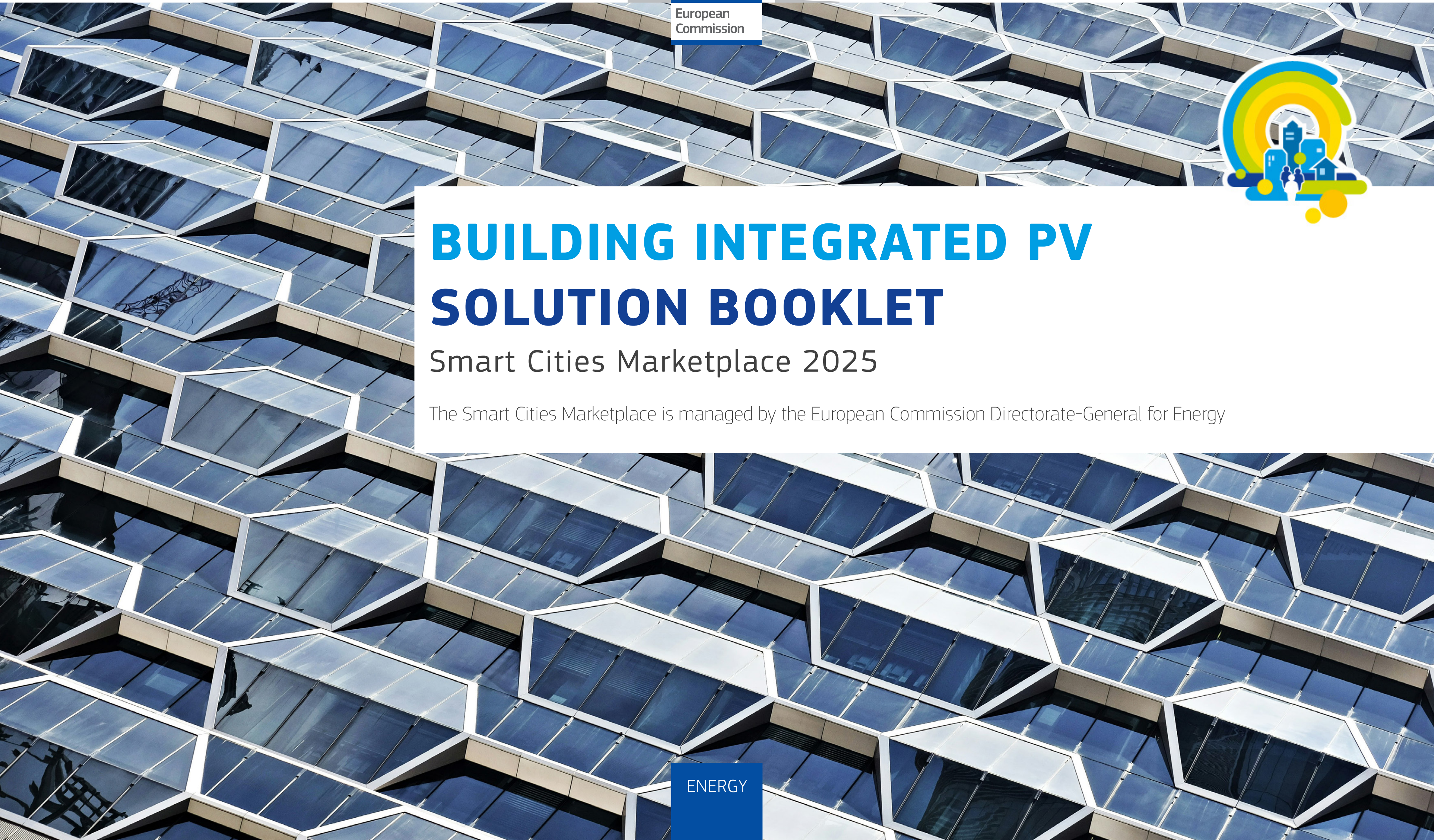
European Commission



BUILDING INTEGRATED PV SOLUTION BOOKLET

Smart Cities Marketplace 2025

The Smart Cities Marketplace is managed by the European Commission Directorate-General for Energy

ENERGY

European Commission

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2025 version

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WHAT IS THE SMART CITIES MARKETPLACE?

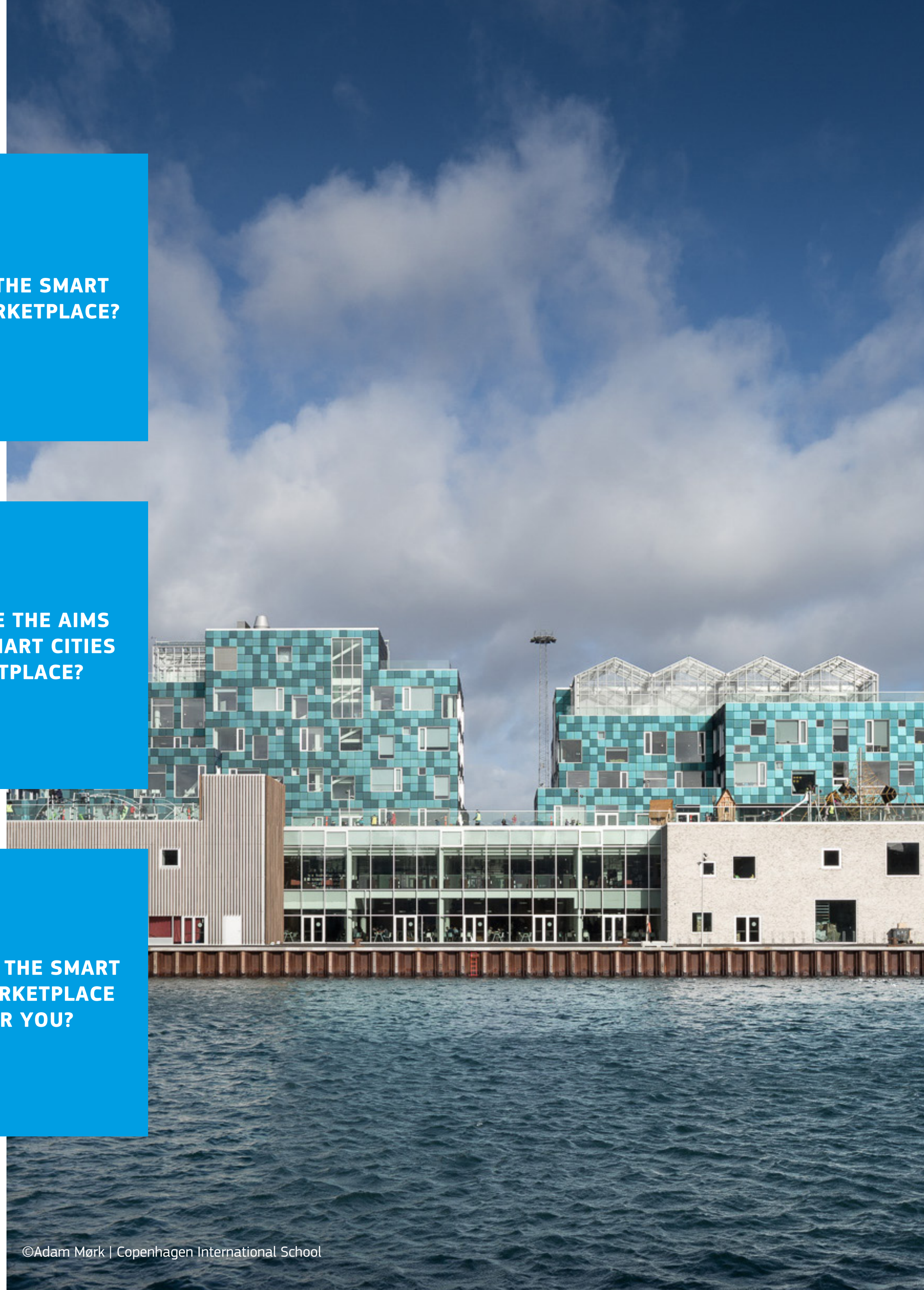
The Smart Cities Marketplace is an initiative supported by the European Commission bringing together **cities, industry, SMEs, investors, banks, research and other climate-neutral and smart city actors**. The Smart Cities Marketplace Investor Network is a growing group of investors and financial service providers who are actively looking for climate-neutral and smart city projects.

WHAT ARE THE AIMS OF THE SMART CITIES MARKETPLACE?

The Smart Cities Marketplace has thousands of followers from all over Europe and beyond, many of which have signed up as a member. Their common aims are to **improve citizens' quality of life, increase the competitiveness of European cities and industry** as well as to **reach European energy and climate targets.**

WHAT CAN THE SMART CITIES MARKETPLACE DO FOR YOU?

