A roof surface has to be suitable for the assembly of the tiles/shingles if the roof - south facing (or west/east). It also has to remain un-shaded, (by building, high trees etc) and ideally have a slope of 20 degrees or more.





Figure 18. London Transport Museum. Source: Sundog

With a power of 51.5kWp, the London's transport Museum's roof was renovated in 2006 by using a combination of Redland PV tiles and some standards modules. The individual "tiles" are linked with electrical plug-type connectors to form larger units.

### 3.1.5. Flexible Laminates

Flexible laminates are designed to be attached onto existing building materials such as metal roofing. They provide some specific features, which the rigid, conventional ones do not.

Products from this group use newer and innovative materials platforms (such as thin-film and organic PV) and can be used in a variety of different applications, mainly **flat and curved roofs**.

Flexible PV by definition rules out the use of c-Si, due to its rigidity. Therefore it is thin

film that is used within this category of products. Many of the flexible modules are designed to avoid conventional framework of rigid panels and can be adhesively bonded to roofing materials. They bring along many advantages like light weight, avoidance of heavy wind loads (because they do not allow wind beneath them) and avoidance of rack mounting system since they can be directly glued to the roofing material.

Thanks to the above mentioned features, the mounting procedure of the panels on roofs as well as other building structures is different (easier) than the conventional, rigid

ones. One of the products belonging to this group is a high performance single ply waterproofing membrane with integrated flexible and lightweight PV modules. Supplied on rolls it offers the benefits of the waterproofing membranes with the advantage of converting solar energy to electrical power. This kind of building integrated products, allow easier planning permission on new build and retro fit projects.

### Flat and Curved Roofs

Flat roofs have the advantage of good accessibility, easy installation and provide a free choice for the orientation of the PV units. Care must be taken during the fixing of the array to avoid breaking the integrity of the roof. The added weight of the PV array on the roof must be considered, as must the uplifting force of the wind, which can blow the modules away. Modules for flat roofs integration can be made of fibre elements and in different sizes with multiple possible configurations, which results in easy maintenance and a quick interlocking mounting process.

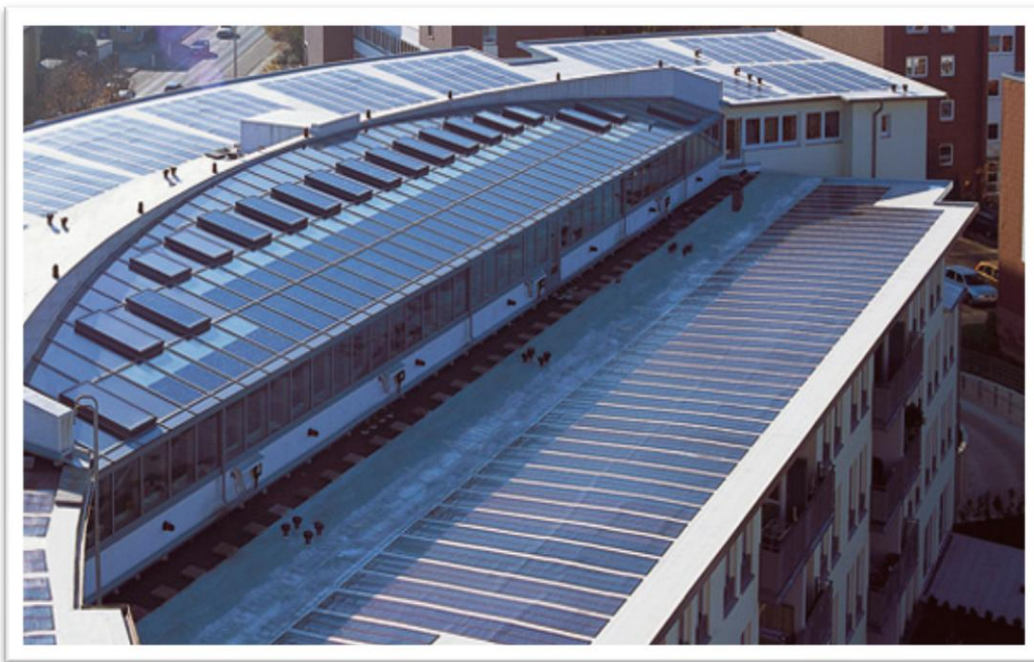


Figure 19. Membrane Evalon Solar (Source: Alwitra).

