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# PV GRID PARITY MONITOR

## Residential Sector

3rd issue

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# 1
# Executive summary

# 1 Executive summary

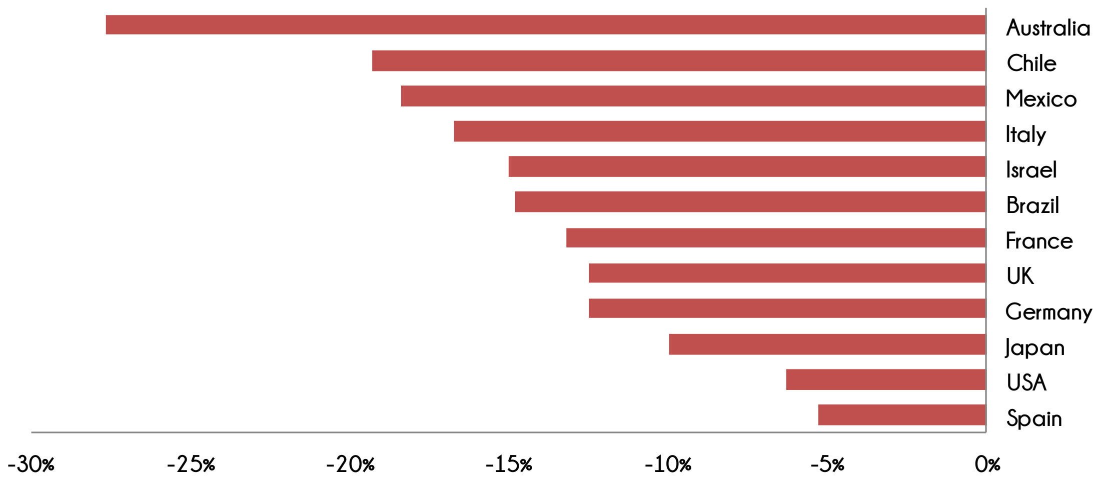
*MERGER NOTIFICATION*

*In January 2014, Creara and Eclareon (Spain) merged their business to form Creara Energy Experts (from now on CREARA) and consolidate their leadership in sustainable energy services.*

This is the 5th issue of the Grid Parity Monitor (GPM) Series, the 3rd issue of the residential segment. This issue focuses exclusively on the residential sector (3 kW PV systems) in 12 countries spread in 5 different continents. Two new markets in Asia (Japan and Israel) are included in this latest GPM release, in addition to the 10 countries analyzed in previous issues: Australia, Brazil, Chile, France, Germany, Italy, Mexico, Spain, UK and California in the US.

The GPM analyses show that full grid parity has been reached in several countries: Australia, Chile (Copiapó), Germany, Italy, Japan and Mexico for DAC consumers. The decreasing trend of installation costs, one of the main drivers of the cost of PV generation (expressed as LCOE), has recently slowed down in mature markets. Overall, from 2009 to 2014, the LCOE in the residential segment decreased in all of the cities analysed: from a 28% annual decline in Australia to a 5% in Spain.

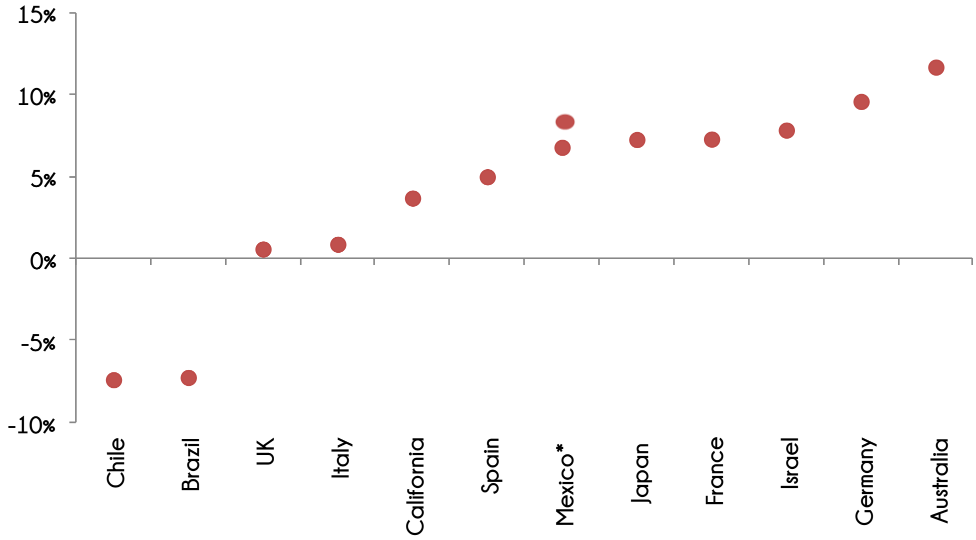
Figure 1: Evolution of PV LCOE for residential consumers from 2009 to 2014 (1st half)




Source: CREARA Analysis

Moreover, residential electricity costs have been increasing in most markets, with Chile and Brazil as the only exceptions.

Figure 2: Evolution of retail electricity prices for residential consumers from 2009 to 2014

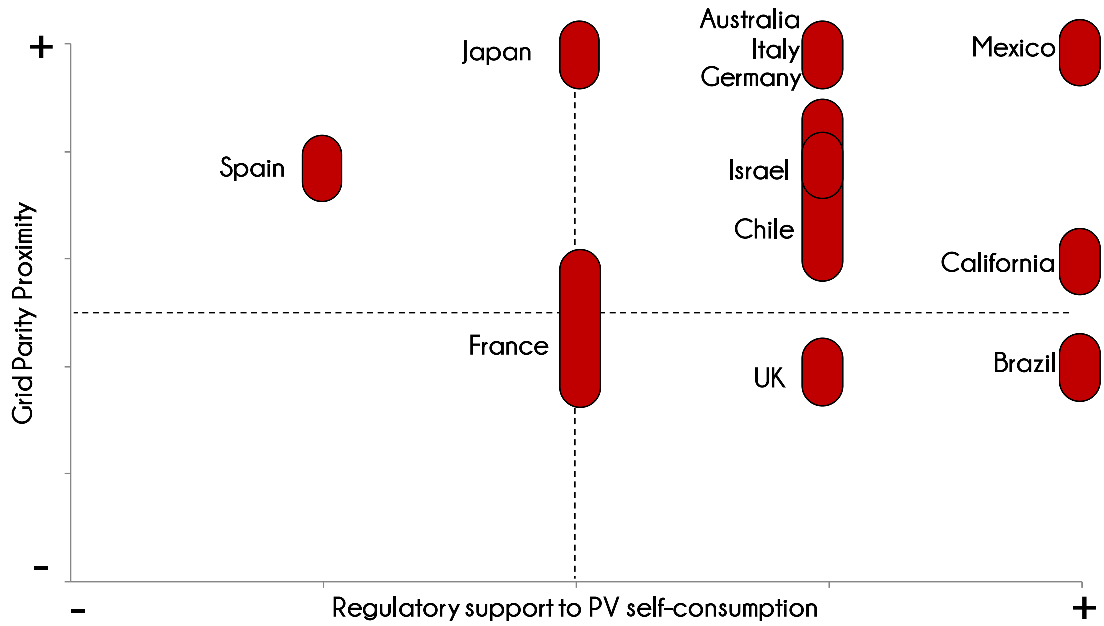



Note: * For DAC users, retail electricity prices have increased by 8,91% whereas standard retail electricity prices have increased by 6,8%. The standard prices were used for the other countries.

Source: CREARA 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: Position Matrix of the countries analyzed




Note: Data of 1st semester 2014
Source: CREARA Analysis

The following conclusions can be drawn from the above Figure:

- PV Grid Parity is being delayed in the UK and Brazil, due to low irradiation levels in the former and a relatively high discount rate and system prices in the latter.
- In France and Japan, the regulatory framework does not foster the self-consumption market, as the FiT received for the energy exported to the grid is higher than the retail price of electricity[1].
- California has a trendsetting net metering policy and generous incentives that enable high margins throughout the entire value chain.
- In Spain, although a clear grid parity situation exists, there is currently no regulation to foster the self-consumption market by enabling self-consumers to feed their excess generation into the grid in exchange for a compensation.
- In Chile and Israel, grid parity and governmental support represent an excellent opportunity to develop a sustainable PV market based on self-consumption. This is clearly seen in Australia, Italy and Germany, which are already in full grid parity.
- In Mexico, the combination of grid parity and an effective regulation generates an attractive investment opportunity for DAC consumers.

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, albeit not without additional challenges:

- The absence of conscious consumers, which is sometimes the reason why market creation is limited.
- The operation of the electricity system, which becomes more complex with higher penetration of distributed generation.
- The current design of electricity tariffs, which in many cases fails to make the business model of utilities compatible with that of self-consumers.

[1] In France this applies only to BIPV, which receives more support than BAPV.

# 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 one cities in twelve 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 analysis 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[2]) has already been reached in several of the cities analysed 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

[2] 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.

to the increasing importance of distributed generation, and in so doing ensure that it is properly monitored, channelled, and regulated.

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 commercial and utility-scale sectors may represent a very interesting opportunity as well but they should be analysed separately since several characteristics differ from those of residential installations (PV installation costs, retail electricity prices, etc.). The commercial and utility-scale sectors will be analysed 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[3].
- To simplify the analysis, it is assumed that the prosumer invests in the PV system with own funds. Financing mechanisms were not considered.
- Only one or two cities per country were analysed. This implies that in some countries (such as Chile, Brazil, and Japan) 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 analysed in this report.

[3] 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).

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[4] 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:

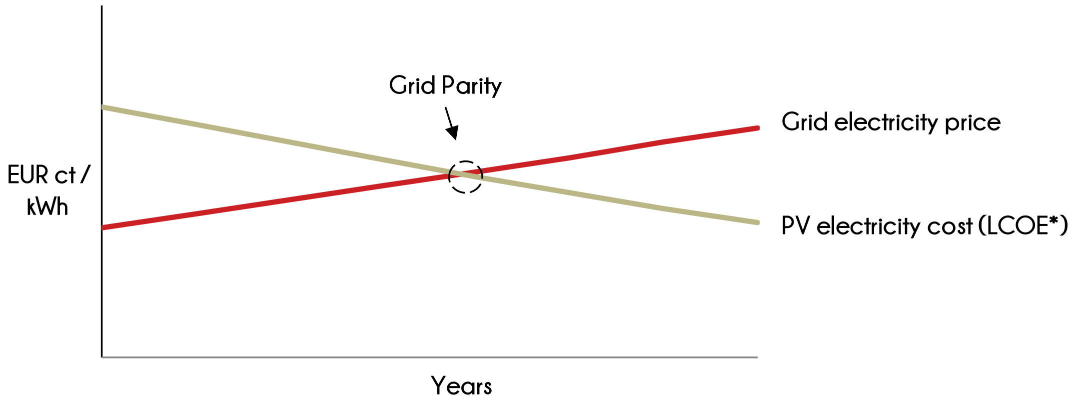
- If self-consumption is not regulated, the PV prosumer receives no compensation in exchange for the excess PV electricity fed into the grid.
- If an self-consumption regulation exists (e.g. a net metering/net billing mechanism), the owner of the installation does receive a compensation (either monetary 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.

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

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.

*Figure 4: Simplistic Illustration of PV Grid Parity*




Note: * Levelized Cost Of Electricity
Source: CREARA 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, Israel, Italy, Japan, 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 4 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 periodically to show the evolution of PV grid parity proximity.
- It analyses not only potential markets in Europe but also some of the most promising ones outside Europe (Brazil, California, Chile, Israel, Japan and Mexico).

The PV Grid Parity Monitor consists of two main sections:

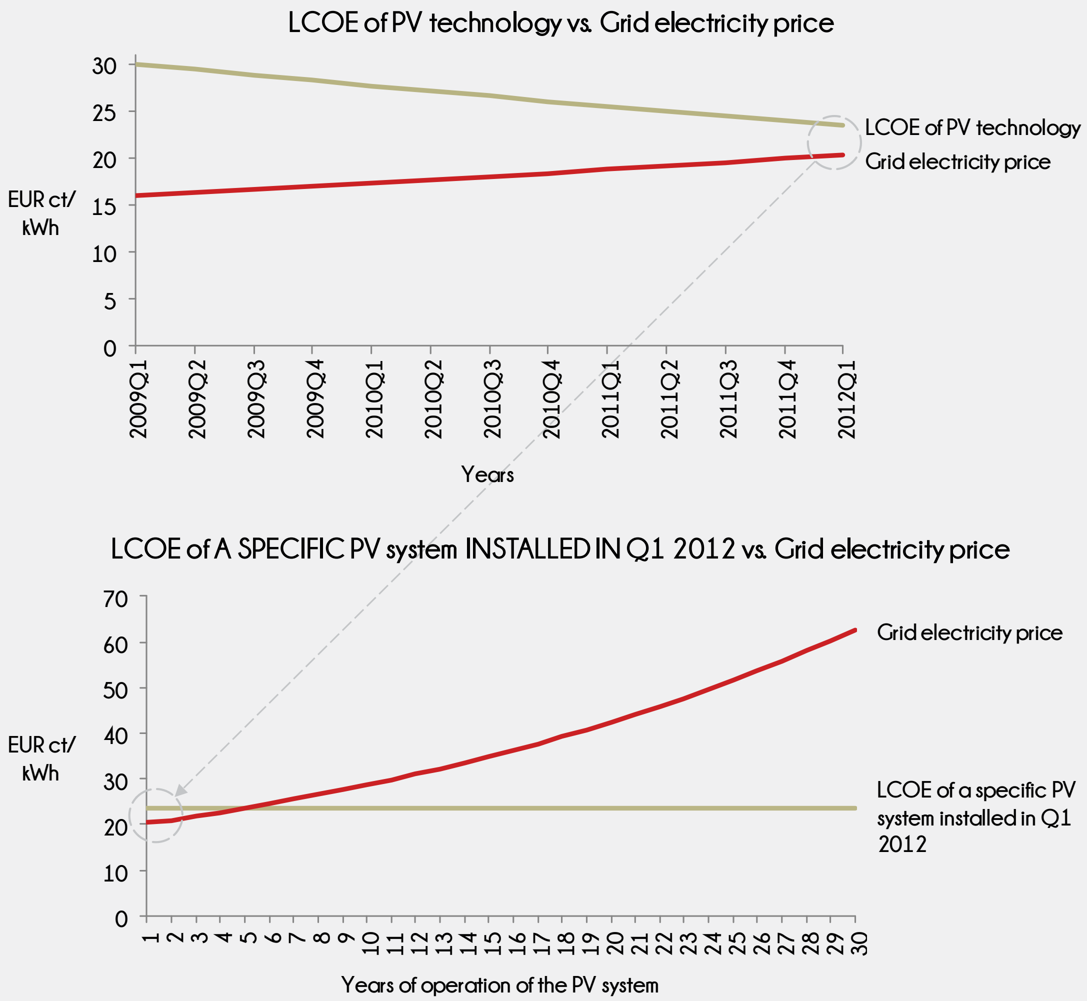
- Results Section, where PV LCOE is quantified for each of the locations under study and PV grid parity proximity is analysed.
- Methodology Section, which includes a thorough explanation of the LCOE concept, and the main assumptions and inputs considered.