Explore the possibilities, **shape** your project ideas, and close a **deal** for launching your smart city solution! If you want to get directly in touch with us please use info@smartcitiesmarketplace.eu



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WHAT AND WHY

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WHAT AND WHY

In 2019, with the adoption of **the Green Deal**[1], Europe declared its goal to become a **climate-neutral continent by 2050**. The Green Deal aims for efficient use of resources for a clean and circular economy. Transforming the energy sector towards a decarbonized, digitalized and decentralized system, integrated with other sectors such as urban development, agriculture, industry and mobility is at the heart of this transition. **The Clean Energy Package**[2] further reinforces this decision by defining specific quantitative goals and actions.

To achieve these goals, **clean energy** should be paramount in planning, designing, construction, retrofitting and use of our living spaces, and our buildings.

From 2020 onwards, all new buildings have to be **near Zero Energy Buildings**, meaning they produce the energy needed on their premises. However, 75 % of EU buildings were built before energy performance standards existed and the **refurbishment rate of buildings needs to increase threefold** for the decarbonization targets to be reached (SCIS Policy Paper)[3]. Additionally, the EU has expressed the ambition to have 100 Positive Energy Districts in planning by 2025[4].

As part of REPowerEU, the EU Solar Strategy[5] was adopted in mid-2022. This strategy aims to bring online over 320 GW of solar photovoltaic capacity by 2025 (more than doubling the 2020 level) and almost 600 GW by 2030.

1 commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal
2 energy.ec.europa.eu/topics/energy-strategy/clean-energy-all-europeans-package
3 smart-cities-marketplace.ec.europa.eu/insights/publications/upscaling-urban-residential-retrofit-eus-low-carbon-future-challenges-and
4 setis.ec.europa.eu/working-groups/positive-energy-districts
5 europarl.europa.eu/legislative-train/package-repowereu-plan/file-eu-solar-strategy?sid=8501

BIPV roof ©Sunstyle

In early 2024, the European Solar Charter[6] was signed. This act is a reaction to the substantial decrease in the price of imported Chinese PV panels. It sets out a series of voluntary actions to be undertaken to support the EU photovoltaic sector.

6 energy.ec.europa.eu/topics/renewable-energy/solar-energy/european-solar-charter

Energy efficiency and local clean energy supply are key in realising the ambitions that Europe has put forward. Thermal energy supply can be done in many ways, including recuperation of waste heat, supplying district heating systems and solar thermal heating. Local generation of clean electricity in cities is much more challenging and the technology choices often come down to biofueled Combined Heat & Power (CHP) or Photovoltaics (PV). Biofuels are not favoured, among other reasons due to local emissions and the use of such CHP is linked to local heat demand, which is location and season dependent. **Large-scale implementation of PV** in our cities is therefore a necessity, in some cases combined with the heat-demand-driven electricity generation of the CHP.

Solar panels based on **PV technology** are well-known, easily applied and scalable to the energy needs, at least within the limits of the surface area that is made available. PV panels are mostly installed as PV systems placed on the ground, water surfaces or rooftops. PV installations added to an existing building and with the sole purpose of electricity generation are not termed Building Integrated but Building Applied PV systems or BAPV.

Further reading on smartcities-infosystem.eu/solutions

Punta arenas hospital ©Onyx | onyxsolar.com

A Building Integrated PV (BIPV) is a building construction element that produces electricity. BIPVs are installed as part of the building envelope, roof, façade, or glass surfaces. BIPV can lead to **synergy between energy efficiency and clean energy generation** for deep building retrofits and new buildings. This is not a new concept, but the technology options have been improving over the past two decades.

International standards define that, aside from electricity generation, BIPV has to provide one or more of the following functionalities:

- Mechanical rigidity or structural integrity
- Primary weather impact protection: rain, snow, wind, hail
- Energy economy, such as shading, daylighting, or thermal insulation
- Fire protection
- Noise protection

Though the market share of BIPV is small (<2% of all PV installations) compared to conventional PV, BIPV technology is market ready and comparable in price[7] to other building elements needed for net Zero Energy Buildings (nZEBs). This is also demonstrated by BIPVBoost[8], in which several recent applications of BIPV were assessed. As expected, large surfaces of BIPV reduce the price per m^2. The **BIPV application is not to be seen without other decisive factors**:

- Material savings, e.g. cost of alternative finishing of the building envelope in the absence of the BIPV;
- The electricity generated and currently used within the building, i.e. the self-consumption rate. This parameter indirectly indicates the extent to which the economic value of the generated electricity is maximized;
- Reduced heat transfers and reduced permeability to solar radiation can be achieved thanks to BIPV surfaces;
- Attention to a green image that is of relevance and of commercial value for companies and is a statement of a policy for public buildings.

Hence, BIPV should not be considered a primary source of income but a supplementary investment offering reasonable payback periods. Projects such as Increase, BIPVBoost, and PVsites, and the working group 3 of ETIP PV focus on BIPV further support policies that contribute to a more robust European BIPV industry, a cost reduction in sales prices and a clear enabling policy framework. While competitiveness thresholds are foreseen to be reached by 2025, expected cost reductions are as high as 47% by 2030[9]. Considering these numbers, **any city in Europe could start with BIPV implementation today and have its first buildings in use in the coming years.**

7 etip-pv.eu/publications/etip-pv-publications/download/solar-skins-an-opportunity-for-greener-cities
8 bipvboost.eu/public-reports/download/cost-competitiveness-status-of-bipv-solutions-in-e
9 bipvboost.eu/public-reports/download/cost-reduction-roadmap-for-the-european-bipv-secto

CITY CONTEXT

©Han Vandevyvere

CITY CONTEXT

Urban areas are densely populated with 75 % of Europeans living in these areas. The rooftop surface available for PV panel installation is limited, making it challenging to satisfy the city's energy needs. In comparison to classical PV panels, BIPV panels are a structural part of the building and serve as a façade, roof, or tinted glass for shading. **BIPV is produced to be semi-transparent, coloured, rigid, or flexible and can have different shapes and sizes.**

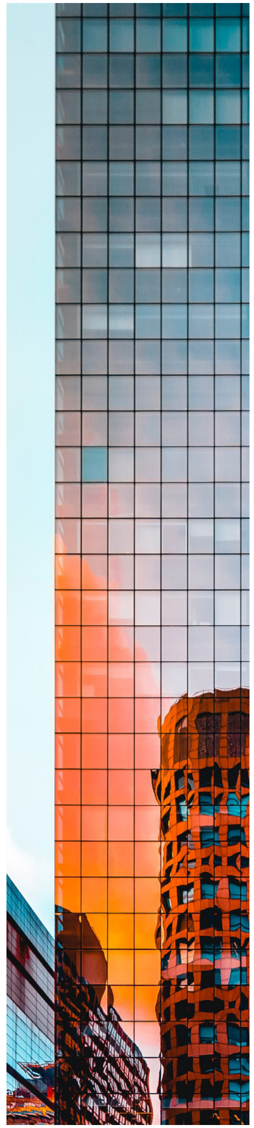
Local governments and communities have a major role to play in the further uptake of BIPV through:

- Creating an enabling framework for an interdisciplinary approach to urban/neighbourhood planning, design, and retrofitting including BIPV;
- Taking a frontrunner role and making BIPV a visible, architecturally integrated element of active buildings;
- Sharing lessons learned and best practices from existing and ongoing BIPV projects through the Covenant of Mayors[10] and Energy Cities[11].

Aside from offices, public, residential, and commercial buildings, PV can be integrated in mobility and urban landscaping structures within the city, such as:

- Parking structures;
- Sound barriers and guardrails on roads;
- Shading structures;
- Bus stops;
- Rain and wind protection;
- Outdoor pavement or PV floors.

There have been many demonstration projects around Europe in the past decade, but the information is usually shared within project consortia and, through scientific articles, or disseminated under the tag of the passive, near-zero energy, or positive energy buildings. Because BIPV can incorporate various PV technologies, some of which remain in the research phase, it is often viewed as complex and expensive. However, BIPV has passed that stage.



©Jonas Ferlin, Pexels

10 eu-mayors.ec.europa.eu
11 energy-cities.eu

Below are a number of examples that can be used to illustrate the previous text.

