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International Energy Agency
Photovoltaic Power Systems Programme

Task 15 Enabling Framework for the Development of BIPV

PVPS

BIPV: Education and Training Activities for Solar Architecture

2026

Report IEA-PVPS T15-25:2026

What is IEA PVPS TCP?

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

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

The IEA PVPS participating countries are Australia, Austria, Belgium, Canada, China, Denmark, Finland, France, Germany, India, Israel, Italy, Japan, Korea, Lithuania, Malaysia, Morocco, the Netherlands, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, Thailand, Türkiye, the United Kingdom and the United States of America. The European Commission, Solar Power Europe and the Solar Energy Research Institute of Singapore are also members.

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What is IEA PVPS Task 15?

The objective of Task 15 of the IEA Photovoltaic Power Systems Programme is to create an enabling framework to accelerate the penetration of Building-Integrated Photovoltaics (BIPV) products in the global market of renewables, resulting in an equal playing field for BIPV products, Building-Applied Photovoltaics (BAPV) products and regular building envelope components, respecting especially economic, technological, legal, aesthetic, reliability and normative issues.

SUGGESTED CITATION

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COVER PICTURE

Field visit to a solar building during the advanced training "Solarchitecture Essentials" in Ticino, Switzerland (photo: SUPSI).

INTERNATIONAL ENERGY AGENCY
PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

BIPV:
Education and Training Activities for Solar Architecture

IEA PVPS Task 15
Enabling Framework for the Development of BIPV

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LIST OF ABBREVIATIONS

ACE	Architects' Council of Europe
BAPV	Building-Applied Photovoltaics
BEM	Building Energy Modelling
BIM	Building Information Modelling
BIPV	Building-Integrated Photovoltaics
CAS	Certificate of Advanced Studies
CEC	Continuing Education Credits
CPD	Continuous Professional Development
DAS	Diploma of Advanced Studies
ECTS	European Credit Transfer and Accumulation System
EAAE	European Association for Architectural Education
IEA	International Energy Agency
IEA PVPS	IEA Photovoltaic Power Systems Programme
MAS	Master of Advanced Studies
OECD	Organisation for Economic Cooperation and Development
PG	Postgraduate
PPD	Postgraduate Professional Development
PV	Photovoltaics
TCP	Technology Collaboration Programme

GLOSSARY

Bachelor's degree	Undergraduate academic qualification.
Master's degree	Graduate academic qualification.
Executive master's degree	Specialised postgraduate academic qualification.
Continuing education credits	A unit of measurement awarded for completing accredited continuing education programs, often used to fulfil professional certification or licensure requirements.
Short-term specific training	Focused, time-limited training programs designed to teach specific skills or knowledge in a particular area.
Extended specific training	Specialised training program lasting more than one week.
Hybrid learning	Educational format/model where lectures can be taken in-person or online
Seminar	Educational event where experts share knowledge or insights on a specific topic, typically with limited audience interaction through Q&A sessions.
Workshop	An interactive, hands-on event focused on skill building or problem-solving, where participants actively engage in activities and discussions.

EXECUTIVE SUMMARY

The integration of BIPV into the construction sector represents a significant yet underutilised opportunity for advancing sustainable energy in the built environment. Despite a broad range of over 80 BIPV products available in the European market [1,2], currently BIPV accounts for only 1%–3% of the PV market both in the European Union (EU) and globally. This suboptimal performance is largely due to persistent structural barriers—such as fragmentation between the solar and construction industries, regulatory uncertainty, and a lack of integrated skills and trained workforce—which have hindered investor confidence and slowed market uptake. Aside from a few countries which stand out with pilot projects and a growing market, this trend remains an exception; similar challenges are observed across the EU, USA, India, and other countries, where BIPV remains a very niche market.

In response, Sub-Task E of Phase 3 of IEA PVPS Task 15 focuses on overcoming these barriers by fostering a perspective on the interdisciplinary collaboration, integrated value chains, and development of a qualified workforce. The sub-task builds on insights from Phase 2, which identified insufficient knowledge exchange and weak networks between the solar and building sectors, along with a critical shortage of trained professionals [3].

Sub-Task E investigates key challenges in the BIPV sector, including knowledge gaps and workforce shortages across market segments. It explores strategies for integrated knowledge, upskilling, retraining, and attracting professionals, promotes cross-sectoral synergies with construction and electrical sectors, and supports the development of targeted training and educational materials for solar architecture.

Initial outputs in this report include a comprehensive first review of existing BIPV education and training offers worldwide, highlighting major topics and approaches currently adopted in knowledge transfer and the mapping of available professional training activities across different countries as a basis to reflect on the need for better-aligned and structured education and training. These efforts lay the foundation for actionable strategies to address eventual skill gaps and especially to promote a more integrated, diffused and dynamic BIPV ecosystem to support the broader strategy of workforce development and market transformation.

1 INTRODUCTION AND REFERENCE FRAMEWORK

In the global transition toward renewable energy and sustainable development, the built environment plays a central role. Among the emerging solutions, Building-Integrated Photovoltaics (BIPV) stands out not only as a clean energy technology but also as an architectural opportunity merging functionality with aesthetics, energy generation with design. To realise the full potential of BIPV, a well-prepared, interdisciplinary workforce is essential. This report aims to investigate the current state of education and training activities in the fields of solar energy and architecture, with a focus on developing the skills necessary to integrate BIPV into mainstream architectural practice for the design and engineering of BIPV solutions.

At present, education and training systems are struggling to keep pace with the growing demand for expertise in sustainable architecture, particularly in integrating solar solutions such as BIPV. Both the solar and construction sectors are expanding rapidly, yet workforce development and skill readiness remain key bottlenecks. Addressing these issues requires a coordinated and forward-thinking approach that encompasses academic institutions, industry, public authorities, and professional organisations.

Understanding the current dynamics of education and training in solar and architecture is vital to identifying existing gaps and potential pathways for improvement. Education in architecture and in the building, domain is not only a technical necessity; it is a driver of cultural and systemic transformation. The integration of solar technologies into the built environment demands an evolution in both architectural curricula and vocational training models. Skills development becomes the foundation for innovation, professional mobility, and long-term impact in sustainable construction. The solar sector is poised to become a cornerstone of global power generation, with the built environment offering immense potential for PV deployment. However, this opportunity is accompanied by significant workforce challenges. For instance, recent EU Solar Jobs Reports [4] underline how the lack of qualified professionals across multiple disciplines—including engineering, design, installation, and planning—is slowing progress toward renewable energy targets. These challenges are not exclusive to Europe: countries such as the US, India, and others face similar hurdles in aligning labour force capabilities with national solar ambitions.

Bridging these gaps requires not just technical training, but a shift in educational philosophy, embedding solar buildings literacy and environmental design into all levels of learning and professional development. While the demand for green-collar jobs continues to rise, the precise nature of workforce shortages remains difficult to assess. Reports highlight the importance of national skills assessments and stronger data collection, as well as collaboration between governments and the private sector. These insights call for targeted actions, including curriculum updates, qualification recognition frameworks, and incentives for lifelong learning to ensure that the renewable energy transition is not stalled by human capital constraints. Architects and urban planners play a pivotal role in shaping energy-positive environments. Institutions such as the Architects' Council of Europe (ACE) [5] and the European Association for Architectural Education (EAAE) [6] have emphasised the need to elevate architectural education, ensuring it is aligned with sustainability goals. Their initiatives advocate for comprehensive academic programs, practical experience, cross-border recognition of qualifications, and the systematic promotion of Continuous Professional Development (CPD). CPD is not only vital for adapting to new construction methods and materials but is also crucial in enabling architects to remain agile in an increasingly complex regulatory, environmental, and technological landscape. This imperative for upskilling applies equally across continents, where similar frameworks are emerging to address the evolving role of architects in the green transition.

Equally important is the role of research and innovation in advancing architectural practice. Collaboration between academia, practitioners, and public authorities enables the exchange of knowledge and supports the creation of sustainable, high-performance buildings. Research partnerships generate new methodologies, support design experimentation, and facilitate the adoption of emerging technologies such as BIPV. Governments and institutions can further support these processes by promoting education, research, and public awareness, fostering ecosystems where architectural innovation can thrive.

Looking ahead, it is critical that national and international actors align their efforts to prepare professionals for the challenges of solar architecture. Public campaigns and educational reforms are necessary to promote the value of green-collar jobs and attract new talent to the field. Platforms like IEA facilitate cross-border collaboration and knowledge exchange, but local and national institutions must play a decisive role in implementing change on the ground. At the heart of this shift is a growing recognition of PV not just as an energy source, but also as an integrated component of architecture. The widespread adoption of BIPV will require not only technology and investment, but also a generation of skilled professionals to lead the way.

This report begins by mapping the current educational and training landscape for BIPV across countries, identifying existing initiatives, revealing critical gaps, and proposing pathways for strategic improvement. The analysis starts with a country-by-country overview of available courses, thanks to the experts' network and first research, highlighting their geographic distribution and identifying regions with more developed or emerging BIPV educational offerings. It then explores the characteristics of these courses in more detail, including their target audiences and the learning formats adopted. At this stage, no references have been included to parallel initiatives promoted by industries or specific for installers, which often play a significant role in knowledge transfer to professionals. The methodological approach, therefore, focuses on recognised advanced studies or training programs, since this represents a first mapping of the current context.

Subsequent sections examine how these training programs are structured in terms of duration and academic level, and how well they align with the qualification requirements and roles of their intended participants. This includes an analysis of the professional roles across different academic levels, the relation between learning formats and course content, and assessing how various modules are delivered in practice.

Finally, a dedicated section presents selected best-case examples of training programs, offering a deeper look into course content, structure, and delivery methods. Altogether, the report serves as a foundational resource to understand where the sector stands in terms of education and training, and where it needs to go to support the growing role of BIPV in sustainable architecture.

2 EDUCATION AND TRAINING IN BIPV: DATABASE DEFINITION

2.1 Introduction

The objective of this report is to provide a first structured and comparative overview of academic and professional courses related to BIPV technology on a global scale. It has been developed to collect, organise, and compare key information on training programs, supporting the identification of emerging educational trends and offering a structured resource in the field of training and technological development. The categories included in the database have been selected to enable a consistent evaluation of courses, taking into account variables such as academic level (undergraduate, graduate, professional), learning format (in-person, online, hybrid), duration, course content, and accreditations. Where available, details on expected learning outcomes, teaching goals, and prerequisites are also included, providing a standardised framework for comparison.

It is important to underline that the course mapping presented in this study should be considered a preliminary observation. It draws primarily on Task 15 expert collaboration, professional networks, and shared knowledge, rather than on an in-depth full market investigation. Furthermore, no quality assurance of the individual educational offers is provided by Task 15. The database should therefore be seen as a starting point to better understanding and expanding educational opportunities in the BIPV sector—particularly within architecture and building—while also supporting the development and refinement of training programs that can address the evolving needs of this pedagogical, educational and technological field.

2.2 Methodology

The data for this database were collected, thanks to experts' collaboration and analysis, from a wide range of institutions, including academic organisations, professional bodies, and industry experts, ensuring a comprehensive representation of BIPV-related training programs worldwide. The data were initially gathered through various channels, such as publicly available course catalogues, institutional websites, and direct collaborations with the institutions offering the courses. The data collection refers to courses that were active and running at the time of the report preparation. Although no fixed temporal window was defined, only training programs confirmed as currently delivered at the date of the report were included in the database. Once collected, the data were uploaded into the database, where they underwent a thorough analysis and validation process conducted by the university.