## 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 properly asses 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

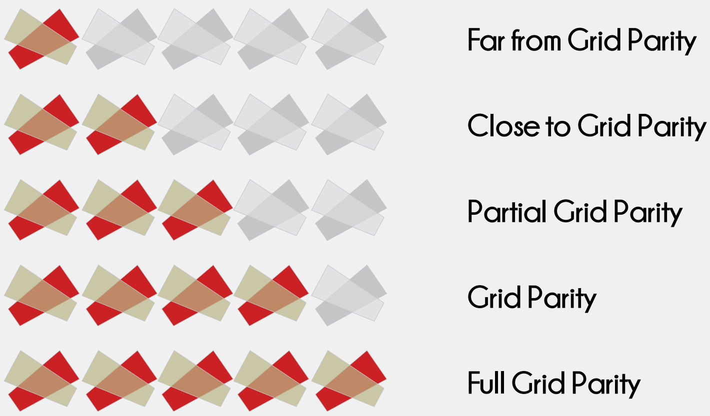
# PV GPM results

# 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 S1 2014 in two cities of most 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[5], 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.

[5] 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)*

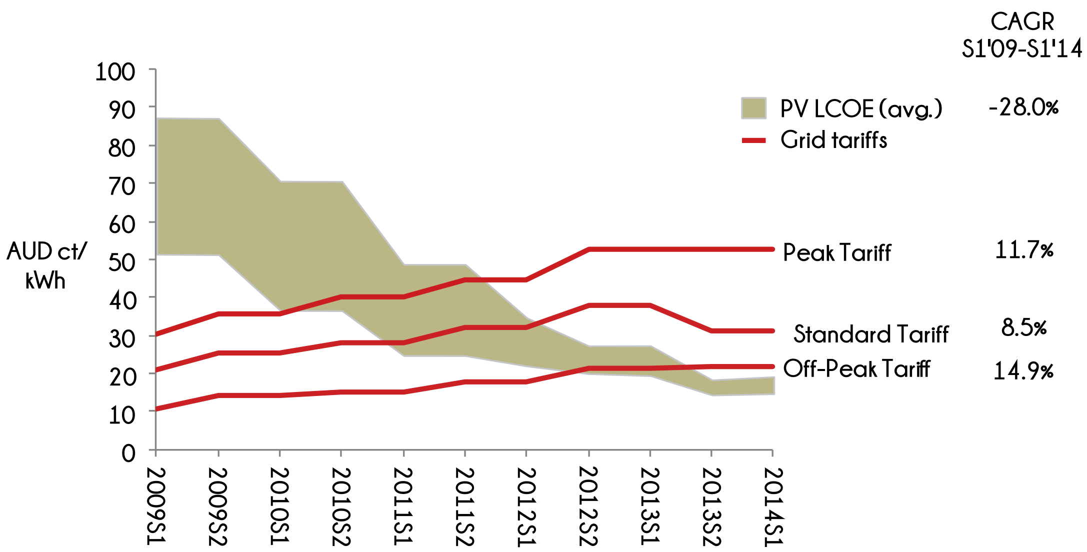



*Figure 9: Sydney's Grid Parity proximity*

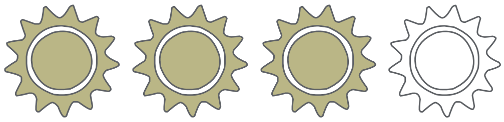
- In Australia, full grid parity has been reached mainly as a result of the following trends:
  - The important decrease experienced by PV LCOE in the last few years (a CAGR of -28.0% in the analysed period).
  - A significant increase in retail electricity prices which, for the standard tariff, is estimated at 8.5% per year from 2009 to first semester 2014.

## 3.1.2 Regulatory support to PV self-consumption

- The price of electricity, tariffs and incentives vary dramatically between States. 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.

- 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, who 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.
- 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.

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

[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)*

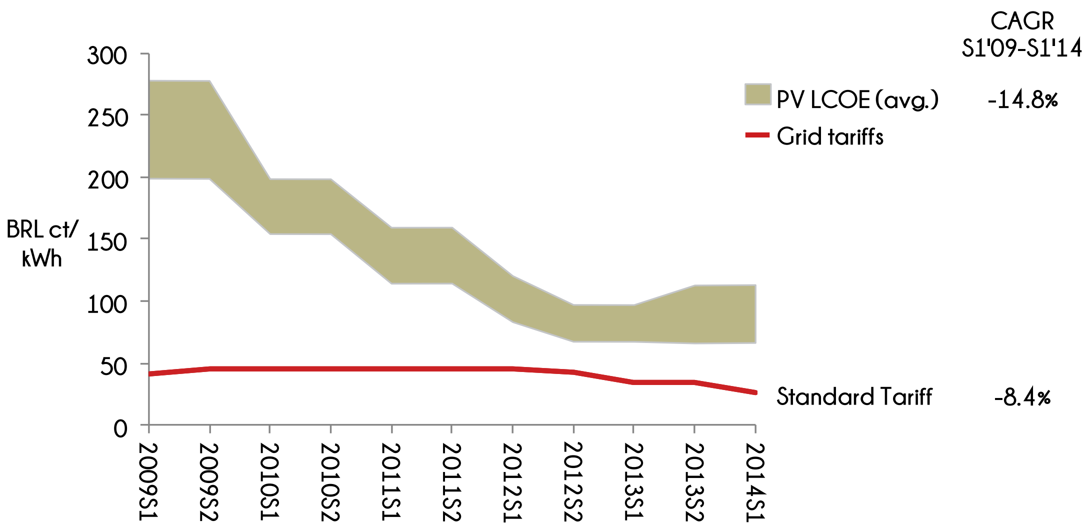



*Figure 12: São Paulo's Grid Parity proximity*

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

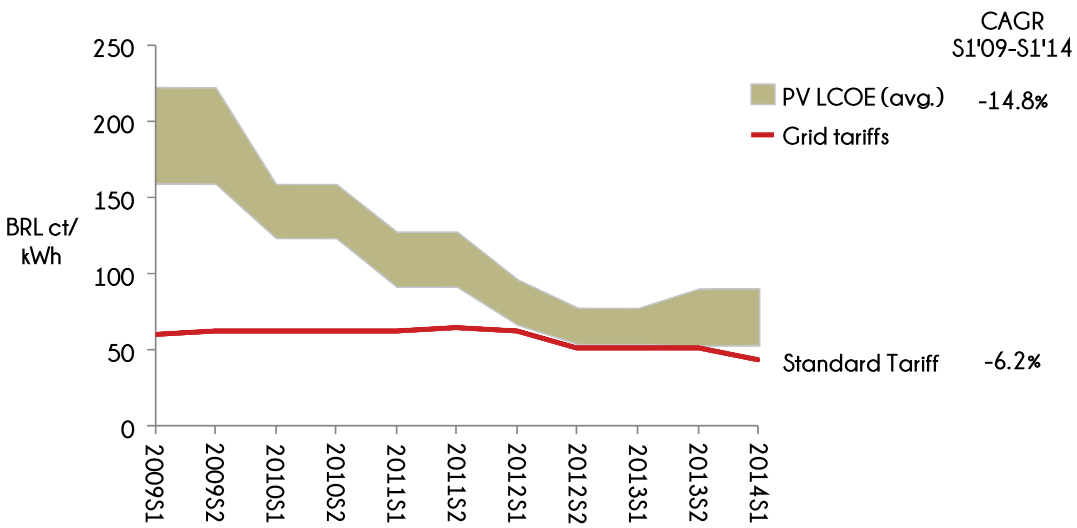



*Figure 14: Itacarambi's Grid Parity proximity*

- In January 2013, the Brazilian Government implemented a reduction of electricity tariffs, which for the consumers analysed amounts to an annual reduction between 6 and 9%.
  - 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 -14.8% in the last 5 years).
- While in São Paulo PV technology is still far from being competitive against grid electricity, in Itacarambi grid parity could be reached sooner due to the relatively high irradiation levels.

### 3.2.2 Regulatory support to PV self-consumption

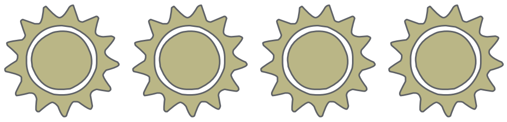
- A net-metering regulation for renewable energy systems up to 1 MWp is in place since January 2013[8]; with the following main characteristics:
  - Users will only pay for the difference between the energy consumed and the one fed to the grid.
  - Compensation will be held within the same rate period (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

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

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

- Apart from the net-metering scheme and some tax advantages, there is no significant support for PV generation in Brazil, since renewable energies tend to compete on equal terms with conventional technologies.

*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, the reduction of electricity tariffs has pushed PV grid parity further away in Brazil.
- The 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)*

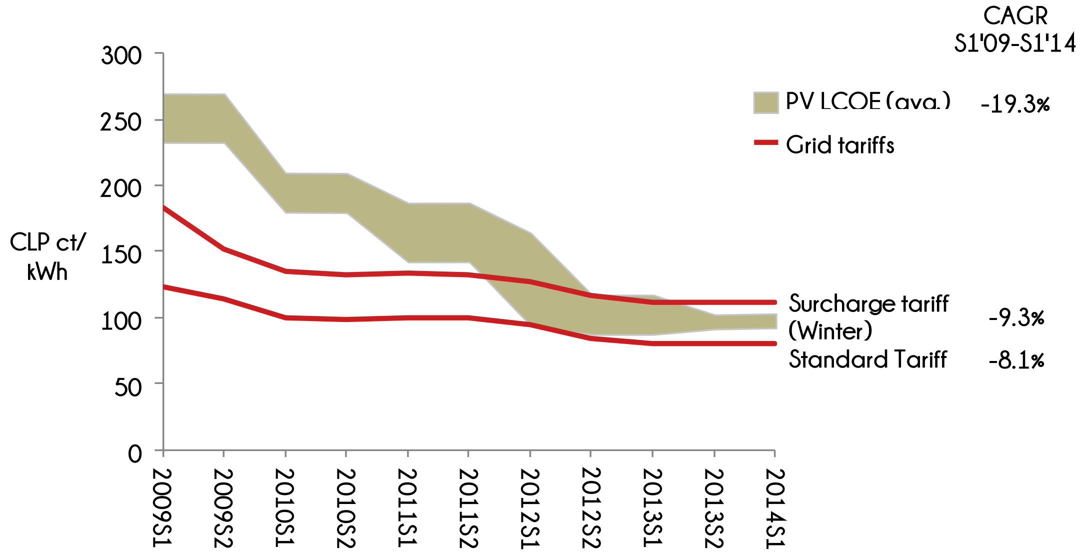



*Figure 17: Santiago's Grid Parity proximity*

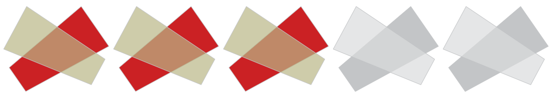


*Figure 18: Past evolution of retail electricity price and PV LCOE in Copiapó, Chile (including taxes)*

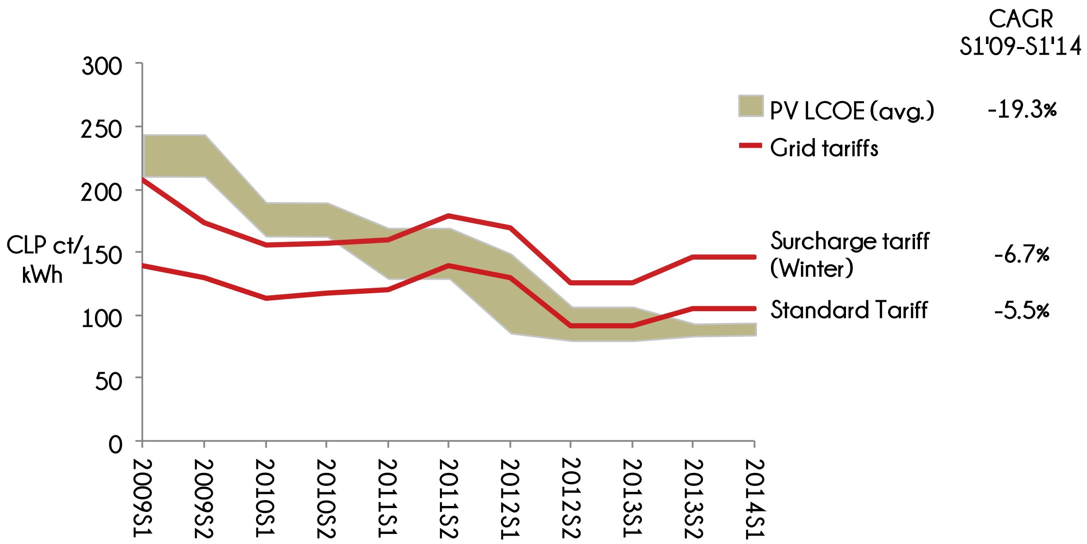


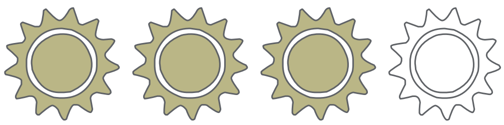

*Figure 19: Copiapó's Grid Parity proximity*

- 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 it is also lower than the standard (non-TOU) electricity rate.

