Supported by:

PV GRID PARITY MONITOR

Residential Sector

2nd issue

Platinum sponsors:

Technical partners:

MAY 2013

Platinum sponsors:

Gold sponsors:

Partner associations:

Supported by:

ECLAREON warrants that this information conveys the results of an independent and objective analysis, which is free of bias from internal or external pressures from sponsors or other sources.

Lead authors:

David Pérez (Partner)
Víctor Cervantes (Manager)
María Jesús Báez (Associate)
Francisco Teniente Domínguez (Analyst)

Contact information:

ECLAREON S.L.
Email: dpn@eclareon.com
Tel: +34.91.395.01.55
Web: http://www.eclareon.com

INDEX

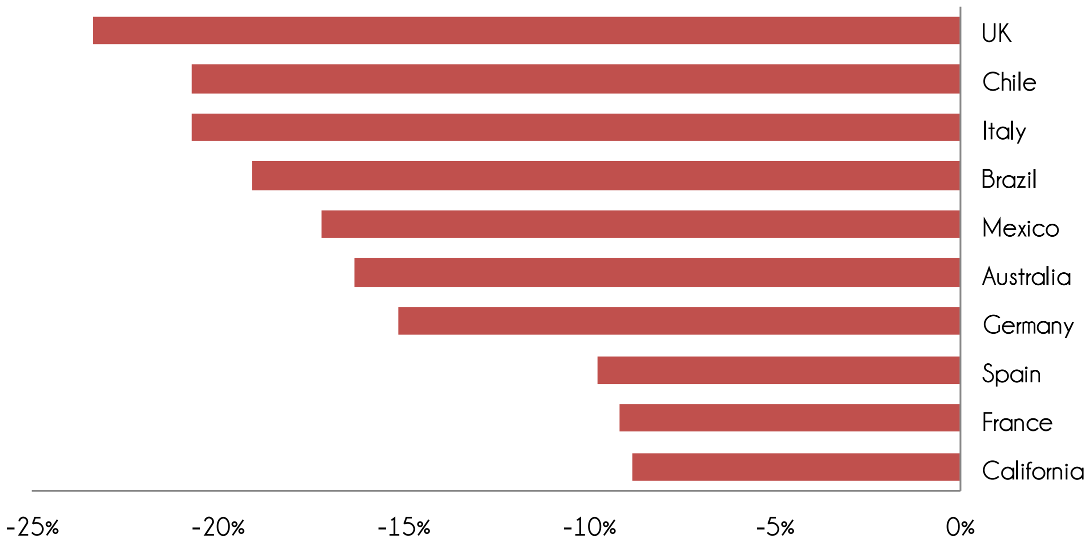
1

Executive summary

1 Executive summary

This is the second issue of the PV Grid Parity Monitor for residential consumers. Since the first issue of the residential GPM (2nd half 2012), almost every country improved its grid parity situation. This is due mainly to the reduction of the PV LCOE, as depicted in the Figure below. This has been caused by a reduction in the cost of PV systems, driven by lower equipment prices (across the board) and increased competition in emerging markets (like Brazil, Chile or Mexico).

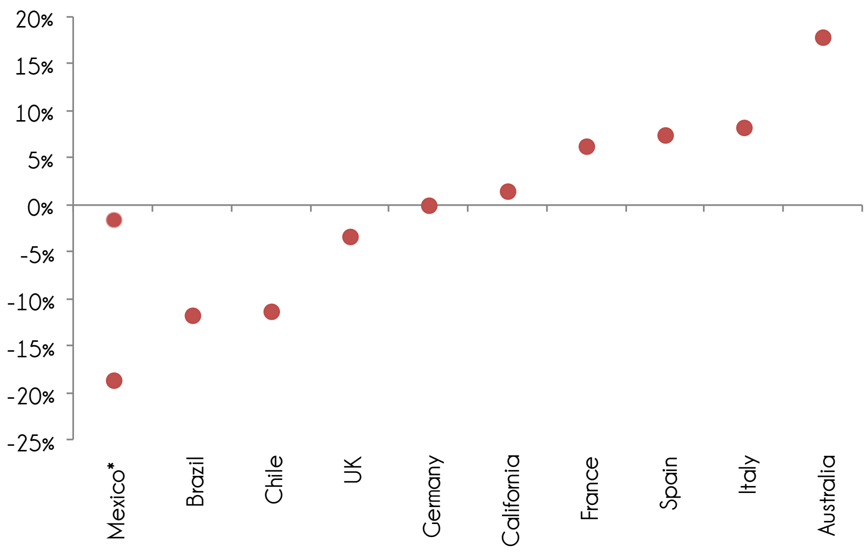
Figure 1: Evolution of PV LCOE for residential consumers from 2nd half 2012 to 1st half 2013



Source: Eclareon Analysis

If we have a look at the evolution of residential electricity costs (see Figure below), we notice a growing trend in most European markets, while LatAm countries enjoyed reductions.

Figure 2: Evolution of retail electricity prices for residential consumers from 2nd half 2012 to 1st half 2013

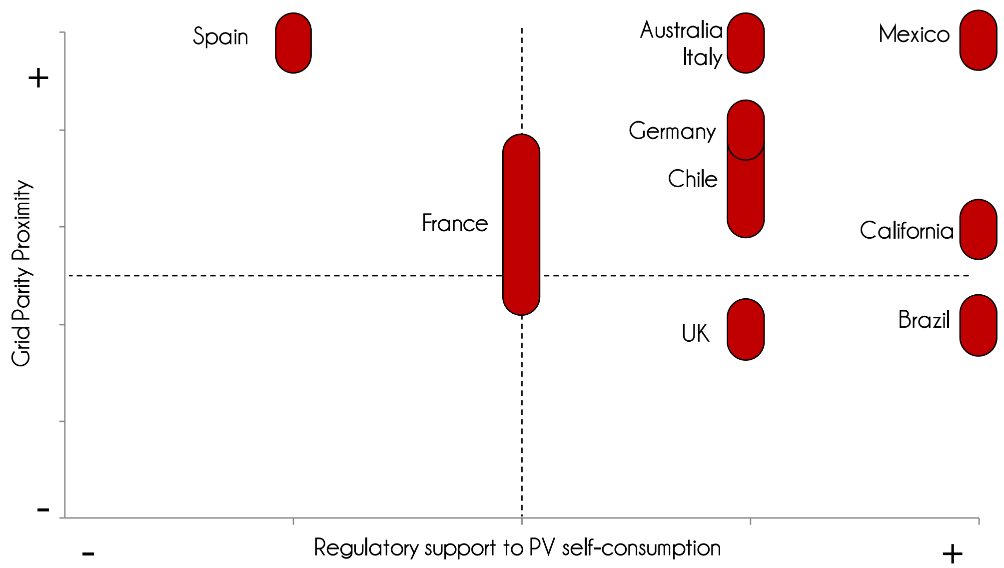


Note: * For DAC users, retail electricity prices have decreased by -0,66% whereas standard retail electricity prices have decreased by -18,60%. The standard prices were used for the other countries.

Source: Eclareon Analysis

As well as Grid Parity proximity, regulatory support to grid parity (mainly via net metering or net billing mechanisms) varies significantly from country to country. These two variables ("Grid Parity Proximity" and "Regulatory support to PV self-consumption") are represented in the Figure below.

Figure 3: Positioning Matrix of the countries analyzed



Note: Data of January/February 2013

Source: ECLAREON Analysis

The following conclusions can be drawn from the above Figure:

- PV Grid Parity is being pushed away by a high discount rate in Brazil and low irradiation in UK, added to the high installation prices in both markets.
- In California, PV is still far from being competitive mainly due to generous government incentives that enable high margins throughout the entire value chain and push up prices.
- The South of France has already reached grid parity, while the North of the country is still far from competitiveness due to low irradiation levels.
- In Mexico, PV self-consumption is a good investment opportunity for DAC consumers (households that pay more than twice the price of the average residential tariff).
- In Spain, although a clear grid parity situation exists, there is no convenient regulation allowing PV self-consumers to feed their excess generation into the grid in exchange for a compensation (either monetary or energy compensation).
- In contrast, the net-metering system in California is a trendsetter on how to promote PV self-consumption. The recently approved regulations in Brazil and Chile seem, on a first evaluation, an excellent instrument to foster PV self-consumption.

This economic reality should lead to the creation of PV markets based on self-consumption PV systems, especially in countries where grid parity is more evident. This is something already happening in some cases. Although poor regulatory support is often a barrier for market creation, we think that the absence of conscious consumers (who still do not understand and do not trust self-consumption schemes) and a well-prepared PV industry (mainly in emerging markets) are the main reasons not to see larger volumes being generated.

2

Introduction

2 Introduction

The PV Grid Parity Monitor analyses PV competitiveness with retail electricity prices for residential consumers and assesses local regulation for self-consumption of twenty cities in ten countries. It is based on a rigorous and transparent methodology (detailed in Section 4) and has used real and updated data provided by local PV installers, local PV associations and other reliable players from the PV industry. It also includes a specific and in-depth analysis of retail electricity rates for each of the cities taken into consideration.

The results of the analyses show that PV Grid Parity (defined as the moment when PV LCOE becomes competitive with retail electricity prices, assuming that 100% of the electricity is self-consumed instantaneously[1]) has already been reached in several of the cities analyzed in this report. This fact does not imply that PV technology does not need governmental support anymore. On the contrary, in order to make the development of a PV self-consumption market possible, policymakers should concentrate their efforts on reducing administrative barriers and creating or improving regulatory mechanisms to allow PV self-consumers to feed their excess generation into the grid in exchange for a compensation (either monetary compensation under the net-billing system or energy compensation in the net-metering mechanism). On this side, our analysis shows that regulations can still be improved in many countries. It should be noted that it is the combination of both elements (grid parity and proper regulation) what generates the investment opportunity. The existence of one of them only, will not generate any market effect.

Even in the ideal case where PV Grid Parity is combined with an efficient regulatory framework, a massive market is not likely to develop owing to the nature of the investment (i.e., based on savings). However, given that grid parity is an economic reality, policymakers should create the proper frameworks to adapt the energy system to the increasing importance of distributed generation, and in so doing ensure that it is properly monitored, channelled, and regulated.

---

[1] Since 100% of instant self-consumption is not likely to happen in residential systems, net metering/net billing or equivalent mechanisms will be crucial to achieve economic feasibility for this kind of installations, provided that a good match of generation and consumption curves is not possible.

It is important to understand that Grid Parity represents a unique opportunity to develop a local and sustainable power generation technology in a cost-effective way, however, proper regulatory changes must be made to make this possible. This is part of the Smart Grid Challenge, which will require taking into consideration economic factors to design the grid of the future: one prepared for a massive penetration of distributed generation.

Important considerations

- This report is exclusively focused on the residential sector. Self-consumption PV installations in the industrial and commercial sectors may represent a very interesting opportunity as well but they should be analyzed separately since several characteristics differ from those of residential installations (PV installation costs, retail electricity prices, etc.). The industrial and commercial sectors will be analyzed in a separate issue of the GPM Series.
- This report only compares PV LCOE with retail electricity prices. However, under some local net-metering/net-billing or equivalent mechanisms, PV electricity fed into the grid is compensated/priced below retail electricity rates, making this investment less attractive.
    - When this regulation exists, a case-by-case analysis should be conducted to determine the economic viability of each individual PV installation (installations with a high percentage of self-consumption will be more profitable than installations that feed an important part of their production into the grid).
- Only two cities per country were analyzed. This implies that in some countries (such as Chile and Brazil) where irradiation and retail electricity prices vary significantly, the Grid Parity diagnosis might largely differ from region to region.
- Other barriers that could hinder the development of the PV self-consumption market (e.g. administrative barriers) have not been analyzed in this report.

Over the last few years, cost-competitiveness of PV technology has experienced a considerable evolution: the remarkable growth of the global PV market generated economies of scale, which added to constant technological improvements and demand-supply imbalances have led to a significant decline in costs of this technology.

Jointly with the cost reduction of PV-generated electricity, the constant increase in electricity prices has been pushing the arrival of PV "grid parity": the moment when the cost for a consumer of generating its own PV electricity is equal to the price paid to the utilities for grid electricity.

Important assumption for Grid Parity definition

As a result of the mismatch[2] between PV generation and electricity consumption, part of the electricity produced by the PV system will not be instantaneously self-consumed by the household and will thus be fed into the electric grid. The value of this “Excess PV electricity” depends on each country’s regulation:

- If self-consumption is not regulated, the PV producer receives no compensation in exchange for the excess PV electricity fed into the grid.
- If an self-consumption regulation exists (e.g. a net metering/net billing mechanism), the owner of the installation does receive a compensation (either monetary or as consumption credits in kWh) for the excess PV electricity fed into the grid.
    - Depending on the regulation, the value of this compensation can be equal to retail electricity price or lower.

For the sake of simplicity, this report compares PV Levelized Cost Of Electricity with retail electricity prices but the reader must bear in mind that, depending on the local self-consumption regulation, a part of the PV generation (i.e. excess PV electricity) might be lost or valued at a lower rate.

Once PV grid parity is reached, for some end-consumers of electricity it would make sense from an economic point of view to self-consume PV-generated electricity instead of purchasing electricity from the grid.

[2] Storage systems (batteries) are not considered in this report.

Figure 4: Simplistic Illustration of PV Grid Parity

Note: * Levelized Cost Of Electricity
Source: Eclareon Analysis

As expected, this reality has excited the curiosity of electricity consumers, regulators, utilities, PV manufacturers and installers, among other parties.

In line with this interest, the objective of the PV Grid Parity Monitor is to increase awareness of residential PV electricity self-consumption possibilities by periodically analyzing PV cost-competitiveness in some of the main current and potential PV markets: Brazil, Chile, Germany, Italy, Mexico, Spain, and USA (California).

In order to assess PV cost-competitiveness in each country, the costs of generating PV electricity should be compared to residential retail electricity prices:

- The cost of PV-generated electricity is expressed as the Levelized Cost of Electricity (LCOE), defined as the constant and theoretical cost of generating a kWh of PV electricity that incorporates all the costs associated with the PV system over its lifetime.
    - In this study, PV LCOE is based on country-specific (and city-specific, if applicable) variables needed to accurately quantify the cost of PV-generated electricity (average PV system lifespan, initial investment, O&M costs, electricity generation over the system's lifespan and discount rate, among others).
- When considering retail electricity prices, a maximum of 3 different variable electricity prices paid by residential consumers for each of the cities under study are presented.

The PV Grid Parity Monitor may well be one of the most comprehensive analyses of PV grid parity to date, because:

- It is based on a rigorous and transparent methodology (detailed in Section 4).
- It uses real and updated data as inputs, which include turnkey quotations of local PV-system installers from each of the countries under study, not estimates.

- It includes specific and detailed information per country (and city, when applicable) such as the discount rate, retail electricity prices, and inflation.
- It is recurrent, as it will be updated every semester to show the evolution of PV grid parity proximity.
- It analyzes not only potential markets in Europe but also some of the most promising ones outside Europe (Brazil, California, Chile, and Mexico).

The PV Grid Parity Monitor consists of two main sections:

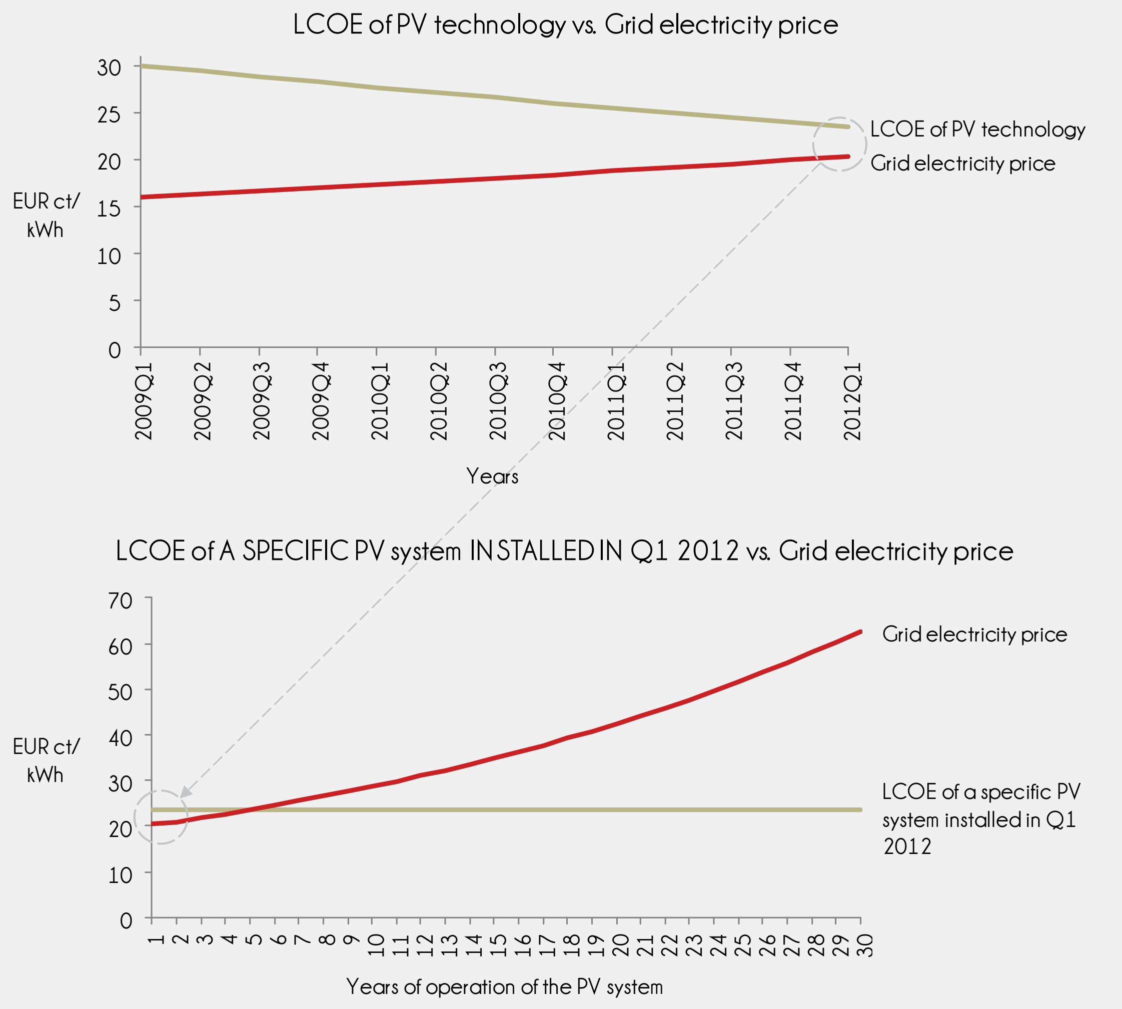
- Results Section, where PV LCOE is quantified for each of the locations under study and PV grid parity proximity is analyzed.
- Methodology Section, which includes a thorough explanation of the LCOE concept, and the main assumptions and inputs considered.

LCOE vs. electricity grid prices: Considerations for a fair comparison

When analyzing cost-competitiveness of PV technology against grid electricity, one should bear in mind that what is really being compared is the cost of electricity generated during the entire lifetime of a PV system against today's retail price for electricity. This reality has important implications because, while future grid electricity prices are likely to change, PV LCOE is fixed as soon as the PV system is bought.

Consequently, to counteract this mismatch, when assessing PV competitiveness against the grid, PV LCOE should ideally be compared against today's electricity price, but accounting for the estimated future increase in retail electricity rates over the entire PV system lifetime.