The PV-cells used in Alwitra®'s EVALON®-Solar system consist of layers of amorphous silicon vapour deposited on a stainless steel substrate and pick-up grid which, combined into modules, are then integrated in manufacture with EVALON® single-ply roofing membrane. The result is a combined high-performance roofing membrane and source of electricity generation, installed in a single process.



Figure 20. BIOSOL Thin Film Plate. Source: Centrosolar

### 3.2. Distribution of BIPV products in the market

About three quarters of BIPV applications are currently based on crystalline silicon technology. It is estimated that it makes up for more than 70% of the total BIPV products sold on the market (see figure 21). This is also foreseeable since it is the most mature technology and it represents about 85% of the overall PV market.

The products based on crystalline silicon are normally the standard in-roof panels and cladding systems, (semi-)transparent modules and the rigid PV tiles and shingles. Crystalline silicon is still very popular for BIPV applications because conventional

panels can be easily adapted for building integration; in fact this is the most economical approach to BIPV. Because most PV companies are active in the field of conventional crystalline silicon panels, many of them have made the step towards BIPV.

Thin film technologies make up the remainder share of the marketed products. Most of the products using thin film technology are those that can make optimal use of the benefits of thin film, namely their ability to be made flexible and their good performance under diffused light conditions. As their module efficiency tends to be lower



than for crystalline silicon module, the cost per m<sup>2</sup> is also lower presenting a competitive advantage. The products using thin film technology are mainly the flexible ones, such as flexible laminates or the flexible PV shingles and the ones that can be installed under non-optimal inclination conditions, such as (semi-)transparent modules that are used in façades and skylights. Most of these products are based on silicon thin film. The other technologies (inc. CIGS, CdTe) make up only a very small part of the current BIPV market.

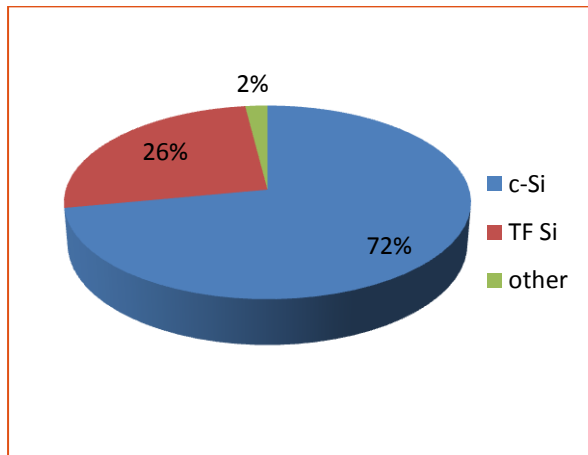


Figure 21. Overview of the share of the different technologies in the BIPV market. Source: Nanomarkets, EPIA analysis

Thin film technologies such as CIGS and CdTe as well as third generation technologies such as organic PV and dye-sensitized solar cells (DSSC) are expected to grow substantially in the coming years. Hence, BIPV can be considered an

interesting application for all existing technologies. Building Integrated Photovoltaics is such a diversified market that there will be room for all different technologies. Chapter 4.2 explains the different opportunities for the different technologies.

Because of the many different types of applications and a lack of a comprehensive database for BIPV projects; only some general ideas regarding how the BIPV products are distributed are provided:

- In most markets, the most popular products are the standard in-roof modules as well as PV tiles and shingles. This is mainly because they are the lowest in cost of all BIPV products and the least complex to be manufactured and installed.
- The second most popular products are the flexible laminates; specially suited for large industrial flat roofs.
- Semi-transparent modules and cladding systems make up a relatively small part of the market; mainly driven by commercial applications and public buildings such schools, airport, train stations and administrative office buildings.

## **4. Comparison between different BIPV products and cell technologies**

### **4.1. Comparison between BIPV products**

A comparative between the different BIPV solutions used is given in table 3. The most representative advantages and disadvantages are presented, as well as the most typical applications and key segments addressed with each specific BIPV product.

