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# An economic analysis of the solar photovoltaic/thermal (PV/T) technologies in Sweden: a case study

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**Abstract.** The solar energy share in Sweden will soar over the next decades. Such transition offers not great opportunity but uncertainties for the emerging solar PV/thermal (PV/T) technologies. There are still critical challenges for PV/T development in Swedish scenario. This paper aims to investigate the local policies and market structures in Sweden by a set of analytical economic frameworks and a case study. A macro-economic exposure analysis in Swedish context is conducted and a PEST model is then applied for analysis of external environment of PV/T industry in Sweden. The PV/T market is further analysed based on a case product by means of SWOT and Porter's five forces. The whole study concludes that the market of solar PV/T is expanding mostly towards small-and medium-sized energy plants. The market position of the case company meets the trend of PV/T market, which has an overwhelming competence against its competitor in the domestic market. This paper is expected to clarify the economic situations of PV/T in Sweden and promote its further development towards sustainable and low-carbon economics.

**Keywords:** PV/T; Policy; Market; Strategy

## 1. Introduction

The energy goals for Sweden are stated in the Government's integrated climate and energy policy bills, which include energy policy targets by 2020 of a 40% reduction in greenhouse gas emissions, at least 50% use of renewable energy, and a 20% more efficient energy end use. In addition, the use of fossil fuels for space and tap water heating is to be phased out by 2020 [1]. These facts are significantly motivating the development of energy efficiency solar gains and decarbonized economy in Sweden for the aid in transition to future sustainable economic growth and social welfare. Such transition offers not only great opportunity but also uncertainties for the emerging solar PV/thermal (PV/T) technologies. Currently, there is no research specifically addressing the economic evaluation of PV/T technologies in Swedish scenario. There are still critical challenges for PV/T development in Sweden, such as unclear market size/position and weak development strategy. It is likely that the economic results would be different if the study is performed in another country or even in the same country today, as costs, tariffs, and policies are changing. It is thus necessary to clarify the local policies, and market structures for the PV/T technology in Sweden. This paper aims to investigate the local policies and market structures in Sweden by a set of analytical economic frameworks and a case study. A macro-economic analysis in Swedish context is conducted in section 2 along with a PEST analysis. The PV/T market is further analysed in section 3 based on a case product in section 4 by means of SWOT and Porter's five forces. This paper is expected to clarify the economic situations of PV/T in Sweden and promote its further development towards sustainable and low-carbon economics.



## 2. Macroeconomics of Sweden and PEST analysis related to PV/T industry

### 2.1. Macro-economic analysis of Sweden

According to the data from World Bank [2], the annual GDP growth rate in Sweden has been rather stable during the last decades, with an average value of about 2.0%, reaching maximum of nearly 6.0% in 2010 and minimum of -5.18% in 2009 owing to the economic crisis. The Sweden GDP growth rate is projected to trend around 2.60% in 2020, mainly depending on net exports and government spending [3]. The Energy use in Sweden varies with the GDP growth rate, which dropped slightly in the last 25 years from a high of 5800 kg of oil equivalent per capita to around 5000 kg of oil equivalent per capita, but the overall volume of energy use is quite stable. The share of renewables increased a lot, ranging from 38% to 64% during the period from 1990 to 2016, which is projected to grow more in near future. These data indicates that Sweden's GDP is growing, and it will consume much more renewable energy, rather than the traditional fuels, during its further development, which opens large opportunities for energy generation firms. The inflation rate in Sweden decreased considerably in general from 2008 until 2017, with an averaged value of 1.20%, achieving peak value of 4.40% in first quarter of 2009 and lowest value of -1.60% in third quarter of 2009. Specifically, the consumer prices increased for housing and utilities (3.1% and 2.8%); meanwhile, cost declined for furniture and household equipment (-0.5% vs 0.4%). The inflation rate in Sweden is modelled at 2.40% by the end of 2017, and in the long-term, it is projected to trend around 2.60% in 2020 [3]. The interest rate in Sweden displays a mean value of 1.2% from 2008 until 2017, with highest value of 4.60% in 2009 and lowest value of -0.50% in 2016. It shows a significant drop in this period. In order to maintain a strong economic activity, the central bank of Sweden is expected to keep the repo rate steady at -0.50% until the year of 2020 [3]. The deposit interest rate is much smaller than the inflation rate, which aims to stimulate the economic activities and call up new business or banking models to return customers' investment at higher rate. The overall wages, and consumer spending in Sweden are keep increasing significantly from 2008 to 2017 [3]. A great increase in the household saving rate is observed from around 5% in 2005 to less than 16% in 2018 [4]. All these figures demonstrate an increasing buying power (potential investment capacity) of consumers.