### 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), and later in September 2014 its technical note was published.
  - PV electricity surpluses are valued at an monetary rate in the subsequent electricity bill, which is estimated on the basis of node prices and are lower than the retail electricity price.
- The Renewable Quotas Law obliges utilities to buy at least 5% of their annual traded electricity from renewable energy sources.
  - This obligation will start to increase gradually from 5% in 2014 to 20% in 2025; economic penalties for non-compliance are set (30$ per MWh).
  - 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*



[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.

### 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, which has recently been implemented is, on a first evaluation, a proper incentive to generate a PV self-consumption market.
- 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)*

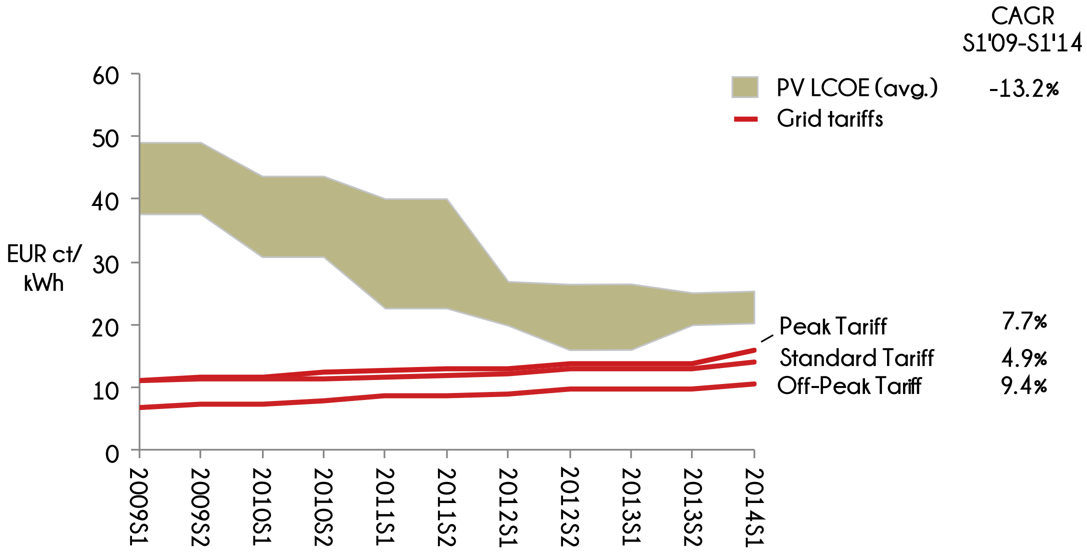



*Figure 22: Paris's Grid Parity proximity*

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

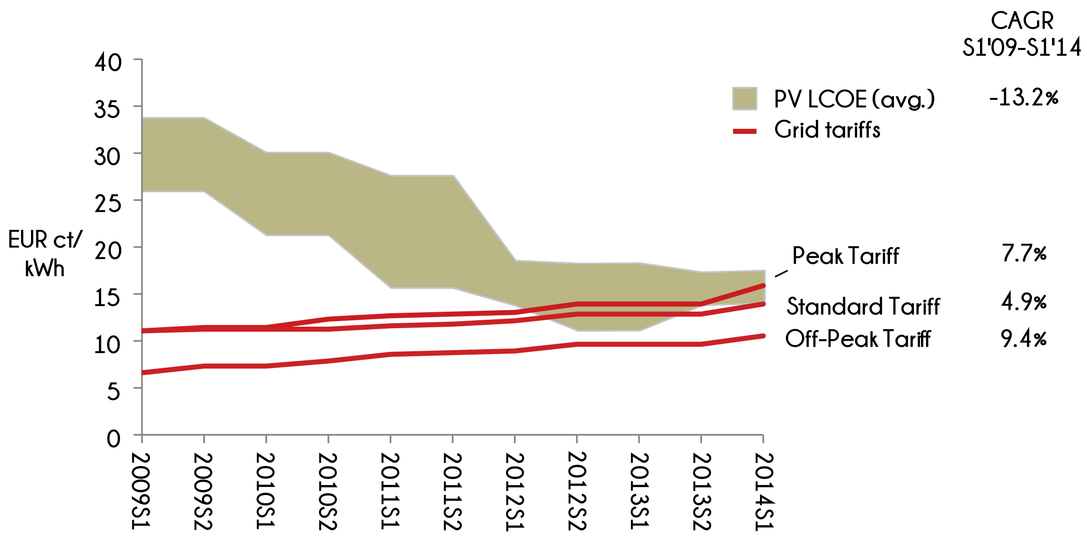



*Figure 24: Marseille's Grid Parity proximity*

- PV LCOE has been decreasing an average of 13% per year from 2009 to 2014.
- However, grid electricity prices have increased steadily (4.9% Compound Annual Growth Rate for the standard tariff), a trend that could eventually drive grid parity.
- 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.

### 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). [12]
  - Residential BIPV remuneration levels significantly exceed those of BAPV, with BIPV FiTs still higher than the standard electricity price for residential consumers.
- Given that for both BIPV installations the FiTs are still higher than the retail price of electricity, self-consumption is not being incentivized for those systems.
- While the French Minister of Ecology, Sustainable Development and Energy announced at the end of 2013 that the FiT scheme could be stopped, at a recent press conference, Ségolène Royal affirmed that FiTs will be maintained for small renewable power systems and pre-commercial installations.
- Residential consumers can also benefit from other iniciatives:
  - A tax credit of 11% of the equipment costs with certain limits depending on the PV system characteristics
  - Reduced VAT rate of 10% on equipment and installation costs[13] (only for systems below 3kWp).

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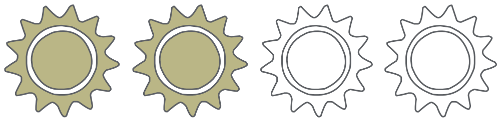
[12] The installation prices used in this study refer to BAPV systems not to BIPV.

[13] Available for systems installed since January 2014.

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



### 3.4.3 Conclusions

- Currently, FiTs for BIPV 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*

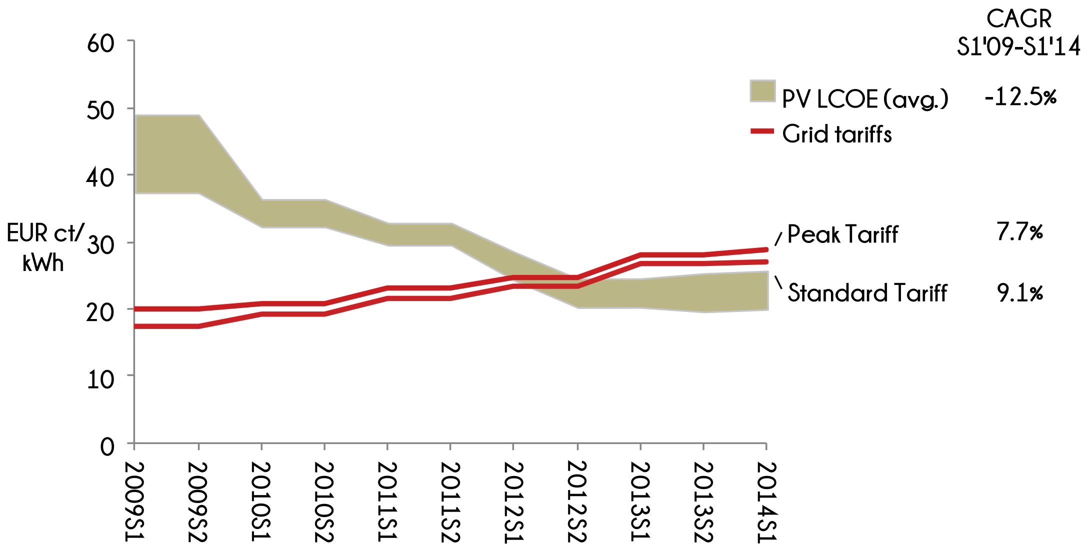



*Figure 27: Berlin's Grid Parity proximity*

*Figure 28: Past evolution of retail electricity price and PV LCOE in Munich, Germany*

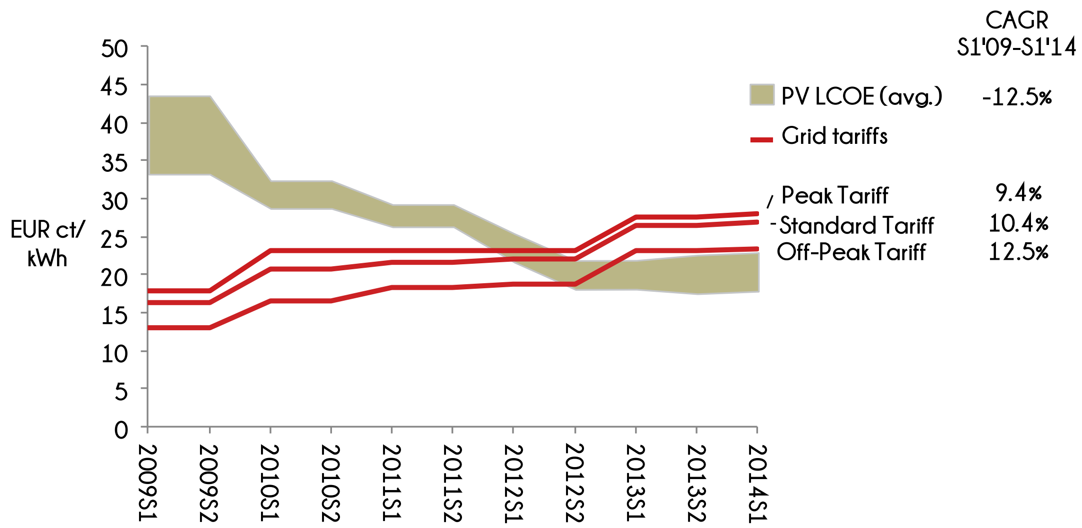



*Figure 29: Munich's Grid Parity proximity*

- Despite the low irradiation levels in Germany, PV grid parity has already been reached in Munich and in Berlin, since 2013.

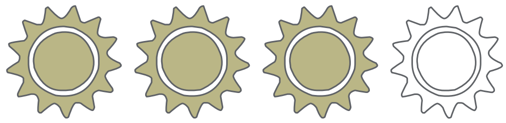
- PV grid parity proximity in a country with relatively low irradiation levels such as Germany can be explained by three main factors:
  - System prices in Germany are among the lowest quotations received.
  - The discount rate used for the calculation of LCOE is low (5%, see Section 4.3), as it reflects the return a German electricity consumer would require from a relatively safe investment.
  - Retail electricity prices are considerably high, and have been increasing gradually in recent years.

### 3.5.2 Regulatory support to PV self-consumption

- Since 2012, severe FiT cuts for small-scale PV installations have been introduced in the Renewable Energy Sources Act (Erneuerbare Energien Gesetz, EEG).
- EEG FiT program fosters the self-consumption market in an efficient way.
  - 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 (~13 cEu/kWh vs. ~29 cEu/kWh).
- Another recent change also affects the small-scale segment: the percentage of the yearly power production entitled to receive the tariff is restricted for certain installation sizes (the so-called market integration model).
- 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, the storage benefit would foster the self consumption market.

- Germany's Government is debating the introduction of reforms of its landmark renewable energy laws which would impact the PV market[15].
  - The FiT could be wed out entirely by 2018 and replaced with a tendering or bidding system.
  - Small producers and businesses who self-consume their generation have to pay 50 percent of the renewable energy surcharge.

*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 for 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[16] 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.

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[15] "Renewable Energy World".

