An Overview of PVT modules on the European Market and the Barriers and Opportunities for the Dutch Market

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Abstract

The market for Photovoltaic-Thermal (PVT) systems and the number of PVT module suppliers is growing. We will present a summary of our recently published market survey of PVT modules. In our market investigation we found 54 different PVT module types that are currently being sold. The largest share of these, roughly three out of four, are uncovered flat plate PVT collectors. Furthermore, a list of barriers and opportunities will be presented as perceived by a wide range of stakeholders in the Netherlands. The main opportunities that were identified are a higher combined thermal and electrical yield per square meter. Furthermore, a combination with heat pumps and the possibility to achieve a (near) zero energy building and aesthetic integration was seen as an opportunity. Several barriers were identified. The largest is the complexity of the system design, the optimization of the system and installation. Furthermore, the high upfront costs and the lack of standardization were mentioned as barriers.

Keywords: PVT collector, PVT market study

1. Introduction

The market for Photovoltaic-Thermal (PVT) systems and the number of PVT module suppliers is growing. This paper presents a market survey of PVT modules and a classification of PVT heat pump systems. Furthermore, a list of barriers and opportunities will be presented as perceived by a wide range of stakeholders in the Netherlands.

In the built environment, the main energy use consists of electricity and heat. Regular PV systems convert approximately 15-20 % of the incoming radiation to electricity, while ca. 75% is converted into waste heat. In hybrid Photovoltaic-Thermal (PVT) systems, a part of this energy is transferred to a liquid or air, and harvested as (useful) heat. This way, multi-functional PVT roofs can play an important role in the supply of local renewable energy, both in the form of electricity and heat. A promising option to reach near zero energy residential buildings is the combination of PVT collectors with a heat pump.

This benchmark report takes a look at the PVT market in Europe with a special focus on the Netherlands. We will answer the following research questions:

- Which PVT collector producers are active on the market?
- What type of PVT collector are produced?
- What are the current market prices for PVT collectors?
- What are the opportunities and barriers for PVT products in the Netherlands

2. PVT Market Survey

2.1. Module classification

Several previous market surveys have been published and include a classification of modules (Zondag, et al., 2006; Adam, et al., 2014; Zenhäusern, et al., 2017; Department for Business, Energy and Industrial Strategy, 2017). The attention for PVT systems and the number of suppliers is steadily growing. There are a lot of parameters that can vary and characterize a PVT module. These include e.g.:

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- Type of PV laminate: crystalline silicon, CIGS, CdTe, III-V etc.
- Type of collector: flat plate liquid, flat plate air, concentrator, vacuum tube
- Type of heat transfer medium: air, water or water-glycol mixture
- Type of absorber: sheet and tube, a free-flow and a dual channel, roll bond.
- Type of insulation: covered, uncovered with or without thermal insulation
- Building integrated or not building integrated
- Method for attaching the PV module to the absorber

In this benchmark we use the classification as defined in the PVT Norm Project (Adam, et al., 2014), see also figure 1.