Thanks to a comprehensive data collection effort, this report is grounded in a curated database of 32 training courses spanning 14 countries. The dataset reflects a wide international spectrum of initiatives dedicated to education and upskilling in the field of BIPV and solar architecture. The database captures a broad range of course types, ranging from undergraduate and graduate academic programs to professional short-term and extended training offerings. It encompasses essential attributes such as academic level, target audience, learning format, course duration, credit/certification structure, costs, key topics, teaching goals, expected learning outcomes, and accreditation. This multidimensional dataset offers a unique lens through which to understand the global landscape of solar architecture education and provides a foundation for cross-country comparison and identification of best practices.

The diversity of learning formats—spanning in-person, online, and hybrid modalities—highlights the variety of pedagogical approaches in use. Moreover, the data reveal efforts to target different stakeholder groups, including students, architects, engineers, planners, developers, and consultants, reflecting the interdisciplinary nature of BIPV as a field at the intersection of energy and design. This international scope and structured richness make the database a valuable resource for mapping educational trends, identifying gaps, and supporting the strategic development of future BIPV training pathways.

The structure of the database is organised into five macro-categories, which encompass the key variables relevant to the BIPV courses (**Figure 1**). These categories were selected to allow for an in-depth evaluation of the courses and their characteristics. The following sections provide a detailed breakdown of each category, highlighting the criteria used for data classification and the rationale behind their inclusion.

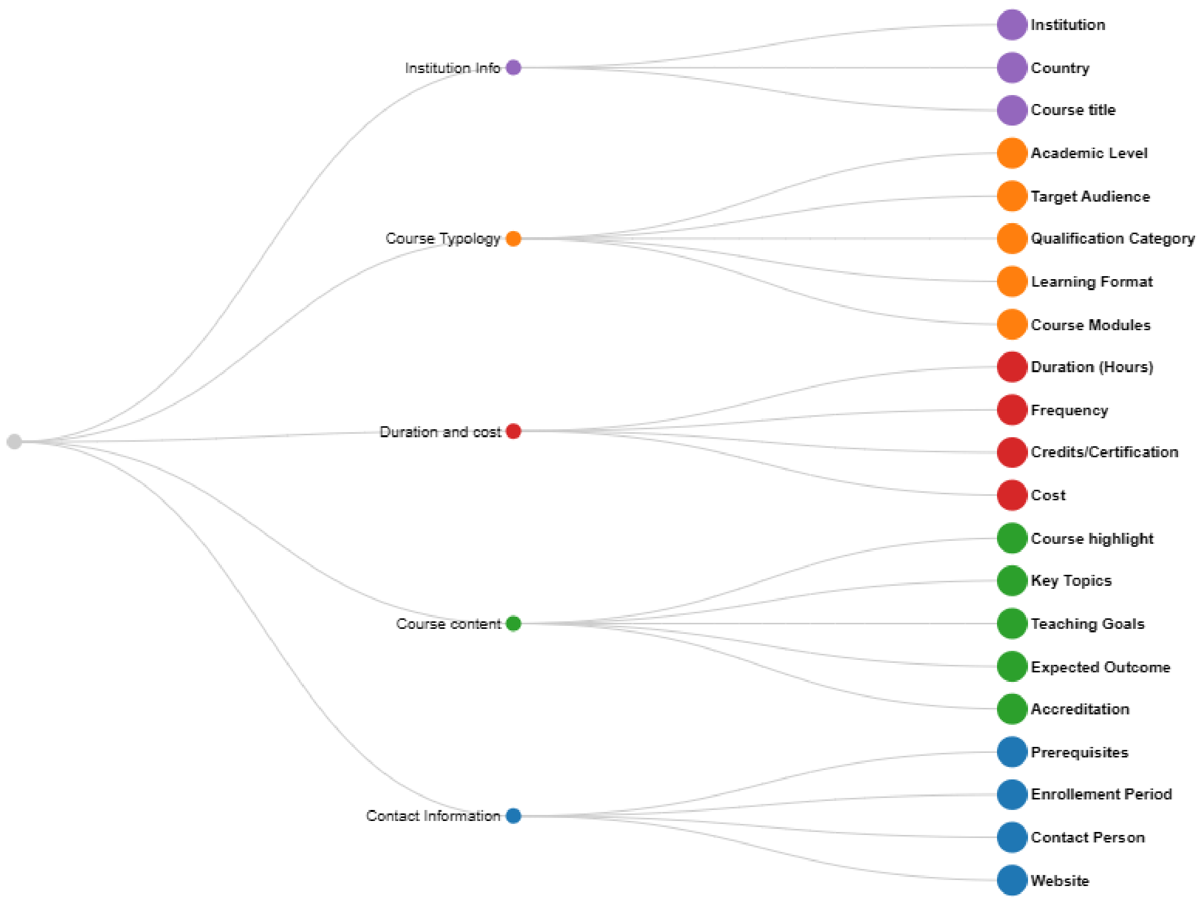

Figure 1: *Structure and hierarchy of the database.*

2.2.1 Institution info

In this category, the following details about the institution teaching the course are collected:

- Institution: The name of the institution offering the course.
- Country: The country where the course is delivered.
- Course title: The title of the course being offered.

2.2.2 Course typology

This category pertains to the general classification of courses based on their nature and educational objectives. It provides insight into the type of educational pathway offered, whether academic or professional, and how it aligns with the learning needs of participants.

- Academic level: Defines the depth and specialisation of the course, divided into three main categories: undergraduate, graduate, and professional. Undergraduate programs correspond to the bachelor's level and provide foundational academic knowledge; graduate programs refer to post-bachelor's education, typically at the master's level or immediately beyond, offering advanced specialisation and research-oriented skills; and professional courses are designed for individuals already active in the sector who wish to update or expand their practical competencies in response to evolving industry needs.
- Qualification category: Describes the type of qualification awarded upon completion of the course, ranging from bachelor’s or master’s degrees to post-graduate certifications or professional qualifications. They can be academic or professional, such as CEC, which are commonly offered in short-term specific training and extended specific training programs.
- Target audience: Specifies the groups for whom the course is designed. It includes students seeking to acquire new skills or professionals aiming to enhance their abilities and expertise.
- Learning format: Describes the delivery mode of the course. Courses may be delivered in-person, where students participate in physical lectures, online, offering remote learning opportunities, or in hybrid formats, combining in-person and online components, providing flexibility to accommodate diverse learning needs.
- Course modules: Each course is structured into modules that focus on specific topics. These may include lectures, workshops, site visits, online lectures, or interactive modules, offering a diverse range of learning experiences tailored to the course's objectives.

2.2.3 Duration and cost

Duration and cost include details about the course frequency and financial aspects:

- Duration (hours): Specifies the total hours required to complete the course, indicating its intensity. To ensure consistency, all durations were taken from available data or estimated using 25 hours per ECTS, following the European standard for workload calculation.
- Frequency: Describes how often the course is offered, such as weekly, monthly, or annually.
- Credits/Certification: describes the types of recognition awarded upon course completion. Credits may be issued as ECTS or CEC. Certifications are typically

completion certificates, which may be accredited by various organisations, depending on the course and its provider.
- Cost: Provides information on course fees and any additional costs involved (as of 2025).

2.2.4 Course content

The course content category outlines the core elements of the course, providing a comprehensive overview of what participants will learn, achieve, and earn upon successful completion. It includes:

- Course highlight: Key aspects or unique features of the course, such as hands-on experiences or guest speakers.
- Key topics: The main subject areas covered, such as photovoltaic technologies, energy efficiency, and integration in building systems.
- Teaching goals: The objectives the course aims to achieve, such as skill development or critical thinking.
- Expected outcome: The competencies or skills students should gain by the end, such as proficiency in BIPV design or energy analysis.
- Accreditation: Official recognition of the course by relevant bodies, like academic degrees or professional certifications.

2.2.5 Contact information

This category provides essential details for prospective students and professionals to engage with the course provider. It includes:

- Prerequisites: Specifies any prior knowledge or qualifications required to enrol in the course.
- Enrollment period: Indicates the timeframe during which students can apply or register for the course.
- Contact person: The name and contact details of a person who can provide additional information or assistance regarding the course.
- Website: The course or institution's website for further details and online registration.

3 BIPV COURSES: RESULTS AND ANALYSIS

This chapter presents a structured overview of current educational and training programs related to BIPV and solar architecture. The data collected represents a snapshot of existing course offerings, rather than an assessment of the relative importance or impact of professional roles. Therefore, the analysis does not imply a ranking or prioritisation of professions nor course offers, but rather reflects the availability of training opportunities as they exist today. Indirectly, this may hint at varying degrees of engagement or interest among different sectors, though such conclusions should be drawn with caution. Furthermore, it is important to note that the analysis is based on a limited dataset of courses and should be interpreted as an indicative rather than exhaustive representation of the broader educational potential.

The course mapping reveals a diversity of formats, target audiences, and durations, with a notable focus on the professional upskilling of architects and engineers. Many programs offer short-term, specialised training designed for rapid skill acquisition, while others integrate BIPV topics into longer academic curricula. This reflects a growing recognition of BIPV’s strategic role in the transition to sustainable construction and renewable energy integration.

Several countries offer courses spanning both the academic and professional spheres, demonstrating a balanced educational approach that supports both foundational learning and continuing education. Others adopt more targeted strategies, such as short-term courses tailored to industry professionals or intensive academic modules for students in architecture and engineering.

The target audience analysis indicates a predominance of professionals, particularly architects and engineers, though students also represent a substantial share. Other roles, including entrepreneurs, consulting firms, and contractors, are present but less represented, suggesting potential opportunities for expanding training efforts to these groups. Additionally, learning formats vary, with a clear emphasis on in-person instruction, workshops, and site visits, highlighting the importance of experiential and applied learning in the field of BIPV.

In summary, this chapter offers a multi-dimensional view of current solar architecture training practices, emphasising both the diversity and limitations of the current landscape. While the findings reflect encouraging developments in interdisciplinary and applied education, they also suggest growth opportunities, particularly in reaching underrepresented target groups and in expanding flexible learning formats that can adapt to the evolving needs of the construction and energy sectors.

The analysis uses heatmaps and linear dendrograms to analyse and present data on BIPV training courses. These visualisation techniques simplify the interpretation of complex datasets, offering a clearer understanding of key trends and relationships. Heatmaps were applied to display the intensity and distribution of variables such as course duration and learning format. This approach highlights patterns and clusters within the data. Linear dendrograms were used to classify and compare elements such as professional roles, academic levels, and course modules. These graphs provide a hierarchical view, emphasising proportional representation and connections between categories. These methods ensure the data are presented in a clear and accessible format, supporting meaningful insights into BIPV education.

Figure 2*: SolarchitecTOUR organised during the WCPEC 2022 by SUPSI in collaboration with ETAFlorence and supported by ENEA, Sunage, and Onyx Solar, a solar building tour in Milan (photo: ETA Florence).*

3.1 Overview of course distribution by country

The international mapping of educational initiatives in solar architecture highlights a wide geographical distribution of programs, demonstrating global engagement advancing sustainable design and photovoltaic integration in the building environment (**Figure 3**). Based on the current dataset, training opportunities have been identified in Australia (1), Austria (5), Denmark (2), Germany (2), India (3), Norway (2), Singapore (1), South Korea (1), Spain (2), Switzerland (7), and the United States (3), as well as through international (4) or cross-regional platforms involving countries in South America (2).

Each of these countries contributes to the overall landscape with a variable number of courses, developed and implemented by academic institutions, professional bodies, or interdisciplinary platforms. The presence and distribution of these programs reflect broader national and regional efforts to promote knowledge in solar architecture, support innovation in the building sector, and respond to global sustainability goals.

The inclusion of transnational programs, such as those categorised under "International" or jointly offered across regions like the USA and South America, emphasises the growing role of cross-border educational cooperation and knowledge exchange.

