Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 111 (2017) 993 – 999

Energy Procedia

8th International Conference on Sustainability in Energy and Buildings, SEB-16, 11-13 September 2016, Turin, ITALY

Status and outlook for building integrated photovoltaics (BIPV) in relation to educational needs in the BIPV sector

Momir Tabakovic[a], Hubert Fechner[a], Wilfried van Sark[b,*], Atse Louwen[b], George Georghiou[c], George Makrides[c], Eliza Loucaidou[d], Monica Ioannidou[d], Ingrid Weiss[e], Sofia Arancon[e], Stephanie Betz[e]

[a]*FH Technikum Wien, ENERGYbase, Giefinggasse 6, 1210 Wien, Austria*
[b]*Copernicus Institute of Sustainable Development, Utrecht University, Heidelberglaan 2, 3584 CS Utrecht, the Netherlands*
[b]*University of Cyprus, Panepistimiou 1 Avenue, P.O. Box 20537, 1678 Nicosia, Cyprus*
[c]*Deloitte Ltd, 213 Arch. Makariou III Avenue, 3030 Limassol, Cyprus*
[e]*WIP-Renewable Energies, Sylvensteinstrasse 2, D-81369 Munich, Germany*

Abstract

This paper reviews the present status and outlook of the building integrated photovoltaics (BIPV) market on a global and European scale. In particular, it provides a comprehensive review of the market situation and the future trends for Austria, Cyprus, France, Germany, Italy and the Netherlands until the year 2020. In addition, as education is seen as one of the barriers for BIPV deployment, results of a survey are presented that was conducted among BIPV stakeholders with the aim to identify major knowledge gaps in education and target audiences as well as teaching goals. From that potential courses dedicated to the needs of each target audience related to BIPV can be developed.

Peer-review under responsibility of KES International.

Keywords: Building Integrated Photovoltaics; BIPV; market; education

1. Introduction

The market for building integrated photovoltaics (BIPV) is still to be considered as a niche market, but with high potential to increase in the next years. To bring BIPV from a niche market to a mass market some specific activities in the technical, legal and cultural, but also in the educational sector will be necessary. BIPV brings the worlds of

* Corresponding author. Tel.: +31 30 253 7611
E-mail address: w.g.j.h.m.vansark@uu.nl

Peer-review under responsibility of KES International.
doi:10.1016/j.egypro.2017.03.262

construction and photovoltaic technology together with all the challenges and chances inherent to such a change of paradigm.

Most existing photovoltaic modules are developed as purely technical elements, starting only from the "energy production" point of view, by sizing the modules to optimize energy collection, manufacturability, handling, and installation, but only giving marginal attention to architectural integration issues [1]. It is increasingly being stated that photovoltaic (PV) modules must be developed to respond to their own technical constraints but should furthermore become architectural elements, which are also easy to integrate into the new or existing building envelope [2]. They should possibly fulfil more than one function, consequently supporting designers' integration efforts and reducing the overall cost.

BIPV has a multifunctional role as building envelope material and power generator, thus providing substantial savings in terms of electricity and material costs. This means also that there is now room for a new palette of module types with a clear "building function", each addressed to a specific building application, such as metallic cladding, glazed façade element, balcony fence, tilted roof shingle, etc. [3].

While the field of application of BIPV has been defined in various ways, as a rule specific BIPV products always serve a dual and full function as construction and electricity-producing components. BIPV Modules are considered to be building-integrated, if the PV modules from a construction product providing a function as defined in the European Product Regulation CPR 305/2011 [4]. Thus the BIPV module is a prerequisite for the integrity of the building's functionality. If the integrated PV module is dismounted (in the case of structurally bonded modules, dismounting includes the adjacent construction product), the PV module would have to be replaced by an appropriate construction product according to the prEN 50583 standard [5]. BIPV modules could be considered as an "integral" element of the building contributing both, as a technical unit, to produce electricity but also, as functional and constructive unit since is an essential part of the building skin, to replace conventional building materials. Building envelopes have the following main protection and regulation functions: protection from intrusion, rain, wind and noise, insulation from winter cold and excessive summer heat (weather protection), regulation of the visual relations inside/outside and outside/inside, as well as the supply of fresh air, daylight, and passive solar gains, and regulation of users' comfort, while reducing the use of non-renewable energies.