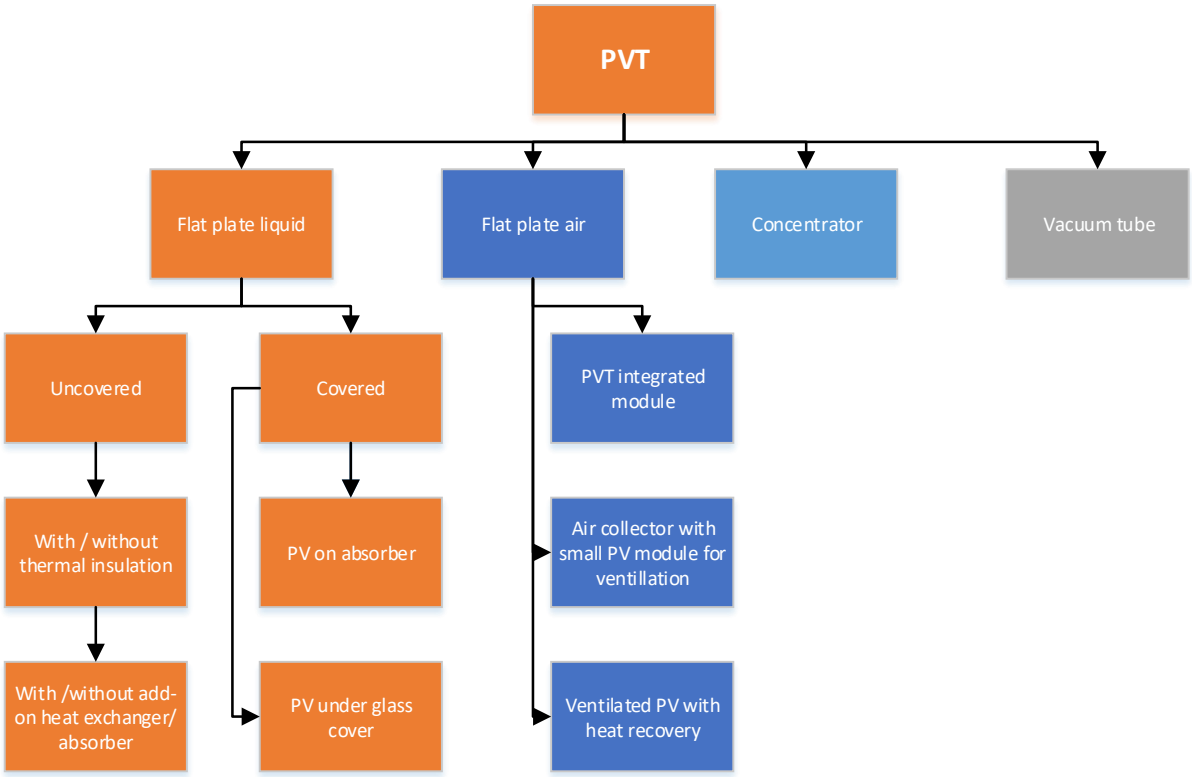

Fig. 1: PVT Module Classification (adapted from (Adam, et al., 2014))

2.2. Market analysis

A market analysis on available PVT products was carried out in 2017. The modules have been categorized into different categories. Out of the 92 different PVT modules found, 54 modules are currently sold, out of which 11 originate from the Netherlands. Furthermore, 6 products are in development and 32 have been taken out of production. A full list is provided in the PVT benchmark report (de Keizer, et al., 2018).

The PVT market is very dynamic, with new companies entering the market, as well as PVT products being taken off the market. The last decade has seen a growing number of companies offering PVT modules. This is thought to have originated from a decline in prices of photovoltaic modules as well as a stronger focus on reducing fossil energy use in the built environment.

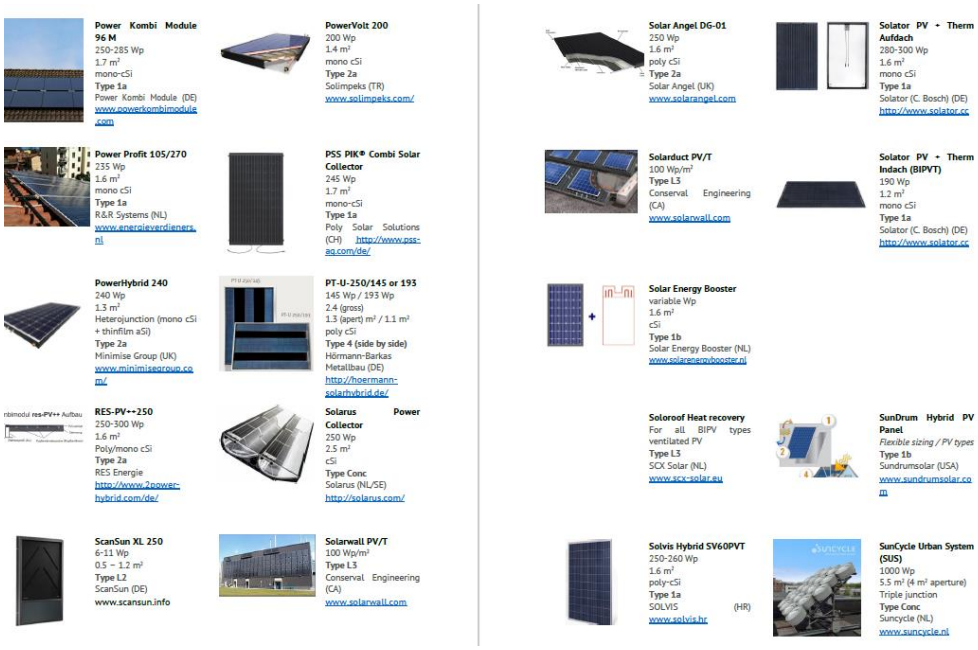

Fig. 2: Screenshot of PVT module overview, the report can be downloaded at www.seac.cc

The classification in Figure 2 shows a large share of uncovered flat plate liquid collectors. These account for 72% of the total PVT module availability. In the Netherlands, the uncovered flat plate liquid modules even represent 82% of all modules. Uncovered flat plate collectors perform well for applications that require a low temperature, like regeneration of a ground-source heat pump or in general with heat pumps. Furthermore, for covered PVT products there is a large tradeoff between the desired higher temperature for thermal applications and the desired low temperature for PV cells. Furthermore, stagnation can lead to very high PV temperatures.

