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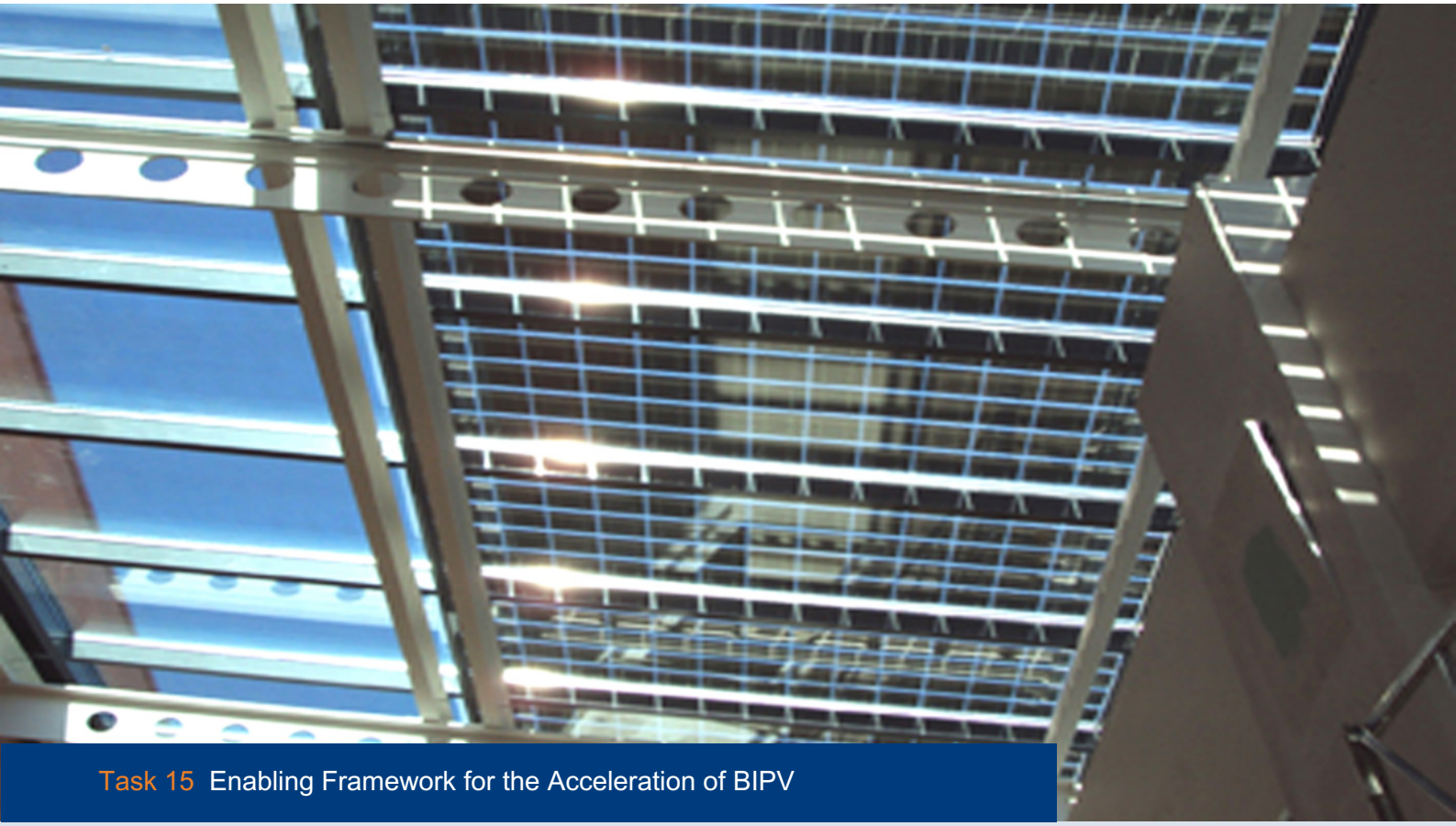

Task 15 Enabling Framework for the Acceleration of BIPV

PVPS

Analysis of the Technological Innovation System for BIPV in Italy

2024

Report IEA-PVPS T15-17:2024

What is IEA PVPS TCP?

The International Energy Agency (IEA), founded in 1974, is an autonomous body within the framework of the Organization for Economic Cooperation and Development (OECD). The Technology Collaboration Programme (TCP) was created with a belief that the future of energy security and sustainability starts with global collaboration. The programme is made up of 6.000 experts across government, academia, and industry dedicated to advancing common research and the application of specific energy technologies.

The IEA Photovoltaic Power Systems Programme (IEA PVPS) is one of the TCP's within the IEA and was established in 1993. The mission of the programme is to "enhance the international collaborative efforts which facilitate the role of photovoltaic solar energy as a cornerstone in the transition to sustainable energy systems." In order to achieve this, the Programme's participants have undertaken a variety of joint research projects in PV power systems applications. The overall programme is headed by an Executive Committee, comprised of one delegate from each country or organisation member, which designates distinct 'Tasks,' that may be research projects or activity areas.

The 25 IEA PVPS participating countries are Australia, Austria, Belgium, Canada, China, Denmark, Finland, France, Germany, Israel, Italy, Japan, Korea, Malaysia, Morocco, the Netherlands, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, and the United States of America. The European Commission, Solar Power Europe, the Smart Electric Power Alliance, the Solar Energy Industries Association, the Solar Energy Research Institute of Singapore and Enercity SA are also members.

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What is IEA PVPS Task 15?

The objective of Task 15 is to create an enabling framework to accelerate the penetration of BIPV products in the global market of renewables, resulting in an equal playing field for BIPV products, BAPV products and regular building envelope components, respecting mandatory issues, aesthetic issues, reliability and financial issues.

Subtask A of Task 15 is focused on the analysis of the Technological Innovation System (TIS) for BIPV on national levels in order to identify systemic problems and recommend actions for industry and/or policymakers that want to support the development of the BIPV market and innovation system. This document is one of the national TIS-analysis reports. A synthesis of national TIS-analyses will be made based on this and other national reports.

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COVER PICTURE

GSE, *Catalogue of Photovoltaic Plants Integrated with Innovative Characteristics*

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INTERNATIONAL ENERGY AGENCY

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

Analysis of the Technological Innovation System for BIPV in Italy

IEA PVPS Task 15

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LIST OF ABBREVIATIONS

BAPV	Building Applied Photovoltaics
BIPV	Building Integrated Photovoltaic
CEI	Comitato Elettrotecnico Italiano (Italian Electrotechnical Committee)
CENELEC	European Electrotechnical Committee for Standardization
EPO	European Patent Office
FiT	Feed-in Tariff
IEA	International Energy Agency
IEA PVPS	International Energy Agency, Photovoltaic Power Systems Programme
IEC	International Electrotechnical Commission
NECP	National Energy and Climate Plan
PIMBY	Please In My Back Yard
PV	Photovoltaics
RES	Renewable Energy Sources
TIS	Technological Innovation System
UIBM	Ufficio Italiano Brevetti e Marchi
WIPO	World Intellectual Property Organization

EXECUTIVE SUMMARY

This report analyses the Technological Innovation System (TIS) of Building Integrated Photovoltaic (BIPV) technology in Italy. Today, innovation can be considered the key to the development of a sector. The TIS analyzes and evaluates the (possible) development of a particular technological field, the structures, the processes, and the factors supporting or hampering it.

Italian BIPV experienced a strong innovation period with the past Feed-in Tariff (FiT) Law supporting the so-called totally integrated PV and Innovative BIPV, which resulted in more than 2,5 GW of BIPV out of a total PV capacity installed of 18 GW. After the end of the FiT era, the market slowed down and in 2017 it experienced a slight recovery. However, as shown in this report, the typologies of the systems incentivized through the past FiT schemes remain today, with new products entering the market.

The structural factors of the system such as technology, actors, networks and institutions are highlighted in chapter 3. Chapter 4 shows the phase of development of BIPV in Italy.

In chapter 5, the functional analysis of the TIS has been carried out, exploiting the results of interviews with stakeholders, publications and detailed analysis of patent applications for BIPV products over more than twenty years. With the above-mentioned results, eight functions have been analyzed and later scored, in order to assess if each function is sufficient for the development of the TIS.

This analysis shows a niche market with significant potential from the past FiT law and for the new challenges of the Italian National Energy and Climate Plan, with some difficulties to overcome, like i.e., the lack of a BIPV (product) association, and other subjects to face. Among the last ones, it is worth to mention product costs, performance, BIPV reputation and the need to work with superintendencies in order to install BIPV in the centers of the historical cities.

Chapter 6 investigates the weaknesses and strengths of the system, thus leading to the Recommendations chapter (chapter 7), which explores the main topics analyzed and their possible solutions, such as, i.e., the need to integrate (or to better indicate) BIPV technology into national regulation, or the demand of training for public administration and of involving finance in the BIPV business. Other recommendations are related to certifications and patents costs.

The report closes with a question concerning an issue related to the integration of BIPV in historical heritage of Italian cities, and it is related on one side to technology, on the other, the language of architecture. This question is the cornerstone for BIPV development in Italy and it opens to further analysis.

1 INTRODUCTION

The aim of developing an analysis of a Technological Innovation System (TIS) is to facilitate and support the implementation of BIPV in Italy and support the innovation and industrial development of BIPV solutions.

The BIPV topic has always been relevant for the historical heritage of Italian cities and landscape. From the early 2000s, different incentive schemes addressed the issue of how to integrate this new material in historical buildings, in order to find different solutions for different urban contexts to overcome permitting issues.

This work is part of a wider path that Gestore dei Servizi Energetici (hereafter, GSE), the Italian implementing body in charge of supporting renewable energies, energy efficiency and sustainability, has undertaken for a long time. Indeed, after the end of past PV/BIPV incentive schemes, GSE, thanks to its institutional role, maintained an important, long-lasting relationship with stakeholders which allowed the realization of market analysis and reports.

The TIS framework is well-described and anchored in academic literature (M.P. Hekkert, A. Bergek). System components of the TIS structure such as actors and institutions are identified, and their interactions and networks assessed. Moreover, TIS functions like Knowledge Development, Knowledge Dissemination, Entrepreneurial Experimentation, Resource Mobilization, Development of Social Capital, Legitimation, Guidance of the Search, and Market Formation are analysed, highlighting possible interactions between functions.

With TIS analysis, an unbiased point of view about BIPV structures and processes over time is developed, exploiting the interviews of stakeholders of the market, publications, patents, etc., and identifying issues, cross-cutting topics, barriers and, sometimes, possible solutions to overcome it. In the Recommendations chapter considerations and proposals for possible measures to support the deployment of BIPV are outlined for policy makers and industry.

