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International Energy Agency
Photovoltaic Power Systems Programme

Task 15 Enabling Framework for the Development of BIPV

PVPS

Analysis of the Technological Innovation System for BIPV in Austria
2024

Report IEA-PVPS T15-21:2024

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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 analysing the Technological Innovation System (TIS) for BIPV on national levels 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

Semi-transparent BIPV roof with bi-facial modules (source: Kioto Solar)

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INTERNATIONAL ENERGY AGENCY

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

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IEA PVPS
Task 15
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LIST OF ABBREVIATIONS

BAPV	Building Applied Photovoltaics
BIPV	Building Integrated Photovoltaics
BOKU	University of Natural Resources and Life Sciences in Vienna
CEN.	European Committee for Standardization
CENELEC	European Electrotechnical Committee for Standardization
CPR.	Construction Products Regulation
DOP	Declaration of Performance
EAG.	Austrian Renewables Expansion law
OIB	Österreichisches Institut für Bautechnik
OVE	Österreichischer Verband für Elektrotechnik
ÖNORM.	Austrian Standards
IEC	International Electrotechnical Commission (iec.ch)
IEA	International Energy Agency
ISO	International Organization for Standardization
LSG	Laminated safety glass
LVD	European Low Voltage Directive
PV	Photovoltaics
PVPS-IEA	Photovoltaic Power Systems Program of the International Energy Agency
TIS	Technological Innovation System
TPPV	The Austrian Photovoltaic Technology Platform
TU	Technological University
UAS	University of Applied Sciences
ÖFHF	Austrian Professional Association for Ventilated Facades

EXECUTIVE SUMMARY

This report analyses the Technological Innovation System (TIS) of Building Integrated Photovoltaics (BIPV) in Austria. The study's scope is consistent with the IEA PVPS Task 15 report [1].The analysis aims to facilitate and support the innovation, development, and implementation of industrial solutions of BIPV technologies. In Austria, the use of BIPV is still a niche application and covers under 2% of all implemented PV systems [1]. BIPV technology in Austria has historically developed with the support of different public financial incentives, national and European. The history of BIPV is somehow tightened to the history of PV.

The first BIPV prototypes were developed by PV companies in the framework of national or European research activities, with the first development and innovation projects starting around 2003. In general, it should be mentioned that in the last years, PV and BIPV companies have increased specialization in the production of BIPV, especially colored and semitransparent PV modules. In this regard, a wide range of variants are offered (printing, coating, films). The colored components are mainly purchased from glass companies or polymer film producers. Another trend in Austria is the production of transparent glass/glass modules for integration in facades, skylights, winter gardens, or courtyard roofing. In 2020, the government of Austria presented a program called EAG (Erneuerabre Ausbau Gesetz) or Renewable Expansion Act [3.3.1 Hard institutions]containing certain working points to be implemented by 2024. Some of the measures are directly or indirectly relevant to the BIPV development and installation. Such as the PV encapsulation films using interference pigment technology from Lenzing Plastics.

This TIS assessed the BIPV market through eight functional areas and provided the following results:

- The analysis of knowledge development showed that it can be classified as moderate. On the one hand, there are not enough training and further education opportunities in the field of BIPV available, but on the other hand, the PV manufacturers and research institutions are driving forward the development of knowledge in the field of BIPV.
- Knowledge dissemination is well advanced internationally within the research community but insufficient at the practical, national level, particularly between the PV industry and the construction sector. Architects are demanding more information from PV manufacturers and suppliers, who share their information only irregularly with the architectural community. Usually, architects obtain this information from PV technology platforms through workshops, brochures, and projects. However, architects have to engage with it more extensively. The goal is to make BIPV more appealing to architects. Thus, we have to summarize that knowledge dissemination is inadequate/weak.
- Entrepreneurial willingness to experiment can be classified as moderate. Overall, it can be said that there are four players in the Austrian BIPV market and a substantial number of newcomers and small innovative players who could take the role of innovation drivers. However, there are too few opportunities for highly specialized small companies.
- Resource mobilization is well positioned financially and in terms of network services. However, and this is essential if we want to expand the BIPV market strongly, there is a lack of skilled personnel (human resources) to carry out the expansion, which is why this function is rated to only be moderate.
- The scoring of social capital is weak. The connection where there is a lack of communication is between the (BI)PV planner and the architects. In most projects, the (BI)PV planner is not involved in the early stages of the building design process. In addition, conventional PV planners have no experience or are hesitant of planning BIPV systems.

- The legitimacy is moderate, but as the acceptance of PV improves from year to year, the chance of better acceptance of PV integrated into the building, i.e., BIPV, also increases. However, there are still reservations and resistance towards individual, specific BIPV projects. This resistance could be reduced by increasing knowledge about the multifunctional possibilities of BIPV at the decision-maker and customer stage as well as by showing best practice examples
- Guidance of the search is moderate, as there are no specific political targets for BIPV, but there are for PV. However, the government and relevant authorities aim to implement clean energy development positively and apply applicable policies and regulations. There is an increased subsidy for innovative PV solutions [2] which also includes BIPV.
- It can be stated that the market formation of BIPV in Austria still offers room for improvement. When it comes to governmental-driven incentives and support for the BIPV-market development, the missing technical standards (e.g., fire safety regulations) and the absence of regulatory obligations on renewable energies in the local building codes are the biggest weaknesses.

The structural and functional analysis is followed by a coupled structural-functional analysis. This assessment will help identify weaknesses and strengths and recommend strategies that will enable the growth of BIPV from a niche market to a major market segment.

The aim is for photovoltaics (PV) on buildings to be primarily designed as Building Integrated Photovoltaics (BIPV) to reduce additional costs. This, combined with the avoided costs for other components of the building, should result in cost parity with Building-Applied Photovoltaics (BAPV). It is also crucial to encourage all manufacturers of building envelope components to ensure that their products offer the dual benefit of serving as building components while also generating electricity. By doing so, such products can become standard in the industry. The transition from BAPV to BIPV was already analyzed in a 2015 BIPV brochure [2] from the Austrian Photovoltaics Technology Platform (TPPV), which discussed the advantages of an integrated solution versus an attached solution and outlined the necessary steps to make BIPV the standard for building PV.

The recommendations are summarized as follows: i) It is important to involve (BI)PV in the early stages of the building planning process. ii) successful implementation projects must be made public through various channels to increase knowledge about BIPV technology and its possibilities (e.g., lighthouse projects in public buildings). iii) PV standards and construction codes have to be harmonized. iv) The Austrian government should stipulate the use of PV in the obligatory building specifications. v) Another recommendation would be to enact a law requiring every sealed area to be checked for dual use with (BI)PV.

One positive development worth mentioning is the Climate Fund's Lighthouse call, which focuses specifically on integrated PV and offers higher grants for BIPV than the Renewable Expansion Act] , demonstrating increased interest and commitment to this technology. In addition, the TPPV Innovation Awards, which were awarded for the first time specifically for building-integrated PV and now include other topics of PV integration outside of buildings, are a sign that the industry is broadening its perspective and recognizing the importance of BIPV beyond traditional applications. These developments could help to further promote the acceptance and deployment of BIPV and drive innovation in this area.

Nevertheless, it is important to consider the significantly higher costs of BIPV products, as well as the greatly increased planning effort that arises when PV becomes an integral building product.

1 INTRODUCTION

The aim of this Task 15 Technological Innovation System (TIS) analysis is **to facilitate and support the implementation of BIPV in Austria and support the innovation and industrial development of BIPV solutions**. The TIS framework provides a tool that enables a structured and objective perspective on the entire value chain of BIPV, including the interaction between its parts (networks) and its stakeholders (actors). Thus, the analysis identifies what actors participate in the Austrian technological innovation system, the networks they use to interact, and the institutions that condition all of them.
The outline of the report is based on a well-established analysis procedure, which is based on a methodology that is presented in more detail in [2], [3] and [4], among others. The experimental basis of this Austrian TIS analysis is based on two master theses carried out at the UAS Technikum Wien for Task 15 [5] and [6]. The basic structure and interactions between the main components of the TIS are shown in Figure 1.

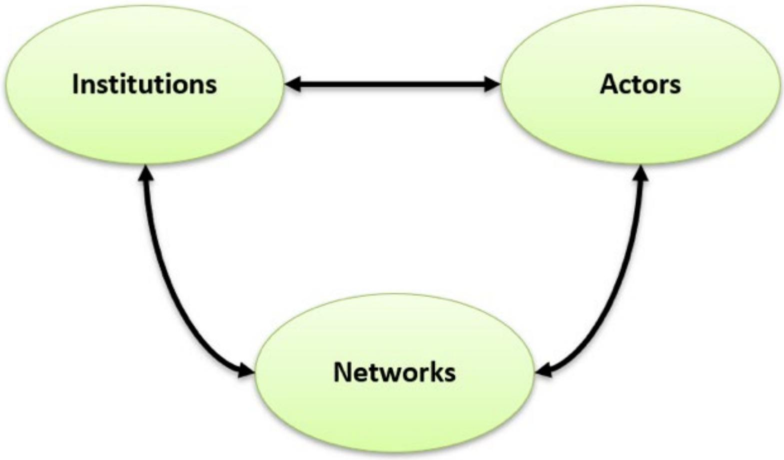


Figure 1: Basic structure and interactions between the main TIS components (Authors Illustration).

Apart from identifying the stakeholders (actors, institutions, and networks), it is necessary to analyze several functions related to knowledge development, knowledge diffusion, entrepreneurial experimentation, resource mobilization, social capital development and legitimation, guidance of the search, and market formation of BIPV in Austria. The functions are first studied separately, obtaining a pattern that facilitates the implementation of goals within the development of the TIS. Positive and negative aspects surrounding the technology enable the identification of barriers and drivers. Eventually, key policy issues emerge, and this information is fed back to the TIS.

1.1 METHODOLOGY

The basic methodology of this work was the TIS analysis [1]. The TIS analysis for Austria is based on literature research and expert interviews. The methodology of the TIS analysis included several points, starting with clarifying the framework in which the work was conducted and the structural analysis. The eight functions were described through literature research, and initial results were recorded. The functional analysis represents the primary analysis of the TIS analysis. The eight functions [1] are analyzed for the functional analysis as follows:

- Knowledge development
- Knowledge dissemination
- Entrepreneurial experimentation
- Resource mobilisation
- Development of social capital
- Legitimation
- Guidance of the search
- Market formation

During this phase, 17 expert interviews were conducted with various actors in the innovation system. Eight of the 17 experts were selected to assess the influence of stakeholders on the development and sales/commercialization of BIPV. One person was selected from each stakeholder group.
For data collection, both primary and secondary literature were used. Secondary data includes data retrieved from national and European innovation project databases, grey literature such as company and industry reports, and peer-reviewed articles. Another aspect of information gathering was interviews with experts in certain stakeholder categories. The list of interviewed people can be seen in Table 4.

2 DEFINITION OF THE TECHNOLOGICAL INNOVATION SYSTEM FOR BUILDING INTEGRATED PHOTOVOLTAICS

This section gives a brief initial overview of BIPV to clearly show and define which technology is the focus of this analysis. To do this, the scope of the analysis is defined, and the development of the technology and the innovation system (actors, networks, and institutions) over time are described.

2.1 SCOPE OF THIS ANALYSIS

The technical scope of this analysis is: BIPV modules and systems and the following definitions are used:

Definitions used within the scope [7]

- A BIPV module is a PV module, and a construction product 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 that 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].

In this TIS analysis, no limitation is made concerning application categories as defined in IEC 63092 ([8]).

2.2 HISTORICAL TECHNOLOGICAL DEVELOPMENT

BIPV technology in Austria has historically developed with the support of different [1] public financial incentives, national and European. The history of BIPV is somehow tightened to the history of PV.

The first BIPV product in Austria was sold by the company “SED Solardachstein”. The product they offered were solar roof tiles, which were developed by the company in the 1990s.
In the years after that, prototypes were developed by PV companies in the framework of national or European research development and innovation projects.. In 2003, an Austrian company called "Ertex Solartechnik GmbH” entered the market [9]. At that time, "Ertex Solartechnik GmbH” was one of the first companies in the world to offer laminated safety glass with integrated PV cells. Coming from glass production and glass processing, this was a new market for them. In 2019, Ertex-Solar was sold to the "VINCI Energies" group. Besides "Ertex Solar GmbH," "Sonnenkraft GmbH" is probably the largest module producer and PV project developer in Austria and is considered the leading specialist for PV and solar thermal systems in Austria. In 2005, today's "Sonnenkraft GmbH" [10]. was founded under the name "KIOTO Photovoltaics GmbH" and specialized mainly in solar collectors. In recent years, the company has specialized more and more in BIPV.
In 2010, the company "PVP (PV Products) GmbH" was founded with a focus on a pure PV module producer. Later, PVP realized individual and innovative BIPV projects, among others, in Switzerland. After the bankruptcy in 2014, PVP was bought by "Sonnenkraft GmbH and integrated into their company." The former main site of PVP in Wies is now one of the Sonnenkraft production plants.
In 2009, MGT-ESYS (Mayer Glastechnik Energy Systems) GmbH, located in Feldkirch/Vorarlberg [11], was founded as a subsidiary of the glass producer MGT. Smaller and individual BIPV projects are specially implemented and realized by MGT-esys. "DAS Energy" [12] has its origin in the previously founded company "Diamond Aircraft," which is still active in aircraft construction. In addition to the aircraft business, the company began to develop lightweight photovoltaic modules in 2009 using fiberglass materials from aircraft constructions. Out of these research activities, the company DAS Energy Ltd. was founded in 2010. With the market readiness of DAS Energy and the sale of Diamond Aircraft, photovoltaics became the company's core business in 2017.

Besides these four main BIPV module producer (Sonnenkraft GmbH, Ertex Solar, DAS Energy, and MGT-esys), which remain active today, there were other companies active in BIPV, that were either sold internationally (e.g. PVP sold to Sonnenkraft), dissolved or took their focus away from BIPV. In this context, the following companies are important to mention:
"Energetica Industries" was a classical PV supplier that realizes BIPV projects sometimes but rather focuses on the PV mass market or module mass production and is since End of 2023 no more active.
"PVT Austria" was a module and cell manufacturer which also produces colored modules. After a bankruptcy in 2016, the company is no longer involved in PV-production.
Recently, the company "Crystalsol Gmbh" has started new product development in flexible photovoltaics with a focus on building integration. Here, the patented Crystalsol technology combines the advantages of single crystalline materials and a cost-effective roll-to-roll production, but has not taken the step to the market so far.
Another example comes from the company EDS ‘Energie Dach System’ (Energy Roof System) The EDS product is a tile- and roof-integrated photovoltaic system that offers the aesthetics of roof tiles.

