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A comparative review of building integrated photovoltaics ecosystems in selected European countries

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ABSTRACT

Building integrated photovoltaics (BIPV) is one of the most promising contributors to net-zero energy buildings, while also increasing the aesthetic value of the built environment. Nevertheless, it currently is predominantly operating in a niche market of ~ 1% of the global photovoltaics market. In this paper we provide a thorough Multi Criteria Decision Analysis of the BIPV ecosystem (markets, stakeholders, and policy and legislation) in various European countries, i.e. the Netherlands, France, Germany, Switzerland, and the United Kingdom. Environmental legislation and building requirements were found to be similar, as all countries have the European Energy Performance of Buildings Directive (EPBD) in common. It was found that implementation of the EPBD differs per country, evidenced by different support schemes in effect. Also, harmonisation of building codes hampers BIPV development. The analysis provides a basis for developing a BIPV ecosystem, which may differ per country. Also, clearly the BIPV sector crosses national boundaries, and should therefore be reviewed and developed from an international perspective.

1. Introduction

The market for Photovoltaics (PV) has been turbulent in the past years, with sharp price reductions in 2012 and increasing interest in the technology and its gains. It now has entered a more mature phase, after a severe shakeout of PV companies. Prices have stabilized, market volumes show a healthy growth and national support schemes are being reduced or redefined. At the same time an interesting market segment is emerging: building integrated photovoltaics (BIPV) [1–4], that integrates PV into the building envelope.

The contribution of photovoltaics to renewable electricity generation is 1.8% globally (status end 2016) [5], and in the 28 member states of the European Union (EU28) PV electricity is responsible for ~ 10% of the total renewable energy production [6]. Also, the EU28 is well under way to reach the 20% renewables target in 2020 [6], and policy is now being developed to reach the 27% renewables target in 2030 [7]. Roof and façade PV potential have been analysed and a near 1 TWp capacity for EU has been determined [8]. Compared to the present PV capacity of 103 GW in EU28 a huge potential exists, especially noting that a considerable amount of PV is installed in large-scale field installations. In fact, another paper [9] reported that PV integrated or added to buildings would be able to cover 24% (France) to 40% (Italy) of electricity demand in various EU member states.

The main definition of BIPV is that it involves (construction) elements in the building envelope that contain at least one additional function besides generating electricity (e.g. insulation or exterior weather barrier). Generating decentralized energy within the built environment aids to provide a redundancy of the current electricity network, defines a state of independence, improves energy efficiency in the building and avoids transportation losses in electricity grids [10]. Its key market driver is the European Energy Performance of Buildings Directive (EPBD) 2010/31/EU [11], which is being renewed in the so-called 'Winter Package' [12]. The present directive states that all new buildings of the 28 EU member states should be nearly zero energy buildings (NZEBs) by 2020. Clearly, one possible solution to realize NZEBs is the generation of renewable electricity on-site, by means of (BI)PV, or even urban wind.

Adding PV on the roofs of buildings, especially when these buildings are taller than 3 storeys, may not be generating sufficient energy to meet the building electricity demand. Façades offer additional potential for PV [8], either applied to the façade surface itself (Building Added/Attached/Applied PV, BAPV), or integrated in the façade (BIPV) in

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particular as the use of large glass façades is a growing trend. Specific BIPV designs and engineering have been reviewed recently, see, e.g., [1–4,13–16], and references therein. BIPV applications offer the possibility to replace regular building envelope components into prefab integrated components that at the same time generate electricity [3] BIPV applications are flexible in size, shape, colour, and appearance and can be combined with materials commonly used in construction, such as glass or metal [2]. This contributes to the aesthetic value of a building, allowing flexibility in architectural design [17]. Performance of BIPV in urban areas depends on orientation and tilt, just like PV panels on roofs, but more importantly on the surrounding buildings or other shadow-casting structures. Modeling of performance to predict annual yield of BIPV is more complex than regular PV [18].

The present size of the global BIPV market is about 2.3 GW (or ~ 1% of the global PV market) [19], with Europe constituting the largest market (42% of global market) in particular due to attractive incentives in France, Italy and Germany. The BIPV market is still a niche market. Based on the EPBD and its renewal to include building renovations a ten-fold increase of the European BIPV market is estimated for 2020, leading to a market share of 3% of the global PV market [19]. Several barriers need to be surpassed though, which relate to integration of the PV industry and the building industry. This may hamper the relative market size of BIPV to the market size of PV itself. Interestingly, about two-thirds of the European BIPV market is realized in new buildings, and one-third in renovation [20]. Façade BIPV accounts for half of the projects. A recent inventory shows hundreds of BIPV products offered [4].