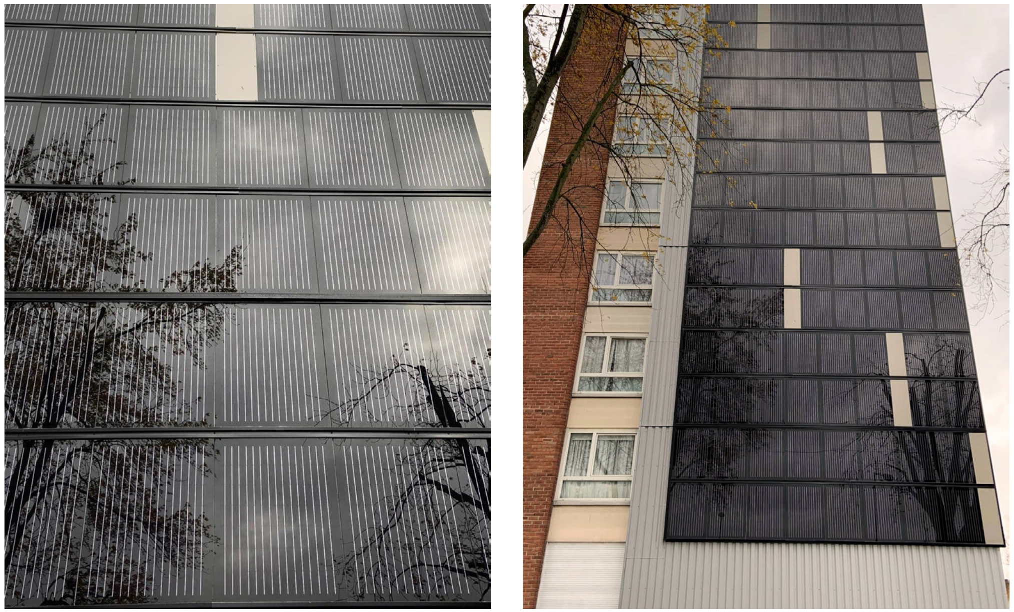
BIPV in new buildings

The Treurenberg near-zero energy office building in Brussels, Belgium. BIPV panels are used for the façade of the top two floors. BIPV panels and building-adapted (classical) PV installed on the roof cover the building's annual energy consumption, with a total installed capacity of 122 kWp.

BIPV in building retrofits

The apartment building from the 1970s has underwent a retrofitting process. The BIPV façade required previous intervention that consisted of the removal of the existing brick cladding and the improvement of the thermal insulation. BIPV panels are attached to a metal structure fixed to the concrete wall. The integration design was influenced by the aesthetic criteria of the building's architectural retrofit. The BIPV system features Si-based PV with a total installed power of 16.91 kWp, covering 130,45 m^2 of the building façade. This installation serves as a demonstration site for the EU BIPV project, PV sites[12].

Façade BIPV in a new building in Brussels. ©Assar Architects | assar.com



BIPV ventilated façade of apartments building, Wattignies, France. ©Onyx | onyxsolar.com PV Sites demonstration project.

12 pvsites.eu

PV integrated in guardrail

The province of North Holland, in collaboration with TNO, Solliance Solar Research, Heijmans, Femtogrid, Amsterdam University of Applied Sciences, implemented a demonstration project of PV integration in 72 m long double guardrail along the N194 near Heerhugowaard. The project is subsidised by the iDEEGO (innovation Sustainable Energy and Energy Saving Built Environment) scheme of the top sector Energy, facilitated by the National Enterprising Netherlands (RVO) in the Netherlands.

Taking building energy consumption and production into account during planning and design stages would make integration of different energy technology solutions, such as BAPB and BIPV, simpler and less costly. This approach allows for adapting the design to optimise energy yield and utilise standardised BIPV panels. Additionally, it enables optimising the on-site planning and implementation processes.

PV integration in 72 m long double guardrail along the N194 near Heerhugowaard, the Netherlands.
©Solliance | solliance.eu

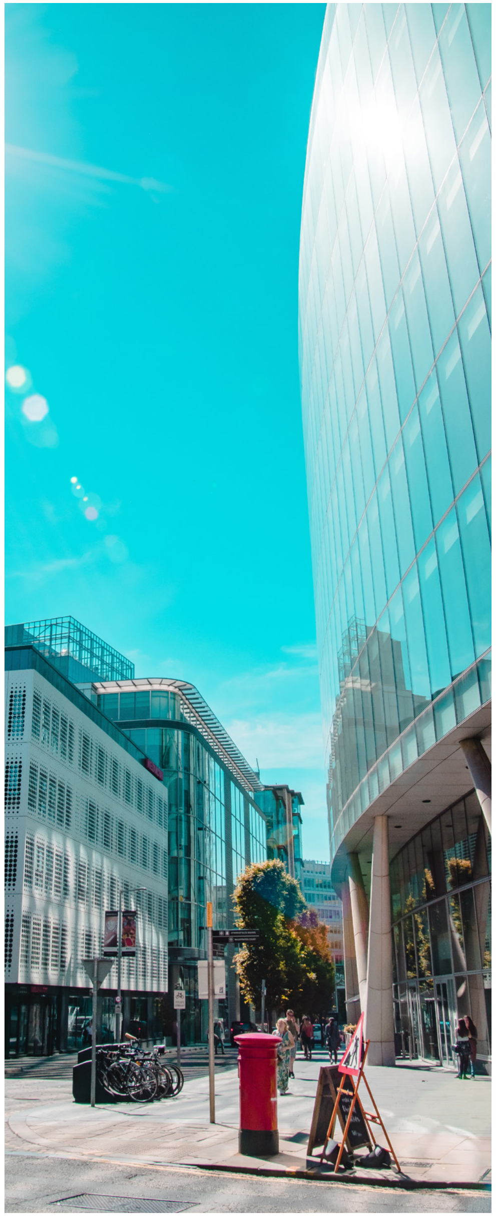
Several organisations have been working extensively on evaluating the potential related to BIPV in the urban landscape in Europe. While they all foresee a promising role for BIPV, they also identify several barriers and obstacles:

When designing a BIPV, **shading** has to be taken into account. In urban settings, renewal and densification of surrounding areas could negatively impact the design or the yield during operation. This is due to differences in shading estimations between design and operating conditions. Urban planning should implement guidelines specifying the type of development and maximum allowable height in specific areas. The shading that can consequently be calculated on a given new design can be considered as an architectural boundary condition rather than a no-go.

Examples are decisively important to inspire and encourage further uptake. Such **examples should be promoted in public buildings** and encouraged in commercial and residential buildings. A wide media coverage, official openings, and other means of attracting attention should be organised.

The uptake of targets on renewable energy generation in cities should be stricter and based on **estimations of technological feasibility**. Subsidies could be provided to close the business case and contribute to a reasonable return on investment.

Cooperation with **local distribution grid operators** could simplify procedures for integrating renewables. Connection constraints could be addressed at the neighbourhood level rather than for individual buildings. This enables the realisation of positive energy districts in the most cost-effective way, applying renewable energy technologies where it is the most beneficial and/or provides the maximum yield.



©Lewis Roberts, Unsplash

Lessons learned

- Integration of BIPV is easier and can be realised at lower cost if **included during the planning and design phase**.
- BIPV should be seen as a synergy between energy efficiency and renewable energy for retrofit to near-zero energy buildings and a **key contributor in realizing Positive Energy Districts**.
- Implementation of BIPV in **public buildings** helps to increase awareness of the potential and best practices for BIPV.

- Urban planning should include **assessments and identification** of preferred locations for BIPV on buildings
- Best practices and **lessons learned from previous projects should be widely shared** through initiatives such as Covenant of Mayors[13], Energy Cities[14], and other initiatives.
- BIPV technology is constantly improving and decreasing in price and complexity. Information about this technology should be **widely shared and regularly updated**.

13 eu-mayors.ec.europa.eu
14 energy-cities.eu

CSEM has developed the KALEO technology, which enables the production of illustrated solar panels. ©COMPÁZ | compaz.art

SOCIETAL AND USER ASPECTS

SOCIETAL & USER ASPECTS

Stakeholder support & citizen engagement

BIPV represents a **multisectoral technology**: it includes electricity **generation** and building **construction** material/glass as part of the building envelope, **design** aspects affecting aesthetics as well as light, and **grid integration** aspects. It might further imply boundary conditions (location and size) for nearby structures, buildings, and trees. The implementation and mainly the operation of the BIPV set-ups will often require cooperation with the distribution company and regulator. Although the emergence of BAPV was once seen as a threat by grid operators, most now align with EU ambitions and have supportive grid connection policies for renewable energy systems.

BIPV could be seen as a **local or regional industry creating jobs and contributing to economic growth**.

In the transition period to a fully mature market with highly competitive pricing, it is crucial to engage the architects, the construction sector, as well as the end-users, local communities, and urban planners. This transition period should be used to **gain and share experience**, deliver **flagship projects**, and foster **collaboration across sectors**. Working closely with urban planners on the integration of BIPV in landscape elements and community spaces is essential.

In addition, **involving citizens and end-users** from the start helps raise awareness and increase acceptance of BIPV in various applications. By showcasing visible, community-centred projects, citizens can become familiar with BIPV technologies and understand their benefits. Meanwhile, architects, construction professionals, and urban planners can gain firsthand experience in seamlessly integrating BIPV into urban landscapes and everyday environments.

An interdisciplinary approach that brings together energy experts, architects, construction professionals, urban planners, and community representatives is essential. This ensures that BIPV solutions are effectively planned, widely accepted, and tailored to meet the needs and preferences of the people who will ultimately benefit from the integration of BIPV.

Read more about the major barriers to the implementation and replication of a smart energy project as well as citizen engagement on:
smart-cities-marketplace.ec.europa.eu/sites/default/files/2021-02/scis_solution_booklet_citizen_engagement.pdf

Stroomversnelling initiative, Netherlands

Reconstruction of homes to near-zero Energy Buildings by implementation of efficient heating options, insulation of houses and installation of rooftop BIPV. The solutions are implemented with the housing co-operations in order to introduce economies of scale and reduce renovation costs for users. The solutions are prefabricated and easily implemented.