It is crucial that in order for the BIPV market to grow leading to economic and social progress education and training must be developed. To fulfil this need the project "Dem4BiPV" [6] was formulated and granted and is based on the principle of European cooperation through which innovative educational material utilizing ICT means will emerge on the topic of BIPV, which is of crucial importance for the future development and penetration of the PV market in Europe with a potential significant contribution in meeting Europe's energy challenges. This project has been designed and structured so as to meet educational needs of the PV market and contributes positively to EU benchmarks for 2020 in relation to education. It also indirectly tackles fast-rising youth unemployment, as it places emphasis on delivering the right skills for employment in the BIPV industry and increasing the efficiency of higher education in the field of sustainable energy and on working collaboratively with all relevant stakeholders.

2. Market overview

2.1. Application areas

A recent study provided useful insights into the most common applications of BIPV in Europe [7]. One-third of the BIPV applications are realized in renovation projects, two-thirds in new buildings. Half of the BIPV components are realized in façades, one-third on roofs, and the rest as a combined roof/façade product. BIPV is realized in residential buildings (19%), public infrastructure (14 %), showroom offices (13%), universities and schools (9%), historical buildings (7%). Other buildings include hotels, sport venues and agricultural buildings. Most of the installations were in agricultural, buildings, hotel, functional urban structures and residential buildings [7]. At the moment about 200 BIPV products are offered, addressing the major applications pitched roofs, facades and flat and curved roofs [2].

2.2. Installed capacity development

The BIPV market is rapidly growing in the last years. The global market is estimated at 2.3 GW in 2015 compared to 1.5 GW in 2014, constituting a near 50% increase. Developed countries, especially Europe and the United States, are dominating the global BIPV market, in terms of installed capacity due to higher customer willingness to adopt practices on account of increasingly stringent environmental regulations, coupled with rising pressures to minimize energy consumption from buildings to reduce CO_2 emissions. With 41.7 % Europe is leading the BIPV market of installation capacity in 2015. Table 1 shows results of a BIPV market analysis for 2014-2020 by region: US, Canada, Japan, Europe, Asia-Pacific (excluding Japan) and rest of the world. It is noteworthy that the CAGR of Asia/Pacific is nearly 50% for the period 2014-2020.

Table 1. Global market BIPV development and forecast from 2014-2020 in MW and compounded annual growth rate (CAGR) [3]

Region/Country	2014	2015	2016	2017	2018	2019	2020	CAGR (%)
Asia/Pacific	300	492	772	1,159	1,672	2,329	3.134	47.8
Europe	650	967	1,441	2,103	2,929	3,807	4,838	39.7
Rest of world	81	125	184	263	355	451	561	37.9
USA	319	476	675	917	1,200	1,491	1,766	33.0
Canada	42	61	86	119	157	190	228	32.6
Japan	143	201	268	349	434	520	612	27.5
Total (GW)	1.5	2.3	3.4	4.9	6.7	8.8	11.1	

Growing at a Compounded Annual Growth Rate (CAGR) of 39% over the analysis period 2014-2020, annual installation capacity of BIPV market is projected to further surpass 11 GW by the year 2020. The growth is justified through the rapidly plunging installed cost per watt, combined with enhanced aesthetics of BIPV, improving efficiency of c-Si modules as well as flexible thin-film panels, and unabated desire among residential and commercial owners to “go green” and to reach national energy efficiency targets.

In the upcoming years, the BIPV market is expected to grow strongly driven mainly by the revival of the construction industry. New constructions, retrofits and refurbishment works in both commercial and residential sectors are also expected to drive up strong demand for BIPV products in the coming years. Future growth prospects in the global BIPV market are significantly dependent on the extent of efforts by key members of the BIPV supply chain to enhance design and integration of PV into building structure, development of BIPV specific building codes and standards, and availability of attractive incentives at local and federal level to ensure cost-effectiveness of BIPV products. Segment-wise, BIPV roofing represents the largest segment in the global BIPV market, with an estimated 38.4% share of annual installation capacity in 2015. From an estimated 890 MW in 2015, the BIPV roofing market is projected to reach about 3 GW by 2020, growing at a CAGR of 29%.