In general, it should be mentioned that for 5-6 years, all companies have increased specialization or activity in the production of colored PV modules. In this regard, a wide range of variants are offered (printing, coating, films). These technologies are mainly purchased from glass companies. Another trend in Austria is the production of transparent modules. For example, Ertex offers customized façade modules, for which the degree of transparency and cut-outs can also be selected.

2.3 HISTORICAL DEVELOPMENT OF THE INNOVATION SYSTEM

In Figure 2 the historical development of the yearly new installed and cumulative capacity of BIPV is shown. It is split into roof-integrated, façade-integrated, and other installation ways of building integration. It shows that from 2010 to 2013, roof-integrated BIPV systems were the main installed type if BAPV technologies are not counted. After 2013, the yearly installed capacity of roof-integrated BIPV systems decreased by 45,4%. After the year 2013, the newly installed capacities of roof-integrated PV systems stayed at a stable level; only in 2016 and 2018 the installed capacities dropped again. From 2019, there was a large increase in the annual installed photovoltaics in Austria in general, which also led to a higher amount of installed BIPV. In particular, roof-integrated applications were installed more frequently in 2021 compared to 2020, leading to an increase of 168% in the cumulative power of roof-integrated PV. Since 2021 the cumulative installed PV capacity approximately doubled every year, which also lead to a increased installation in BIPV systems.

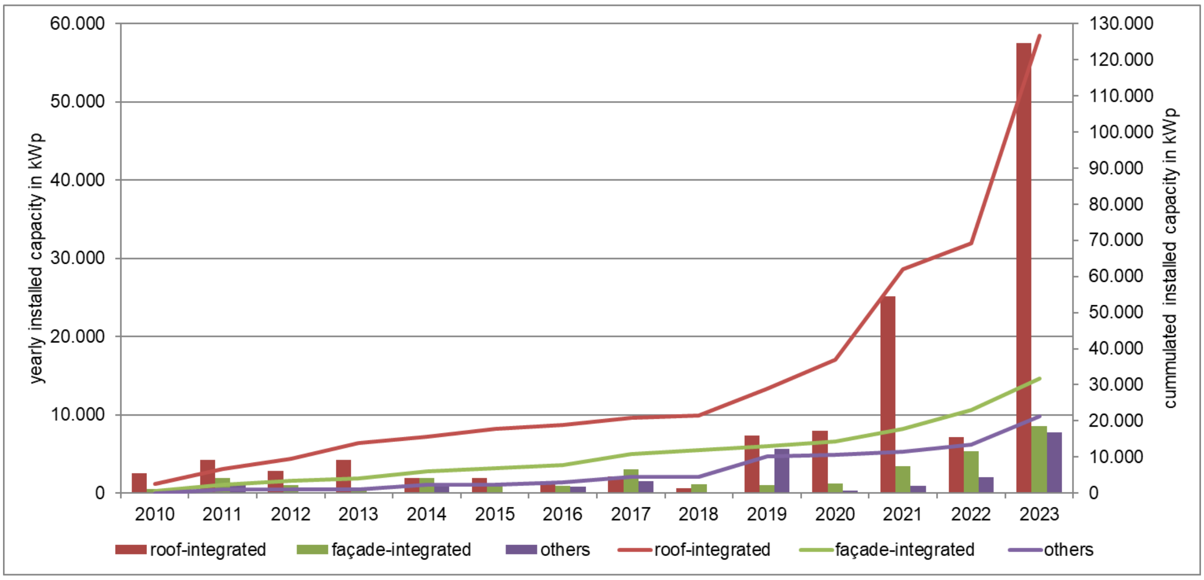


Figure 2: Yearly new installed and cumulative capacity of BIPV systems split into roof-integrated, façade-integrated and others (Authors Illustration with sources from [15])

As a country in which the architecture of buildings has always played a major role, BIPV could herald a new, modern era in Austria in which architecture and renewable electricity production go hand in hand [11]. For this, architects, construction companies, and private individuals must be convinced of the economic and ecological advantages that BIPV brings with it. This can be achieved to a large extent through the dissemination of knowledge but also through regulatory and legislative interventions from the federal or regional authorities with the help of subsidies, funding, and information packages. Almost a quarter of Austria's electricity demand could be covered by using roof and facade surfaces for PV respectively for BIPV systems [11].

Since the market diffusion of photovoltaics at the beginning of the 1990s, the market development of photovoltaics has been recorded and documented in Austria [16]. Thanks to the Green Electricity Act, photovoltaics experienced its first major boom in 2003. Due to the capping of tariff subsidies, the upswing collapsed again in 2004. In 2013, there was a record increase, and since 2015, the annual installed capacity has been increasing continuously and started to surge decisively in 2019 and again in 2021, which is also shown in Figure 3.

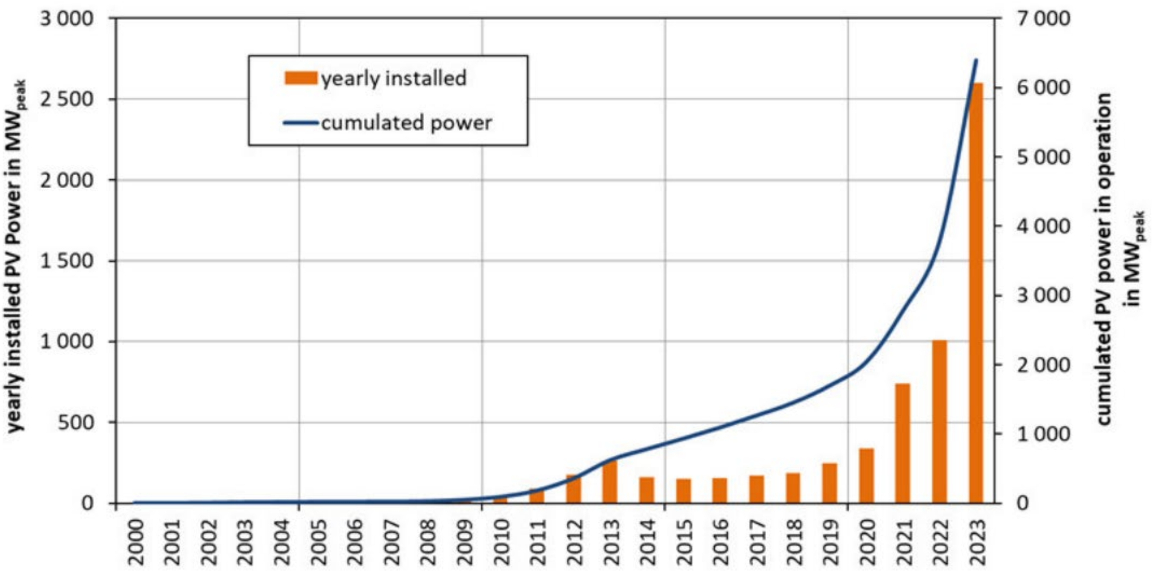


Figure 3 The market development of photovoltaics in Austria until 2023 [15]

In 2023, the total amount of installed PV capacity in Austria reached 6,4 GW_{peak}. This represents an increase of 69 % compared to 2022. As shown in Figure 3, the sum of produced electricity by PV plants in operation amounted to approximately 6,4 TWh in 2023, assuming that 1000 kWh of electrical energy is produced per 1 kW peak of PV power.
A further sharp increase in newly installed PV and BIPV systems is estimated for 2024, as energy prices continue to rise significantly in Austria, as they have in the rest of Europe, while PV system and plant prices continue to fall steadily and constantly. Therefore, renewable energy systems are becoming increasingly interesting from a financial point of view, especially for private individuals.

3 STRUCTURAL ANALYSIS

The structure of the innovation system shows how the individual actors interact with each other, as well as which actors are present within the system and the preconditions (i.e., institutional framework).

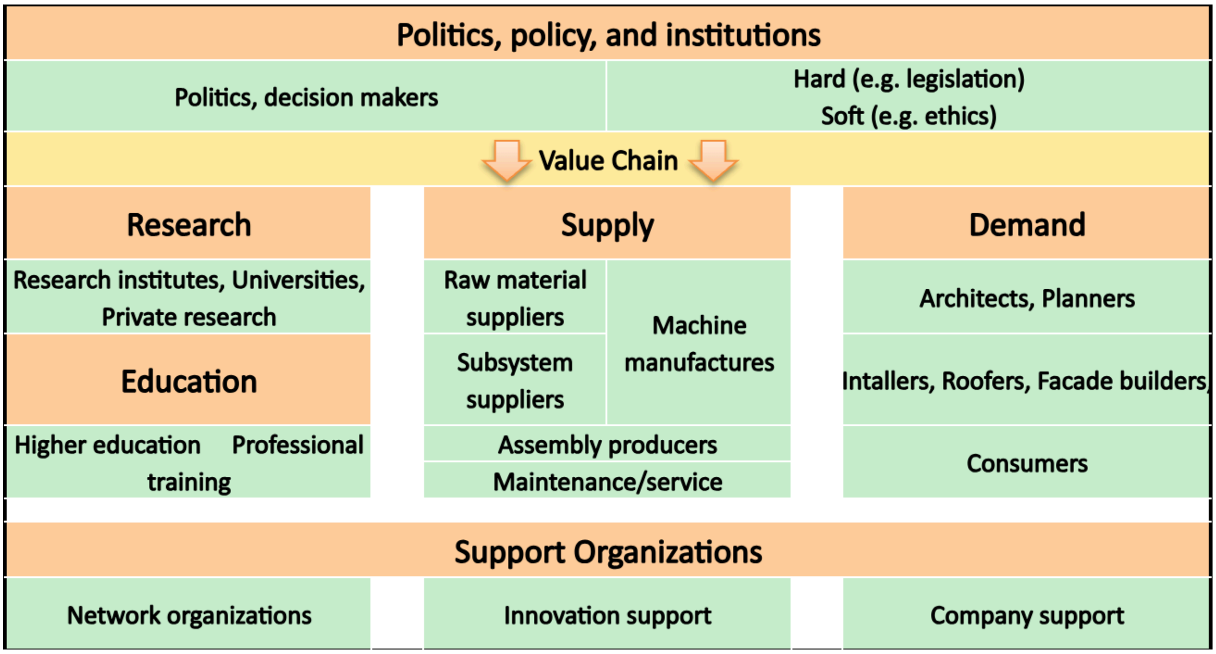


Figure 4 Structure of the innovation system (Authors Illustration)

At the top of the structure in Figure 4 the legal framework for building integrated photovoltaic (BIPV) is shown. These provide the framework to which all actors must adhere. The middle section contains the actors who communicate with each other most of the time and represent the start of the value chain. These include, in the left column, the research and educational institutions that serve to generate and disseminate knowledge. The middle column consists of the manufacturers of BIPV. Included are, for example, material procurers, machine parts manufacturers, manufacturers of frame systems, and maintenance workers. The right column reflects the users of these components. Architects, planners, installers, roofers, façade builders, and the customers themselves are represented in this column. The lower bar represents the support organizations. Included here are network organizations, banks, or company supporters.

3.1 TECHNOLOGY

The areas of knowledge included in the BIPV innovation system in Austria are:
Research, development, and innovation in materials and cells for BIPV: Thin-film materials, semi-transparent electrodes, Roll-to-roll manufacturing process, inverter module manufacturing, and system testing; the organisms and companies involved in those developments are research centers, university departments, non-university research centers and companies related to BIPV modules.

There are some façade-engineering companies and BIPV engineering with relevant experience in BIPV; they are aware and informed about BIPV national, European, and related international standards (e.g., glazing requirements, fire safety); they are multinational or export their products and solutions. The companies Sonnenkraft GmbH [10], DAS Energy Ltd. [12], and Ertex Solartechnik GmbH [9] can offer complete service, from the consultancy and the design of the BIPV modules to the final installation of the BIPV system and their operation and maintenance. Most of their BIPV products are customized. There are also companies like Arconsol [15], which offer not only BIPV support in project development and product design but also education and training in BIPV technologies. In general, there is a lack of specific BIPV maintenance companies; there is significant activity in regular PV maintenance. Renewable energy consultancies have started to include PV in buildings, although they are not usually skilled in BIPV solutions (with few exceptions). Companies offering turn-key PV self-consumption solutions do not usually include BIPV as an option; building companies and the BIPV sector are starting to collaborate to find financial support in the framework of national or European projects; the Technological Platforms have started collaborating for that purpose. Currently, there are no productions for crystalline cells in Austria. Silicon, ingot, and wafer productions are also not represented in Austria.

Other technology providers in Austria are:

- Aerocompact is a manufacturer of smart mounting solutions and is particularly specialized in innovative solutions for substructures in PV roof applications.
- ATB-Becker e.U. stands for the development of PV application technologies since 1986 and not only supplies components for PV and storage applications but also offers software solutions, planning, consulting, and training.
- CALMA-TEC Lärmschutzsysteme GmbH [17] produces and supplies PV-powered noise protection wall modules for roads, railways, and industrial plants.
- Eder-Blechbau [18] is a specialist in Solar Facade systems as well as in PV carports
- Fronius International GmbH [19]is a significant PV inverter producer in Austria, which reported production of 7 GW of inverter power for 2023. Fronius International GmbH is the only inverter producer in Austria. Besides inverters, Fronius offers a wide spectrum of PV-energy management solutions.
- Lenzing Plastics GmbH & Co KG [20] is the world's leading manufacturer of products based on polyolefins and fluoropolymers. Lenzing Plastics has been working on the development of photovoltaic films for several years. Lenzing Plastics makes it possible to colour photovoltaic modules using encapsulation films. The encapsulation films are dyed and the coloured photovoltaics can be integrated into the façade, the roof or even into listed roofs and buildings.
- Ulbrich of Austria [21] is a world leader in PV Ribbon products that interconnect and transmit current for crystalline solar cells and thin film.
- Voestalpine Stahl GmbH [22] is one of Europe's leading steel producers. The products supplied by Voestalpine Stahl are used for the automotive, electrical, domestic, and processing industry segments. In addition, special fabrications for BIPV module frames are also made.
- Welser Profile [23] is a leading manufacturer of special profiles, profile tubes, and complete profile systems made of steel, stainless steel, and non-ferrous metals. On average, up to 5 new solutions leave the Welser works per day and are used reliably in the PV and solar industries, in agricultural and environmental technology, as well as in the construction industry.