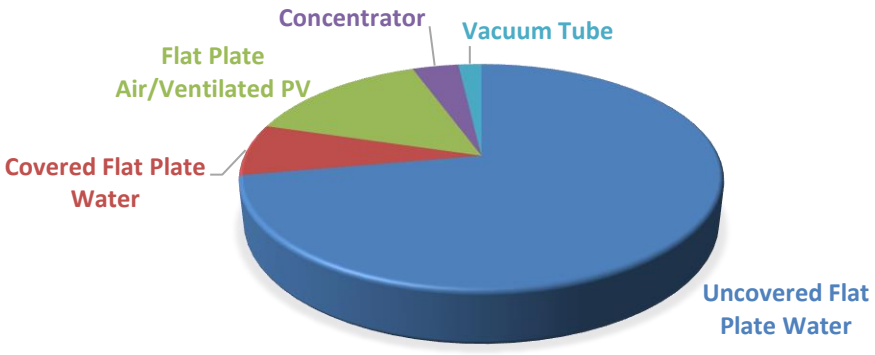

Fig. 3: Types of PVT modules on the market

A price survey for uncovered flat plate liquid PVT modules was conducted. The results are shown in Figure 3. The left graph shows a box plot of the module price, the middle shows the normalized module price in €/m2 and the right graph shows the price per Wp. It can be seen that there is a large range in pricing. The average price of PVT modules is 323 €/m2 with a standard deviation of 98 €. The PVT price is about half of that in 2005, however, this decline is mainly caused by declining PV prices. Since PVT is still a technological niche, there are expectations that prices can decline further in the future.

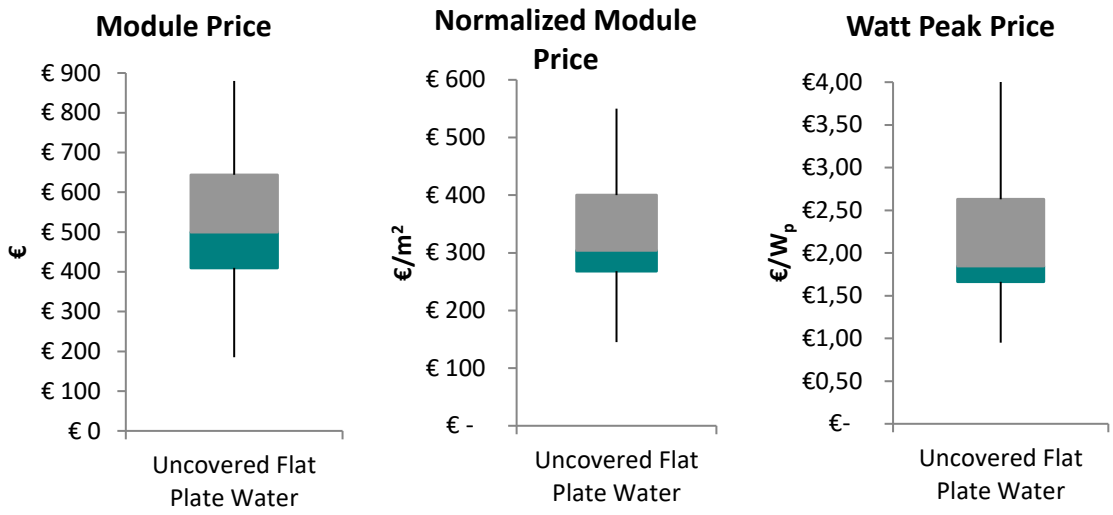

Fig. 4: PVT Module Price, Normalized Module Price and Watt-peak Price

3. Barriers and opportunities

PVT is a promising technology, as the exergy output of the module can be higher than that of solar thermal collectors or photovoltaic modules per square meter. However, this alone is not a guarantee for becoming a dominant technology or conquering a large share of the market. In this section, we present the current barriers and opportunities for PVT in the Netherlands as perceived by different stakeholders. 28 interviews of different stakeholders in the Netherlands were carried out, among the interviewees were PVT, PV, solar thermal and heat pump producers, government parties, experts, installers and project developers. Furthermore, a literature study was carried out that included 15 research papers that were published between 2000 and 2016.

Many opportunities are identified in the literature and interviews, while also many barriers are mentioned. The literature seems more optimistic than the interviewees. Table 1 shows an overview of the most frequently mentioned barriers and opportunities.

According to literature, the advantages of PVT heavily outweigh the disadvantages. About half of the papers analysed, mention economic aspects for PVT as an opportunity as well as a high energy efficiency and yields. However, from the interviews it was concluded that the economic profitability is still low, while initial investment costs are high and that can be a hurdle. Some synergy effects in literature that would lead to lower pricing, like use of one installer and less material costs than both a separate PV and solar thermal system were not confirmed in the interviews. However, this does not mean it cannot grow into an opportunity in the future.