Overall, this mapping outlines an evolving educational framework, marked by regional specificities and a shared commitment to advancing the role of solar strategies in architecture and construction practices worldwide.

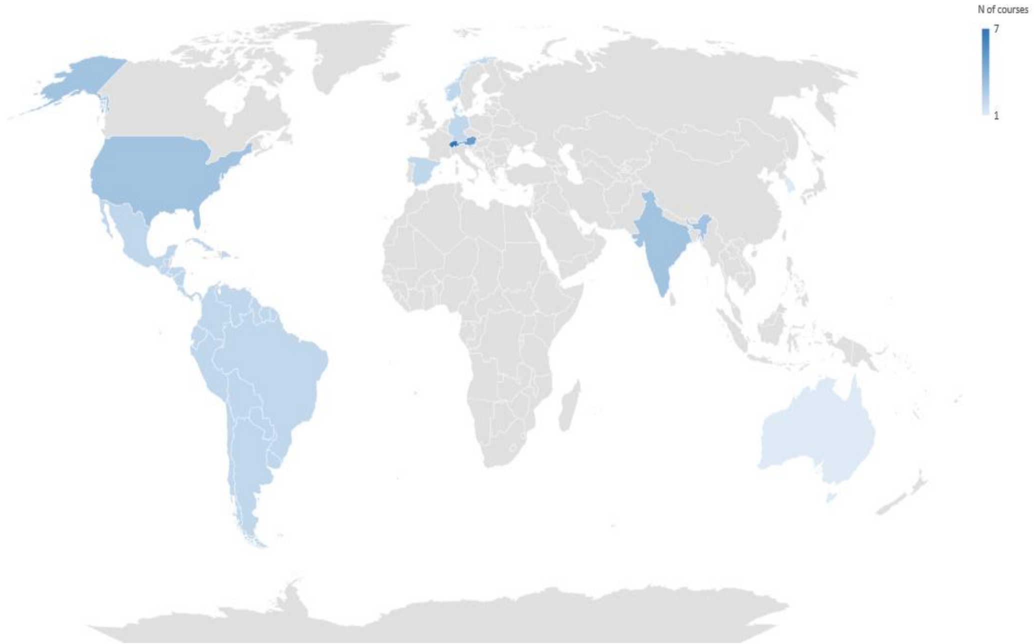

Figure 3*: Geographical distribution of identified courses in solar architecture, using a blue gradient to reflect the density of reports in each country. Darker tones indicate greater educational activity in the field.*

3.2 Course duration by country

The heatmap (**Figure 4**) provides a clear overview of the variation in course durations and academic levels across different countries in solar architecture education. Professional training stands out, with a significant number of short-term, focused modules offered globally. These range from as little as 3-8 hours in Austrian and Swiss offerings to more extended programs like Switzerland's 300-hour professional courses, reflecting the global demand for continuous skill development in solar architecture. The average duration of professional courses is approximately 54 hours. Countries including the USA (40–60 hours) and Singapore (19 hours) fall within or close to this range, reflecting a shared emphasis on modular, skills-based learning for practitioners.

Graduate programs also show considerable variations, with some countries, such as Australia, offering brief but focused 16-hour seminars, while others, for example, South Korea, provide more comprehensive 300-hour courses. However, many countries offer durations near the average of 101 hours, such as Austria (100 hours), Germany (125 hours), Denmark (62.5–125 hours), and India (50 hours). These values suggest that graduate education often balances between accessibility and advanced specialisation, with an orientation toward deeper technical and research-based competencies.

Undergraduate courses, typically more extensive, show a broader spectrum of duration, as seen in Austria (150 hours) and Norway (187.5 hours), focusing on fundamental knowledge in photovoltaic integration and energy-efficient design.

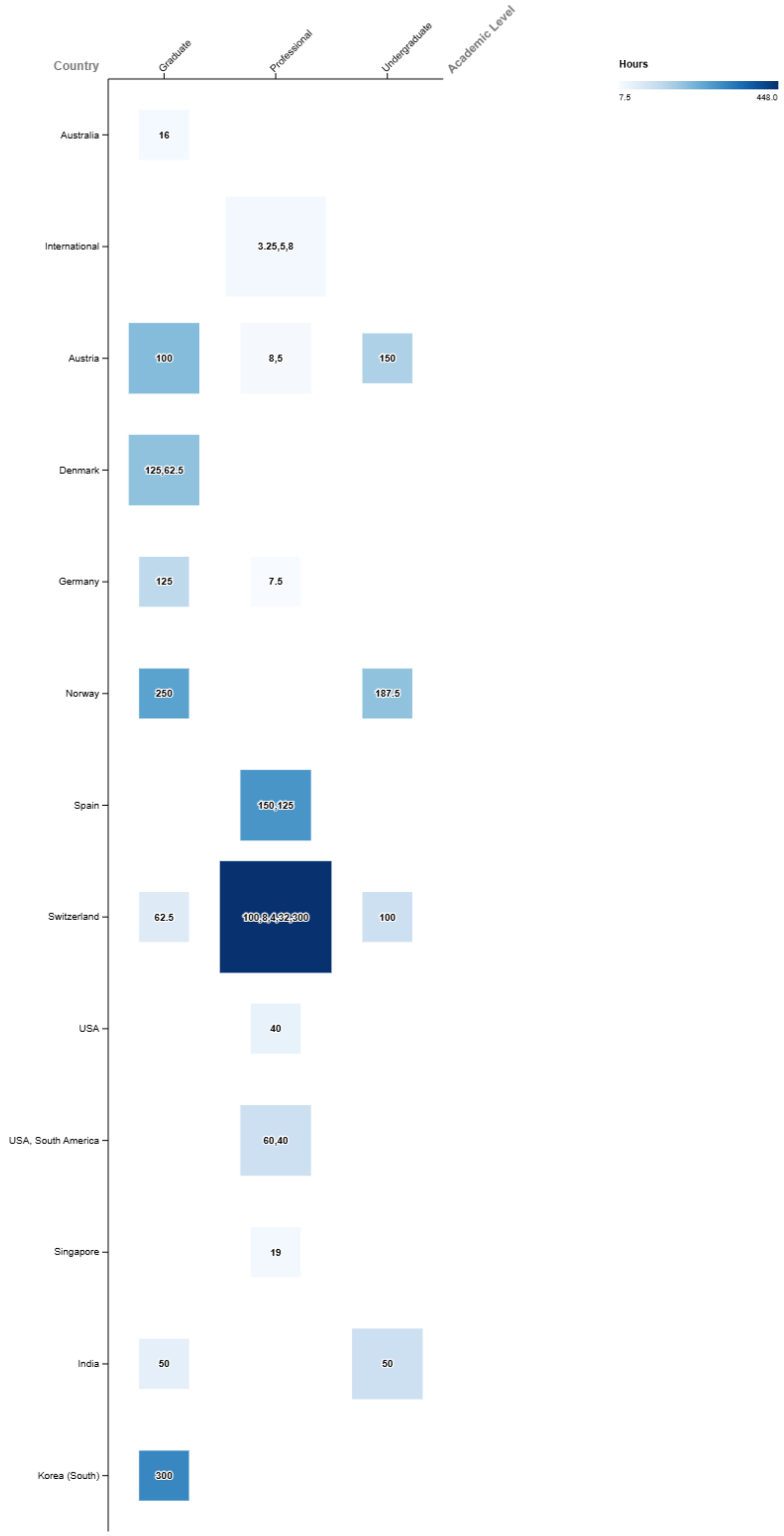

Figure 4: *Heatmap showing countries (vertical axis) versus academic level (horizontal axis). Course duration is visually represented by the colourmap intensity, while the number of courses is visualised by square size (1–5). Numeric labels within each square indicate the corresponding duration in hours for the mapped courses.*

The data also reveal an interesting trend in countries such as Denmark, Germany, and Switzerland, where a blend of academic and professional training is offered, often with programs lasting between 50 and 125 hours. This balance reflects the recognition of the need to combine foundational education with real-world professional experience in solar architecture.

Overall, this international overview illustrates a dynamic and expanding educational landscape. The variety of formats, durations, and target audiences reflects a shared recognition of the strategic role that education plays in advancing solar architecture. These initiatives contribute to building a skilled workforce, supporting innovation, and fostering a broader cultural shift toward the integration of photovoltaic technologies in the built environment.

It would be relevant to assess whether countries offering more training opportunities also show higher levels of BIPV implementation. However, a direct correlation cannot yet be established, as this analysis focuses solely on educational provision and does not include market data. Qualitative feedback from courses such as Solarchitecture Essentials nevertheless suggests practical impact: trainers reported the launch of new projects and strengthened collaboration between participants (e.g., industries and architects) following course completion. While not statistically verifiable, these indicate that training can act as a catalyst for implementation.

3.3 Course distribution by duration and academic level

The violin plot (**Figure 5**) comparing course durations between academic and professional formats displays how solar architecture education is structured globally. The two educational tracks reflect distinct goals: professional training is designed for rapid, targeted skill acquisition, while academic education aims to provide a more comprehensive and research-oriented foundation. This differentiation mirrors the broader needs of the solar architecture field, which requires both immediate technical competencies for practitioners and long-term theoretical and interdisciplinary understanding for future innovation.

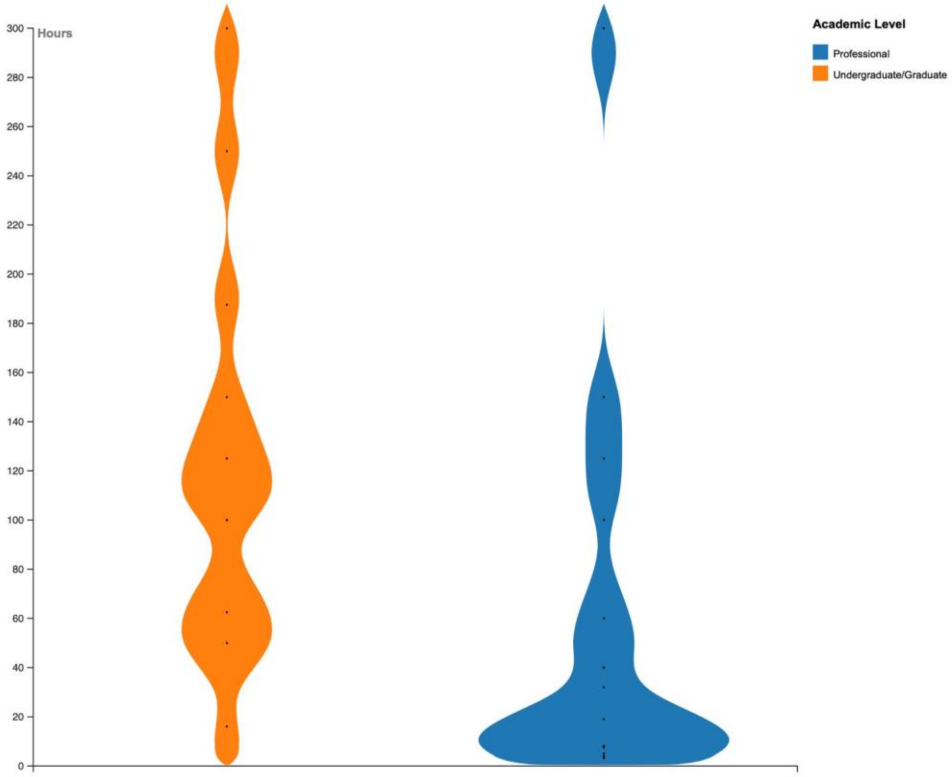

Figure 5*: Violin plot illustrating the distribution and density of course durations (vertical axis) for two distinct academic levels (horizontal axis): professional training (blue) and combined undergraduate/graduate courses (orange).*

Academic programs comprising both undergraduate and graduate levels show considerable variability in duration, with an average of 115 hours and a standard deviation of 79.2 hours. Their distribution is clustered around longer durations, with a distribution centred between 40 and 70 hours, or 100 and 150 hours, and outliers extending from brief seminars (16 hours) to full-term curricula (300 hours). In contrast, professional courses exhibit a shorter mean duration of 51 hours, yet a similarly high standard deviation of 76.6 hours. Most of these offerings are concentrated below 40 hours, with several examples under 10 hours, but some extend up to 300 hours, blurring the line between continuing education and formal academic instruction. This wide dispersion underscores the modular and flexible nature of professional training, tailored to diverse learners' needs, while also revealing how both formats increasingly overlap in terms of duration and content.