3.2 ACTORS AND NETWORK

The main point of an innovation system framework is that all the actors are connected and, therefore, function in networks. A network analysis was conducted to gain deeper insight into the connection and importance of the different actors. This network analysis shows the importance of different actors in the innovation system. The size of the stakeholder categories (Research Institutes, Universities, Platforms, Producer, Façade-specialists, Roof-specialists, Building Physicists, Architects, Planners, and Politics/Regulations) was determined by questioning eight BIPV experts mentioned in the table. The size of the actors inside the stakeholder categories was determined by different aspects. In Table 1 the results of the questionnaire can be seen. The answers of each person are averaged per question. Also, the average of both questions is indicated. The results show that the stakeholder group with the biggest impact are the producers of BIPV modules with 5.69 points followed by architects and planners with a score of 4.81 points. The stakeholder group with the least impact according to this questionnaire are universities with 3.25 points. The rating for policy by the architects and producers is given as n.a. in Table 1, as the interviewees indicated they could not assess this. These two data points were not included in the calculation of the average.

Table 1: Results of the questionnaire of eight BIPV experts on the influence of the different stakeholder groups on the BIPV innovation system (1 = no influence, 6 = great influence) (Authors Illustration)

1. How big is the influence of the actors on the technological development of BIPV in Austria?	Platform	Producer	Architect	Planer	Universities	Research Instititutes	Building-Physicists	Facade-specialists	Roof-specialists	Politics
Architects	4	6	6	4	5	6	5	4	2	n.a.
Producers	3	6	6	5	3	3	2	5	1	n.a.
Research Institutes	5	6	2	3	5	6	1	2	1	2
Universities	5	5	2	2	5	6	6	3	1	5
Platforms	6	6	6	6	6	6	6	6	3	5
Planer	2	5	6	5	2	3	2	4	2	5
Sales	2	6	6	6	4	4	6	6	6	3
Politics	4	6	3	5	2	2	6	6	5	6
Average	**3,88**	**5,75**	**4,63**	**4,50**	**4,00**	**4,50**	**4,25**	**4,50**	**2,63**	**4,33**

2. How big is the influence of the actors on the sales/commercialisation of BIPV in Austria?	Platform	Producer	Architect	Planer	Universities	Research Instititutes	Building Physicists	Facade-specialists	Roof-specialists	Politics
Architects	4	6	6	4	2	4	3	6	2	n.a.
Producers	4	4	5	5	2	2	3	4	4	n.a.
Research Institutes	4	6	1	5	2	3	1	4	3	3
Universities	4	6	6	6	4	4	6	6	6	6
Platforms	2	5	4	4	2	4	3	5	5	4
Planer	1	6	6	6	1	2	2	2	2	3
Sales	6	6	6	6	5	5	6	6	6	3
Politics	6	6	6	5	2	2	2	6	6	6
Average	**3,88**	**5,63**	**5,00**	**5,13**	**2,50**	**3,25**	**3,25**	**4,88**	**4,25**	**4,17**
Average both questions	**3,88**	**5,69**	**4,81**	**4,81**	**3,25**	**3,88**	**3,75**	**4,69**	**3,44**	**4,25**

In Figure 5, the network structure of the Building-Integrated Photovoltaics (BIPV) innovation system is illustrated. In order to delineate the BIPV network with the highest possible accuracy, a group of eight BIPV specialists participated in an online survey. This survey was designed to ascertain the proportions within the network, incorporating insights from Austrian experts affiliated with the International Energy Agency's Photovoltaic Power Systems Programme (IEA PVPS) Task 15 [24]. The detailed questions posed in this online questionnaire are provided in Appendix A for reference.

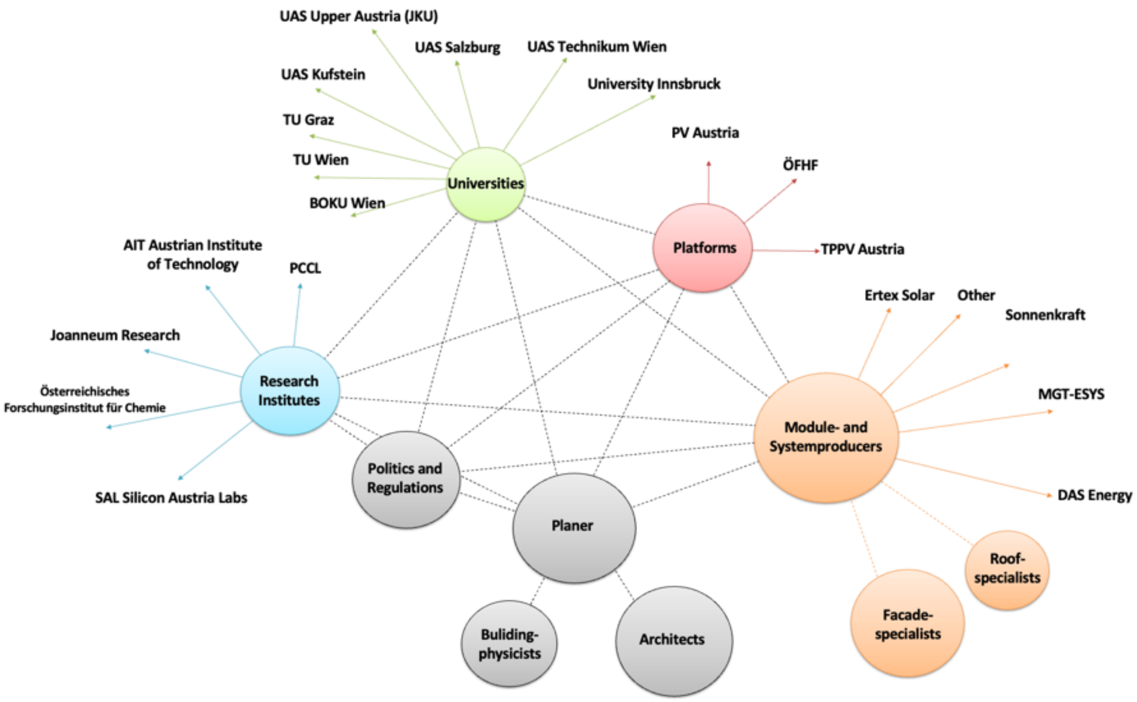


Figure 5: Overview of the current BIPV network (Authors Illustration)

In Figure 5, the interconnections among stakeholders within the BIPV sector are depicted, highlighting their relationships with various groups. These connections, particularly to smaller stakeholders, signify group affiliations, as also denoted by the color-coded links. Five principal groups are identified within this network: Module-and-System Producers, Platforms, Universities, Research Institutes, and the sector of Politics and Regulation. This last group further includes Planners, subdivided into Building Physicists and Architects. Notably, Façade Specialists and Roof Specialists within BIPV are categorized under Module-and-System Producers.

It is important to note that some roof manufacturing companies such as Prefa and Wienerberger use photovoltaic modules from European PV manufacturers and integrate them into their construction products. For instance, Kioto Photovoltaics is a frequent outsourcing partner in this context. 'Other Companies' like Sunplugged, Wienerberger, and Bramac also play significant roles in this ecosystem. While some have commenced producing BIPV modules, others focus on research or are in the developmental stages of their product offerings.
Also, Eternit refers to the integration of photovoltaics into building products by Eternit, a company specializing in fiber cement products. Eternit offers BIPV solutions where PV technology is integrated into their building products to provide both aesthetic and functional benefits.

3.2.1 INDUSTRY AND MARKET

There are several suppliers in the value chain. To be able to conduct a more precise and comprehensive survey and analysis, several additional suppliers would have to be interviewed, which was not part of this TIS analysis. In Table 2 the suppliers of BIPV are described.

Table 2 List of suppliers

Supplier	Description
Raw material suppliers	This refers to all raw materials that are ultimately required for a BIPV system. Not only for the production of the PV module but also for the electronics used in this technology and the material required for mounting and fixing the PV module. In the case of the PV cell, or more precisely the crystalline PV cell, the starting material is silicon.
Electronic device and component manufacturers	The term "electronics manufacturer" refers to all manufacturers who produce the required electronics. This ranges from connectors to required cables to the inverter. Currently, there is only one inverter manufacturer in Austria, the company Fronius International GmbH.
Producer of silicon wafers, ingots, and cells	After obtaining the raw materials, wafer production is the next step in manufacturing a PV module. For this, the required silicon is melted and purified. After melting, the resulting ingots are cut to a thickness of a few tenths of millimeters to obtain wafers. Meanwhile, they are doped with foreign atoms to make them into PV cells.
Mounting system manufacturers	Mounting system manufacturers are manufacturers who produce the mounting systems for PV systems.
Building component manufactures	Building component manufacturing refers to services such as roofing or facade construction. These service providers in particular will have a lot to do with BIPV shortly.
BIPV companies	In addition to conventional PV systems, there are already companies involved in BIPV. Shortly, these companies in particular will have to deal with roofers and facade builders and, in the best case, work closely together.
Wholesalers	As BIPV is still a niche product in Austria. According to experts, there are three wholesalers for this product. When BIPV technologies achieve a sufficient market penetration and can compete in the global or EU market the market and wholesalers will adapt accordingly.
Architects	Architects are usually the first link in the planning process. In addition to building owners and investors who decide whether or not BIPV/PV will be used, they are responsible for designing a BIPV system that suits the owners' and investors' ideas. At present, opinions are divided on this issue in Austria. While some say that a BIPV system, or at least a PV system, must be included, others say that a PV system does not meet the requirements for an aesthetic building envelope.
Engineering offices	Engineering offices are usually responsible for the calculation of the planned BIPV system. There are already engineering offices in Austria that are experienced in calculating BIPV systems.
Construction companies	Construction companies are ultimately the ones who must install and fix the PV system. Roofers and facade builders again play a major role here.
Installers	An electrician is required to connect a PV system to the inverter and the grid. This person must be familiar with the subject of PV systems so that no problems can arise during connection.
Energy suppliers and Grid operators	The electricity producers and grid operators must first approve a PV system before it can be connected to the grid. This is necessary to ensure that the PV system does not cause voltage, current, or other problems that could affect the quality and reliability of the power grid and to guarantee the general security of the electricity supply.
Energy management systems suppliers	Energy management systems are important for controlling and monitoring (BI-) PV-systems and all connected loads. In Austria, the SmartFOX system (Dafi GmbH), the systems from Levion Technologies GmbH and the systems from Fronius International GmbH are particularly worthy of mention here.

3.2.2 GOVERNMENT AND POLICYMAKERS

The most important legislative bodies in the European Union are the European Council, the European Parliament, and the European Commission. These 3 bodies are responsible for legislation at the European level.
For Austria, the Ministry for Climate Protection, Environment, Energy, Mobility, Innovation and Technology is responsible for renewable energies.

3.2.3 INTERMEDIARIES AND SUPPORTING ORGANIZATIONS

Austria has many higher education institutes, divided into universities of applied sciences (UAS) and universities. There are 21 universities of applied sciences and 22 state universities. Of these, there are at least 4 state universities and 4 universities of applied sciences that are involved in research in the field of BIPV those are the TU Vienna, Boku Vienna, TU Graz, University Innsbruck, UAS Technikum Vienna, UAS Upper Austria, UAS Salzburg and UAS KufsteinOf these, however, most also offer degree programs that include at least one course on the topic of BIPV. Universities are important for the dissemination and teaching of new technologies, even though the universities sometimes lag with technology, the teaching of the basics and the visual material in laboratories is important.

Austrian Institute of Technology (AIT) [25]: "*AIT is Austria's largest non-university research institution and plays in the top league worldwide in many infrastructure topics"* (AIT, 2021). AIT primarily develops technologies, methods, tools, and demonstration models for customers from the industry. They also advise on infrastructure issues, for example by conducting studies and evaluations or developing concepts and programs. AIT is conducting numerous research projects on the topic of BIPV. A good example of this is the Be-Smart project, which has set itself the goal of accelerating the energy transition through the use of BIPV in new construction and renovation projects and transforming BIPV into one of Europe's main energy sources.

Technology platform photovoltaic (TPPV) [26]: “The association Technologieplattform Photovoltaik Austria was founded in May 2008 as a joint initiative of companies producing photovoltaics in Austria and the relevant Austrian research institutions” (Technologie Plattform Photovoltaic, 2021). The TPPV is committed to optimizing innovation and research for the domestic photovoltaic industry to increase Austria's share of the global photovoltaic market. TPPV also regularly organizes the Innovation Award for Integrated Photovoltaics, where mainly BIPV projects are selected in several categories. Here are mostly particularly innovative BIPV projects, which can also be used as international showcase projects. The platform is financed solely by member companies and partners.

PV Austria [27]: “The Federal Association Photovoltaic Austria is the inter-company and non-partisan interest group for the improvement of the framework conditions for photovoltaics and electricity storage in Austria” (Photovoltaic Austria, 2021b). The goal of PV Austria is to represent the industry with a strong voice vis-à-vis politics, business, and the public and to create the necessary framework conditions for photovoltaics. PV Austria offers webinars and information on BIPV to improve public awareness of this technology and to disseminate the available know-how.

To meet Austria's expansion targets by 2030 [28], more skilled workers are needed. Austria has been promoting the principles of sustainable development in their environmental, social and economic dimensions for decades. Climate action and adaptation to climate change are fundamental to the implementation of the 2030 Agenda in Austria. The Austrian Federal

Government is committed to the target of climate neutrality by 2040 and is following a consistent decarbonisation path with its current government program.
That is why PV Austria and TÜV Austria are launching a training offensive. An additional 30,000 specialists should be trained, especially among planners and installers. This training should last 2 days and should include both theory and practice, BIPV is only 5% of the training.

3.3 INSTITUTIONS

The hard factors include legislation and standards while soft factors include ethics, norms, and behavior.

3.3.1 HARD INSTITUTIONS

In 2020, the government of Austria presented a government program containing certain working points to be implemented by 2024. This government program is called the Renewable Expansion Act or "Erneuerbare Ausbau Gesetz" (EAG).
Some of the measures are directly or indirectly relevant to the BIPV development and installation.
The most important points regarding BIPV are:

- The federal states are to implement climate-relevant measures in the building regulations
- PV systems are to be used in the construction and renovation of noise barriers. This is mostly integrated into the envelope.
- A clear target definition is to be created for the further development of the national energy and climate plan.
- The standards of building regulations should be further developed, especially those of OIB Guideline 6 (Österreichisches Institut für Bautechnik (in English: Austrian Institute for Civil Engineering).
- A technology-open energy research offensive for decarbonization is to be developed
- A strategy for the use of alternative energy sources in mobility is to be developed.

