

PHOTOVOLTAIC SYSTEM AND COMPONENTS PRICE DEVELOPMENT IN THE NETHERLANDS

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ABSTRACT: Market inventories have been made since fall 2011 for modules, inverters, and systems that are available for purchase in the Netherlands to provide the fast growing Dutch market with proper market information. The most recent inventory was made in December 2016. After the drop in module price in 2012 the average selling price of modules has been found to stabilize, while inverter prices continue to decrease. PV system prices have decreased considerably by ~20% since 2011, with some fluctuations. December 2016 average selling prices are 1.109 €/Wp and 0.29 €/Wp for modules and inverters, respectively, with 10-15% lower price for modules from China. System prices have seen a temporary increase mid 2013 and 2016. Average installation costs amount to 0.34 €/Wp. Grid parity is obvious: for a residential 2.5 kWp system the levelized cost of electricity (LCOE) is calculated to be 0.133 €/kWh for a system price of 1.77 €/Wp (including installation), based on an energy yield of 900 kWh/kWp, 25 years system lifetime, 3% discount rate, and 1% operation and maintenance (O&M) cost.

Keywords: PV modules, inverters, system price, kWh price, grid parity, LCOE, market analysis

1 INTRODUCTION

The Dutch photovoltaic (PV) market has been growing very fast in the past years, with 2 GW installed capacity at the end of 2016, see Fig. 1. Market research to assess the development of the cost of modules, inverters, and complete systems has been performed since October 2011 [1-3]. The availability of price data is of importance to consumers as potential investors in PV systems. We have found that the average selling price of modules, inverters, and systems decreased considerably, predominantly in the year 2012. In this paper an update (status end 2016) of the market prices for modules, inverters and complete systems is presented.

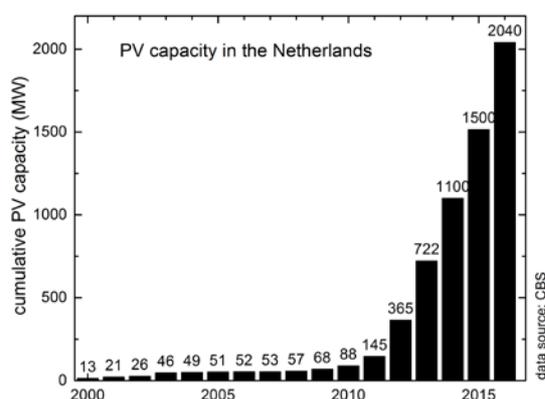


Figure 1. Development of cumulative installed PV capacity in the Netherlands (data source: CBS [4]).

We continued our effort in making further inventories of the PV market in the Netherlands. As before, we collected price data on PV modules, inverters, other system components including installation and consultancy, and complete systems. We also determined the market size and prices of modules of non-European origin in the Netherlands. Finally, for a number of different typically sized PV systems, performance and cost calculations were performed. This allowed for the determination of the levelized cost of electricity of PV systems in order to assess consumer grid parity.

2 METHODOLOGY

The collection of market data was performed using extensive Internet searches that identified the relevant retailers of PV modules, inverters, complete systems, and other Balance of System (BOS) components. We have identified the country of origin for most of the modules. Note that all prices in this paper are quoted *including* 21% VAT, as this is relevant for consumers.

The Levelized Cost of Electricity (LCOE) was calculated using

$$LCOE = \frac{\alpha I + OM}{E}, \quad (1)$$

where α is the capital recovery factor, I the initial investment, OM the operation and maintenance cost, and E the annual electricity production. The capital recovery factor is defined as

$$\alpha = \frac{r}{1 - (1+r)^{-L}} \quad (2)$$

with r the discount rate, and L the lifetime of the system.

In the Netherlands a large number of 4-6 module systems are installed, and still are offered, mostly for historical reasons: system size then can be as small as about 600 Wp, and installation is straightforward do-it-yourself, complying to electricity regulations. A typical household roof system that contributes substantially to a typical annual electricity demand of 3500 kWh is sized at 2.5 - 3 kWp. Present legislation in force until 2023 allows for unlimited net metering. We therefore also include a 5 kWp system in our calculations. Larger systems for commercial buildings and offices range from 10-50 kWp. Larger systems as solar parks are excluded here, as information on prices are not available. We have chosen four typical sizes for the LCOE calculation: 0.6, 2.5, 5, and 50 kWp. We used interest rates of 3%, 6% and 8%. Further, energy ratings of systems in the Netherlands are between 800 and 1000 kWh/kWp, depending on correct and optimal installation. System lifetime is 25 years, and O&M cost is taken as 1%.

3 RESULTS

3.1 PV modules

In the first inventory of PV modules at the end of October 2011, 165 different types were collected. Only mono and multicrystalline silicon modules were found. The average selling price was 2.28 €/Wp; the average capacity was 144 Wp/m². In the inventory taken at the end of December 2016 much more modules were collected (1348 different types, also some thin film silicon and CdTe modules, ~5% of total). In December 2016, the average price per rated power was 1.109 €/Wp, which is 48% lower than at the end of October 2011, as illustrated in Fig. 2. It is clear that the largest price reduction occurred in 2012. In fact, a slight increase is seen for 2016, while the large error bars must be noted.