Figure 5: Differences between LCOE of PV technology and LCOE of a SPECIFIC PV system



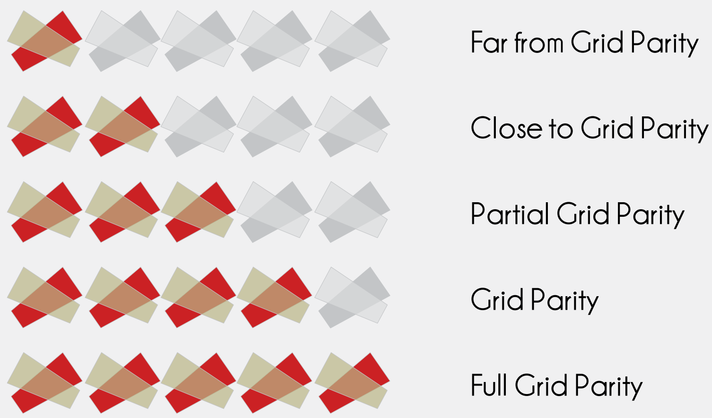
3
PV GPM results

3 PV Grid Parity Monitor results

In this section, the PV Grid Parity Monitor compares the evolution of PV LCOE to retail electricity prices from S1 2009 to January/February 2013 in two cities of each of the countries under study and assesses PV Grid Parity proximity in each location according to the following criteria:

Criteria used to asses PV Grid Parity proximity

Figure 6: Qualitative scale for the assessment of Grid Parity proximity



Where:

- Far from Grid Parity: The lowest PV LCOE is greater than 150% of the highest grid electricity rate.
- Close to Grid Parity: The lowest PV LCOE is greater than 100% and lower than 150% of the highest grid electricity rate.
- Partial Grid Parity: The highest time-of-use (TOU) grid electricity rate (i.e. that is only applicable during a specific period of time, e.g. during part of the day, in summer, from Monday to Friday, etc.) is greater than the lowest PV LCOE and lower than the highest PV LCOE.
- Grid Parity: The standard grid electricity rate (or the lowest TOU grid electricity rate) is greater than the lowest PV LCOE and lower than the highest PV LCOE.
- Full Grid Parity: The highest PV LCOE is lower than the standard grid electricity rate or lower than the lowest TOU grid electricity rate.

Moreover, the regulatory framework for PV self-consumption in each country is briefly summarized in order to assess the presence of mechanism necessary to move PV self-consumption forward.

Criteria used to assess the national support for PV self-consumption

Figure 7: Qualitative scale for the assessment of the national support for PV self-consumption

Where:

- Very poor: There is no net-metering/net-billing or equivalent system that fosters the self-consumption market[3], or any other support mechanism (feed-in tariffs, tax credit, etc.) for PV.
- Poor: There is no net-metering/net-billing or equivalent system. Other support mechanisms (feed-in tariffs, tax credit, etc.) for PV exist but they do not incentivize self-consumption.
- Good: A net-metering/net-billing or equivalent system exists but the compensation for PV electricity fed into the grid is lower than retail electricity price.
- Excellent: A net-metering/net-billing or equivalent system exists and the compensation for PV electricity fed into the grid is equal to retail electricity price.

[3] Throughout this report, when referring to systems such as net-metering and net billing, other systems with the same effects on the market are also included.

3.1 Australia

3.1.1 Grid Parity Proximity

Figure 8: Past evolution of retail electricity price and PV LCOE in Sydney, Australia (including taxes)

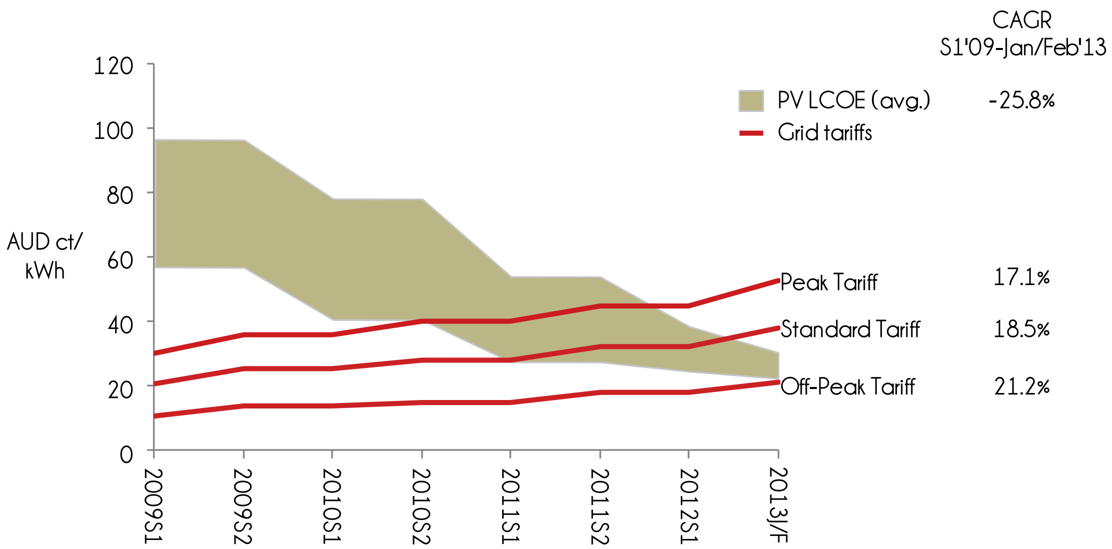


Figure 9: Sydney's Grid Parity proximity

- In Australia, full grid parity has been reached mainly as a result of the following trends:
  - The important decrease experienced by PV LCOE in the last few years (a CAGR of -25.8% in the analyzed period).
  - A significant increase in retail electricity prices which, for the standard tariff, is estimated at 18.5% per year from 2009 to January/February 2013.

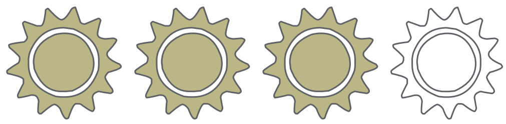
3.1.2 Regulatory support to PV self-consumption

- In the State of New South Wales (NSW) new installed PV systems can benefit from the net metering scheme.
- Under net metering, the consumer will self-consume some part of the PV electricity generated and will export to the grid the excess generation, receiving a payment for

the exported amount which typically ranges between 6 to 8 cA$ per kWh (4.6 to 6.2 cEu[4]).[5]

- The net-metering system in NSW fosters the self-consumption market in an efficient way, as consumers are better off maximizing self-consumption (and saving the price of grid electricity), given that the tariff received for the excess generation is lower than the grid electricity price.
- On top of the above benefits, residential PV systems can receive subsidies through the Commonwealth Small-Scale Renewable Energy Scheme to reduce the initial investment of the PV system via small-scale technology certificates (STC)[6] which can be sold to electricity retailers, which are obliged to purchase a target number per year.
    - As State and Federal policies in Australia change regularly, the PV situation could be affected by, for example, changes to STC rules.

Figure 10: Assessment of regulatory support to PV self-consumption



3.1.3 Conclusions

- In Australia, Grid Parity represents an excellent opportunity to develop a cost-effective and sustainable PV market based on self-consumption.
- The net-metering system in NSW fosters the self-consumption market in an effective way, as the tariff received for the excess generation is lower than the grid electricity price.

[4] Exchange rate as of February 2013.

[5] The feed-in tariff for exported electricity in NSW is voluntary, not mandatory and so some customers get zero.

[6] One certificate can be created for each MWh of PV generated.

- Even if Grid Parity (defined as the moment when PV LCOE equals retail electricity prices) has been reached, regulatory cover[7] is still necessary to foster the PV self-consumption market.
- As 100% self-consumption is not likely to happen for a residential consumer, a proper valuation of the excess of energy has to be performed to properly understand the business case of a specific consumer.

[7] It has to be well understood that this does not imply any kind of economic support.

3.2 Brazil

3.2.1 Grid Parity Proximity

Figure 11: Past evolution of retail electricity price and PV LCOE in São Paulo, Brazil (including taxes)

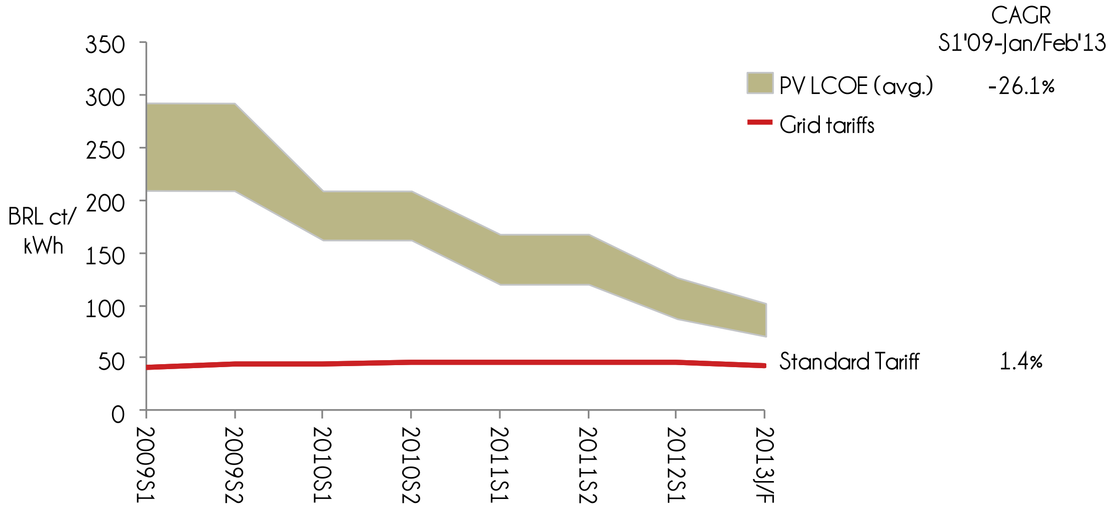


Figure 12: São Paulo's Grid Parity proximity

Figure 13: Past evolution of retail electricity price and PV LCOE in Itacarambi, Brazil (including taxes)

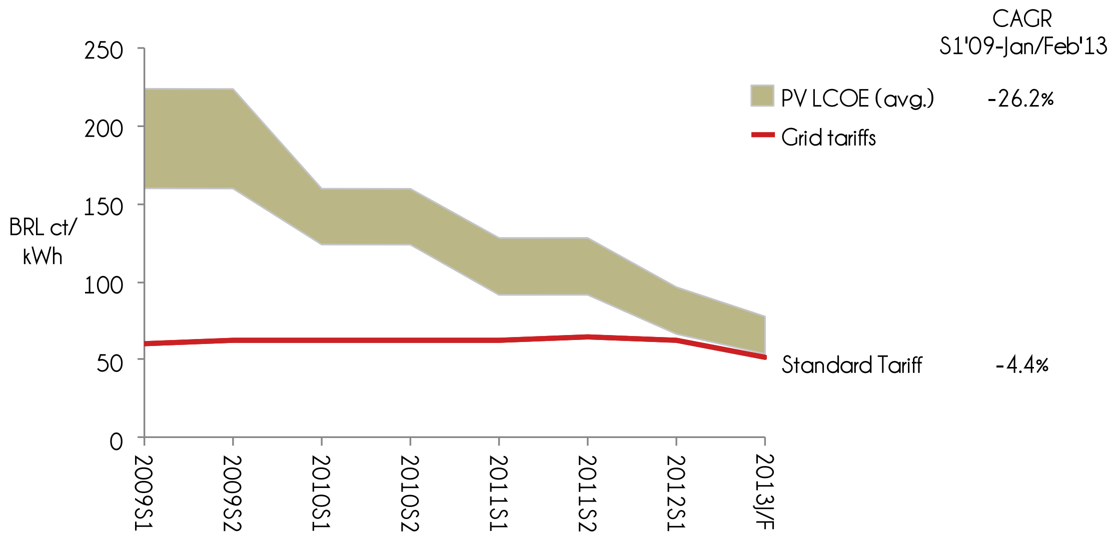


Figure 14: Itacarambi's Grid Parity proximity

- In January 2013, the Brazilian Government implemented a reduction of electricity tariffs, which for residential consumers ranges from 18% to 26% depending on the distribution company.
  - As a result of this measure, PV grid parity is being pushed further away in Brazil.
- Despite relatively high irradiation levels, PV LCOE is higher in Brazil than in other countries; this is mainly due to:
  - Higher installation prices caused by customs duties levied on PV equipment and by the immaturity of the PV market, which enables inefficiency and high margins throughout the entire value chain.
  - A higher discount rate used in the LCOE calculation, which reflects high local inflation rates and thus higher return expectations among Brazilians.
- Nevertheless, PV LCOE has experienced a considerable decrease (a Compound Annual Growth Rate of around -26% from 2009 to January/February 2013).
- This increase in PV competitiveness combined with Itacarambi's high irradiation levels and electricity prices make Grid Parity in the residential segment a near future reality in this northern city of Minas Gerais.
- On the contrary, in Saõ Paulo PV technology is still far from being competitive against grid electricity.

3.2.2 Regulatory support to PV self-consumption

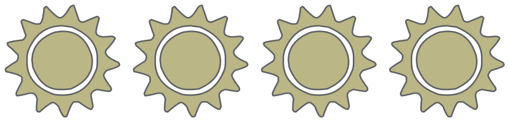
- A net-metering regulation for renewable energy systems up to 1 MWp is in place since January 2013[8]; with the following main characteristics:
  - Users will only pay for the difference between the energy consumed and the one fed to the grid.
  - Compensation will be held within the same rate period (peak - peak / off-peak - off-peak).
  - Energy surpluses can be compensated during a 36-month period or in other consumption units (other buildings) as long as they belong to the same owner

[8] The net-metering regulation was approved in April 2012, but distribution companies had 8 months to adapt their technical standard and products.

and are located within the geographical scope of the utility (remote net metering).

- Apart from the net-metering scheme, there is no significant support for PV generation in Brazil, since renewable energies tend to compete on equal terms with conventional technologies.
  - The Ministry of Energy is considering new measures to promote renewable energies, e.g. specific tenders for PV energy.
  - They will not come into force at least until 2013 / 2014.

Figure 15: Assessment of regulatory support to PV self-consumption



3.2.3 Conclusions

- High installation prices and a high discount rate still prevent PV technology from being competitive against grid electricity in the residential segment.
- Moreover, a recent reduction of electricity tariffs has pushed PV grid parity further away in Brazil.
- The recently approved net-metering regulation seems, on a first evaluation, an excellent instrument to foster the PV self-consumption market. Nevertheless, it is still too soon to determine its actual impact on the market.
- Even if Grid Parity (defined as the moment when PV LCOE equals retail electricity prices) has been reached, regulatory cover[9] is still necessary to foster the PV self-consumption market.
- As 100% self-consumption is not likely to happen for a residential consumer, a proper valuation of the excess of energy has to be performed to properly understand the business case of a specific consumer.

[9] It has to be well understood that this does not imply any kind of economic support.

3.3 Chile

3.3.1 Grid Parity Proximity

Figure 16: Past evolution of retail electricity price and PV LCOE in Santiago, Chile (including taxes)

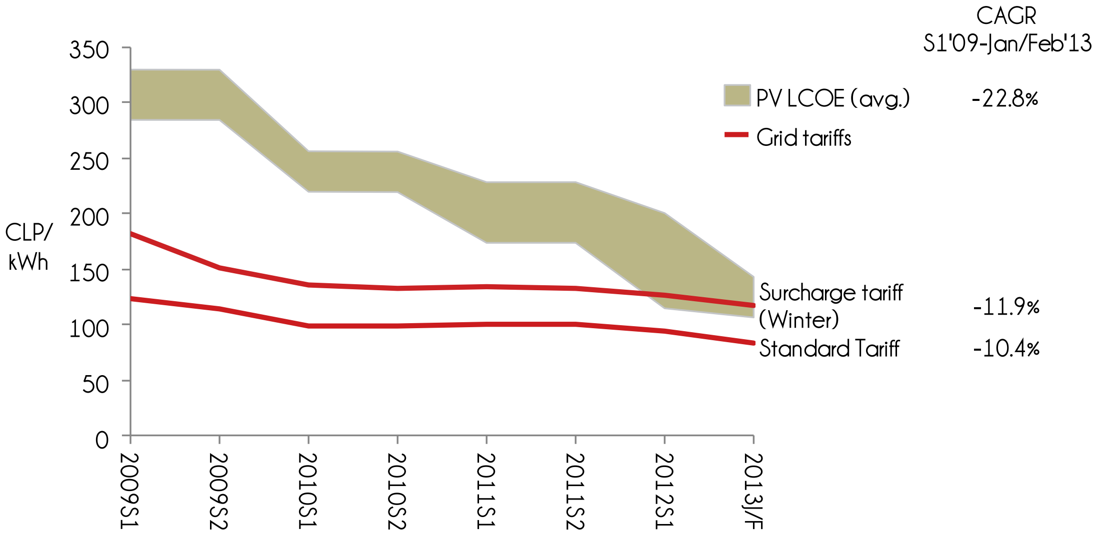


Figure 17: Santiago's Grid Parity proximity

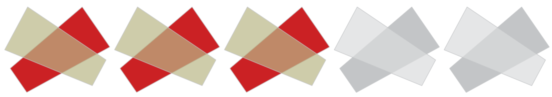


Figure 18: Past evolution of retail electricity price and PV LCOE in Copiapó, Chile (including taxes)

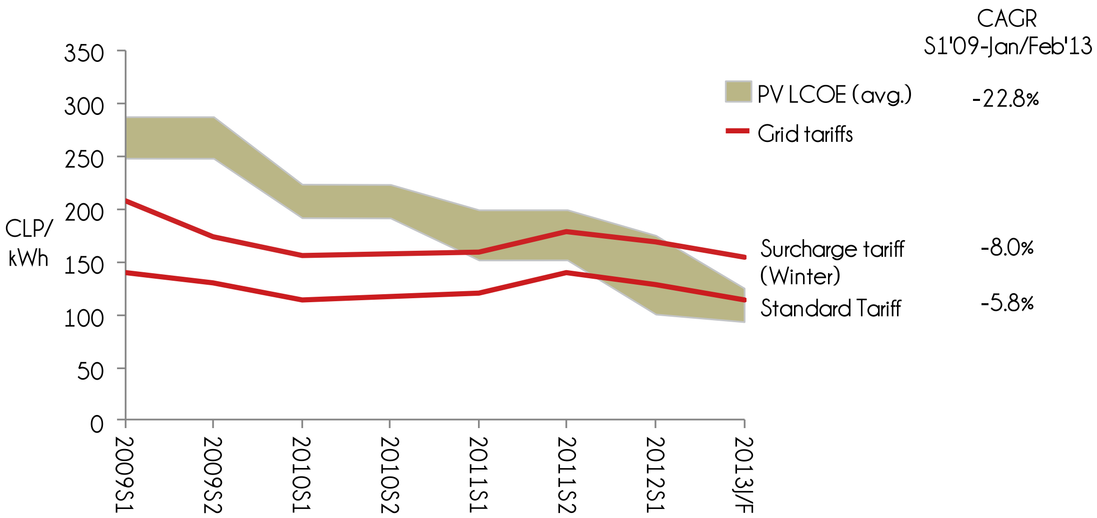


Figure 19: Copiapó's Grid Parity proximity

- Grid electricity prices have further decreased in the first months of 2013, however, this downward trend is not likely to be sustained in the future.
    - The recent decrease of electricity prices is explained by the significant variability of Chilean power exchanges, very dependent on several factors such as the availability of hydropower resources or fuel supply problems with other countries (e.g. natural gas conflicts with Argentina since 2004).
- PV Grid Parity has already been reached in the residential segment, albeit to different extents in different locations of Chile.
    - In Santiago, Grid Parity is only partial since PV LCOE is only competitive with the rate applicable to excess consumption in winter.
    - In Northern Chile[10], PV LCOE is not only significantly lower than the rate applicable to excess consumption in winter but, for the most competitive quotations, it is also lower than the standard (non-TOU) electricity rate.
- Moreover, the small-scale PV market in Chile is still relatively immature, therefore there is margin for further price reductions, which could push full grid parity proximity closer.

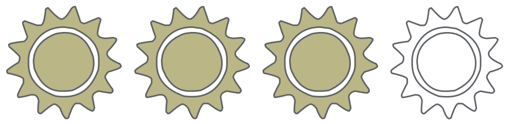
3.3.2 Regulatory support to PV self-consumption

- In March 2012 a net billing regulation for PV installations up to 100 kW was approved (Law 20.571).
    - PV electricity surpluses will be valued at an economical rate (lower than the retail electricity price) and used for later electricity consumption or, if this is not possible, the self-consumer will get the monetary value from the electricity companies.
    - This law will not come into force until a technical code is published, which was planned for the end of 2012 but has not been done yet.
- The Renewable Quotas Law obliges utilities to buy at least 5% of their annual traded electricity from renewable energy sources.