The Austrian Government put out a new law regarding the build-up of renewable energy sources called „Erneuerbare-Ausbau-Gesetz" (EAG) (in English: renewable expansion law). In this law, different goals are set out. The main goal is put out in § 4 Abs. 2 which is to reach 100 % produced electricity using renewable energy sources [35]. To achieve this goal, the amount of produced electricity will be raised as set out in § 2 Abs. 4. The result of this clause is that the produced renewable electricity has to rise to 27 TWh by 2030. The 27 TWh are sub-divided into 11 TWh increase in photovoltaics, 10 TWh increase in wind power, 5 TWh increase in waterpower, and 1 TWh increase in biomass. To support the increase of 11 TWh of photovoltaic a project to equip one million roofs with PV-Systems is laid out in the clause [35].The only time building integrated photovoltaic is mentioned in this law is in § 56 Abs. 7 where there is an additional investment supplement for building integrated and especially innovative systems.

In Austria, several standards must be complied with for both elevated photovoltaic and building-integrated photovoltaic. These include, for example, the fire protection guideline or the guideline against blinding of PV systems [31] . Some relevant standards in the PV sector are given in Table 3.

Table 3 Relevant standards in the PV sector [30]

Name Standard	Description
ÖVE Standard R11-1	Requirements for firefighter protection
ÖNorm M 7778	Installation planning and installation of thermal solar collectors and PV models
ÖVE Standard R 6-2-1	Lightning and overvoltage protection
ÖVE Standard R 6-2-2	Principles of application on surge protection devices
ÖVE Standard R11-3	Guideline against glare from PV systems
ÖNorm EN 1991-1-3	Snow load with national annex
ÖNorm EN 1991-1-4	Wind load with national annex

In Austria, each of its nine federal states has its building code. Therefore, the building codes differ from each other. Here are two examples from Vienna and Styria.

Viennese Building Code

In § 118 Par. 3b of the Viennese building code a new building, except resident buildings, has to install solar energy sources of at least 1 kWp per 100 m² conditioned gross-floor area or another environmentally friendly technical system with the same nominal power [32].
For residential buildings § 118 Par. 3c has to be applied. New residential buildings have to install at least 1 kWp per characteristic length of the building and for each 300 m² conditioned gross-floor area of solar energy sources or different environmentally friendly technical systems with the same nominal power [32].
The mandatory use of renewable energy systems is not applicable if the planned execution conflicts with other building regulations, other regulations under federal or state law, or is by technical or financial means not appropriate. If this is the case for new buildings which are not resident these technical systems have to be built on one or more substitute areas within the Viennese municipal area. These two paragraphs are not mandatory for family houses, with more than two housing units as well as allotment houses [32].

Lower Austrian Building Code

In the Lower Austrian Building Code in § 66a the conditions are shown under which the installation of a photovoltaic system is necessary.
For new buildings with more than 300 m². Each combination of the following two variants is permissible:

1. to install a photovoltaic system on the building, with a module area of at least 25% of the built-over area, or
2. to construct the building in such a way that a photovoltaic system can be installed on 50% of the roof surfaces suitable for this purpose

On new or additional structures of non-residential buildings, a photovoltaic system must be installed if an energy performance certificate must be issued and if this certificate shows an externally induced cooling demand greater than 0.
If air conditioning systems with a nominal output of more than 12 kW each are installed on buildings, a photovoltaic system must be installed on the building. The module area of the photovoltaic system must be at least 2 m² per kW of the total nominal output of these air conditioning systems.

Styrian Building Code

The Styrian building code entered into effect in September 2022 and for the first time contains minimum requirements for photovoltaic and solar thermal systems in new buildings, similar to the requirements in the Viennese building code. For new residential buildings with a conditioned gross floor area of more than 100 m², solar energy systems must be installed. Photovoltaic systems with an area of at least 3 m² or solar thermal systems with an area of at least 1 m² shall be installed for every 100 m².

In the case of new buildings, except residential buildings, with a gross floor area above ground of more than 250 m², photovoltaic systems with an area of at least 6 m² or solar thermal systems with an area of at least 2 m² must be installed on the building surfaces or other structural elements for every 100 m² of gross floor area.

In the case of new construction of roofed structures, excluding buildings, with an above-ground roof area of more than 250 m², photovoltaic systems with an area of at least 6 m² or solar thermal systems with an area of at least 2 m² must be installed on the building surfaces for every 100 m² of above-ground roof area.

OIB Guidelines

The Österreichisches Institut für Bautechnik (in English: Austrian Institute for Civil Engineering) (OIB) [33] puts out guidelines to harmonize the building regulations in Austria. The federal states can declare the OIB guidelines binding in their building regulations. However, it is possible to deviate from the OIB guidelines by the provisions in the relevant ordinances of the federal provinces if the building applicant proves that an equivalent level of protection is achieved as would be the case if the OIB guidelines were complied with. This is to ensure the necessary flexibility for innovative architectural and technical solutions. In this guideline, there is no commitment to install solar energy sources at all.

3.3.2 SOFT INSTITUTIONS

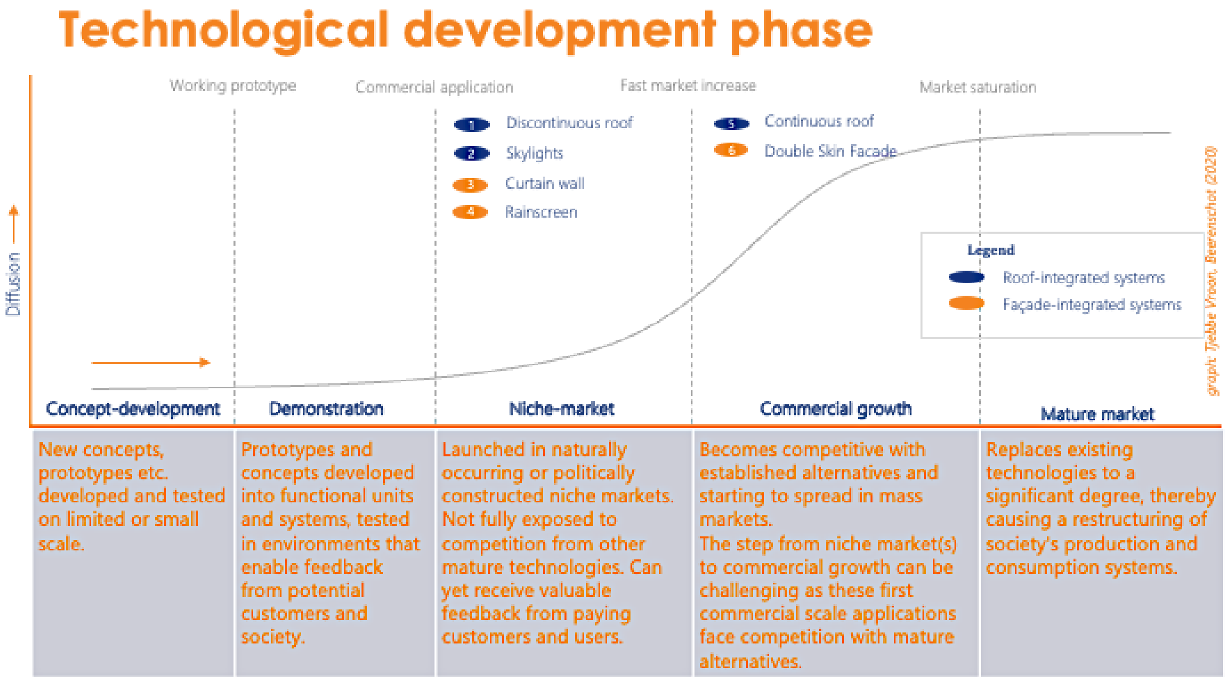
The social acceptance in Austria regarding renewable energies is quite good [33]. According to the study, Austrian population is in favour of renewable energies. Especially Photovoltaics are very popular with an acceptance of 83%. Photovoltaics are also in first place among citizen participation projects, ahead of wind and waterpower projects.

The situation is different in the construction industry. According to the responses from the expert interviews, different languages are still being spoken here to some extent, which makes standardized cooperation more difficult. The construction industry is not sufficiently responsive to photovoltaic manufacturers and vice versa. There are currently no harmonized standards that allow the simple mounting of standard modules on building objects. The reason for that is the standardization of PV modules, which primarily follows the European Low Voltage Directive (LVD), which states that PV modules must comply with the module safety standards EN IEC 61730-1 and 61730-2. To use something as a building material, a Declaration of Performance (DOP) has to be done according to the Construction Products Regulation (CPR).

The standardization of IEC, CENELEC, and OVE for electric standardizations and all other ISO - CEN - ÖNORM standards are not harmonized. While electrical products had a world market from the beginning and standards were soon international, the world of construction standardization is still based on many local traditions. Standards in construction were more often developed from the bottom up. These differences are hard to overcome, although there is a joint BIPV working group IEC TC82 JWG 11 [36], which provides a link between IEC TC82 PV and ISO TC160 SC1 Glass in the Building.

4 PHASE OF DEVELOPMENT AND TARGET DEFINITION

In Austria, BIPV technology is mainly in the niche-market phase, although there are already commercial products that may be competitive with other construction products. This occurs with BIPV elements for ventilated façades, curtain walls, and skylights, mainly for the tertiary segment. The target is reaching the commercial growth phase.



[8]

Figure 6: Development phases for BIPV in Austria. Blue circles indicate Roof- integrated PV systems solutions, and orange circles façade-integrated solutions.

Figure **6** illustrates the diverse product types identified along with their estimated stages of development. Ongoing research focuses on new materials for Building Integrated Photovoltaics (BIPV), with a range of BIPV products either available in the market or currently in development. Companies primarily involved in design and manufacturing have identified these products, while predevelopment prototypes and research initiatives originate from R&D centers and universities. The illustration highlights various solutions for Discontinuous roofing (e.g. tiles), skylights Discontinuous roof and double skin facades are categorized in the niche-market phase. Discontinuous roofs and double skin facades have already reached commercial growth. Considering the responses from interview participants, it's commonly noted that building integrated photovoltaic (BIPV) is typically seen as entering the initial stages of the take-off phase. This evaluation aligns with both other responses and the diagnostic questions posed across various development phases. Although BIPV is already available in the market, its growth rate is not rapid enough to achieve market saturation.

5 FUNCTIONAL ANALYSIS

To dive deeper into the Austrian Building Integrated Photovoltaic (BIPV) innovation ecosystem, 17 semi-structured interviews were conducted. The sampling methods employed included theoretical sampling and snowball sampling, chosen to encompass the entire spectrum of actors within the Austrian BIPV innovation system. Appendix B provides a comprehensive list of the questions asked during these interviews. Table 4 presents a summary of the interviews, detailing their organizations and stakeholder categories.

The functional analysis combines insights gleaned from the structural analysis with responses gathered from expert interviews. The findings are depicted numerically, ranging from 1 (absent) to 5 (highly developed). Collaborating with Task 15 Subtask A experts, the data was thoroughly assessed, yielding the subsequent results.

Table 4: List of interviewees (Authors Illustration)

Position	Organization type	Stakeholder Category
Asset Manager	Energy supplier	Supply
Business Manager PV	Research Institute	Research/Education
CEO	Architecture	Supply
CEO	Building Physics Office	Supply
CEO	Electric Engineering Office	Supply
CEO	PV-Systems Retailer	Supply
Chairman	Network	Support Organisation
Consultant	Network	Support Organisation
Product Manager BIPV	Module Producer	Supply
Project Manager	Module Producer	Supply
Project Manager	Ministry	Government
Program Manager for PV	Building Department	Government
Program Manager for PV	Magistrate	Government
Researcher and Lecturer	University	Research/Education
Research Director, Architect	University	Research/Education
Research Engineer	Research Institute	Research/Education
Sales Manager	Module Producer	Supply

5.1 KNOWLEDGE DEVELOPMENT

The analysis for knowledge development has shown that in Austria the research is more focused on the technical aspect of BIPV than on the social aspects. Numerous research and test institutes enable continuous further development. At the same time, these institutes enter research alliances with universities of applied sciences and universities to also provide for non-market-relevant research. To get a good analysis, the interviewees were asked questions about the quality of knowledge development and whether it is sufficient to advance the development of the BIPV sector.

Looking at knowledge development at universities of applied sciences and universities, one interviewee said that there are only a few funding programs in Austria specifically for BIPV research. Since there is also hardly any basic research money, one is dependent on a few research projects. However, photovoltaic producers and research institutes help here. Especially photovoltaic producers put a lot of emphasis on research to improve their products. Here, they are focusing primarily on the further development of color design, module size, and performance, but also easier installation in roofs and facades. Counting the publications of all research institutes and universities in Austria. Between 1997 and 2021, 50 publications were found that deal with the topic of BIPV. The pioneer and innovation driver in the Austrian context is the AIT with 26 of the 50 publications. At present, however, there is no pure BIPV research institute in Austria.

Among the universities, Graz University of Technology and Vienna University of Technology have the highest number of publications. Since 2012, Graz University of Technology has published at least one publication on the topic of BIPV every year except 2020, a total of 12 publications, and thus leads the ranking of the universities. The TU Vienna still manages 11 publications but has not submitted any since 2018. For completeness, it must be said that these publications are due to journals, as not every university collects all its publications and makes them available online. In Appendix B the results of published research of the different universities and research institutes in the timeframe from 1997 to 2021 are summarized.

In Appendix C the number of the research on national and international research projects on BIPV done by universities and research institutes can be seen. Among the research institutions, AIT also has the highest score in this case. The reason for this is the high number of research projects.

Only UAS Kufstein, UAS Technikum Vienna, and UAS Salzburg have both bachelor's and master's degree programs in which the topic of BIPV is included. Among the research institutions, the AIT also has the highest score in this case. The reason for this is the high number of research projects and the high number of publications.