On a global level, Europe and the United States dominate the BIPV market, while Asia is addressing BIPV as well [21]. Table 1 shows the results of a BIPV market analysis by region including expectations up to 2020. Irrespective of the region, the compounded annual growth rate is > 30%, except for Japan. This is envisaged as the costs are expected to decrease fast while the attractiveness of BIPV in terms of aesthetics and flexibility lead to market growth. In addition, the construction industry is recovering from the economical crisis, allowing for new constructions and renovation of buildings in the commercial and residential sectors.

In support of the development of BIPV in the Netherlands a BIPV roadmap has been developed, which identifies eleven of challenges in the field of technology (T), market (M) and ecosystem (E) to achieve a 5% BIPV share of total PV capacity in the Netherlands by 2020 [22], see Fig. 1. These challenges are integration of functions (T1), flexibility in colour, shape and size versus acceptable cost (T2), flexibility in colour, shape and size versus acceptable efficiency (T3), flexible choice of substrate materials (T4), unifying demand (M5), collective market approach (M6), information/communication of BIPV (M7), new business models (M8), collaboration in the value chain (E9), cross-sectorial collaboration (E10), BIPV in education and training (E11).

Table 1
Global market BIPV development and forecast from 2014 to 2020 in MW and compounded annual growth rate (CAGR) [19].

Region/Country	2014	2015	2016	2017	2018	2019	2020	CAGR (%)
Asia/Pacific	300	492	772	1159	1672	2329	3134	47.8
Europe	650	967	1441	2103	2929	3807	4838	39.7
Rest of world	81	125	184	263	355	451	561	37.9
USA	319	476	675	917	1200	1491	1766	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	

A first BIPV ecosystem analysis for the Netherlands was presented recently [23], and the present study has continued on these outcomes by reviewing the international situation for BIPV and the role of the Netherlands in this. The focus countries that were studied in this research are France, Germany, Switzerland and the United Kingdom. The purpose of this research was twofold, to determine what a specific country can learn from the situation for BIPV in other European countries (internal analysis) and to assess which countries show interesting opportunities for BIPV companies from that particular country (external analysis). Such a combined internal and external analysis could be performed for every country, but in this paper the Netherlands is taken as a case study example.

2. Methodology

The steps that were taken during the study are shown in Fig. 2. By using a stakeholder analysis and a so-called DESTEP-analysis (Demographic, Ecological, Socio-cultural, Technological, Economic and Political ecosystem factors) it was assessed per country, which parts of the ecosystem are already well established, and which gaps are still existing. This information was analysed in both an external and internal analysis for the case of the Netherlands, from which recommendations were derived.

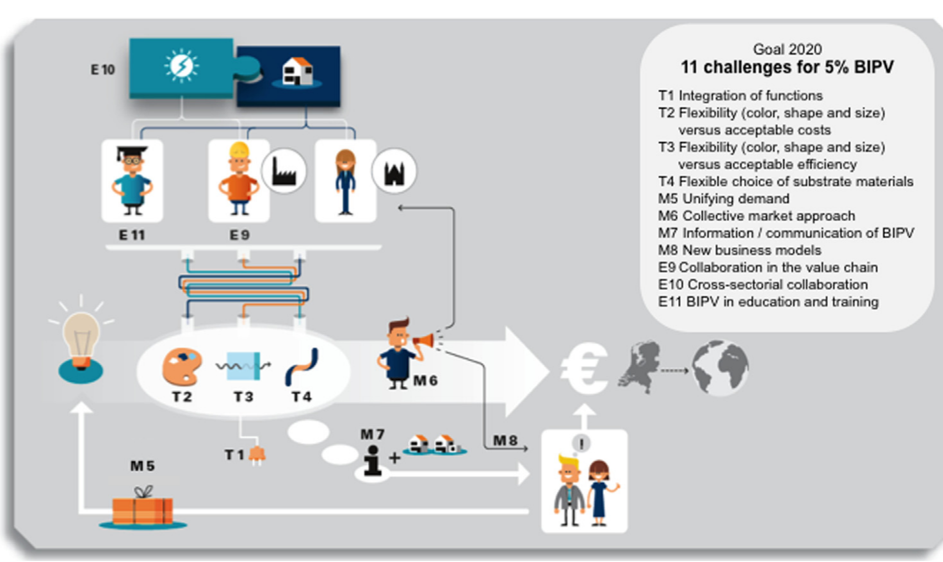

Fig. 1. Challenges to achieve a 5% BIPV share of total PV capacity in the Netherlands by 2020 [22].