### 2.2. PEST analysis for general business environment in Sweden

**Political factor:** Sweden has committed to 100% renewable energy by 2040, in which solar energy is planning to contribute to 5-10% to electricity generation compared to today's marginal level of less than 0.1% [5]. The government promotes renewable electricity through a quota system, tax regulation mechanisms and a subsidy scheme. In Sweden, tax exemptions are the main incentives to support renewable heating [5]. In Sweden, the grid operator is obliged to connect electricity generation systems to the grid, transmit electricity and expand the grid. But renewable energy is not yet given priority. Companies operating a district heating network are obliged to negotiate terms to connect a heating plant. Since 1 January 2008, a new law on energy declaration of buildings has been in force in Sweden. The government issued a national programme for energy efficiency and energy-smart construction. This energy policy established the conditions for efficient and renewable energy use and cost-effective energy supply in Sweden with low negative impacts on environment and climate. Sweden introduced green electricity certification in 2003. Green electricity must come from renewable recourses, such as wind, solar, geothermal or wave power, biofuels or small-scale hydroelectric plants. Electricity retailers are required to buy a proportion of 'green electricity' as part of their normal supply, while power producers receive certification for the renewable electricity they generate.

**Economic factor:** The Swedish economy is thriving, which contracted during the global financial crisis and Eurozone crisis, but it has rebounded since then, showing economic growth at about 2.80% in 2017 when consumption and investments persisted, and depreciation of the Swedish Krona boosted exports. Public finances are healthy and the banking sector is well capitalised. Sweden has invested heavily in alternative energy sources since the oil crisis of the early 1970s. Sweden has found a way to reduce emissions while the economy is growing. Swedish businesses investing in renewable energy are increasing, and other sectors are putting greater emphasis on green energy and energy saving. In

addition, the government invests heavily in information and advice for households on how to incorporate renewable energy systems. The Swedish solar market is still limited, but it has begun to grow with the aid of government funding. For 2013–2016, the Swedish Energy Agency is investing SEK 123 million in research into solar cells, thermal solar power and solar fuels [6].

**Social factor:** The whole society of Sweden indeed shows a great awareness and concern about environmental dilemmas. Swedish carbon emissions are low compared with those of other countries. Sustainable development throughout society is the objective of Sweden's environmental work both inside and outside its borders, although this requires major behavioural changes at all levels and in all areas of society and a new environmental policy. Sweden is playing a leading role in corporate social responsibility, which, also known as sustainable business practice, is used to describe the work done by companies has a positive impact on society, environment or economy.

**Technical factor:** New environmental technologies have emerged as a new economic sector in Sweden. An essential part of the increase is due to renewable energy technologies that doubled since the oil crisis of the 1970's. Bioenergy and hydroelectric power contribute more than half the increase, but the country has also invested in wind, solar and geothermal energy. Renewable technologies are being applied in Sweden across all sectors, and there is a strong correlation between economic growth and reductions in waste and greenhouse gases, the optimum use of natural and human resources, and the production and conservation of energy through ongoing innovation. Sweden is the world leaders in bioenergy, and is playing the leading role in other renewable sectors, such as concentrated solar technology, thin film solar cells, energy storage and smart grid. However, Sweden's position in the innovation league is declining because its industrial structure is outdated. Many large Swedish companies relied too much on technological breakthroughs a long time ago, which is profitable but not sustainable as they usually increase production capacity for higher revenue.

### 3. Market analysis of PV/T industry in Sweden

The Sweden's market for solar photovoltaic (PV) energy is very small. Nevertheless, the installation rate of PV continues to increase. In 2016, a total of 79.2 MWp were installed, showing the annual PV market grew with 63 % as compared to the 48.4 MWp installed in 2015. For the PV market, the off-grid PV application accounts for a very small share, with only 1.5 MWp installed in 2016; while the market for grid-connected PV systems has grown rapidly in Sweden, with 77.7 MWp systems installed in 2016 [6]. There has been a clear shift from a market dominated by off-grid systems to a grid-connected market, in which the grid-connected distributed PV systems dominates the market, mainly due to the tax law for large centralized PV systems. Solar energy in Sweden is expected to contribute 5-10% to electricity generation in 2040, which means the share of solar electricity production within the total power generation mix will rise from 0.1% in 2016 to 5-10% in 2040, which is up to 100 times of current solar power capacity if the total electricity generation remain stable as past decades. However, the PV market in Sweden is still relying much on subsidies, and the PV system prices must continue to go down, or the electricity prices to go up if PV needs to contribute to an appreciable part of the Swedish energy mix. Moreover, the Swedish PV market is becoming broader as more and more players with other core businesses, such as utilities and real estate owners, are taking an increasing interest in the PV market. A high competition on PV market will be expected in the near future.