In conclusion, despite insufficient educational initiatives in the realm of BIPV, it is the photovoltaic producers and research institutions that drive the expansion of the BIPV market. Enhanced funding for research in this area at universities of applied sciences, coupled with collaborative research partnerships with institutes, could further bolster the advancement of BIPV. Overall, this role is moderately fulfilled, earning a score of **3 out of 5.**

5.2 KNOWLEDGE DISSEMINATION

In terms of knowledge dissemination, Austria holds a commendable position internationally; however, there is a noticeable absence of domestic knowledge sharing and collaboration among various stakeholders and relevant sectors. When queried about international knowledge sharing concerning BIPV, one interviewee highlighted the representation of individuals in the IEA PVPS Task 15, ensuring effective knowledge exchange. Additionally, there have been Erasmus projects involving Cyprus, the Netherlands, and Germany. However, knowledge exchange at the national level, particularly among countries or municipalities, proves to be more challenging.

Respondents indicated an almost non-existent national exchange of BIPV knowledge. When discussing knowledge exchange between the BIPV industry and stakeholders in the building sector, one interviewee noted a deficiency in knowledge, particularly among architects. In some instances, photovoltaic planners are only engaged towards the project's conclusion, hindering BIPV integration into buildings. The Austrian PV Technology Platform (TPPV) organizes meetings addressing such issues, yet developers and investors remain inadequately informed in certain cases.

Knowledge dissemination occurs among academia, users, and industry, with the indicator for this factor being the type and quantity of networks [3]. Some interviewees expressed concerns about the insufficient dissemination of knowledge for such a complex topic as BIPV. Limited training opportunities contribute to a scarcity of expertise in both planning offices and construction sites. Bridging the gap between electrical engineering and construction engineering is essential, necessitating a connection between the two disciplines in planning offices and on-site. A positive development worth noting is the Climate Fund's Lighthouse call, which targets integrated PV specifically and provides higher grants for BIPV compared to the EAG. This underscores the growing interest and dedication to advancing this technology.

Increased pilot projects could enhance knowledge dissemination by showcasing BIPV applications and capabilities, thereby stimulating commercial expansion and market growth. While Austria hosts some demonstrators and contributes components or expertise to projects abroad, the uptake within the Austrian market remains sluggish.

In conclusion, while international knowledge dissemination exists, it falls short domestically, particularly between the photovoltaic and construction sectors. Architects seek more information from manufacturers and suppliers, who sporadically share information with the architectural industry. To bolster national knowledge dissemination, multiple and larger technology platforms are essential, with the TPPV serving as a promising example. Overall, this aspect is inadequately addressed, earning a score **of 2 out of 5.**

5.3 ENTREPRENEURIAL EXPERIMENTATION

As already described in Chapter 3.2, two companies are decisive in Austria regarding research, development, production, and sales of BIPV technologies.

When queried about the availability of suitable actors to foster entrepreneurial experimentation, one interviewee remarked that they are scarce. While there are numerous pioneers, they primarily operate out of necessity rather than with a focus on innovation. To engage in more experimentation and collaboration, these pioneers would require additional specialized expertise. Presently, the workforce in the BIPV sector predominantly comprises individuals from electrical or building services backgrounds. Hence, there is a pressing need for more targeted education to facilitate widespread experimentation and research collaboration. Moreover, it is anticipated that in the future, facade manufacturers will need to play a more active role in advising customers on the advantages and disadvantages of BIPV technologies compared to conventional facades.

In Conclusion, it is observed that the Austrian market comprises two major players and a considerable number of newcomers and small innovative entities poised to drive innovation. However, there is a shortage of small players and opportunities for highly specialized small companies. Consequently, this aspect is moderately addressed, receiving a score of **3 out of 5.**

5.4 RESOURCE MOBILIZATION

The Resources function consists of three sub-functions: physical infrastructure, financial infrastructure, and human resources.

Human resources

Regarding the question, of whether there are enough trained staff, most interviewees answered that there are insufficient trained staff. Many could imagine a new apprenticeship that would include BIPV. This apprenticeship is not intended for the manufacturers, but rather for the planners, the roofers, and the facade builders.

Figure 7 shows the development of jobs in the Austrian photovoltaic market. The data collection of the photovoltaic planners and installers was carried out by [16]. As many companies do not make a clear distinction between the different business areas in their company, it is difficult to determine the exact number of workplaces for this purpose. In this study, 25 system planners and installers were surveyed, representing about 35 % of the newly installed capacity in Austria in 2023. In this way, the average jobs per installed MW_{Peak} were determined and extrapolated to the installed photovoltaic capacity of 2023 [16] .

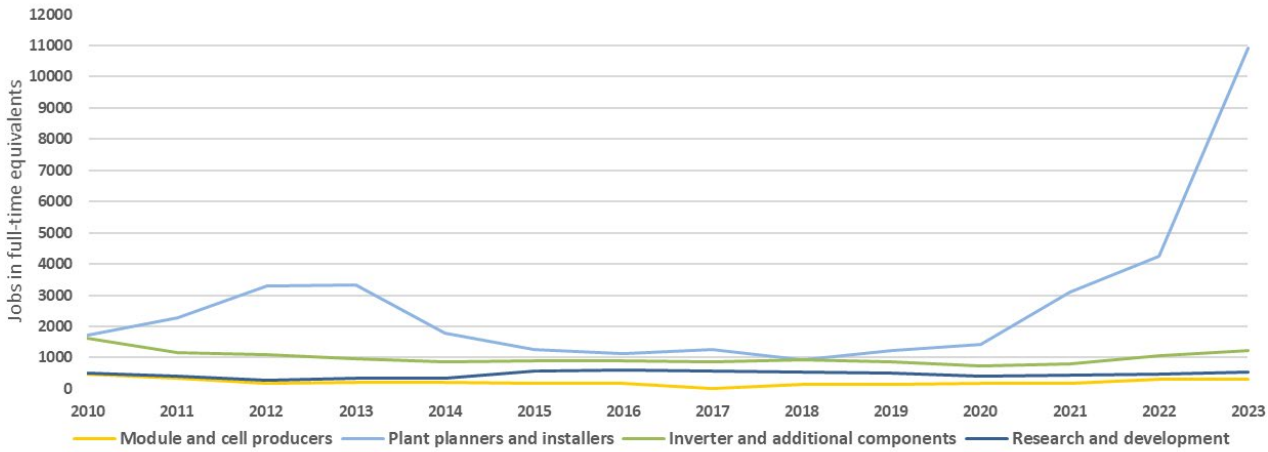


Figure 7 Jobs in the Austrian PV market from 2011 to 2021 (Authors illustration with sources from[15])

Figure 7 shows that system planners and installers account for 10.931 jobs in 2023, which account for 84,2% of all jobs in the photovoltaic market [16]. The manufacturers of inverters and additional components are in second place with 1.214 jobs or 9,4%. In the area of research and development, there are 525 jobs, or 4%. The largest increase from 2023 of 158% was recorded by the Austrian system planners and installers. It can be seen that although there is a high rise in PV related Jobs, which is to be expected due to the rapidly growing number of PV-Systems in Austria (Figure 2), the interviewed experts were nevertheless in agreement, that there are not enough specialized workers for PV and BIPV. As a further rise in systems and therefore BIPV-Systems is to be expected in the next years, the number of specialized workers and the number of people choosing such a profession is also expected to rise further.

Financial resources

In Austria, there are several ways to finance a photovoltaic system. Amongst others the most important is funding according to the EAG, funding from federal states and bank loans/lease agreements. Those are summarised as follows:

- Investment grants according to the EAG
- Market premium according to EAG
- Additional funding for innovative PV systems according to EAG
- Local promotions from individual federal states
- Solar loans and Solar leasing

The EAG ("Erneuerbare Ausbau Gesetz") the Austrian Renewable Expansion Act is the most important source of funding. For the year 2023, € 600 million has been made available by the Austrian government as a subsidy. This subsidy strategy aims to surpass the PV construction records of recent years.
The investment grant is used most frequently and foresees that depending on the size of the PV system, a subsidy of 140-285€/kWp is granted. In addition to the pure investment subsidy, a market premium is also envisaged for PV plant owners who feed their surplus electricity into the grid to make this more profitable.
Especially important is the subsidy for particularly innovative systems, for which an additional 30% of the investment costs of the system are subsidized. Innovative systems include BIPV, among others. This is the most important monetary incentive in Austria to build a BIPV system instead of a conventional PV system.

In conclusion, regarding the aspect of resource mobilization, Austria demonstrates strength in financial resources and network services. However, a critical factor in facilitating significant expansion in photovoltaics is the shortage of skilled personnel necessary to drive this growth. Despite a notable increase in the workforce within the photovoltaic sector in Austria over recent years, with further growth anticipated, this aspect is deemed only moderately fulfilled, earning a score of **3 out of 5.**

5.5 DEVELOPMENT OF SOCIAL CAPITAL

Some of the interviewees were satisfied with the level of relation inside the value chain. The point where they lack communication is between the (BI)PV planner and the architects. The architect in contrast is involved right from the beginning. If the architect does not plan the (BI)PV in the building at the early stages it will be very difficult for the (BI)PV planner to integrate a (BI)PV system because in most cases the (BI)PV modules do not fit perfectly into the building envelope. One point the interviewees pointed out is that conventional PV planners are scared of planning BIPV systems. This can be attributed to the missing of special BIPV standards which makes it difficult for new actors to join the BIPV network. The relationship and communication between planners and producers is according to the interviewees good. The Technology platform Photovoltaic (TPPV) has made a major contribution to this.

In conclusion, the area where communication is deficient lies between the (BI)PV planners and architects. Typically, (BI)PV planners are not engaged during the initial phases of project planning, and there is a reluctance among conventional PV planners to undertake BIPV system planning. Given these observations, this function is rated **2 out of 5** for weak fulfillment.

5.6 LEGITIMATION

Analyzing this function deals with the legitimation of the technology with the current legislation, the industry, and society. The key indicators and questions for this function are focused on the acceptance of the technology by industry and society, the resistance towards the new technology, which regulations respectively policies are most important as well as what or who influences legitimacy.

The acceptance of PV generally is good, especially as BIPV has the chance to increase the acceptance even more. The most important positive attitudes according to the interviewees are optic aesthetical integration and the production of renewable electricity. The negative attitudes towards BIPV are the higher investment costs when comparing it to BAPV, problems when changing a module, and the additional work. It has to be noted that the BIPV planners who were interviewed expressed none of these negative attitudes from the customer side. The interviewed architects said that this is very dependent on the customer. If the customer is open to PV, likely, they are also open to BIPV. All of the interviewees agreed that focusing only on BIPV is not the best option to tackle the upcoming PV expansion, instead, there has to be a mixture of BIPV, BAPV, and freestanding photovoltaic. But they all agreed that in already sealed areas BIPV should become the standard especially in new buildings but also in renovations the potential is high. One interviewee pointed out that the value creation in Austria is way higher in BIPV projects than in freestanding PV projects.

There is a lot of innovation and product development ongoing but it is not enough, especially from the Austrian producers. To improve that some interviewees suggested starting an advertising campaign because most decision-makers do not know the possibilities of BIPV. From the informal side, the TPPV contributes the most to creating legitimation according to one interviewee. PV Austria is doing what it can but the financial situation of the PV sector is way smaller than that of other technologies. The contribution to creating legitimation from the formal side is not present.

In conclusion, the acceptance of PV is getting better, and the technology BIPV has the chance to increase that even more. Nevertheless, the resistance towards BIPV projects is still present. This resistance should easily be decreased by elucidation of the decision-makers and clients about the possibilities of BIPV. Another aspect is the early integration of (BI)PV planners in the planning process of the building. This is still missing in most of the projects. Therefore, the score of this function is **3 out of 5**, moderate fulfillment.

5.7 GUIDANCE OF THE SEARCH

The vision from all interviewees is, that every already used land and building should be equipped with PV and BIPV. Free-standing PV should only be used when there is no other way. Another vision from two interviewees was that hype around BIPV, just like the hype of green roof gardens, has to be produced. This can be done by for example a big marketing offensive.
The vision of industry and the market differs quite from each other. The producers are already satisfied with their coloring options. Especially the architects wish far more possibilities for the coloring of the modules. However, all interviewees agreed that there have to be more easily applicable systems, more or less plug-and-play solutions. If this is the case, they see no burden in an expansion of the BIPV market.

In the Austrian government program, different goals for renewable electricity and renewable energy are pointed out. In the electricity sector, the long-term goal is to reach 100 % of electricity from renewable sources net in the year 2030. This 100 % renewable electricity goal is part of the main goal to achieve 46 to 50 % renewable energy sources in the energy production of Austria by 2030 [28].

An own standard for BIPV is just in the creation as one interviewee said, but for Austria, it is very difficult to join because no one from Austria is in this working group. In the whole ISO TC 160, no Austrian expert is represented nationally or internationally represented. This was then the reason to form the IEC TC82 JWG 11 with members from ISO and IEC. But ISO TS 18178 and IEC 61730, etc. are still conflicting and not harmonized.

In conclusion, it is evident that while there are no explicit policy objectives specifically targeting Building Integrated Photovoltaics (BIPV), there is a clear goal concerning Photovoltaics (PV) in general. The majority of interviewees express satisfaction with this PV objective, foreseeing its potential to expand the PV market. The overarching vision is that the growth in PV adoption will naturally extend to BIPV as well. Furthermore, there exists a subsidy program for innovative PV solutions, encompassing BIPV within its scope. However, the absence of industry standards poses a challenge, hindering the participation of new stakeholders in the Technological Innovation System (TIS). Consequently, this aspect is considered moderately fulfilled, with a score of **3 out of 5.**

5.8 MARKET FORMATION

This function analyses the market formation in three different sectors, market formation by the government, by entrepreneurs, and by lead-users.
The phase of development that BIPV technology currently occupies in Austria is the niche market phase, as agreed upon by all stakeholders.

The institutional hindrances are the missing technical standards of BIPV. There are standards for PV but not for BIPV. According to the interviewees, this leads to higher costs for the BIPV system because the planners have no clear direction on how to plan such systems. This argument was enervated by the two interviewed planners who said the miss of these standards is no hindrance at all. This hindrance can also be decreased by the creation of knowledge. Most of the PV planners do not have enough knowledge and experience with BIPV projects therefore they have to do additional work which is reflected in the planning costs according to one interviewee.

All interviewees agreed that the users are not aware of the technology and its benefits. This ranges from architects and planners to private clients up to political decision-makers. The technology of PV is already on the minds of the people, but BIPV is not, one interviewee pointed out. To achieve a bigger recognition factor advertising campaigns could help but currently, there are none.