Understanding how course duration correlates with the type of qualification awarded offers deeper insight into the educational architecture of solar design programs worldwide. Unlike broader comparisons by academic level or learning format, this analysis focuses on the specific outcome of each course—whether a bachelor, master, executive master, or specialised training—to examine the depth and intensity of learning required to achieve that qualification. This distinction is crucial because it reveals the implicit expectations associated with different credentials and how much time institutions allocate for foundational knowledge, advanced specialisation, or upskilling. To ensure comparability across diverse educational systems and course formats, all durations were either taken directly from available data or estimated by assigning 25 hours per ECTS credit. This standard allows for a consistent interpretation of workload and learning effort, regardless of local credit definitions or delivery modes.

Figure 6 shows a clear escalation in duration with the academic weight of the qualification. Bachelor's degrees range between 50 and 187.5 hours, indicating substantial engagement with theoretical and technical foundations, while master's programs span a broader range—from 20 to 300 hours—suggesting that some institutions offer compressed master's-level training, whereas others maintain a more extended, research-oriented format.

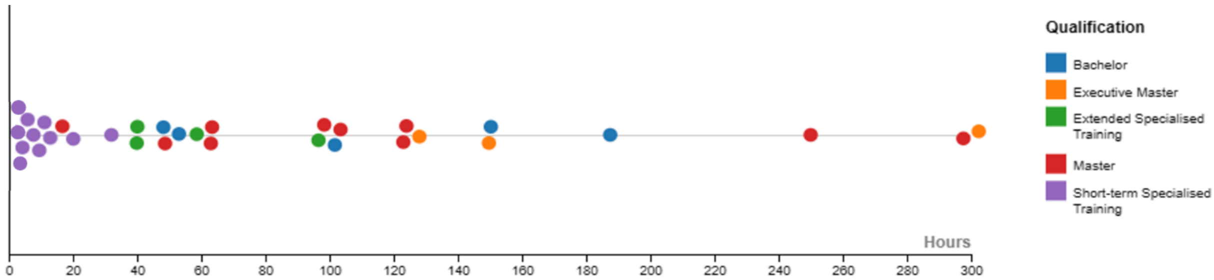

Figure 6: *Courses are plotted along the horizontal axis according to their duration, with qualification level indicated by a colour-coded scale.*

Executive master's courses consistently cluster at the upper end (125 to 300 hours), reinforcing their role as intensive, leadership-focused programs for professionals. In contrast, Short-term Specialised Training concentrates in the low-duration range, between 3.25 and 32 hours, highlighting its purpose as modular, skill-targeted learning. Extended Specialised Training occupies a middle ground (40–100 hours), bridging quick interventions and full academic degrees, and may serve either as continuing education or preparatory pathways. These distinctions reinforce the layered nature of solar architecture education: from short, targeted certifications to comprehensive, long-duration degrees. This trend also underscores how duration acts as a proxy for both depth of content and expected learner commitment, aligning closely with the complexity of the qualification granted.

3.4 Target audience by qualification level

This analysis explores the distribution of courses according to target audience, qualification level, and training duration (**Figure 7**). The objective is to assess how different professional profiles are served by various educational formats in terms of intensity and depth of learning.

The data reveal a marked distinction between academic and professional pathways. Programs targeting students are exclusively through bachelor's and master's degrees, with training durations ranging from 50 to 300 hours.

Programs aimed at professionals—including architects, engineers, building contractors, building professionals, managers, entrepreneurs, consulting firms, and scientists—are structured as short-term or extended specific trainings and executive masters. These vary from 3.25 to 300 hours, indicating a modular approach that allows for flexibility in terms of time commitment.

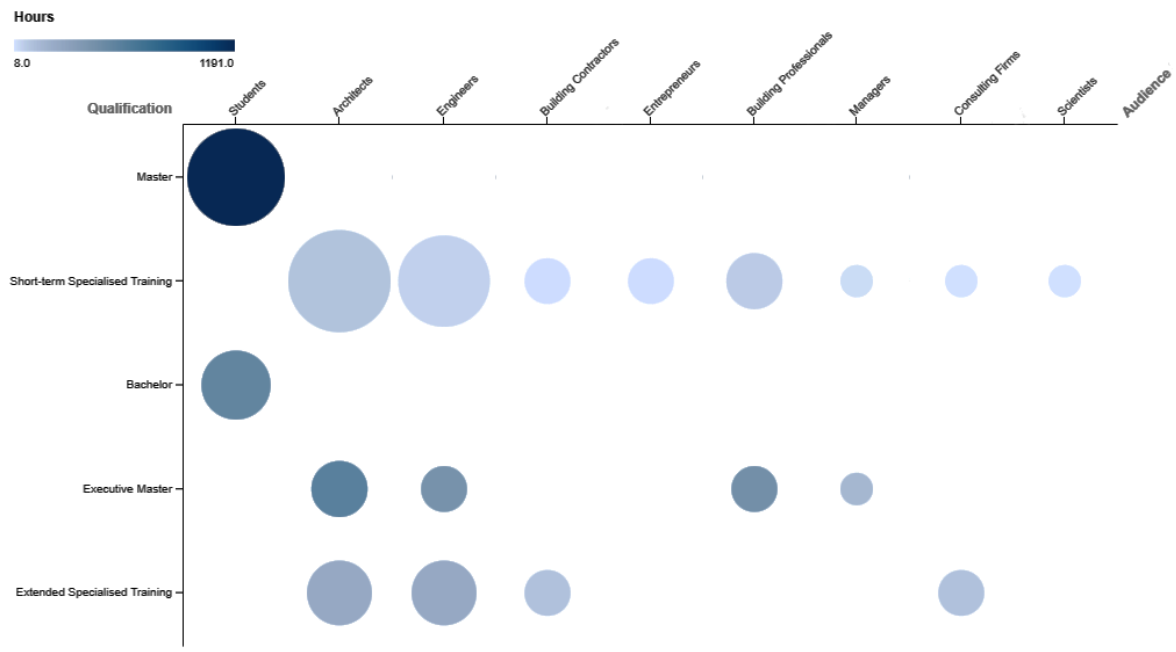

Figure 7: *Heatmap displaying qualification level on the vertical axis and target audience on the horizontal axis. Circle size indicates the number of courses, while the colourmap represents the total course duration.*

Architects and engineers emerge as the most consistently targeted audiences across professional programs. Other roles, such as contractors, managers, and entrepreneurs, appear less frequently and are often included only in more comprehensive formats.

While this structure supports differentiated learning based on professional needs and availability, it also reveals a narrow focus on certain profiles, with limited outreach to broader stakeholder groups involved in BIPV deployment.

In conclusion, the current educational offer shows a relatively well-defined segmentation between academic and professional training. However, to ensure broader and more inclusive BIPV adoption, there is a clear need to expand training opportunities to underrepresented professional categories, especially targeting decision makers in construction sector and policy makers, and to support wider international accessibility.

3.5 Learning format by country and qualification level

In the evolving field of solar architecture education, understanding the intersection between geographic distribution, qualification levels, and learning formats is crucial. The delivery mode of a course, whether in-person, online, or hybrid, can significantly influence its accessibility, pedagogical approach, and alignment with local or global educational strategies. By examining how different countries deliver solar architecture training across various qualification levels, this helps identify where innovation in learning formats is concentrated and where traditional approaches still prevail, reflecting broader infrastructural, cultural, and technological contexts.

The heatmap (**Figure 8**) reveals several noteworthy patterns. In-person learning remains the dominant format, particularly in Europe, where Austria, Switzerland, Denmark and Norway and India primarily offer bachelor's, master's, and even short-term courses face-to-face. This suggests a continued emphasis on studio-based or practical, hands-on learning, which remains central to architectural and engineering training.

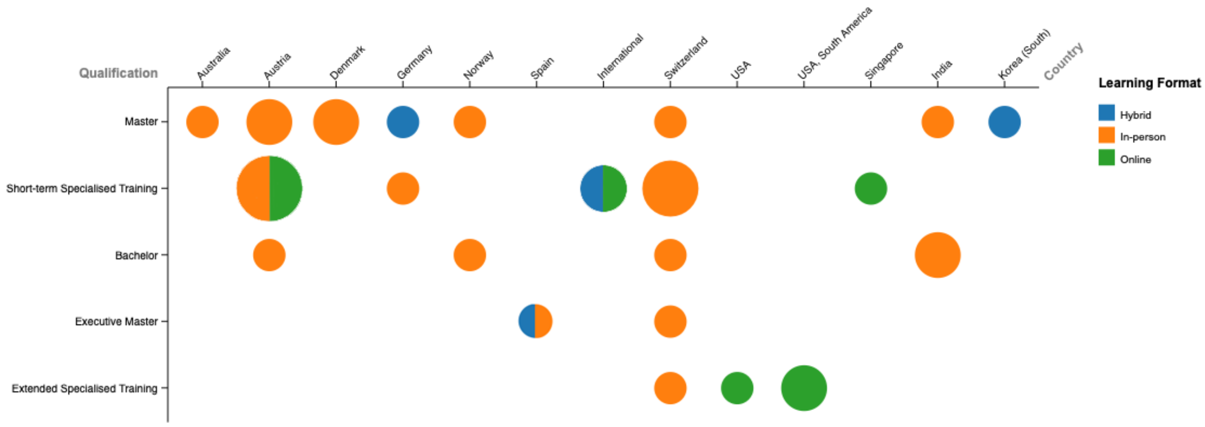

Figure 8*: Heatmap illustrating countries on the horizontal axis and qualification level on the vertical axis. Circle size represents the number of courses (1–3), while the colour denotes the learning format.*

Online formats are largely associated with extended specialised training, offered from international consortia and in the USA, South America and Singapore, reflecting a push toward flexibility and global accessibility, especially for continuing professional education. Hybrid models, while less common, emerge in key cases such as Germany, South Korea, and Spain, where they are used for master's and executive-level qualifications, possibly to balance academic rigour with the demands of working professionals. Overall, the diversity in delivery formats across qualifications and regions highlights a dual shift: toward digitally enabled lifelong learning and toward maintaining face-to-face depth in foundational academic training.

The suitability of online, hybrid, or in-person formats is also notably influenced by the nature of the learning objectives and expected outcomes. Digitally delivered courses tend to be more effective when the content can be taught through structured materials, guided self-learning, and remote interaction, whereas formats involving experiential learning, knowledge transfer, and practical skill acquisition often benefit from direct engagement and supervised activities. In this sense, delivery modes should be interpreted not only as logistical choices, but also as pedagogical strategies aligned with the type of competencies being developed.

The heatmap in **Figure 9** provides an overview of educational offerings in solar architecture across various countries, with a focus on the distribution of courses among different target audiences. All courses are reported, with the "Student" category summarising foundational educational programs such as undergraduate and graduate courses. In contrast, the "Professionals" category targets those already active in the construction and related industries, focusing on both short-term and extended specialised training.