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

## 3.6 Israel

### 3.6.1 Grid Parity Proximity

*Figure 31: Past evolution of retail electricity price and PV LCOE in Tel Aviv, Israel (including taxes)*

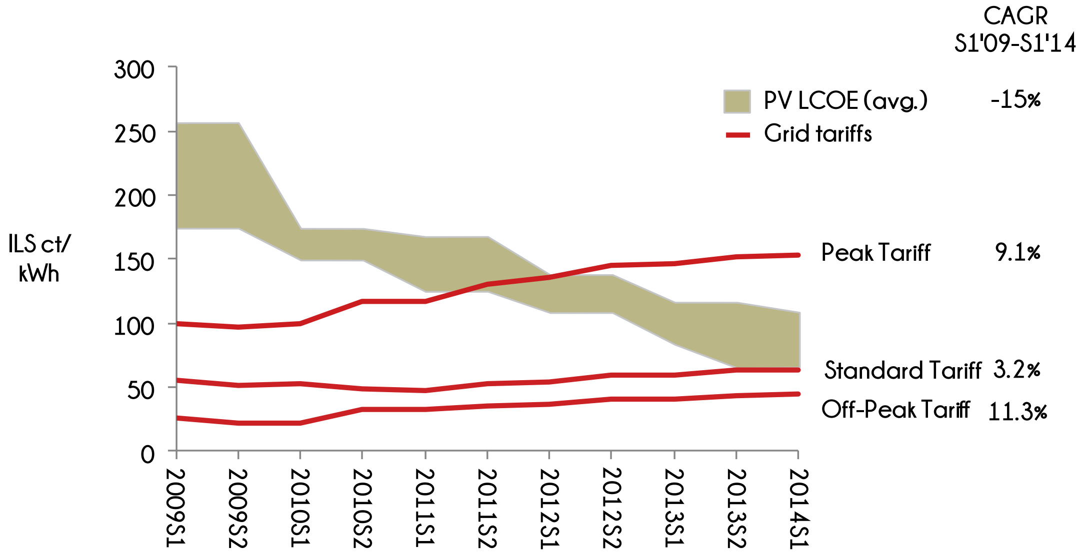



*Figure 32: Tel Aviv's Grid Parity proximity*

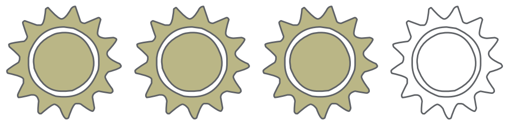
- Grid Parity has been reached in Israel, as the most competitive PV LCOE is now equal to the rate applicable to the standard tariff.
- Since 2009, the PV LCOE has decreased 15% while the standard electricity tariff has been increasing, albeit at a lower annual rate (3.2%).
- Moreover, the small-scale PV market is still relatively immature, therefore there is margin for further price reductions.

### 3.6.2 Regulatory support to PV self-consumption

- In 2008 the Israeli Public Utility Authority (PUA) implemented a FiT program for small scale (up to 50kWp) PV installations.
- Subsequently, in 2013, the PUA implemented a net-metering scheme for PV systems up to 5MW and established a cap of 400 MW for 2013-2015. As of January 2014 some 20 MW of PV systems were installed under the scheme.

- Self-consumers feed the excess generation into the grid in exchange for energy credits, which are used to offset their electricity consumption during the following 2 years.
- A "grid integration cost", accounting for the use of the grid, is deducted from the energy credits.
- Moreover, energy credits can be transferred to any other consumer, in a grid price set on a day basis of connecting to the grid.

*Figure 33: Assessment of regulatory support to PV self-consumption*



### 3.5.3 Conclusions

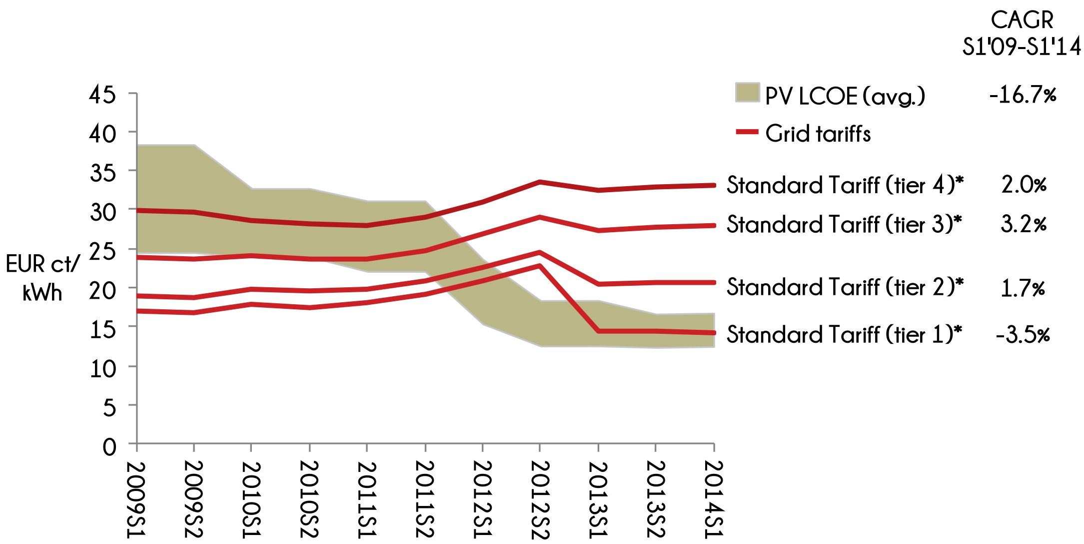
- In Israel, Grid Parity and the governmental support represent an excellent opportunity to develop a sustainable PV market based on self-consumption.
- Even if Grid Parity (defined as the moment when PV LCOE equals retail electricity prices) has been reached, regulatory cover[17] is still necessary 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.

# 3.7 Italy

## 3.7.1 Grid Parity Proximity

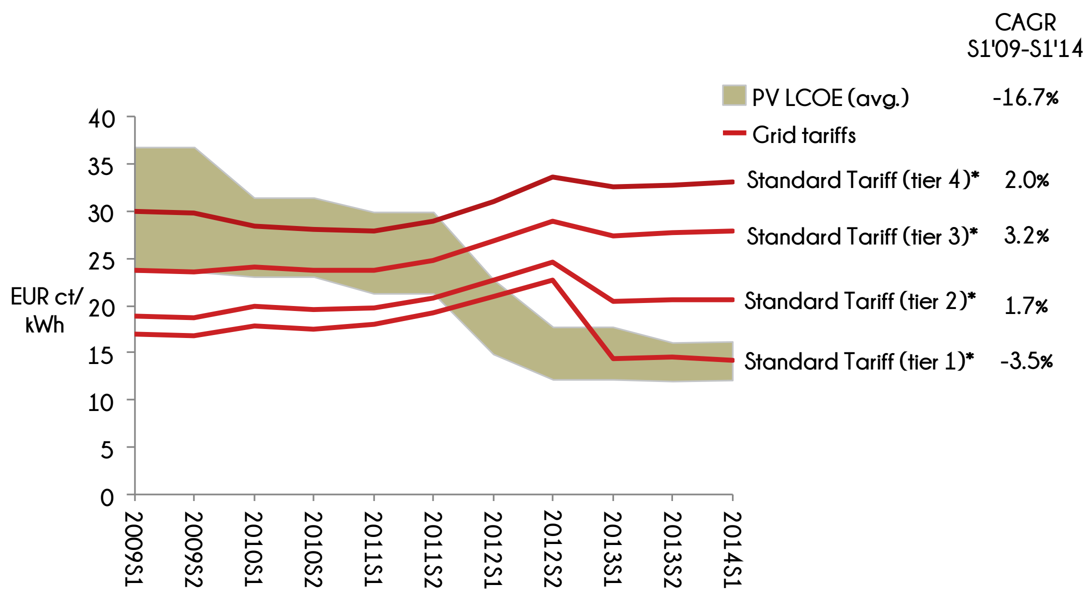
*Figure 34: Past evolution of retail electricity price and PV LCOE in Rome, Italy (including taxes)*




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 35: Rome's Grid Parity proximity*

*Figure 36: Past evolution of retail electricity price and PV LCOE in Palermo, Italy (including taxes)*




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

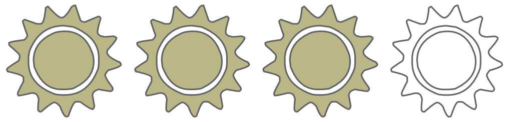
*Figure 37: Palermo's Grid Parity proximity*

- 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 16.7% per year from 2009 to 2014.
  - 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).
- The LCOE of the most competitive systems is already lower than the lowest variable grid electricity tariff.
  - The higher the consumption level of the user, the more convenient is self-consumption.

### 3.7.2 Regulatory support to PV self-consumption

- The Scambio Sul Posto mechanism allows users with PV systems under 500 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 would be modified soon, when the GSE (Gestore dei Servizi Energetici) publishes the new technical regulation.
- The Conto Energia (FiT scheme) and the self-consumption premium were eliminated in July 2013, because the set budget was reached.
- There are additional incentives for PV:
  - Reduced VAT on PV equipment and installation costs (10% as opposed to 20%).
  - There is a TAX deduction for PV systems that ranges between 36 to 50% of the construction costs.

*Figure 38: Assessment of regulatory support to PV self-consumption*



### 3.7.3 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 Italy.
- Even if Grid Parity (defined as the moment when PV LCOE equals retail electricity prices) has been reached, regulatory cover[18] 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.

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

## 3.8 Japan

### 3.8.1 Grid Parity Proximity

*Figure 39: Past evolution of retail electricity price and PV LCOE in Tokyo, Japan (including taxes)*

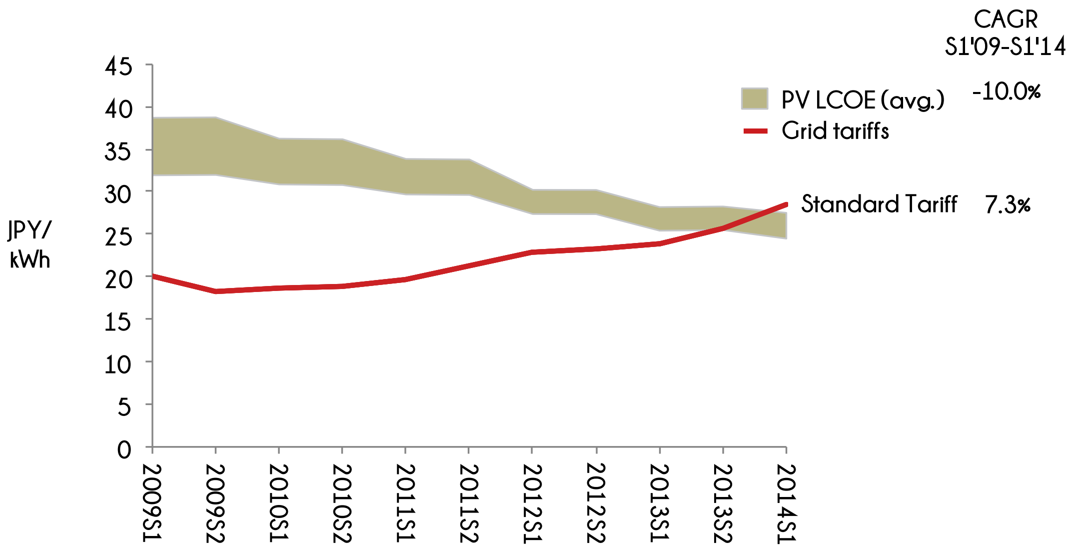



Figure 40: Tokyo's Grid Parity proximity

- Full PV Grid Parity in Tokyo has been reached, mainly as a result of three main factors:
  - PV systems have dropped sustainably.
  - The discount rate used in the LCOE calculation is relatively low.
  - The electricity prices are high and have been gradually increasing (CAGR of 7.3%).
- It should be noted that one of the highest electricity tariffs is the one in Tokyo, so this situation does not display grid parity's proximity all over Japan.
  - In adittion it is expected that as a result of the decrease in fuel prices electricity rates will drop eventually.

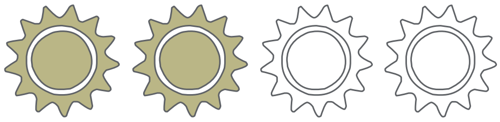
### 3.8.2 Regulatory support to PV self-consumption

- In July 2012, the Japanese Government implemented a FiT program that enables PV systems below 10 kW to self-consume part of their PV generation, and receive a payment for the excess electricity.

- The tariff levels have been revised downwards twice, and they are currently above the retail price of electricity from the grid.

- Residential consumers can also benefit from investment subsidies.
    - The installation must meet certain requirements to be eligible and the subsidy varies with the investment price.

*Figure 41: Assessment of regulatory support to PV self-consumption*



### 3.8.3 Conclusions

- In Japan, grid parity is an excellent opportunity to develop a profitable and sustainable photovoltaic market based on self-consumption.
- 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.