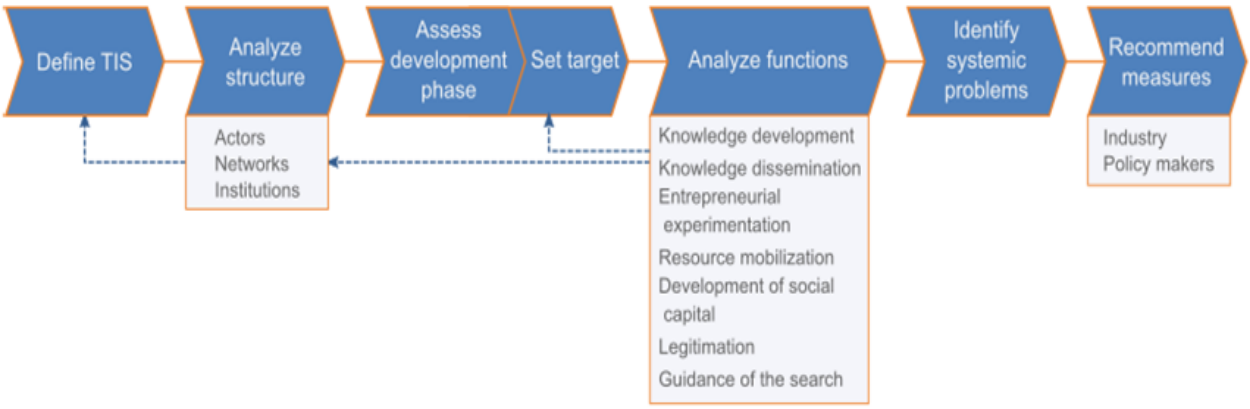

Figure 1. TIS process, source Guide for Technological Innovation System Analysis for Building-Integrated Photovoltaics. IEA-PVPS Task 15 [1]

2 DEFINITION OF THE TECHNOLOGICAL INNOVATION SYSTEM FOR BUILDING-INTEGRATED PHOTOVOLTAICS

This chapter shows an overview of BIPV to outline the technology in focus for the analysis.

2.1 Scope of this Analysis

The subjects of the analysis are BIPV modules and systems, as indicated below:

- A BIPV module is a PV module and a construction product together, designed to be a component of the building. A BIPV product is the smallest (electrically and mechanically) non-divisible photovoltaic unit in a BIPV system which retains building-related functionality. If the BIPV product is dismounted, it would have to be replaced by an appropriate construction product [2].

- A BIPV system is a photovoltaic system in which the photovoltaic modules satisfy the definition above for BIPV products. It includes the electrical components needed to connect the PV modules to external AC or DC circuits and the mechanical mounting systems needed to integrate the BIPV products into the building [2].

The above-mentioned definitions are integral to the examination of the Italian Building-Integrated Photovoltaics (BIPV) market. It is noteworthy that the prevailing definitions and requirements from the former Feed-in Tariff (hereafter, FiT) Law continue to predominantly shape the landscape of products that persist in the market today.

2.2 Historical Technological Development

In Italy the path towards BIPV started around the early 2000's with the program "10.000 thousands Photovoltaic Roofs", funded by the Italian Minister of the Environment [3]. In this first program, the architectural integration of PV systems in Italy received a special attention, with the allocation of specific financial resources for projects with high architectural value. The general program aimed at realizing photovoltaic plants with a size between 1 and 20 kW, grid-connected and installed on buildings. The national subsidy covered up to 75% of the eligible costs of the BIPV system.

Afterwards, a Feed-in Tariff scheme was introduced in Italy in 2005, with four successive ministerial decrees (all named "Conto Energia"). The first FiT Law was designed by the Decree of July 2005 [4], foreseen by the Legislative Decree n.387 of December 2003 that endorsed the European Directive on renewable energy sources [5]. The Regulatory Authority for Electricity and Gas appointed GSE as the implementing body in charge of granting incentives. The second edition of the FiT Law of February 2006 envisaged a generic 10% increase of the support for building integrated systems [6].

A new decree in 2007 (second FiT Law, [7]) has redefined the tariffs and introduced new rules. Tariffs were designed to promote small plants (distributed generation) and architectural integration according to three different degrees of implementation: not integrated (mostly

ground mounted plants), partially integrated and totally integrated systems, with rising tariffs. The partial integration case was designed to consider the vast majority of existing buildings, with PV modules installed on flat roofing or with the same tilt of an underlying sloped roof (BAPV). BIPV was rewarded with a higher incentive for the implementation of PV modules as a component of the building envelope. Another important innovation of the second FiT scheme was to consider the energy efficiency aspect. This was globally quite unique and followed the guidelines of the Decree 192/05 and the implementation of the European Directive 2002/91/EC on the energy performance of the building. A further increase in tariffs (up to 30%) was granted for plants under the net-billing scheme, improving energy efficiency of the annexed building and for PV plants installed on a new building. The result of the second FiT scheme showed that more than 30% of the plants accessed the BIPV totally integrated tariff (both in number and in capacity), with an installed capacity of around 2,3 GW for a number of around 78.000 BIPV installed plants. BIPV modules were mostly standard modules and thin film ones [8]-[9], integrated in a way to meet the FiT definitions and requirements.

The subsequent decrees (third, fourth and fifth FiT Law, [10]-[12]) set new rules to support PV and BIPV plants. Concerning BIPV, a specific role for photovoltaic architecture was foreseen, through the introduction of 'Innovative BIPV' concept, emphasizing the link between the BIPV plant and the building: the BIPV system substitutes the traditional building element and ensures waterproofing of the building structure.

Two product categories are foreseen by the decrees for innovative BIPV products: Innovative Modules and BIPV Special Components. Innovative Modules consist of a special building product, unique and indivisible, commercially identified and certified in accordance with technical standards set in the decrees. This category includes small tiles specifically designed to integrate in traditional roofs, with dimensions similar to traditional tiles, flexible PV modules certified along with their support, transparent modules for facades. For standard traditional PV laminates (modules without the frame), innovation means a European patented mounting system specifically designed to guarantee a waterproof building structure. The mounting system of Innovative Components becomes the frame of PV laminates.

A capacity of almost 300 MW of Innovative BIPV technology has been installed in Italy, for a number of more than 15.000 plants. Concerning typology of product, most of the Innovative BIPV plants are built with Special Components (around 80% of capacity and 90% of number) due to lower costs and easier maintenance. Out of around 18 GW of capacity under past FiT Law, around 2,5 GW are BIPV plants, under different definitions of BIPV (totally integrated, innovative integration).

Once the FiT scheme was over, GSE detailed data due to incentive mechanisms were no longer collected. GSE continued, within its institutional commitments, interactions with stakeholders in order to better understand the evolution of the PV and BIPV markets. In the framework of IEA PVPS Task 1 activities, between 2020 and 2021 a questionnaire was sent to industry stakeholders previously published in the GSE *Catalogue of Photovoltaic Plants Integrated with Innovative Characteristics* [13] in order to understand the market share, prices, capacity installed and new products (if any). The results show that, despite a significant reduction after the end of FiT era, a BIPV market still exists in Italy and that new MWs of additional BIPV have been installed, with renewed growth since 2017, even if it is difficult to

define a proper number. At the end of 2022, a PV capacity of around 25 GW is installed in Italy, of which 2,5 GW installed in 2022. Almost all the capacity not installed on the ground (2 GW) in 2022 is on building, due to a tax deduction scheme [14]-[16].

2.3 Historical Development of the Innovation System

During the second FiT scheme, the main actors in the BIPV market were from the PV industry, which was starting to diversify its business, while research centres and universities were working on the subject.

From the third FiT Law, new definitions included in the FiT decrees and in the related GSE Guidelines and Technical Rules [17]-[22] reflect the characteristic of a changing market, pushing a mechanism involving new actors. Indeed, the two product categories foreseen by the decrees, BIPV Innovative Modules and BIPV Innovative Special Components, come from two different markets. On one side, historical PV producers of standard modules with Special Components; on the other side, new entrants from the construction industry attracted by this new booming market where they would be able to experiment with their Innovative Modules. They both had to address the concept of BIPV innovation requested by the decrees. Today the market consists mainly of actors working on the above-mentioned two product categories of the previous decrees, even if the construction sector partially exits from the market.

Moreover, the need of mounting systems with a European patent[1] led many patent attorneys to the BIPV market, as well as certification bodies, because the photovoltaic laminate had to be tested with the patented mounting system adopted (some producers adopted two or three different mounting systems). As a matter of fact, certification has been indicated by industry and other stakeholders as a relevant barrier that remains even today.

During FiT era, university courses, together with many dissemination initiatives about BIPV, arose, together with interviews and articles done by press.

Public Administrations / Regions / Municipalities had a central role, confirmed by the fact that some of them, even after the end of the FiT scheme period, continued to apply the GSE BIPV guidelines as a requirement in order to access funding.

After the end of the FiT Law, the market declined, with a recovery since 2017 [23].

Today, after few years from the end of FiT mechanisms, BIPV market is (again) mainly driven by PV industry, some producers and patent attorneys are working on new products even without a specific requirement or legal obligation. Many universities and research centers deploy knowledge and a relevant role is being played by Public Administration, due to permitting issues in Italian cities. In this regard, as highlighted in the report, some superintendencies are showing interest to integrate BIPV products in historical centers.

[1] Products with a European patent applications with a preliminary opinion positively evaluated by the European Patent Office were also eligible.

3 STRUCTURAL ANALYSIS

As highlighted in paragraph 2.3, BIPV producers came at an early stage of the market from PV industry, working on standard “Special Components” and construction industry developing special building products (Innovative Modules), as shaped by decrees and guidelines.

Even if after the end of FiT Law the contribution of construction sector started to decline, today Italian BIPV market can be generally defined with the same categories (Special Components, tiles) with few industry stakeholders diversifying their business, adding new solutions to traditional ones, like tiles (see paragraph 5.1.1). Moreover, it is important to highlight that a niche of producers of custom BIPV modules (such as, i.e., double glass modules with spaced cells), foreseen in the past decrees and involved in specific projects, is still existing on the market.

Italy experienced several incentive schemes with a focus on BIPV, from capital subsidies to five FiT Laws. Today, a driving force for BAPV and BIPV is the so-called Superbonus, a tax-deduction mechanism.

Real time self-consumption is allowed for PV, BAPV and BIPV plant categories, and other measures, such as energy communities and energy income projects are implemented. Concerning energy communities, the measure approved by the Italian Parliament in 2019/2020 allows final consumers/RES producers to group together in order to share electricity locally produced by new RES plants. Two categories of prosumers are foreseen: RES consumers acting collectively in a group located in the same building and RES energy communities. At the end of 2022, 67 energy communities are commissioned for a total installed capacity of 1,4 MW (so far, all from PV source).

The municipality of Porto Torres (Sardinia region), in cooperation with GSE, introduced in 2017 the so-called reddito energetico, energy income project. The municipality allocated public resources to purchase PV systems, sold on loan to families in energy poverty conditions, to support them through PV self-consumption, reducing their energy bills. The revenues of the net-billing feed a public fund, in order to support the purchase of PV plants for other families. After this pilot project, many other municipalities and regions are carrying out similar support mechanisms.

All these measures are not focused on BIPV, but they do not exclude it, and self-consumption is a cross-cutting issue (see paragraph 5.9).

The structure categories are indicated below.

3.1 Technology

The technologies and areas of knowledge listed below are included in the innovation system in Italy.

BIPV materials. Research Institutes in Italy, as well as Universities, are active in developing materials for BIPV, sometimes with PV/BIPV industry.

New BIPV products. An important effort is made by universities, research centres and industry, to develop new solutions dedicated to historical cities, such as small tiles and coloured modules, in order to integrate them in an urban context. The patent applications search (see paragraph 5.1.1) showed some players mainly from the concrete building industries developing new products to integrate BIPV into the buildings (such as thin film PV modules with a cementitious substrate, or other).