The Swedish solar thermal market is decreasing significantly from 2011. The total number of the installed solar thermal collectors in 2016 was only about 2,823, nearly half of the installed capacity in 2015. The solar thermal market faces increasing competition with other energy technologies, such as biomass boilers, district heating, heat pumps, PV. Typical solar thermal products in Sweden are flat plate and vacuum tubes collectors, while the concentrated solar thermal plants and PV/T products are very rare. Their application includes the fields of hot water and space heating, in operation with other energy system in the meanwhile. The market price of flat plate collectors has dropped in line with the overall development of collector prices across Europe, while vacuum tube collectors have become more expensive owing to less and less players in the area. IEA SHC [1] point out that the main market drivers are the national building code and indirect tax deduction for repair, conversion and extension

work can be made for installing solar heating systems. In contrast to PV, there is no direct financial support to solar thermal market. Other barriers are the lower prices of alternative energy technologies and the lack of information on solar heating systems among actors and consumers. The Swedish solar thermal market is disruptive. It has to face high competition from alternative energy systems, but with limited indirect policy support. Great barriers are found for its further development.

Technology drivers offer opportunities for disruptive market innovation. The innovative PV/T technology cogenerates of electricity and heat from the same area, but with less installation cost than installing both individual PV and solar thermals collector, resulting in the lower cost-to-performance ratio (e.g. 1.27 SEK/kWh of levelized cost of energy, 18,812.55 SEK of net present value and 10 years of payback period during its 25 years lifespan [7]) and enabling the possible development of solar thermal market along with the growing PV market. As a result, it offers opportunities for innovation in Swedish solar thermal market. Meanwhile, PV/T technology lowers the energy price per square meter, reducing the dependence degree of PV on governmental subsidy and thus making the target set by the government achievable [8]. Because PV market is shifting to the grid-connected distributed systems, and solar thermal market is indirectly driven by national codes for low-energy buildings and nearly zero-energy buildings, it is expected the Swedish PV/T market will expand mostly in building sector.

#### 4. A Case study of a Swedish company (Absolicon) with PV/T product (X10PVT)

##### 4.1. Market position

In the past, Absolicon company's marketing strategy was to cultivate the market by building up pilot plants with customers to demonstrate how to reduce their energy costs with solar energy [9]. Absolicon's current marketing strategy is to establish a distributor network in export markets and make the sales volumes more efficient. They are looking for a distributor or customer to expand the sales. In the long run, Absolicon recognizes that partnerships are needed to scale up production and reach customers. To increase its market competitiveness, Absolicon develops a production line in the same time that can radically reduce manufacturing costs. Fig. 1 shows the cost comparison between Absolicon's X10PVT and other commercially available PV/T products.