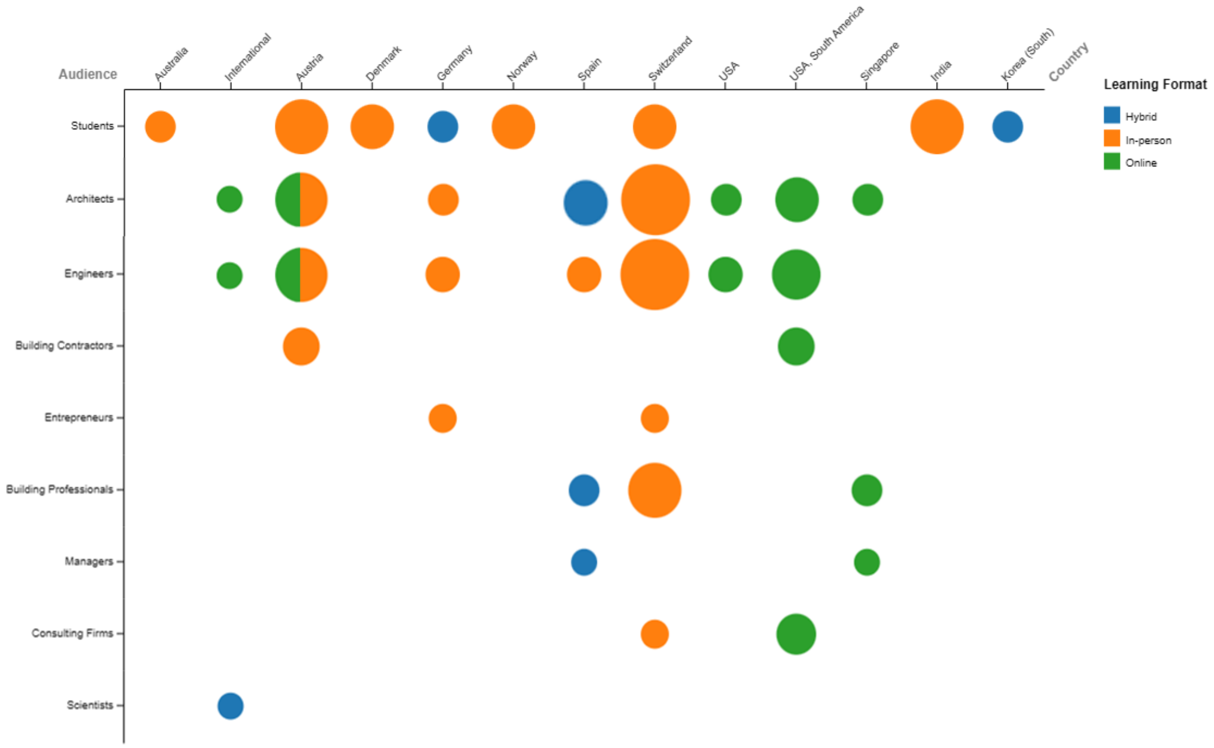

Figure 9: *Heatmap illustrating the country on the horizontal axis and the target audience on the vertical axis. The size of the squares represents the number of courses (1-4), while colour denotes the learning format.*

A dominant feature across the dataset is the prevalence of in-person learning, which remains the primary mode of delivery for both academic students and professional participants. For students at undergraduate and graduate levels, the preference for face-to-face instruction is consistent.

Online learning is aimed primarily at professionals, such as architects, engineers, building contractors, entrepreneurs, and consulting firms. The use of online formats in these contexts suggests a clear orientation toward flexibility and accessibility. These programs are likely designed to accommodate the time constraints of working professionals and to expand educational reach beyond geographic boundaries.

The findings on teaching methods indicate a certain openness within the professional sector toward diversified training modalities. Other professional figures, such as managers, consultants, and entrepreneurs, are primarily addressed through in-person or online formats, with no programs tailored specifically for them within hybrid structures. This suggests that while some level of integration of these roles exists, targeted and differentiated learning pathways for such audiences remain underdeveloped.

3.6 Distribution of target audiences by academic level

This analysis focuses on the professional profiles of the individuals reached by the courses. The percentages shown in **Figure 10** refer to the total number of professional roles identified across all courses, rather than to the number of courses themselves. This distinction helps clarify the true composition of the target audience, offering a more accurate picture of who is being trained and to what extent each group is engaged in BIPV knowledge transfer.

The data reveal a clear focus in BIPV training on two main groups: architects and students, each making up 25% of targeted participants. This hints at a dual educational strategy—addressing both current design professionals and future practitioners. Engineers follow closely at 24%, underlining the interdisciplinary nature of BIPV, which relies on both technical and architectural skills.

Other roles are weakly represented: building professionals (8%) and consulting firms (5%) show a moderate industry presence. Managers, entrepreneurs, and contractors (each at 3%) appear marginal, suggesting that strategic and operational roles are not the primary training focus. Researchers (2%) are the least represented, suggesting that current training offers are primarily geared toward practical implementation. Overall, the training landscape prioritises design and implementation, preparing professionals and students for the integration of photovoltaics in the built environment.

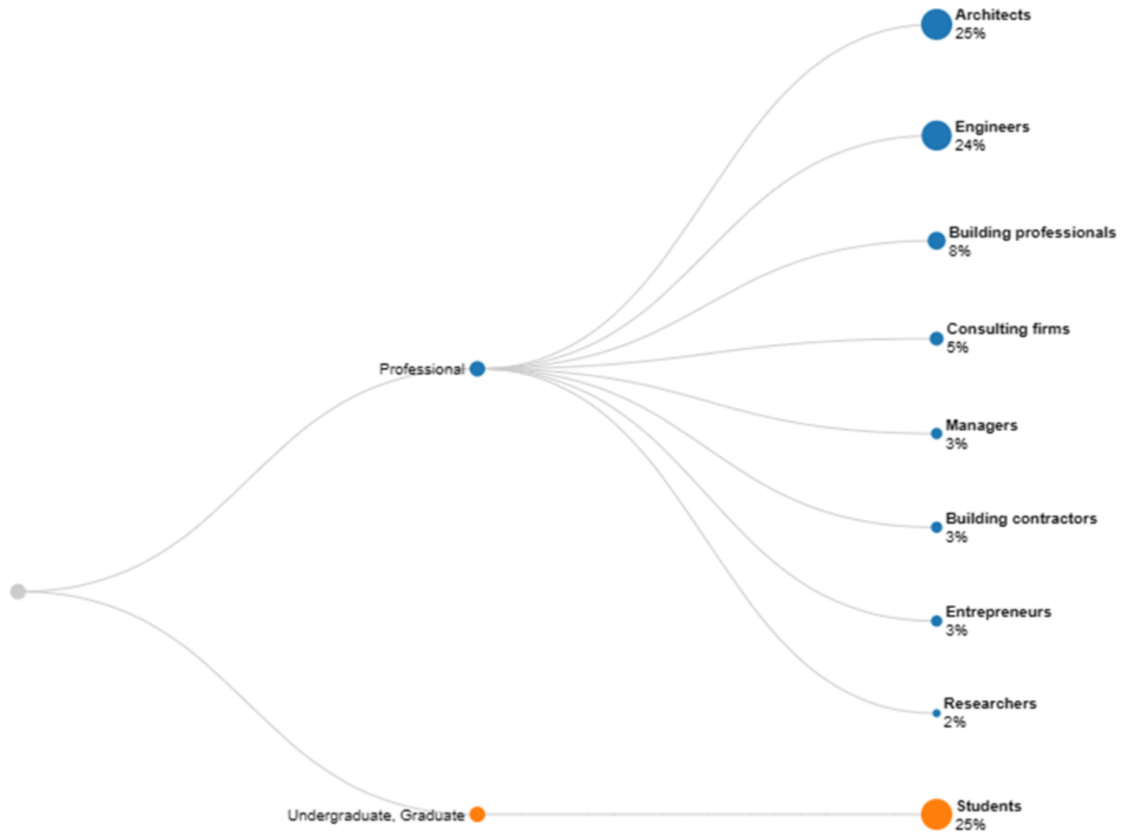

Figure 10: *Hierarchical chart of target audience distribution by academic level. Percentages indicate the proportion of each audience group relative to the total sample, noting that individual courses may target multiple roles.*

3.7 Distribution of course modules by learning format

To better understand how BIPV training is delivered, the frequency of course modules across all programs was analysed (**Figure 11**). Since each course can include several modules, the data reflect the share of each learning activity relative to the total number of modules identified. This offers insights into pedagogical strategies that shape knowledge transmission in the field.

The data confirm a strong prevalence of in-person formats, especially lectures (33%), workshops (16%), and site visits (10%). These modules reflect a clear emphasis on direct engagement and hands-on learning, which remain crucial in the teaching of building-integrated photovoltaics. Other in-person methods, such as lab sessions (5%), seminars (3%), projects (3%), and industry visits (2%), support this practical, immersive educational approach.

Online formats play a smaller but meaningful role. Online lectures (7%), interactive meetings (5%), and interactive modules (3%) offer flexibility and access, expanding the reach of BIPV training programs.

Interestingly, quizzes are split equally between in-person and online formats (5% each), highlighting their adaptability to both delivery modes. Semester assignments and projects, both in-person, indicate that longer-term assessment methods are still primarily tied to traditional settings.

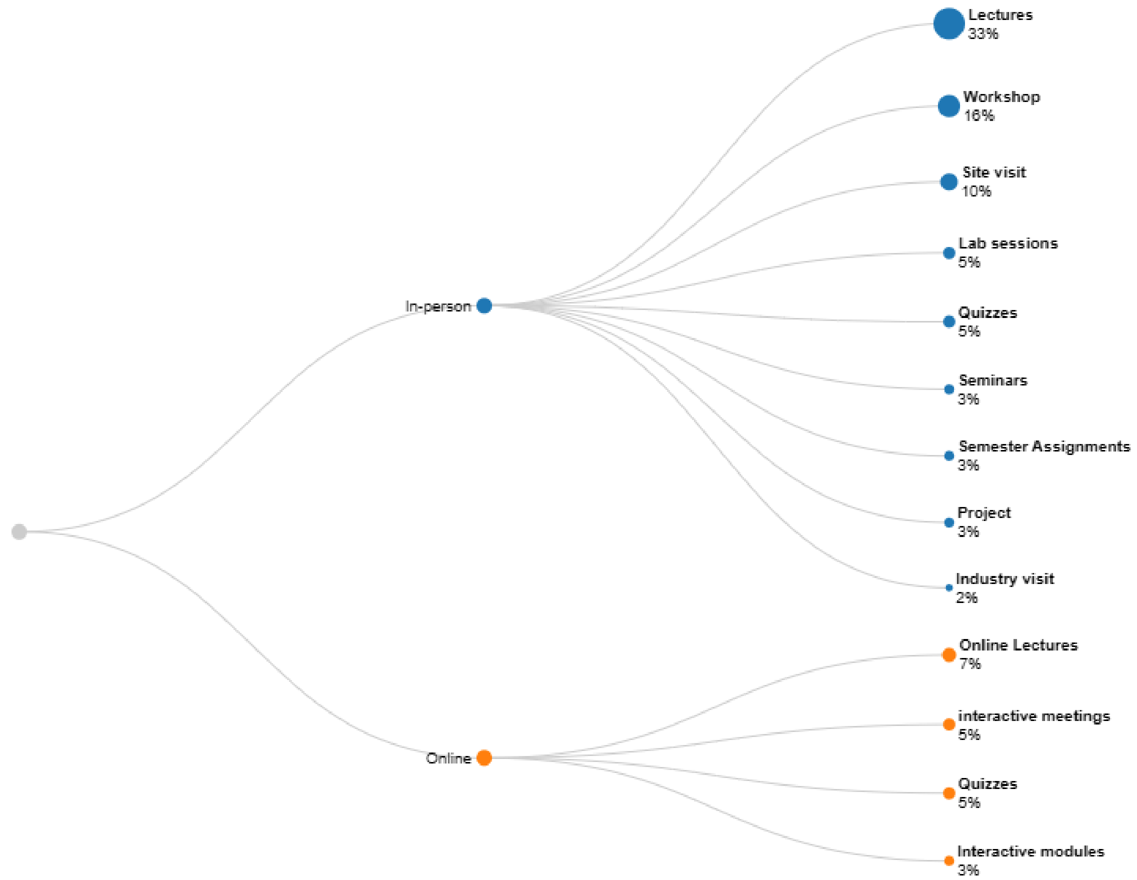

Figure 11: *Hierarchical chart of course module distribution by learning format. Percentages indicate the share of each course module relative to the total number of modules, noting that individual courses may comprise multiple modules.*

In conclusion, the current training landscape favours in-person learning modalities that prioritise practical experiences. Therefore, online learning plays an important role in providing flexibility, as well as immersive, experiential content with site and industry visits, which are key components of effective BIPV training.