The demand profile of a BIPV system is clearly articulated by the customers. The BIPV system should have a long lifespan, should be easily replaceable, should fulfil its duty as a building product, and should have low investment costs. The existing products meet most of these demands, especially the easy replaceability and the duty as a building product. The lifespan cannot be known exactly because the technology is very new and the level of experience on this topic is very low according to the interviewed producers. Another problem to increase the experience about the lifespan of BIPV modules is the fast innovation velocity. If there is an innovation in the production, the old products are taken out of the production line. This makes it even more difficult when specific modules have to be changed. The demand for low investment costs can be addressed in different ways. The current zeitgeist in the PV market is that the investment costs have to be as low as possible without questioning the quality of the product. If the customers change their perspective on quality, the BIPV has a good chance to increase the market value one interviewee explained. Another interviewee pointed out that in many cases BIPV systems contain individualized products. This individualization increases the investment costs significantly. If the producers find a way to produce individualized modules at low costs the BIPV market could expand. Another interviewee said the lack of many different standardized BIPV products makes it difficult for architects and planners to include BIPV in their projects.

The last subsegment of this function is to analyze user-driven market formation

Especially private users are unaware of the possibilities of BIPV, therefore they are dependent on the planners. But, as the interviewees pointed out, most of the planners are also unaware of BIPV or they are aware but have too little experience with it therefore the investment costs increase. They all agreed that the project sizes are too small to reach a big market diffusion. Additionally, the projects need to be put out to the public, even more, to reach a better knowledge of the technology in society. Regarding the project types, most of the interviewees said that the need for demonstration projects is still necessary to create legitimation in society. Some interviewees stated that the technology is already well developed and there is no need for demonstration projects.

In conclusion, it can be stated that the market formation of BIPV in Austria has still room for improvement. On the governmental-driven market formation, the missing of technical standards and the absence of regulatory commitments on renewable energies in the local building codes are the biggest weaknesses. The analysis of entrepreneur-driven market formation made clear that the technology is not well-known in society. This ranges from private customers to architects up to political decision-makers. Another aspect in this category is the current zeitgeist on the quality and price of PV modules. In the last analyzed segment, user-driven market formation the lack of awareness about BIPV in society is brought into the spotlight even more. Therefore, the score of this function is **2 out of 5**, weak fulfillment.

5.9 SUMMARY OF THE FUNCTION ANALYSIS

BIPV in Austria is situated in the niche market phase. The functional analysis is composed of the results already obtained from the structural analysis and the responses from the expert interviews. The results are presented in numerical form from 1 (not present) to 5 (very well developed). Together with IEA PVPS Task 15 Subtask A, the data was evaluated, and the following results were obtained.
The functions of entrepreneurial experimentation and production and the function creation of legitimacy are the key functions. Guidance of the search, resource mobilization, and market formation are important supportive functions.
In Figure 8, the completed radar chart displays the scores for each functional aspect of fulfillment. These scores range from 2, indicating weak fulfillment, to 3, reflecting moderate fulfillment. Notably, the key function of Legitimation achieves a score of three, signifying moderate fulfillment. This is attributed to the overall acceptance of PV technology increasing, with BIPV poised to play a significant role in further enhancing acceptance. Moreover, addressing resistance against BIPV can be facilitated by providing decision-makers and clients with clearer insights into the potential benefits of BIPV.

Similarly, the support function of guidance in the search process also earns three points, indicating the potential for improved functional fulfillment in the future. However, the support function of general market information receives only two points, highlighting areas with scope for greater enhancement.

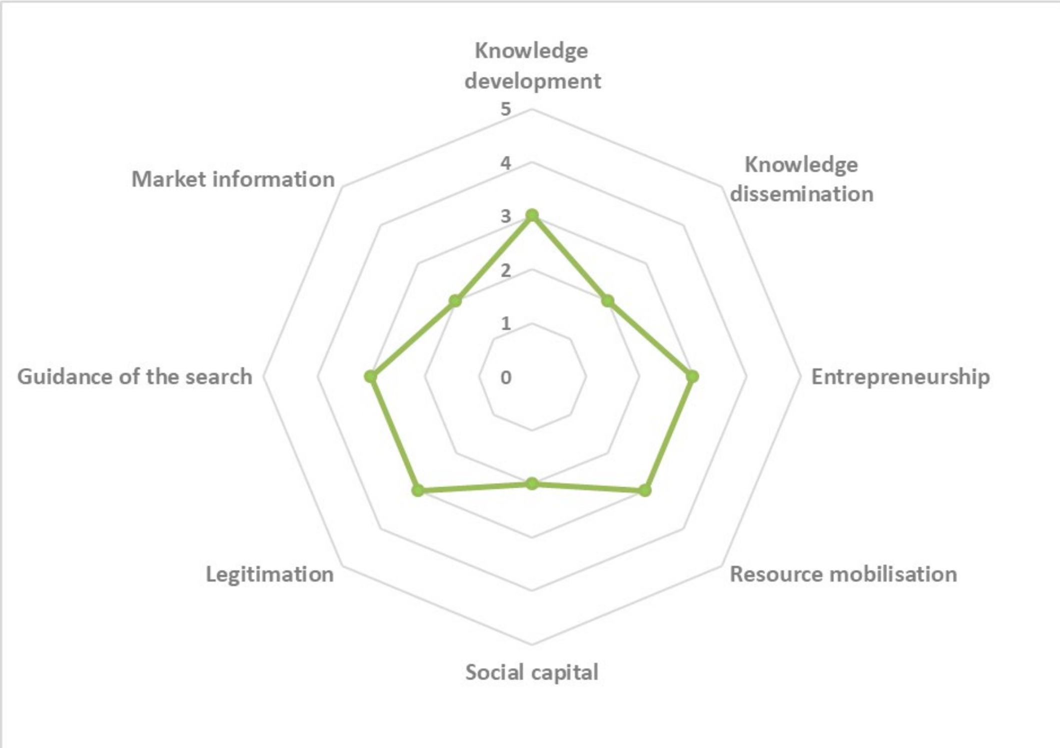


Figure 8: Functional fulfilment assessment for TIS functions. Fulfillment degrees: 1 – absent, 2 – weak, 3 – moderate, 4 – strong, 5 – excellent (Authors Illustration)

The score for the entrepreneurial experimentation function stands at 3 out of 5, indicating moderate fulfillment. One aspect of this function is the number of patents (see Appendix D) alongside the presence of producers in the market. Currently, Austria hosts only a few major producers whose products enjoy national and international demand. However, the limited number of these large producers hampers the pace of research. Conversely, the market also comprises numerous small to medium-sized companies, hinting at its potential for growth. It is anticipated that the market will attract more significant producers in the future, thereby accelerating research and development efforts.

For the knowledge development function, a score of 3 out of 5 suggests moderate fulfillment. Despite the presence of numerous universities and universities of applied sciences in Austria, only a select few study fields focus on photovoltaic or integrated photovoltaic technologies. One indicator for this function is the number of publications, with the majority being attributed to a research institution called AIT rather than academic institutions. However, it should be noted that not all publications are included in university databases, thus leading to an unknown quantity. Another indicator is the number of projects in which universities participate, a trend expected to improve over time.

Regarding knowledge dissemination, a score of 2 out of 5 indicates weak fulfillment. According to expert interviewees, communication and knowledge dissemination among stakeholders are lacking. For instance, architects often lack training in BIPV, hindering their ability to work with it effectively. Additionally, PV planners are typically engaged too late in projects, limiting their ability to make changes or adjustments. While there are existing platforms in Austria aimed at improving knowledge dissemination, these efforts are currently focused either on the research or industrial sectors. Future collaboration among platforms may enhance knowledge exchange.

The mobilization of resources function receives a score of 3 out of 5, indicating moderate fulfillment. The main weakness identified in this function is the shortage of skilled workers, both among planners and construction personnel. Many respondents advocate for the creation of a new apprenticeship profession centered around photovoltaics. Despite a rapid increase in skilled workers, it is deemed insufficient to meet current demands. Additionally, indicators such as physical and financial resources are relatively stable, with grid expansion initiatives progressing steadily and robust financial support from state, federal governments, and banks. However, addressing the shortage of human resources is crucial for realizing new energy laws. Table 5 provides a summary of the functions, highlighting their strengths, opportunities, and weaknesses.

Function	Strengths/Opportunities	Weaknesses	Assessment
F1: Knowledge development	• Substantial research done by manufacturers and universities • Many (innovative) projects from manufacturers and universities	• Few funding programs • Less knowledge of the building site • Not enough training opportunities	3 out of 5 Moderate
F2: Knowledge dissemination	• Sufficient number of universities • Highly active Platforms, Networks, and institutes to generate a diffusion • Well-presented globally	• Lack of knowledge especially by architects • National exchange on BIPV knowledge is insufficient	2 out of 5 Weak
F3: Entrepreneurial experimentation	• Many small and medium entrepreneurs • A lot of specialized solutions but no universal solution	• Only a few developing companies • Low amount of patents • There are many pioneers, but they are mainly survivalists	3 out of 5 Moderate
F4: Resource mobilization	• The financial infrastructure is well-developed • There are several subsidies both in the private sector and at the state level • The physical infrastructure is equally well-developed • Strong growth in the number of skilled workers in the PV industry	• Not enough trained staff, both in the office and on the construction site • Not enough training opportunities • Not enough testing facilities in Austria that cover both the electrotechnical aspect and the construction aspect	3 out of 5 Moderate
F5: Social capital development	• Good relationship between planners and producers	• Lack of communication between architects and (BI)PV planners • The current situation intimidates new actors • Lack of communication results in higher costs □ fewer BIPV systems	2 out of 5 Weak
F6: Legitimation	• High acceptance of BIPV	• Some prejudice is still present • BIPV is still mostly planned in late building phases	3 out of 5 Moderate
F7: Guidance of the search	• Clear PV goal • Clear vision inside the TIS • Additional subsidy for BIPV	• Lack of plans to reach government PV goals • Different visions from stakeholders • Lack of laws and standards	3 out of 5 Moderate
F8: Market formation	• Interviewees see a bright future • Big potential in renovations	• (BI)PV is highly influenced by subsidies • Too small project sizes • low awareness amongst potential customers	2 out of 5 Weak

Table 5 Summary of the results of the functional analysis

6 IDENTIFYING SYSTEM WEAKNESSES AND STRENGTHS

The structural and functional analysis is followed by a coupled structural-functional analysis. This is done around both the systemic strengths and problems. These systemic problems include actors' problems, institutional problems, interaction problems, and infrastructural problems.

6.1.1 ACTORS' PROBLEMS AND STRENGTHS

The results show that both presence- and capacity-related actor problems exist within the Austrian building-integrated photovoltaic (BIPV) system. Although there are several photovoltaic producers in Austria, only two producers are estimated to share the main part of the market. These are also the ones who have the necessary financial means to push the research. The number of smaller photovoltaic producers shows that the BIPV market can grow, but these smaller producers can hardly keep up with the big ones in terms of research. This is one reason why the function of Entrepreneurial experimentation has a low rating.
In Austria, there are many actors in the BIPV value chain. These actors help each other to better understand BIPV by creating several pilot projects. In addition, some platforms aim to stimulate and improve the exchange of knowledge.
Looking at institutional problems, one notices that there is a lack of training places for the topic of BIPV in Austria. As can be read in Chapter Knowledge Development there are several colleges and universities in Austria, but hardly any of them have BIPV as a subject of study. For this reason, it can be concluded that there is a lack of trained technicians who are familiar with the topic of BIPV.

6.1.2 INSTITUTIONAL PROBLEMS AND STRENGTHS

Another critical point is the lack of standards for BIPV, there are hardly any. In part, standards for standardized photovoltaics are used for this purpose. Because BIPV modules are not standardized, all modules must be certified. However, some customers fail to do this, which leads to incorrect module sizes and thus to poorer cabling and possibly increased fire hazard.

6.1.3 INTERACTION PROBLEMS AND STRENGTHS

The Austrian BIPV market is largely dominated by small module producers, universities, and research institutes. Universities communicate mainly on a research-level with producers and partly also with research institutes but not with other actors like planners and architects. Producers, on the other hand, communicate with almost all actors, but since actors such as planners and architects seldom have anything to do with BIPV, the larger BIPV companies are more likely to be communicated with here than the small entrepreneurs. Interaction between these parties would be important for three reasons:

- To improve knowledge diffusion to these parties
- To align BIPV with other building component technologies and systems coordinate installations, and
- To scale up BIPV through industrialization and improved value chain coordination.

On the first point, communication between all actors would be of great advantage, since not all actors know exactly what BIPV can do. The second point is that combinations with traditional building components and installations can lead to symbiotic interactions. There is a lack of communication between BIPV producers, planners, and construction companies.
In addition, Austria lacks the skilled workers needed to drive the desired expansion. The number of jobs in the BIPV sector in Austria has been stagnating for years. The building

product companies must be more active in this area and develop models and systems that can ensure easy installation and removal of BIPV components. This also requires the necessary specialist personnel, who could be trained in parallel with the development.

When BIPV is part of an integral installation system, all installations in that system (including BIPV) benefit from the added value of the whole system. Once BIPV is part of an integral installation system, it is more difficult to remove it from planned buildings during the implementation phase. As a result, construction companies must integrate even more. On the third point, BIPV companies and large companies from related industries can benefit from each other's skills when working together. This is because start-ups and small and medium-sized enterprises (SMEs) are better at exploration activities and building expertise, while large firms and established companies often have a broader knowledge base and the financial resources to exploit and industrialize new technologies.

Strengths in terms of interaction between actors in Austria are severely limited. However, there are national and international platforms that promote the interaction of actors. The platforms PV Austria and TPPV are strongly committed to networking and interaction between the actors. While PV Austria addresses stakeholders from industry and the public, TPPV is aimed at scientific stakeholders.

6.1.4 INFRASTRUCTURAL PROBLEMS AND STRENGTHS

One strength of the topic of infrastructure is the network infrastructure. Although the Austrian electricity grid is not fully developed, scenarios for further expansion have already been worked out. These scenarios are based on the expansion of renewable energies and are intended to ensure grid stability and long-term supply and system security. This applies to all renewable energy sources, not just PV. There are also many options in terms of funding in Austria. As already mentioned in Chapter 5.4, there are subsidies available from the state as well as from energy suppliers. In terms of subsidies from the federal states, it is important to achieve a certain performance with PV or BIPV, while the energy suppliers rely on a landlord/tenant model.