Performance and reliability. With the past FiT Law, certification became a key issue, because until 2007 certification of process quality was on a voluntary basis and certification bodies were few. Afterwards, there has been a significant qualitative improvement together with a fast growth of certification bodies, due to FiT requirements, an improvement that still lasts today.

Innovation. Italy has always played a role in BIPV innovations, judging from the number of patent applications. Applications were submitted even before and after the Innovative BIPV FiT Law, which requested a patent for the mounting system of the so-called “Innovative Components” (see paragraph 5.1.1).

Glass construction. As highlighted in the patent applications search (see paragraph 5.1.1), the topic of glass building products has been faced before and after FiT era by different actors of the market. It has always been a niche production, with (often) a dedicated industry, sometimes together with construction industry.

Table 1. Technical regulations

Document	Title (Italian)	Title (English)	Description
Technical Guide CEI 82-25	Guida alla progettazione, realizzazione e gestione di sistemi di generazione fotovoltaica	Guide to the design, construction and management of photovoltaic generation systems	The purpose of this Guide is to provide general information regarding the Regulatory treatment of photovoltaic generation components and systems (or photovoltaic systems), contained in the various Parts of the Guide.
Technical Report CEI 82-74	Metodi di calcolo delle azioni del vento e criteri di dimensionamento di strutture di supporto di moduli fotovoltaici o di collettori solari	Methods for calculating wind actions and sizing criteria for support structures for photovoltaic modules or solar collectors	This Technical Report provides guidelines for the calculation of wind actions and the analysis of support structures of photovoltaic modules or solar collectors mounted on the ground or on buildings.
Technical Report CEI 82-89	Rischio d'incendio nei sistemi fotovoltaici - Comportamento all'incendio dei moduli fotovoltaici installati su coperture di edifici: protocolli di prova e criteri di classificazione	Fire risk in photovoltaic systems - Fire behaviour of photovoltaic modules installed on building roofs: test protocols and classification criteria	The purpose of this document is to propose useful solutions for the classification of the fire behaviour of the roof of the building on which a photovoltaic system with superimposed modules (BAPV) is built.
Technical Standard CEI EN 50583-1	Il fotovoltaico negli edifici Parte 1: Moduli fotovoltaici per l'integrazione architettonica (BIPV)	Photovoltaics in buildings Part 1: BIPV modules	This document applies to photovoltaic modules used as construction products. It focuses on the properties of these photovoltaic modules relevant to essential building requirements as specified in the European Construction Product Regulation CPR 305/2011, and the applicable electro-technical requirements as stated in the Low Voltage Directive 2006/95/EC / or CENELEC standards
Technical Standard CEI EN 50583-2	Il fotovoltaico negli edifici Parte 2: Impianti fotovoltaici con integrazione architettonica (BIPV)	Photovoltaics in buildings Part 2: BIPV systems	This document applies to photovoltaic systems that are integrated into buildings with the photovoltaic modules used as construction products. It focuses on the properties of these photovoltaic systems relevant to essential building requirements as specified in the European Construction Product Regulation CPR 89/106/EEC, and the applicable electro-technical requirements as stated in the Low Voltage Directive 2006/95/EC / or CENELEC standards.

Table 2. Legislative regulations

Title (Italian)	Title (English)	Description
D.Lgs. 28/2011 (Decreto Romani)	D.Lgs. 28/2011	This decree, in implementation of directive 2009/28/EC and in compliance with the criteria established by the law of 4 June 2010 n. 96, defines the tools, mechanisms, incentives and framework institutional, financial and legal, necessary for the achievement of quota targets up to 2020 of energy from renewable sources on gross final consumption of energy and the share of energy from renewable sources in transport
Legge 30 dicembre 2021, n. 234 (Bonus Fotovoltaico)	PV Bonus	Incentive for those who have incurred expenses to install storage batteries to store the energy produced by photovoltaic systems. The incentive consists of a tax credit to be used in the tax return for the 2022 tax year
DL n. 63/2013 (Ecobonus)	Ecobonus	Tax relief that affects energy renovation works. Installation of solar panels for the production of hot water. Fiscal deduction of 60%, admissible expenditure limit 60'000€
DL n. 34/2020 (decreto Rilancio) (Superbonus 110%)	Superbonus 110%[2]	110% deduction (so-called Superbonus) on documented expenses for energy efficiency measures and seismic risk reduction. PV is driven intervention, allowed with building energy efficiency refurbishment - Photovoltaic solar systems connected to the electricity grid on buildings, up to a maximum expenditure of 48,000 € and in any case up to 2,400 €/kW of rated power - Storage systems integrated into solar photovoltaic systems, under the same conditions as solar photovoltaic systems and in any case up to 1,000 €/kWh of storage capacity

[2] There have been some modifications in the last year.

3.2 Actors and Networks

BIPV Industry:

- *specialized BIPV manufacturers*, sometimes with small companies of a larger industrial group. Few producers of small tiles for historical cities and niche producers of glass-glass BIPV modules are on the market.

- *manufacturers originating from PV industry*, the first and most active in the BIPV market, mainly with mounting system solutions. They received a boost from FiT schemes, especially from the Innovative FiT scheme with the so-called Special Component. Today, many Special Components are still on the market with a price comparable to PV and BAPV solutions.

- *manufacturers originating from construction industry* were on the market during FiT era with their own products, mainly flexible modules on metal sheet, tiles, curved modules, etc. Today they are mainly working with the tax-deduction scheme with roofing, glass, plastic and ceramics materials. Building envelope/façade industry is starting to enter into BIPV market.

Wholesalers, installers. For particular solutions industry provides sales and installation. For more standardized solutions, usually they share the PV and BAPV market.

Architects. Most architects are interested in BIPV as a building element, but only a part of them have the necessary knowledge to work with BIPV. Some of the well-known architects working on an international level are supported for BIPV and building energy efficiency design by external/third-party professional.

Consultants. Architects working for important stakeholders, or other consultants working in the RES sector.

Utilities and energy companies. They are involved in the PV and BIPV sectors, offering PV/BIPV among their energy solutions. During the Innovative FiT scheme, few of them offered BIPV products. In the last few years, due to tax-deduction measures, they also offered building refurbishment.

Universities and research centers have always played an important role in BIPV, with the research for new materials and products, certification, performance, and in the last years, the development of business models.

Design companies. As highlighted in the patent application search (see paragraph 5.1.1), in the last years some new BIPV design products were developed.

Press. Specialized press on energy and RES topic is important in Italy not only to disseminate technical and regulatory knowledge, but also to drive the path towards sustainability. In the interviews with stakeholders, press had always the most unbiased positions and an unexpected awareness regarding relevant issues.

Networks. As highlighted in the report, in Italy a BIPV specific (producers) association is missing, thus BIPV producers participate to PV associations. However, Italy participates in

most of the relevant BIPV related EU projects (such as, i.e., BIPV Boost project, https://bipvboost.eu/) as well as to RES and PV dedicated international agencies like IRENA and IEA, with the specific focus on BIPV in IEA PVPS Task 15.

3.3 Institutions

The term 'institution' refers to the social structures which organize the primary social practices, roles and interactions. In other words, the rules of the game in a society. A distinction can be made between hard and soft institutions. Hard institutions include decrees, regulations, codes, standards, often enforced by authorities, while soft ones, like i.e., awareness, values, are shaped by the collective interaction of actors.

3.3.1 Hard Institutions

- There are national support mechanisms for RES (like FiT measures, energy communities, tax deduction, etc.), which do not support specifically BIPV, with few Regional exceptions.
- Most codes and standards related to PV are similar to the European standards, since Italy is a CENELEC member. There are additional electrical regulations that affect the PV systems' reliability and safety. The low Voltage Electrotechnical Regulation has been recently updated and harmonized with the IEC and CENELEC standards.
- European standards EN 50583, parts 1 and 2, are also Italian standards (Norma CEI EN 50583). However, since these are not European Harmonized Standards, and they are not mentioned in the Technical Building Code, their fulfilment is not compulsory. Italy has actively participated in the development of EN 50583 and IEC 63092. However, since IEC 63092 is not a European standard, it is not adopted as an Italian standard either.
- Public procurement regulations do not show a specific attention to BIPV, therefore BIPV competes with BAPV, which usually is cheaper.
- The building energy certificate is mandatory in case of selling or renting buildings or apartments. The energy certificate shows the results of the calculation of the building energy need (considering, i.e., thermal insulation) and the building performance including systems for heating, cooling and hot water production. Thus BIPV, even if RES/PV production is indicated in the certificate, is not considered as a building material but only a device producing energy.

3.3.2 Soft Institutions

- Climate change concern is a reason behind the Italian support of RES. The environmental and visual impact of ground mounted PV plants is an issue becoming more and more sensitive (NIMBY effect). On the other side, it is worth to notice a PIMBY (Please on My Back Yard, see note 6 page 32) effect regarding BAPV and BIPV.
- In some new building developments, after the effect of the past FiT Law, BIPV is included in the project. Anyway, some architects do not consider BIPV's benefits

compared to BAPV, thus self-consumption projects (energy communities, etc.) often foresee BAPV.

- The need of innovation in BIPV due to historical cultural contexts is driving more interest for niche products such as special tiles.
- The construction industry, after the past FiT Law supporting BIPV, is working with more standardized solutions.

4 PHASE OF DEVELOPMENT AND TARGET DEFINITION

Italy, after the booming market of the past FiT era which showed an important number of 2,5 GW of BIPV plants installed [23], is now a niche market. However, despite a significant reduction, producers interviewed by GSE reported a new growth in 2017 in terms of installed capacity. Figure 2 shows the phase of development of different solutions. As highlighted before, BIPV producers and products today are structured mostly as during the FiT Law.

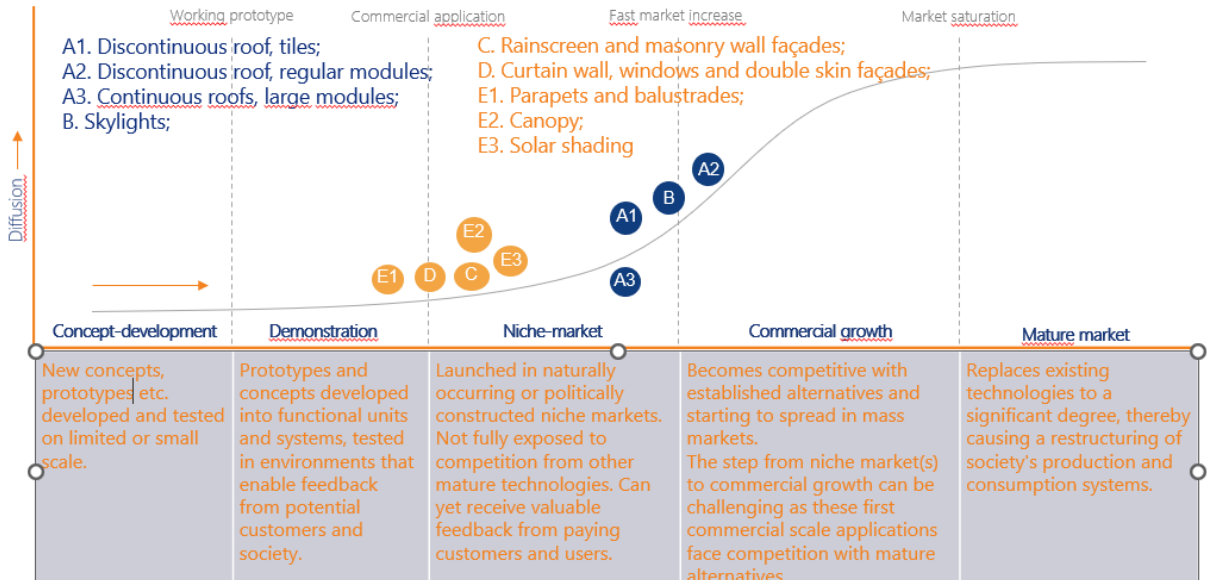

Figure 2. Phase of development of different BIPV solutions in Italy.