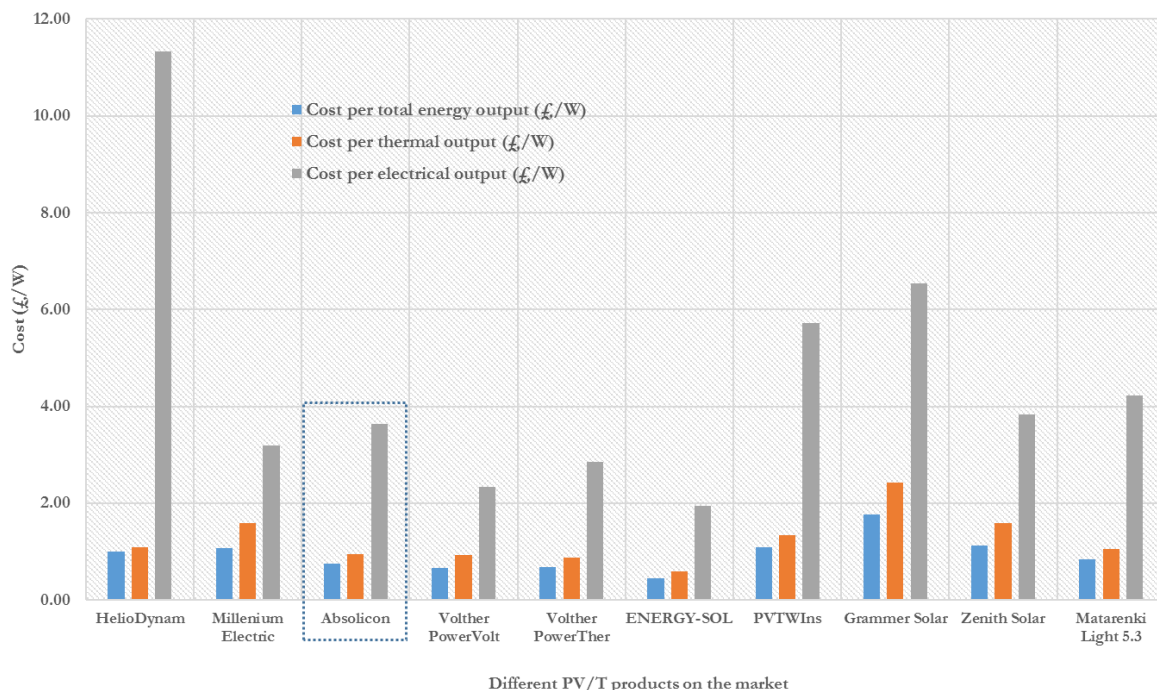


Fig. 1: Cost comparison of commercially available PV/T products

At the similar energy output level, i.e. thermal output of about 400 W/m<sup>2</sup>, electrical output of 100 W/m<sup>2</sup>, the cost for Absolicon's X10PVT product is around 400 £/m<sup>2</sup>, positioning it in the middle class

of the cost category. But considering its thermal output is at higher temperature (higher exergy) than the flat-plate ones (e.g. Volther), the cost per exergy of X10PVT is the lowest in this case. When comparing to the concentrated types, such as Heliodynamics of 1.1 £/W and Zenith Solar of 1.2 £/W (belongs to ‘Suncore’ company), the cost of Absolicon’s X10PVT is nearly the lowest at 0.75 £/W. The three types of concentrated PV/T products are similar cost, but targeting at different energy output and applications. So in short, Absolicon successfully keeps its cost competence at the market and has clear customer group who needs medium-sized plants at 500 W/m<sup>2</sup> in total. This market position meets the trend of solar market in Sweden, which shift towards small and medium-sized energy plants.

#### 4.2. SWOT analysis

**Strength:** Absolicon is an existing leading player in the Swedish market. It has two production lines with considerable manufacturing capacity for low cost products. It is strong in R&D and innovativeness by organic/sustainable and collaboration with research institutions. Its multiple business streams strengthen the company’s competitive advantages and reduces its vulnerability.

**Weakness:** Absolicon has a slow grow rate when its revenue was nearly the same in the past three years. It has negative operating profit due to the low return of its investment in pilot projects and poor distribution and sales networks. Its operation efficiency is overall low. It lack a flexible business model and multiple business streams. **Opportunities:** there is a growing demand especially for the PV, and most of the governmental policies support the deployment of Absolicon’s products. The modelling results shown in Chapter 6 demonstrate the potential application areas and ways for the company’s product. The company has a clear vision of solar market and its customer group. It attracts a lot of attention by doing a few pilot projects, and this would further help the company to attract more investment at current laxer economic environment. This is also desired for the retrieve of solar thermal market by inputting innovative products. **Threats:** Absolicon relied heavily on liability and capital rising while it spent a large amount of investment for the pilot projects in the past two years, which however, has a low return and may increase its future financial risk. The company only has three products and will face competition when the market grows. The Swedish PV industry is becoming broader as more players with other core businesses, such as utilities and real estate owners, are taking an increasing interest in the PV. A high competition in PV industry will be expected in the near future.

#### 4.3. Porter’s 5 forces

Fig. 2 illustrates an overview of competitive pressure of Absolicon. The high degree of competitive pressures lie in power of customers and threat of substitution, while the competitive rivalry and power of suppliers stay low and the threats of new entry is medium.