The strengths in terms of institutions in Austria also lie with the universities and research and testing institutes. Even though there are only a few study programs related to BIPV, these are expandable. Of course, this would require funding from the government, or perhaps it is possible through a partnership with photovoltaic (PV) producers. Recommendations

This chapter presents actionable recommendations for both the industry and policymakers, based on the analyses conducted. The initial recommendation pertains to the industry, while the subsequent one targets policymakers. Moreover, for universities or educational and training institutions, a broad recommendation emerges: the necessity for an expansion of educational offerings in BIPV. Individuals engaged in BIPV require specialized knowledge encompassing photovoltaics, energy technology, building technology, and system integration. Particularly crucial is a comprehensive understanding of the interconnections, necessitating dedicated courses or continuing education programs.

6.2 RECOMMENDATIONS FOR THE INDUSTRY

In order to advance BIPV to the next stage of development, the industry must focus on several key areas. Firstly, it is crucial to integrate (BI)PV into the early stages of the building planning process. By involving (BI)PV in architectural considerations from project inception, it becomes simpler to aesthetically and technically integrate it into designs. Moreover, fostering trust between architects and (BI)PV planners is paramount. Organizing workshops and training courses aimed at both parties could enhance mutual trust and collaboration.

In terms of acceptance and knowledge of BIPV, the industry must work on increasing the visibility of BIPV projects. BIPV technology holds the potential to enhance overall acceptance of PV due to its appealing aesthetic appearance. Implementing advertising programs to raise awareness of BIPV among the public could be effective, given the limited existing knowledge about the technology.

Given that BIPV remains relatively unfamiliar to society, there remains a high demand for demonstration projects. While the technological components may be sufficiently developed, there is still a lack of recognition for BIPV. Therefore, it is imperative to showcase demonstration projects through various channels to enhance understanding of BIPV technology and its capabilities.

In terms of production, the industry should prioritize the development of easier-to-install BIPV systems. Architects, planners, and customers predominantly seek "Plug&Play" BIPV systems. Offering a diverse range of such systems could propel the BIPV market into its next phase. Additionally, there is a growing demand for BIPV modules in various colors, particularly from architects. However, not all architects prioritize color, as some customers prefer to showcase their BIPV systems in their original form. Addressing standardization issues is also crucial. The industry should engage more in standardization efforts to ensure consistency and reliability across BIPV systems.

Currently, BIPV modules are tested using the same methods as conventional PV modules. However, due to their different functions and installations, these testing methods may not be entirely suitable. To ensure robust testing of BIPV modules, there needs to be differentiation in testing methods between BIPV and PV modules. This would necessitate harmonizing PV standards and construction standards to achieve a comprehensive approach.

6.3 RECOMMENDATIONS FOR POLICYMAKERS

Policymakers play a crucial role in shaping the trajectory of technological advancements. In the context of BIPV technology in Austria, several recommendations for policymakers emerge. Foremost, the Austrian government should prioritize addressing BIPV within national laws. While the new EAG marks a positive step, its goal to increase photovoltaic electricity production by 11 TWh may fall short without a comprehensive PV expansion strategy. Integrating BIPV into such a plan could significantly enhance market expansion. Revision of national building codes, taking cues from initiatives like the Viennese building code's PV commitment for new buildings, could serve as a useful framework, fostering a conducive environment for BIPV. Additionally, implementing legislation requiring evaluation of (BI)PV compatibility for every sealed area could further propel BIPV adoption, although the focus should remain on promoting renewable energy sources due to the challenges of legislating specific technologies.
The absence of definitive BIPV standards presents a barrier to entry for new stakeholders. Therefore, establishing and enforcing standards for BIPV modules/systems is imperative to ensure consensus among executing companies and local authorities regarding BIPV system construction.
While the new EAG increases investment subsidies for BIPV systems, research indicates the need for further augmentation in these subsidies. Insufficient financing is also evident in

product research and development, as well as university research efforts. Unlike the rapidly advancing PV technology, BIPV still requires substantial research and development support. This underscores the importance of addressing BIPV within Austrian political agendas.
Addressing these issues necessitates the implementation of more pilot projects to showcase BIPV applications and available opportunities. These projects serve as exemplars of best practices, demonstrating how BIPV can be effectively utilized and stimulating further adoption.

REFERENCES

[1] P. K. ,. K. K. ,. T. V. .. M. van Noord, "Guide for Technological Innovation System Analysis for Building-Integrated Photovoltaics 2023," IEA PVPS TCP, 2023.

[2] K. K. P. C. (KPC), "Musterr- und Leuchtturmprojekte Photovoltaik," [Online]. Available: https://www.umweltfoerderung.at/betriebe/muster-und-leuchtturmprojekte-photovoltaik. [Accessed 01 09 2024].

[3] Österreichische Techologieplattform PHOTOVOLTAIK, "Positionspapier Bauwerkintegrierte Photovoltaik (BIPV)," Österreichische Techologieplattform PHOTOVOLTAIK, Wien, 2015.

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

[5] M. Hekkert, S. Negro, G. Heimeriks and R. Harmsen, Technological Innovation System Analysis: A manual for analysts, Utrecht: Utrecht University - Faculty of Geoscience, 2011.

[6] H. Hellsmark, A. Bergek, T. Hellström and U. Malmquist, Technological innovation systems within the energy sector: A practical guide to identifying system flaws that motivate specific political actions, Statens energimyndighet, ER 2014:23, 2014.

[7] T. Schostal, "A TIS analysis of BIPV in Austria concerning the functions entrepreneurial experimentation, knowledge development, knowledge dissemination and mobilisation of resources," UAS Technikum Wien, Vienna, 2021.

[8] A. Türk, "Innovation System Analysis over development of social capital, legitimation, guidance of the search, and market formation of Building Integrated Photovoltaics in Austria," UAS Technikum Wien, Vienna, 2021.

[9] M. van Noord, "Guide for Technological innovation System Analysis for Building-Integrated Photovoltaics," International Energy Agency - Photovoltaic Power Systems Programme, IEA-PVPS Task15, 2023.

[10] IEC International Electrotechnical Commission, "IEC International Electrotechnical Commission," 2020. [Online]. Available: https://www.iso.org/organization/70.html.

[11] Ertex Solartechnik GmbH, "Ertex-solar," 2022. [Online]. Available: https://www.ertex-solar.at/.

[12] Sonnenkraft GmbH, "Sonnenkraft," 2024. [Online]. Available: https://www.sonnenkraft.com/de/.

[13] MGT-esys GmbH, "MGT-esys," 2023. [Online]. Available: http://www.mgt-esys.at/. [Accessed 31 Jänner 2024].

[14] DAS Energy Ltd., "DAS Energy," 2024. [Online]. Available: https://das-energy.com/de/home. [Accessed 31 Jänner 2024].

[15] S. A. C. D. M. E. M. E. H. F. C. F. M. F. F. H. M. J.-F. K. L. D. M. S. M. E. P. R. S. S. C. S. C. S. P. W. E. W. P. Biermayr, Innovative Energietechnologien in Österreich Marktentwicklung 2023, Wien: Bundesministerium, 2024.

[16] H. Fechner, E. Sehnal, A. López-Polo und R. Haas, „Gebäudeintegrierte Photovoltaik Teil 1," Klima- und Energiefonds, Vienna, 2009.

[17] arconsol, "arconsol," 2021. [Online]. Available: https://arconsol.com/. [Accessed 31 Jänner 2024].

[18] Calma-Tec Lärmschutzsysteme, "calma-tec," 2024. [Online]. Available: http://www.calma-tec.com/. [Accessed 31 Jänner 2024].

[19] Reinhard Eder Blechbauges.m.b.H., "Eder Blechbau," 2024. [Online]. Available: https://www.eder-blechbau.at/. [Accessed 31 Jänner 2024].

[20] Fronius International GmbH, "Fronius," 2024. [Online]. Available: https://www.fronius.com/de-at/austria. [Accessed 31 Jänner 2024].

[21] Lenzing Plastics GmbH & Co KG, "Lenzing Plastics," 2024. [Online]. Available: https://www.lenzing-plastics.com/. [Accessed 31 Jänner 2024].

[22] Ulbrich Stainless Steels and Special Metals Inc., "Ulbrich," 2024. [Online]. Available: https://www.ulbrich.com/. [Accessed 31 Jänner 2024].

[23] voestalpine Stahl GmbH, "voestalpine," 2024. [Online]. Available: https://www.voestalpine.com/stahl/Gesellschaften/voestalpine-Stahl-GmbH. [Accessed 31 Jänner 2024].

[24] Welser Profile GmbH, "Welser," 2022. [Online]. Available: https://www.welser.com/. [Accessed 31 Jänner 2024].

[25] IEA PHOTOVOLTAIC POWER SYSTEM PROGRAMME, "IEA-PVPS," 2024. [Online]. Available: https://iea-pvps.org/research-tasks/enabling-framework-for-the-development-of-bipv/. [Accessed 31 Jänner 2024].

[26] AIT Austrian Institute of Technology GmbH, "AIT," 2024. [Online]. Available: https://www.ait.ac.at/. [Accessed 31 Jänner 2024].

[27] Technologie Plattform Photovoltaik, "TPPV," 2023. [Online]. Available: www.tppv.at. [Accessed 31 Jänner 2024].

[28] Bundesverband Photovoltaic Austria, "PV Austria," 2024. [Online]. Available: https://pvaustria.at/. [Accessed 31 Jänner 2024].

[29] Chancellery, Austrian Federal, "Bundeskanzeleramt," 2020. [Online]. Available: https://www.bundeskanzleramt.gv.at/themen/nachhaltige-entwicklung-agenda-2030.html. [Accessed 31 Jänner 2024].

[30] Nationalrat und Bundesrat , "Parlament," [Online]. Available: https://www.parlament.gv.at/. [Accessed 31 Jänner 2024].

[31] Photovoltaic Austria, "Normen für PV und Stromspeicher," URL: https://pvaustria.at/normen/ (accessed 19.04.2023), 2021.

[32] Stadt Wien | Geschäftsstelle Landtag, Gemeinderat, Landesregierung und Stadtsenat (Magistratsdirektion, "wien.gv.at," [Online]. Available: https://www.wien.gv.at/mdb/ltg/2020/. [Accessed 31 Jänner 2024].

[33] Österreichisches Institut für Bautechnik, "oib.or.at," [Online]. Available: https://www.oib.or.at/. [Accessed 31 Jänner 2024].

[34] G. M. A. N. S. S. G. Nina Hampl, "ErneuerbareEnergien inÖsterreich 2024-Der jährliche Stimmungsbarometer der österreichischen Bevölkerung zu erneuerbarenEnergien," Institut für Strategisches Management, Wirtschaftsuniversität Wien, Wien, 2024.

[35] ISO TS 18178 and the IEC 63092 series, "IEC," [Online]. Available: https://www.iec.ch/ords/f?p=103:14:1316849337697::::FSP_ORG_ID:27503. [Accessed 31 Jänner 2024].

[36] "BMK," Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (BMK), [Online]. Available: https://www.bmk.gv.at/themen/energie/energieversorgung/netzinfrastrukturplan.html. [Accessed 31 Jänner 2024].

[37] C. Reise and B. Farnung, "Uncertainties in PV System Yield Predictions and Assessments," Report IEA-PVPS T13-12, 2017.

[38] Institut für Produktions-, Energie-, und Umweltmanagement, Alpen-Adria-Universität Klagenfurt; Institut für strategisches Management, Wirtschaftsuniversität Wien; Deloitte Österreich und Wien Energie, "Erneuerbare Energien in Österreich. Der jährliche Stimmungsbarometer der österreichischen Bevölkerung," 2022.

[39] Austrian Power Grid (APG), "Netzentwicklungsplan 2020 für das österreichische Übertragungsnetz," 2020.

[40] Sunplugged GmbH, "Sunplugged," 2024. [Online]. Available: https://sunplugged.at/. [Accessed 31 Jänner 2024].

[41] eFriends Energy GmbH, "eFriends," [Online]. Available: https://www.efriends.at/. [Accessed 31 Jänner 2024].

[42] OurPower Energiegenossenschaft SCE mbH, "Ourpower," [Online]. Available: https://www.ourpower.coop/. [Accessed 2024 Jänner 2024].

[43] Österreichische Koordinationsstelle für Energiegemeinschaften, "Energiegemeinschaften," [Online]. Available: https://energiegemeinschaften.gv.at/. [Accessed 31 Jänner 2024].

APPENDIX A

Questionnaire

General/Introduction		
	1	Look at the value chain flow chart. Do you find anything important (actor group, organization) missing?
	2	Look at the BIPV applications. Do you find anything important missing? What development phase would you say BIPV and applications are in?
	3	How have you and your organizations worked with/for BIPV?
	4	Thoughts or targets on size of the BIPV-market?
	5	What would you say is/are the main hindrances for BIPV to reach the presented goal?
General questions		
	6	What is the scale of your business and where do you see it five years from now?
	7	If relevant, how would you describe your activities in entrepreneurship and/ or innovation (RE:BIPV)?
	8	What are the perceived risks related to BIPV, and what risk mitigation strategies are being used by you?
	9	Are there sufficient and suitable types of actors contributing to entrepreneurial experimentation? [If not: Which ones are missing?]
	10	From which sectors do the firms active in the BIPV sector originate (e.g. construction or PV sector)?
	11	How would you characterize construction projects in which BIPV is applied, pilot/demonstration projects or mature/fully commercial projects? [What type of project should be initiated more? Who should initiate and/or execute this type of project?]
	12	To what extent do BIPV firms align their products to other solutions used in the built environment? (compatibility, interfaces, software, etc.) [How could this be improved?]
	13	In your opinion, which type of BIPV (roof tiles, façade surfaces, sun protection, roofing, ...) has the greatest potential in Austria?
	14	What actions could entrepreneurs implement to further develop the BIPV market?
	15	What actions could entrepreneurs deploy in terms of business model development?
	16	Are BIPV products sufficiently standardized (for easy application/implementation)? [How could this be improved?]
Knowledge development		
University, research institutes		

	17	What main actors do you think are watching / driving so that the knowledge about BIPV increases / develops?
	18	Do you think the amount and quality of knowledge is appropriate and sufficient for further development of the BIPV sector? [Is knowledge lacking in certain areas, e.g. technical, institutional, market preferences…? Or among certain actors?]
Knowledge dissemination		
	19	Is there sufficient knowledge exchange between BIPV manufacturers and suppliers? [How could this be improved?]
	20	Describe the knowledge exchange between BIPV industry and actors in the construction sector. [Specific actors missing? Important knowledge missing?] And other adjacent industries (e.g. property owners, energy sector)? [How could this be improved?]
	21	Describe knowledge exchange across geographical borders that you engage in?
	22	Are there sufficient networks and/or connections between parties through which knowledge can be exchanged? [Which actors should be more connected? How/ where could this happen?]
	23	14. For innovation nerds:
	24	- Are there problematic parts of the innovation system in terms of knowledge exchange?
	25	- Is knowledge exchange forming a barrier for the IS to move to the next phase?
Resource mobilization		
	26	Are there sufficient financial resources available for the further development of the BIPV market? [How could this be improved?]
	27	Are there sufficient suitable and well-trained employees available to be able to develop and implement BIPV? [How could this be improved?]
	28	Is the physical infrastructure developed well enough to support further diffusion of technology (e.g. production capacity, test beds, or energy network)? [How could this be improved?]
	29	Are the required (primary) material resources available on a sufficient scale?
	30	Recycling
	31	Is there enough manufacturing capacity in your company to create a market expansion?
Development of social capital		
	32	How would you describe the general confidence and well-functioning cooperation between actors in the BIPV value chain? Who trusts (or does not trust) whom, and why?
	33	In order for an area to develop, it is important that you can have confidence in others. What does your confidence look like for other actors in the BIPV area?