# 3.9 Mexico

## 3.9.1 Grid Parity Proximity

*Figure 42: Past evolution of retail electricity price and PV LCOE in Mexico City, Mexico (including taxes)*

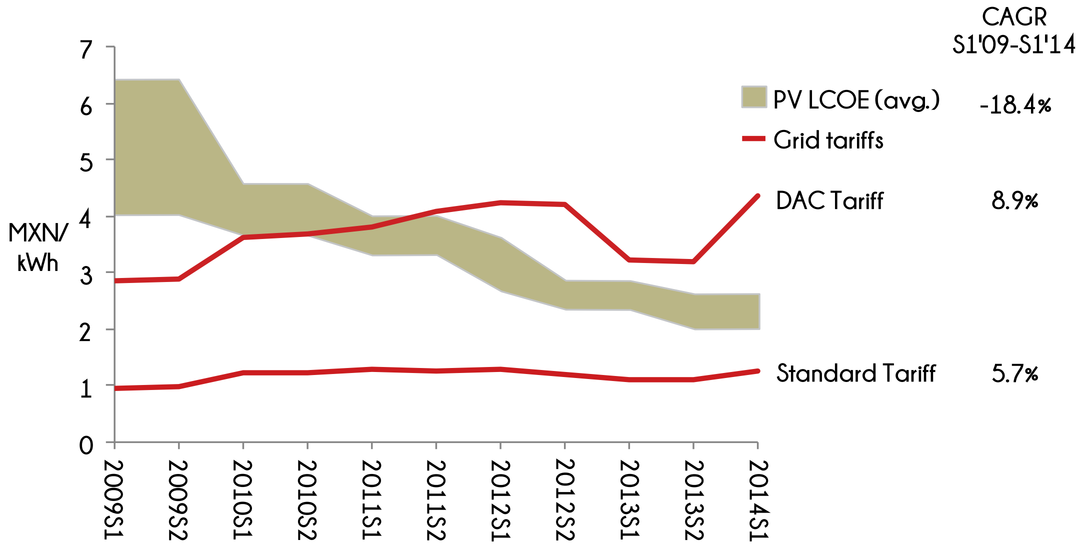



*Figure 43: Mexico City's Grid Parity proximity*

*Figure 44: Past evolution of retail electricity price and PV LCOE in Hermosillo, Mexico (including taxes)*

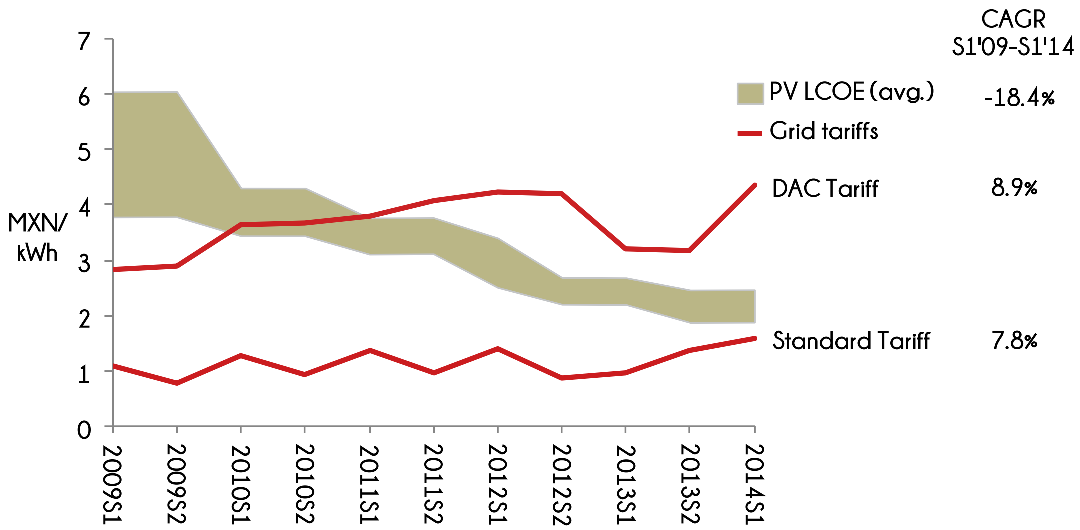



*Figure 45: Hermosillo's Grid Parity proximity*

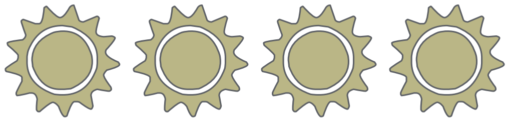
- For DAC electricity consumers (households with high electricity consumption that pay more than twice the price of the average residential tariff), it is already worthwhile from an economic point of view to self-consume PV electricity instead of buying it from CFE (single National utility).
- Although PV LCOE has experienced a significant decrease from 2009 to 2014 estimated at -18.4% Compound Annual Growth Rate, for the average electricity consumer PV is still not competitive against grid electricity prices.

### 3.9.2 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 2013, some 4,600 residential users were in the net-metering scheme (2.3 times the number reported at the end of 2012).
- 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 do.
- 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 Government introduced at the end of 2013 an in-depth energy reform for the oil and gas industry, as well as the electricity market; the reform led to extensive changes in legislation in 2014 that will be finished with market rules in 2015. The expectation is that the implementation of these changes will have a strong impact in the development of the PV market.

- The introduction of the renewable energy certificates (CEL, Spanish acronym) will futher improve the competitiveness of PV.
- The market is now open to the private sector for both energy generation and energy retailers, an opportunity for the expansion of the PV market.

*Figure 46: Assessment of regulatory support to PV self-consumption*



### 3.9.3 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.

## 3.10 Spain

### 3.10.1 Grid Parity Proximity

*Figure 47: Past evolution of retail electricity price and PV LCOE in Madrid, Spain (including taxes)*

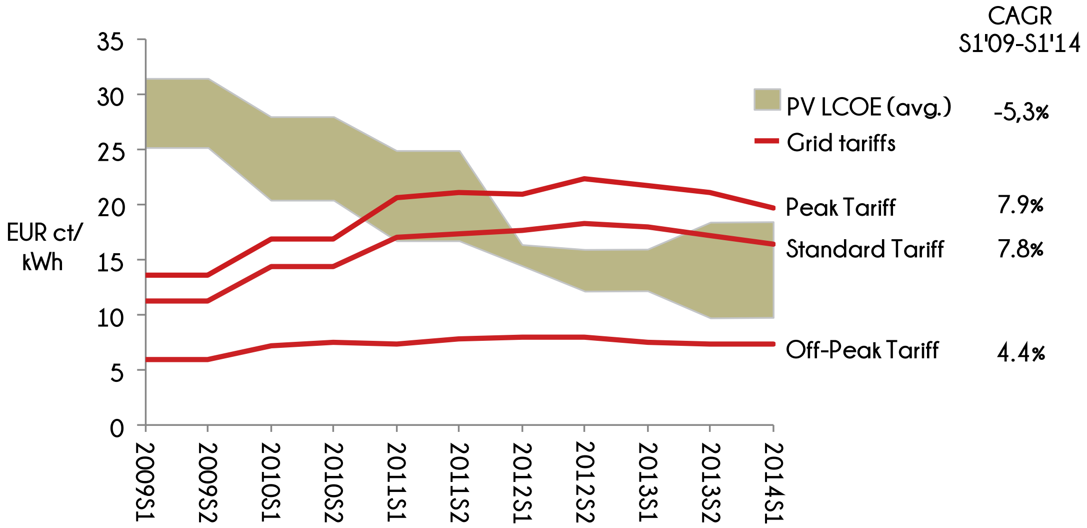



*Figure 48: Madrid's Grid Parity proximity*

*Figure 49: Past evolution of retail electricity price and PV LCOE in Las Palmas (Canary Islands), Spain (including taxes)*

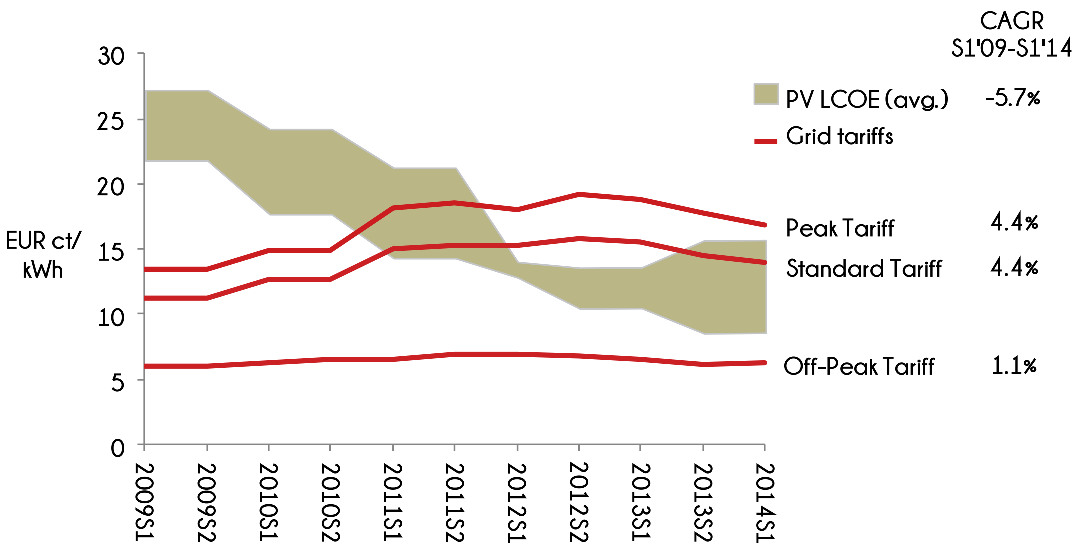
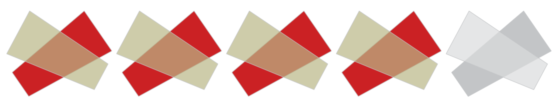



*Figure 50: Las Palmas' Grid Parity proximity*



- Grid parity has been reached both in Continental Spain and in the Canary Islands. This is mainly due to:
  - The significant decrease experienced by PV LCOE in the last few years (an average annual decrease of 5.5% in Madrid and in the Canary Islands from 2009 to 2014).
  - The increase of standard electricity prices (although it should be highlighted that the upwards trend has recently reversed).
- It is important to note that the perception on regulatory risks (regarding not only PV support but also electricity prices) has negatively impacted grid parity proximity.
  - To avoid PV injections to the grid, some installers now sell systems that include PV inverters with power controls[21]. Other installers have (partially) shifted their core business to other products.
  - Moreover, the fixed component of the electricity tariff has recently been increased, while the variable component has been reduced.

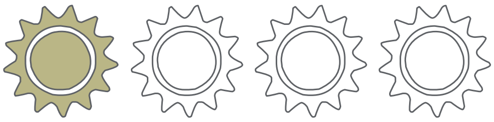
### 3.10.2 Regulatory support to PV self-consumption

- In Spain, any electricity consumer can generate PV electricity for self-consumption, albeit without receiving any compensation for the excess generation.
  - There is neither a feed-in tariff scheme nor a net-metering (or comparable) mechanism in place.
- However, the latest proposal for the self-consumption market totally de-motivates the installation of these PV systems. The measures designed by the Government could include the following elements:
  - No compensation for the excess PV generation fed into the grid.
  - A fee for every kWh of PV self-consumption.

[21] A system with energy injections requires prosumers to sell the excess electricity in the spot market through a market representative, which is not economically viable in most cases.

- It should be pointed out that, as an exception, special economic incentives could be established in the Balearic and Canary Islands, where irradiation is among the country's highest and electricity among the country's most expensive to generate, but this is still to be developed.

*Figure 51: Assessment of regulatory support to PV self-consumption*



### 3.10.3 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 a regulation to enable 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[22] 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.

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

## 3.11 UK

### 3.11.1 Grid Parity Proximity

*Figure 52: Past evolution of retail electricity price and PV LCOE in London, UK (including taxes)*

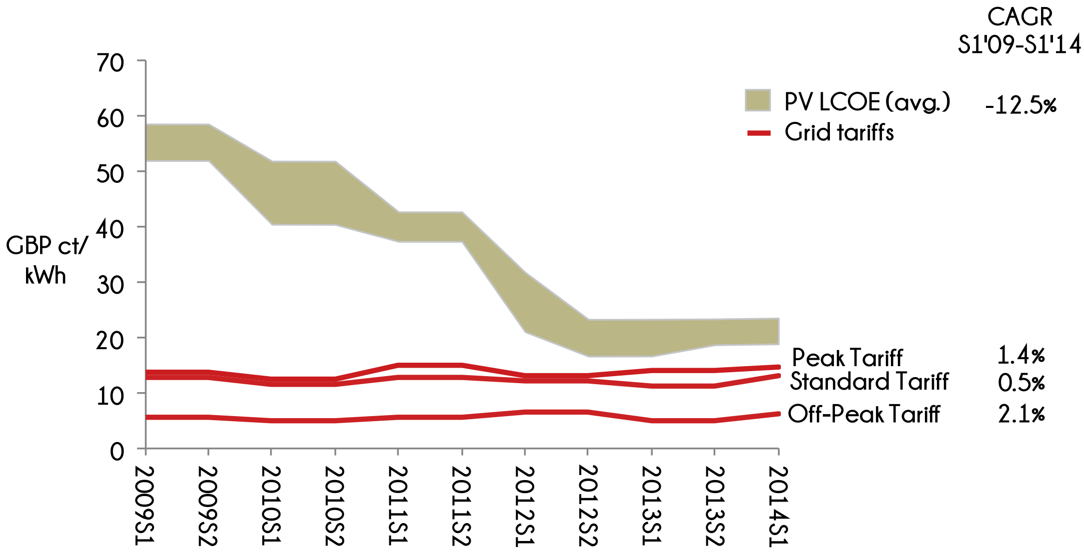



*Figure 53: London's Grid Parity proximity*

*Figure 54: Past evolution of retail electricity price and PV LCOE in Plymouth, UK (including taxes)*

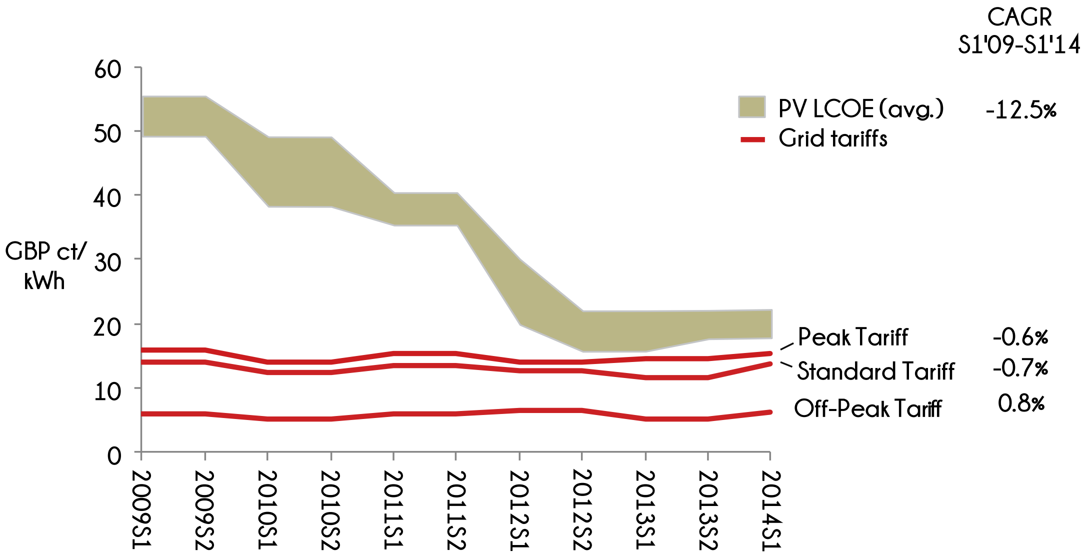



*Figure 55: Plymouth's Grid Parity proximity*

- In the UK, PV Grid Parity is still far from being reached.
  - PV LCOE has experienced a considerable decrease since 2009 (an average Compound Annual Growth Rate of -12.5% in the analysed period).
  - However, system prices have stagnated in the last two years.