[10] It should be highlighted that Copiapó is not the city with the highest radiation levels in the country, but is used as a reference owing to its total population jointly with its relatively high radiation levels, as some cities with higher radiation have a lower number of inhabitants.

- This obligation will start to increase gradually in 2014 from 5% to 10% (in 2024); economic penalties for non-compliance are set.
- Utilities can produce their own renewable energy or buy it from other energy producers such as self-consumers.
- This could encourage utilities to support the development of the PV self-consumption market.

Figure 20: Assessment of regulatory support to PV self-consumption



3.3.3 Conclusions

- Grid Parity has been reached in Northern Chile, whilst in other locations with lower irradiation only partial grid parity has been reached.
- The net billing regulation, when implemented, is likely to generate a PV self-consumption market.
    - A second evaluation once the technical code is published is necessary to determine if the net billing regulation will suffice to foster the market or if any other support is needed.
- Even if Grid Parity (defined as the moment when PV LCOE equals retail electricity prices) has been reached, regulatory cover[11] is still necessary to foster the PV self-consumption market.
- As 100% self-consumption is not likely to happen for a residential consumer, a proper valuation of the excess of energy has to be performed to properly understand the business case of a specific consumer.

[11] It has to be well understood that this does not imply any kind of economic support.

3.4 France

3.4.1 Grid Parity Proximity

Figure 21: Past evolution of retail electricity price and PV LCOE in Paris, France (including taxes)[12]

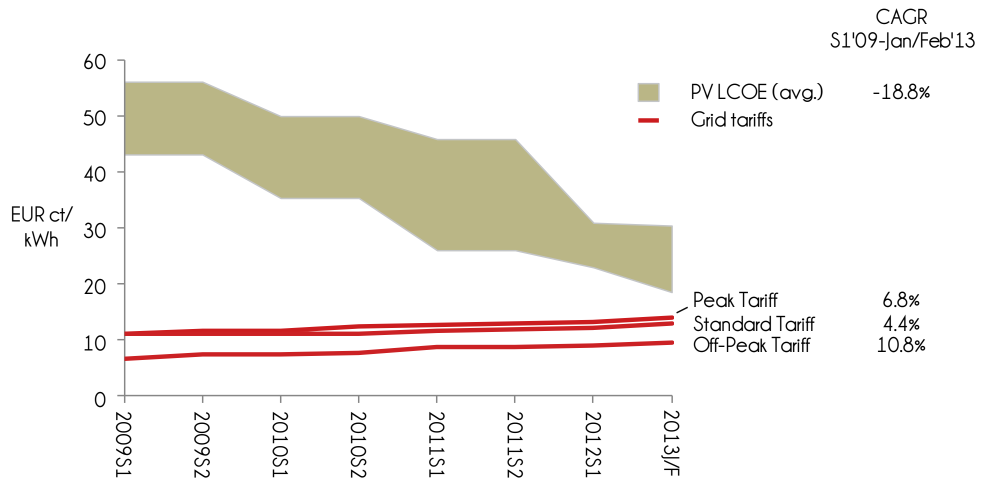


Figure 22: Paris's Grid Parity proximity

Figure 23: Past evolution of retail electricity price and PV LCOE in Marseille, France (including taxes)[12]

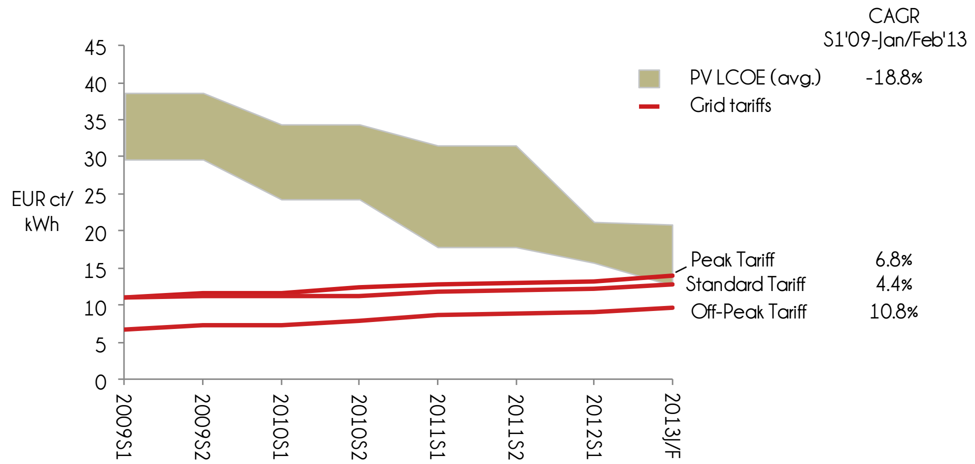
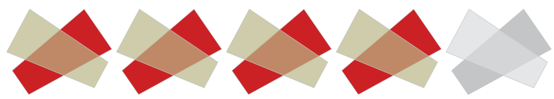


Figure 24: Marseille's Grid Parity proximity



---

[12] PV prices correspond to January/February 2013, thus the effect on LCOE of the recent import duty set by the European Commission on Chinese solar products is not considered.

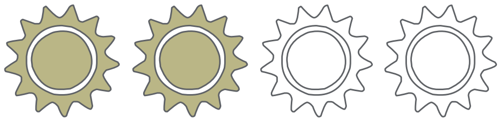
- PV LCOE has been decreasing an average of 18.8% per year since 2009, while grid electricity prices have increased steadily (4.4% Compound Annual Growth Rate for the standard tariff).
  - These trends are pushing PV competitiveness forward in France.
- In Marseille, as a result of the high solar irradiation, the most competitive LCOE is already slightly lower than the standard electricity price.
- However, in Paris grid parity proximity is still far from happening, as the most competitive LCOE is still higher than electricity prices from the grid.

3.4.2 Regulatory support to PV self-consumption

- In France, small-scale PV systems can receive a FiT that compensates for the excess electricity fed into the grid.
  - The FiT depends on the type of PV system: whether the system fully replaces the building structure (BIPV) or not (BAPV).[13]
  - Residential BIPV remuneration levels significantly exceed those of BAPV (35 cEu/kWh versus 18 cEu/kWh in Q4 2012).
  - Moreover, for both BIPV and BAPV, FiTs are still higher than the standard electricity price for residential consumers.
- Given that for both BIPV and BAPV installations the FiTs are still higher than the retail price of electricity, self-consumption is not being incentivized.
  - In the longer run, self-consumption will gain relevance provided that FiTs are being reduced and electricity from the grid becomes more expensive.
- Residential consumers can also benefit from other support measures:
  - A tax credit of 11% of the equipment costs with certain limits depending on the PV system characteristics
  - Reduced VAT rate of 7% on equipment and installation costs (only for systems below 3kWp).

[13] The installation prices used in this study refer to BAPV systems not to BIPV.

Figure 25: Assessment of regulatory support to PV self-consumption



3.4.3 Conclusions

- While the north of France is close to grid parity, the south has already reached grid parity, as a result of its higher irradiation levels.
- Currently, FiTs in France do not incentivize the PV self-consumption market.
  - In the longer run, self-consumption will gain relevance provided that FiTs are being reduced and electricity from the grid becomes more expensive.
- Even if Grid Parity (defined as the moment when PV LCOE equals retail electricity prices) has been reached, regulatory cover[14] is still necessary to foster the PV self-consumption market.
- As 100% self-consumption is not likely to happen for a residential consumer, a proper valuation of the excess of energy has to be performed to properly understand the business case of a specific consumer.

[14] It has to be well understood that this does not imply any kind of economic support.

3.5 Germany

3.5.1 Grid Parity Proximity

Figure 26: Past evolution of retail electricity price and PV LCOE in Berlin, Germany (including taxes)[15]

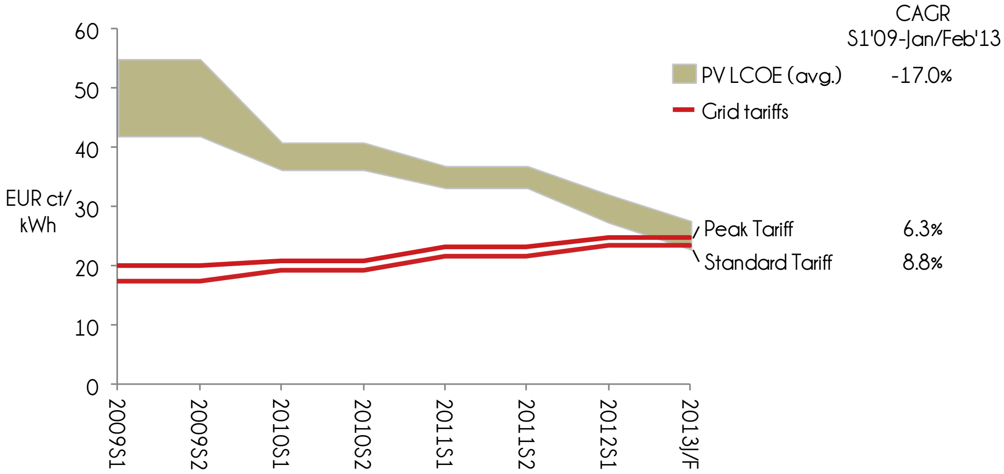


Figure 27: Berlin's Grid Parity proximity

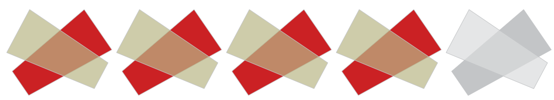


Figure 28: Past evolution of retail electricity price and PV LCOE in Munich, Germany (including taxes)[15]

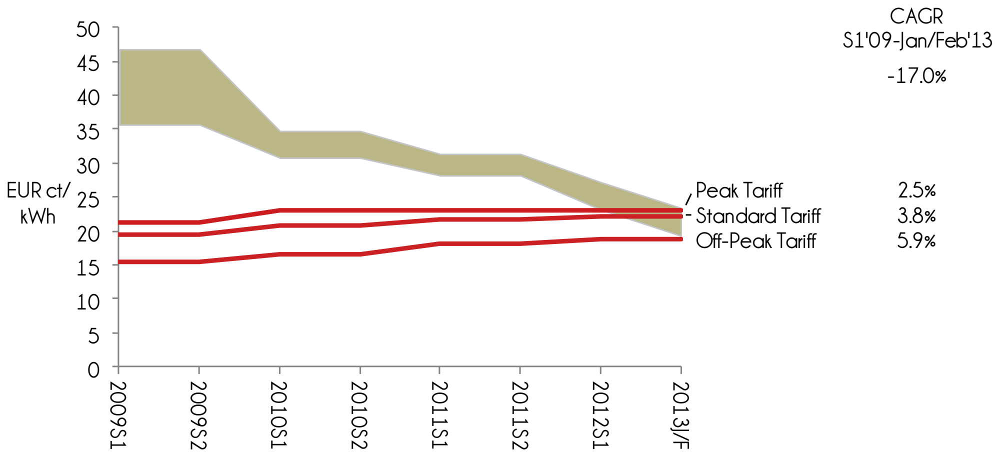


Figure 29: Munich's Grid Parity proximity

[15] PV prices correspond to January/February 2013, thus the effect on LCOE of the recent import duty set by the European Commission on Chinese solar products is not considered.

- Despite the low irradiation levels in Germany, PV grid parity has already been reached in Munich:
  - PV LCOE of the most competitive quotations received for January/February 2013 is lower than SWM peak tariff and than the standard (non-TOU) tariff.
- Partial PV grid parity has recently been reached in Berlin:
  - PV LCOE of the most competitive quotations received is lower than SWM peak tariff and slightly lower than the standard tariff.
- PV grid parity proximity in a country with relatively low irradiation levels such as Germany can be explained by three main factors:
  - System prices in Germany are among the lowest quotations received a clear sign of market maturity.
  - The discount rate used for the calculation of LCOE is low (5%, see Section 4.3), which reflects the return a German electricity consumer would require from such a relatively safe investment.
  - Retail electricity prices are considerably high.

3.5.2 Regulatory support to PV self-consumption

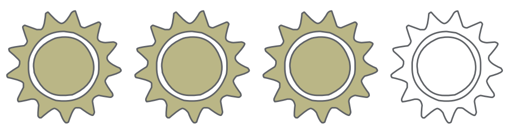
- In 2012, the latest amendment of the Renewable Energy Sources Act (Erneuerbare Energien Gesetz, EEG) introduced severe FiT cuts for small-scale PV installations.
  - In January 2012, FiT for new installations was cut by 15%[i].
  - A further reduction was introduced in April 2012[16] when the tariffs were set down by another 20% with additional monthly reductions of 1% from May 2012.
  - From then on the monthly tariff reduction depends on the capacity installed throughout the previous 12 months, whereas large capacity increases result in lower tariffs and vice versa.
- EEG FiT program fosters the self-consumption market in an efficient way.

[16] The definite version of the regulation was not published until August 2012 with retroactive changes from April 2012 onwards as the Bundesrat (upper house of the German parliament) had initially stopped the regulation proposal.

- Historically, PV owners were encouraged to self-consume PV-generated electricity with a premium paid for each kWh of self-consumed PV electricity.
- Recently, the self-consumption premium was eliminated but the drastic FiT cuts make feeding PV electricity into the grid less attractive than self-consumption since FiT for small-scale systems are currently lower than the retail electricity price.

- Another recent change also affects the small-scale segment: as of 2014, the percentage of the yearly power production entitled to receive the tariff will be restricted for certain installation sizes (the so-called market integration model).
  - For small installations (< 10 kWp), 100% of the yearly generated electricity will still be remunerated.
  - For installations with a capacity of 10 – 1,000 kWp only 90% of the yearly-generated electricity will receive the tariff, the remaining energy should be either self consumed or sold at market value. Alternatively, the installation owner can opt for receiving the monthly average market price from the spot market if the electricity is fed into the grid.
- There are additional incentives for PV, owners of PV installations can apply for the possibility of receiving a refund of either the VAT paid for the installation investment or the VAT attributed to the FiT received. (This incentive is not taken into consideration in the LCOE calculation).
- Moreover, a potentital storage benefit would foster the self consumption market.

Figure 30: Assessment of regulatory support to PV self-consumption



3.5.3 Conclusions

- Low PV installation prices, a low discount rate and high retail electricity prices compensate low irradiation levels for Germany to reach Grid Parity in the residential segment.
- The EEG FiT scheme fosters the self-consumption market in an efficient way, as FiTs for small-scale systems are currently lower than the retail electricity price.

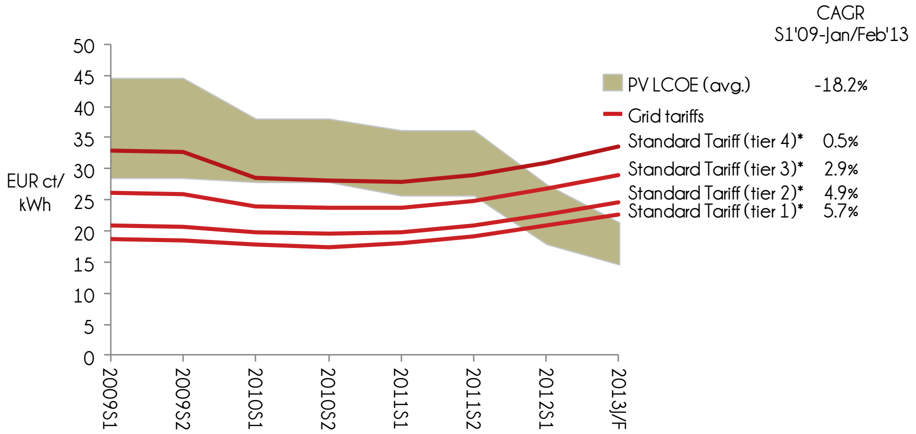
- Even if Grid Parity (defined as the moment when PV LCOE equals retail electricity prices) has been reached, regulatory cover[17] is still necessary to foster the PV self-consumption market.
- As 100% self-consumption is not likely to happen for a residential consumer, a proper valuation of the excess of energy has to be performed to properly understand the business case of a specific consumer.

[17] It has to be well understood that this does not imply any kind of economic support.

3.6 Italy

3.6.1 Grid Parity Proximity

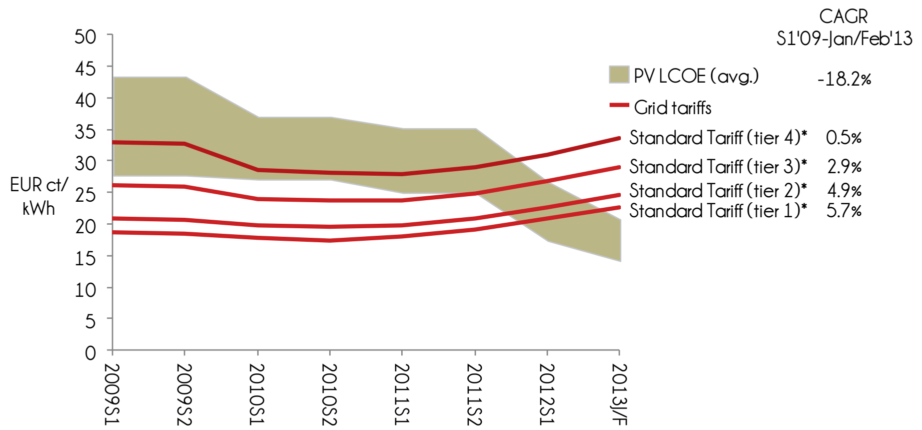
Figure 31: Past evolution of retail electricity price and PV LCOE in Rome, Italy (including taxes)[18]



Note: * Tiers correspond to different consumption levels, tier 1: ≤ 1,800 kWh/year, tier 2: from 1,801 to 2,640 kWh/year, tier 3: from 2,641 to 4,440 kWh/year, tier 4: ≥ 4,441 kWh/year

Figure 32: Rome's Grid Parity proximity

Figure 33: Past evolution of retail electricity price and PV LCOE in Palermo, Italy (including taxes)[18]



Note: * Tiers correspond to different consumption levels, tier 1: ≤ 1,800 kWh/year, tier 2: from 1,801 to 2,640 kWh/year, tier 3: from 2,641 to 4,440 kWh/year, tier 4: ≥ 4,441 kWh/year

Figure 34: Palermo's Grid Parity proximity

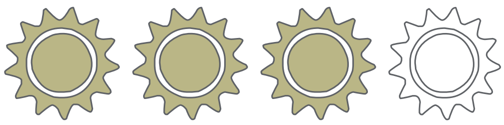
[18] PV prices correspond to January/February 2013, thus the effect on LCOE of the recent import duty set by the European Commission on Chinese solar products is not considered.

- Full PV Grid Parity has been reached in Italy mainly due to:
  - Cost-competitive PV system installation costs, which drove a decrease of PV LCOE of 18.2% per year from 2009 to January/February 2013.
  - High irradiation levels in comparison to those in most other EU countries.
  - Relatively expensive variable grid electricity prices.
  - The discount rate used in the LCOE calculation, which is not an obstacle for PV cost-competitiveness, and which is currently within the middle-range of the countries under study (see Section 4.3).
- LCOE is already lower than the lowest variable grid electricity tariff.
  - The higher the consumption level of the user, the more convenient is self-consumption.

3.6.2 Regulatory support to PV self-consumption

- The Scambio Sul Posto mechanism allows users with PV systems under 200 kW to obtain credits used to offset their electricity bill for each PV kWh fed into the grid.
  - It is expected that the methodology used to calculate the credit amount will be modified soon, when the GSE (Gestore dei Servizi Energetici) publishes the new technical regulation.
- The most recently published version of the Conto Energia (5th), published in August 2012, made the Scambio Sul Posto no longer compatible with the FiT. In compensation for this, a self-consumption premium was introduced.
- Both the Conto Energia and the recently introduced self-consumption premium will be eliminated as soon as the set budget is reached, which is expected to happen during the first quarter of 2013.