In the light of Figure 2, only A2 solutions are today in a commercial phase. They are the former "Special Components" of past FiT mechanism, with standard laminates with a mounting system guaranteeing waterproofness of the building envelope. As a matter of fact, the larger BIPV capacity installed with the past support scheme is built with these solutions, with a system cost close to standard BAPV systems.

The solution A1, consisting on an assembly of photovoltaic cells on traditional tiles for historical centres, has been and it is still today probably the main subject of research in Italy, due to the historical heritage and the related permitting issues. Unfortunately, it is a system that more than others suffers from certification costs.

It is important to highlight that B products (skylights), mainly Special Components with a patented mounting system to integrate in industrial buildings from the past FiT Law (often with the replacement of asbestos), are still on the market.

Solutions highlighted in orange in Figure 2 are not so widespread, because they were not considered integrated by the past FiT Laws, since the past requirements foreseen BIPV as an element to substitute and integrate into a building with an energy need and a specific

performance. Today research is working on curtain wall, windows and double skin facade, with some industrial partners.

Solutions highlighted in blue are expected to reach the commercial phase in the following years, while orange ones will probably need more time.

5 FUNCTIONAL ANALYSIS

In this chapter the assessed eight key functions of TIS process (as adopted in IEA PVPS, Task 15, STA, in the Guide for Technological Innovation System Analysis for Building-Integrated Photovoltaics, [1]) for Italian BIPV market are described in detail. Publications and patents, together with results of specific interviews/questionnaires to the main stakeholders of Italian BIPV market have been exploited to outline each function, assessing a score from 1 (absent) to 5 (excellent) to it.

The stakeholders interviewed (around forty) are among the categories highlighted in the picture below. They are related to BIPV, except those belonging to the category of "*Designer, Installers not PV/BIPV*". Their answers are included in this report in order to have a different point of view from outside the PV/BIPV market regarding their opinion on opportunities/barriers of BIPV, understanding also their willingness to become part of the market.

Stakeholders were directly interviewed, sometimes more than once, when needed, in order to clarify emerging topics and issues. Over time, questionnaires and interviews have been analysed and completed with results of other works, interviews and data annually prepared for the reports of the Italian participation in IEA PVPS Task 1 Strategic PV Analysis & Outreach.

Within the functional analysis, a specific focus on the development in the last twenty years of European/international/Italian patents and utility models related to BIPV product/process has been carried out to better understand the development of BIPV innovation.

Regarding the answers of the questionnaires/interviews, it emerged that some of them are related to the specific interest of the stakeholder interviewed. A work to assess an unbiased point of view has been carried out, in which specialized press answers have been useful for the scope.

Figure 3: Stakeholders interviewed.

5.1 Knowledge Development

Italy has a long history on BIPV knowledge and definitions since the PV Roof Programme of early 2000's which foresaw a special award for BIPV plants.

National competencies on BIPV developed broadly during Italian FiT era (2005-2013, around 18 GW PV installed of which 2,5 GW of BIPV), due to PV/BIPV incentive mechanisms (from first to fifth FiT Law). Knowledge on BIPV topic was developed also by universities and research centres.

It is a shared opinion that without a specific support (meaning: economic and/or knowledge, depending on the stakeholder interviewed), there is the risk to lose existing knowledge.

The actors holding the knowledge and pushing the growth of the BIPV technology today are, in descending order:

- PV/BIPV industry (the first engaged on the topic);
- universities and research institutes;
- architects and institutions (it is a common opinion that institutions should be more active on the BIPV topic);
- construction industry.

An important issue to be faced today, pointed out by some stakeholders, is the need of a new "solar language" for BIPV related to the cultural/architectural context of individual countries/cities which allows to facilitate authorization process and social acceptance. With past FiT Law, especially with the concept of Innovative BIPV involving the whole building, a huge effort has been made, through requirements to access incentives.

Within FiT framework, BIPV became a building element with characteristics of the substituted traditional building material. A new "solar language", requested especially from architects and specialized press, concerns the relation between the building material (in this case BIPV) and urban/architectural context. In this sense, however, the creation of *ad hoc* BIPV elements for different urban and architectural integration could result in a standardization issue. In the light of the above, it is possible to draw a timeline of BIPV in Italy (see Figure 4).

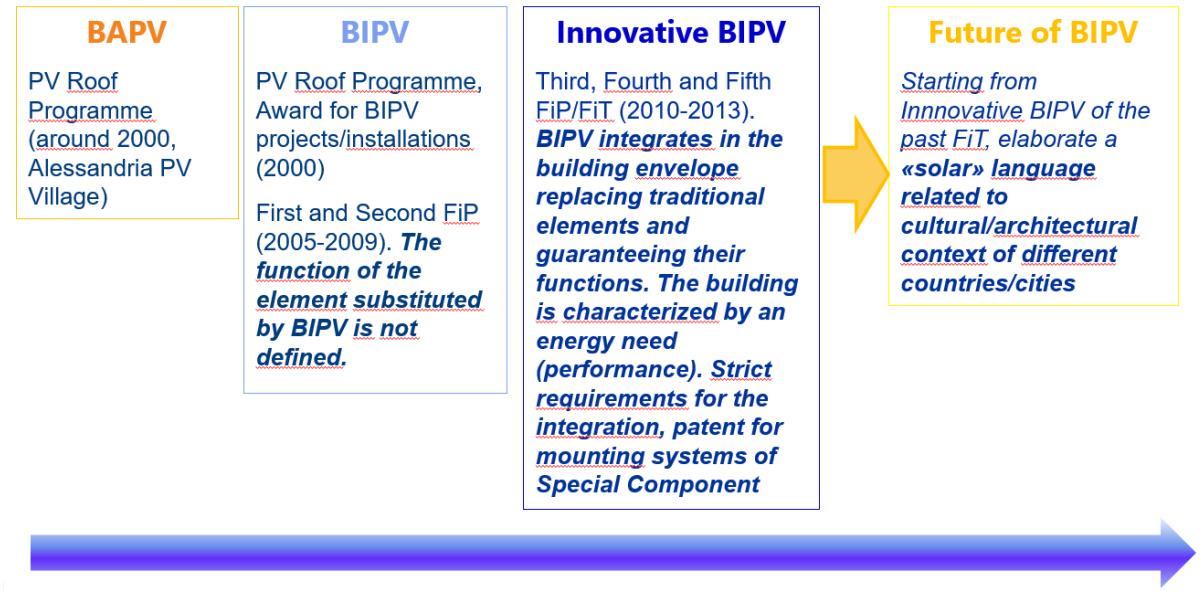

Figure 4: Timeline of BIPV in Italy. Is the new solar language, proposed by some stakeholders, a barrier for standardization?

5.1.1 Patent Applications and Patent Granted (Applicant: Italian)

A special attention in the Knowledge Development function has been given to BIPV patent applications search, because from the beginning of the analysis it was clear that Italy, even beyond the BIPV Innovative FiT decree and guidelines asking for patented mounting systems, is a country investing in intellectual property.

The results of the patent analysis affected the whole report, since the following aspect has been analysed in four different time periods[3] (before FiT in Law, 2000-2005, during FiT Law of 2005 - 2010, during Innovative FiT Law, 2010-2013 and after FiT Law, 2014-2023):

- applicants;
- inventors;
- applicant sector (PV/BIPV industry, construction industry, etc.);
- type of building foreseen by invention;
- commercial product;
- commercial product on the market;
- producers diversifying business of patented products.

Data on the websites of the European Patent Office (EPO), World Intellectual Property Organization (WIPO) and Ufficio Italiano Brevetti e Marchi (UIBM), as well as GSE files and documents have been exploited for the research.

[3] For most of the BIPV patent applications

The results of the analysis show a total number of 100 applications[4] for patent/utility models[5] during the years 2000-2023, of which 41 patents were granted, 53 patent applications refused/deemed to be withdrawn and 6 patent applications under proceeding, as highlighted in the following figure.

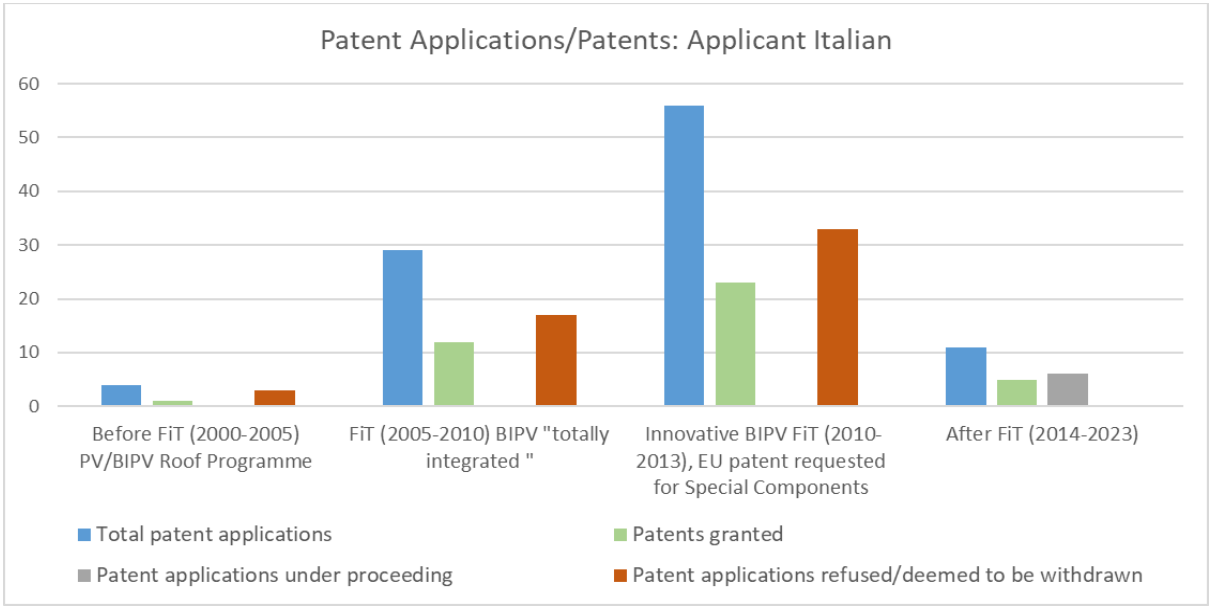

Figure 5. Patent applications, patent granted, patent refused/deemed to be withdrawn, patent applications under proceeding from 2000 to 2023.