Figure 12: *Participants in the "Solarchitecture Essentials" advanced training course engage in experiential activities, including a visit to outdoor facilities. The course was organised by SUPSI as part of the SEAMLESS-PV European project (2025 edition, Madrid, Spain; photo: SUPSI).*

3.8 Insight into current BIPV courses

This section presents a breakdown of some BIPV courses, outlining the key topics and activities covered. The following tables present a structured breakdown of the course content, offering insights into the learning objectives and progression throughout the training. These details are essential for understanding how the courses address the specific needs of both academic and professional participants.

3.8.1 Undergraduate and graduate courses

Undergraduate and graduate courses in BIPV are designed to provide students with a comprehensive understanding of the principles, technologies, and applications of BIPV systems. These courses typically combine foundational education in solar energy and photovoltaics with more specialised topics tailored to the architectural and engineering aspects of BIPV. The structure of these courses typically balances lectures, practical workshops, and hands-on exercises, ensuring that students gain both theoretical knowledge and practical skills. They are often offered over a period of 10 to 12 weeks, with weekly hours varying depending on the number of credits awarded at the end of the course. The completion of these courses typically requires passing an exam or participating in a group project, which tests the students' ability to apply what they have learned in real-world contexts.

An undergraduate course (detailed in **Table 1**), worth 4 ECTS credits, is offered at SUPSI (University of Applied Sciences and Arts of Southern Switzerland) and is designed specifically for bachelor students. It provides a thorough introduction to the integration of solar technologies in architectural design. Comprising ten interactive modules, the course covers key topics such as sustainable development, solar geometry, photovoltaic fundamentals, and BIM-based solar potential analysis. Emphasising experiential learning, it includes practical site visits and industry workshops that offer direct exposure to BIPV materials, technologies, and real-world applications. The program culminates with a final design workshop where students synthesise their knowledge and skills to create innovative solar architecture projects that effectively balance technical performance and aesthetic quality.

Table 1: *Overview of the bachelor course of 4 ECTS at the University of Applied Sciences and Arts of Southern Switzerland (Source: SUPSI).*

Solar Architecture			
Switzerland – SUPSI – 4 ECTS – Bachelor students			
Lecture, Duration, Format	**Methodology**	**Modules**	**Key content**
Solar Architecture 1 **3h** **In-person**	Lessons, questions, quizzes, surveys, and visits	Architecture and sustainable development	Awareness of BIPV design potential and feasibility
Solar Architecture 2 **3h** **In-person**	Lessons, questions, quizzes, surveys, and visits	Introduction to photovoltaics, the sun, solar pathfinder	Understand solar geometry, sunlight analysis, and photovoltaic basics
Solar Architecture 3 **3h** **In-person**	Interactive presentation, Q&A, and action learning	Solar potential analysis: From masterplan to project	Assess solar potential at different scales and use BIMsolar for system sizing
Solar Architecture 4 **3h** **In-person**	Interactive presentation, Q&A, action learning and visits	Experiences in solar technology: solarchitecture.ch, outdoor visit to ISAAC, the poetics of contrasts, solar as an element of beauty	Explore case studies, industry insights, and the aesthetic potential of solar design

Solar Architecture 5 **3h** **In-person**	Interactive presentation, Q&A, and action learning	Multifunctional envelope technology, design criteria and detailed engineering	Learn about BIPV-integrated facades and detailed engineering for solar applications
Solar Architecture 6 **3h** **In-person**	An interactive working group with an assignment	Solar design exercise – 1, material library	Apply solar design principles and explore solar materials
	Q&A and short exercises		
Solar Architecture 7 **3h** **In-person**	An interactive working group with an assignment	BIM_SOLAR 2: Simulations and design, solar design exercise - 2	Conduct solar simulations and refine design skills
	Q&A and short exercises		
Solar Architecture 8 **3h** **In-person**	An interactive presentation, Q&A, action learning, and visit	Sunage - Workshop at the company, visit to the production facility and atelier	Gain industry insights and understand solar technology manufacturing
	Q&A and short exercises		
Solar Architecture 9 **3h** **In-person**	An interactive working group with assignments	Exercise and review	Refine projects and address design challenges
	Q&A and short exercises		
Solar Architecture 10 **3h** **In-person**	An interactive working group with assignments	Final workshop, final discussion of works	Present final designs and demonstrate solar architecture expertise
	Q&A and short exercises		

Figure 13: *Visit to the material library at SUPSI, part of Lecture 6 in the Solar Architecture course: group work focused on exploring solar materials (Photo: SUPSI).*

Table 2 shows an overview of the content of the 5 ECTS BIPV course for graduate master students at DTU (Technical University of Denmark) concludes with a group assignment where the participants design and engineer a BIPV roof. The assignment is built up following the lectures and progressively builds up to a full engineering design of a BIPV roof and thereby presents the most relevant considerations needed in a BIPV design. This course design provides a structured overview of the key principles, technologies, and considerations necessary for understanding BIPV systems in architectural design and construction. The course facilitates multidisciplinary collaboration as students of different academic backgrounds are invited to work together for their group assignment. Particularly, the course aims to bring together students from building science and those with a background in renewable energy. Further, the course integrates both theoretical and practical elements, addressing essential topics such as photovoltaic principles, module technologies, energy yield modelling, and performance effects (e.g., temperature, insolation), providing students with a toolbox for architectural integration of BIPV. This course targets both students in architectural and civil engineering as well as sustainable energy engineering, and awards credits towards certain specialisations within the relevant master's programs.

Table 2: *Overview of the master course of 5 ECTS at the Technical University of Denmark (Source: DTU - https://kurser.dtu.dk/course/41461).*

<table>
<tr><th colspan="4">BIPV</th></tr>
<tr><th colspan="4">Denmark – DTU – 1250 euro – 5 ECTS – Master students</th></tr>
<tr><th>Lecture, Duration, Format</th><th>Methodology</th><th>Modules</th><th>Key content</th></tr>
<tr><td>Introduction to BIPV - Presentation of assignment
4h
In-person</td><td>Lectures working on group report, group formation</td><td>Introduction to BIPV, definitions, opportunities, market insights, national feed-in models and associated revenue</td><td>Recall the definition of BIPV systems, be familiar with opportunities within BIPV, and recall examples of BIPV</td></tr>
<tr><td rowspan="2">Building practices and the building process
4h
In-person</td><td>Group exercise, evaluation of BIPV installations and potential</td><td rowspan="2">Review of common building practices, BIPV definition and classification according to IEA PVPS Task 15, Introduction of BIM</td><td rowspan="2">Memorise typical roof and facade constructions, classify BIPV application categories, and recall a building process</td></tr>
<tr><td>Semester quiz and group report for the semester</td></tr>
<tr><td rowspan="2">Solar radiation
4h
In-person</td><td>Exercise in solar radiation and angles</td><td rowspan="2">Solar radiation, transposition models, clear sky radiation, shading</td><td rowspan="2">Apply the isotropic transposition model, interpret clear sky radiation, and estimate shade impact on radiation</td></tr>
<tr><td>Semester quiz and group report for the semester</td></tr>
<tr><td rowspan="2">Mechanical forces and requirements
4h
In-person</td><td>Lectures working on group report</td><td rowspan="2">Load actions on roofs, forces on BIPV, and dimensioning of fixations</td><td rowspan="2">Identify the load actions on a building, and estimate the fixation forces for BIPV products</td></tr>
<tr><td>Semester quiz and group report for the semester</td></tr>
<tr><td rowspan="2">Solar cells fundamentals
4h
In-person</td><td>Lectures working on group report</td><td rowspan="2">Photovoltaic principle, IV-curves, diode model, performance effects:
a. Temperature,
b. Irradiance</td><td rowspan="2">Relate bandgap to light absorption, recall principles of photovoltaic conversion, and apply the single diode model</td></tr>
<tr><td>Semester quiz and group report for the semester</td></tr>
<tr><td>PV and particular BIPV modules
4h</td><td>Lectures working on group report</td><td>Cell interconnection (videos), module technologies for</td><td>Estimate the output of serial and parallel PV cells, and construct a</td></tr>
</table>

In-person	Semester quiz and group report for the semester	BIPV, fabrication of PV, and BIPV module design guidelines	BIPV module for a certain application
Investors and MLPE **4h** **In-person**	Lectures working on group report, quiz Semester quiz and group report for the semester	MPP tracking and electronic conversion, inverter and optimiser sizing (videos), short on grid compliance	Explain power point tracking, recall conversion losses, and apply sizing rules to a BIPV system using clear sky irradiation for sizing non-optimal surfaces
PV system modelling and economy (also in PV Sol) **4h** **In-person**	Lectures working on group report Semester quiz and group report for the semester	Energy yield modelling (videos), PV Sol demo, economy and extra cost approach	Explain principles of energy yield modelling, perform BIPV system modelling in PV sol (energy-wise and financial), and apply marginal cost calculations
Trade fair visit (Building Green) - Trade fair for green building materials **4h** **In-person**	Trade fair visit Semester quiz and group report for the semester	Explore "green" building materials, meet Danish suppliers of BIPV	Learning outcome for this day is what, in teaching terms, is called "institutionalisation", so the attendees meet in person
Aesthetics and coloured BIPV **4h** **In-person**	Lectures working on group report, revisiting buildings from the exercise of the 2nd lecture Semester quiz and group report for the semester	Appearance toolbox, glass textures, glare and glint, colour formation and description, colouration losses, colouration principles and product examples	Apply the appearance toolbox to improve the aesthetics of BIPV projects/products, recall the efficiency losses, and estimate the loss from colours (and other aesthetic means)
Energy frame and LCA according to the Danish building code **4h** **In-person**	Lectures working on group report Semester quiz and group report for the semester	Energy frame for buildings (Danish implementation of the EPBD), BIPV impact on the LCA assessment of buildings according to Danish legislation	Estimate the energy frame on a building, estimate the energy frame gains from a (BI)PV installation, and calculate the impact on the LCA assessment of the building owing to a BIPV system

Fire safety and feedback session **4h** **In-person**	Lectures working on group report	Fire safety, mitigation strategies for fire risks, and feedback on the group project	List ignition sources and means to reduce
	Semester quiz and group report for the semester		

In general, it can be observed that master's courses address more detailed and specialised topics compared to bachelor's programs. While bachelor's courses offer a broad introduction to solar architecture and BIPV, emphasising fundamental principles, design applications, and simulations, master's programs explore technical, scientific, and electrical aspects in greater depth.