Product	Specific Advantages	Specific Disadvantages	Applications	Key segments
<b>Standard in-roof systems</b>	<ul style="list-style-type: none"> <li>• Suitable for old and new roofs</li> <li>• Well established application</li> <li>• Easy to handle</li> <li>• Under the scope of the French and Italian BIPV definition</li> <li>• Very competitive</li> <li>• High efficiency/performance</li> </ul>	<ul style="list-style-type: none"> <li>• Limited aesthetic value due to level of visibility</li> <li>• Scope of application limited to certain roof types.</li> <li>• The multifunctional aspects of PV are not fully exploited</li> </ul>	✓ Pitched Roofs	Residential and Commercial buildings
<b>Semitransparent system ( glass/ glass module)</b>	<ul style="list-style-type: none"> <li>• Most unobtrusive and possibly most aesthetic BIPV solution</li> <li>• Ideal suited for prestigious buildings with well-visible facades and skylights</li> <li>• Marginal daylight elimination / capacity to diversify light intake</li> <li>• Cell shapes can be attractive</li> <li>• With Thin Films cells they have uniform appearance, suitable for flush mounting</li> </ul>	<ul style="list-style-type: none"> <li>• The units can be very heavy</li> <li>• The prices are normally high since they are usually tailor-made products</li> <li>• As they can be seamlessly integrated, the public may not notice the presence of PV modules</li> <li>• Difficulty in hiding the cables</li> <li>• Limited sizes and shapes of cells</li> <li>• Silver tabbing crosses the transparent spaces between cells</li> </ul>	✓ Semitransparent Façades ✓ Skylights ✓ Shading Systems	Commercial and Public buildings
<b>Cladding systems</b>	<ul style="list-style-type: none"> <li>• Well suited if the PV system is to be recognized (green image owner)</li> <li>• Different colors and visual effects can be included</li> <li>• High efficiency systems</li> </ul>	<ul style="list-style-type: none"> <li>• Lower system performance (due do design restrictions)</li> <li>• The lower parts of facades are normally not used due to possible shadows</li> <li>• Installation cost can be very high</li> </ul>	✓ External Building Walls ✓ Curtain Walls	Commercial and public buildings
<b>Solar Tiles and shingles</b>	<ul style="list-style-type: none"> <li>• Aesthetic solution, mainly for residential pitched roofs</li> <li>• High-efficiency products</li> <li>• Very light product which eases the installation</li> </ul>	<ul style="list-style-type: none"> <li>• Small unit size lead to longer installation time</li> <li>• Unfavorable cost-performance ratio</li> <li>• High risk of breakage</li> </ul>	✓ Pitched Roofs	Residential buildings  Old buildings
<b>Flexible laminates</b>	<ul style="list-style-type: none"> <li>• Very light weight (suitable for weak roofs)</li> <li>• Easy handling and installation</li> <li>• Low BOS cost</li> <li>• No roof penetration</li> <li>• Curved installations possible</li> </ul>	<ul style="list-style-type: none"> <li>• It doesn't replace other functions of building components functions: BIPV status at stake</li> <li>• Very low efficiency which results in larger system areas</li> </ul>	✓ Flat and curved roofs	Commercial and industrial buildings (with large unused roofs)

Table 3. Comparative analysis between different BIPV solutions. Source: EPIA

## 4.2. BIPV opportunities with different technologies

### 4.2.1. Opportunities for Crystalline Silicon PV Suppliers

Crystalline silicon PV is widely favoured for rigid BIPV products for three major reasons. First is the maturity of this technology and market which has led to diversification of product offerings. Secondly, as the crystalline silicon market is mature and thus the products are becoming a commodity good, BIPV products also allow crystalline silicon PV suppliers to distinguish their products from other suppliers' products. Third is the higher conversion efficiency of crystalline silicon PV versus the other existing technologies. This element becomes crucial when surface availability is limited.

On the other hand, this technology presents some disadvantages. One of the major drawbacks of crystalline silicon PV is the fact that it uses silicon wafers and they impact the appearance of the products. There are few ways to avoid having the wafers front and center in the BIPV products, especially BIPV glass products. And while many observers consider the c-Si cell patterns attractive, many others find them unappealing. Thus, there is an opportunity for BIPV suppliers and designers to find ways to camouflage, hide, or otherwise make more universally appealing

the crystalline silicon cells that are used in BIPV products.

Another aesthetical limitation deals with the interconnection of the cells within a module. Crystalline silicon PV depends on silver fingers for collecting current from the front surface as well as thick silver tabbing to connect the electrodes in almost all cases. These silver stripes are in contrast to the more uniform appearance of both the silicon cells themselves and of most building materials. In addition, the tabbing stripes may run in directions that give the BIPV products an awkward appearance.