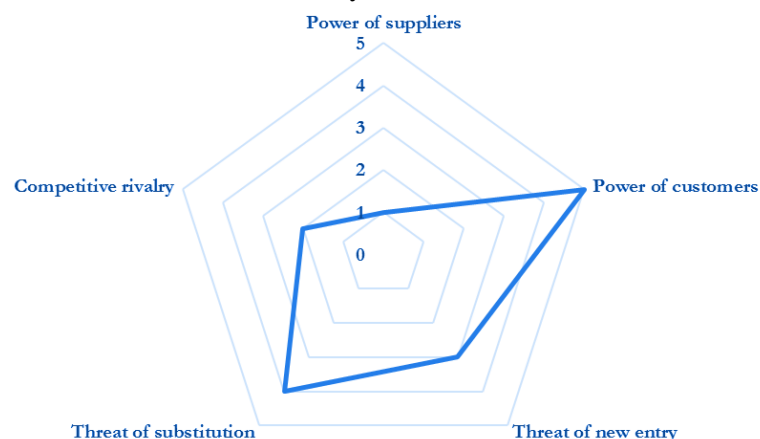


Fig. 2: Degree of Porter’s five competitive Forces

**Power of suppliers (very low):** most of the components of Absolicon’s products are similar to other PV and solar thermal collectors, from Europe and elsewhere in the world. There is a wide range of selection of suppliers. The company’s raw materials are mainly silicon PV cells, glass and metals, such as aluminium and copper. Other material expenses related to the suppliers, such as plastic,

chemicals, thermal oil, follow the general price trends in the markets. **Power of customers (very high):** Absolicon's sale relies heavily on a limited distributors and customers. They are still working on demonstration of their products through pilot projects. In addition, the potential customers have several alternative products, such as standard PV, wind turbine, heat pump, industry waste heat, and other renewable or energy-efficient recourse products. The company has a business only in a small part of Europe and China, where customers' choice is very sensitive to the performance of whole company. **Threat of new entry (medium):** It is hard to establish the concentrated PV/T production line and this is why Absolicon received an order of production line from a Chinese company. There is very limited players on the market who can produce the concentrated PV/T systems as reviewed in section 2. However, it is much easier for interesting players to enter into the flat-plate and flexible PV/T market, since the major manufacturing of these two PV/T products is very similar to that of solar thermal collectors. Moreover, there were many resources and suppliers available for components and raw materials, while the distributors could sell different products at the same time. There is even no need for high capital costs of the production lines of flat-plate and flexible PV/T systems since OEM is very common. So the entry level was considered as medium and it is hard for new players to compete with the Absolicon by offering low-price concentrated PV/T products, but it is easier for new players to start the flat-plate and flexible PV/T products. **Threat of substitution (high):** Although Absolicon provides competitive products at small-and medium plants for combined solar power and heat generation, the threat of substitution stays high since the solar power and heat market are offered with a variety products, such as flat-plate and flexible PV/T, standard PV, and solar thermal collectors. The competition against other types of power and heating products was also high, such as wind turbine, heat pump, bio-boilers industry waste heat, which are different in costs, efficiency, scale/capacity, categories, or even business models. **Competitive rivalry (low):** there are few manufacturers for PV/T products globally, especially for the concentrated PV/T. As a result, the competence for Absolicon remains advanced. On the other hand, the competition is growing with the market, especially due to the gradual participation of large international solar companies.

## 5. Conclusion

PV/T technologies offer opportunities for the Swedish solar market, which are projected to increase at small-and-medium scales. A high competition in PV/T industry will be expected in the near future since it has to face high competition from alternative energy systems. The market position of the case company meets the trend of PV/T market in Sweden. The high degree of competitive pressures lie in power of customers and threat of substitution, while the competitive rivalry and power of suppliers stay low and the threats of new entry is medium.

## Reference

- [1]. IEA SHC, 2017. Status of Solar Heating/Cooling and Solar Buildings - 2017. <http://www.iea-shc.org/country-report-sweden> Accessed on 22/08/2017.
- [2]. World bank, 2017. <https://data.worldbank.org/country/sweden?view=chart> Accessed on 02/10/2017
- [3]. Trading economics, 2017. <https://tradingeconomics.com/sweden> Accessed on 30/09/2017
- [4]. OECD, 2017. <https://data.oecd.org> Accessed on 30/09/2017
- [5]. Swedish energy agency, 2017. Proposals for strategy for increased use of solar. <https://energimyndigheten.a-w2m.se/Home.mvc?ResourceId=5599> Accessed on 19/08/2017.
- [6]. J Lindahl. National Survey Report of PV Power Applications in Sweden – 2016. Swedish Energy Agency.
- [7]. Y Gu, X Zhang, J A Myhren et al., Techno-economic analysis of a solar photovoltaic/thermal (PV/T) concentrator for building application in Sweden using Monte Carlo method. *Energy Conversion and Management* 165 (2018) 8-24.
- [8]. Y. Tripanagnostopoulos, M. Souliotis, R. Battisti, A. Corrado. Energy, cost and LCA results of PV and hybrid PV/T solar systems. *Progress in Photovoltaics* 13 (2005) 235–250.
- [9]. Absolicon, 2017. <http://www.absolicon.se/product/absolicon-x10-pvt/> Accessed on 30/09/2017.