Stroomversnelling | stroomversnelling.nl initiative in the Netherlands.
©Onyx | onyxsolar.com, Partner in PV sites, Flickr

BIPV in Copenhagen International School building

The façade of the Copenhagen International School consists of 12 000 square-shaped, coloured BIPV panels. The BIPV is a rain-cover vented façade which allows better performance of Si-based panels. The electricity generated from 720 kWp of BIPV can satisfy half of the school's electricity consumption. The uniform blue colour of the BIPV panels is assured with the special coating over the Si-based PV panel, allowing for variation in colour with minimal impact on the panel efficiency. The building has achieved numerous architecture awards, including the 2017 ICONIC award.

More: Copenhagen International School | www.copenhageninternational.school

ICONIC award website | en.innovative-architecture.de

©Adam Mørk. Copenhagen International School building with 12 000 square-shaped, coloured BIPV panels.

Aesthetically appealing decentralized energy

The main advantage of BIPV over traditional PV technology is its ability to offer aesthetically appealing solutions. In order to compete with other construction materials used for building envelopes (façade, windows, roofs), **BIPV offers a variety in colour, design, transparency, flexibility, size, and shape.** While most BIPV solutions today are tailor-made, the industry has the potential to offer mass produced solutions in standard sizes and configurations.

BIPV can come in a variation of configurations, where continuous research results in more options that are becoming available:

- Single colour
- PV with a design
- Transparent
- Flexible
- Size and shape

Single colour: Single, solid colour from white over blue, green and red to grey and black.

Coloured BIPV Solar silo in Basel, Gundeldinger Feld | gundeldingerfeld.ch

Reconstruction of historic building with coloured BIPV.
©Argola Solvatec, SolarSilo Basel 2015.

PV with a design PV design to match your building or structure, have your logo on it or any printed designs.

PV with a design by CSEM and Kaleo at Banque Cantonale Neuchâteloise (BCN):

©CSEM | csem.ch, and Kaleo

Transparent: PV panels can be semi-transparent with combination of opaque and transparent areas or uniformly semi-transparent. Semi-transparent PV panels can be colour-neutral or have a specific colour.

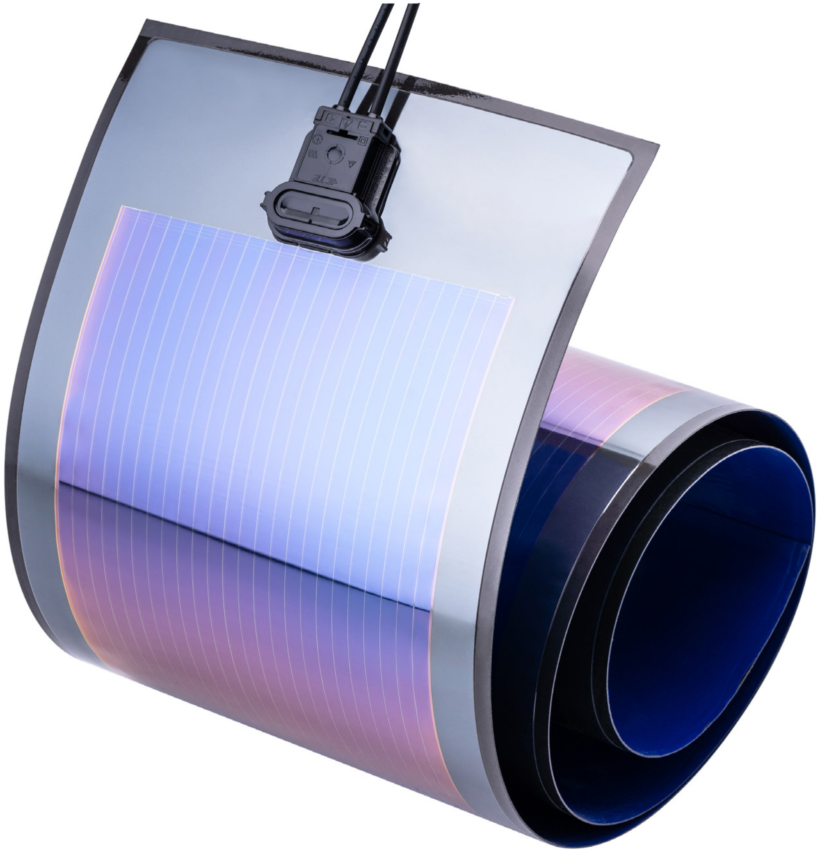
Onyx Solar residential installation of semi-transparent and neutral colour solar glass:

©Onyx | onyxsolar.com

Flexible: PV technology consisting of very thin layers of material fabricated as flexible, lightweight modules that can be integrated into any curved surface of buildings or structures.

Size and shape: BIPV can be customised to any size or shape needed for the specific building structure.

Flexible PV (Heliatek flexible thin-film PV):



PV with hexagonal shape and non-standard size at the German pavilion, Expo Milan 2015:

Schmidhuber | schmidhuber.de German pavilion. ©Alex Breier

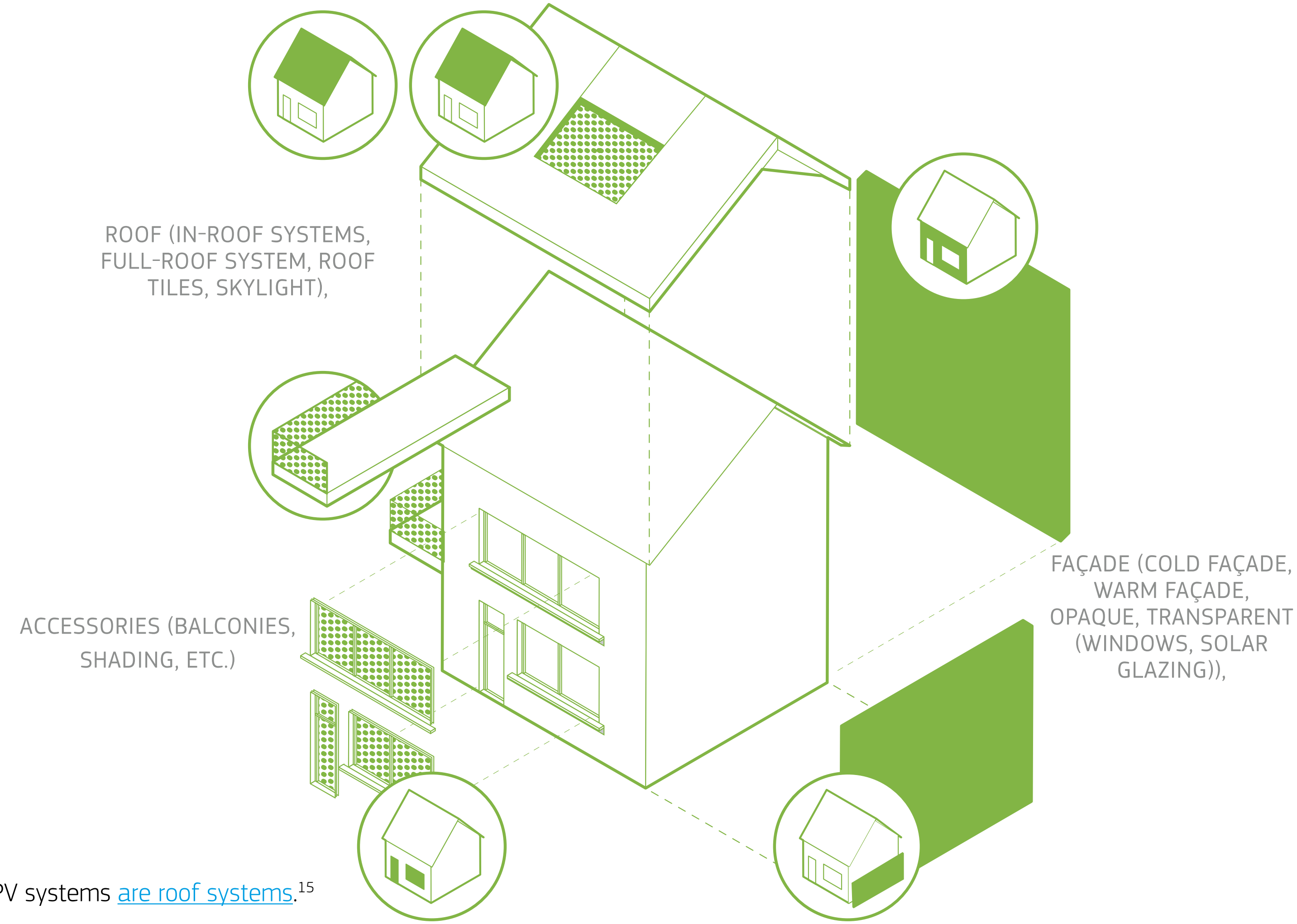
TECHNICAL SPECIFICATIONS

Schmidhuber German pavilion. ©Andreas Keller

TECHNICAL SPECIFICATIONS

Type of the BIPV system

BIPV systems are categorised into:



Currently 80 % of worldwide installed BIPV systems are roof systems.[15]

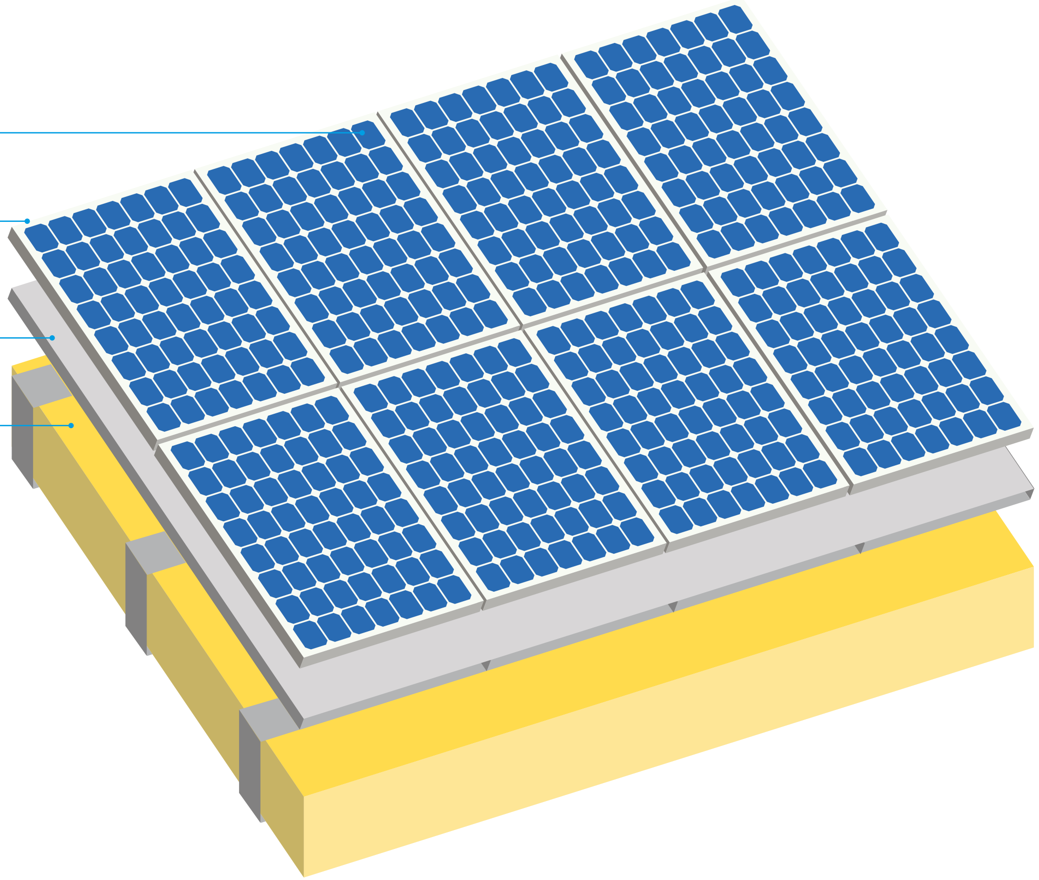
15 sciencedirect.com/science/article/pii/S0360544220310380?via%3Dihub

Components of a BIPV system

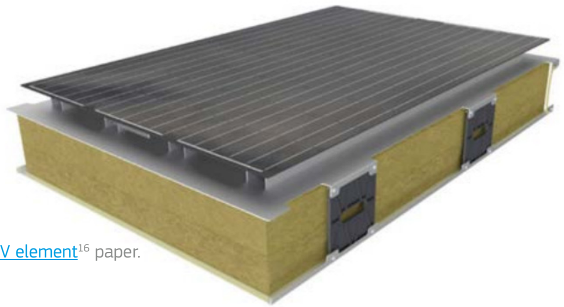
BIPV is defined as a photovoltaic component generating electricity while simultaneously being an integral, essential and permanent part of a building structure.

A BIPV is hence composed of the following elements:

- PV component
- Electrical components
- Mounting or structural components
- Optional components (insulating material, sensors etc.).



BIPV can be integrated on site or be prefabricated to include all of the above components. Prefabricated solutions are easier to implement and provide a cost advantage, and benefit more from standardisation. The latter, combined with automation in the production, is expected to lead to a relevant cost reduction.



Source: Prefabricated roof BIPV element[16] paper.

16 polipapers.upv.es/index.php/vitruvio/article/view/4476

Components of the BIPV system

PV component

The PV components vary depending on the material they are made of. PV technology is grouped into:

- Silicon wafer-based PV (Si-PV) and
- Thin-film based PV (TFPV).

Si-PV are well-known. They are relatively high in efficiency (22% is a standard)[17] compared to commercially available thin-film alternatives but require more energy upfront[18].

Mono-crystalline cells have slightly higher efficiencies compared to polycrystalline panels; therefore, the former are often sold as a premium product. The difference comes from the fact that a mono-crystalline cell is made from a single crystal, and that provides a microstructure in which the electrons have more space to move, resulting in a better flow of electricity and less temperature dependency. The visual difference is in the colour.

Mono-crystalline cells are black; multi-crystalline cells have a blue or bluish colour. Damage due to temperature asymmetry (e.g., from partial shade or snow coverage) is more likely with mono-crystalline than multi-crystalline panels. However, mono-crystalline panels typically come with longer guarantees. Thin film PV, on the other hand, is less temperature dependent.

TFPV has many types and can be grouped into:

- Commercially available (amorphous-Silicone (a-Si), cadmium telluride (CdTe) and copper indium (gallium) selenide (CI(G)S)) and
- Researched technologies (organic PV (OPV), perovskite, dye sensitized, etc).

The structure and functioning of thin film solar cells are similar to those of silicon wafer cells. The main differences are in the thin flexible arrangement of the different layers and the materials used. Research shows small scale TFPV devices are comparable in efficiency to Si-based ones. However, upscaling to panel size devices still results in efficiencies lower (top level thin film cells are today at around 18%) compared to conventional Si-based technology. The low cost of thin film PV and further technological advancements improving the efficiency and design options are the major drivers for the expected market increase.

Unlike regular PV panels, BIPV panels are usually frameless and packaged to be aesthetically pleasing and lightweight. BIPV elements with various colours or semi-transparency compromise on the energy performance. However with improvements in processing of panels and packaging, the decrease in performance loss caused by characteristics such as colours or semi-transparency can be limited to 10% of energy loss[19], i.e. about 2,2% in absolute losses.

17 ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/photovoltaics-report.pdf
18 ijcem.in/wp-content/uploads/2016/06/a-review-comparison-of-silicon-solar-cells-and-thin-film-solar-cells.pdf

19 iea-pvps.org/key-topics/iea-pvps-15-r07-coloured-bipv-report

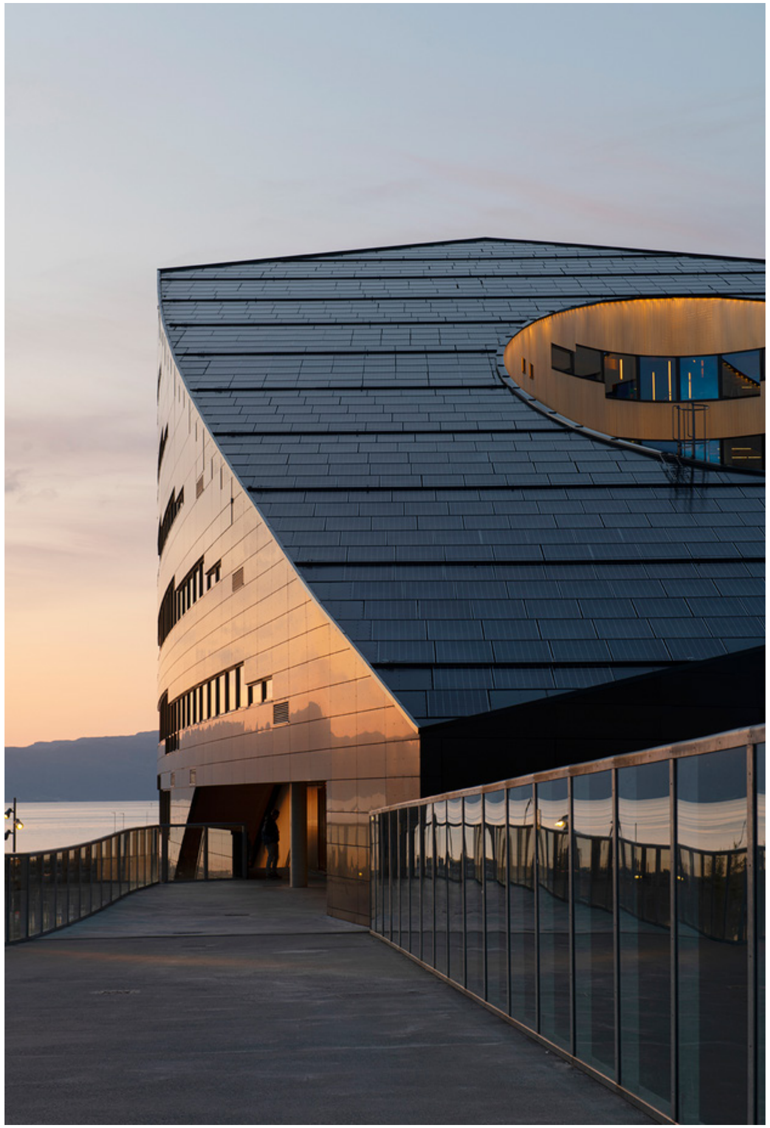
Electrical components

Electrical components include wiring, DC/AC inverters or DC/DC converters, and ancillary components like fuses and switches, which depend on the design of the electrical system in the building. The choice of electrical components will define the complexity and, hence, the cost of the system, as well as its reliability and operation.