During the years of the Innovative BIPV FiT Law (2010-2013), a significant increase of patent applications has been observed, due to the requirement of an EU patent on the mounting system of the so-called Innovative Special Components.

It is important to note that even with the previous incentive scheme (2005-2010), innovation in BIPV products was raising. After the end of FiT Law, the number of BIPV patent applications decreased, even if a fair number is still there, considering the patent applications under proceeding. As a matter of fact, even before (and after) FiT requirements requesting a European patent, the BIPV innovation is a topic addressed by market actors, seen also the issue of integration in historical urban context.

This is also proven by the fact that, as shown in the figure below, patent applications for particular tiles (highlighted in red) started to increase in early 2000's, before Innovative FiT scheme of 2010-1013 and to decrease after, seen the higher costs for certifications.

[4] The number includes the ones found on EPO, WIPO and UIBM. It cannot be excluded that there are other patent applications not considered.

[5] A utility model system provides protection of so-called "minor inventions" through a system similar to the patent system.

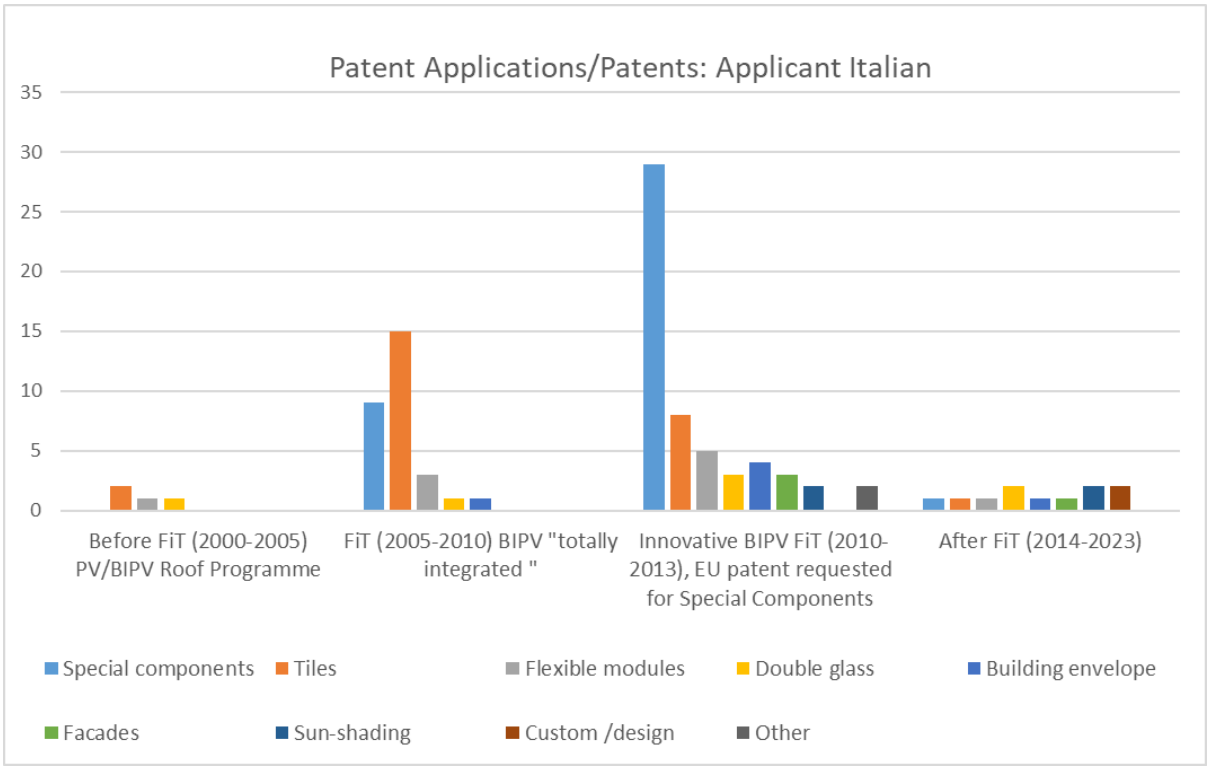

Figure 6. Patent applications/patents according to different category product from 2000 till 2023.

In the last years patent applications for custom products systems such as design, glass-glass modules and brise-soleil systems were submitted and they are now under proceeding.

Concerning the type of the building related to the installation of the product, a percentage of 45% of the total patent applications refers to residential sector, while 20% to industrial one (due mostly to Special Components and flexible modules on metal sheet), sometimes with the scope of substituting asbestos and/or create skylights in industrial buildings.

PV industry, including all the subjects working in the RES field, is the chief sector investing in BIPV intellectual property over the years, as highlighted in figure 7, while construction industry invested less in the past years of FiT Law. Regarding universities and research centres, data show fewer applications, even if, as highlighted before, it cannot be excluded that there are few other patent applications for which the analysis was not possible (see also note 3).

Another important data is that relating to products with a patent application/patent that are still on the market today. The results indicated in Figure 8 show that the market today is mainly structured according to the BIPV product categories foreseen by the past FiT Law, with Special Components and tiles (mostly on discontinuous roofing), flexible modules and double glass modules, even if new solutions with patent applications under proceeding are on the market.

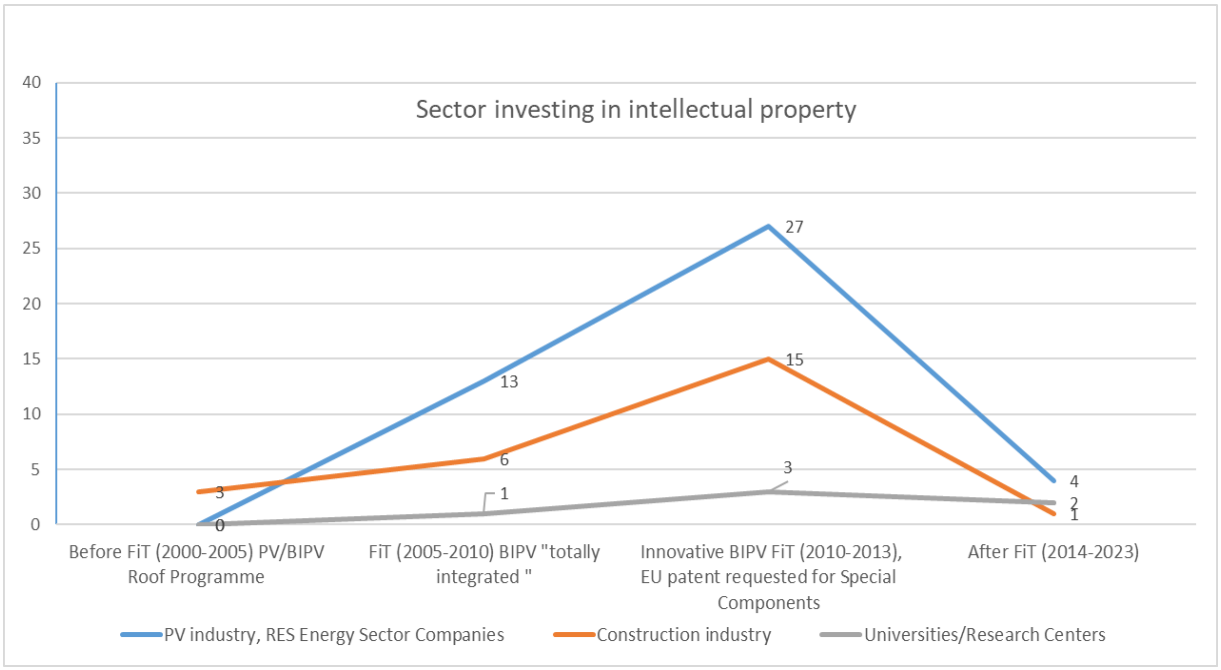

Figure 7. Sector investing in intellectual property within BIPV.

It is worth to underline about BIPV tiles that the sector investing in intellectual property are equally divided among PV Industry, Construction industry and Universities/Research centers.

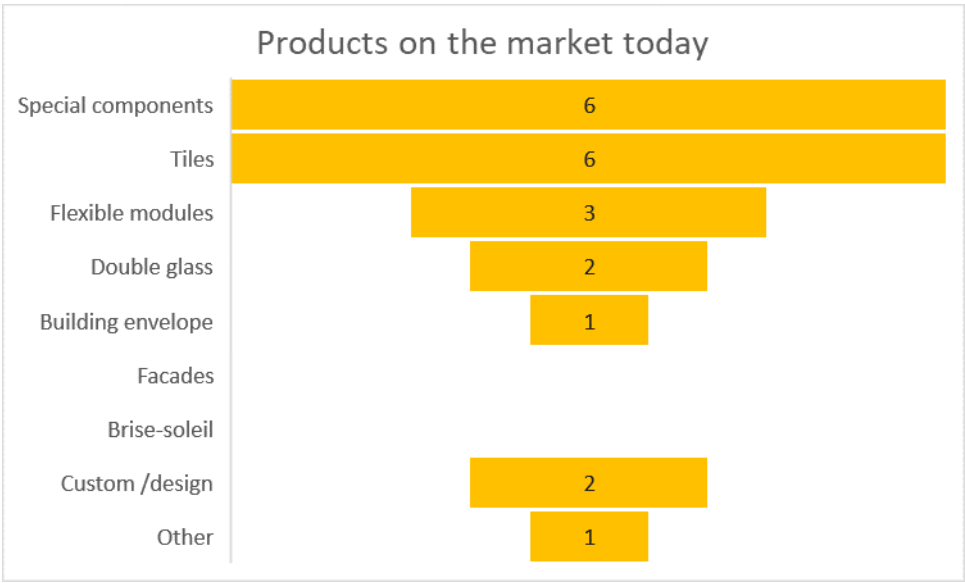

Figure 8. Products with a patent applications/patents on the market today (see note 3).

For about 10% of the patent applications stakeholders diversified business, modifying the original products or adding new solutions to existing ones.

Summary.

The strong boost from past FiT mechanism determined an important basis of knowledge still existing today and which is enough for the current market size (which is, in any case, difficult to estimate). After the end of FiT in 2013, knowledge and market decreased; without a specific support there is the risk to lose existing knowledge.

The number of applications and granted patents reflect the past booming market and the market recovery in 2017, with new products in the last few years. PV industry, the first engaged in BIPV years ago, is pushing to increase/develop knowledge in order to exploit their existing products or to develop prototypes, together with universities and research centres.

Patent applications analysis shows stakeholders committed in new products innovation development.

Function assessment. ***Moderate.***

5.2 Knowledge Dissemination

The first publications on BIPV appeared in Italy in the early 2000's. Progressively, an increasing number of articles and books (it is difficult to estimate, given the number of subjects/authors involved) were published and BIPV became more and more a widespread topic.

The FiT incentive mechanism, managed by GSE, supported and boosted knowledge dissemination. Several documents like *Application Rules of FiT Law* (published by GSE together with a *BIPV Guidelines* and a *Catalogue of Photovoltaic Plants Integrated with Innovative Characteristics*), deployed knowledge, along with several courses in universities and PV/BIPV focus groups held mainly by GSE.

In the first years after the end of FiT era, some Regions and municipalities continued to apply the GSE guidelines to grant BIPV capital incentives. After 2013, the market saw a significant decrease but it started to grow in 2017, although not with previous power volumes. As a matter of fact, knowledge remained by those who worked during past FiT era, and which are still working in the field.