The structure of the BIPV courses in the academic institutions allows for a balance between breadth and depth, with some programs offering more intensive, focused content on specific topics, while others provide a broader, more comprehensive overview. The flexibility in weekly hours and course duration enables students to choose courses that align with their interests and prior knowledge, making it possible to either follow a more general curriculum or opt for specialised, time-efficient modules. This approach allows for the development of a compact, customizable learning path that can be tailored to the needs of individual students within the broader context of their academic journey.

Figure 14*: Bachelor's students (left) and master's students (right) visit CIEMAT's BIPV installations during a technical tour (photo: CIEMAT).*

3.8.2 Postgraduate programs offered by academic institutions

Postgraduate education offers a variety of advanced qualifications aimed at professionals looking to deepen their expertise. Although the terminology of these qualifications may vary between countries, they generally follow a common structure based on academic credits, such as ECTS in Europe or Credit Hours in the USA.

Academic institutions define specific qualifications based on the number of academic credits awarded for various courses, corresponding to different levels of postgraduate education. Each country has its own system, typically grouping three categories of qualifications. In Switzerland, Certificate of Advanced Studies (CAS) programs, with 10 credits or more [7], refer to specialised courses. Similarly, in England, Postgraduate Professional Development (PPD) programs focus on professional updates. Programs with over 60 credits, such as Master of Advanced Studies (MAS) in Switzerland, Germany, and Austria, or Postgraduate (PG) Diplomas in England [8], correspond to longer, more advanced courses. However, no programs of this length have been identified with an exclusive focus on BIPV. Instead, relevant BIPV content is usually integrated within broader curricula on sustainable architecture or energy systems, with only short, specific modules dedicated solely to BIPV.

Postgraduate education in BIPV encompasses various specialised programs aimed at professionals and researchers seeking advanced expertise. These include short-term qualifications such as the CAS, typically comprising 10 or more ECTS credits, focusing specifically on BIPV technologies. More extensive qualifications, such as postgraduate certifications with 60 or more ECTS credits, integrate both BIPV-focused courses and broader interdisciplinary subjects, including sustainability, environmental impact, and the economic and social considerations of sustainable building practices.

To deliver a comprehensive and practice-oriented learning experience, a multidisciplinary team of experts leads the CAS in BIPV at EPFL Extension School. The curriculum integrates technology, architecture, and energy systems, as outlined in the course modules in **Table 3**.

The CAS program is structured into ten modules, with the final one dedicated to an extensive individual project. The first nine modules cover essential theoretical and practical aspects of BIPV. The full program awards a total of 12 ECTS credits.

The program offers a structured pathway from photovoltaic fundamentals to advanced applications in building integration. Participants are introduced to PV technologies and architectural archetypes before moving into specialised modules on manufacturing, regulation, energy management, and performance analysis. Digital design and simulation tools are incorporated to support interoperability, while commissioning and maintenance ensure operational relevance. The course culminates in a substantial hands-on project, enabling learners to translate theory into practice through a detailed BIPV case study.

As a CAS, the program combines theoretical grounding with practice-oriented training in a modular, time-efficient format. It is designed for professionals seeking targeted upskilling and can also serve as a stepping stone toward broader qualifications such as DAS or MAS.

Table 3*: Overview of the modules of the master course of 12 ECTS at the Ecole Polytechnique Fédérale de Lausanne / EPFL Extension school (Source: EPFL - https://www.formation-continue-unil-epfl.ch/formation/bipv-cas/).*

Building-Integrated Photovoltaic			
Switzerland – EPFL – 12 ECTS – Architects, Engineers, Building Professionals			
Lecture, Duration, Format	**Methodology**	**Modules**	**Key content**
BIPV in the architectural 1 day In-person	Lessons, questions, quizzes, case studies, surveys, and visits Q&A, hands-on session with short exercises	Introduction to the CAS, preconceived ideas about PV, overview of existing technologies and PV modules, and architectural projects	Understand PV fundamentals and integration, identify misconceptions and assess module options
Building types and BIPV 1 day In-person	Lessons, questions, quizzes, case studies, surveys, and visits Q&A, hands-on session with short exercises	Architectural and energy archetypes in Switzerland, databases, online help and fundamental decisions, architects' feedback and case studies	Analyse Swiss building typologies, use databases for decision-making, and evaluate real BIPV projects
Architectural Design with the BIPV 1 day In-person	Lessons, questions, quizzes, case studies, surveys, and visits Q&A, hands-on session with short exercises	Solar exposure and potential active surfaces, architectural integration techniques, technological approach, design strategies, economic and environmental model	Assess solar potential, apply integration methods, and develop cost-effective and sustainable designs
Construction solutions for the PV 1 day In-person	Lessons, questions, quizzes, case studies, surveys, and visits Q&A, hands-on session with short exercises	Manufacturing process of PV products, production of custom-made PV, visual aspects, suppliers and materials, Swiss and international PV market	Understand PV production, evaluate custom solutions and materials, and analyse the Swiss and global market

Regulations and institutional framework of the minutes 1 day In-person	Lessons, questions, quizzes, case studies, surveys, and visits	Local, cantonal and federal standards, fire safety, heritage, institutional incentives, evolution of labels (Minergie, SNBS) and the role of the PV	Navigate standards and safety rules, assess heritage constraints and funding opportunities, and understand certification requirements
	Q&A, hands-on session with short exercises		
Electricity flow: Management, optimisation and opportunities 1 day In-person	Lessons, questions, quizzes, case studies, surveys, and visits	Opportunities, energy supply and transition, PV installation: sizing, daily and seasonal storage technologies, dynamic management of electricity flows, self-consumption and autarky	Optimise PV sizing and storage, manage electricity flows and enhance self-sufficiency
	Q&A, hands-on session with short exercises		
Holistic performance of the BIPV 1 day In-person	Lessons, questions, quizzes, case studies, surveys, and visits	Performance analysis: energy, economic and climate, impact on the energy balance of the building, calculation methods, holistic assessment: energy performance, profitability and carbon footprint	Evaluate energy and economic performance, apply methods to assess impact and sustainability
	Q&A, hands-on session with short exercises		
Digital tools: Design and collaboration 1 day In-person	Lessons, questions, quizzes, case studies, surveys, and visits	System sizing for facilities, Building Information Modelling (BIM), Building Energy Modelling (BEM), simulations, and project interoperability	Use BIM and BEM for PV design, run simulations and ensure system compatibility
	Q&A, hands-on session with short exercises		
BIPV: Operation, monitoring and maintenance 1 day In-person	Lessons, questions, quizzes, case studies, surveys, and visits	Commissioning and documentation, operating models, monitoring and maintenance techniques, fault detection and management methods	Implement commissioning and monitoring, detect and resolve system issues efficiently
	Q&A, hands-on session with short exercises		

Hands-on individual project and presentation 192 h In-person and online	Project	Hands-on individual project (plans, simulations and written report) and make an oral presentation within the specified time frame	Apply acquired knowledge to a full BIPV project (renovation or new construction), develop detailed plans, templates, and reports
	Project evaluation		

3.8.3 Short-term specialised training

Short-term specialised training programs are characterised by their intensive structure, typically condensed into one to three days. These courses are designed to deliver focused, high-impact learning on specific BIPV-related topics, enabling participants to quickly acquire relevant technical and design knowledge.

While many of these trainings are conducted in person, particularly when site or industry visits are included, others may be offered online or in hybrid formats, depending on the objectives and audience. This format flexibility allows institutions to reach a broader range of learners, including international professionals and those with limited availability.

A representative example is the “Solarchitecture Essentials” course developed by SUPSI, outlined in **Table 4**. Structured across three consecutive in-person modules, the course targets architects, engineers, and building professionals. It combines expert-led instruction with applied learning environments such as site and industry visits. This format supports a progressive acquisition of skills—from conceptual understanding (Solar architecture), to contextual application (Site visit), to systemic industrial insight (Industry visit). The program's pedagogical rationale is to expose learners to BIPV from multiple vantage points—academic, professional, and industrial—thus fostering both critical thinking and technical fluency. Short-term specialised training courses are essential instruments for disseminating targeted, up-to-date knowledge and for fostering a practical understanding of BIPV systems across multiple stakeholder groups. Their flexibility and relevance position them as valuable complements to longer academic programs, especially in fast-evolving domains like BIPV.

Table 4: *Overview of the in-person short-term specialised training at the University of Applied Sciences and Arts of Southern Switzerland (source: SUPSI, www.solarchitecture.ch).*

Solarchitecture Essentials			
Several locations – SUPSI – 2 ECTS – Architects, Engineers, Building Professionals			
Lecture, Duration, Format	**Methodology**	**Modules**	**Key content**
Solar architecture **1 day** **In-person**	Expert presentations, real-world case studies, and technical lectures	Current state of the solar market, integration of BIPV in architecture, fundamentals of photovoltaic technology, introduction to design and modelling workflows using BIM, discussion of product certifications and regulations, exploration of cost-effectiveness and market challenges, role of buildings in energy communities like ZEV.	Participants gain a clear understanding of BIPV systems, from technical principles to design tools and regulatory frameworks. They develop the ability to evaluate economic feasibility, identify integration challenges, and recognise the potential of buildings within decentralised energy networks.
	Q&A, short exercises, quizzes		
Site visit **1 day** **In-person**	Site visits, case study presentations	Practical BIPV application through real-world case studies and on-site learning, reflection on materials used, construction challenges, and decision-making processes	BIPV design and implementation by analysing real case studies and engaging in critical reflection. They learn to identify practical challenges, assess material choices, and observe how design intentions are translated into actual buildings.
	Q&A		
Industry visit **1 day** **In-person**	Industry visit, lessons, workshop	Industry insights through company history, strategic partnerships, and product range, practical exposure via real project examples and a hands-on workshop experience	Insight into the industrial and practical aspects of BIPV, from production to implementation. They understand planning influences and observe manufacturing processes.
	Q&A		

Figure 15*: Hands-on activities from the 2025 editions of the "Solarchitecture-Essentials" course. Top: Site and laboratory visits during the Ticino (Switzerland) edition. Bottom: A visit to the Onyx Solar industry facility during the Madrid (Spain) edition (Photo: SUPSI).*

3.8.4 Extended specific training

Extended specific training programs are designed to provide in-depth knowledge over a longer duration, oppositely to short-term formats. These courses are often modular, allowing learners to progressively build competencies across various aspects of BIPV—including technical principles, design integration, financial analysis, and implementation strategies. Depending on the provider, these courses may be delivered online, in person, or in hybrid formats, ensuring flexibility and broader accessibility.

A representative example from the Architectural Solar Association (ASA) of an extended training program is structured around multiple modules, each lasting approximately 6 hours and utilises video lectures, discussion forums, quizzes, and assignments to engage learners and assess knowledge acquisition (**Table 5**). The self-paced structure allows participants to progress according to their schedule, while still ensuring depth and continuity across learning outcomes.

Extended programs are particularly suited for professionals who seek a comprehensive and methodical exploration of BIPV. Their modular nature enables progressive learning, while the inclusion of evaluative components ensures that learners gain not just information, but also applicable skills.