For the year 2015 the BIPV market in Europe is estimated at 967 MW installed capacity and has the lead in BIPV installations worldwide. The attractive incentives in France, Italy and Germany have led to the increase in acceptability of these products in the residential sector. Figure 1 shows the European recent past, current and future of BIPV capacity in MW by country (France, Germany, Italy, Spain and rest of Europe) 2014 to 2020. The data is reported at the manufacture level. Countries analysed under rest of Europe include Austria, Belgium. Bulgaria, Czech Republic, Denmark, Finland, Greece, Hungary, Ireland, The Netherlands, Norway, Poland, Portugal, Romania, Russia, Slovakia, Sweden, Switzerland, Turkey and the UK. Error tolerance for the data is ~10% [3].

With support of special tariffs available for BIPV, markets such as the UK and Alpine countries are displaying healthy growth. Growing awareness about the merits of BIPV technology coupled with distinctive tariffs played a significant role in driving BIPV installations across Europe. The BIPV market in Europe is also being positively impacted by the regulatory framework in place for enhancing energy efficiency of residential and non-residential

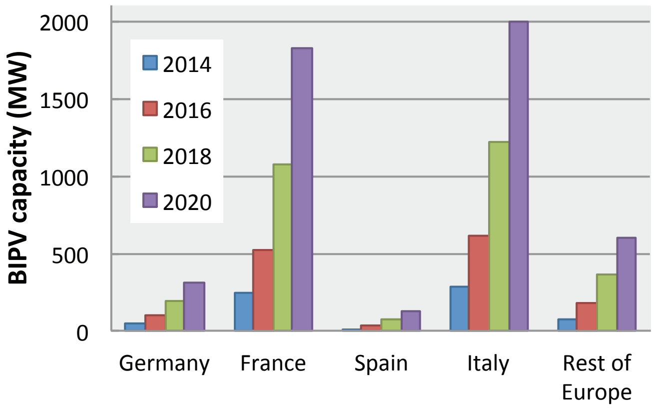

Fig. 1. European recent past, current and future (2014-2020) analyses of BIPV market for Germany, France, Spain, Italy and rest of Europe [3].

buildings. Stringent regulations are also being adopted due to rising energy costs, growing environmental concerns and political resolutions to reduce CO_2 emissions. Also, several European governments have agreed for setting passive house standards for new buildings by 2020, which has the goal to build nearly zero houses. On the European level the Energy Performance in Buildings Directive (EPBD) [8] and the Renewable Energy Directive [9] was set up.

The EU member states are making attempts to adopt renewable energy, particularly solar energy in buildings as a step forward to meet the energy targets. The EPBD aims to improve energy performance of buildings within the EU and increase the share of renewable energy. In addition the directive also requires all new buildings in the EU to meet the requirements of "nearly-zero energy buildings" by 2020. BIPV could support this target through the power production to meet own energy requirements and of course the efficient structures of construction. Of further importance is the fact that BIPV seamlessly integrates into the building's structure or envelope, whereby there is no need for extra space for BIPV installations compared to large-scale PV plants.

3. Educational needs

From the above it is clear that BIPV is seen as a potentially large market globally, as well as potentially a large market for European PV industry to excel in aesthetical and smart innovative PV products as answer to the traditional PV products produced predominantly in Asia. Since currently a gap exists in knowledge and skills of graduate architects, engineers, planners and designers etc. in relation to BIPV system aspects, innovative educational material is needed for education on BIPV on differing levels. This will thus improve the quality and relevance of higher, middle and lower education to labour market needs. The project Dem4BIPV [6] is addressing this by preparing five outputs: 1) framework and requirements analysis, 2) didactic content for students, 3) manual for academics, 4) development of Virtual Learning Environment (VLE) and Course adaptation, and 5) Deployment of remote labs. Especially the use of advanced ICT in developing virtual labs will allow large amounts of students to be trained in and exposed to BIPV.

3.1. Stakeholder analysis

Before educational material can be developed a thorough analysis of educational needs is performed using a questionnaire among identified stakeholders. First, an internal questionnaire among the Dem4BIPV project partners revealed the main stakeholder groups, i.e. related to buildings (architects, building contractors, building planners, manufacturers of building envelop products, electrical engineers), BIPV manufacturers (BIPV producers, mounting systems producers, façade manufacturers), installers (PV installers, electricians, façade installers), investors, research organisations.

