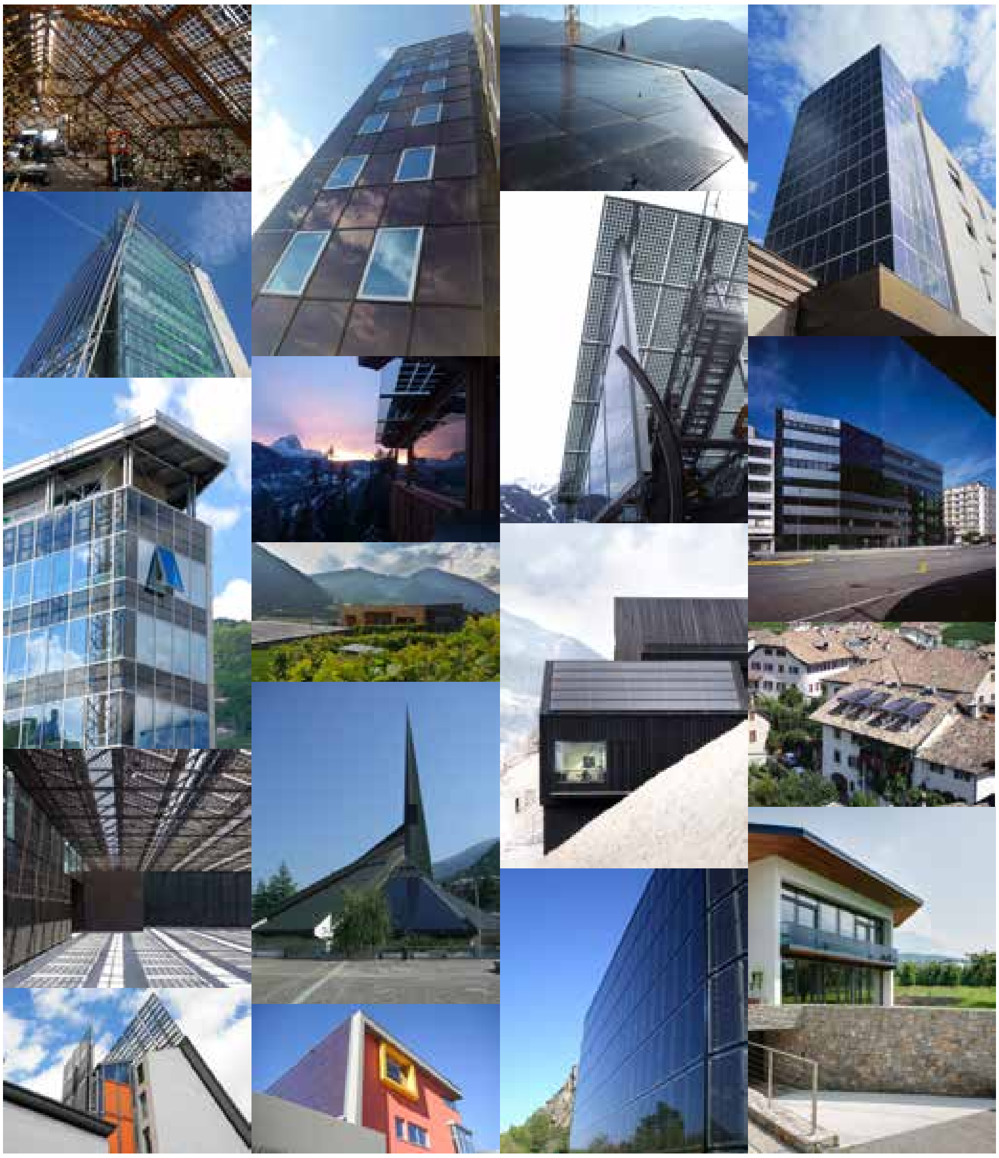
Analysing BIPV affordability

BIPV | One argument frequently used against building-integrated PV is its high cost relative to normal building materials. But as Laura Maturi and Jennifer Adami argue, evidence gathered from real-life BIPV projects suggests otherwise



Several recent international surveys [1] [2] carried out among BIPV stakeholders reveal that one of the main obstacles for the widespread deployment of building-integrated PV (BIPV) systems is the high cost. The economic issue is still perceived as a barrier by architects and contractors, who are the main BIPV stakeholders.

