IS GRID PARITY AN INDICATOR FOR PV MARKET EXPANSION IN THE NETHERLANDS?

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ABSTRACT: Grid parity occurred in the residential sector in the Netherlands in the period 2011-2012, because the levelized cost of electricity (LCoE) for a typical residential PV system (0.6-5 kWp) was well below 0.2 euro/kWh, for interest rates between 3 and 8%, while the retail electricity price was 0.23 euro/kWh, propelling a significant increase in installed PV capacity in the residential sector. It is revealing to discuss the constellation of factors that have led to grid parity in the Netherlands, and whether they will lead to continued market expansion. These factors include those relevant to the industry (i.e. the cost learning curve and the overcapacity) as well as those specific to the Netherlands (various policy incentives, net-metering, as well as large-scale purchasing actions). 'Grid parity' may not reflect the growth perspectives for the industry because it gives no information on the adequacy of the PV system prices to impel market expansion, or on the complexity and controls on grid electricity pricing, which depend only to a small degree on generation costs. Low PV system prices were accompanied by an increase in installations but 'unhealthy' prices will not necessarily mean continued market expansion. The continuation of the cost learning curve to drive down PV prices depends to a certain degree on R&D budgets, which are under severe pressure in the current environment. Grid parity in the residential sector has been accompanied by a surge of installations, however this trend is not being paralleled by the non-residential sectors.
Keywords: grid parity, Netherlands, system price, PV market

1 INTRODUCTION

When the cost of generating electricity using a photovoltaic (PV) system is less than or equal to the price of electricity from the grid, PV is said to have reached 'grid parity'. In the Netherlands, PV became competitive in the residential sector with grid electricity in the period 2011- 2012, according to the survey of the Dutch PV market reported in this paper.

The amount of renewable energy in the total Dutch energy supply reached 4.4% in 2012, up from 4.3% in 2011, with renewable electricity contributing 2.05% of the 2012 energy consumption. [1] In July, 2013, the Dutch government and a range of civil organizations, facilitated by the Dutch Social and Economic Council (SER), settled on the outlines of an Energy Agreement for Renewable Energy that is slated to come for final negotiation in late August, 2013. [3] The goals of 14% renewable energy in 2020, and 16% in 2023, have been articulated as prominent aims of the accord. [4] The development from 4% to 14% in 7 years will require a more intense focus on developing renewable energy than in previous years.

In this paper, the PV system prices in the Netherlands in 2012 are documented, the levelized cost of electricity (LCoE) is calculated and compared to the electricity price to determine the status of grid parity. Next, the salient facts about the market development in 2012 are compiled in order to reflect upon the most influential factors in the market growth. These factors are the policy instruments (especially residential net-metering and investment subsidy), the decreasing price of PV systems, and the increasing electricity price. Finally, each factor is discussed in a bit more depth, with an outlook on the prospects for both residential, small business and industrial sectors. The aim is to identify the most prominent economic and policy drivers for the observed expansion in PV installations in the light of the goal to achieve significant renewable energy penetration by 2020.

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2 METHODOLOGY

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.

The LCOE for 4 different PV system sizes (0.6, 2.5, 5, and 50 kWp) are calculated. The size of a PV row house roof system is typically 2.5 kWp for an average Dutch household (i.e. consuming 3500 kWh/year). A typical, mortgage-related interest rate is 6%, while a soft-loan rate may be possible at 3%. Commercial rates may be 8% or higher. Further, energy yields of systems in the Netherlands are between 800 and 950 kWh/kWp, depending on the specific installation. The electricity price modeling reflects the increase, over the period 2010-2012, of average consumer electricity prices of just under 8%.