Table 5: Detailed table of an *online extended specific training at the Architectural Solar Association (source: ASA).*

<table>
<tr><th colspan="4">Architectural Solar Principles</th></tr>
<tr><th colspan="4">USA – Heatspring – Free – 40 CTS – Architects, Engineers</th></tr>
<tr><th>Lecture, Duration, Format</th><th>Methodology</th><th>Modules</th><th>Key content</th></tr>
<tr><td rowspan="2">Introduction to architectural solar
6h
Online</td><td>Lectures, online discussions</td><td rowspan="2">What is architectural solar? Power vs. energy, PV technology overview, the architectural solar continuum</td><td rowspan="2">Define architectural solar and its importance. Understand the basics of solar module technology. Understand how solar modules are rated and how that relates to energy. Define the six application categories of architectural solar and understand the considerations associated with each of them. Identify a range of installation types and where they fit within the architectural solar continuum.</td></tr>
<tr><td>Quizzes, assignments</td></tr>
</table>

Architectural solar design & Integration principles 6h Online	Lectures, online discussions	Integrating solar into the design process, building performance, PV performance, modelling, system typologies and technology selection, equipment layout, codes and standards, design metrics	Understand how to design a PV system in a way that is compatible with the architectural design process.
	Quizzes, assignments		
Architectural solar financial principles 6h Online	Lectures, online discussions	Solar cost estimation, incentives, incremental cost, cash flow analysis and return on investment (ROI), financing models	Understand the concept of “incremental cost”. Understand how an architectural solar installation is valued. Be able to run a comprehensive LCOE & cash flow analysis.
	Quizzes, assignments		
Architectural solar Implementation principles 6h Online	Lectures, online discussions	Project timelines, on-site renewable requirements, solar-ready overview and benefits, new construction vs. retrofit procedures	Understand barriers of implementing projects and how to overcome them.
	Quizzes, assignments		

3.8.5 Beyond conventional formats: docufilm on solar architecture

An additional example of an accessible method for spreading knowledge about solar technologies is the creation of a series of educational videos focused on BIPV, emphasising architectural quality and real-world applications. Conceived by SUPSI as part of the European project Seamless-PV [9], this initiative aims to explore BIPV through a narrative and visual format specifically tailored to an architectural audience. Moving beyond conventional training formats, the docufilm series adopts a storytelling-based methodology that makes complex content more engaging and comprehensible to a broader professional and academic community.

The learning objectives of the project are multifaceted. Through real examples and direct testimonies from architects and stakeholders, the videos seek to develop a critical understanding of how BIPV can be embedded in the built environment, respecting both aesthetic vision and functional criteria. The series is designed to stimulate architects, students and urban planners through a docufilm divided into thematic episodes. Each episode focuses on a single building case study and follows a coherent narrative structure: presenting the context and architectural concept, describing the photovoltaic integration strategies and reflecting on challenges and results through interviews with the design teams. The use of video allows for a rich combination of elements: site footage, aerial views, animated diagrams and technical data are all integrated to communicate complex ideas in an intuitive and visually powerful way.

This first docufilm (**Table 6**), available on the newly created "Training" section of the platform Solarchitecture.ch [10], is dedicated to the theme of photovoltaics as a building material and its application and landscape integration. The five buildings selected in the Swiss region of Ticino (CH) for this initial package exemplify different approaches to BIPV, demonstrating how solar technologies can adapt to a range of architectural typologies and contexts.
The video series presents five case studies that highlight the integration of photovoltaic technology in architecture, showcasing its potential to enhance environmental, social, and economic sustainability. The project contributes to an emerging architectural narrative where solar technology is no longer perceived as an add-on, but as a generator of form, meaning and environmental responsibility. By combining architectural storytelling with technical information, the docufilm offers a versatile educational tool suitable for university courses, professional training and public engagement.

Table 6: Detailed table of a docufilm "Energy and Form: building with Integrated Photovoltaics" (source: SUPSI).

"Energy and Form: building with Integrated Photovoltaics"-docufilm		
CH – SUPSI – Free – 1 hour – Architects, Designers, Engineers		
Structure of the docufilm:		
Introduction **(10 min)**	Overview of BIPV, educational objectives and scientific context of the docufilm	SUPSI BIPV Team (scientific and contextual framing)
The case-study-1 **(10 min)**	Integration of photovoltaics into a sustainable administrative building	Researcher, Architect
The case-study-2 **(10 min)**	Kindergarten project with integrated solar roof and landscape connection	Researcher
The case-study-3 **(10 min)**	Dynamic BIPV façade with solar tracking and shading functionalities	Researcher, Architects
The case-study-4 **(10 min)**	Renovation and extension of a historic building with BIPV	Researcher, Architects
The case-study-5 **(10 min)**	Largest BIPV façade in the region as a public pilot building	Researcher, City council
Conclusion **(5 min)**	Summary and final reflections on key themes	SUPSI BIPV team–General reflection on energy, form, and sustainability

4 CHALLENGES AND CONCLUSIONS

As solar architecture evolves into a strategic component of sustainable construction, architectural education faces both a challenge and an opportunity: to adapt swiftly and comprehensively to this transformation. This chapter identifies initial reflections on current gaps, emerging opportunities, and priority areas for curriculum innovation with respect to BIPV. The findings presented here are mainly derived from Task 15 contribution and represent a foundational stage in a broader inquiry, to be expanded through upcoming activities and detailed case studies, stakeholders' input, and curricular benchmarking in subsequent phases of research.

Balancing technological progress and educational adaptation

While policy frameworks and environmental targets increasingly promote net-zero and positive-energy buildings and districts, many programs in architecture, urban design, and building technology still potential to improve the integration of active solar energy systems, especially when sustainability and circularity aspects are addressed.

Skills in energy modelling, material integration, and urban-scale sustainable planning are increasingly relevant, yet BIPV is often addressed peripherally. The current diversity of BIPV course formats reflects a certain degree of innovation and responsiveness, but also reveals a lack of stabilisation across institutions and regions, due to the very limited number of initiatives.

First emerging educational models, including advanced short training courses and advanced studies learning environments, are starting to offer professionals more flexible, applied learning pathways. These formats were found to be particularly effective when they combine technical content with active learning and real-world design challenges. At the same time, the classic long-form academic programs, such as post-graduate certifications, are beginning to propose initial offerings, although interest in them remains limited as of the date of the report is limited.

This initial analysis indicates that there is already a variety of programs for reskilling professionals and educating students at the university level, with different formats and approaches. However, what emerges is that the contribution of such courses to broader curricula and professional pathways is not always clear, and the extent to which they foster interdisciplinary competence and roles remains irregular. Further development of BIPV education could therefore play an important role in supporting compliance with photovoltaic technologies, while also integrating graduates to drive a general innovation in the design of complex, interdisciplinary, and responsive buildings and urban systems.

Reskilling for specialisation in solar architecture

As BIPV systems become more central to net-zero energy building strategies, the need for dedicated professional competencies is increasingly evident. However, one of the primary barriers to effective implementation lies in the fragmented definition of roles and responsibilities across the design and construction process. The question of *who* is responsible for BIPV design and integration remains unresolved in many markets.

In some projects, architecture and engineering firms lead the BIPV design process, while in others, specialised consultants are also engaged to oversee technical integration, performance modelling, or material selection. In yet other cases, manufacturers or BIPV solution providers play a decisive role, shaping design choices and system specifications.

The technical depth required to deliver high-performance BIPV systems spans several domains, including façade design and engineering, electrical integration with building systems, cost-performance optimisation, compliance with evolving regulations, and an understanding of BIPV-specific material technologies. These skills are critical for ensuring both the aesthetic quality and functional reliability of solar-integrated buildings. They also require more specialised know-how, particularly in early-stage architectural integration and interdisciplinary collaboration. Training programmes should therefore not only address technical excellence but also equip professionals with the capacity to articulate the long-term value proposition of BIPV to clients, investors, and public authorities.

Our first data collection shows that formats and levels of depth in current professional BIPV courses vary widely. This indicates a growing interest in the topic but also highlights a fragmented landscape in terms of instructional design and learning outcomes.

Promising models are emerging in some countries, where academic programs are combined with hands-on professional training, or where modular curricula enable participants to build competencies progressively, often leading to specialised certifications. While most initiatives target architects and engineers, the market still reveals a limited engagement among participants and an absence of clearly defined professional development in this field.

The current process variability in real projects for BIPV actors creates uncertainty within project teams and hampers a clear articulation of professional needs and the broader scalability of best practices. In this context, upskilling initiatives still offer a vital mechanism for research, enabling new forms, new ways for professionals to adapt and propose added value to the rapidly evolving demands of the energy transition and sustainable constructions.

However, in our experience, the goal of these training models should not be to complicate existing professional roles or disrupt established workflows, but rather to provide agile, targeted skills that can be readily applied within the current construction and design process. By equipping professionals with practical tools and knowledge - such as understanding BIPV system requirements, regulatory interfaces, and interdisciplinary coordination -reskilling efforts can support smoother project delivery without adding unnecessary complexity.

Moreover, expanding BIPV education should not be limited to technical professionals. A broader outreach strategy is necessary to engage non-technical but highly influential stakeholders, such as policy-makers, real estate and financial institutions.

Preliminary observations and roadmap for further research

The course mapping presented in this study should be regarded as a preliminary observation, largely informed by expert collaboration, professional networks, and shared knowledge. It does not constitute an in-depth investigation but rather offers a snapshot of how leading experts and institutions in BIPV are currently shaping educational avenues. The limited number of courses observed illustrates that BIPV education today is still largely framed through a specialised, expert-driven perspective rather than being fully integrated into mainstream architectural, building and urban design curricula. In principle, BIPV should form a natural component of disciplines on City Science, Building Engineering and Architecture, yet for now we see only a few emerging cases where it is introduced as a dedicated specialisation. It is also worth noting that much of the current knowledge base in BIPV education originates from PV experts, rather than from trainers rooted in building, architecture, and urban disciplines.

The predominance of in-person delivery (over 60% of documented modules) underlines the continued value of hands-on learning, real-time interaction, and in some courses networking opportunities that foster practical competencies in BIPV, especially through design workshops, prototyping, and field-based learning. At the same time, promising innovations are emerging through hybrid and online models, as seen in the USA and several European contexts, which broaden accessibility for international learners and working professionals Architects (in continuous education) and students (in basic education) account for over 50% of participation, whereas contractors, consulting engineers, and entrepreneurs remain significantly underrepresented (each below 10%), pointing to an untapped opportunity to extend BIPV training to other stakeholders critical for implementation and market uptake.

This initial assessment provides a first data-driven baseline for understanding the current architecture of BIPV education and training. A first analysis underscores some possible areas for targeted action: (1) integration of solar design principles into architecture, building technology and urban core curricula, (2) structured upskilling pathways for professionals, (3) synergy use of both experience in-person and flexible hybrid learning models, and (4) broader engagement of underrepresented professional groups. An additional aspect worth exploring is informal learning. Video training modules, recorded webinars, specialised YouTube channels, and even documentary films on sustainable architecture increasingly complement formal education. Although rarely certified, these media-based formats contribute significantly to rapid knowledge dissemination, professional updating, and broader public awareness of BIPV. Future stages of research should better explore these dimensions, also including specific analysis, and real case studies in the development of some pilot models. Emphasis should also be placed on identifying high-impact pedagogical practices and scalable frameworks for curricular innovation.

In conclusion, aligning architectural, urban education and building engineering with the demands of solar innovation and sustainability is both a challenge and an opportunity. The preliminary findings and observations suggest that a cohesive, interdisciplinary, and practice-oriented educational framework can be essential to equip current and future practitioners for the integration of BIPV and other solar technologies in the built environment and urban design.

Ultimately, in our opinion, addressing these challenges will require a concerted effort across academia, professional organisations, and industry stakeholders to realign educational priorities with the environmental, technological, and societal imperatives shaping the science of cities and of our future built environment.

5 LIVE SURVEY

To support the continuous update of content and the monitoring of BIPV training initiatives, we have included a QR code linking to an online form.

This tool allows contributors to share information about new courses or training programs over time, helping to build an open and dynamic database that supports IEA activities and the international BIPV community.

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