Figure 35: Assessment of regulatory support to PV self-consumption



3.6.3 Conclusions

- Thanks to competitive PV system installation costs, high irradiation levels and expensive grid electricity prices, PV Grid Parity has already been reached in the residential segment in the whole country.
- Both the Conto Energia (with a recently created self-consumption premium) and the Scambio Sul Posto support PV self-consumption.
  - However, the Scambio Sul Posto will likely remain as the only support system for auto-consumption as soon as the budget of the Conto Energia is reached.
- Even if Grid Parity (defined as the moment when PV LCOE equals retail electricity prices) has been reached, regulatory cover[19] is still necessary to foster the PV self-consumption market.
- As 100% self-consumption is not likely to happen for a residential consumer, a proper valuation of the excess of energy has to be performed to properly understand the business case of a specific consumer.

[19] It has to be well understood that this does not imply any kind of economic support.

3.7 Mexico

3.7.1 Grid Parity Proximity

Figure 36: Past evolution of retail electricity price and PV LCOE in Mexico City, Mexico (including taxes)

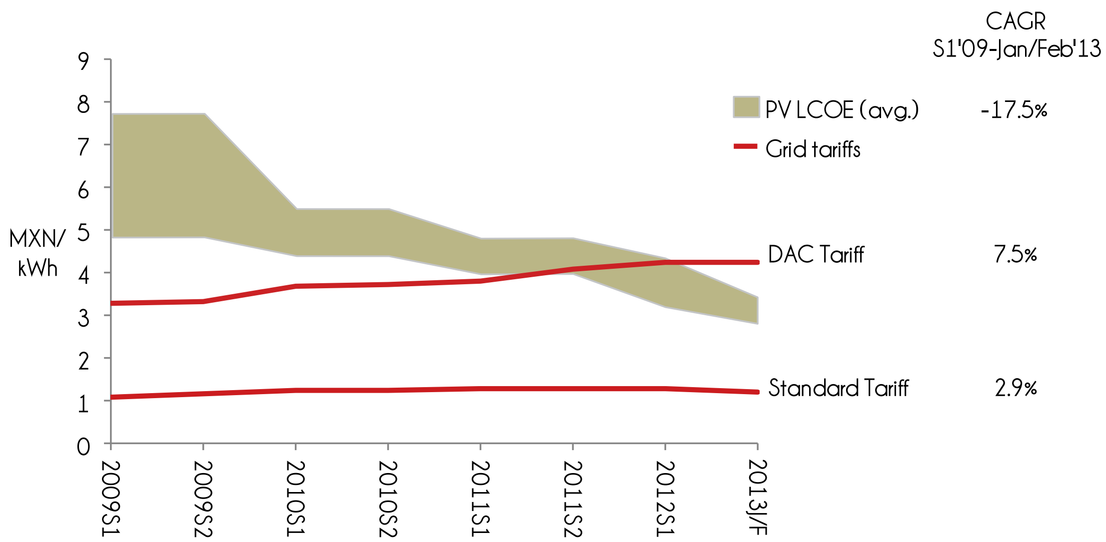


Figure 37: Mexico City's Grid Parity proximity

Figure 38: Past evolution of retail electricity price and PV LCOE in Hermosillo, Mexico (including taxes)

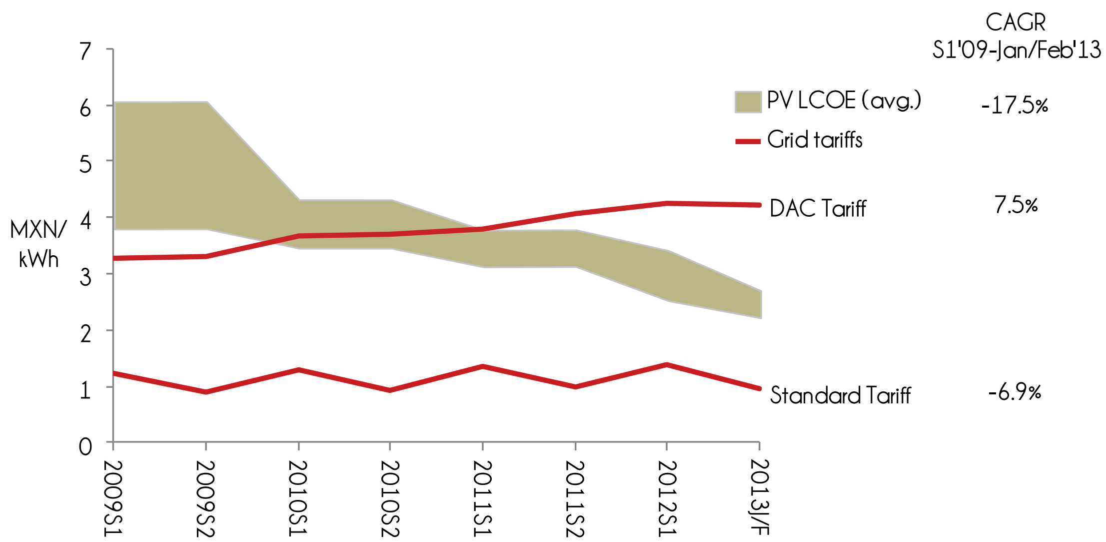


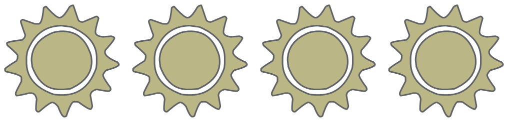
Figure 39: Hermosillo's Grid Parity proximity

- For DAC electricity consumers (households with high electricity consumption that pay more than twice the price of the average residential tariff), it is already worthwhile from an economic point of view to self-consume PV electricity instead of buying it from CFE (single National utility).
- Although PV LCOE has experienced a significant decrease from 2009 to January/February 2013 estimated at -17.5% Compound Annual Growth Rate, for the average electricity consumer PV is still far from being competitive.

3.7.2 Regulatory support to PV self-consumption

- A net-metering mechanism (Medición Neta) was created in 2007 for renewable energy based systems under 500 kW.
  - It allows the users to feed into the grid part of their electricity and to receive credits (in kWh) for it, used to offset their electricity bill.
  - According to CFE, by the end of 2012, some 1,600 residential users were in the net-metering scheme (2.5 times the number reported at the end of 2011).
- In December 2012, the National Fund for Energy Savings announced the start of financing of PV systems for DAC users, with a 5 year repayment term, at lower interest rates than commercial banks.
- There are no additional incentives (feed-in tariff, rebates, etc.) for small and medium scale renewable energy installations for residential users.
  - For non-residential consumers, there is the incentive of an accelerated depreciation of the investment.
- For larger installations, a reduced and distance-independent transmission fee allows users to "self-consume" electricity generated by a PV installation that can be located thousands of kilometres away from the energy consumer.
- Since 2012, net metering is also available to multi-family housing.
  - Each tenant will pay the difference between its individual consumption from the grid and the specific PV-generated electricity allocated by the CFE to that tenant's utility account, according to a pre-arranged share.
- Mexico´s newly elected Government has launched some initiatives which could signal a rise of renewable energies on its agenda.

Figure 40: Assessment of regulatory support to PV self-consumption



3.7.3 Conclusions

- The combination of grid parity and an effective regulation generates a good investment opportunity for DAC consumers.
    - However, grid parity is still far for standard residential consumers.
- Even if Grid Parity (defined as the moment when PV LCOE equals retail electricity prices) has been reached, regulatory cover[20] is still necessary to foster the PV self-consumption market.
- Most of the residential systems currently installed are close to 100% self-consumption. Nevertheless, a proper valuation of the excess of energy has to be performed to properly understand the business case of a specific consumer.

[20] It has to be well understood that this does not imply any kind of economic support.

3.8 Spain

3.8.1 Grid Parity Proximity

Figure 41: Past evolution of retail electricity price and PV LCOE in Madrid, Spain (including taxes)[21]

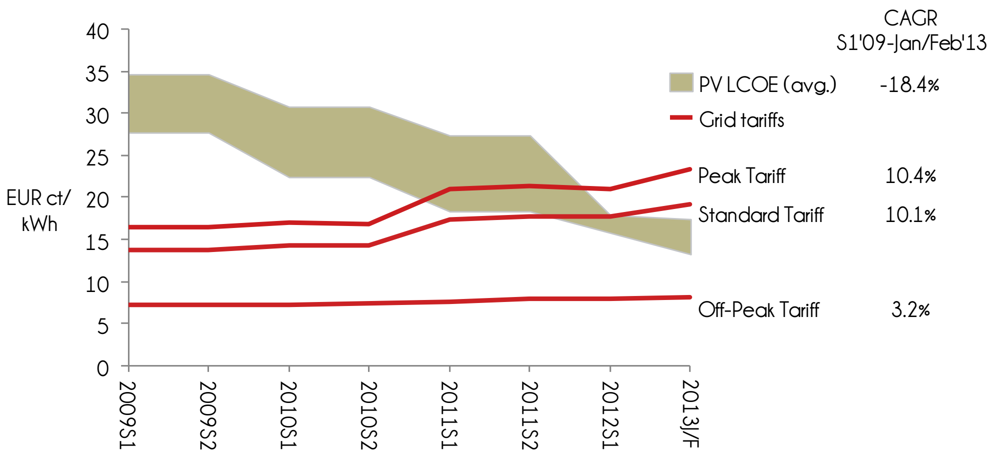


Figure 42: Madrid's Grid Parity proximity

Figure 43: Past evolution of retail electricity price and PV LCOE in Las Palmas (Canary Islands), Spain (including taxes)[21]

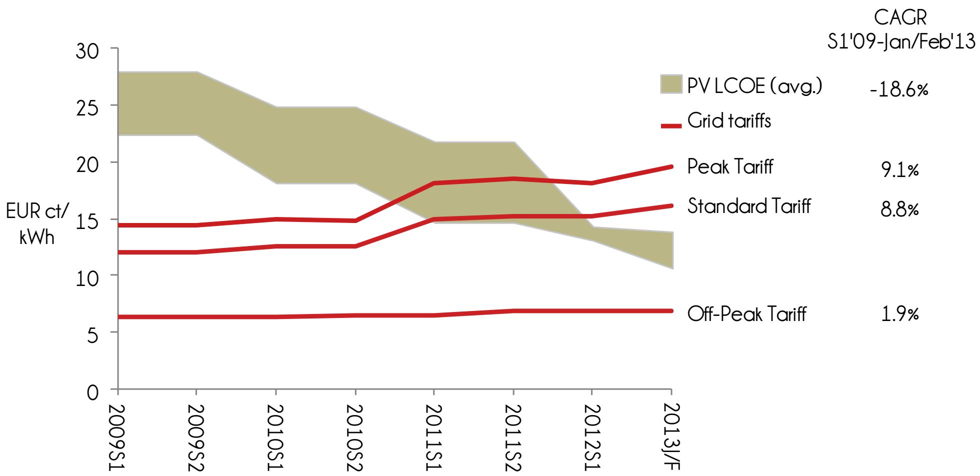


Figure 44: Las Palmas' Grid Parity proximity

[21] PV prices correspond to January/February 2013, thus the effect on LCOE of the recent import duty set by the European Commission on Chinese solar products is not considered.

- Both in Continental Spain and in the Canary Islands, PV is already competitive against the standard (non-TOU) retail electricity price. This is mainly due to:
  - The significant decrease experienced by PV LCOE in the last few years (an average annual decrease of over 18% in Madrid and in the Canary Islands from the first semester of 2009 to January/February 2013).
  - An important and constant increase in retail electricity prices[22], which was intensified by the recent increase in VAT rates from 18% to 21% in Continental Spain and from 5% to 7% in the Canary Islands.

3.8.2 Regulatory support to PV self-consumption

- In Spain, a residential electricity consumer can generate PV electricity for self-consumption.
  - However, there is no specific net-metering regulation. The only way to solve the excess of electricity is selling to the market, which is not interesting from an economic point of view.
- Recently, a 7% energy tax was approved, affecting all electricity generators.
  - This energy tax could eventually affect PV self-consumers, depending on the details of the future net-metering regulation.
- In contrast, other two developments should be pointed out:
  - RD 1699/2011 (approved by the previous Government in December 2011) simplifies the grid connection process for small (< 100 kW) renewable energy installations.[23]
  - It is expected that a net-metering regulation (Balance Neto) will be published in the following months. This process started in November 2011, when the Ministry of Industry sent a Royal Decree draft to the National Energy Commission, which later published a favourable report in April 2012.

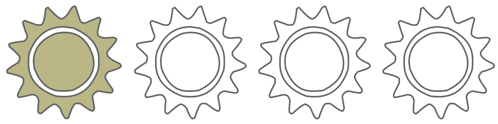
---

[22] The tax on electricity is lower in the Canary Islands than in Continental Spain, difference that explains the lower electricity prices reported for the Canary Islands.

[23] It should be noted that, according to UNEF, PV projects for self-consumption are encountering difficulties in the grid-connection process.

- In the meantime, several Autonomous Communities (such as Extremadura, Catalonia, Castilla and Leon and the Balearic Islands) have published specific circulars on the administrative requirements to legalize residential PV systems for self-consumption.

Figure 45: Assessment of regulatory support to PV self-consumption



3.8.3 Conclusions

- Grid Parity represents an excellent opportunity to develop a cost-effective and sustainable PV market based on self-consumption in Spain. For this to happen, a proper and holistic review of the existing Regulation has to be made.
- It is essential that the Spanish Government publishes the Balance Neto regulation (already drafted) to allow PV self-consumers to feed their excess generation into the grid in exchange for a compensation.
- Even if Grid Parity (defined as the moment when PV LCOE equals retail electricity prices) has been reached, regulatory cover[24] is still necessary to foster the PV self-consumption market.
- As 100% self-consumption is not likely to happen for a residential consumer, a proper valuation of the excess of energy has to be performed to properly understand the business case of a specific consumer.

[24] It has to be well understood that this does not imply any kind of economic support.

3.9 UK

3.9.1 Grid Parity Proximity

Figure 46: Past evolution of retail electricity price and PV LCOE in London, UK (including taxes)[25]

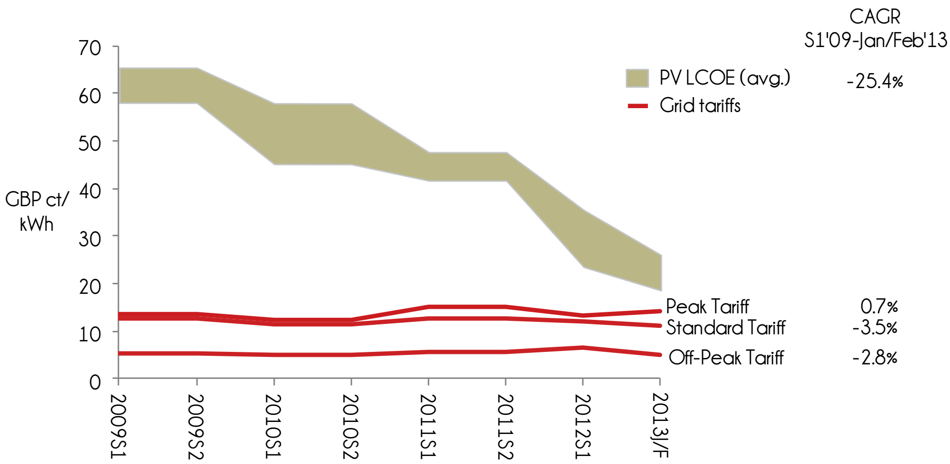


Figure 47: London's Grid Parity proximity

Figure 48: Past evolution of retail electricity price and PV LCOE in Plymouth, UK (including taxes)[25]

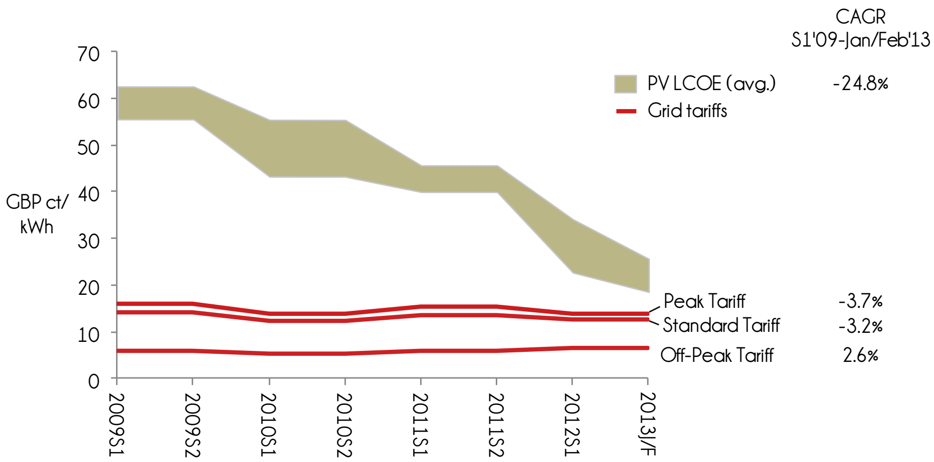


Figure 49: Plymouth's Grid Parity proximity

[25] PV prices correspond to January/February 2013, thus the effect on LCOE of the recent import duty set by the European Commission on Chinese solar products is not considered.

- In the UK, PV Grid Parity is still far from being reached.
- Nevertheless, PV LCOE has experienced a considerable decrease since 2009 (an average Compound Annual Growth Rate of -25.1% in the analyzed period).

3.9.2 Regulatory support to PV self-consumption

- In the UK, the main support mechanism for small-scale PV systems is the FiTs scheme, which was introduced in 2010[26].
- Smaller-scale PV systems (<30kWp) eligible to receive a FIT are given not only a tariff for the PV electricity produced (generation tariff) but also a bonus for the excess electricity fed into the grid (export tariff)[27].
  - The generation tariff is a set rate for each kWh of PV electricity generated, guaranteed for 20 years and index-linked.
  - The export tariff amounts to 4.5p (5.2 cEu)[28] for each kWh fed into the grid (i.e., the excess PV electricity).
    - If small-scale PV systems do not have an export meter installed (and therefore the amount of electricity fed into the grid cannot be measured), a fixed percentage of self-consumption is assumed (in this case, it amounts to 50%).
- The support scheme in the UK fosters PV self-consumption.
  - The user will be better off by self-consuming the greatest proportion of PV electricity generated, as it is always more convenient from an economic point of view to self-consume PV electricity (and save the cost of electricity from the grid) than to feed the excess PV electricity into the grid (and receive the export tariff on top of the generation tariff).
- In addition to the FiT, PV self-consumers can benefit from VAT reduction and fiscal incentives.

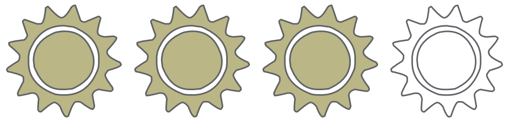
---

[26] PV systems up to 5 MW can benefit from FiTs.

[27] Generators can choose between receiving the export tariff for the excess PV electricity fed into the grid and negotiating a PPA.

[28] Exchange rate as of February 2013.

Figure 50: Assessment of regulatory support to PV self-consumption



3.9.3 Conclusions

- PV technology is still far from being competitive against grid electricity prices in the residential segment in the UK.
- However, the FIT scheme for small-scale PV systems fosters the PV self-consumption market in an efficient way.
- Even if Grid Parity (defined as the moment when PV LCOE equals retail electricity prices) has been reached, regulatory cover[29] is still necessary to foster the PV self-consumption market.
- As 100% self-consumption is not likely to happen for a residential consumer, a proper valuation of the excess of energy has to be performed to properly understand the business case of a specific consumer.

[29] It has to be well understood that this does not imply any kind of economic support.