Today, most residential and commercial buildings have AC networks, whereas (BI)PV produces electricity in DC. Other elements such as batteries and certain loads, also use DC. Every conversion step introduces losses, whether DC to AC, AC to DC or DC to DC.

The conversion from AC to DC can occur at the single PV element using microinverters or at string inverters, which can also provide a DC link to batteries. A hybrid system with distributed DC converters and string inverters can also be used.

If BIPV panels are connected to a string inverter, they are more affected by power output reductions caused by uneven shading (e.g., clouds) and offer less flexibility in how panels are positioned. Micro-inverters or DC/DC power optimizers allow for more flexibility and can be adapted to **plug-&-play prefabricated BIPV elements**. The integration also impacts component lifetime and the ability to replace them. The exact selection is engineering work and depends on aesthetical requirements, distances between panels and inverter, and maintenance needs[20].



Powerhouse Brattørkaia Project | powerhouse.no. Copyright: Ivar Kvaal

20 lirias.kuleuven.be/retrieve/537735

Mounting components

Mounting components are dependent on the BIPV application. They ensure the secure positioning of BIPV elements, easy installation, system modularity, and optimal system performance. Mounting systems/components needed for a BIPV installation (e.g., ventilated façade, skylight, curtain wall…) differ from those required for a typical glass/glass installation.

Kaleo | kaleo-solar.ch technology developed by CSEM thanks to the BCN support | Copyright: CSEM | csem.ch

Optional components

Optional components can be installed prior to or after BIPV system installation or can be made part of the prefabricated BIPV element. Optional components depend on the BIPV system application and can include insulation material, rigid construction elements, sensors for temperature or air quality, etc.

Prefabricated BIPV solutions can allow for easy and simple installation and hence be more cost-effective, especially when large amounts of the same elements can be produced and installed. The BIPV market has to move from tailored BIPV solutions to a mass-market, cost-effective approach, with a clear focus on ordinary buildings and applications. This involves innovation at different levels[21], i.e. in terms of flexibility and automation in manufacturing, creating multifunctional products for the building skin, process management based on digitalization, advanced performance assessments, and procedures that support the market to ensure quality, safety and reliability.

There is an important role for cities and municipalities in the transition towards such a mass market, i.e. the enabling and exemplary role. Large social housing companies, which manage many similar buildings, could include BIPV in prefabricated renovation elements. This could accelerate the transition to a mass market and broader use of BIPV.

21 pv-magazine.com/2019/09/28/the-weekend-read-establishing-a-cost-effective-bipv-sector-in-europe

Lessons learned

- BIPV technology includes various elements and choices. An architecture and engineering company are both needed to make the best choices.
- Public authorities can play an exemplary role and enable access to BIPV products for a broad consumer group in the near future.
- Ongoing research in TFPV technologies can help bring BIPV options that are more cost-effective and offer greater design flexibility.

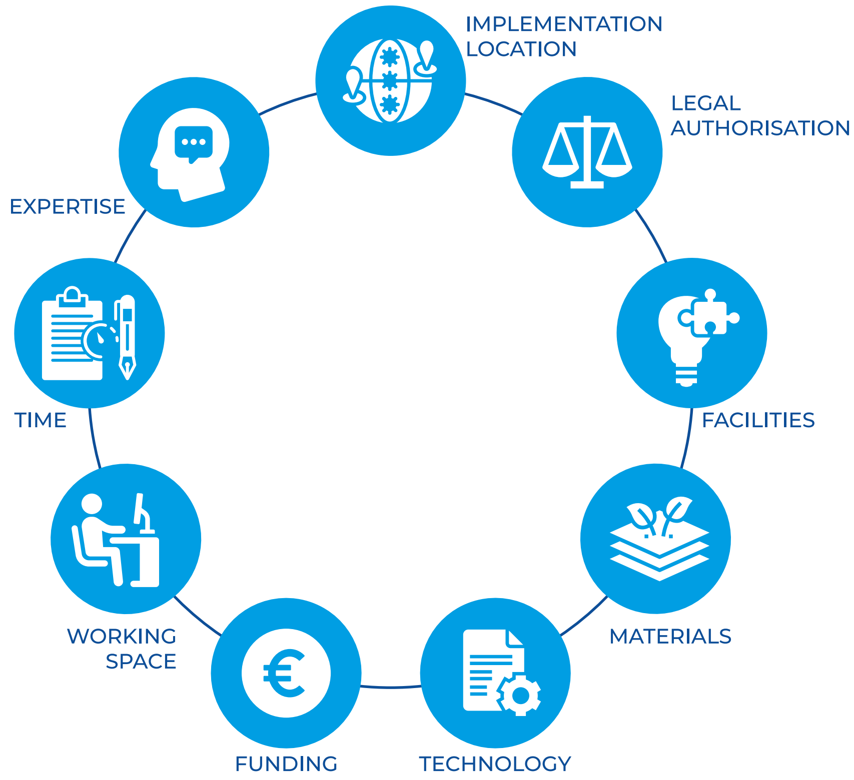


Figure: Map of recurring conditions for the development, implementation, and replication of innovations to be supported by urban living labs. Adapted from Amsterdam Institute for Advanced Metropolitan Solutions.