### 3.11.2 Regulatory support to PV self-consumption

- In the UK, the main support mechanism for small-scale PV systems is the FiT scheme, which was introduced in 2010[23].
- 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)[24].
  - 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 4.6p (5.5 cEu)[25] for each kWh fed into the grid (i.e., the excess PV electricity).
- 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 other support mesaures:

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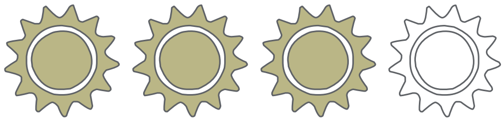
[23] PV systems up to 5 MW can benefit from FiTs.

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

[25] Exchange rate as of July 2014.

- Since 2010, VAT reduction from 20% to 5% for existing buildings, and tax exemption for new installations on residential buildings.
- Exemption from the CCL tax for owners of PV electricity generation systems.

*Figure 56: Assessment of regulatory support to PV self-consumption*



### 3.11.3 Conclusions

- PV technology is still far from being competitive against grid electricity prices in the residential segment in the UK, even though the LCOE has experienced a considerable decrease.
- 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[26] 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.

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

## 3.12 USA (California)

### 3.12.1 Grid Parity Proximity

*Figure 57: Past evolution of retail electricity price and PV LCOE in Los Angeles, California (including taxes)*

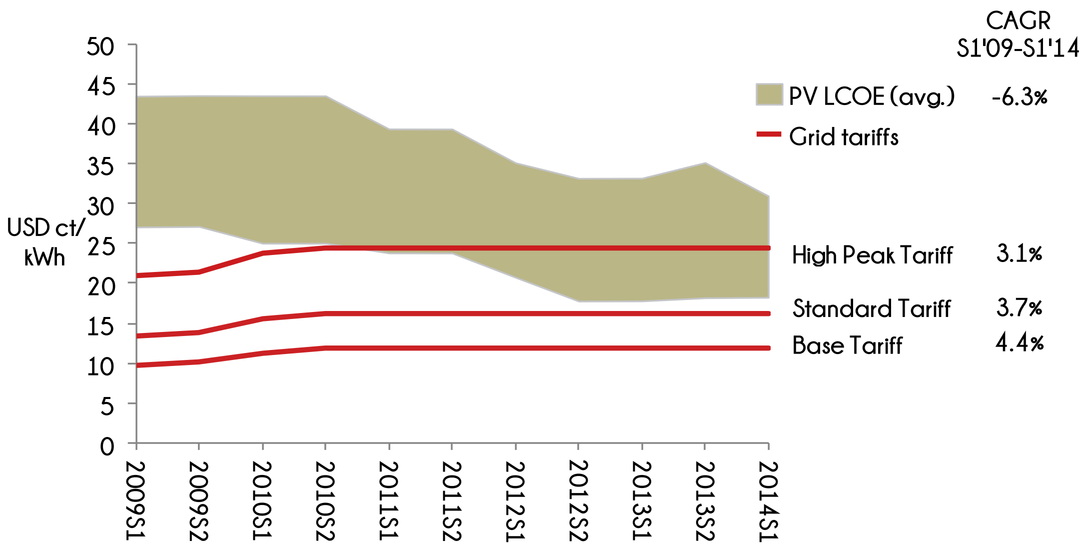



*Figure 58: Los Angeles' Grid Parity proximity*

*Figure 59: Past evolution of retail electricity price and PV LCOE in San Francisco, California (including taxes)*

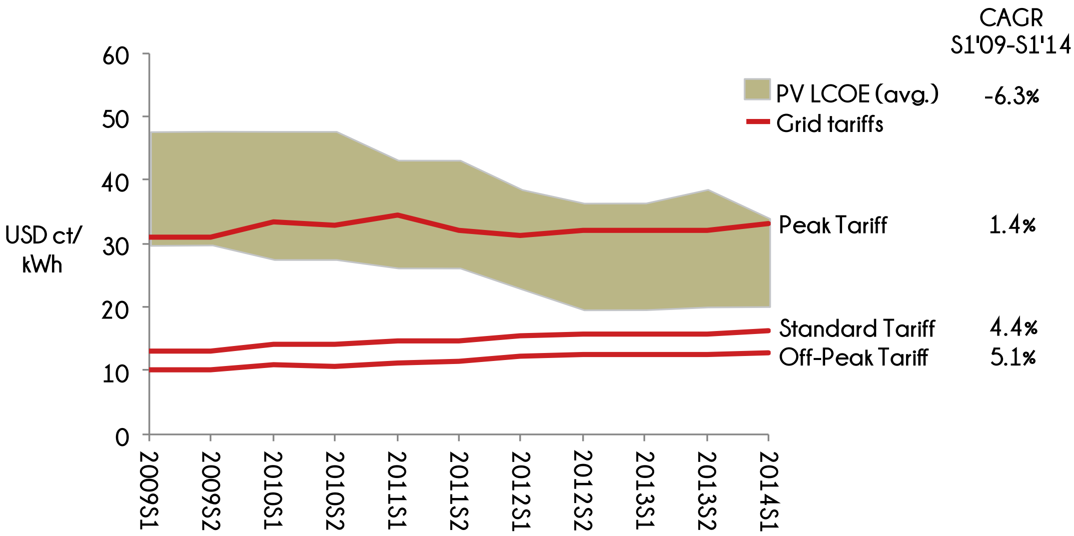


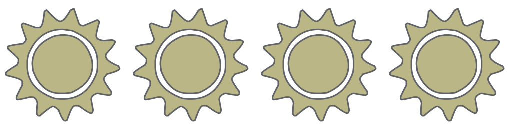

*Figure 60: San Francisco's Grid Parity proximity*

- Both in Los Angeles and San Francisco, PV LCOE of the most competitive quotations is already lower than the highest TOU electricity rates.
  - Therefore, PV self-consumption is an attractive alternative for consumers with a relatively high proportion of electricity demand during peak hours.
- It is worth highlighting that 3rd party ownership mechanisms also drive the economics (and development) of PV for self-consumption. This was not taken into consideration in the LCOE calculation.

### 3.12.2 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 50,000 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 61: Assessment of regulatory support to PV self-consumption*



### 3.12.3 Conclusions

- 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[27] 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.

[27] 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[28]/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[29] |
| $E_t$ | *kWh* | PV electricity generated on year t |
| I | *MU* | Initial investment |

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

[29] Costs include taxes and grow with inflation.

| Nomenclature | Unit | Meaning |
|---|---|---|
| r | % | Discount rate |

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 [30])
- 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.

## Third Party Financing and LCOE

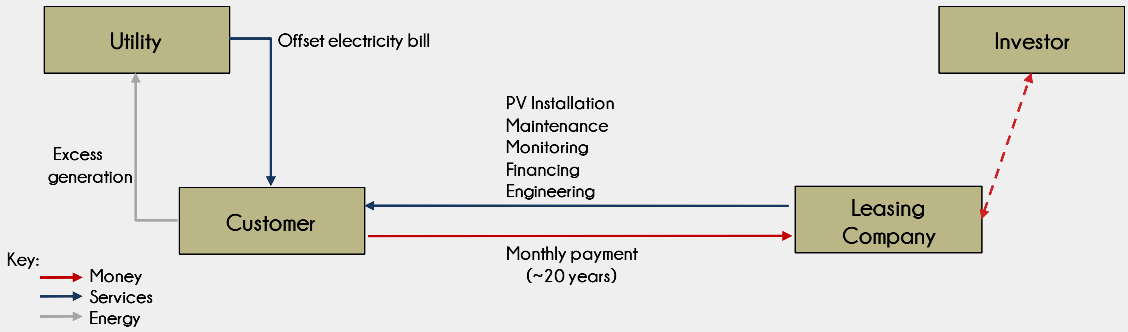
- In some locations such as California, third party ownership (TPO) of residential PV systems is a widespread financing solution.
  - Currently, third party owned PV systems account for above 60% of total installations[31].

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

[31] Banking on Solar: An Analysis of Banking Opportunities in the U.S. Distributed Photovoltaic Market, David Feldman and Travis Lowder, NREL, November 2014

- Electricity consumers who opt for a solar lease pay a monthly lease fee instead of incurring the capital expenditure (initial investment) associated to the PV systems.

*Figure 62: Schematic of a leasing scheme with Net-Metering*




- The growth of the self-consumption market has been driven to a great extent by this financing option.
  - TPO models provide a low risk alternative to go solar and enable consumers to save on the upfront capital expenditure of the PV system.
- Although TPO mechanisms reduce the risk perception of the investment, a case-by-case analysis is still required to properly assess the resulting LCOE, which can either increase or decrease in comparison to the alternative business model.

### 4.1.1 Real or Nominal LCOE?

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

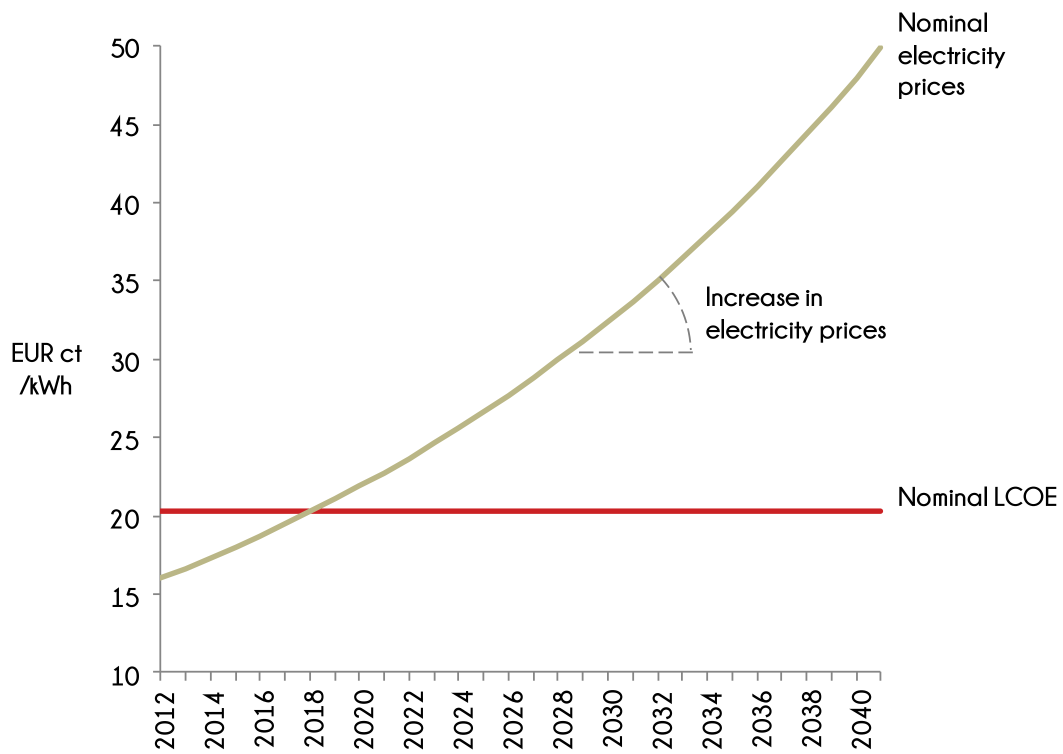
- Nominal LCOE is a constant value in nominal currency (each years' number of current Euros, or the applicable local currency if different from the Euro), unadjusted for the relative value of money.
- Real LCOE is a constant value expressed in the local currency corrected for inflation, that is, constant 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[i].
- Using one definition could be more suitable than using the other one depending on the objective of the analysis.

- 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…"

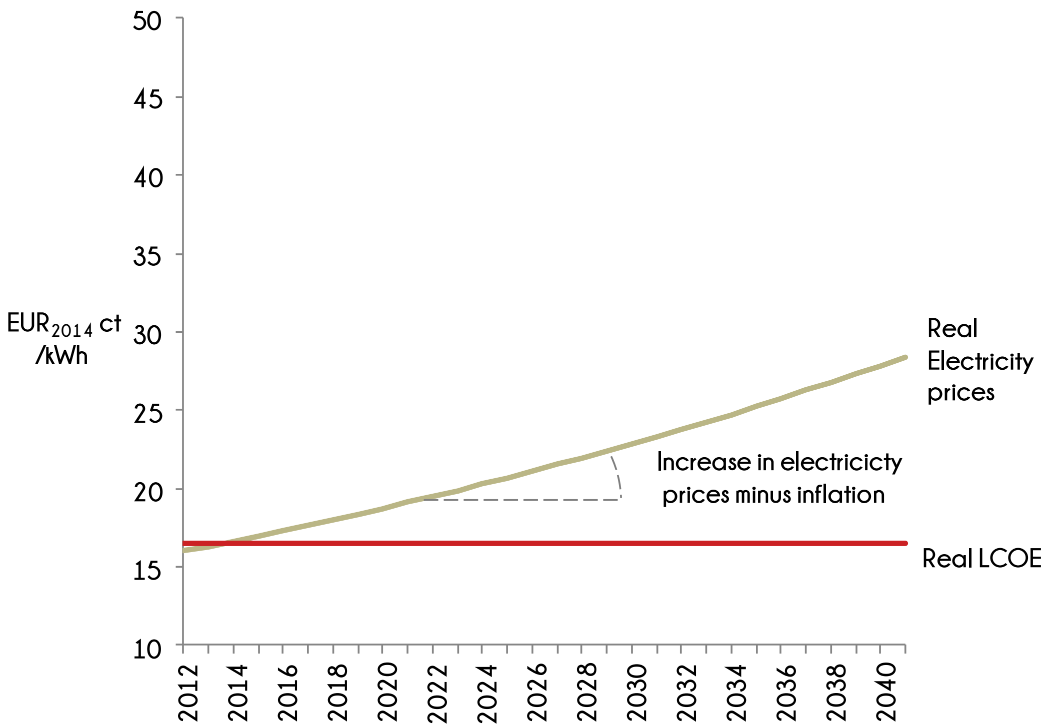
*Figure 63: Grid Parity Proximity for a 2012 PV Installation – Nominal*




Source: CREARA 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 64: Grid Parity Proximity for a 2012 PV Installation – Real*




Source : CREARA Analysis

Given that the aim of this report is to analyse 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, CREARA has been supported by several renowned entities from the PV sector, as summarized below:

- SunPower Corporation provided CREARA with technical assistance and contact information of some PV installers from its Authorized Partner network. These were contacted and participated as collaborators (see Annex).