3.10 USA (California)

3.10.1 Grid Parity Proximity

Figure 51: Past evolution of retail electricity price and PV LCOE in Los Angeles, California (including taxes)

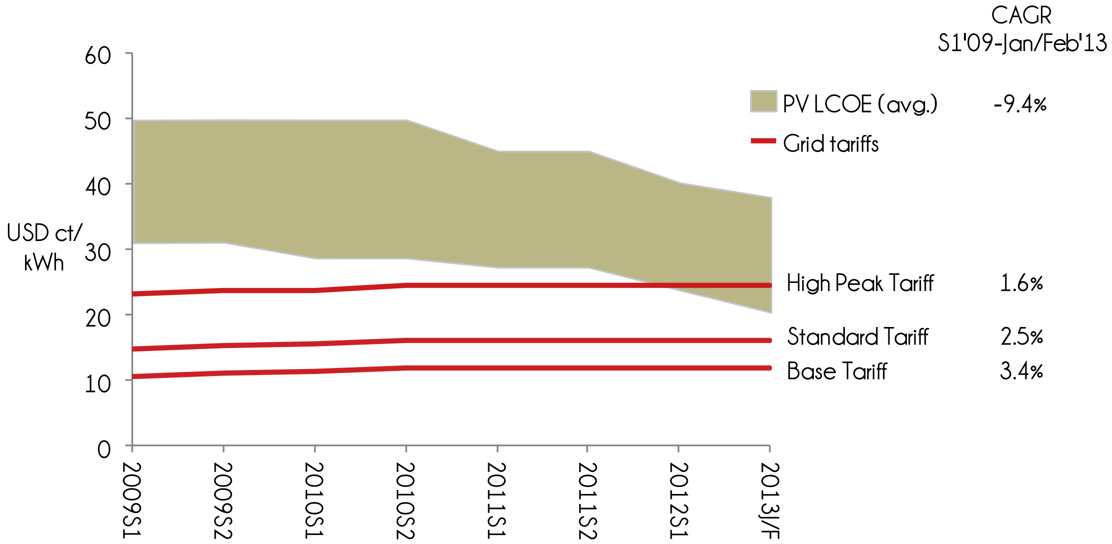


Figure 52: Los Angeles' Grid Parity proximity

Figure 53: Past evolution of retail electricity price and PV LCOE in San Francisco, California (including taxes)

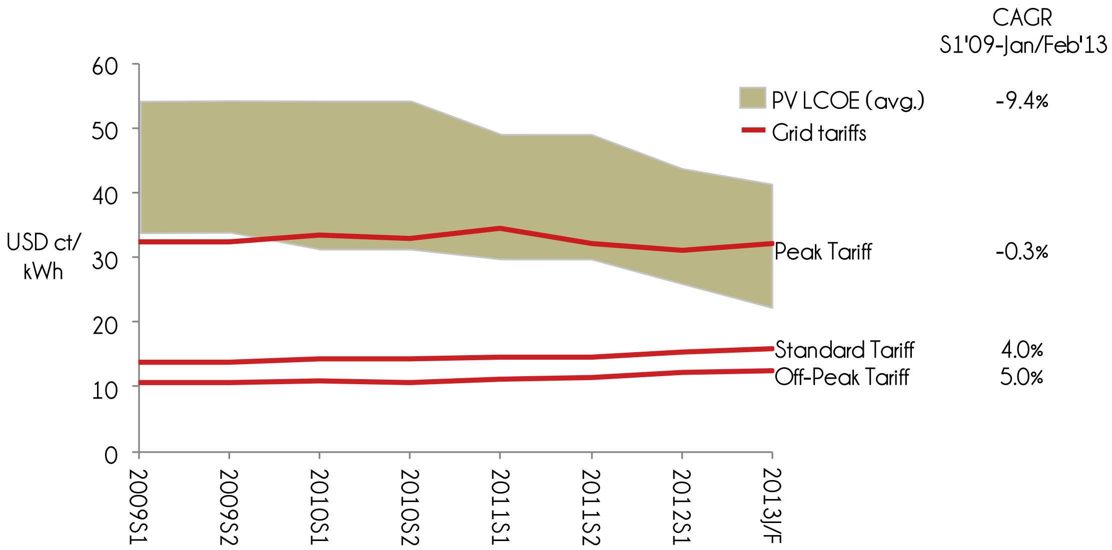


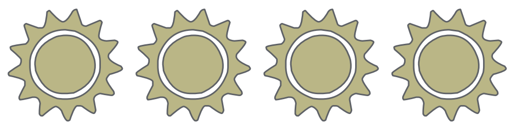
Figure 54: San Francisco's Grid Parity proximity

- Both in Los Angeles and San Francisco, PV LCOE of the most competitive quotations is already lower than the highest TOU electricity rates.
- Nevertheless, Grid Parity is still far from happening since PV LCOE is significantly higher than standard (non-TOU) electricity rates.
  - California has not witnessed such a considerable decrease in PV LCOE as other countries have (a CAGR of -9.4% in from 2009 to January/February 2013).
  - This is caused by high PV installation prices, which remain well above international competitive price levels due to local incentives that enable high margins throughout the entire value chain.

3.10.2 Regulatory support to PV self-consumption

- A net-metering mechanism is in place since 1996. It allows users that install small (< 1MW) renewable energy-based systems to feed into the grid part of their electricity and to receive a financial credit for it. This credit is used to offset the user's electricity bill.
  - It has been very successful: over 40,000 customers have already enrolled in California's net-metering program.
- On top of net-metering, other programs such as the California Solar Initiative (CSI) offer generous cash rebates for solar installations.
- Simplified interconnection procedures and accelerated interconnection timelines exist for small (< 1MW) self-generation renewable energy systems.

Figure 55: Assessment of regulatory support to PV self-consumption



3.10.3 Conclusions

- PV is still far from being competitive against grid electricity mainly due to generous government incentives that enable high margins throughout the entire value chain.
- The Californian net-metering system is a trendsetting policy on how to promote PV self-consumption in a cost-effective way.

- Even if Grid Parity (defined as the moment when PV LCOE equals retail electricity prices) has been reached, regulatory cover[30] is still necessary to foster the PV self-consumption market.
- As 100% self-consumption is not likely to happen for a residential consumer, a proper valuation of the excess of energy has to be performed to properly understand the business case of a specific consumer.

[30] It has to be well understood that this does not imply any kind of economic support.

4

Methodology

4 Methodology

To show the validity of the results depicted within Section 3, an explanation of the calculation methodology of LCOE is provided, the main assumptions are clarified, and inputs are justified. In addition, electricity prices for each city are explained. Inputs and results will be updated and released every 6 months.

4.1 Calculation of PV LCOE

PV Levelized Cost of Energy (LCOE) is defined as the constant and theoretical cost of generating PV electricity, whose present value is equal to that of all the total costs associated with the PV system over its lifespan. The value derived herein can be expressed either in nominal local currency per kWh (incorporating expected inflation) or in real local currency per kWh (adjusted for the time value of money). In this analysis, nominal LCOE will be calculated (see next section; "Nominal or Real LCOE?").

Equation 1 shows this identity:

Equation 1: LCOE Calculation (1)

$$\sum_{t=1}^{T}\left(\frac{LCOE_{\ t}}{(1+r)^{\ t}} \times E_t\right) = I + \sum_{t=1}^{T}\frac{C_{\ t}}{(1+r)^{\ t}}$$

Table 1: LCOE Nomenclature

Nomenclature	Unit	Meaning
LCOE	*MU[31]/kWh*	Levelized Cost of Electricity
T	*Years*	Economic lifetime of the PV system
t	-	Year t
C_t	*MU*	Operation & Maintenance (O&M) costs and insurance costs on year t[32]
E_t	*kWh*	PV electricity generated on year t
I	*MU*	Initial investment
r	*%*	Discount rate

[31] MU stands for Monetary Unit; LCOE will be expressed in local national currency per kWh.

[32] Costs include taxes and grow with inflation.

Assuming a constant value per year, LCOE can be derived by rearranging Equation 1, as follows:

Equation 2: LCOE Calculation (2)

$$LCOE = \frac{I + \sum_{t=1}^{T} \frac{C_t}{(1+r)^t}}{\sum_{t=1}^{T} \frac{E_t}{(1+r)^t}}$$

As such, the variables, which are paramount to derive the LCOE, are the following:

- Average PV system lifespan (T)
- Initial investment (I)
- O&M costs (Ct)
- PV-generated electricity over the system's lifespan (Et [33])
- Discount rate (r)

It should be noted that the methodology does not take into account cash inflows such as tax incentives or feed-in tariffs. Therefore, LCOE intends to reflect the cost-competitiveness of PV versus retail electricity prices without accounting for any external stimulus.

4.1.1 Real or Nominal LCOE?

For a given PV system, LCOE can be expressed in nominal or real terms:

- Nominal LCOE is a constant value in nominal currency (each years' number of current Euros, or the applicable local currency if different from the Euro), unadjusted for the relative value of money.
- Real LCOE is a constant value expressed in the local currency corrected for inflation, that is, constant currency of one year in particular.

In order to decide which expression is more suitable for this analysis, the following considerations were made:

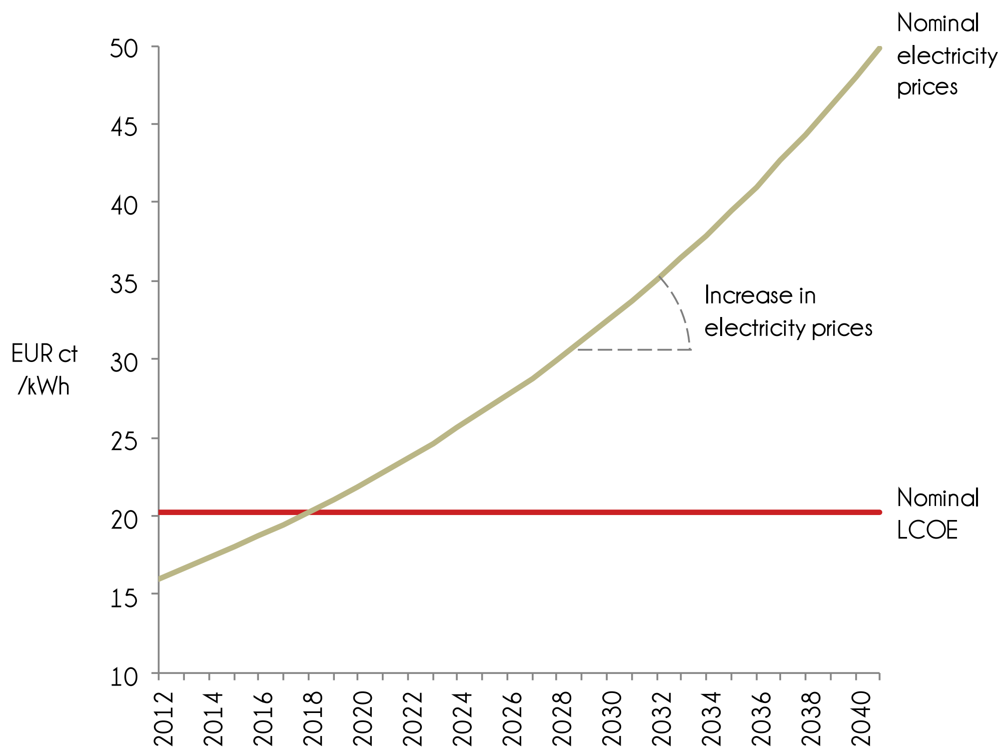
- Both expressions are widely accepted and used in several consulted reports[ii].
- Using one definition could be more suitable than using the other one depending on the objective of the analysis.

---

[33] Go to Section 4.3.5 for a complete explanation of how the PV electricity generated in a given year (E_t) is derived.

- On the one hand, if LCOE is used to compare the relative cost-competitiveness of different generation technologies, both expressions are considered appropriate as long as the same unit is used between alternatives.
- As is the case of this report, if LCOE is used to compare the cost of consuming PV-generated electricity with that of buying it from the grid from the viewpoint of a residential electricity consumer, and given that both alternatives (PV and grid electricity costs) should be expressed in the same unit (nominal or real currency per kWh), the terms in which the target audience understands grid parity proximity will determine which LCOE should be used.
  - A consumer often thinks in current real world prices: "I'm currently paying 16 cents per kWh to the utility, probably next year I will have to pay close to 17 cents. So, if today I install a PV system and electricity prices continue to increase…"

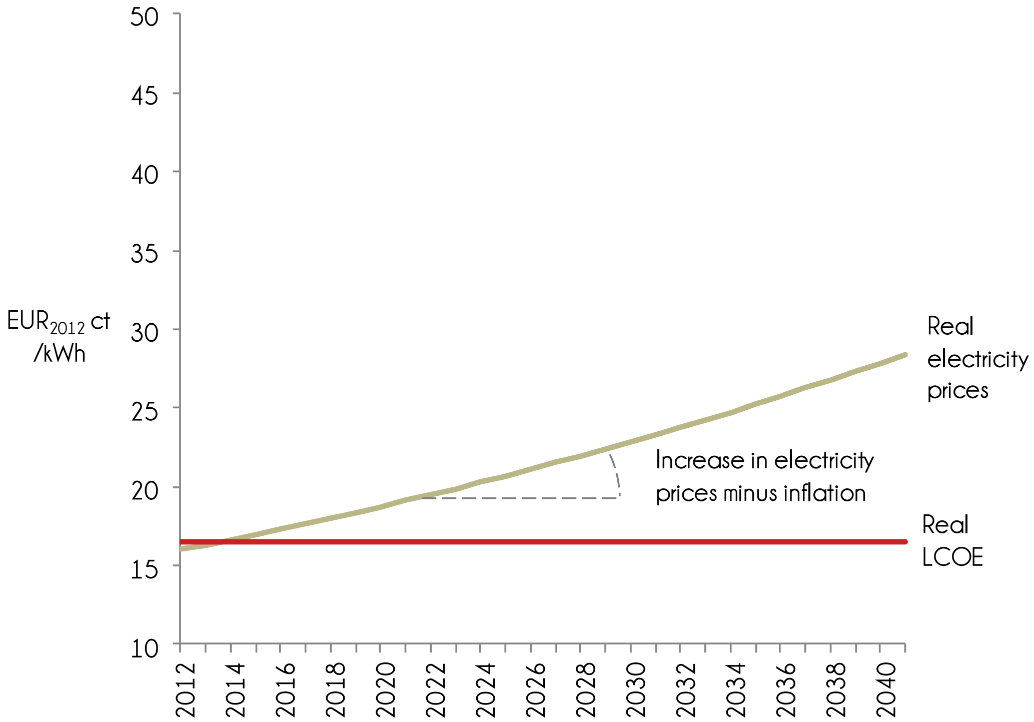
Figure 56: Grid Parity Proximity for a 2012 PV Installation – Nominal



Source: Eclareon Analysis

  - When comparing PV LCOE and electricity prices, thinking in real terms (let us say in 2012 currency) does not seem as straightforward as the reasoning mentioned above. It's complex to think about the increase in electricity prices adjusting it for inflation.

Figure 57: Grid Parity Proximity for a 2012 PV Installation – Real



Source: Eclareon Analysis

Given that the aim of this report is to analyze the proximity of grid parity from the viewpoint of a residential consumer, and the target audience tends to understand electricity prices in nominal terms, it seems more reasonable to express LCOE in nominal currency.

4.2 Inputs from Primary Sources

In order to perform a complete cost analysis, local PV installers from were consulted on the total cost of installing, operating and maintaining a residential PV system over its economic lifetime. It is assumed that no cost differences exist within country boundaries. Contact details of the collaborator companies are shown in the Annex.

In addition to this, ECLAREON has been supported by several renowned entities from the PV sector, as summarized below:

- SunPower Corporation provided ECLAREON with technical assistance and contact information of some PV installers from its Authorized Partner network. These were contacted and participated as collaborators (see Annex).
- 3TIER provided irradiation data of the cities analyzed in the report (see section 4.3.5.1).

- National PV Associations validated the input information and final results of their respective countries.

Table 2: Collaborating associations

Country	Association
Australia	APVA
Chile	ACERA
France	ENERPLAN
Mexico	ANES
Spain	UNEF
UK	BPVA

4.2.1 Investment cost

Within each of the countries under study, collaborators shared the turnkey price (including taxes) of a PV system of 3kWn/3.3kWp for a grid-connected single-family unit (without a storage system), assuming:

- Each installer's most often used components (modules, inverters, structures, etc.).
- Average rooftop characteristics (height, materials, etc.).

The companies interviewed gave price quotations as of January of each of the last 3 years, and the most recent ones as of January/February 2013. Since March 2013 the price of crystalline silicon PV modules, wafers and cells imported from China to the EU are affected by the European Commission's new anti-dumping tariff. It should be noted that the effect of this regulation on PV installation prices was not considered in this issue of the GPM Series.

For each location, inputs on the investment cost vary depending on two different scenarios:

- On the best-case scenario, the investment cost corresponds to the lowest quotation received.
- On the worst-case scenario, the investment cost corresponds to the highest quotation received.

For California, in addition to company quotations, the CSI (California Solar Statistics) database, which reports local end-customer pricing for PV installations, was used. Residential PV prices relative to each of the years under study were gathered and, for each year, observations between the 10^{th} and 90^{th} percentile were analyzed (80% of the total observations, which amounted to over 90 quotations per year). Of these, the lowest and highest average price were reported.

For Australia, in addition to company quotations, the APVA (Australian PV Association) provided a range of real PV system quotations in the country.

4.2.2 O&M Costs

A residential PV system could be broadly considered maintenance free, requiring just a few hours of work per year, mainly for cleaning the PV modules, and checking the performance of the inverter (when necessary). The cost of inverter replacement, mentioned in the next section, is added to O&M costs at the end of the inverter's lifetime (year 15).

For this analysis, an average of 2 hours of maintenance per year, valued at the corresponding local labour cost per hour[34], is considered. As it is expected that in 2012 hourly compensation will decrease in some of the countries under study, this input will be updated accordingly as soon as data is available. For the time being, O&M costs are assumed to grow with the estimated inflation rate in each country from 2011 until the end of the PV system lifetime (go to page 59 for more information on inflation rates).

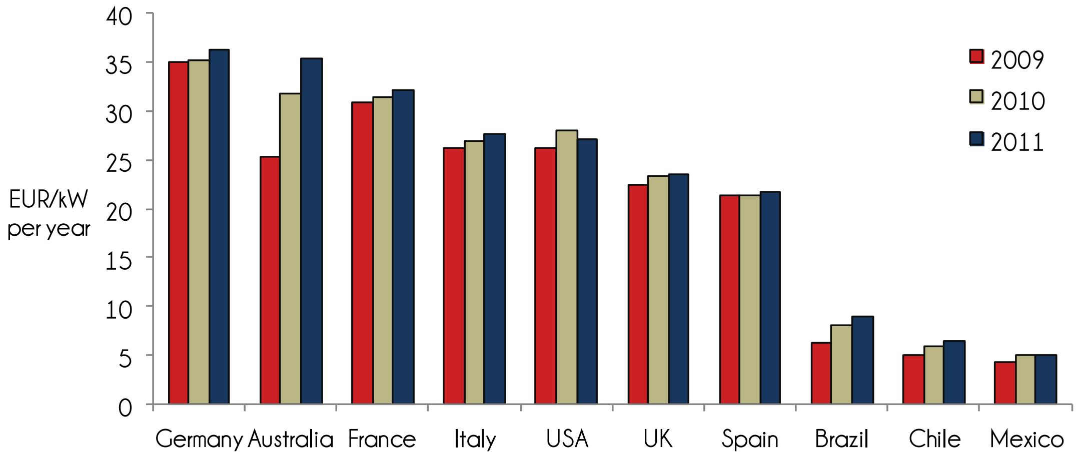
In addition, a mark-up for the O&M service is added to the local hourly compensation. Markets with a fierce competitive landscape will generally have lower mark-ups than less competitive markets. Given the complexity of quantifying such differences, added to the relatively low impact of O&M costs in LCOE, these specificities will not be accounted for.

According to several sources from the European PV market, O&M mark-ups range from 20% to 60% for commercial PV installations. Given that PV residential installations usually receive larger mark-ups than commercial ones, and with the aim of using conservative values for inputs, a 60% mark-up is considered for small-scale PV system's O&M service.

Annual O&M costs per kW for residential PV systems are as follows:

[34] Hourly compensation is defined as the average cost to employers of using one hour of labour in the manufacturing sector; labour costs include not just worker income but also other compensation costs such as unemployment insurance and health insurance.