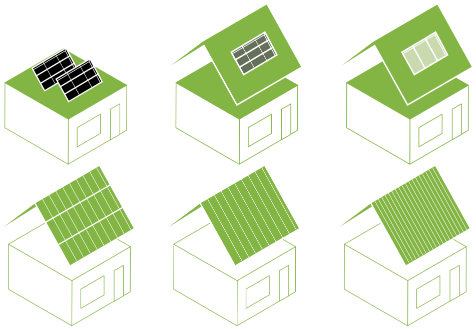
BUSINESS MODELS & FINANCE

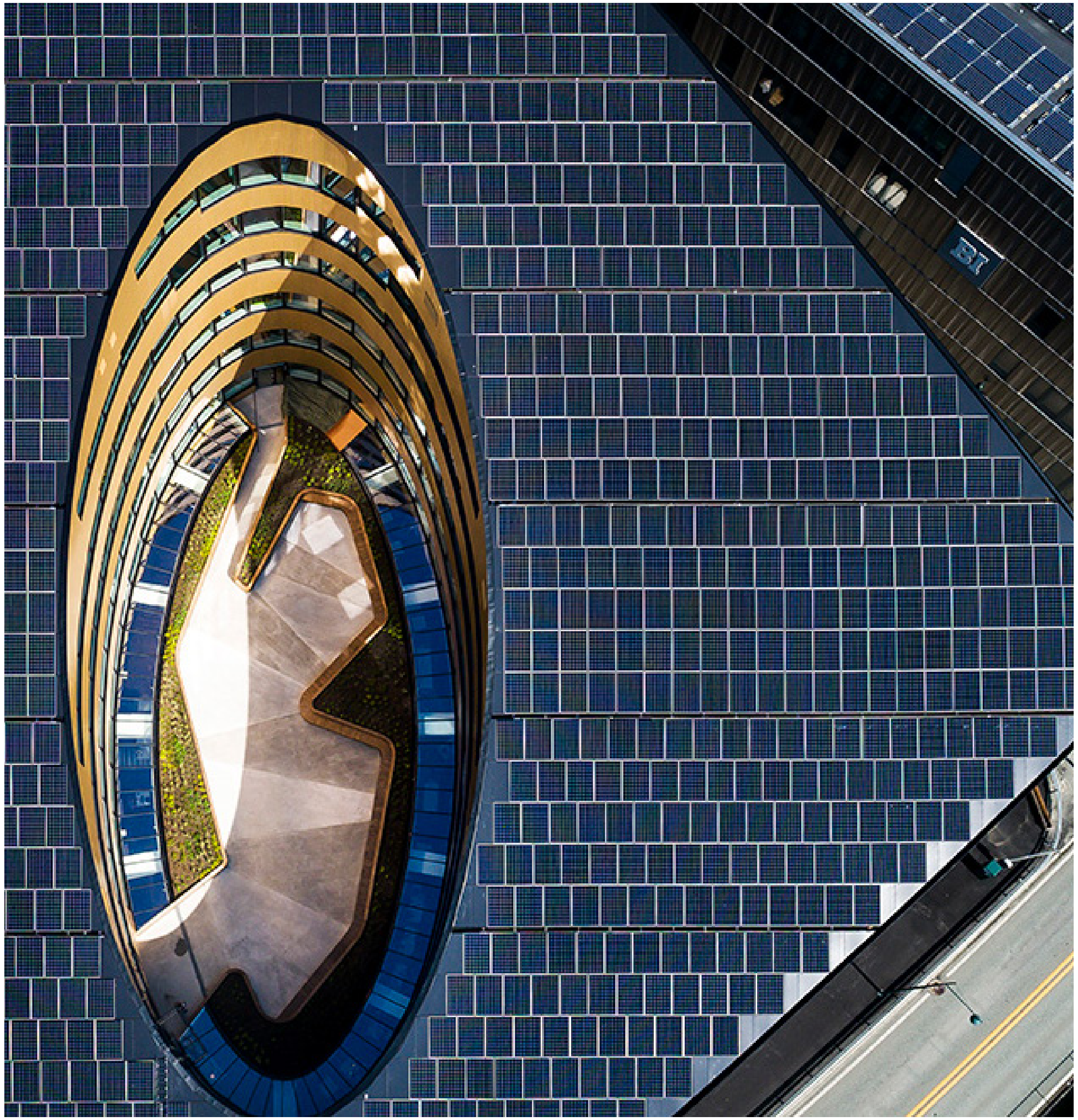
©David Christian, Unsplash

BUSINESS MODELS & FINANCE

BIPV is still a small market. In the previous two decades, the motivation to install BIPV was not financial but mainly ecological, aesthetic, or driven by research.

However, new buildings are required to be zero-energy by 2030, and large-scale refurbishment is necessary under the Energy Performance in Buildings Directive[22]. With improvements in BIPV technology, BIPV systems now have prices comparable to other nZEB façade materials[23]. Retrofitting buildings to nZEB standards as required by EPBD, cannot always rely on conventional PV panels installed on the roof. Therefore the building retrofit and installation of BIPV may provide an appealing solution. Diverse financing models, as with other renewable or bio-based energy systems, could help address the initial investment cost.





Powerhouse Brattørkaia Project | powerhouse.no ©Ivar Kvaal,

22 eur-lex.europa.eu/legal-content/EN/TXT/?toc=OJ%3AL%3A2018%3A156%3ATOC&uri=uriserv%3AOJ.L_.2018.156.01.0075.01.ENG
23 pdfs.semanticscholar.org/e7be/2b17275e83d1b901a96d419cec3f0300539c.pdf

Possible business models

Installation of BIPV can be financed by the building owners or in collaboration with a third party. Most of these business models[24] have been developed for implementation of energy efficiency measures and renewable energy. They are already in use and include[25]:

1. Energy Performance Contracting (EPC)

A third party (Energy as Service Company, ESCO) implements the BIPV project, as a service. In this case BIPV can be offered together with other energy management or energy efficiency services. The ESCO is mainly paid based on the energy generation or energy savings resulting from the project. The owner of the building does not pay for the full investment costs of the project and maintenance is guaranteed by the third party for benefits generated by the project. Depending on the potential of the project, financing can be fully covered by savings due to the renewable energy generation.

2. Power purchase agreement (PPA)

This is a long-term electricity supply agreement, where a third-party designs and implements the BIPV project. As a result, building tenants use the electricity from the BIPV system for an agreed fixed price for a certain number of years.

3. Lease contract

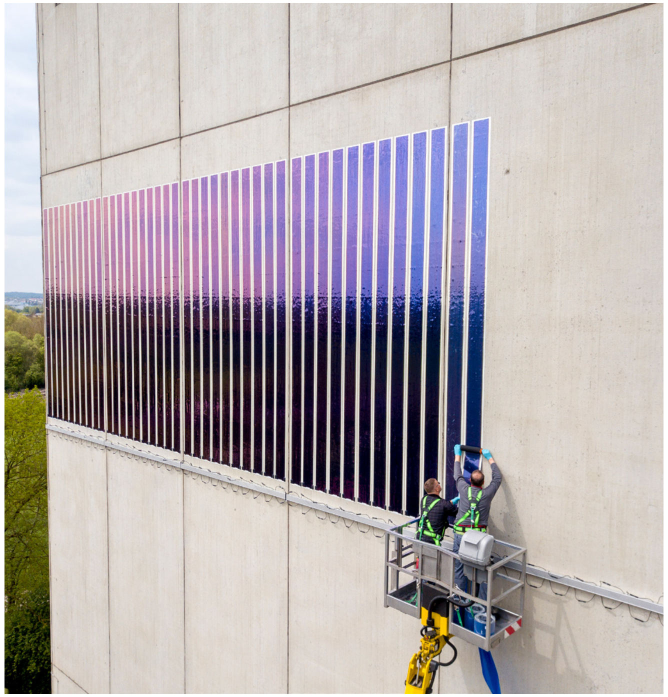
The third party implements the BIPV project and takes over the risk and costs of the project. In exchange, the building owner (private or public) rents the BIPV system for a specific number of years from the third party for self-consumption under agreed conditions for maintenance and leasing.

By offering a new perception of solar energy, Kaleo technology could in time contribute to an increase in architectural solutions that integrate photovoltaic systems. ©COMPÁZ | compaz.art

24 iea-pvps.org/wp-content/uploads/2020/02/Inventory_on_existing_business_models_opportunities_and_issues_for_BIPV_by_task_15.pdf
25 Solar Skins: An Opportunity For Greener Cities | etip-pv.eu/publications/etip-pv-publications/download/solar-skins-an-opportunity-for-greener-cities

4. On-bill financing

On-bill financing is the same as a lease contract, except the third party is a utility company. This way, building owners receive only one invoice. The utility company takes over the risk and cost of the BIPV project, as well as maintenance for a specified number of years. Building owners pay less for electricity compared to previous bills due to energy savings or electricity generated by the BIPV system.



Building applied PV Crop Mill. ©Heliatek | heliatek.com / Innogy | innogy.com

Building integrated PV. ©Argola Solvatec

5. Green public procurement

This form is for public buildings and structures, and it is used for goods, services, or works with a reduced environmental impact. Therefore, public authorities could require refurbishment of a building to meet nZEB standards and include BIPV to ensure local energy generation.

Financial performance

Taking into account lifecycle cost analysis for each EU country, BIPV implementation in the building envelope showed average EU discounted payback periods of 6 to almost 30 years. This range is due to the difference between the roof BIPV system and the façade BIPV system installed on the south, east, west, or north-facing side of a building. The south-facing façade is most favourable.

Researchers at the University of Stavanger[26] recently assessed the economic value of BIPV compared to other nZEB materials. They concluded that BIPV gives equal or better payback in energy savings and even more so if all the societal and environmental benefits (including emission savings) are taken into account. Therefore, in the lifetime of BIPV it can serve the purpose of the nZEB envelope and generate additional benefits from energy production.

Researchers from the University of Stavanger showed[27] that applying BIPV to the north façade would likely reimburse investment costs over its lifetime in nearly all European countries.

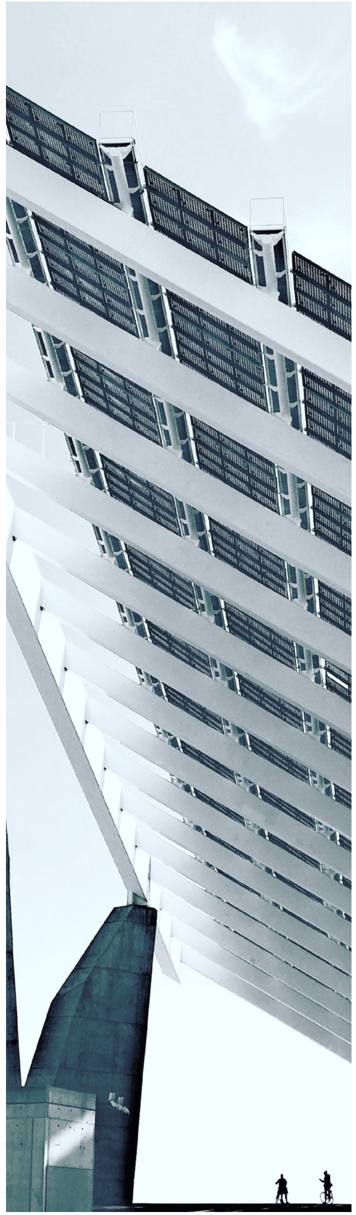
26 uis.no
27 sciencedirect.com/science/article/pii/S0360544220310380

Orientation and energy yield

Ongoing research at EnergyVille[28] focuses on performance of BIPV in façades in different climatic zones and on different orientations. The results indicate that orientation is dependent on latitude, due to the height of the sun and hence the angle of the solar radiation compared to the vertical façade. Therefore, as stated by the researchers, low-latitude locations might need to exploit west and east façades, in addition to the south façade. This is especially true for low-latitude locations, where electricity demand might increase during summer as solar irradiation on the south façade decreases due to high solar altitudes.