Today there is still training on BIPV, especially in universities, but the educational level is, sometimes, not enough for the scope of a cultural process of considering BIPV as a matter of architecture. Education does not always include BIPV as a building element contributing to the building performance and energy need. Anyway, all architects/engineers/installers not involved in PV/BIPV interviewed are willing to improve their education through specific courses. Specific BIPV training would be important for superintendencies in charge of granting authorizations in historical cities.

Nowadays, there is an existing knowledge exchange between manufactures and suppliers even if, probably, after the end of FiT Law it has been lost a little bit. Concerning knowledge exchange between industry and construction sector, if this was really active during FiT era, starting from 2014 it has been reduced with the construction sector working more with

economic support dedicated to building energy efficiency interventions (i.e., with several tax deduction schemes).

During the FiT Law, due to the generous incentives, many actors appeared on the market; by that time, GSE was a kind of network (because of its activity of dissemination/connection among parties). In any case, a specific association for BIPV (industry) has not been created. This is an important issue and several stakeholders ask for it, since a BIPV association could create a common basis to better coordinate activities, stakeholders and to set targets.

Italy participated/s and/or contributed/s (with several stakeholders) to the main international research programmes: HEART, EnergyMatching, PVadapt; Solar-Win, 4RinEU, Be-Smart, BIPVBOOST, etc., as well as to the activities of the main international agencies, like IRENA and IEA. Since 2018, a BIPV web platform mainly focussed on Italian BIPV projects is powered by Eurac Research.

Summary.

Since early 2000's, the topic of BIPV in urban/architectural context have been faced with articles and books, with an important boost to dissemination by GSE during FiT era, together with technology/legal focus. Even universities were (and still are) engaged with courses. It is worth highlighting that not all the courses deepen important topics like performance or BIPV as a matter of architecture.

Knowledge exchange between industry and construction sector after FiT era has decreased.

Function assessment. ***Weak to moderate.***

5.3 Entrepreneurial Experimentation

Most of the existing BIPV solutions on the Italian market are among the so-called Special Components category, mainly from the PV industry. The reduction in the market size brought efficiencies as producers with contracts with more manufacturers of mounting systems during FiT era are now focused on a single mounting system for their PV laminates. Moreover, they are trying to develop new products and they are working for standardization and to increase performance.

Concerning other products, such as, i.e., small tiles for historical city centres, the producers suffer the most (like in the past FiT era) due to the requirements for certification and related costs. Their effort on new products was oriented to meet the requirements of the incentive scheme in the past, while today it is oriented to develop solutions accepted by local authorities. for the integration in valuable architectural/urban context of Italian historical cities. For these products standardization can be difficult, resulting in ongoing research for new materials and prototypes to overcome authorization barriers, with rising product costs. Almost all producers in this category complain about costs, asking for economic support. An important part crossing all stakeholders interviewed consider the cost as important, since today there are not national incentives for BIPV (like, i.e., FiT Law). However, more than one interviewee, also participating

in yearly GSE surveys for IEA PVPS Task 1 activities, reported that costs are not so significant, except for particular or custom solutions. Given the two definitions for BIPV products adopted for the FiT scheme, still reflecting today's market, it can be observed that some standardized BIPV systems costs are comparable to BAPV costs. It is important to underline that some stakeholders pointed out that, sometimes, it is more a matter of perception (see paragraph 5.6, Legitimation). The problem of costs is worsened by the lack of business models.

BIPV (and PV) industry, together with construction industry (considered also PV obligations on buildings) have a central role towards a widespread use of BIPV, even if construction industry after FiT era has partially left the market. Anyway, those actors face the issues of cumbersome procedures to operate in the market (authorization mainly, from state to regions, to provinces, to municipalities). An important interest in BIPV potential is shared among market players, as seen in patent applications analysis. For example, industry might strengthen its competitive position. They are working for a new BIPV development phase.

Given the above, it follows that the second important role is for the lawmaker, together with Public Administrations managing rules and authorization processes. A third of stakeholders considers permitting procedures along with administrative complications as an important risk for BIPV deployment.

Research centres and universities are very active on the topic. As highlighted by some stakeholders, product innovation cannot exist without its performance certification. Certification (such as, i.e., CEI EN 61215 and CEI EN 61730) is another issue to be faced since it involves additional costs, especially for niche producers.

Consulting sector, after the boom of past FiT era, is trying to understand opportunities, products and performance, while BIPV end-of-life management in the future could be an issue.

Financial system should be more involved with appropriate business models, pushing the market.

Construction projects in Italian BIPV market are considered to be in a transitional phase: neither pilot/demonstration, nor mature/fully commercial.

Summary.

The BIPV market nowadays is mainly structured according to schemes defined by past decrees, mostly with the BIPV industry integral part of the PV industry.

BIPV tiles (or similar products) producers are developing new products, most of them complaining for the cost of the certification and asking for (new) incentives. These are the products which could help in overcoming authorization issues in Italian historical towns centres. Some new solutions are entering the market today.

Function assessment. ***Moderate.***

5.4 Resource Mobilization

This is one of the most divisive topics, even within the same stakeholder categories. Some stakeholders ask for national incentives focused on BIPV. This position involves the issue of costs. BIPV module costs dropped, on average, by 35% in 2013-2021, while "soft costs" decreased less. At the end, the total plant cost fell by 25% [23]. In any case, from 2021 PV plant costs started to grow for market inefficiencies (it can be assumed that even BIPV plant cost faced the same issue) [24]-[25], with a slight reduction in 2023.

Concerning costs and incentives, a more *super partes* position, backed mostly by press interviewed, highlights that the costs are related to the size of the company and type of product. Small BIPV particular tiles are more expensive than standard solutions.

Few regions/municipalities started, in recent years, to support BIPV, while tax deduction schemes as well as other mechanisms (like self-consumption, energy communities, energy income, etc.) do not distinguish between BIPV and BAPV.

Regarding human capital, it can reasonably be said that a certain degree of knowledge among employees remained from FiT era, and that now this can be enough for this market size, but if the BIPV market is to develop again, training for new employees is required. Recently some superintendencies are starting to consider BIPV as the only option to comply with RES legal obligations in Italian cities and historical centres, looking for BIPV training for their employees.

Grid connections regulation is under revision to simplify the procedures in force. Connection regulation is complex and it is often subjected to changes in order to follow the huge number of requests of connections.

Summary.

Good basis of trained personnel from past FiT Law. Some superintendencies are starting to consider BIPV as the only option to comply with RES legal obligations in Italian cities and they are looking for BIPV training for their employees. The cost of BIPV products increased in the 2021-2022, even if slightly decreasing in 2013, could bring to more pressure for incentives. Existing measures like tax deduction, net-billing, energy communities etc. do not distinguish between BAPV and BIPV.

Function assessment. ***Weak to moderate.***

5.5 Development of Social Capital

There is a general confidence and a common understanding among actors (especially between industry and installers), even if not in the whole value chain, since final users, architects and institutions (not involved in the past FiT mechanism) are less trained and motivated on the topic. For confidence along value chain, it would be important to involve financial institutes and public administrations involved in authorizations processes.

A basic knowledge/language remained from the past FIT period, even if some stakeholders declared that a "shared" language comes necessary from a regulatory obligation.

Industry seems to show a kind of common understanding, except for privacy/confidentiality data, aiming to achieve standardization of BIPV products and procedures which could help to find a common language.

After the end of FiT Law, most of the construction industry (with few exceptions) stopped the production of their own BIPV elements, thus partially exiting the market. However, they are still involved in PV/BIPV business through tax-deduction schemes for PV coupled with building energy efficiency interventions. Relations between (BI)PV industry and construction sector still exists, based on specific projects.

Summary.

General trust among stakeholders based on the past FiT Law, even if not in the whole value chain, with the exception of some local institutions, final users and some architects. Construction industry partially left the BIPV market after the end of FiT Law.

Function assessment. ***Moderate.***

5.6 Legitimation

All stakeholders interviewed believe in the positive attitudes to BIPV, highlighted below:

- awareness of BIPV topic due to past FIT schemes;
- Please In My Back Yard (PIMBY[6]) effect concerning both BAPV and BIPV on the roof;
- possibility of having a building characterized by energy efficiency plus PV self-consumption, with tax deduction schemes/net-billing/self-consumption/energy communities/energy income (measures not focused on BIPV);
- BIPV is important to achieve the target of NECP (80 GW of PV by 2030);
- social regard for architecture and landscape;
- in case of creation of a new "solar language" in which BIPV is not only an energy plant but a system declined on building performance and, more important, on the culture of single countries, BIPV would really be a new cultural revolution, probably welcomed by superintendencies that have an urgent need of innovative BIPV solutions in order to integrate it in specific high value architectural contexts.

Large companies can afford legitimation since they can afford to invest in public relations and institutional affairs, while small ones have more difficulties to do it. During past FiT era all

[6] Acronym developed in the last few years in opposition of the word NIMBY, expression of activism in favour of RES.

companies contributed. Institutions like GSE, ENEA and RSE are still working on RES social acceptance and legitimation.

There is a common opinion about the fact that there are difficulties towards BIPV from local authorities related to historical cities, even if some improvements are evident[7]. Administrative simplifications have been introduced in 2021 for RES plant authorizations, more in depth, for PV substituting asbestos and for small BIPV with a capacity up to 50 kW. Recently some superintendencies are becoming interested in BIPV topic.

According to most stakeholders interviewed, there is not, in general, a conflict of interest between BIPV and BAPV. However, the topic depends on the typology of technical solution (some BIPV solutions are more expensive) and on the possibility to design the BIPV plant in the first step of the building project.

Concerning costs, according to some stakeholders and press, it is more a matter of perception of the costs than an actual issue, with the exception of some solutions and/or small producers.

GSE received complaints from some owners of BIPV plants under past FiT schemes, complaining that the "BIPV component" was not as reliable as a building component, both in terms of energy performance and waterproofness. Thus, work on BIPV's reputation is needed.

There is a lack of rules and national guidelines, like those during FiT era (2005 – 2013) which continued to be applied in some regions after incentive schemes. Some stakeholders suggest to start from the past rules and guidelines in order not to lose everything that has been done in the past. These documents could become a starting point to improve standardization, contributing to legitimacy.

Summary.

PIMBY effect for BIPV due to recent energy crises and to a sustainable building culture deployed during past FiT Law, in which self-consumption, energy efficiency and behavioural awareness (nudge, education) have a central role. Performance issues have been reported for plants under past FiT scheme. Some difficulties from local authorities in granting authorizations for BIPV in historical centres even if the recent decrees approved in the last two years are expected to address them. Growing PV (and BIPV) prices in 2020-2022 (in 2023 starting to fall slightly).

Function assessment. ***Weak to Moderate***

[7] Simplifications of the authorization process were introduced in 202[1]/2022. Stakeholders were interviewed in a period ranging from the second half of 2021 and the beginning of 2022.

5.7 Guidance of the Search

A BIPV target as well as definitions and rules are missing, even if lately some Public Administrations and superintendencies started the process of investigating BIPV in historical cities, seen RES obligations.