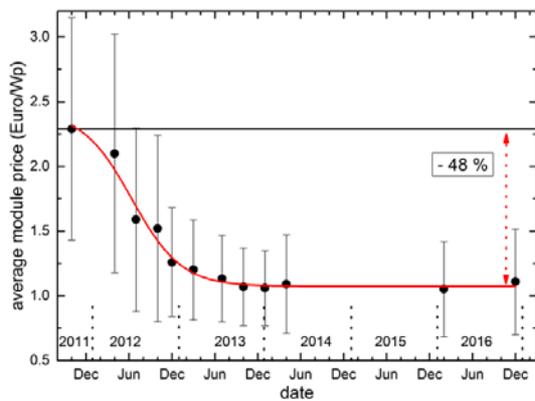


Figure 2. Development of PV module price (including tax) between October 2011 and December 2016.

Our analysis of the country of origin of the modules revealed that 40.2% of the modules originate from China, as shown in Fig. 3. Figure 4 shows that modules from China have a 10-15% lower average price compared to the average price of all modules.

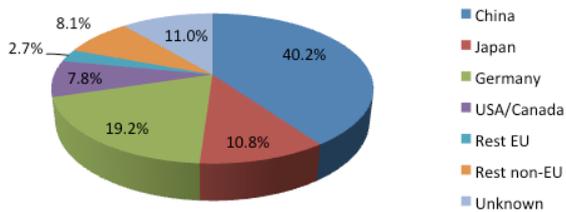


Figure 3. Country of origin of the modules (status December 2016).

3.2 Inverters

At the end of October 2011, the inverter inventory contained 98 unique ones, with average selling price of 0.45 €/Wp. The December 2016 update showed a price decrease to 0.287 €/Wp presently (40.2% decrease) as shown in Fig. 5, with the December 2016 update containing 777 inverters.

3.3 Complete systems

Since the first time that the inventory for systems was made in April 2012, the number of systems for tilted (flat) roofs in the inventory rose dramatically from 1557 (1477) in December 2012 to over 24000 in December 2016. The average selling price for tilted systems

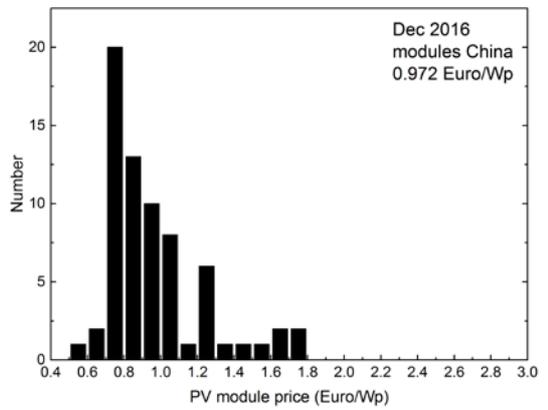
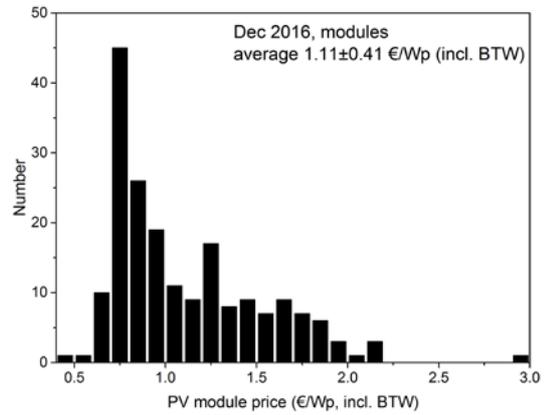


Figure 4. Distribution of PV module price for (a) all modules (top), and modules from China (bottom).

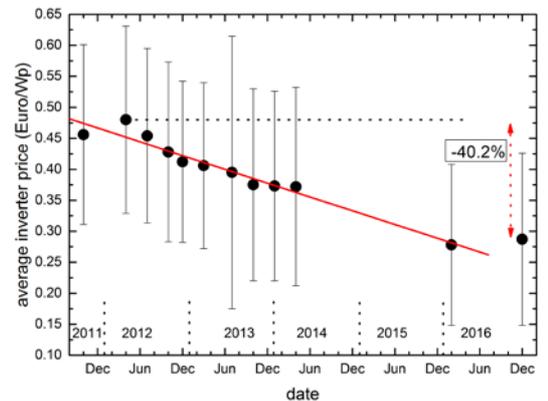


Figure 5. Development of inverter price (including tax) between October 2011 and December 2016.

(excluding installation) decreased by 20% between April 2012 and December 2016, from 1.63 to 1.32 €/Wp for tilted systems, and from 1.67 to 1.39 €/Wp for flat systems. Early 2013 and in 2016 the system price experienced an increase. The 2013 price increase was due to anticipated EU import duties for Chinese made panels, while the 2016 price increase possibly is due to market conditions.