On the other hand, the drastic cost breakdown of PV in recent years has enormously decreased BIPV prices leading to cost competitiveness with standard building materials.

It is thus essential to increase the trust of architects, investors and financial stakeholders, by showing business cases and real stories. Architects' perceptions are highly influenced by tangible examples and real experiences – more than by theoretical calculations.

We have analysed 16 realised BIPV projects as business case studies, providing information on their final user costs. The case studies were selected from among more than 40 examples collected in a local "call for case studies. Our investigation field is not focused on "extraordinary, 'archistar'-designed" BIPV projects, but on "ordinary BIPV high quality", meaning BIPV examples of a high quality, but which have high replication potential in Europe. The sample group includes several kinds of integration typologies from both private and public sector applications.

Case studies

In order to collect the most representative case studies for our investigation (i.e. ordinary BIPV high quality examples), a local call for case studies was launched by contacting most of the engineers, architects and professionals of the Trentino-Alto Adige region of northern Italy. This region has been very active in recent years in the BIPV field by boosting PV use and building energy efficiency through several measures: incentive schemes, dedicated policies, awareness raising, guidelines development and public engagement in the use of PV in public buildings. Out of more than 40 collected cases, the best ones were selected through an internal workshop.

The meaning of the acronym BIPV in this case-study analysis is intended to convey a broader meaning compared to the EN 50583-1:2016 "Photovoltaics in buildings" standard definition and in particular refers to a triple concept of integration: technology, aesthetic and energy integration. Technology integration is meant as the capability of the PV system to be "multifunctional" (as intended in the EN Standard) and aesthetic refers to the architectural appeal. "Energy integration" refers to the capability of a PV system to interact

The case studies analysed by EURAC challenge the cost argument often made against BIPV

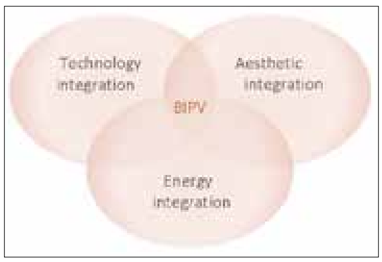


Figure 1. BIPV integration concept

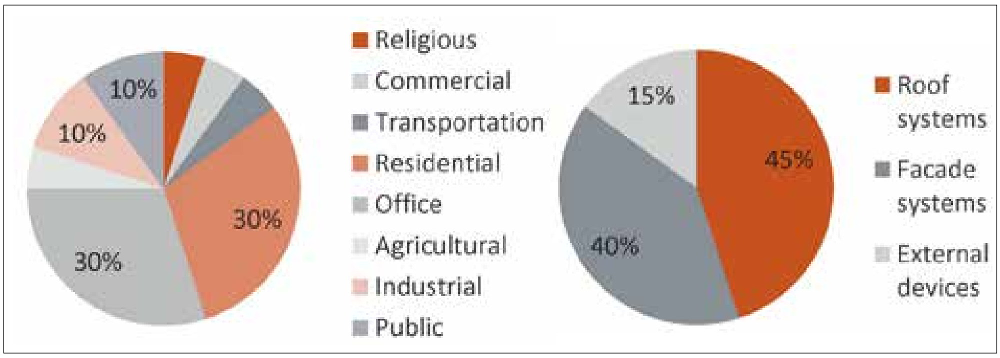


Figure 2. Building typologies (left) and architectural integration types (right) presented in the case studies

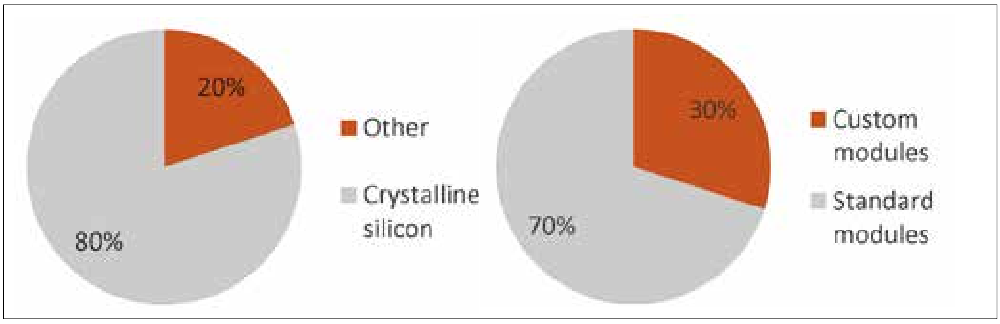


Figure 3. PV technologies (left) and module types (right) presented in the case studies

with the building and district energy system in order to maximise the local use of the produced electricity.