Finally, although crystalline silicon PV boasts the highest conversion efficiencies among PV technologies suitable for BIPV, the fact that BIPV is almost always flat, stationary, and has its orientation determined by the building surfaces—rather arbitrarily when it comes to the direction of solar incidence—detracts from its efficiency. Crystalline silicon PV, more so than other kinds of PV, strongly depends on the angle of incidence of light for maximum efficiency. Off-axis illumination, cloud cover, and shadowing have stronger detrimental impacts on crystalline silicon PV than on thin-film PV.

There are also other opportunities for crystalline silicon PV suppliers to profit from the BIPV markets, but they mainly deal with ways of splitting the cost of the PV with the cost of the building materials with which it is integrated. This could be best done by positioning the products as high-end "smart" building materials, with the PV costs being absorbed in the premium that customers are willing to pay for high-end building materials. This kind of BIPV product, for example, can be made to emulate roofing slate, in terms of dimensions, shape, texture, and colour.

#### **4.2.2. Opportunities for Thin-Film PV Suppliers**

While nearly all current BIPV tile and shingle products are based on crystalline silicon PV, Thin Film PV (TFPV) can offer better coverage of unusually shaped tiles as well as conformity to tiles that aren't flat. This is a market that is fairly wide open to TFPV suppliers and obviously lends itself to builders, architects and building owners who want their property to look a little bit different.

Thin-film PV-based BIPV products are almost always made with thin-film silicon PV, which means conversion efficiency is limited to about 8-10 percent. But these products compete with crystalline silicon-based BIPV products that may achieve significantly higher efficiencies. Therefore, it is quite clear that the markets that

TFPV suppliers will be able to address will grow as the efficiencies of TFPV increase. It is also pretty clear that the most obvious and fastest route to higher efficiencies is to use CIGS or CdTe PV technology. However, efficiency is not the only factor which influences the overall system performance. Higher temperatures have a negative effect in the system performance. This is especially important in non-ventilated facades and roofs where module temperature can raise up to 80-85°C (normally they operate at 40-45°C). In this regard, TFPV is less affected than crystalline silicon PV and therefore they can perform better. Furthermore, TFPV suffers less from indirect irradiation than TFPV does, with steep drops in performance as the angle of solar incidence gets steeper. This is because the conversion efficiency of crystalline silicon PV gets dramatically lower in less intense light. In contrast, thin-film PV stays pretty consistent regardless of light intensity.

Because of their versatility and ease of installation, flexible BIPV laminates offer a good solution to reduce significantly installation costs as there is no need of specialized BIPV installers. But this can also be a risky opportunity. Amateur installations run the risk of poor aesthetics and durability problems that may hurt the image of the flexible laminates over the longer term.

### **4.2.3. Opportunities for 3<sup>rd</sup> generation technologies (Organic PV, Dye Sensitive solar cells)**

There is also a significant future opportunity specifically for organic PV (OPV) and dye-sensitized PV (DSC) for producing truly transparent BIPV glass. The opaque cells that are integral to semitransparent BIPV glass have been a deal breaker for the use of BIPV glass in applications where visibility is important, such as in most windows.

Truly transparent BIPV glass—with cells that are tinted but not opaque—would open these applications to the possibility of BIPV glass. This is especially true if the PV layer can be made uniformly tinted, without spaces or any opaque traces. OPV and DSC are the closest technologies to achieving this.