Average installation cost is 0.34 €/kWp, and varies with installation size, as can be seen in Figure 7.

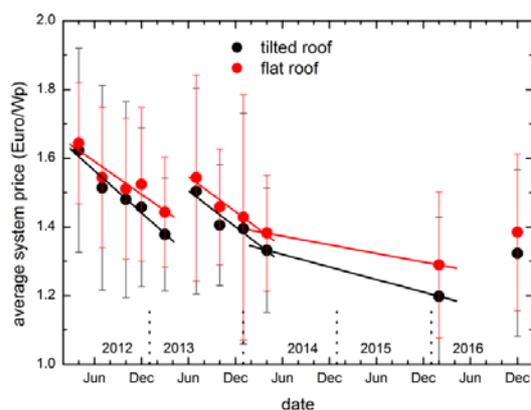


Figure 6. Development of system price (including tax, excluding installation) between April 2012 and December 2016.

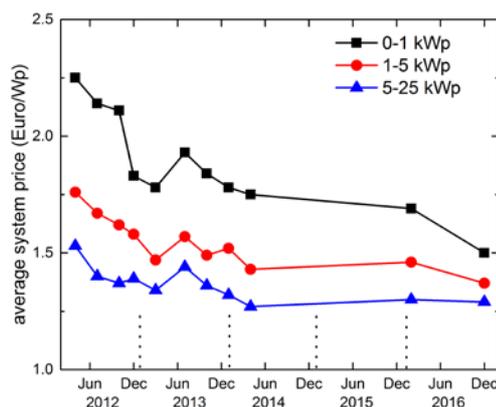


Figure 8. Development of average system price, including installation.

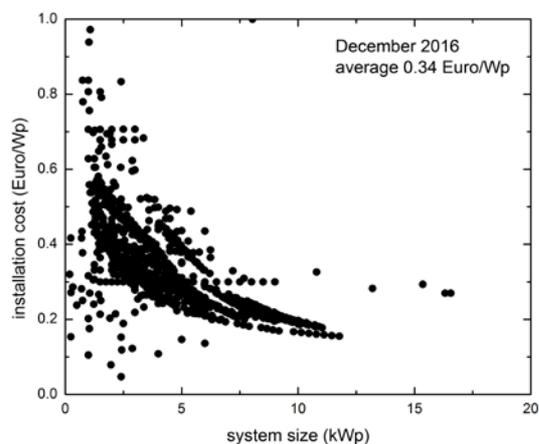


Figure 7. System installation cost as a function of system size, December 2016.

The average prices for three system size ranges have been determined from the inventory data, i.e., for 0-1 kWp, 1-5 kWp, and 5-25 kWp. This is also performed for installation cost, in order to calculate levelized cost of electricity. Table I shows the results, while Fig. 8 shows the development of system price including installation.

Table I: Prices of four typically sized PV systems

system size kWp	price €/Wp	installation €/Wp	total €/Wp
0.6	1.50	0.60	2.10
2.5	1.37	0.40	1.77
5	1.26	0.30	1.56
50	1.14	0.20	1.34

3.5 Levelized cost of electricity

For the four system sizes the LCOE is calculated for three different values of the interest rate (3, 6 and 8%), including installation cost. Results are shown in Table II; only for the smallest system and highest interest rate values are higher than the current price of electricity (0.23 €/kWh) that utilities charge to customers. Clearly, grid parity continues for soft and mortgage type loans, i.e., the cost of electricity is lower than that charged by utilities. This clearly holds for systems of 2.5-5 kWp, and depends on energy yield as well. With energy rating values of 1000 or 800, LCOE values will be 11% lower or 11% higher, respectively.

Table II: Levelized cost of electricity for the four typically sized PV systems. Data for two yield values are shown, 850 and 900 kWh/kWp. Data illustrate that grid parity has been reached.

		850 kWh/kWp		
system size kWp	price €/Wp	interest rate		
		3%	6%	8%
0.6	2.10	0.167	0.218	0.256
2.5	1.77	0.140	0.184	0.216
5	1.56	0.124	0.162	0.190
50	1.34	0.106	0.139	0.163
		900 kWh/kWp		
system size kWp	price €/Wp	interest rate		
		3%	6%	8%
0.6	2.10	0.157	0.206	0.242
2.5	1.77	0.133	0.174	0.204
5	1.56	0.117	0.153	0.180
50	1.34	0.100	0.131	0.154

4 CONCLUSION

A continued market analysis is performed which shows the development of prices on the market for PV modules, inverters, and complete systems. With the data available, we find that PV module price is stabilizing, while inverter price is steadily decreasing. For PV systems the prices have decreased, although with some fluctuations up and down. Modules from companies based in China are cheaper than others.

Our method of acquiring data is based on the availability of price data on websites that sell PV components and systems. We increasingly encounter inactive websites, or websites at which price information cannot be downloaded directly, as a quote for a system is required. This has led to a lower amount of data for our analysis, which may have affected our results.

5 ACKNOWLEDGEMENTS

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6 REFERENCES

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