Given the historical heritage of Italian cities and the ambitious goal of NECP, BIPV has a huge potential, but there is also the need of clear goals and stable regulation. Moreover, the national existing measures supporting PV technology, like self-consumption, tax-deduction, net-billing, energy income, etc., do not focus specifically on BIPV, even few regions started to support integrated RES and integrated BIPV. Furthermore, a BIPV target is missing, together with business models and a possible road map.

Both industry and other actors believe in a growth of BIPV market in Italy. As reported in IEA PVPS Task 1 report “Building Integrated Photovoltaic Policies in Italy”, published at the end of 2021, the market after the end of FiT Law in 2013 started to slow down, and from 2017 a new growth can be observed.

Industry aims to reduce costs, to increase performance and to work for product standardization asking for a national policy to boost again the BIPV market, while BIPV owners are aligned on industry effort on costs and performance, looking also the issue of reliability. Concerning module certification cost issue, it seems that the topic is sensitive especially for small manufacturers trying to develop new products.

According to many stakeholders, standardization and certification play an important role in product quality and for the reputation of the BIPV; it is a quite shared opinion that certification is the only way to qualify an innovative system (even if rules must be simpler than the past ones under FiT Law).

New regulations and technical specifications/guidelines are necessary (there is the need of new rules, today in many cases the past FiT rules and/or product categories are the only point of reference), together with an appropriate training of those who will apply it. Industry specifically asked for it.

Summary.

The stakeholders believe in a new BIPV growth, started in 2017, that could be supported by the latest simplifications of authorizations. Superintendencies of historical cities are moving towards BIPV. There is not a defined target on a national level for BIPV.

Function assessment. ***Moderate.***

5.8 Market Formation

Italy, according to the most part of interviewees, is in a bridging phase (not nursing, not mature) for BIPV penetration with more than 2,5 GW installed. Some stakeholders are concerned that without new stimulus/guidelines, all the experience accumulated might be lost (and partially, it

already happened). BIPV has a huge potential, thanks to Italian culture heritage and NECP target. However, existing mechanisms do not take into account specifically BIPV technology (see Paragraph 5.8, Guidance of the Search).

There is a widespread belief that with the present size of the market there are enough actors coming from the past FiT era, but the necessary growth of the market would need more actors. Some stakeholders highlighted the importance of a domestic production chain.

The most important barrier is related to system costs. This barrier does not exist for all technical solutions, since standardized BIPV products are more aligned to PV products. Other customized products or tailor made for urban context, like i.e., tiles are more expensive (it might be the double or even more). Thus, several stakeholders call for incentives, especially for particular products that could meet requests of cultural authorities and/or for their certification. Standardization is considered as a key for cost reduction. In this framework, a financial institutes commitment in BIPV process with dedicated business models is missing.

Regarding authorization issues, administrative simplifications have been adopted in the last two years, even if a cumbersome regulatory framework still exists. Moreover, there are some difficulties to frame the difference between BAPV and BIPV.

Concerning innovation, according to some stakeholders (mainly press) larger companies, as emerged before, find it easier to innovate/develop, especially when working with standardized products. Smaller companies face more difficulties to develop and innovate, especially if they are working with niche products that have higher cost. Moreover, with the recent energy crises the costs of raw materials have increased, adding difficulties to innovation processes.

All buildings are considered suitable for upscaling the BIPV market. The key role of Public Administration in the deployment of the technology has been emphasized by regulation, with a priority for installations on new buildings and especially for those in the historical cities, despite their higher costs. As already mentioned, there is a new interest to integrate BIPV in historical centres.

Summary.

BIPV technology is mature and topics like energy transition and building energy efficiency have a central role in the political agenda. BIPV is important to reach NECP target of 80 GW of PV by 2030. BIPV system cost, particularly for niche products, remains a barrier for the deployment of the technology.

Function assessment. *Weak.*

5.9 Summary of the Functional Analysis

The analysis carried out, based on the answers received from the stakeholders, highlights intertwined cross-cutting issues. To give a few examples, performance issues affect

technology reputation which in turn impacts on social acceptance that in turn can impact the debate about permissions, up to a market slowdown.

Another very important common subject among the answers, which becomes a strength or weakness depending on the function and the questions raised, is the issue of existing support measures for BIPV such as tax-deduction, net-billing, energy communities (generalizing, self-consumption). In the function "Resource Mobilization", the general aspect of self-consumption seems to have a negative meaning, thus becoming a weakness, since these domestic measures are not specifically foreseen for BIPV. Otherwise, in the function "Guidance of the Search", it is clear the need of BIPV installation in historical centers and the opportunity/possibility to do it with national policies, together with new actors on the markets (like local administrations); in other words, in this perspective, the above mentioned measures even if are not dedicated to BIPV they do not exclude it and, given the critical issues in the urban area, they encourage it.

In the analysis a key element emerged in the debate on BIPV in Italy, which cannot fit into either one of the two categories of strength or weakness of single functions. It is the issue of BIPV between the so-called "solar language" and standardization. This point is presented and discussed in the Recommendations chapter.

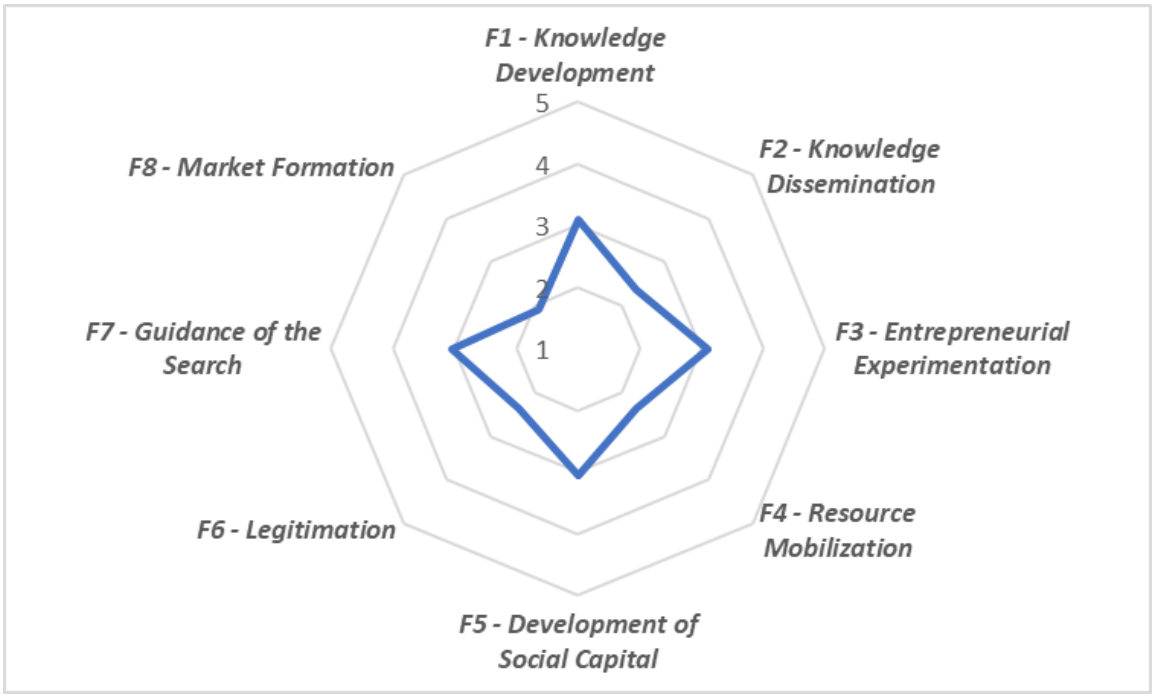

Figure 9. Results of the fulfilment assessment of the TIS functions. Numbers indicate the degree of fulfilment: 1 – absent; 2 – weak; 3 – moderate; 4 – strong; 5 – excellent.

Table 3. Summary of the results of the functional analysis

Function	Strengths/Opportunities	Weaknesses	Assessment
F1. Knowledge Development	• Strong boost from past FiT era which determined an important basis of knowledge still existing today and which is enough for the current market size • The good number of applications and granted patents reflect the past booming market and the market recovery in 2017 • PV industry (the first engaged in BIPV) is pushing to increase/develop knowledge in order to exploit their BIPV products. • Universities and research centers are involved also in the deployment of BIPV	• After the end of FiT in 2013, knowledge and market decreased: without a specific support there is the risk to lose existing knowledge	*Moderate*
F2. Knowledge Dissemination	• Lot of publications from early 2000's and after FiT era • Universities and research centers involved in dissemination • Knowledge exchange between manufactures and suppliers is still active • PIMBY effect on knowledge from architects not involved in BIPV	• Dissemination in universities sometimes not enough to create/complete an awareness of a BIPV module as a building element. Even performance is not always an addressed topic • Knowledge exchange between industry and construction sector, starting from 2013 (end of FiT Law) slightly declined, with the exception of specific projects • Not always in-depth knowledge of the technical characteristics of the BIPV in some local Public Administration	*Weak to moderate*

Function	Strengths/Opportunities	Weaknesses	Assessment
F3. Entrepreneurial Experimentation	• BIPV product market nowadays is mostly structured according to definitions of past FiT decree • PV industry working on "Innovative Component" by FiT decree is active and looking for other solutions/products as well as tile producers • New products with patent applications under proceeding	• Part of construction industry involved in BIPV in the past FiT Law with their own products, today is on the market with other products or back to the core business	*Moderate*
F4. Resource Mobilization	• Basis of trained personnel from the past FiT schemes • The need of BIPV in historical centers is pushing training in public administration • Regions are starting to support BIPV	• Existing measures like self-consumption, energy communities, tax deduction, etc., do not distinguish between BAPV and BIPV • Costs increased in 2021-2022. First data of 2023 show a slight decrease. • Most of BIPV tiles (or similar products) producers, developing new products, are complaining for the cost of the certification	*Weak to moderate*
F5. Social Capital Development	• General confidence and common understanding among actors (even if not in the whole value chain), based on the past FiT era • Basic language remained from the past	• Most of the construction industry has partially left the BIPV market over time after the end of FiT Law (with some exception), thus loosing the language and the common understanding of BIPV	*Moderate*

Function	Strengths/Opportunities	Weaknesses	Assessment
F6. Legitimation	• Large BAPV/BIPV positive attitude, especially due to energy crises, together with a sustainability culture of buildings (started during past FiT decrees), in which self-consumption, energy efficiency and behavioral interventions/awareness (nudge, education) have a central role • Italy's NECP by 2030, requests to add 80 GW of PV both ground and on building • Some Public Administrations recently started to consider including BIPV in the Italian city centers • Simplification of permission and administrative procedures for RES installations in 2021/2022	• Performance issues reported to GSE for plants under past FiT schemes • Difficulties towards BIPV of part of local authorities for plants in historical city centers (something is changing), that can bring to permitting issues. There is a political pressure to overcome authorization issues • Growing PV prices in the past two years, in 2023 starting to fall slightly	*Weak to Moderate*

Function	Strengths/Opportunities	Weaknesses	Assessment
F7. Guidance of the Search	• Both industry and other actors believe in a growth of BIPV market in Italy • Superintendencies of historical cities are moving towards BIPV, since they are facing a new awareness regarding the need of photovoltaic technology (and other RES) in urban context in order to reach RES targets. • Many economic levers (even if not specifically focused on BIPV) like tax deduction scheme, self-consumption, energy communities, and obligation on buildings could become opportunities to deploy BIPV	• No BIPV national policies, even if Regions start to support BIPV in some tenders • No defined target for BIPV	*Moderate*