Technology Product	Thin Film	Crystalline Silicon
<b>Standard in-roof systems</b>	<ul style="list-style-type: none"> <li>No market penetration ☹</li> </ul>	<ul style="list-style-type: none"> <li>Higher yields and higher efficiency (less area needed). ☺</li> </ul>
<b>Semitransparent system ( glass/ glass Module)</b>	<ul style="list-style-type: none"> <li>Design option due to different colors ☺</li> <li>Thin Films cells have uniform appearance, suitable for flush mounting ☺</li> <li>High cost and very low efficiency ☹</li> </ul>	<ul style="list-style-type: none"> <li>Marginal daylight elimination / capacity to play with light intake ☺</li> <li>Ideal for Skylights ☺</li> <li>Limited sizes and shapes of cells (unappealing ) ☹</li> <li>Silver tabbing crosses the transparent spaces between cells ☹</li> </ul>
<b>Cladding systems</b>	<ul style="list-style-type: none"> <li>Better performance under non-ventilated facades (higher temperature) ☺</li> <li>Design option due to different colors ☺</li> <li>Better performance with indirect/diffuse light ☺</li> </ul>	<ul style="list-style-type: none"> <li>Futuristic/ Green building marketing ☺</li> <li>lower performance under non-ventilated facades (higher temperature) ☹</li> <li>lower performance with indirect/diffuse light ☹</li> </ul>
<b>Solar Tiles and shingles</b>	<ul style="list-style-type: none"> <li>CIGS solution to become operational ☺</li> <li>No products available so far ☹</li> </ul>	<ul style="list-style-type: none"> <li>Higher yields and higher efficiency (less area needed). ☺</li> <li>Wide range of products available ☺</li> </ul>
<b>Flexible laminates</b>	<ul style="list-style-type: none"> <li>Very low weight (suitable for weak roofs) ☺</li> <li>Easy handling and installation ☺</li> <li>No roof penetration ☺</li> <li>Curved installations possible ☺</li> <li>Low efficiency (large area needed) ☹</li> </ul>	<ul style="list-style-type: none"> <li>No products available so far ☹</li> </ul>

Table 4. Comparative analysis of PV technologies regarding their suitability to BIPV. Source: EPIA, Nanomarkets, EUPD

### 4.3. The price of BIPV

While the prices of standard PV modules are very well known and communicate in the PV sector, when it comes to BIPV, the subject gets much more complex since there are a large number of factors which affect the final price of BIPV system. Furthermore, BIPV products are normally subject to comparison with other building materials since their aim is to replace those (conventional) materials and their functionalities; however BIPV additionally offers the unique advantage of electricity production which makes the price comparison even more difficult.

BIPV products are in many cases tailored-made products which need to be adapted in each specific project. This fact increases significantly the production cost since the economies of scale and manufacturing standardized process are difficult to be achieved. Moreover, the whole price of a BIPV system includes the installation cost (which tends to be largely higher than for other conventional materials) and other components like the inverter and the cables.

In order to compare the prices and the competitiveness of BIPV with other building materials, roofs and facades need to be addressed independently.

Understanding the price of conventional roofing materials is a key factor for deciding whether BIPV will represent a competitive roofing solution. Prices of conventional roofing materials vary, of course, but at the economy end, rigid asphalt shingles range from \$100 or less per square<sup>2</sup> to about \$200 per square. At the high end, natural slate roofing can cost upwards of \$4,000 per square. In between, there are several options (including both rigid and flexible materials) including wood shingles or shakes, concrete and ceramic tiles, and standing seam steel roofing, all of which are in the range of a few hundred dollars to \$1,000 or more per square. In any case, with much larger dimension and suitability, flexible building materials tend to be somewhat less costly than their rigid counterpart [source: Nanomarkets].

On the side of photovoltaics, the price per square meter will depend, among many factors, on the material used (technology) and the energy efficiency. It will strongly depend on the degree of integration, too. For instance, while standard in-roof modules are in the range of 1.8-3€/Wp, solar roof tiles and shingles will be in the

#### 4.3.1. PV Integration in Roofs

<sup>2</sup> A square is a unit of area used to measure roofing materials; equal to 100 square feet or 9.29 square meters

range of 3-5€/Wp. In the case of flexible laminates, prices will be ranging from 1.5 to 3€/W. If we consider an efficiency of 12% for crystalline solutions (first two cases), prices will range from 215-360€/m<sup>2</sup> upwards to 600€/m<sup>2</sup>; and, if we consider an efficiency of 6% for thin film base flexible modules, the price would go from 90 to 180 €/m<sup>2</sup>.

From the above very rough estimations we can deduce that already today the most expensive crystalline silicon based rigid solutions become cost competitive with high end slate roofs (this without taking into account the profits generated from the electricity produced). Once, the BIPV prices fall below 1€/Wp, these product will become competitive with steel, tile, and shake roofs (without considering the electricity generated). In the other side, Flexible BIPV products offer the opportunity to address the low end of the building materials market and to greatly expand the addressable market in the mid-range of building materials (especially more present in commercial buildings).