Figure 58: Indicative O&M Costs per year [iii]



Source: U.S. Department of Labor; U.S. Bureau of Labor Statistics; Division of International Labor Comparisons; Instituto Nacional de Estadísticas de Chile; Eurostat; Eclareon analysis

4.2.3 Inverter Replacement

EPIA assumes a technical guaranteed lifetime of inverters of 15 years in 2010 to 20-25 years in 2020.[iv] For this analysis, an inverter lifetime of 15 years is assumed, i.e. the inverter will be changed once during the 30-year PV system lifetime.

In order to estimate the cost of replacing the inverter, the cost reduction rate (so-called learning factor) of this component has been considered, assuming that the cost of production declines by a constant percentage with each doubling of the total number of units produced.

Consulted sources estimate a learning factor of 5% to 20% for inverters:

- According to some sources, the learning rate for PV modules and balance-of-system (BOS) is about 20%. For inverters, however, the learning rate appears significantly lower, approximately 10%.[v]
- Other studies claim that inverters have similar progress ratios[35] to PV modules, whose historical (1975–2001) learning rate amounted to 23%.[vi]
- EPIA assumes a learning factor of 20% for small-scale inverters (used in residential systems).[vii]

---

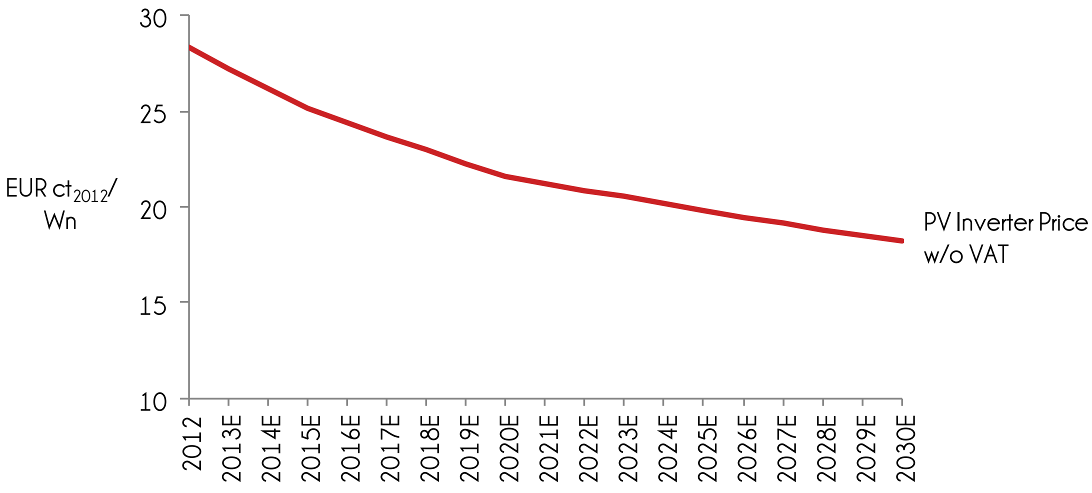
[35] The progress ratio (PR) (or learning rate) indicates future cost reductions and relates to the learning factor (LF) such that $\boldsymbol{LF = 1 - PR}$.

Based on these sources, and to avoid underestimating the cost of replacing the inverter, a 10% learning factor has been assumed.

The current cost of replacing a PV inverter was derived from collaborator companies from the German market, as Germany is considered a mature PV market towards which future worldwide prices will converge. Price components that do not depend on the level of maturity of the market, such as import fees, are not taken into consideration. Measured in Euro cents per Wn, the current cost of an inverter has been converted to each country's local currency if different from the Euro.

Future inverter production volumes were estimated on the basis of EPIA projections on global PV installed capacity under the average-case (so-called accelerated) scenario[36] as shown in EPIA/Greenpeace Solar Generation VI. With a 10% learning factor as mentioned above, future inverter prices were calculated. The following Figure shows prices measured in Euro cents per Wn.

Figure 59: Historical PV Inverter Prices and Learning Curve Projections 2013-2030



Source: Eclareon Analysis

As shown above, in 15 years inverter prices will drop by around 30% in real terms.

To adapt the above learning curve to each location under study, current local applicable tax rates were considered, and assumed a good proxy for future tax rates. Moreover, to express the future cost of replacing the inverter in nominal terms as the analysis requires, Germany's estimated annual inflation rate was applied (go to Section 4.3.2 for more information on inflation rates).

[36] Three scenarios were estimated: Reference (worst), Accelerated (average), and Paradigm (best).

4.2.4 Insurance Cost

Insurance quotations for a 3.3 kWp rooftop PV system can generally range from 0.6% to 1.2% of the total system cost, so in order to maintain a conservative estimate an insurance cost of 1.2% of the total system cost adjusting for inflation will be considered. In markets with generous FiTs, quotations can certainly exceed the mentioned values, but, as mentioned before, the methodology does not take into account any situation created by external stimulus such as FiTs, which could lead to cost overruns.

For each location, inputs on the insurance cost vary depending on two different scenarios:

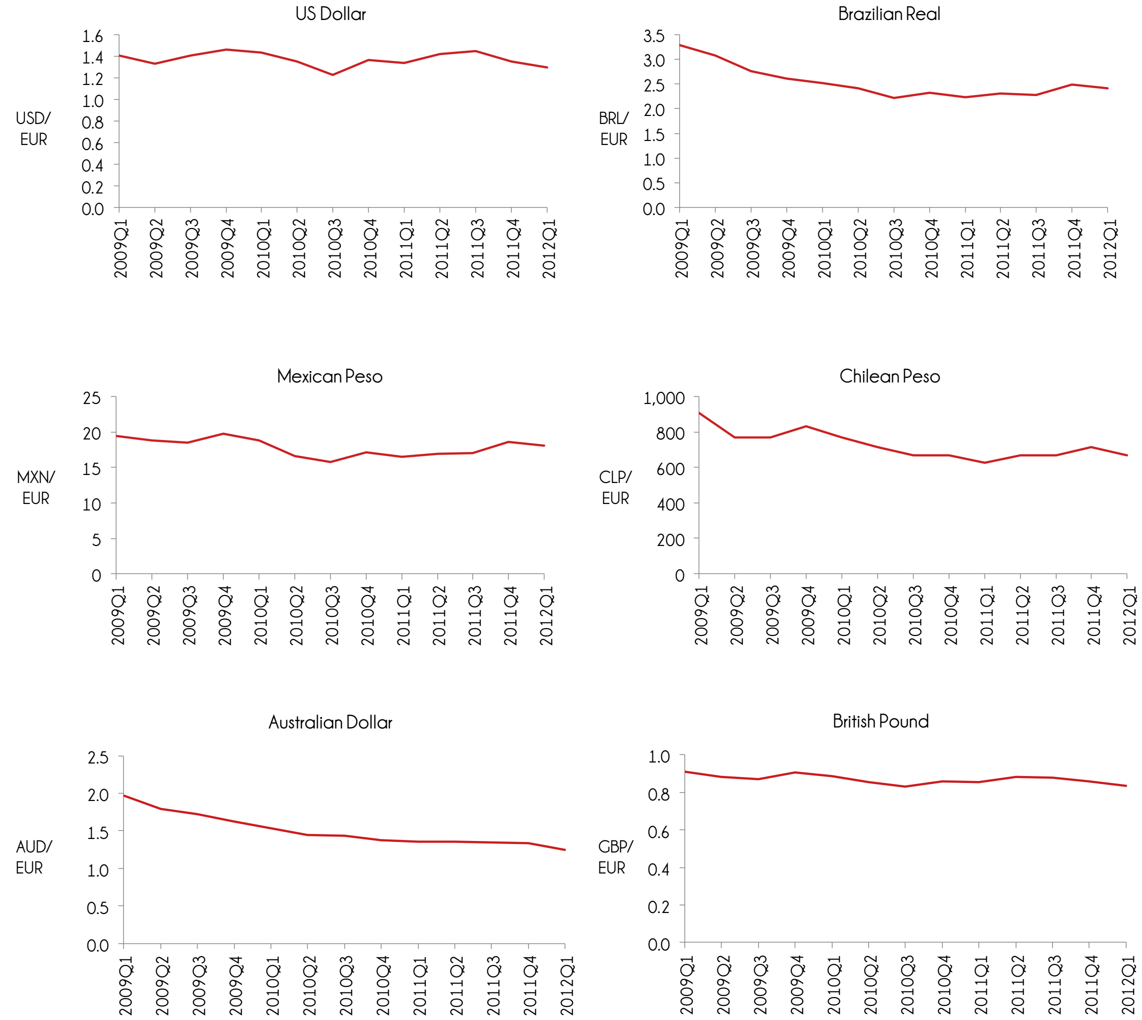
- On the best-case scenario, the lower turn-key quotation received from each location will be considered for computing annual insurance costs.
- On the worst-case scenario, the higher turn-key quotation received from each location will be considered for computing annual insurance costs.

4.3 Other Inputs and Assumptions

4.3.1 Exchange Rate

As previously mentioned, in this report all costs are expressed in national currency. Therefore, values in a metric other than the local one (usually, US Dollars or Euros) are converted into the corresponding national currency, at the following exchange rates (number of foreign currency units per Euro):

Figure 60: Exchange Rates - Foreign Currency Units per Euro [viii]



Source: OANDA

4.3.2 Inflation Rate

The estimated inflation rate is used as a measure of the escalation rate of O&M and insurance costs in each country[37] over the PV system's lifetime. It is estimated as follows:

- For the period 2009-2015: the yearly average percentage change of household prices (Consumer Price Index, CPI) in the past five years (2007-2011).
- From 2015 onwards, the long-term inflation target of each country as published by the respective central banks (namely, European Central Bank, US Federal Reserve, Banco Central de Chile, Banco de México, Banco Central do Brasil).

---

[37] Inflation is assumed to be the same in different cities within a given country.

The table below shows the resulting escalation rates, figures that will be updated as new data is released.

Table 3: Average Inflation per Country [38] [ix]

Country	Historical Inflation Rate	Long-Term Target Inflation Rate
Australia	2.9%	2.5%
Brazil	5.2%	4.5%
Chile	3.6%	3.0%
France	1.6%	2.0%
Germany	1.7%	2.0%
Italy	2.1%	2.0%
Mexico	4.4%	3.0%
Spain	2.3%	2.0%
UK	3.2%	2.0%
USA	2.2%	2.0%

4.3.3 Discount Rate (r)

Taking the perspective of the investor, the discount rate applicable is considered equal to the return required from investing in a small-scale PV system for self-consumption. As the required return is directly related to the risk associated with such an investment, the discount rate should be equivalent to the return that the investor could otherwise receive by investing in a project showing a similar risk profile.

PV for self-consumption: Motivations behind a green investment

Interest rates are usually determined by the real risk-free rate, plus several premiums such as that of inflation, default risk, maturity, and liquidity.

When investing in a small-scale PV system, though, decision-making might be influenced not only by an economic return but also by non-economic factors, which are difficult to quantify.

[38] Sources: OECD Stats; BBVA Research; US Federal Reserve; European Central Bank; Banco Central de Chile; Banco de México; Banco Central do Brasil; Reserve Bank of Australia.

- Firstly, individuals can make a "green investment" to hedge against rising prices of electricity from the utility, eliminating (generally a portion of) future price uncertainty.
- Moreover, PV investments are sometimes governed by non-economic motivations such as environment sustainability, social responsibility, security facing blackouts, etc.

It should be noted that, as the amounts to be invested (< 20,000 EUR) are small enough, it is assumed that each investor finances the PV installation in full equity (i.e., doesn't require a loan).

Bearing in mind the complexity of estimating the compensation required by each individual investor for investing in a PV system for self-consumption, the components of the required return have been simplified and defined as follows:

- The inflation premium, which compensates investors for expected inflation and reflects the average inflation rate expected over the lifetime of the investment.
- An additional risk premium, which is the incremental return that the investor will require above the inflation premium in order to invest in a residential PV system for self-consumption.

Thus, we can view the required return as being composed of two main returns for bearing the risks of an investment in a small-scale PV system:

Equation 3: Discount Rate

$$\boldsymbol{r = IP_c + IR}$$

Table 4: Discount Rate Nomenclature

Nomenclature	Unit	Meaning
r	%	Discount rate (required return)
IP_c	%	Inflation premium (country-specific return)
IR	%	Risk premium (investment-specific)

4.3.3.1 Inflation Premium (Country-Specific)

Without accounting for the time preference for current consumption over future consumption[39], the average inflation rate expected over the PV system's lifetime is the minimum return any investor would require for committing funds. The less risky the investment, the faster the required return will converge to the value of the expected inflation rate.

As previously shown in Table 3, historical inflation rates, as well as long-term targets, vary substantially between countries, differences that should be incorporated on expectations on the inflation rate over the (30-year) system lifetime. Moreover, for all the countries under study except for Germany, the long-term target inflation rate is lower than the average historical inflation rate, which might reveal that expected inflation rates are probably lower than historical rates.

Taking into consideration the above facts, and with the aim of maintaining a conservative stance on risk expectations (and thus, on grid parity proximity), it is assumed that investors will expect an average inflation rate throughout the lifetime of the asset equal to the historical average inflation rate for the last 5 years (2007 to 2011). The inflation premium considered is thus set as follows:

Table 5: Inflation Premium per Country [40] x

Country	Inflation Premium
Australia	2.9%
Brazil	5.2%
Chile	3.6%
France	1.6%
Germany	1.7%
Italy	2.1%
Mexico	4.4%
Spain	2.3%

[39] The time preference for current consumption over future consumption is generally reflected by the real risk-free rate.

[40] Sources: OECD Stats; BBVA Research; US Federal Reserve; European Central Bank; Banco Central de Chile; Banco de México; Banco Central do Brasil; Reserve Bank of Australia.

Country	Inflation Premium
UK	3.2%
USA	2.2%

4.3.3.2 Risk Premium (Investment-Specific)

Considering that, in general, the required compensation for bearing the risk of investing in a PV system is higher than that required for the loss of purchasing power in time (determined by expected inflation), the risk premium (RP) is defined as the incremental return that the investor will require above the expected inflation rate in order to invest in a residential PV system for self-consumption.

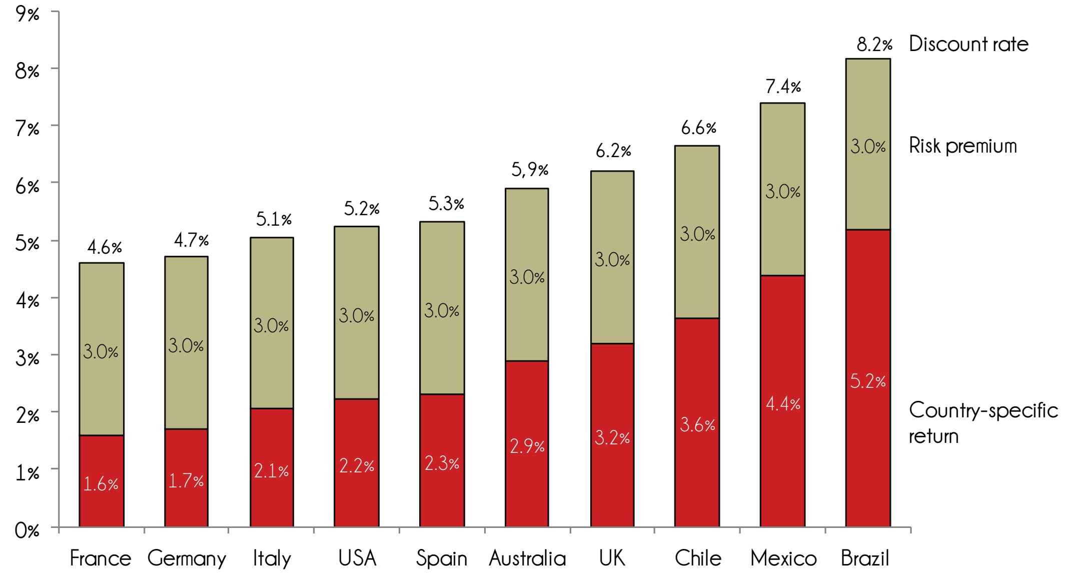
As expected, the RP will depend on the investor's perception of several investment-specific risks as well as individual preferences and other characteristics of the investor (not exhaustive):

- Investment-specific risks
  - How does the investor perceive the performance risk of PV modules?
  - Considering a 30-year investment, how does the investor perceive the risks associated with such timeframe?
  - How does the investor perceive the difficulty of converting the investment into cash?
- Individual characteristics
  - Does the investor have other motivations for investing apart from the expected return?
  - What is the opportunity cost of investing in a PV system for self-consumption?
  - How relevant is liquidity for the investor?
  - How relevant is for the investor to reduce exposure to increasing electricity prices?

As such, each investor will have a unique RP based on a combination of answers to questions such as the ones posed above, but for the sake of simplicity, such differences will not be accounted for. It is assumed that risks solely associated with investing in a PV system, above the inflation premium, are similar worldwide. That is, the RP will only reflect the risks associated with this particular investment, but which are not country-specific.

Considering all the above factors, it is considered that investors are reasonably compensated for taking the uncertainty of investing in a PV system for self-consumption if they receive a 3% return above the inflation premium. The discount rate for each country is thus set as follows:

Figure 61: Discount Rate per Country



Source: OECD Stats; BBVA Research; US Federal Reserve; European Central Bank; Banco Central de Chile; Banco de México; Banco Central do Brasil; Reserve Bank of Australia; Eclareon analysis

The above discount rates are reasonable required returns for such an investment and in line with those applied in other studies.

4.3.4 PV System Economic Lifetime

The economic lifespan of the PV system was estimated on the basis of the following sources:

- Most of the reports consultedxi consistently use 25 to 35 years for projections.
- Moreover, PV Cycle[xii], European association for the recycling of PV modules, estimates the lifetime of a PV module at 35 years.

Consequently, and with the aim of avoiding overestimating the proximity of grid parity, a PV system lifetime of 30 years has been chosen for this analysis.

4.3.5 PV Generation

The PV-generated electricity is calculated as follows:

Equation 4: PV Generation on year t

$$E_t = E_0\,(1-d)^{t}$$

(where: $E_0 = PV\ system\ capacity \times Annual\ irradiation \times PR$)

Table 6: PV Generation Nomenclature

Nomenclature	Unit	Meaning
t	-	Year t
E_t	kWh	PV electricity generated on year t
E_0	kWh/yr	PV electricity generated on year 0
-	kWp	PV system capacity
-	kWh/kWp/yr	Annual irradiation
PR	%	Performance ratio
d	%	Degradation rate

Consequently, considering that the PV system capacity has already been set (3.0 kWn, 3.3 kWp), in order to estimate the annual PV generation of a 3.3 kWp rooftop installation in 14 different cities, the following variables were defined:

- Local solar irradiation
- Degradation rate
- Performance ratio

4.3.5.1 Local Solar Irradiation

Solar resource estimates, provided by 3TIER (except for Mexico City and Hermosillo), are summarized in the following Table:

Table 7: Irradiation on a plane tilted at latitude (kWh/m²/year)

Country	City	Irradiation
Australia	Sydney	1,713
Brazil	São Paulo	1,691
	Itacarambi	2,200
Chile	Santiago	1,877
	Copiapó	2,154
France	Paris	1,164
	Marseille	1,694
Germany	Berlin	1,083
	Munich	1,267
Italy	Roma	1,611

Country	City	Irradiation
	Palermo	1,656
Mexico[41]	Mexico City	1,956
	Hermosillo	2,486
Spain	Madrid	1,782
	Las Palmas	2,008
UK	London	1,070
	Plymouth	1,119
USA	San Francisco	1,831
	Los Angeles	2,001

These estimates were obtained by 3TIER using the satellite-based approach[42] and over a decade of data. This methodology has been extensively validated against ground measurements of solar resource. Worldwide, the horizontal irradiations estimated with this methodology have an uncertainty of approximately 5%.

Regionally, the solar resource predictions may have a larger uncertainty because resource estimates are particularly problematic in areas with a high concentration of atmospheric aerosols[43].

The estimates presented here do not include any ground observations and therefore the results should be treated with caution.

4.3.5.2 *Degradation Rate*

The degradation rate (d) of the PV system was estimated according to the following sources:

- Banks usually estimate degradation rates at 0.5 to 1.0% per year[xiii] to use as input on their financial models.