In the PV Parity project [2], the LCOE for a 3.5 kWp system for a Dutch household, consuming on average 3500 kWh per year, was calculated using a slightly different approach. The capital recovery factor was calculated using a typical weighted average cost of capital between 2.3% and 4.5% annually, reflecting a debt cost of between 3.5 -6.7% per year, depending on the debt/equity ratio. The system cost was taken to be 1.8 €/W_p, with no public financing. The results of the PV Parity project included projections of the development of the PV system LCOE as compared to the electricity prices from 2012 to 2030. The price of the PV system in the Netherlands was forecast to decrease at a rate of 3%/year up to 2018, followed by a learning rate of 15% in the PV manufacturing costs from 2018 to 2030. Retail and wholesale electricity prices were predicted to increase at rates of 3%/year and 1.5%/year, respectively, based on historical trends. [5]

2.2 PV System Data

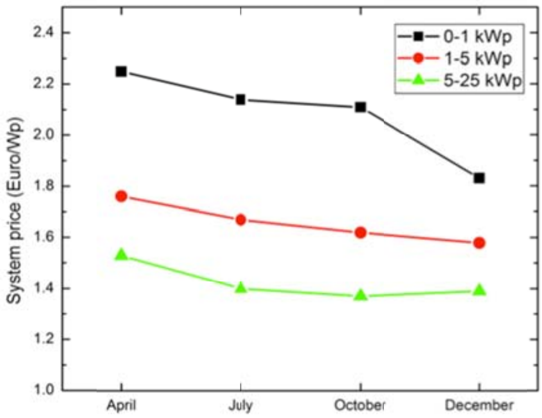

Figure 1. Price development in 2012 for PV systems, excluding installation, in the Netherlands, according to system size, for both tilted and flat rooftop systems.

Price data for PV systems were collected over the period 2012-2013, and included systems designed for both tilted and flat roofs. Figure 1 shows the development of PV system price according to system size for both flat and tilted systems. PV module prices decreased by 44% over 2012. [6]

Table 1. Prices for PV systems and installation, 2012

system size kWp	price €/Wp	installation €/Wp	total €/Wp
0.6	1.83	0.60	2.43
2.5	1.58	0.40	1.98
5	1.39	0.30	1.69
50	1.39	0.20	1.59

For systems smaller than 5 kWp a very broad range of prices is found. A broad range of system prices is observed, with smaller systems having a wider variation. The system prices including installation are found to be (Table 1): 2.43 €/Wp for 0.6 kWp, 1.98 €/Wp for 2.5 kWp, 1.69 €/Wp for 5 kWp, and 1.59 €/Wp for 50 kWp. The latter price is more of a conservative estimate, as systems sizes larger than 13.8 kWp are not offered. The price drop for PV panels continued into 2013, as shown in Figure 2.

3 RESULTS & DISCUSSIONS

3.1 LCOE calculations and grid parity status

For the four system sizes, with associated prices, the LCOE is calculated for three different values of the interest rate. Results are shown in Table 2; the values reaching grid parity are highlighted in yellow and are equal or lower than the 2012 price of electricity (0.23 €/kWh) charged by utilities. Grid parity has been reached

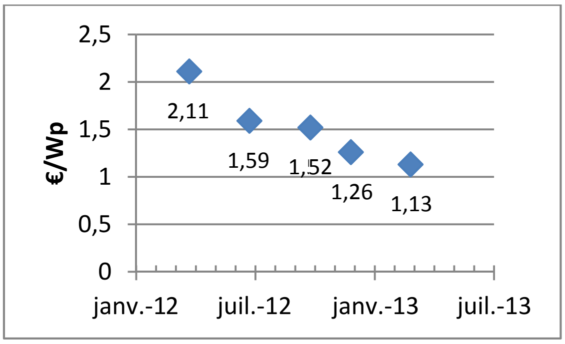

Figure 2, Trend of all panel prices from April 2012 to March 2013.

for soft and mortgage type loans on systems of 2.5-5 kWp. The siting of the system will determine it's energy yield, but the most typical energy yields for the Netherlands lie in the range of 800-950 kWh/kWp. A handy rule-of-thumb is that the system price (in €/Wp) can be divided by ~10 to reach LCOE (in €/kWh). Figure 3 and 4 show the development of LCOE for residential and small scale commercial consumers.