#### 4.3.2. PV integration in Facades

The cost of architectural glass varies widely but it can range from around 100€ or less per square meter for basic glass to several hundred Euros for multi-pane glass with features such as IR-reflecting, impact resistant, heat insulation, etc. Since

architectural glass can be such a high-value material, the cost of incorporating PV cells into it can be a relatively small portion of the total project cost. And that is before considering the value of the PV electricity produced. The opportunity here is to sell BIPV glass as purely an architectural cost, and to treat the electricity generated as a "free" bonus of selecting BIPV architecture.

The price of glazed BIPV strongly depends on the technology used, the colour chosen (which affect the efficiency and the manufacturing cost), and the efficiency. In the case of crystalline silicon technology, the light-through levels will depend on the separation between cells; the density of cells within the module range from about 70% to 30% increasing significantly the light passing through but reducing critically the efficiency as well as the price per square meter. As a rough estimation we consider the price of semitransparent PV module to range from 400 to 800€/ m<sup>2</sup> as an average, with some very special products reaching prices beyond the 1000€/m<sup>2</sup>.

In Figure 22, it can be observed that while glazed BIPV can hardly compete with low cost laminated glass, it becomes a competitive option if compared to more sophisticated architectural glass (without taking into account the electricity generated). The high cost of architectural glass is therefore a clear advantage for glazed BIPV

because the cost of adding PV functionality can be a smaller portion of the overall cost of the materials. This produces an important opportunity for BIPV glass suppliers because BIPV glass can be viewed as an "economical" way to add PV to a building. And that is before considering the value of the PV electricity produced. The opportunity here is to sell BIPV glass as purely an architectural cost, and to treat the electricity generated as a "free" bonus of selecting BIPV architecture.

### 4.3.3. Future prices

It is also important to note that the cost of photovoltaics and BIPV is rapidly falling. BIPV is currently more expensive than conventional PV, even when some

conventional building materials are replaced; as we have noted, only high-end building materials—excluding architectural glass—are currently anywhere close to the cost of BIPV. But as the cost of PV and BIPV continue to fall, BIPV becomes less costly than those high-end building materials and approach comparability with mid-range materials. As this happens, the division of cost between the building skin and the PV functionality will benefit BIPV, targeted to match or complement mid-range building materials to a greater extent. And this will in turn open a much wider addressable market.

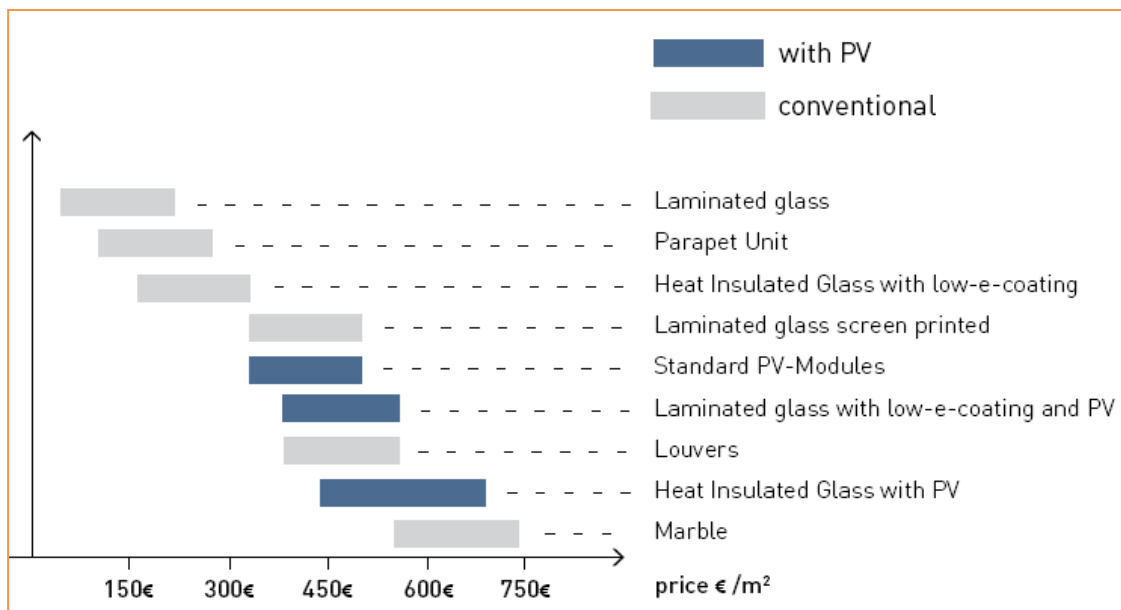


Figure 22. Example of a Price comparison of different building materials and PV products for a facade solution. Source: Architekturbüro Hagemann, 2008