3.2. Questionnaire

A questionnaire was developed in order to collect opinions on the educational needs related to various topics grouped together. We identified a large number of topics, but only the topics that were deemed important were used. The groups and topics used are listed in Table 2. Participants in the questionnaire were able to state their opinion on a 4-points scale (no need, not so strong need, fairly strong need, very strong need), besides 'don't know'. The questionnaire was available on the Internet for 2 months (February and March 2016).

Table 2. Groups and topics used in the questionnaire.

Group	Topic
Constructional integration	Combination with conventional building materials
	Building envelope material properties
	Moisture protection
	Orientation/inclination
Energetic integration	Electrical interconnection
	Electrical protection
	Effects of integration type on energy performance
Design integration	Glass (optical, colours,..)
	Sun protection
	Different BIPV /products / materials / technologies
	Aesthetics (variety of colours, sizes and types)
	BIPV software /tools for early integration in the design process
Regulatory barriers	Building law (EPBD - Energy)
	Heritage law
	Noise regulation
	Heat regulations
	Renewable Energy Directives
Economical barriers	Price of the BIPV systems
	Payback time
	Maintenance of the modules
	Feed-in tariffs
Standards	EC (low voltage directive)
	CENELEC
	prEN 50583
Maintenance and recycling	Recycling
	Exchange of the Modules
Manufacturing barriers	Customization vs. Standardization
Market driven barriers	Market maturity
Cultural barriers	Cultural barriers
Lack of information	Best practice examples/demonstration examples

3.3. Questionnaire analysis

In total 82 completed questionnaires were analysed. Results are shown in Figure 2. The educational needs for many of the topics were found to be strong or very strong. In fact, for 30% of the topics the sum of ‘strongly needed’ and ‘very strongly needed’ was larger than 75%. The topic ‘aesthetics’ scored highest with 92% combining ‘strongly needed’ and ‘very strongly needed’, followed by BIPV software /tools, market maturity, and building envelope material properties. This shows that the desire for innovative educational material for education on BIPV is not only important for the BIPV community (i.e., BIPV manufacturers, BIPV producers, mounting systems producers, façade manufacturers, PV installers, electricians and of course research organizations). The result ‘strongly needed’ and ‘very strongly needed’, followed by BIPV software /tools, market maturity, and building envelope material properties. This shows that the desire for innovative educational material for education on BIPV is not only important for the BIPV community (i.e., BIPV manufacturers, BIPV producers, mounting systems producers, façade manufacturers, PV installers, electricians and of course research organizations). The result indicates that also other stakeholders like architects, building contractors, building planners, manufacturers of building envelope products, electrical engineers, investors are interested in BIPV education. These are new players in the BIPV sector, who were not related to BIPV in the past. We thus conclude that BIPV education has to be multi-disciplinary to meet the knowledge skills of different branches and create a common understanding. Also the level of education ranges from higher education, postgraduate students in relevant fields (i.e. architecture, engineering, etc.), to vocational and tertiary sector employees (i.e. PV installers) and also professionals (i.e. architects, engineers, planners etc.). Educational needs are diverse in nature, thus requiring new methods of teaching and learning, so that students, both professional and vocational acquire relevant skills that enhance their employability and bring BIPV from a niche market to a mass market.