Table 2. LCOE (€/kWh)for PV systems sited for energy yield between 800-950 kWh/kWp,at various interest rates, with 1% O&M assumed.

energy yield kWh/kWp	size kWp	price €/Wp	3%	6%	8%
800	0.6	2.43	0.205	0.268	0.315
	2.5	1.98	0.167	0.218	0.257
	5	1.69	0.142	0.186	0.219
	50	1.59	0.134	0.175	0.206
850	0.6	2.43	0.193	0.252	0.296
	2.5	1.98	0.157	0.206	0.242
	5	1.69	0.134	0.175	0.206
	50	1.59	0.126	0.165	0.194
900	0.6	2.43	0.182	0.238	0.280
	2.5	1.98	0.148	0.194	0.228
	5	1.69	0.127	0.166	0.195
	50	1.59	0.119	0.156	0.183
950	0.6	2.43	0.162	0.212	0.250
	2.5	1.98	0.132	0.173	0.203
	5	1.69	0.113	0.148	0.174
	50	1.59	0.106	0.139	

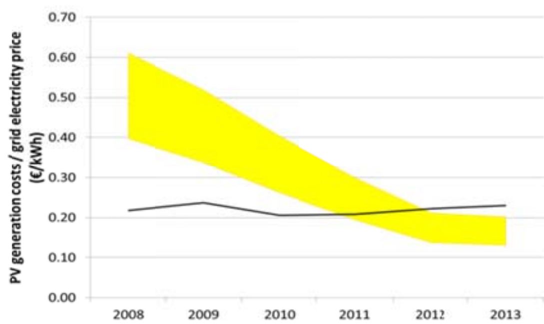

Figure 3. Levelized cost of electricity (LCOE) of PV generated electricity (yellow) versus the electricity price for residential consumers in the Netherlands. LCOE values are calculated using Eq.1 with 25 years economic lifetime, 900 kWh/kW$_p$ annual yield and a 3%-8% range of interest rates.

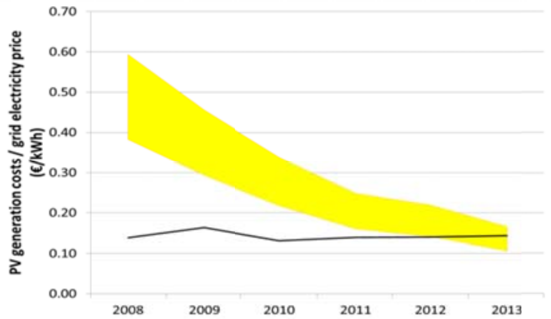

Figure 4. Levelized cost of electricity (LCOE) of PV generated electricity, based on current PV module prices, versus the electricity price for small-scale commercial consumers (using ~50,000 kWh/year) in the Netherlands LCOE values are calculated using Eq.1 25 years economic lifetime, 900 kWh/kW$_p$ annual yield and a 6%-12% range of interest rates.[1]

3.2 PV market development in 2012 in the Netherlands

Annual installations more than tripled in 2012 over the previous year, bringing the cumulative PV installations from 145 MW in 2011 to 340 MW in 2012. [1] About 85% of the cumulative installations are residential, 15% commercial and no significant fraction of ground-mounted or industrial applications. [2] The growth in 2012 was almost entirely in the residential sector.

3.3 Factors influencing the PV market growth

PV system prices. Since the 1970's, PV module prices have decreased by about 20% with every doubling of production volume, reflecting the 'learning' of the industry on how to produce their product more efficiently. In 2011, the European Photovoltaic Industry Association published a report which used the 'learning curve' to forecast that PV system prices would decline by roughly 7% per year (for 900 kWh/kW irradiance conditions, between 2011 and 2015). [7] This rate reflects a relatively healthy relationship between supply and demand.

Over the last decade, Europe has provided most of the demand for PV modules. In 2012 however, the backpedaling of support schemes in Europe's largest PV markets have retarded demand. Observing the current major contraction, market analysts expect 70% of PV companies to go out of business by the end of 2013. [8] These difficult conditions have caused even the top four PV manufacturers worldwide (Yingli Green Energy, First Solar, Trina Solar and Canadian Solar) to suffer net losses in 2012. [9]

Slowed demand caused an overcapacity of supply creating the conditions for producers to seek to unload their inventory at reduced prices, in order to more quickly return the market to a better balance. The 44% drop in module prices observed in 2012 in the Netherlands is largely an effect of overcapacity in the PV industry, estimated to be about 50 GW in 2012. [10] With the projected current growth of the global PV industry of 30-45 GW in 2013, it is expected that the overcapacity will be corrected by mid-2014 or early 2015. [11]