## 5. Conclusions

Throughout this report, it has been shown that there is a large number of BIPV products already applicable to the building envelope allowing for many different designs and application. Many constructors, architects and system installers have already worked with them in various situations and can confirm their applicability highlighting their advantages and disadvantages for each of the cases. However, their potential is much greater and many more solutions can be developed if the cooperation among the mentioned actors and the PV industry is strengthened.

This cooperation will result in a larger product range at a more competitive price. More sizes, colours, shapes and materials to match architects' requests. Higher efficiencies, better overall performance and mechanical strength to satisfy the engineers and constructors; lighter products, easier to handle and to install, less sensitive to shadows and emplacement constraints to fulfil installers' expectations; and finally, a larger and common BIPV market, with harmonized building regulation and tailored made financial incentives for BIPV; this would trigger the investors' demand and would allow the PV industry to scale up and develop suitable standardized BIPV products at more competitive prices.



Figure 23. Source: Schott Solar



## 6. References

The sources of the pictures and graphs are indicated along the documents.

The information is extracted from various websites and reports which can be found at the following sites of interest:

- [www.epia.org](http://www.epia.org)
- [www.design-buildsolar.com](http://www.design-buildsolar.com)
- [www.eupd-research.com](http://www.eupd-research.com)
- [www.bipv.ch](http://www.bipv.ch)
- [www.nanomarkets.net](http://www.nanomarkets.net)

## Annex 1. French legislation on requirements for BIPV

In April 2007, the French general directorate for energy and raw materials (DGEMP) and the directorate for energy demand and energy markets (Dideme) released a guide describing the eligibility criteria for BIPV installations (DGEMP, Dideme, 2007). It does not provide a list of official BIPV products, but defines

when PV installations are considered integrated to the building, hence can benefit from the special feed-in tariff. Current specific rules for the eligibility of the innovative (« prime d'intégration au bâti ») or simplified (« prime d'intégration simplifiée ») BIPV FiT premium are as follows:

Requirements for innovative BIPV (all requirements need to be fulfilled)	Requirements for simplified BIPV
Installed on the roof of a closed (on all lateral sides) and covered building that ensures the protection of people, animals, goods and activities. With exception of buildings that are used for living, the PV system must be installed at least two years after the date of completion of the building. The PV system is installed in the roof plane.	The PV system is installed on the roof building that ensures the protection of people, animals, goods and activities. The system is parallel to the roof plane.
The PV system replaces building elements that ensure closure and covering and the system ensures sealing. After installation, the demounting of the PV modules or the PV films cannot be done without harming the sealing function ensured by the PV system or rendering the building 'useless'	The PV system replaces building elements that ensure closure and coverage and ensures the system ensures sealing.
For PV systems with rigid modules, the modules make up the principal element in the sealing of the system.	The total peak power of the installation as defined in article 2 of the current arrest is higher than 3kWp.
For PV systems with flexible films, the assembly has been effectuated in the factory or on site. The assembly on site is effectuated in the framework of a "contrat de travaux unique".	
Exceptions: <ul style="list-style-type: none"> <li>- a PV installation with rigid modules and for which the producer completes the request for grid connection conforming article 2 of this arrest before the 1st of January 2011,</li> </ul>	Exceptions: <ul style="list-style-type: none"> <li>- from the 1st of January 2011, a PV installation with a total peak power of less or equal to 3kWp is eligible to the « prime</li> </ul>