Function	Strengths/Opportunities	Weaknesses	Assessment
F8. Market Formation	• BIPV technology is mature and topics like energy transition, sustainability and building energy efficiency have a central role in the political agenda • Italy's NECP target of 80 GW of PV by 2030 • Social awareness and motivation for sustainability • In general, all kind of buildings are suitable for the upscaling of BIPV. Most of the PV capacity installed in 2022 is on building • The key role of BIPV in public Administration buildings has been emphasized in regulation, with a priority for new buildings and especially for those in the historical city centers, despite their higher costs • Several administrative simplifications for authorization process have been adopted in the last two years	• Product costs, even some stakeholders highlight that the issue of cost is sometimes (and for some niche product) more a perceived problem than an actual one (except for some solutions) • The regulatory framework for authorization is cumbersome, with many actors involved • Reliability issue, especially for particular solutions • There is a widespread belief that with the present size of the market there is a sufficient number of actors (coming from the past FiT era), but the necessary growth of the market would need more actors • Missing a massive information campaign (like in the past FiT era) about the need/importance to install PV and BIPV to reach 2030 goals and to achieve energy independency • Lack of financial institutes involvement in BIPV process	*Weak*

6 IDENTIFYING SYSTEM WEAKNESSES AND STRENGTHS

6.1 Actors' Problems and Opportunities

After the booming market of the past FiT Law, today there is a sufficient number of actors for the present size of the BIPV market, even if a desirable growth of the market would need more actors. Only a few manufacturers today work on products eligible for historical centers of Italian cities, like small BIPV tile producers, since they suffer higher costs of the products compared to standard ones, mainly for certification costs.

Opportunities for players working in the above-mentioned category of products come from the new interest of superintendencies in integrating BIPV in historical centers, due to the increasing pressure to reach RES and building energy efficiency targets.

6.2 Institutional Problems and Opportunities

A specific association of BIPV producers (and institutions supporting BIPV) is missing, and missing is a shared path with institutions to understand BIPV solutions which could overcome permitting delays. Regulation in 2021 introduces some simplifications per BIPV permitting, even if the regulatory framework is complex due to all the actors involved in the process.

Public Administrations have the commitment to be an example in managing their buildings. This is a unique opportunity to deploy knowledge and awareness not only on behavioral issues, but also about integration of BIPV and, more in general of RES, into the buildings.

PV technology is one of the main focuses of Italian national energy policy and a new boost is expected, due also to new regulations on energy communities. Unfortunately, there is no longer a national policy for BIPV, but it would be important to investigate the possibility of reintroduction of an *ad hoc* policy for BIPV.

6.3 Interaction Problems and Opportunities

Past FiT Law has been like a connection element along the (BI)PV value chain. After the end of past incentive schemes, the exchange between PV industry and construction sector started to decline. The construction sector (with some exceptions of products still on the market) is working with economic support dedicated to building efficiency interventions (i.e., tax deduction). For these projects, the construction sector relies mostly on PV industry products.

As a matter of fact, the (new) involvement of the construction sector is one of the keys for a further BIPV development, since the concept, started during past FiT Law, that BIPV is not only a device producing energy but an element of the building structure, is quite shared among stakeholders. This involvement could be different from the past, when a significant number of producers were on the market. Today, the "involvement" of the construction sector means being a part of a bigger picture, with a specific role and a commitment in relation to Italian cities and architecture, both for new buildings and refurbished ones, which need aligned actors on energy and sustainability goals.

A specific association of BIPV producers and institutions might help to solve interaction problems and to exploit the opportunities in order to strengthen the sector.

6.4 Infrastructural Problems and Opportunities

Financial system has always been involved in utility scale plants market ever since the past FiT era. Regarding BIPV, after the FiT decrees, financial institutes cannot be considered among the main actors today. The financial sector, together with the superintendencies that have shown this new interest for the BIPV, could play an important role in boosting (again) the market. The first, with specific business models related to existing measures like energy communities and self-consumption, the latter, with easier authorization processes in historical centers of Italian cities.

7 RECOMMENDATIONS

Some topics to be addressed to (again) boost the BIPV sector in Italy have emerged in the analysis.

Finding a specific place for BIPV in regulation would be very important not to lose the path followed with the past FiT Law. This would help to overcome the issue that designers/architects/engineers usually propose to "add" the PV system to the roof but don't even take it into consideration the opportunities that the project could offer. Moreover, an even more incisive action is needed in terms of education and information on successful projects.

Concerning institutions and Public Administrations, some stakeholders suggested an updated training about RES, BIPV and building energy efficiency for their employees.

Most of stakeholders interviewed believe that financial institutes should be more involved and active in BIPV market. A possible way, beyond the introduction of new business models, is suggested by final users (BIPV owners). Most of the interviewed feel they are part of a wider sustainable future project, but they would like their effort to be somehow recognized (or awarded). They suggest to increase the real estate value of buildings/apartments where BIPV is installed, or to provide a kind of “BIPV label”. This action would achieve the dual purpose of involving both financial and building sector in the BIPV market, both attracted by green buildings opportunities and challenges.

According to many stakeholders, standardization and certification play an important role in product costs, quality and for the reputation of BIPV. It is a quite shared opinion that certification and patent application is the only way to guarantee performance and to qualify an innovative system. The proposed solution is to grant a support to cover (part of) product certification costs and/or patent fees, especially for small producers of niche products such as BIPV tiles. It would be important to boost this BIPV type of products, in order to overcome permitting issues in historical cities. The number of patents related to BIPV products in Italy, due also to past FiT requirements, is a relevant sign of innovation of this technology in Italy.

Most of the stakeholders ask for product standardization as a key for BIPV deployment. Could standardization be an issue for local authorities, architects and press, which are loudly asking for a “solar language” capable of taking into account different materials, architectures, landscapes? In this scenario, is it possible to find a common ground where BIPV, finally, meets local architecture, overcoming permitting issues and guaranteeing reliability? And which role has the construction industry in this architecture characterized by new construction materials?

REFERENCES

[1] Van Noord, M., Kovacs, P., Karltorp, K., & Vroon, T., Guide for Technological Innovation System Analysis for Building-Integrated Photovoltaics. IEA-PVPS Task 15, 2023.

[2] Karl Berger et al., 'International definitions of "BIPV"', International Energy Agency - Photovoltaic Power Systems Programme (IEA-PVPS), Report IEA-PVPS T15-04, 2018.

[3] F. Tilli, A. Berni, A. Grassi and M. Pellegrino, "The feed in Tariff Scheme in the Italian Case. An Attempt of Removing Barriers for PV Architectural integration and for Increasing Building Energy Efficiency", ISES-AP - 3rd International Solar Energy Society Conference – Asia Pacific Region (ISES-AP-08), 2008.

[4] Ministerial Decree of 28 luglio 2005, "Criteri per l'incentivazione della produzione di energia elettrica mediante conversione fotovoltaica della fonte solare", Gazzetta Ufficiale n. 181 of 5 August 2005.

[5] Legislative Decree of 29 December 2003, n. 387, "Attuazione della direttiva 2001/77/CE relativa alla promozione dell'energia elettrica prodotta da fonti energetiche rinnovabili nel mercato interno dell'elettricità", Gazzetta Ufficiale n.25 of 31 January 2004 - Supplemento Ordinario n. 17.

[6] Ministerial Decree of 6 February 2006, "Criteri per l'incentivazione della produzione di energia elettrica mediante conversione fotovoltaica della fonte solare", Gazzetta Ufficiale n. 38 of 15 February 2006.

[7] Ministerial Decree of 19 February 2007, "Criteri e modalità per incentivare la produzione di energia elettrica mediante conversione fotovoltaica della fonte solare, in attuazione dell'articolo 7 del decreto legislativo 29 dicembre 2003, n. 387", Gazzetta Ufficiale n. 45 of 23 February 2007.

[8] Gestore dei Servizi Elettrici, "Guida al Conto Energia", 2007 (updated March 2009, April 2010).

[9] Gestore dei Servizi Elettrici, "Guida agli interventi validi ai fini del riconoscimento dell'integrazione architettonica del fotovoltaico", 2007 (updated April 2009).

[10] Ministerial Decree of 6 August 2010, "Incentivazione della produzione di energia elettrica mediante conversione fotovoltaica della fonte solare", Gazzetta Ufficiale n. 196 of 24 August 2010.

[11] Ministerial Decree of 5 May 2011, "Incentivazione della produzione di energia elettrica da impianti solari fotovoltaici", Gazzetta Ufficiale n.109 of 12 May 2011.

[12] Ministerial Decree of 5 July, 2012, "Attuazione dell'art. 25 del decreto legislativo 3 marzo 2011, n.28, recante incentivazione della produzione di energia elettrica da impianti solari fotovoltaici (c.d. Quinto Conto Energia)", Gazzetta Ufficiale n.159 of 10 July, 2012.

[13] Gestore dei Servizi Energetici, "Catalogue of Photovoltaic Plants Integrated with Innovative Characteristics", April 2012 (updated August 2012).

[14] Gestore dei Sevizi Energetici, *In*Fotovoltaico Statistiche Trimestrali Sul Settore Fotovoltaico In Italia, Dati al 31 dicembre 2022.

[15] Gestore dei Sevizi Energetici, Rapporto Statistico Solare Fotovoltaico 2022, aprile 2023.

[16] Gestore dei Sevizi Energetici, Energia e Clima In Italia, Rapporto Trimestrale, Q4 2022.

[17] Gestore dei Servizi Energetici, "Regole Tecniche Per Il Riconoscimento Delle Tariffe Incentivanti Previste Dal Dm 6 Agosto 2010", December 2010.

[18] Gestore dei Servizi Energetici, "Guida alle applicazioni innovative per l'integrazione architettonica del fotovoltaico, Terzo Conto Energia", January 2011.

[19] Gestore dei Servizi Energetici, "Regole applicative per il riconoscimento delle tariffe incentivanti previste dal dm 5 maggio 2011 (quarto conto energia per il fotovoltaico)", July 2011 (updated August 2011).

[20] Gestore dei Servizi Energetici, "Guida alle applicazioni innovative per l'integrazione architettonica del fotovoltaico, Quarto Conto Energia", July 2011 (updated August 2011).

[21] Gestore dei Servizi Energetici, "Regole applicative per l'iscrizione ai registri e per l'accesso alle tariffe incentivanti dm 5 luglio 2012 (quinto conto energia)", August 2012.

[22] Gestore dei Servizi Energetici, "Guida alle applicazioni innovative finalizzate all'integrazione architettonica del fotovoltaico, Quinto Conto Energia", August 2012.

[23] International Energy Agency - Photovoltaic Power System Programme (IEA PVPS), Task 1. "Building Integrated Photovoltaic Policies in Italy", F.Tilli, L.Benedetti, M.Giannì.

[24] International Energy Agency - Photovoltaic Power System Programme (IEA PVPS), Task 1. "National Survey Report of PV Power Applications in Italy 2022".

[25] International Energy Agency - Photovoltaic Power System Programme (IEA PVPS), Task 1. Trends 2022 in Photovoltaic Applications.

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