This is in our view a quite important aspect, which is often not considered in the traditional BIPV definitions. In fact, despite the existing "BIPV" definitions, we believe that in order for BIPV system design to be successful, all three aspects must be considered. The selected BIPV case studies are considered respondent to this triple concept (see Figure 1, previous page).

The selected BIPV systems have been installed in a variety of building typologies. They include office, residential, agricultural, industrial, community, religious, commercial and transportation buildings. Most of them have been integrated during the building construction (around 60%), the other ones represent retrofit intervention.

Several architectural integration types are shown, including opaque and semi-transparent roof, warm, cold and double-skin façades as well as external devices such as parapets and solar shading elements. The most predominant are façade and roof systems.

The different building typologies represent both private and public ownerships, giving an overview of the different approaches to the BIPV matter, especially regarding the decision-making related to economic issues (see Figure 2).

In terms of PV module materials, crystalline silicon technology is the most widely exploited, being used in around 80% of the analysed case studies. Most of the modules are standard products (only 30% are custom-made modules). It shows that in many cases appealing BIPV systems can be realised without needing customisation (Figure 3). A more detailed case studies description is found in [3].

BIPV final user cost

The economic matter is tackled from two different perspectives: the "PV" perspective – normalising the cost to kWp, and the "building" perspective – normalising the cost to m^2.

Looking at the PV perspective, results show that the cost of the analysed BIPV systems, whose construction years lie between 2004 and 2015, ranges from €2,500/kWp to €8,300/kWp, with an average of around €5,500/kWp.

> "BIPV system capital cost lies in an acceptable range and is in fact even cheaper than some standard passive building materials"

This variation can be ascribed to several factors, such as the type of technological integration, type of components and, most important, the construction year, since the cost of PV has seen an impressive decrease in the last few years.

In particular, looking at the technological integration types, the following average values are found:

- Opaque cold façade: ~€7,900/kWp
- Semi-transparent roof-façade: ~€5,100/kWp
- External device: ~€4,900/kWp
- Opaque tilted roof: ~€4,400 /kWp

In order to look at the economic matter from a different perspective, the cost has been normalised to the envelope covered surface (€/m^2), thus using an indicator which is normally used in the building sector. The cost of the analysed BIPV systems ranges from €300/m^2 to €1,300/m^2, with an average of around €600/m^2.

In particular, looking at the technological integration types, the following average values are found:

- Opaque tilted roof: ~€600/m^2
- Opaque cold façade: ~€850/m^2
- Semi-transparent roof-façade: ~€500/m^2
- External device: ~€500/m^2

As the €/kWp index, the cost variation can be ascribed to several factors. In particular, this time a crucial role is played by the PV module efficiency. For this reason, looking at this indicator might be misleading but it is very useful to compare the BIPV system cost with standard building materials. It demonstrates that in fact, the BIPV system capital cost lies in an acceptable range and is in fact even cheaper than some standard passive building materials (e.g. glazed curtain walls, stone and others) [4]. This, without even considering the payback time period, which ranges from four to 11 years for the presented case studies (this information was not available for all cases) and which is "infinite" for standard passive solutions (without taking into consideration energy savings).

As mentioned above, the cost variation of BIPV is widely influenced by the construction year, due to the falling costs of PV recent years. Figures 4 and 5 show the trend over the years of the final user BIPV systems cost, considering the "PV" and "building" perspective.

A clear decreasing trend is shown for the last decade (from 2004 to 2015) with values of ~€8,000/kWp and ~€950/m^2 in

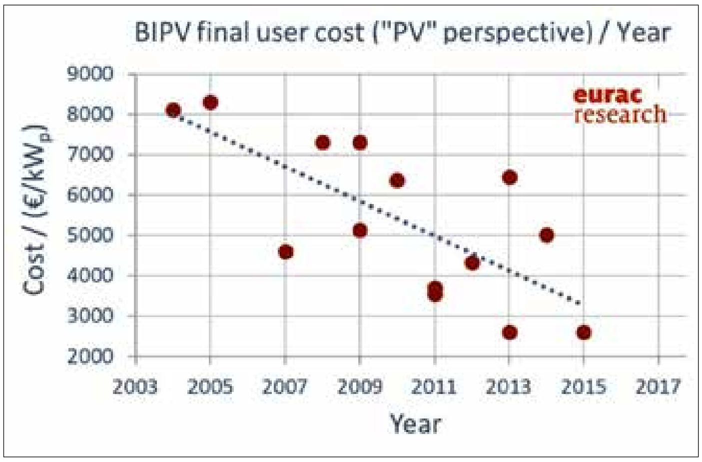


Figure 4. Final user costs of the analysed BIPV systems per construction year, normalised to the system nominal power