The main strength of PVT is based on the compactness: PVT is convenient or maybe necessary for those with limited roof area, as well as for consumers demanding the most energy per unit of area. In practice, many solutions do not require the full roof area, unless a transition to a zero-energy home is made. The main barriers for PVT are either in the technical or economic domain; technical improvements often directly improve the economics.

Tab.1: Overview of opportunities and barriers found from literature (L) and interviews (I)

Strength & Opportunities	**L*** **15**	**I*** **26**		**Weaknesses & Barriers**	**L** **15**	**I** **26**
Compactness and yields	12	18		Complexity of system design and installation, difficulties in optimisation	9	20
Combination of PVT with heat pump	12	25		Reliability	8	6
BIPVT (Building integrated PVT)	8	2		Low economic profitability and high investment costs	8	21
Third-party owned business models (financing schemes)		3		Competition with PV and solar thermal collectors	5	8
Energy performance regulations for dwelling (EPC/BENG) and renewable energy targets	3	11		Lack of testing, standards and certification, EPC calculations unclear	4	9
Aesthetics (homogenous roof)	10	5		Conflict of interests real estate developer and resident		10
				Subsidy Landscape unclear	3	3
				Thermal yield hard to monitor		6
				Lack of awareness	8	12

* L – Literature, I – interview. In the literature also financial attractiveness and reduced cost because of combining installations are mentioned. However, this is currently not the case. Two different installers might make it more complicated. In the interviews also an improved PV performance is mentioned, because of lower temperatures.

Table 1 shows that many barriers are faced by PVT technology. A PVT system is more complex than a PV system for both planning and installation. There are less rules of thumb and easy planning tools available. Demand for hot water and space heating lead to a higher complexity of dimensioning and optimization of the system configuration and component sizes. The thermal performance for a badly designed system as well as reliability can be low. Furthermore, there has been a lack of continuation of PVT producing companies, this can lead to distrust and lack of warranties. The complexity of the installations, mentioned many times by the interviewees was not foreseen by the literature. In fact, the literature opted for lower installation costs due to a combined installation, but in practice, this is far from happening. The main advantage of PVT is seen as the compactness of the modules and the ability to generate high yields. The combination with a heat pump showed to be the preferred system configuration and the aesthetic integration of PVT can be the first major improvement for PVT. Many interviewees argue that uncovered PVT cannot become financially attractive without a heat pump. Many interviewees expect a longer lifetime and higher electrical efficiency in PVT due to cooling, however this is insufficiently proven in practice yet.

The high investment costs are also a barrier, this could partially be overcome by introducing innovative, third-party owned business models, exploiting the system and omitting the threshold of the initial investment. Having low economic profitability is a common factor for innovations. Having no clear regulations, standards and certifications is a common barrier for niche technologies. Furthermore, the possible conflict of interest between real estate developers and residents retains the diffusion of renewable energy technologies. Despite the lack of a clear overview of calculations, it is expected that installing PVT could contribute greatly to the 2020 and future goals of the government. The social factors show that the aesthetics of a PVT system fits between a BIPV and a side-by-side system, and can be improved if the BIPVT development accelerates. The awareness for PVT is still low for both potential consumers as well as the installers, which should be the largest sales channel.

The conclusion can be drawn that PVT is still a technological niche. The early adopters and especially the innovators consider environmental benefits and being precursors by showing new innovations as requisites for adoption. The uncovered PVT module combined with a heat pump is currently the most promising system configuration according to most interviewees. The barriers of high investments costs and low economic profitability are less relevant for the innovators, while they attach value to the transition towards renewables and aesthetics of their building. Such a system would generate domestic hot water as well as space heating and can be

a retrofit, renovation of part of a newly-built dwelling. Such a system with a heat pump is easiest installed in a new dwelling, reducing costs and complexity of the installation. The interviewees consider both the construction and renovation as possible markets for PVT. Furthermore, technological innovation and a growing market could help to overcome certain barriers.

4. Conclusion

The market for Photovoltaic-Thermal (PVT) systems and the number of PVT module suppliers is growing. In our market investigation we found 54 different PVT module types that are currently being sold. 11 of these originate from the Netherlands. The largest share of these, roughly three out of four, are uncovered flat plate PVT collectors.

Opportunities and barriers were identified by interviews and a literature review. The main opportunities that were identified are a higher combined thermal and electrical yield per area. The largest barrier that was identified is the complexity of the system design, the optimization of the system and installation. Furthermore, the high upfront costs and the lack of standardization were mentioned. To become a successful market product, these barriers should be addressed.

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6. Acknowledgements

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