---

[41] The Mexican National Solar Energy Association (ANES) suggested another source was used; as such, data for the Mexican cities is based on SIGER (Geographic Information System for Renewable Energies) and UNAM´s Geophysics Institute Solar Observatory.

[42] http://www.3tier.com/static/ttcms/us/documents/publications/validations/3TIER_Global_Solar_Validation.pdf

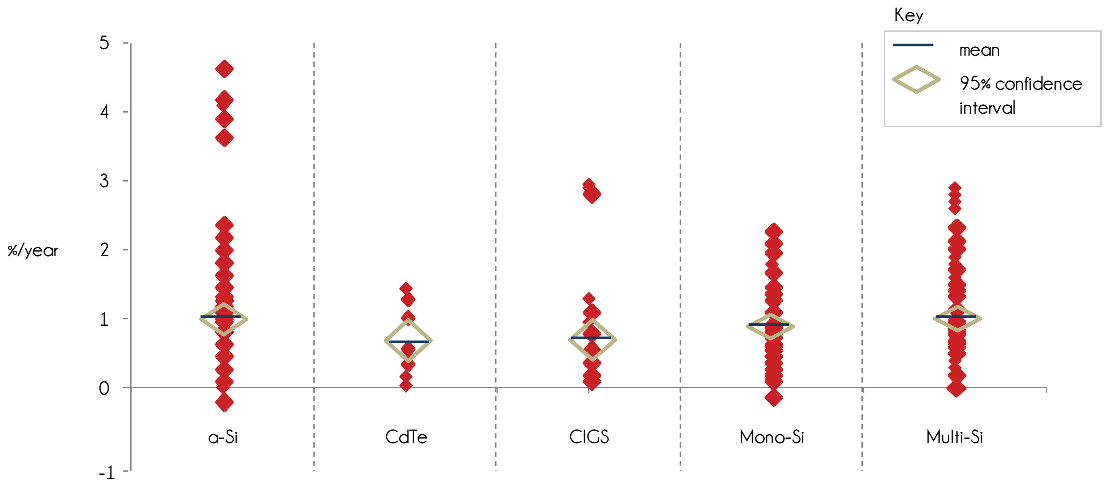
[43] http://www.solarconsultingservices.com/Gueymard-Aerosol_variability-SolarPACES2011.pdf

- Most of the reports consultedxiv use a similar range for projections.

- The results of an extensive research conducted by NREL[xv] (National Renewable Energy Laboratory of the U.S. Department of Energy) arrive to a similar range.

The following Figure depicts the sample gathered by NREL, which includes more than 2,000 long-term PV degradation rates from different locations worldwide, and which has been segmented by technology.

Figure 62: Historical Degradation Rates by Technology and Date of Installation[xvi]



Note: Negative rates indicate an increase in system performance; only systems installed after year 2000 are included
Source: NREL Conference Paper 5200-53712, April 2012

For each technology, the mean of the results is shown by the horizontal bar, and the range of values within the rhombus could act as a good estimate of the expected degradation rate (the range provides a 95% confidence interval).

Taking into account that results show that all the reported rates within the 95% confidence interval are below 1% per year as well other reports consulted, an annual degradation of 0.8% per year has been considered for the analysis.

4.3.5.3 Performance Ratio

The PR intends to capture losses caused on a system's performance by temperature, shade, inefficiencies or failures of components such as the inverter, among others.

For this analysis, an average system performance ratio of 80% will be assumed in all locations, based on the following sources:

- The Fraunhofer Institute for Solar Energy Systems (ISE) investigated [xvii] the PR of more than 100 PV system installations.
  - Annual PR was between ~70% and ~90% for the year 2010.

- Moreover, other researchers believe that typical ranges of the PR amount to >80% nowadays.[xviii]

4.4 Electricity Prices

For a residential consumer, the alternative to consuming PV-generated electricity is buying electricity from the utility grid. In order to consume electricity from the grid, the user has to pay the applicable residential retail electricity price, which has a fixed component (independent of the number of kWh consumed) and a variable component (dependent on electricity consumption).

When comparing PV LCOE with retail electricity prices, the fixed component of the price is assumed a sunk cost in which the consumer will incur anyway. Therefore, only the variable electricity price will be considered.

Generally, by consuming PV-generated electricity, one not only saves the variable retail electricity price, but also all taxes associated with that given consumption. Therefore, all variable taxes consumers pay in their electricity bills (such as the VAT and special taxes) are included in the analysis.

Some utilities offer time-of-use (TOU) rates, providing consumers with electricity at a higher price during times of peak demand than that charged for electricity consumed during the off-peak period. On-site consumption of PV electricity not always coincides with the peak period, but when it does, the consumer can save the (pricey) peak electricity tariff associated with that consumption (plus taxes).

TOU tariffs were taken into consideration for this analysis.

Electricity prices: Applicable assumptions to consider

- Price differences within country boundaries.

  In many of the countries under study, there are considerable variations between electricity price levels.

  In order to simplify the analysis, electricity prices considered herein reflect those applicable only under the tariff rate chosen in each of the cities under study, without precluding residential consumers from paying higher electricity prices in other parts of the country or under different electricity rates.

Nonetheless, the electricity prices chosen for each city intend to reflect those paid for grid electricity that could be replaced by self-consumed PV electricity by the majority of the population in that given location.

- Tariffs that apply to given time periods.

Some of the represented retail electricity prices sometimes only apply to differentiated periods such as day/night, week/weekend, or summer/winter.

When applicable (e.g., when TOU rates are available), a maximum of 3 different final (variable) electricity price levels paid by residential consumers for each of the cities under study are presented: the upper value shows the highest price of electricity from the grid that could be replaced by self-generated PV electricity in that city, the middle value the average one, and the lower value the lowest one. The following Table shows, for each city, the sources and inputs used:

Table 8: Electric Rates per City and Sources

Country	City	Source	Electric Rates			
			Type	High Price	Middle Price	Low Price
Australia	Sydney	EnergyAustralia	Residential TOU and non-TOU	Peak Tariff	"Domestic All Time"	Shoulder Tariff
Brazil	São Paulo	AES Eletropaulo	Residential (B1)	Not applicable	Residential Tariff	Not applicable
	Itacarambi	CEMIG	Residential (B1)	Not applicable	Residential Tariff	Not applicable
Chile	Santiago	Chilectra	Residential (BT1) Area 1 A (a)	Surcharge tariff (Winter)	Not applicable	Standard tariff
	Copiapó	Emelat	Residential (BT1)	Surcharge tariff (Winter)	Not applicable	Standard tariff
France	Paris	Electricité de France	"Tarif Bleu"	Peak Tariff (Heures Pleines)	Base Tariff (Option Base)	Off Peak Tariff (Heures Creuses)
	Marseille	Electricité de France	"Tarif Bleu"	Peak Tariff (Heures Pleines)	Base Tariff (Option Base)	Off Peak Tariff (Heures Creuses)
Germany	Berlin	Vattenfall	Berlin Easy Privatstrom mit Option Spar Aktiv / Easy Privatstrom Tariff	TOU Peak Tariff	Not applicable	Standard (Easy Privatstrom) Tariff
	Munich	Stadtwerke Munchen, SWM	SWM´s M-Strom privat	TOU Peak Tariff	Standard (non-TOU) Tariff	TOU Off-Peak Tariff
Italy	Roma	Autorità per l'energia elettrica i il gas (AEEG)	Tariffe Monorarie (all tiers)	Standard (non-TOU) Tariff (All Tiers)		
	Palermo	Autorità per l'energia elettrica i il gas (AEEG)	Tariffe Monorarie (all tiers)	Standard (non-TOU) Tariff (All Tiers)		

Country	City	Source	Electric Rates			
			Type	High Price	Middle Price	Low Price
Mexico	Mexico City	Comisión Federal de Electricidad (CFE)	DAC / Residential (1)	DAC - residential high consumption	Not applicable	Tariff 1 Residential
	Hermosillo	Comisión Federal de Electricidad (CFE)	DAC / Residential (1F)	DAC - residential high consumption	Not applicable	Tariff 1F Residential
Spain	Madrid	Official State Gazette (BOE)	Last Resort (TUR) Time-of-Use / non-TOU Tariff	Peak Tariff	Standard (non-TOU) Tariff	Off-Peak Tariff
	Las Palmas	Official State Gazette (BOE)	Last Resort (TUR) Time-of-Use / non-TOU Tariff	Peak Tariff	Standard (non-TOU) Tariff	Off-Peak Tariff
UK	London	EDF	Fixed Price Residential Tariff	Economy 7 day rate	Standard Tariff (Unit rate)	Economy 7 night rate
	Plymouth	EDF	Fixed Price Residential Tariff	Economy 7 day rate	Standard Tariff (Unit rate)	Economy 7 night rate
USA	Los Angeles	Los Angeles Department of Water and Power, LADWP	Residential Time-of-Use/ non-TOU Tariff	High Peak Tariff	Standard (non-TOU) Tariff	Base Tariff
	San Francisco	Pacific Gas and Electric Company, PG&E	Tier-2 Residential Time-of-Use/ non-TOU Tariff	Peak/ Part-Peak Tariff	Standard (non-TOU) Tariff	Off-Peak Tariff

It should be noted that in some countries such as Italy, Mexico and the USA, where lower consumption levels benefit from lower tariffs, consuming PV-generated electricity could mean changing from a higher overall tariff price to a lower one. In such a case, the cost savings would be equal not only to the cost of the replaced grid electricity, but also to the price difference between the old and the new (lower) tariff for the electricity bought from the grid. This was not taken into consideration for this analysis.

4.4.1 Australia

New South Wales (NSW) is the largest electricity market in Australia, where there is full electricity retail competition since 2011 and residential consumers can choose between remaining under the regulated market or change to the unregulated market by entering into a market contract.

In practice, residential electricity prices are very similar between both options, as utilities set their prices following very closely the maximum price regulated by the NSW Government each year. Therefore, the regulated electricity price is considered in the analysis.

In NSW, there are only three regulated suppliers, EnergyAustralia, Integral Energy, and Country Energy, each of which has different regulated prices.

Given that Energy Australia[44] is one of Australia's largest energy retailers, its prices are used in the analysis. In particular, the following tariffs are considered:

Table 9: Electricity Rates in Australia

City	High Price	Middle Price	Low Price
Sydney	EnergyAustralia “PowerSmart Home” Peak Tariff	EnergyAustralia “Domestic All Time” (price of remaining usage per quarter[45])	EnergyAustralia “PowerSmart Home” Shoulder Tariff

The non-TOU tariff (Domestic All Time) used to have 2 tiers and currently has 3 tiers, such that quarterly consumption above a certain amount of electricity pays a higher marginal price than consumption below that value. The tariff considered as middle price corresponds to the following consumption tiers:

[44] TRUenergy acquired EnergyAustralia's retail business from the NSW Government.

[45] Go to Table 10 for information on applicable consumption tiers.

Table 10: Consumption Tiers in NSW

	Consumption per Quarter
Before July, 2012	>1,750 kWh
From July, 2012	>2,000 kWh

As for the TOU tariffs, these include a peak period, a shoulder period, and an off-peak period, as follows:

Table 11: Rate Periods in NSW

City	Days	Rate Periods		
		Peak	Shoulder	Off-Peak
Sydney	Working weekdays	2 PM to 8 PM	7 AM to 2 PM 8 PM to 10 PM	Rest of the day
	Weekends and public holidays	Not applicable	7 AM to 10 PM	Rest of the day

As the off-peak rate period is during nighttime hours, it will most certainly not coincide with PV generation. Therefore, only the peak rate and the shoulder rate are used to reflect the maximum and minimum residential electricity tariffs.

4.4.2 Brazil

In Brazil, the residential electricity tariffs are regulated and published by the Brazilian Electricity Regulatory Agency (ANEEL, acronym in Portuguese) every year. The country is divided into more that 60 concession areas, where one or more utilities are in charge of electricity distribution. AES Eletropaulo has the concession of the city of São Paulo (in São Paulo State), while CEMIG is the utility with the concession of Itacarambi (in Minas Gerais State).

There are no TOU rates available for residential consumers in Brazil, so the considered electricity tariffs published by ANEEL (plus applicable federal taxes and state tax[46]) are depicted as a single tariff:

[46] Federal taxes include Social Integration Programs (PIS) and Contribution to the Social Security Financing (COFINS), and the State tax includes the Tax on Circulation of Merchandise and Services (ICMS).

Table 12: Electricity Rates in Brazil

City	Single Rate (range not applicable)
São Paulo	AES Eletropaulo Residential Tariff
Itacarambi	CEMIG Residential Tariff

It should be noted that within Brazil there are considerable variations between electricity price levels. Those considered herein reflect the ones applicable only in the two cities under study, without precluding residential consumers from paying higher electricity prices in other parts of the country.

4.4.3 Chile

In Chile, as in Brazil, the electricity market for residential consumers is regulated by the State and there are no TOU rates available. A standard electricity tariff (called BT1) that varies throughout the country is applicable during the whole year and during winter months (April to September), a special surcharge tariff applies to excess consumptions for users that have a monthly consumption superior to 430 kWh.

In both Santiago and Copiapó, the winter surcharge tariff and the standard tariff represent the high price range and the low price range respectively (no middle price is represented).

Table 13: Electricity Rates in Chile

City	High Price	Middle Price	Low Price
Santiago	Chilectra BT1 Surcharge tariff (Winter) (Area 1A)	Not Applicable	Chilectra BT1 Standard tariff (Area 1A)
Copiapó	Emelat BT1 Surcharge tariff (Winter)	Not applicable	Emelat BT1 Standard tariff

As was the case in Brazil, in Chile there is a considerable variation between electricity price levels throughout the country. Those considered herein reflect the ones applicable only in the two cities under study, without precluding residential consumers from paying higher electricity prices in other parts of the country.

4.4.4 France

In France, residential electricity prices can be either regulated by the Government or set freely by the utilities; however, most of these consumers remain under the regulated market, which is the one considered herein (the "Tarif Bleu" option within EDF, Electricité de France).

Given that the main utility is the state-owned EDF, their residential tariffs were taken into consideration; namely, their TOU rates (peak [*Heures Pleines*] and off-peak [*Heures Creuses*]), and their base tariff (*Option Base*):

Table 14: Electricity Rates in France

City	High Price	Middle Price	Low Price
All Cities	EDF Peak Tariff (*Heures Pleines*)	EDF Base Tariff (*Option Base*)	EDF Off Peak Tariff (*Heures Creuses*)

The peak and off peak periods, however, differ in Paris and Marseille:

Table 15: Rate Periods in France

City	Days	Period	Rate Periods	
			Peak	Off-Peak
Paris	All	1	7 AM to 11 PM	Rest of the day
	All	2	7.30 AM to 11.30 PM	Rest of the day
Marseille	All	1	7 AM to 11 PM	Rest of the day
	All	2	7 AM to 2 PM and 5 PM to 2 AM	Rest of the day
	All	3	7 AM to 1 PM and 4 PM to 2 AM	Rest of the day
	All	4	6.30 AM to 10.30 PM	Rest of the day
	All	5	5.30 AM to 2.30 PM and 5 PM to 12 AM	Rest of the day

A particular time period is attributed by ERDF (Electricité Réseau Distribution France) to a residential consumer, depending on the location and its network conditions.

The electricity prices considered correspond to those applicable to consumers with contracted power of 9kVA[47].

4.4.5 Germany

Stadtwerke München (SWM) is the municipal utility that serves electricity customers in Munich, while Vattenfall, Germany's third largest electricity producer, is one of the most relevant ones in Berlin. For both cities, TOU rates available for residential customers were considered:

---

[47] Contracted power in France ranges from 3kVA to 15kVA, in increments of 3kVA (3kVA, 6kVA, 9kVA and up to 15kVA).

Table 16: Rate Periods in Germany

City	Days	Rate Periods	
		Peak	Off-Peak
Berlin	All	6 AM to 10 PM	Rest of the day
Munich	Monday to Friday	6 AM to 9 PM	Rest of the day
	Weekend and Bank Holidays	Not applicable	All day

For Berlin, the peak tariff determines the retail electricity price range upper value. Given that the off-peak rate applies mainly to night time hours, the off-peak period will most certainly not coincide with PV generation, and thus the lower electricity price considered in Berlin will be the standard (non-TOU) residential electricity rate (no middle price is represented).

For Munich, the peak tariff determines the retail electricity price range upper value and the off-peak the lower value since the off-peak tariff is applicable during weekends and bank holidays, and not only during night-time as in Berlin. Munich´s SWM Standard tariff represents the middle price in that city.

Table 17: Electricity Rates in Germany

City	High Price	Middle Price	Low Price
Berlin	Vattenfall Peak Tariff	Not applicable	Vattenfall Easy Privatstrom Tariff
Munich	SWM´s M-Strom Peak Tariff	SWM´s M-Strom Standard Tariff	SWM´s M-Strom Off-Peak Tariff

4.4.6 Italy

In Italy, the Regulatory Authority for Electricity and Gas (AEEG, acronym in Italian) sets the regulated electricity tariffs every 3 months[48].

Residential tariffs charged in Italy have four Tiers, such that annual consumption above a certain amount of electricity pays a higher marginal price than consumption below that value:

[48] Residential consumers in Italy can choose to go to the free market or to the regulated market.

Table 18: Consumption Tiers in Italy

	Annual Consumption
Tier 1	≤1,800 kWh
Tier 2	1,801 - 2,640 kWh
Tier 3	2,641 - 4,440 kWh
Tier 4	≥4,441 kWh

To assess PV cost-competitiveness for all consumer segments in Italy, all tiers within the standard (non TOU) electricity tariff were measured against PV LCOE.

In particular, standard tariffs for households with a contracted power superior to 3 kW were considered. Taxes corresponding to these consumers were also taken into consideration.

Table 19: Electricity Rates in Italy

City	Prices
All cities	Tier 1, Tier 2, Tier 3, and Tier 4 Standard Electricity Rate

4.4.7 Mexico

In Mexico, there are seven different residential electricity tariff groups, which vary depending on the minimum average temperature in summer of each region[49]. In Mexico City, Tariff 1 applies, while in Hermosillo, Tariff 1F does.

In addition to these 7 tariffs, a special tariff for high consumption (DAC, acronym in Spanish) applies for households whose monthly average consumption (average of the last 12 months) exceeds a certain limit, which for Mexico City is set at 250 kWh and for Hermosillo at 2,500 kWh.

For this analysis, the lower price range is represented by the average price paid within Tariff 1 for Mexico City and tariff 1F for Hermosillo, and the higher price range by the DAC tariff.

[49] The warmer the city, the higher the tariff.

Table 20: Electricity Rates in Mexico

City	High Price	Middle Price	Low Price
Mexico City	DAC - residential high consumption	Not Applicable	Tariff 1 Residential
Hermosillo	DAC - residential high consumption	Not Applicable	Tariff 1F Residential

4.4.8 Spain

In Spain, the electricity tariff paid by the nearly 80%[xix] of residential consumers is the Tariff of Last Resort (TUR, acronym in Spanish), set by the Government. Electricity tariffs without taxes are the same in every region, but differences between applicable tax rates are taken into consideration[50].

TUR time-of-use rates are also taken into consideration. Within a day, each pricing period depends on the season and is as follows:

Table 21: Peak and Off-Peak Rate Periods in Spain

City	Season	Rate Periods	
		Peak	Off-Peak
All cities	Winter	12 PM to 10 PM	Rest of the day
	Summer	1 PM to 11 PM	Rest of the day

The peak tariff is used as a proxy of the highest electricity price, the non-TOU standard tariff of an average price, and the off-peak tariff as a measure of the lowest electricity price.

Table 22: Electricity Rates in Spain

City	High Price	Middle Price	Low Price
All cities	Peak Tariff	Standard Tariff	Off-Peak Tariff

4.4.9 UK

There is full competition in the retail electricity market in the UK; however, the so-called "Big Six" (EDF, E.ON, Centrica, SSE, Scottish Power and power) control almost 100% of the residential energy market. Of these, EDF has the highest share of the retail market in London, and its tariffs have been used for the analysis.

---

[50] In this case, in Madrid electricity prices are subject to the VAT rate while in Las Palmas they are subject to the Canarias Indirect General Tax (IGIC, acronym in Spanish).