There was a concern that the Sino-European trade dispute over the alleged Chinese dumping of PV modules in Europe at unsustainable prices would impose severe penalty tariffs, causing the price of Chinese PV panels to shoot up. In actuality, the European Commission recently decided to allow a collective maximum of 7 GWp per year of Chinese solar panels to be imported without duties, as long as they are sold at a minimum price of 0.56 €/Wp[2], (the low end of the current price range). Sales volumes over 7 GW would be subject to tariffs averaging 46.7%. [12] [13] As of August 2013, prices have stabilized at current levels. [14] [15]

PV companies need to return to a sustainable situation in which the margin in the prices of their products is adequate for their continued operation. They will need to bring prices up or manage to survive until their costs come down. In either case, they must seek out the markets with growing demand. The Asia-Pacific area, now also the hub of PV manufacturing, is displacing Europe as the center for PV deployment. It is now also the fastest growing market, showing a 90% increase over a year ago. [16]

The amount of time it takes for the costs to come down due to innovation e.g. to continue along the 'learning curve', will depend largely on the resources for R&D available to the industry. For many of the top PV module manufacturers, the R&D-to-sales ratio has remained less than 2% from 2007 through 2011 [17], a level indicating an underinvestment in research. [18] The combined corporate and government R&D investment in solar PV contracted by 1% in 2012 as compared to 2011. [19]. The 12 top PV module manufacturers (of which 2 are European) reduced their R&D spending by ~9% in 2012, as compared to 2011, due to the 2nd year of financial losses for the industry worldwide. [20] Therefore in the current conditions, it is hard to predict whether costs will continue to fall due to 'learning'.

PV module prices have been a controlling factor in the arrival of grid parity in the Netherlands, but it appears their continued stability at these levels depends largely on how PV markets outside Europe develop.

During the past few years, residential customers in the Netherlands have participated in collective purchasing actions, many of which offer not only reduced system prices, but also ease barriers for installation and administration. These actions have been highly successful in the Netherlands, but would not have occurred without the important policy foundation for residential customers: net-metering.

The main policy instruments for renewable energy investment by the non-residential sector are the SDE+ subsidy program and various tax incentives. The SDE+ subsidized a sluggish 17 MW of PV systems in 2012, i.e. 8% of the 2012 newly installed PV capacity. [21] [22]

The residential sector has evidenced much more vigorous growth (178 MW). There was a 15% investment subsidy introduced in 2012 for residential consumers to receive a discount of 15% on the PV

[1] In the commercial sector PV systems are entitled to an income tax deduction of 41.5% of the investment costs. For an income tax of 25%, this has been taken into account as a 10.4% investment subsidy.

[2] 0.56 €/Wp is the price on the European Spot Market (Chinese goods customs-cleared), i.e. it is a net price without VAT in Euro per Watt peak. It corresponds to a system price of between 1.1-1.4 €/Wp.

system price at the time of purchase, capped at a maximum of €650/system. In 2012 there were 39,000 subsidy requests for systems averaging 2.92 kWp, drawn from a budget of 21.55 million euros. [23] This amount funded an installed capacity of 12 MWp (at 1.76 €/Wp), and lowered the barrier for residents to purchase about 100 MWp of PV systems. The subsidy offer has now come to an end.

The measure that facilitates the economics of the PV system over its lifetime, however, is net-metering. Net-metering is the accounting and compensation for 1 kWh of electricity injected onto the grid with 1 kWh of electricity drawn from the grid, and is key to the economic value of a residential system.

Since 2004, net-metering has only been allowed for small-scale consumers (i.e. those with a “residential size” electrical connection of 3x80A) who feed-in and receive electricity using the same connection. The initial volume limit of 3000 kWh was increased to 5000 kWh in 2011, and will most probably be entirely removed, de jure, by January, 2014. [22] The intention is to allow non-commercial users such as schools, farms and housing organizations to benefit from installing their own renewable energy generation systems.

In June, 2013, while speaking in a session of the Dutch parliament, however, Minister Kamp of the Bureau of Economic Affairs has expressed the opinion that net-metering should eventually be replaced by a significantly less supportive measure. [23]. The replacement of household analog electric meters with digital meters in the next years will carry with it a discussion of how or if net-metering will continue in the Netherlands.