	34	Would you say that a common understanding and language, mutual recognition etc exists in the business to a sufficient extent in order to facilitate collaboration? [If not-Explain deficiencies etc…]
Legitimation		
	35	Is there a conflict of interest between BAPV and BIPV?
	36	How much resistance is present towards the implementation of BIPV technologies during the initiation and execution of construction projects, i.e. negative talk, do construction projects take longer if BIPV is applied? [During what phase(s) of the project does it occur?]
	37	What positive attitudes towards BIPV are present?
	38	Do BIPV manufacturers and suppliers sufficiently contribute to the legitimacy of BIPV? E.g. by publishing finished projects and best-practices [How could this be improved?]
	39	Do formal and informal institutions sufficiently contribute to the legitimacy of BIPV? E.g. inclusion of BIPV-solutions in standards, guidelines; aesthetic guidelines? [How could this be improved?]
	40	How does this differ between different projects (e.g. new construction versus renovation projects, residential versus commercial buildings)? [How could this resistance be removed?]
	41	Considering that the photovoltaic amount of installed power will significantly increase during the next years, do you consider that BIPV is the best option or would you prefer the big PV increase? Do you see these PV plants increase as a threat for the landscape and the preservation of nature?
Guidance of the search		
	42	What are the visions and expectations of the industry (BIPV, construction) on how BIPV technologies should develop towards the future in terms of growth and technological design? Are the visions and expectations of the different actors within the industry sufficiently aligned? How does this compare to adjacent sectors (e.g. energy sector or the already established PV-business)? [How could this be improved?]
	43	What are the expectations on BIPV from the demand side?
	44	Are there any public policies on BIPV in [country] and if so what are the goals?
	45	Do the public policies of [country] offer sufficient direction and clarity about the future of BIPV and the application of BIPV in the built environment? [How could this be improved?]
	46	Do standards and product certification play a role for the BIPV development in [country]? [Is it mainly hampering or supporting the development? How could this be improved?]
	47	Do you think that the (National) building code includes or considers BIPV sufficiently? (Structure)
	48	Do you see the renovation support in Europe (and your country) as a good opportunity for the BIPV to grow? What do you miss?

General market formation		
	49	In what phase of development do you consider the BIPV market to be? (Explain: Nursing, bridging, mature)
	50	Do you consider BIPV in general, or in certain niches, to be commercially competitive?
	51	Can you describe the type of users ("user groups") your company addresses and their purchasing processes
	52	Is the current size of the BIPV market (financially) sufficient for firms to be able to continue to innovate/develop?
	53	What is your perspective on the future market of BIPV?
	54	What impedes upscaling of the BIPV market?
	55	Which buildings or projects are most suitable for upscaling the BIPV market (residential buildings, commercial/utility buildings, or public buildings)? How does this differ between new construction and renovation projects?
	56	Are there sufficient and suitable types of actors contributing to up-scaling?
	57	Do you think the current standards (i.e. EN 50583) are being taken into account for developing BIPV products? What standards do your products comply with?
Zusammenfassung		
	58	Of the previously mentioned barriers, what are the largest barriers that hamper further development and diffusion of BIPV technologies?
	59	What are the largest opportunities that could possibly foster further development and diffusion of BIPV technologies?
	60	Would you like to add anything that was not discussed during this interview?
	61	Could you suggest some people you consider important in the context discussed here, as potential interviewees?

APPENDIX B

Educational Institutes	Database	Search term	Date	1997	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total	Score
TU Vienna	Own Publication Database	BIPV, Gebäudeintegriert	08.07.2021	1	1	1			2	1	1	3	1				11	3,5
TU Graz	Own Publication Database	Building integrated photovoltaic, Gebäudeintegrierte Photovoltaik	08.07.2021				1	1	1	1	1	1	3	2		1	12	3,9
UAS Salzburg	Own Publication Database	Photovoltaik, Photovoltaic	08.07.2021									1	1				2	0,6
UAS Kufstein	Own Publication Database	Photovoltaik, Photovoltaic	08.07.2021														0	0,0
UAS Technikum Vienna	Researchgate	BIPV, Photovoltaic	13.07.2021									1					1	0,3
	Science Direct	Photovoltaic								1							1	0,3
Boku Vienna	Science Direct	Photovoltaic	13.07.2021							1							1	0,3
University Innsbruck	Science Direct	Photovoltaik, Photovoltaic	13.07.2021										1				1	0,3
UAS Upper Austria	Own Publication Database	BIPV	14.07.2021										1	1			2	0,6
Total																	**31**	**10,0**

Research Institutes	Database	Search term	Date	1997	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total	Score
AIT	Own Publication Database	BIPV	08.07.2021		1		1	1	3	2	7	5	3	1	2		26	9,0
Joanneum Research	Own Publication Database	Photovoltaik, Photovoltaic	08.07.2021									1					1	0,3
	Science Direct	Photovoltaic	13.07.2021														0	
PCCL	Own Publication Database	BIPV	08.07.2021														0	0,0
SAL	Science Direct	Photovoltaic	13.07.2021													1	1	0,3
OFI	Science Direct	Photovoltaic	13.07.2021									1					1	0,3
Total																	**29**	**10,0**

APPENDIX C

Results of the research on national and international research projects on BIPV done by universities and research institutes as well as the formation of the overall score (Authors Illustration in cooperation with (Türk, 2021)

Educational Institutes								
	Number of AUT Projects	Points AUT Projects	Number of EU-Projects	Points EU-Projects	Score Projects	Score Education	Score Publications	Overall Score
TU Vienna	2	3	2	4	7	0	3,5	10,5
TU Graz	1	1	0	0	1	0	3,9	4,9
UAS Salzburg	1	1	0	0	1	5	0,6	6,6
UAS Kufstein	0	0	0	0	0	5	0,0	5,0
UAS Technikum Vienna	2	4	0	0	4	5	0,3	9,3
BOKU Vienna	1	2	0	0	2	0	0,3	2,3
University Innsbruck	2	2	1	1	3	0	0,3	3,3
UAS OÖ	1	1	0	0	1	2,5	0,3	3,8
Sum	**10**	**14**	**3**	**5**	**19**	**17,5**	**9,4**	**45,9**
Research Institutes								
AIT	6	7	1	1	8	2,5	9,0	19,5
Joanneum Research	1	1	0	0	1	0	0,3	1,3
PCCL	0	0	0	0	0	0	0,0	0,0
SAL	0	0	0	0	0	0	0,0	0,0
OFI	1	1	0	0	1	0	0,3	1,3
Sum	**8**	**9**	**1**	**1**	**10**	**3**	**9,7**	**22,2**

APPENDIX D

No	Titel	Erfinder	Anmelder	Veröffentlichungsnummer
1	Roof anchor for collector elements	SEDELMAYER RAINER [AT] SEDELMAYER ROLAND [AT]	SEDELMAYER RAINER [AT] SEDELMAYER ROLAND [AT]	GB2432724A
2	INSULATING GLASS COMPOSITE COMPRISING DIAGONALLY ARRANGED PHOTOVOLTAIC CELLS, AND METHOD FOR THE PRODUCTION AND USE THEREOF	BATTISTUTTI RENE [AT]	BATTISTUTTI RENE [AT] ENERGETICA HOLDING GMBH [AT]	US2012118359A1
4	SOLARMODUL UND COEXTRUDATKÖRPER	MIKATS GUENTHER [AT]	ISOVOLTAIC AG [AT]	EP2507057A1 EP2507057B1
5	Device for fixing a glass panel to a support at the side of a building	ELMER HUBERT [AT] ELMER HUBER [DE]	DORMA GMBH & CO KG [AT] DORMA GMBH & CO KG [DE]	CN1133790C CN1266469A

6	GLASMODUL, GEBÄUDE MIT ZUMINDEST EINEM GLASMODUL SOWIE VERFAHREN ZUR HERSTELLUNG EINES GLASMODULS	HÖLLWART HANS [AT] MÜLLER MARIO J [AT]	SFL TECH GMBH [AT]	EP3214630A1
7	Befestigungssystem für ein plattenförmiges Bauelement auf einem Schrägdach		GREEN ONE TEC SOLAR IND GES M [AT] RWE SCHOTT SOLAR GMBH [DE]	DE20303431U1
8	BEFESTIGUNGSSYSTEM FÜR EIN PHOTOVOLTAIK-MODUL	STOJEC MARIO PAUL [AT]	STOJEC MARIO PAUL [AT]	AT506676A1 AT506676B1
9	EINRICHTUNG ZUR BEFESTIGUNG VON SOLARMODULEN AN BEFESTIGUNGSPROFILEN	BUECHELE PETER [AT]	BUECHELE MICHAEL [AT]	AT412909B ATA14622003A
10	AUFSATZELEMENT FÜR LÄRMSCHUTZWAND	KERSCHBAUMER PETER [AT]	BWR BETONWERK RIEDER GMBH & CO KG [AT]	EP4053341A1
11	Fensterprofil mit Solar-Element	SEIBT CHRISTIAN ING [AT]	IFN HOLDING AG [AT]	EP1703063A1 EP1703063B1
12	Gebäudebauelement mit Photovoltaikfunktionalität sowie Verfahren zum Herstellen eines Gebäudebauelements mit Photovoltaikfunktionalität	STÖLLINGER JOHANNES [AT] WAMBUA JOHN [AT]	STÖLLINGER JOHANNES [AT] WAMBUA JOHN [AT]	DE102014106964A1
14	Vorrichtung zur Befestigung von Solarmodulen auf der Unterkonstruktion einer Dacheindeckung		SIKO SOLAR GMBH [AT]	DE202011101279U1
15	Dach mit einer Photovoltaikanlage		HAUSRUCK DACH GMBH [AT]	AT514315A4 AT514315B1

16	EINFASSUNG ALS BAUSATZ ZUM EINBAU VON SOLARMODULEN ODER DERGLEICHEN IN STEILDÄCHER		BLECHCT HANDELSGESELLSCHAFT M [AT]	AT6164U1
17	VERFAHREN ZUR HERSTELLUNG WITTERUNGSBESTÄNDIGER LAMINATE FÜR DIE EINKAPSELUNG VON SOLARZELLENSYSTEMEN	DEPINE NICOLE [AT] DANILKO JOACHIM [AT]	ISOVOLTA [AT]	EP1904300A1
18	Indachsystem für Solarmodule	GNADENBERGER HARALD [AT] SCHACHINGER HARALD [AT] AIGNER KURT [AT]	WELSER PROFILE AUSTRIA GMBH [AT]	DE102012011529A1
19	SOLAR-MODUL IN EINEM ISOLIERGLASVERBUND UND VERFAHREN ZUR HERSTELLUNG UND ANWENDUNG	BATTISTUTTI RENE [AT] KURNIK SASO [SI]	ENERGETICA HOLDING GMBH [AT] BATTISTUTTI RENE [AT] KURNIK SASO [SI]	WO2010079135A2 WO2010079135A3
20	DACHBESCHICHTUNG ZUR VERSIEGELUNG UND STROMERZEUGUNG	HERBST MARTIN [AT]	HERBST MARTIN [AT]	EP3418467A1
21	PHOTOVOLTAIC MODULE COMPRISING INSULATION LAYER WITH SILANE GROUPS	SULTAN BERNT AKE [SE] WAHNER UDO [AT]	BOREALIS AG [AT]	KR101217028B1 KR20110030459A

22	ENERGIE-SCHALE SOWIE HIERMIT AUSGESTATTETES GEBÄUDE	HAMPEL MANFRED [DE]	INSTITUT FUER NACHHALTIGKEIT FOERDERVEREIN FUER WEITERBILDUNG WSS UND FORSCHUNG FUER KREATIVE NACHHA [AT]	WO2021140244A1
23	Photovoltaikmodul		ANKER JOHANNES [AT] MINTSCHEFF ILIAN [AT] SUNPLUGED GMBH [AT] WALTER KURT [AT]	DE202007017775U1
24	GEBÄUDE		WOLF MODUL GMBH [AT]	AT508643A1 AT508643B1
25	Multifunktionales Fassadenmodulsystem	MÜLLER MARIO [AT] WASCHER HEINZ [AT] KERNLER UWE [AT] BRAUN REISNER [AT] SIEGEL GEORG [AT] GOSZTONYI SUSANNE [AT] MACH THOMAS [AT] STREICHER WOLFGANG [AT] MOßHAMMER FRIEDRICH [AT] MICHAEL GROBBAUER [AT] MARCUS RENNHOFER [AT] KARL BERGER [AT]	HANS HÖLLWAR - FORSCHUNGSZENTRUM FÜR INTEGRALES BAUWESEN AG [AT] TECHNISCHE UNIVERSITÄT GRAZ [AT] AIT AUSTRIAN INSTITUTE OF TECNOLOGOY GMBH [AT]	AT513265B1

26	Photovoltaic window and / or facade element	MICHAEL GROBBAUER [AT] MARCUS RENNHOFER [AT] KARL BERGER [AT]	ÖSTERREICHISCHES FORSCHUNGS- UND PRÜFZENTRUM ARSENAL GESELLSCHAFT M.B.H. [AT]	
				AT512578A1
27	Method for producing structured thin-layer photovoltaics	MICHAEL GROBBAUER [AT] MARCUS RENNHOFER [AT] KARL BERGER [AT]	AIT AUSTRIAN INSTITUTE OF TECNOLOGOY GMBH [AT]	
				WO2013142891A3

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