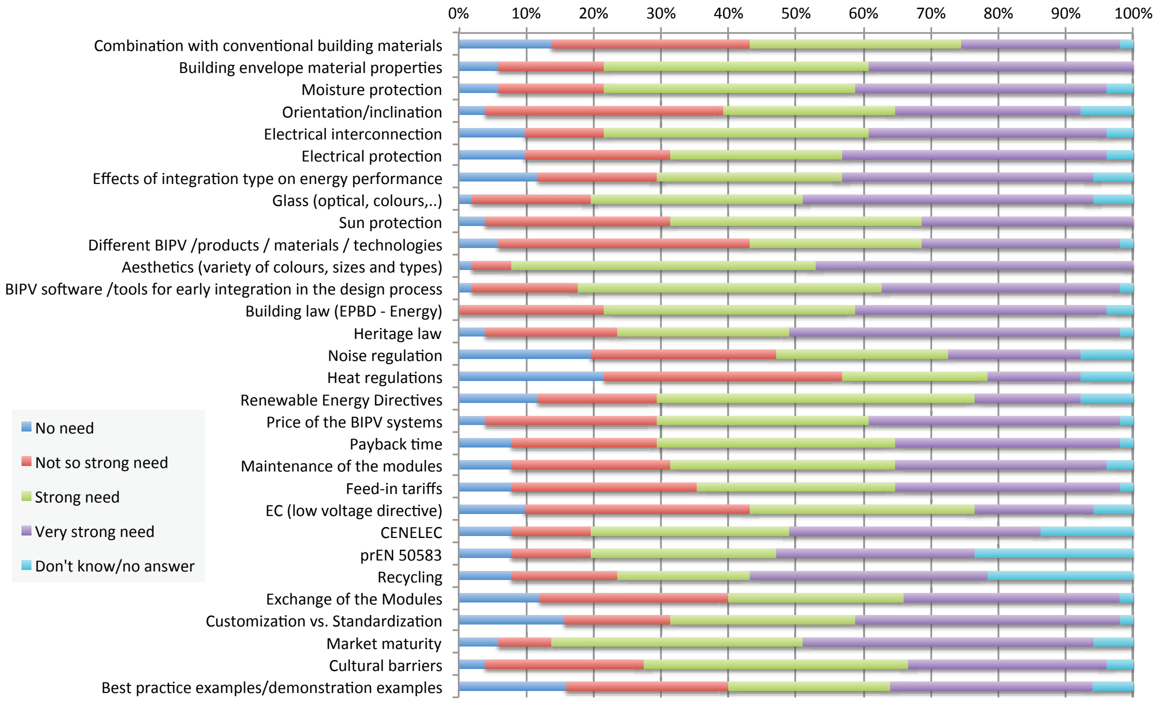

Fig. 2. Analysis of the educational needs in BIPV in different sectors through a questionnaire among identified stakeholders.

4. Conclusion

This paper has briefly reviewed the present status and outlook of the BIPV market, with focus on the European dimension. This was completed with an analysis of stakeholder views on the educational needs in the field of BIPV by means of a questionnaire, as to identify major knowledge gaps in education. This information will be used for the development of course material, i.e., didactic content for students, development of a virtual learning environment and remote labs.

Acknowledgements

This project is funded by the KA2 Strategic Partnerships for higher education programme of Erasmus+ under contract 2015-1-NL01-KA203-008882. The authors would like to thank all persons and organizations that have cooperated in the research questionnaire for sharing their information and knowledge.

References

[1] K. Farkas, L. Maturi, A. Scognamiglio, F. Frontini, M. Cristina, M. Probst, C. Roecker, M. Lundgren, Designing photovoltaic systems for architectural integration, criteria and guidelines for product and system developers, Report T.41.A.3/2: IEA SHC Task 41 Solar Energy and Architecture, (2015).
[2] F. Frontini, P. Bonomo, A. Chatzipanagi, G. Verberne, M. Van den Donker, K. Sinapis, W. Folkerts, BIPV Product Overview for Solar Façades and Roofs - BIPV Status Report 2015, Eindhoven (NL) & Lugano (CH), 2015.
[3] Global Industry Analysts, The global building integrated photovoltaics (BIPV) market, 2015., 2015.
[4] European Commission, Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC Text with EEA relevance, European Product Reg, Off. J. Eur. Union. L 88, 4-4- (2011) 5–43.
[5] Cenelec, Standard Photovoltaics in Buildings, prEN 50583, (2012).
[6] Dem4BIPV, (n.d.). www.Dem4BIPV.eu (accessed October 24, 2016).
[7] E. Delponte, F. Marchi, F. Frontini, C. Polo, K. Fath, M. Batey, BIPV in EU28, from niche to mass market: an assessment of current projects and the potential for growth through product innovation, in: 31st Eur. Photovolt. Sol. Energy Conf. Exhib., 2015: pp. 3046–3050.
[8] European Commission, Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings, Off. J. Eur. Union. L 153 18.6 (2010) 13–35.
[9] European Commission, Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC., Off. J. Eur. Union. L 140, 5-6 (2009) 16–62.