A typical Dutch household with a PV system sized to meet the yearly demand of the household naturally self-consumes roughly between 30-40% of the electricity generated by a rooftop system. [4] [23] The rest of the power flows onto the grid. Everyone seems to agree that this household is entitled to receive a fair compensation for their contribution to the electricity supply. The disagreement comes when discussing the value placed on the unit of decentralized renewable energy.

Vested interests, who take up the argument in Europe as well as the US, say that if this unit of PV electricity is valued at the wholesale electricity market price, then this household gets away with not paying taxes or grid charges for the equivalent amount of electricity that they later pull off the grid. They have also claimed that customers using only ‘grey’ electricity have to pay the grid charges bill for the ‘green’ electricity customers, (i.e. a ‘cross-subsidy’), which is unfair. In the Netherlands, the grid charges are applied as flat fees according to capacity of the electricity connection, but this fact has not stopped the argument from surfacing in the ‘Tweede Kamer’ of parliament. [24] In Flanders, utility companies have successfully lobbied to impose grid access fees on residential PV operators. The fee structure means a reduction of 15% of the PV production benefits. [24]

A thorough analysis of the costs and benefits of net-metering was conducted on the effects of net-metering as carried out by investor owned utilities in California. [25] They concluded that net-metering actually provides a small net *benefit* to the non-green customers of 2 of the 3 utilities, and a small net cost to those of the third utility. They consider the economic consequences due to avoided energy and capacity costs, reduced costs for ancillary services, lower line losses on the transmission and distribution (T&D) network, reduced investments for the T&D network and reductions in purchases of renewable energy to meet required quotas. All of these considerations depend also on the physical electricity infrastructure of the region under consideration. One observation that stands out is that the net magnitude of the economic effect of adding renewable energy to the grid is quite small. This supports the observation by some PV market analysts that the Flanders’ grid access fee is excessive. [24]

The economic benefit of net-metering to utilities and their customers is also clearly dependent on the design of the electricity rates and market. This is unsurprising considering that the current market design, and the business models of utilities, has historically evolved to accommodate only flows of centrally generated electricity, without attention to its carbon footprint. Net-metering is an issue which actually brings to the forefront the need to update the electricity market design to actually encourage decentralized renewable energy generation in order to reach the stated goals for a de-carbonized electricity supply.

This question of the valuation of decentralized, renewable production of energy as compared to the related grid costs and taxes is seeping into the public debate on the costs and benefits of renewable energy. The comments of Minister Kamp in June 2013 have begun this debate in the Netherlands.

Electricity prices are the baseline determining factor in the arrival of the grid parity condition. Electricity prices for residential consumers rose by 4.5 % between 2010 and 2011, and by 3.3 % between 2011 and 2012, with a net change of 8 % between the second half of 2010 and the second half of 2012. Industrial consumers experienced a price decrease between 2010 and 2011 of 4.1%, and an increase of 3.2% from 2011 to 2012. The net change over the 2 years was a decrease of 1%. [27] In the period 2005-2012, electricity prices (without taxes) rose 43% for households, but stayed the same for industrial customers. [27]

The increasing household electricity price will continue to make PV systems a competitive choice for households, certainly as long as net-metering stays in place. The advantages of static electricity prices over the life the PV system will become more valuable over time, and various avenues for widening self-consumption possibilities are being explored, especially in Germany.

Grid-parity has not yet arrived for industrial consumers, and the prospects are not so clear. German industrial electricity prices are below the average and trending downward. On average, Dutch industrial electricity prices are lower than German ones. [29] In June 2013, Minister Kamp expressed his concern over the price difference between the rates for energy intensive industries which are higher in the Netherlands than in Germany. He proposed a rate cut for industries falling into this category. [30]

4 CONCLUSIONS

In the Netherlands, PV system prices and residential electricity prices reached grid parity in 2012. The surge in residential PV installations shows that momentum for PV in the Dutch residential sector is accumulating. This ‘bottom-up’ trend has not been paralleled by the non-residential customers, which correlates with the lack of existing long-term policies to overcome investment hurdles for the non-residential sector. The subsidy has attracted investment by consumers, but is no longer on offer. Net-metering remains the key enabler for the residential sector to choose PV, but beyond a couple of years the outlook for net-metering is uncertain. The diverging trends of the residential sector and non-residential sector have a polarizing potential.

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