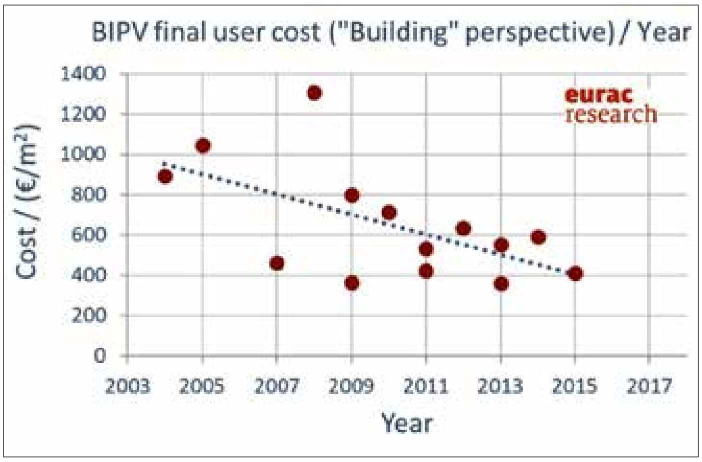


Figure 5. Final user costs of the analysed BIPV systems per construction year, normalised to the envelope covered surface

2004 and of ~€3,300/kWp and ~€400/ m^2 in 2015.

By comparing this data with standard, non-integrated PV systems, we might conclude that the BIPV trend cost in 2015, corresponding to €3,300, is not too far from a ground-PV solution (considering a baseline cost of around €2,500/kWp, typical of small plants in the last few years).

Conclusions

These tangible examples demonstrate that, despite the fact that the economic issue is still perceived as a barrier against the widespread deployment of BIPV systems [1], [2] the use of PV in architecture is in fact viable for many cases. A clear decreasing trend over the years during the last decade is shown (see Figure 4 and Figure 5). Even if some incentive schemes are over in Europe (e.g. the "Conto Energia" for Italy, which lasted from 2005 until 2013), they have paved the way to an irreversible process that cannot now be stopped.

In Italy, the current support schemes rely mainly on two measures: a tax credit, which allows to recoup 50% of the capital cost in 10 years, and the "net billing scheme" managed by agency GSE, which valorises from an economic point of view the energy delivered to the grid. The economic viability of BIPV systems is thus preserved, even if we can somehow read a conceptual shift in the way to reward it: the "Conto Energia" boosted the formal and technological integration (through a higher contribution foreseen for "innovative BIPV"), while the current schemes pursue energy integration, in order to maximise the energy match between the produced and consumed energy.

The energy integration concept is becoming more and more important to meet the new building concept and its energy provision. In fact, also thanks to EU policies such as the NZEB (Nearly Zero Energy Buildings) concept and renewable energy goals [5], [6], buildings are becoming more than just stand-alone units using energy from the grid. They are becoming micro energy hubs consuming, producing, storing and supplying energy, thus transforming the EU energy market from a centralised, fossil fuel-based, national system towards a decentralised, renewable, interconnected and variable system.

Eurac Research is currently coordinating a European research project named EnergyMatching [7] to address these issues related to BIPV energy integration developing new concepts and technologies in this direction. In this context, PV integration is irrevocably destined to play an essential role in the years to come and, learning from the experience gathered in realised projects, BIPV systems have certainly the opportunity to improve in all the three aspects of technology, aesthetic and energy integration.

> "Despite the fact that the economic issue is still perceived as a barrier against the widespread deployment of BIPV systems, the use of PV in architecture is in fact viable for many cases"

References

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[5] European Commission. 2010 "Directive 2010/31/EU of the European Parliament and the Council on the energy performance of buildings (EPBD)."

[6] European Parliament and European Council. 2009. "Directive 2009/28/CE on renewable energy sources (RES)."

[7] Energy Matching H2020 project, www.energymatching.eu

Authors

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