To further improve the design and avoid suboptimal results, EnergyVille is working on better design and simulation tools for BIPV. These tools will be available to the building simulation community and hence engineering companies in the near future.

28 energyville.be



Lessons learned

- **Existing energy efficiency and renewable energy business models** can be used for BIPV with minor changes in conditions due to system specifics.
- Complex and time-consuming BIPV installation on-site can be overcome by **using prefabricated and easy-to-install BIPV elements**.
- BIPV systems offer energy efficiency, environmental, and social value that should be monetised in **lifecycle analysis and compared with other building technology or construction materials**.

Solar Settlement in Freiburg, Germany. ©Rolf Disch Solar Architecture | rolfdisch.de

GOVERNANCE & REGULATION

©Scott Graham, Unsplash

GOVERNANCE & REGULATION

To encourage and support transition to sustainable development, the EU has adopted the Clean Energy Package[29]. Within this package the **Energy Performance of Buildings Directive**, the **Energy Efficiency Directive**, the recast of the **Renewable Energy Directive**, and the **Electricity Market Directive** all support the concept of local generation. BIPV systems have a clear role in this, especially in cities. However, BIPV has not been widely adopted; it remains a niche market for customised applications and is viewed as a complex multisectoral technology to implement. Local, regional, and national governments could play a decisive role in the breakthrough of BIPV and hence its accessibility to a wide range of customers.

Further reading on governance

SCIS From Idea to Implementation Solution Booklet
smart-cities-marketplace.ec.europa.eu/insights/solutions/solution-booklet-idea-implementation

Bold City Vision framework
cityxchange.eu/knowledge-base/framework-for-bold-city-vision-guidelines-and-incentive-schemes

The Smart City Guidance Package
eu-smartcities.eu/news/smart-city-guidance-package

29 energy.ec.europa.eu

Aside from the urban planning efforts and the exemplary role, governments and regulatory bodies could work on and implement policy supporting the integration of BIPV:

- BIPV combines the characteristics of an electric device and a building component. Due to this, it needs to **comply with electrical and building standards**. BIPV must hence comply with IEC 61215, 61646, or 61730 – which are standards for PV modules – and with EN 50583 parts 1&2 – which evaluate basic work requirements for building components and include fire safety, safety in use, thermal performance, acoustics, etc.
- Many countries' regulations (even within EU) have varying definitions of BIPV[30]. Such variations create complex and costly market conditions for industry development. **Harmonised standards and a clear regulatory framework** are needed to boost the implementation of BIPV.
- To simplify the process for BIPV implementation, BIPV regulations and **procedures should be as unified as possible** across countries. Any unnecessary specialization of the procedures can increase complexity and costs and create barriers.
- As BIPV's value depends on renewable energy generation, the lack of clear policy supporting **collective self-consumption** in buildings creates a barrier to ensuring the BIPV system's basic benefits. This will soon be resolved through the concept of collective self-consumption at building level as per the RED recast.
- Insurance companies are often reluctant to incorporate BIPV products, especially regarding fire safety or performance after ageing. Research and testing are therefore needed to build confidence. Proper **insurance policies** should also be developed to ensure safety in the operation and maintenance of BIPV systems and decrease the risk to building owners or third-party investors.
- Particular attention should be paid to incorporating BIPV modules into **refurbishment projects,** as existing conditions could change significantly and new fire safety hazards could arise on site.
- Initiatives that provide **prefabricated and easy-to-install** (plug-and-play) solutions through community or social housing associations provide economies of scale for industry and greater certainty for citizens and investors.

30 ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5c36a19c8&appId=PPGMS

GENERAL LESSONS LEARNED

GENERAL LESSONS LEARNED

- Cities and municipalities have the potential to contribute to the wider adoption of BIPV through **exemplary projects and broad coverage in media**.
- Information dissemination of best practices and lessons learned should be done through **initiatives such as Covenant of Mayors and Smart Cities**.
- Cities and municipalities should assess the **optimal locations for renewable energy generation** within their neighbourhoods and districts, and including BIPV as a potential technology.
- Improved **training and awareness-raising** for architects, the construction sector, installers, investors, local governments, end-users, and communities can significantly boost BIPV adoption.

- **Communication** among different stakeholders should be facilitated for more effective implementation of BIPV systems.
- **Prefabricated BIPV elements** can significantly reduce complexity and costs of installation and implementation.
- The **design and selection of electrical and mounting components** are important to achieve a reliable and well-performing BIPV system. Models are being developed and engineering companies are ready to assist.

- **Si-based technology** has improved in design over the year, offering **different colours and sizes,** while thin-film PV provides greater **design flexibility** and integration options with **lightweight, flexible, and semi-transparent solutions**.
- Several **financing models** can be used, similar to other renewable energy generation and energy efficiency investment projects.
- BIPV offers **environmental and societal benefits**, in addition to energy generation and efficiency, which should be considered during lifecycle comparisons of building solutions.

USEFUL DOCUMENTS

USEFUL DOCUMENTS

BIPV Database[31]

Historic BIPV platform with a database of more than 250 examples and products[32]

One of the most visited and reference platforms of the sector[33]

IEA PVPS Task 15 on BIPV[34]

- Development of BIPV Business Cases[35], 2020;
- Analysis of requirements, specification and regulations of BIPV[36], 2019;
- Coloured BIPV: Market, Research and Development[37], 2019;
- International definition of BIPV[38], 2018.

Solar Power Europe publication "Solar Skins: An Opportunity for Greener Cities – Solar Powe Europe"[39] 2019;

Solar Architecture: Best practices and examples[40];

IRENA publication "Future of Solar Photovoltaics[41]" 2019;

Build Up[42] – European portal for energy efficiency in Buildings;

Energiesprong[43] - EU – Community building renovation to nZEB;

Hiber atlas[44] - Historic building retrofit;

IEA Photovoltaik (PVPS) Task 15: Bauwerkintegrierte Photovoltaik[45]

31 bipv.eurac.edu
32 bipv.ch
33 solararchitecture.ch
34 iea-pvps.org/publications
35 iea-pvps.org/key-topics/development-of-bipv-business-cases-guide-for-stakeholders
36 iea-pvps.org/key-topics/analysis-of-requirements-specifications-regulation-of-bipv
37 iea-pvps.org/key-topics/iea-pvps-15-r07-coloured-bipv-report
38 iea-pvps.org/key-topics/international-definitions-of-bipv
39 energetica21.com/images/ckfinder/files/Solar_Skins_An_opportunity_for_greener_cities_report.pdf
40 solarchitecture.ch
41 irena.org/-/media/Files/IRENA/Agency/Publication/2019/Nov/IRENA_Future_of_Solar_PV_2019.pdf
42 buildup.eu
43 energiesprong.org
44 hiberatlas.com
45 nachhaltigwirtschaften.at/resources/iea_pdf/schriftenreihe-2019-60-iea-pvps-task-15.pdf

Projects:

Increase

» www.increaseipv.eu

SPHINX

» sphinxproject.eu

MASS-IPV

» massipv.eu

BeSmart

» www.besmartproject.eu

PVsites

» www.pvsites.eu

BIPV Boost

» www.bipvboost.eu

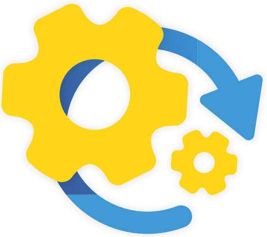
Dem4BIPV – Development of innovative educational material for BIPV

» www.dem4bipv.eu

Smart Cities Marketplace

The Smart Cities Marketplace is a major market-changing initiative supported by the European Commission bringing together cities, industries, SMEs, investors, researchers and other smart city actors.

The Marketplace offers insight into European smart city good practice, allowing you to explore which approach might fit your smart city project.



Matchmaking

The Smart Cities Marketplace offers services and events for both cities and investors on creating and finding bankable smart city proposals by using our Investor Network and publishing calls for projects.

Investor network

Call for Applications – Matchmaking Services

Project finance masterclass

Focus and Discussion groups

Focus groups are collaborations actively working on a commonly identified challenge related to the transition to smart cities.
Discussion groups are fora where the participants can exchange experiences, co-operate, support, and discuss a specific theme.

Focus and Discussion groups

Community

Scalable Cities

A city-led initiative providing large-scale, long-term support for the cities and projects involved in the Horizon 2020 Smart Cities and Communities project.

Scalable Cities

BUILDING INTEGRATED PV
SOLUTION BOOKLET

Smart Cities Marketplace 2025

The Smart Cities Marketplace is managed by the European Commission Directorate-General for Energy