- SOLARGIS provided irradiation data of the cities analysed in the report (see section 4.3.5.1).
- National PV Associations validated the input information and final results of their respective countries.

*Table 3: Collaborating associations*

| Country | Association |
|---|---|
| Australia | APVI |
| Chile | ACERA |
| France | ENERPLAN |
| | OFAEnR |
| Germany | BSW |
| Mexico | ANES |
| Spain | UNEF |
| UK | BRE |
| | 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 5 years, and the most recent ones as of the first semester of 2014.

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 Iniciative) 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 analysed (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[32], is considered. As it is expected that in 2014 hourly compensation will vary in many 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 2013 until the end of the PV system lifetime (go to page 63 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.

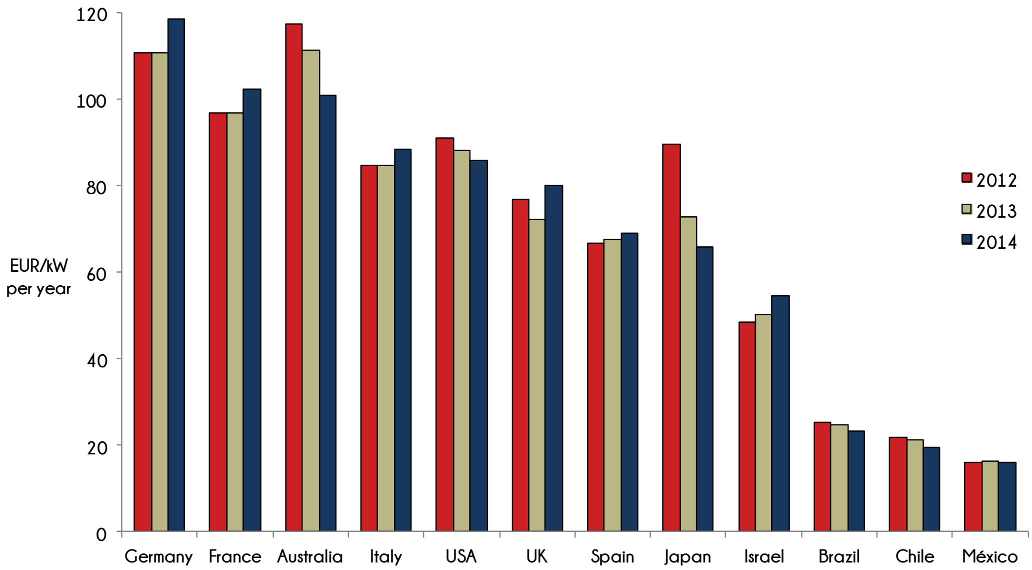
According to several sources from the European PV market, O&M mark-ups range from 20% to 60% for commercial PV installations. Given that PV residential installations

[32] 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.

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:

*Figure 65: Indicative O&M Costs per year* [ii]




Source: U.S. Department of Labor; U.S. Bureau of Labor Statistics; Division of Internationall Labor Comparisons; Instituto Nacional de Estadísticas de Chile; Eurostat; CREARA 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.[iii] 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%.[iv]

- Other studies claim that inverters have similar progress ratios[33] to PV modules, whose historical (1975-2001) learning rate amounted to 23%.[v]
- EPIA assumes a learning factor of 20% for small-scale inverters (used in residential systems).[vi]

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

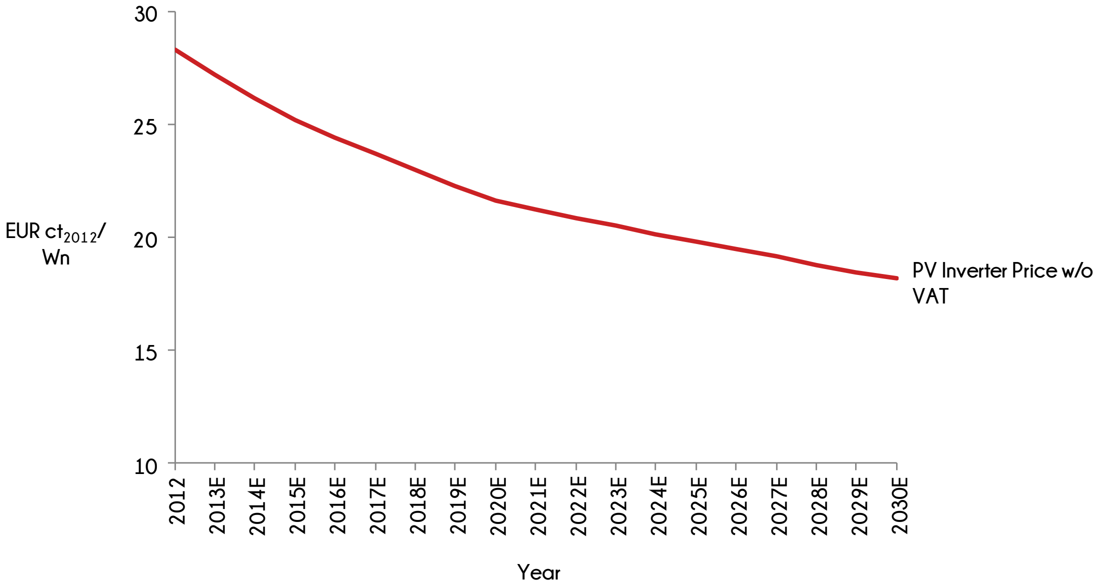
The current cost of replacing a PV inverter was derived from collaborator companies from the German market, as Germany is considered a mature PV market towards which future worldwide prices will converge. Price components that do not depend on the level of maturity of the market, such as import fees, 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[34] 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.

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

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

*Figure 66: Historical PV Inverter Prices and Learning Curve Projections 2013-2030*




Source : CREARA 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).

### 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:

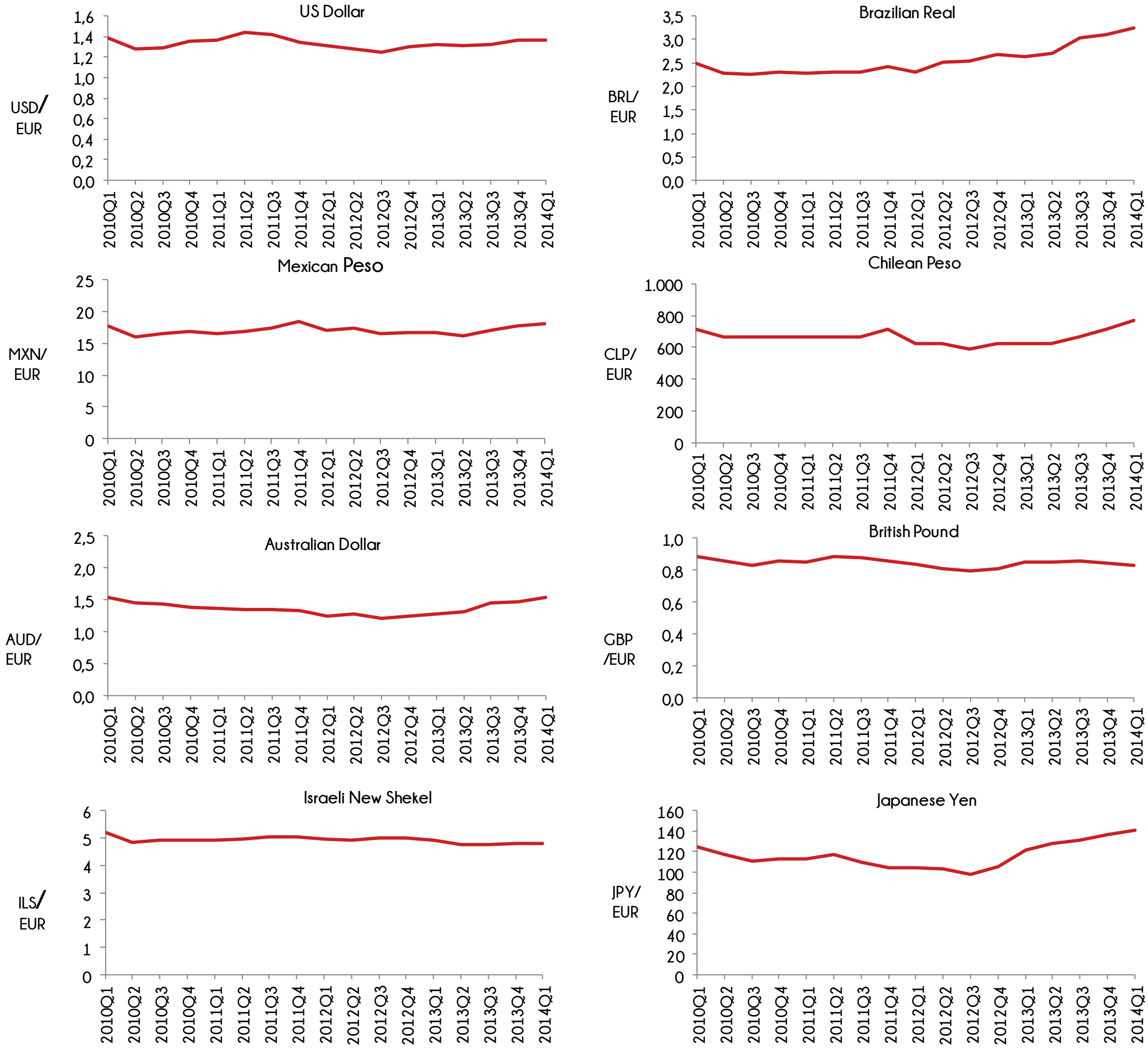
- On the best-case scenario, the lower turn-key quotation received from each location will be considered for computing annual insurance costs.
- On the worst-case scenario, the higher turn-key quotation received from each location will be considered for computing annual insurance costs.

## 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 67: Exchange Rates - Foreign Currency Units per Euro* [vii]




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[35] 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, Bank of Israel, Bank of Japan).

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

*Table 4: Average Inflation per Country* [36] [viii]

| Country | Historical Inflation Rate | Long-Term Target Inflation Rate |
|---|---|---|
| Australia | 2,7% | 2,5% |
| Brazil | 5,4% | 4,5% |
| Chile | 3,4% | 3,0% |
| France | 1,5% | 2,0% |
| Germany | 1,6% | 2,0% |
| Israel | 2,4% | 2,0% |
| Italy | 1,9% | 2,0% |
| Japan | 0,2% | 2,0% |
| Mexico | 4,2% | 3,0% |
| Spain | 1,9% | 2,0% |
| UK | 2,9% | 2,0% |

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

[36] 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 | Historical Inflation Rate | Long-Term Target Inflation Rate |
|---|---|---|
| USA | 2,0% | 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.

- 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*

$$r = IP_c + IR$$

*Table 5: 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[37], 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.