EDF offers two types of tariffs: fixed and standard (variable), which vary depending on the region. For simplicity, the fixed tariff is considered.

Within the fixed tariff option, there are two variants: the "Standard" and the "Economy 7"; which has a day rate and a night rate.

Table 23: Electricity Rates in the UK

City	High Price	Middle Price	Low Price
All cities	Fixed Price Economy 7 day rate	Fixed Price Standard Tariff (Unit rate)	Fixed Price Economy 7 night rate

There are multiple tariff options in the UK, from different utilities, and these tariffs change every 12-24 months. Instead of having a monthly or yearly change on the price, a new tariff comes out and applies to residential customers. This is the case for EDF where there have been different tariffs since 2009. For simplicity, this study has considered the tariffs that are the equivalent or similar to the ones on previous years.

4.4.10 USA (California)

The electricity market in the US is liberalized, so consumers can either purchase electricity from the utility in charge of electricity distribution in their territory or from an independent service provider. Los Angeles (LA) is the selling territory of Los Angeles Department of Water and Power (LADWP), and San Francisco of Pacific Gas and Electric (PG&E).

In San Francisco, PG&E's residential TOU Tariff depends on the consumption level of the household, such that energy use above the baseline amount costs more than that below. As of July 2012, the baseline in San Francisco is set at 16.8 kWh per day in winter and 9.1 kWh per day in summer. According to PG&E, a typical residential customer's electricity consumption is roughly above 17 kWh per day[xx], so it is assumed that a consumer will reach Tier-2 (i.e., consume 101% to 130% above baseline) and thus PV-generated electricity would be competing with Tier-2 tariffs.

In the case of Los Angeles, the residential TOU tariff, as opposed to the basic Standard rate, is not a Tier system. Moreover, TOU pricing only applies to summer months, as the rest of the year a flat rate is charged.

Table 24: Rate Periods in Los Angeles and San Francisco

City	Season		Rate Periods		
			Peak Tariff	Low/Partial Peak Tariff	Base/Off-Peak Tariff
Los Angeles	Summer	Monday to Friday	1 PM - 5 PM	10 AM - 1 PM 5 PM - 8 PM	8 PM - 10 AM
		Saturday and Sunday	Not applicable	Not applicable	All day
	Winter	All	Flat rate		
San Francisco	Summer	Monday to Friday	1 PM - 7 PM	10 AM - 1 PM 7 PM - 9 PM	All other times including Holidays
		Saturday and Sunday	Not applicable	10 AM - 1 PM 5 PM - 8 PM	All other times including Holidays
	Winter	Monday to Friday	Not applicable	5 PM - 8 PM	All other times including Holidays
		Saturday and Sunday	Not applicable	Not applicable	All day

Both utilities offer residential retail rates which vary with the season: summer is high season while winter is low season, which in the case of TOU rates means that the peak tariff in summer will be higher than the peak tariff (or flat rate, in the case of LA) in winter, while the off-peak (or "base") tariff in summer will be lower than that charged in winter.

Therefore, as electricity prices in summer better represent the existing range of tariffs in these cities, the retail electricity price range of each city corresponds to the following:

Table 25: Electricity Rates in USA

City	High Price	Middle Price	Low Price
Los Angeles	LADWP's High Peak Tariff (summer)	LADWP's Standard Tariff (summer)	LADWP's Base Tariff (summer)
San Francisco	PG&E's Peak Tariff (summer)	PG&E's Standard Tariff (summer)	PG&E's Off-Peak Tariff (summer)

5
Annex: PV GPM collaborators

5 Annex: PV GPM collaborators

As explained in Section 4.2, several local PV installers agreed to collaborate with ECLAREON by providing the turnkey price of a small-scale (3.3 kWp) PV system for a grid-connected single-family unit. These companies' contact information is summarized in the following Table.

The relationship between ECLAREON and those companies is limited to the description above. ECLAREON will not be responsible for any loss or damage whatsoever arising from business relationships between these companies and third parties.

Table 26: Grid Parity Monitor Collaborators

Collaborators per Country	
Australia	
Regen Power	
Address	4/90 Catalano Circuit Canning Vale, WA 6155
Tel.	(0061)-894563491
Web	http://www.regenpower.com
Email	nikhil.jayaraj@regenpower.com
Contact Name	Nikhil Jayaraj
Brazil	
SOLLARIC	
Address	06541-065 - Santana de Parnaiba, SP
Tel.	(0055)-1141533726
Web	http://www.sollaric.com.br
Email	paulo@sollaric.com.br
Contact Name	Paulo Hornyansky
Solarterra	
Address	Rua Demóstenes, 627 Conj. 112 - Campo Belo, SP
Tel.	(0055)-1138073929
Web	http://www.solarterra.com.br
Email	mario.cassoli@solarterra.com.br
Contact Name	Mário Dias
BR SOLAR	
Address	Rua Dom Gerardo, 63 - sala 503 - Centro - Rio de Janeiro - RJ
Tel.	(0055)-2125121260
Web	http://www.brsolar.com.br
Email	rbaldini@brsolar.com.br
Contact Name	Ruberval Baldini

Chile	
Terrasolar	
Address	Av. Irarrázaval 3755 - Ñuñoa - Santigao
Tel.	(0056)-25970450
Web	http://www.terrasolar.cl
Email	cantunovic@terrasolar.cl
Contact Name	Christian Antunovic
Tesla Energy	
Address	Calle Local 145, Parque Industrial Michaihue, Concepción
Tel.	(0056)-412854450
Web	http://www.teslaenergy.cl
Email	egarcia@teslaenergy.cl
Contact Name	Eduardo García Bellalta
Lumisolar	
Address	Tobalaba 1569
Tel.	(0056)-24152773
Web	http://www.lumisolar.cl
Email	lumisolar@lumisolar.cl
Contact Name	Arturo Letelier
Riovalle Ltda	
Address	Obispo Alday 188 Lonco Alto Concepcion
Tel.	(0056)-412978121
Web	http://www.riovalle.cl
Email	sol@riovalle.cl
Contact Name	Soledad Vallejos Mackay
Aquito Solar	
Address	Av. Apoquindo 6415, local 120, Las Condes, Santiago.
Tel.	(0056)-28204296
Web	http://www.aquitosolar.cl
Email	sac@aquitosolar.cl
Contact Name	Mauricio Contreras
SumSol Chile	
Address	Heriberto Covarrubias 21, Of. 503. Ñuñoa, Santiago
Tel.	(0056)-22270420
Web	http://www.sumsol.cl
Email	aal@sumsol.cl
Contact Name	Antonio Antón López

France	
GenSun	
Address	1025 rue Henri Becquerel, Parc Club du Millénaire 11, 34000 Montpellier
Tel.	(0033)-0467587601
Web	http://www.gensun.fr
Email	info@gensun.fr
Contact Name	M. Martial Benazet
MCT Solaire	
Address	18 rue des Oziers, lot 17, P.A. Vert Galant, 95310 Saint Ouen l'Aunôme
Tel.	(0033)-0134400284
Web	http://www.mctsolaire.com
Email	mctsolar@wanadoo.fr
Contact Name	Patrice Chasseriaud
Rosaz-energies	
Address	ZI le domaine, b.p.21, 73250 Saint Pierre d'Albigny
Tel.	(0033)-0479842913
Web	http://www.mctsolaire.com
Email	Eric.BAFFERT@rosaz-energies.fr
Contact Name	Eric Baffert
Germany	
Duett Solarsysteme	
Address	Flottenstr 56 ; 13407 Berlin
Tel.	(0049)-03024342690
Web	http://www.duett.de
Email	info@duett.de
Contact Name	Steffen Schicht
Intelli Solar GmbH	
Address	Moltkestr. 131, 50674 Köln
Tel.	(0049)-01787168872
Web	http://www.intellisolar.de
Email	meyer-delpho@intellisolar.de
Contact Name	Florian Meyer-Delpho
Iliotec (SunPower Authorized Partner)	
Address	An Der Irler Höhe 3ª, 93055 Regensburg
Tel.	(0049)-0941297700
Web	http://www.iliotec.de
Email	einkauf@iliotec.de
Contact Name	Christian Hausler

KunzelmannSolar	
Address	Schmalenbachstr 22, 12057 Berlin
Tel.	(0049)-03044042747
Web	http://www.kunzelmannsolar.de
Email	info@kunzelmannsolar.de
Contact Name	Anke Kunzelmann
Sonnen-Froehlich Solar und Alternative Energiesysteme	
Address	Heidestraße 11, 06785 Oranienbaum - Wörlitz
Tel.	(0049)-03402303750
Web	http://www.sonnen-froehlich.de/
Email	st.froehlich@sonnenfroehlich.de
Contact Name	Steffen Froehlich
Italy	
IAT	
Address	Via Catania, 21 Roma
Tel.	(0039)-0644231155
Web	http://www.iatroma.com
Email	iat@iatroma.com
Contact Name	Santelli
Medielettra di Angelo Badalamenti S.a.s. (SunPower Authorized Partner)	
Address	Via Ugo La Malfa 61 b-c-d Casteldaccia PA
Tel.	(0039)-091941804
Web	http://www.medielettra.it
Email	angelo.badalamenti@medielettra.it
Contact Name	Angelo Badalamenti
Enereco	
Address	Via della Tecnica, 87/89, 36030 – SARCEDO – VI
Tel.	(0039)-0445 371979
Web	http://www.enerecosrl.com
Email	denis@enerecosrl.com
Contact Name	Denis Zorzi
Solar Ventures	
Address	Galleria San Babila 4/b, 20122 Milano
Tel.	(0039)-027621241
Web	http://www.solarventures.it
Email	selena.mercandelli@solarventures.it
Contact Name	Selena Mercandelli

Mexico	
Bufete de Tecnología Solar, S.A. (BUTECSA)	
Address	Aniceto Ortega 817. PB-D. Col. Del Valle. CP 03100. México D.F.
Tel.	(0052)-5555940341
Web	http://www.butecsa.com
Email	strevelr@hotmail.com
Contact Name	Rodolfo Martínez Strevel
GRUPO INSOLAR SA DE CV	
Address	AV. 95 LOTE 17 MZA 83 REGION 233 CANCUN, Q. ROO MX 77510
Tel.	(0052)-9982110239
Web	http://www.grupoinsolar.com
Email	systems@grupoinsolar.com
Contact Name	Ing. Jorge de Dios
ENERGÍA RENOVABLE DEL CENTRO S. DE R.L. DE C.V.	
Address	Carretera Estatal 420 S/N KM. 5,6, El Durazno, El Marqués Querétaro
Tel.	(0052)-4421027031 / 4421027026
Web	http://www.erdcsolar.com
Email	ventas@erdcsolar.com / ruben@erdcsolar.com
Contact Name	Rubén Fernández
New EnergyHarvest de México	
Address	Carlos Orozco Romero 195AHda. Del Bosque. CP38020. Celaya GTO
Tel.	(0052)-4611570178
Web	http://www.neh.mex.tl
Email	new.energy.harvest@gmail.com
Contact Name	Ing. Miguel Du Pont
Mansur Solar	
Address	Av. 5 de febrero No. 2125 oficina No. 3 Plaza Norte Jurica, Querétaro
Tel.	(0052)-4421990885
Web	http://www.mansur-solar.com
Email	jaime.m@mansur-solar.com
Contact Name	Jaime Mansur Monroy
Sistemas de Ecología Solar SA de CV	
Address	Av. El Colli 2197, Zapopan, Jalisco
Tel.	(0052)-3331331495
Web	http://www.solarhouse.com.mx
Email	mariom.solarhouse@gmail.com
Contact Name	Ing. Mario Muñoz

Spain	
SUD, ENERGIES RENOVABLES, SL (SunPower Authorized Partner)	
Address	Pl. Sta. Clara, 2, 2° 1ª, Vic, Barcelona
Tel.	(0034)-938866948
Web	http://www.sud.es
Email	info@sud.es
Contact Name	Esther Benito
ABASOL (SunPower Authorized Partner)	
Address	Dr. Fleming nº 12, 09002, Burgos
Tel.	(0034)-947276935
Web	http://www.abasol.com
Email	abasolnorte@abasol.com
Contact Name	Teresa Arroyal
SISTEMAS ELECTRICOS INELVI XXI, SL	
Address	Mercedes Izquierdo, 3, local – SS de los Reyes – Madrid
Tel.	(0034)-912616100
Web	http://www.inelvi.es
Email	montaje@inelvi.es
Contact Name	José Villegas
TECHNO SUN	
Address	Av. Pérez Galdós 37 | 46018 Valencia
Tel.	(0034)-902602044
Web	http://www.technosun.com
Email	b.alfaro@technosun.com
Contact Name	Begoña Alfaro
UK	
Evergen Systems Ltd	
Address	Spectrum House, Dunstable Road, Redbourn, Herts AL3 7PR
Tel.	(0044)-08442470144
Web	http://www.evergen.co
Email	g.smith@evergen.co.uk
Contact Name	Gerald Smith
UK Solar Generation	
Address	79 Highbury Quadrant, London, N5 2TG
Tel.	(0044)-07886846360
Web	http://www.evergen.co
Email	info@uksolargeneration.co.uk
Contact Name	Russel Lyne

1st Solar PV	
Address	3 Queensmead Avenue, Epsom, Surrey, KT17 3EQ
Tel.	(0044)-02083942210
Web	http://www.1stsolarpv.co.uk
Email	john@1stsolarpv.co.uk
Contact Name	John Sandison
Acos Renewable Energy Co Ltd	
Address	31 Broadmeadows Close, Swalwell, Tyne & wear, NE16 3DD
Tel.	(0044)-07932730071
Web	-
Email	andrewcosgrove@sky.com
Contact Name	Andrew Cosgrove
Solar Century	
Address	50 Great Sutton St, London, EC1V 0DF
Tel.	(0044)-02075491000
Web	http://www.solarcentury.co.uk
Email	david.edwards@solarcentury.com
Contact Name	David Edwards
USA (California)	
Standard Renewable Energy	
Address	12900 Valley Branch Ln. #410, Farmers Branch, TX 75234[51]
Tel.	(001)-2147783806
Web	http://www.sre3.com
Email	bdelatorre@sre3.com
Contact Name	Brandon de la Torre
New Horizon Solar Electric, Inc.	
Address	3627 Windspun Dr. Huntington Beach, CA 92649
Tel.	(001)-7147476527
Web	http://www.newhorizonsolar.net
Email	mike@newhorizonsolar.net
Contact Name	Mike Holton

[51] Despite having its office in Texas, SRE gave quotation for a PV system in California.

6

Annex: Acronyms

6 Annex: Acronyms

Table 27: Acronym Glossary

Acronym	Meaning
AEEG	Regulatory Authority for Electricity and Gas (Italy), acronym in Italian
ANEEL	Electricity Regulatory Agency (Brazil), acronym in Portuguese
BOE	Official State Gazette (Spain), acronym in Spanish
BRL	Brazilian Real
CAGR	Compound Annual Growth Rate
CFE	Federal Electricity Commission (Mexico), acronym in Spanish
CLP	Chilean Peso
CSI	California Solar Initiative
DAC	Residential high consumption (tariff - Mexico), acronym in Spanish
EEG	German Renewable Energy Act, acronym in German
EPIA	European Photovoltaic Industry Association
FiT	Feed-in tariff
ISE	Fraunhofer Institute for Solar Energy Systems
LA	Los Angeles
LADWP	Los Angeles Department of Water and Power
LCOE	Levelized Cost of Energy
LF	Learning Factor
MXN	Mexican Peso
NREL	National Renewable Energy Laboratories
O&M	Operations and Maintenance
PG&E	Pacific Gas and Electric (California)
PR	Performance Ratio
PV	Photovoltaic
RD	Royal Decree
RDL	Royal Decree-Law
RP	Risk Premium
SWM	Munich City Utilities (Germany), acronym in German
TOU	Time -of-use
TUR	Tariff of Last Resort (Spain), acronym in Spanish
USD	United States Dollar

7
Annex: References

7 Annex: References

[i] www.bundesnetzagentur.de/cln_1912/DE/Sachgebiete/ElektrizitaetGas/ErneuerbareEnergienGesetz/VerguetungssaetzePVAnlagen/VerguetungssaetzePhotovoltaik_Basepage.html?nn=135464

[ii] NREL, An Economic Valuation of a Geothermal Production Tax Credit, April 2002; IEA & NEA - Projected Costs of Generating Electricity 2010; EPIA - Solar PV Competing in the Energy Sector; A review of solar PV LCOE - Renewable & Sustainable Energy Reviews, September 2011

[iii] U.S. Department of Labor, U.S. Bureau of Labor Statistics, Division of International Labor Comparisons. Instituto Nacional de Estadísticas de Chile, Eurostat, INE, CEPAL, INEGI, OANDA, OECD Statistics, ECLAREON analysis, research, and interviews

[iv] EPIA, Solar Photovoltaics Competing in the Energy Sector – On the road to competitiveness, September 2011; EPIA/Greenpeace, Solar Generation 6, 2011

[v] Jan Schaeffer et al, Learning from the Sun, Final report of the Photex project, August 2004

[vi] Gregory F. Nemet, Beyond the learning curve: factors influencing cost reductions in photovoltaics, August 2005

[vii] EPIA, Solar Photovoltaics Competing in the Energy Sector – On the road to competitiveness, September 2011

[viii] OANDA

[ix] OECD.Stats http://stats.oecd.org/; BBVA Research; US Federal Reserve, European Central Bank, Banco Central de Chile, Banco de México, Banco Central do Brasil

[x] OECD.Stats http://stats.oecd.org/; BBVA Research; US Federal Reserve, European Central Bank, Banco Central de Chile, Banco de México, Banco Central do Brasil

[xi] (Not exhaustive) Studies quoted in K. Branker et al. / Renewable and Sustainable Energy Reviews 15 (2011) 4470– 4482: 2008 Solar Technologies Market Report, Energy Efficiency & Renewable Energy, US DOE, 2010; Deployment Prospects for Proposed Sustainable Energy Alternatives in 2020, ASME 2010; Achievements and Challenges of Solar Electricity from PV, Handbook of Photovoltaic Science and Engineering, 2011

[xii] http://www.pvcycle.org/frequently-asked-questions-faq/

[xiii] International Finance Corporation, World Bank Group

[xiv] (Not exhaustive) Studies quoted in K. Branker et al. / Renewable and Sustainable Energy Reviews 15 (2011) 4470– 4482: Price S, Margolis R. Solar technologies market report. Energy Efficiency & Renewable Energy, US Department of Energy, 2010; January 2008. p. 1–131; Hegedus S, Luque A. Achievements and challenges of solar electricity from photovoltaics. In: Luque A, Hegedus S, editors. Handbook of photovoltaic science and engineering. 2nd ed. John Wiley and Sons Ltd.; 2011. p. 1–38; Doty GN, McCree DL, Doty JM, Doty FD. Deployment prospects for proposed sustainable energy alternatives in 2020. In: ASME Conference Proceedings 2010, vol. 171. 2010. p. 171–82.

[xv] http://www.nrel.gov/docs/fy12osti/53712.pdf

[xvi] Outdoor PV Degradation Comparison, D.C. Jordan, et.al., NREL, Golden, CO 80401, USA

[xvii] Performance ratio revisited: is PR>90% realistic?, Nils H. Reich, et.al., Fraunhofer Institute for Solar Energy Systems (ISE), and Science, Technology and Society, Utrecht University, Copernicus Institute

[xviii] Ueda Y, K Kurokawa, K Kitamura, M Yokota, K Akanuma, H Sugihara. Performance analysis of various system configurations on grid-connected residential PV systems. Solar Energy Materials & Solar Cells 2009; 93: 945–949.

[xix] http://www.energiadiario.com/publicacion/spip.php?article16709

[xx] http://www.pge.com/mybusiness/environment/calculator/assumptions.shtml

Platinum sponsors:

Supported by:

Research and analysis performed by:

Email: dpn@eclareon.com

Tel: +34.91.395.01.55

Web: http://www.eclareon.com

Regulatory Consulting

Strategy Consulting

Financial Advisory

Market Intelligence