<p>is eligible to a “prime d'intégration au bâti” if the PV system fulfills the conditions in paragraphe 1.1 (first and second sentence) and paragraphe 1.2 (first sentence) and if it is parallel to the roof plane.</p> <ul style="list-style-type: none"> <li>- An exception to paragraph 1: a PV installation is eligible to “prime d'intégration au bâti” if the PV system is installed on the building and fulfills one of the following functions: <ul style="list-style-type: none"> <li>3.1. Wall-sustaining window ;</li> <li>3.2. Covering (siding) ;</li> <li>3.3. Shading ;</li> <li>3.4. Holding structure of the window, balcony or terrasse ;</li> <li>3.5. Wall - curtain.</li> </ul> </li> </ul>	<p>d'intégration simplifiée au bâti “ if the PV system fulfills the condition set in paragraphs 1.1 and 1.2, first sentence.</p> <ul style="list-style-type: none"> <li>- exception to paragraph 4: a PV installation is eligible to the « prime d'intégration simplifiée au bâti » if the PV system is installed on the building ensuring the protection of people, animals, goods and activities and fulfills at least one of the following functions : <ul style="list-style-type: none"> <li>6.1. Wall-sustaining window ;</li> <li>6.2. Covering (siding) ;</li> <li>6.3. Shading ;</li> <li>6.4. Holding structure of the window, balcony or terrasse ;</li> <li>6.5. Wall - curtain.</li> </ul> </li> </ul>
<p>In order to benefit from the « prime d'intégration au bâti » or the « prime d'intégration simplifiée au bâti », the producer must deliver a document (attest on honour) to the customer:</p> <ul style="list-style-type: none"> <li>- that certifies that the « intégration au bâti » or the « intégration simplifiée au bâti » have been realised and that all rules of eligibility cited above have been respected;</li> <li>- that includes an attest from the installer that certifies that all the work performed to incorporate the PV system in the building have been realised in a way that satisfies all the requirements, i.e. the rules for conception and realisation of norms NF DTU, the professional rules and technical evaluations (avis technique, dossier technique d'application, agrément technique européen, appréciation technique expérimentale, Pass'Innovation, enquête de technique nouvelle), or all other equivalent rules in other member states of the l'Espace économique européen.</li> </ul> <p>The producer holds this attests as well as the corresponding justifications to the availability of the prefect.</p>	

#### Source:

- <http://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000021673951&dateTexte=&categorieLien=id>
- <http://circulaires.gouv.fr/index.php?action=afficherCirculaire&hit=6>.

## ANNEX 2: The Italian Definition for BIPV

The Italian market, even though seemingly perfect for BIPV (good climatic conditions and high investment capability) only recently started to grow, trying to overcome the administrative and bureaucratic barriers and creating specific tariffs for BIPV. In 2007, the Conto Energia laws were introduced, which granted high FiTs for BIPV, and a clear definition for a BIPV installation. Consumers were provided with several payment options and supportive legislation for utilizing the BIPV tariffs. It was a very positive kick for the market, which has grown rapidly in 2007.

The definition of BIPV according to the present Conto Energia is as follows:

- PV modules with the same inclination of the tilted surface (roof / facade / sheeting) fully replacing the covering material and having the same architectural functionality of the surface itself
- PV modules and their mounting structures fully operating as shelters, canopies, arbors or sheds
- PV modules partly substituting the transparent or semi-transparent covering material thus allowing the natural lightning of the rooms below
- PV modules partly substituting the noise protection modules of an acoustic barrier
- PV modules powering street lightning devices
- PV modules and their mounting structures fully operating as shading devices
- PV modules substituting the covering material of balusters and parapets
- PV modules partly or fully substituting the glass of windows
- PV modules fully substituting the shading elements of blinds/shutters
- Any of the above mentioned surface where PV modules represent the covering formfitting the surface itself PV modules installed on flat roofs and terraces
- PV modules installed on top of tilted surfaces (roofs, facades, parapets and balusters) without replacing the material laid beneath
- PV modules installed on top of street furniture without substituting the material laid beneath.

**Source:** The Information is based on a presentation of the Italian PV association **Gifi**

## Credits

This study has been carried out by the Consortium of the Sunrise Project formed by EPIA (European Photovoltaic Industry Association), WIP, FIEC (the European Construction Industry Federation), AIE (the European Association of Electrical Contractors), UIA-ARES (International Union of Architects).

Project is supported and financed by the 6th Framework programme for Research and Technological development of the European Commission.



## Authors

Daniel Fraile Montoro, EPIA

Pieterjan Vanbuggenhout, EPIA

Joanna Ciesielska, EPIA

## Contact:

Daniel Fraile Montoro

Telephone: +32 2 465 38 84

Email: [d.fraile@epia.org](mailto:d.fraile@epia.org)

Web: [www.epia.org](http://www.epia.org)

Web: [www.pvsunrise.eu](http://www.pvsunrise.eu)