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:

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

*Table 6: Inflation Premium per Country* [38] [ix]

| Country | Inflation Premium |
| --- | --- |
| Australia | 2,7% |
| Brazil | 5,4% |
| Chile | 3,4% |
| France | 1,5% |
| Germany | 1,6% |
| Israel | 2,4% |
| Italy | 1,9% |
| Japan | 0,2% |
| Mexico | 4,2% |
| Spain | 1,9% |
| UK | 2,9% |
| USA | 2,0% |

#### 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?

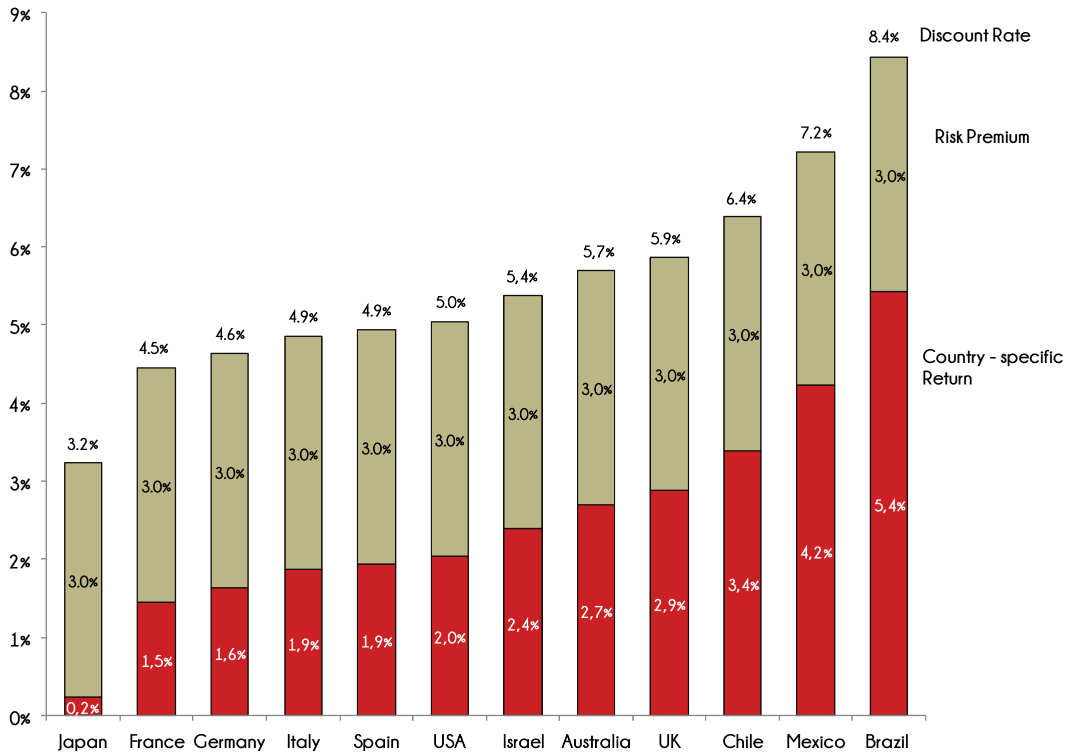
[38] Sources: OECD Stats; BBVA Research; US Federal Reserve; European Central Bank; Banco Central de Chile; Banco de México; Banco Central do Brasil; Reserve Bank of Australia; Bank of Israel; Bank of Japan.

  - 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 68: 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; CREARA 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 consultedx consistently use 25 to 35 years for projections.
- Moreover, PV Cycle[xi], 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 7: 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 21 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 SOLARGIS, are summarized in the following Table:

*Table 8: Irradiation on a plane tilted at latitude (kWh/m²/year)*

| Country | City | Irradiation |
|---|---|---|
| Australia | Sydney | 1,865 |
| Brazil | São Paulo | 1,212 |
| | Itacarambi | 1,799 |
| Chile | Santiago | 2,270 |
| | Copiapó | 2,508 |
| France | Paris | 1,318 |
| | Marseille | 1,905 |
| Germany | Berlin | 1,212 |
| | Munich | 1,365 |
| Israel | Tel Aviv | 1,993 |

| Country | City | Irradiation |
|---|---|---|
| Italy | Roma | 1,840 |
| | Palermo | 1,916 |
| Japan | Tokyo | 1,634 |
| Mexico | Mexico City | 2,314 |
| | Hermosillo | 2,471 |
| Spain | Madrid | 2,008 |
| | Las Palmas | 1,909 |
| UK | London | 1,172 |
| | Plymouth | 1,237 |
| USA | San Francisco | 2,062 |
| | Los Angeles | 2,256 |

These estimates were obtained with pvPlannerSolarGIS[39] from GeoModel Solar, which is a technology and consultancy company in solar resource assessment and photovoltaic energy simulation services. The company is the developer and operator of the SolarGIS global database and online platform. SolarGIS solar resource database is developed from global satellite and atmospheric high-resolution time series data. Based on international data benchmarking, this database is recognized as the most accurate and reliable on the market. The online platform offers interactive and automated access to solar resource, meteorological and PV data services for planning, monitoring, forecasting and management of solar power plants.

SolarGIS includes also pvPlanner online tool, which is used for long-term photovoltaic power estimation for any location in the database. The in-house developed PV simulator provides long-term yearly and monthly electricity production data and reports for any configuration of fixed-mounted or sun-tracker photovoltaic system. The tool exploits solar resource and air temperature database at spatial resolution of 250 metres, which is aggregated from 15 and 30-minute SolarGIS time series covering a history of up to 21 years.

[39] http://solargis.info

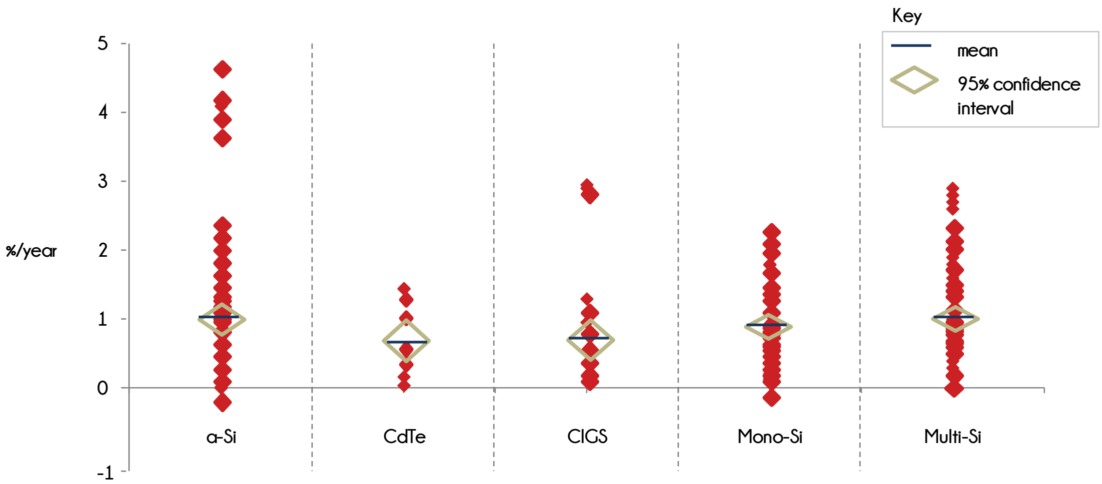
### 4.3.5.2 Degradation Rate

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[xii] to use as input on their financial models.
  - Most of the reports consulted[xiii] use a similar range for projections.
- The results of an extensive research conducted by NREL[xiv] (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 69: Historical Degradation Rates by Technology and Date of Installation[xv]*




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 [xvi] 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.[xvii]

## 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 4 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 9: 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 |
| Israel | Tel Aviv | Israel Electric Corporation | Residential TOU/Residential Standard | TOU Peak Tariff (Summer) | Standard (non-TOU) Tariff | TOU Off-Peak Tariff (Summer) |
| Italy | Roma | 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 |
| | Palermo | Autorità per l'energia elettrica i il gas (AEEG) | Tariffe Monorarie (all tiers) | Standard (non-TOU) Tariff (All Tiers) | | |
| Japan | Tokyo | Tokyo Electric Power Company (TEPCO) | Meter-Rate Lighting B | Not applicable | Residential Tariff | Not applicable |
| 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) | PVPC Time-of-Use / non-TOU Tariff | Peak Tariff | Standard (non-TOU) Tariff | Off-Peak Tariff |
| | Las Palmas | Official State Gazette (BOE) | PVPC 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[40] is one of Australia's largest energy retailers, its prices are used in the analysis. In particular, the following tariffs are considered:

*Table 10: 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[41]) | 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:

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

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

*Table 11: 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 12: 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<br>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 night-time 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[42]) are depicted as a single tariff:

[42] 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 13: 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 14: 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 15: 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 16: 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[43].

## 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

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

relevant ones in Berlin. For both cities, TOU rates available for residential customers were considered:

*Table 17: 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 18: 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 Israel

Electricity rates in Israel are set and regulated by the Utilities Public Authority, designated under the Electricity Act (1996).

TOU rates available for residential customers, which also vary depending on the season, were considered:

*Table 19: Electricity Rates in Israel*

| City | High Price | Middle Price | Low Price |
|---|---|---|---|
| Tel Aviv | TOU Peak Tariff (Summer) | Standard Domestic Tariff | TOU Off-Peak Tariff (Summer) |

For this analysis, the summer rate has been chosen as the most representative for both highest and lowest price since the other rates range between its peak and off-peak rates. The Standard (non-TOU) Domestic Tariff is used as a proxy of the average price.

### 4.4.7 Italy

In Italy, the Regulatory Authority for Electricity and Gas (AEEG, acronym in Italian) sets the regulated electricity tariffs every 3 months[44].

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:

*Table 20: 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 21: Electricity Rates in Italy*

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

### 4.4.8 Japan

In Japan, the Electricity Enterprises Act stipulates 10 exclusive service areas, all of which have one electric power company for residential customers. Tokyo Electric Power Company (TEPCO) is the municipal utility that serves electricity customers in Tokyo.

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

TEPCO's monthly electricity rates are the sum of the demand charge, energy charge (energy charge rate and the fuel cost adjustment rate), Renewable energy power promotion surcharge and the PV Power promotion surcharge.

*Table 22: Electricity Rates in Japan*

| City | Single Rate |
|---|---|
| Tokyo | Residential Tariff |

It should be noted that within Japan there are considerable variations between electricity prices. The prices chosen herein are only applicable for the city under study, Tokyo.

### 4.4.9 Mexico

In Mexico, there are seven different residential electricity tariff groups, which vary depending on the minimum average temperature in summer of each region[45]. 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.

*Table 23: 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 |

### 4.4.10 Spain

In Spain, the electricity tariff paid by the nearly 80%[xviii] of residential consumers is the Voluntary Price for Small Consumers (PVPC, acronym in Spanish), since February 2014,

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

formerly known as 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[46].

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

*Table 24: 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-PVPC standard tariff of an average price, and the off-peak tariff as a measure of the lowest electricity price.

*Table 25: Electricity Rates in Spain*

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

### 4.4.11 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.

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.

[46] 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).

*Table 26: 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.

### 4.4.12 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[xix], 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 27: 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<br>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<br>7 PM - 9 PM | All other times including Holidays |
| | | Saturday and Sunday | Not applicable | 10 AM - 1 PM<br>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 28: 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) |

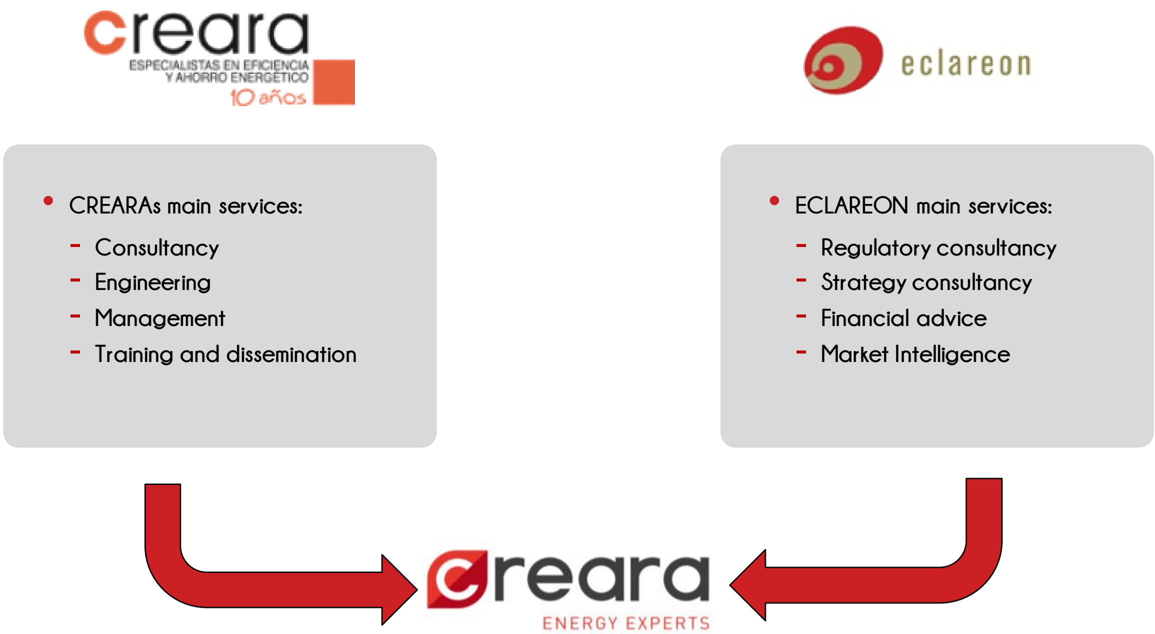
# 5
# About CREARA

# 5 About CREARA

In January 2014, Creara and Eclareon (Spain) merged their business to form Creara Energy Experts and consolidate their leadership in sustainable energy services.

Eclareon is an international strategy consulting and financial advising firm focused solely in the field of renewable energy, energy efficiency and smart grids. In addition, Creara has developed an intense activity in the areas of energy conservation and efficiency, renewable energy, energy supply management and consulting associated with greenhouse gases emissions.

*Figure 70: Creara and Eclareon Services*




Creara and Eclareon have agreed to strengthen their capabilities by merging under the brand CREARA, bringing together the experience in strategic consulting, regulatory consulting and financial advisory services for the energy sector. The resulting company (CREARA, Energy Experts) is a leader in professional services to the energy sector.

# 5

# Annex: PV GPM collaborators

# 6 Annex: PV GPM collaborators

As explained in Section 4.2, several local PV installers agreed to collaborate with CREARA 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 CREARA and those companies is limited to the description above. CREARA will not be responsible for any loss or damage whatsoever arising from business relationships between these companies and third parties.

*Table 29: 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 / rbaldini.abeama@gmail.com |
| Contact Name | Ruberval Baldini |

| | |
|---|---|
| **EMAP Montagens** | |
| Address | Alameda da Serra, 500, sala 502, Vale do Sereno, Nova Lima, MG, Brasil – CEP: 34000-000 |
| Tel. | (0055)- 3132231430 / (0055)-3196322511 |
| Web | http://www.emapmontagens.com.br/ |
| Email | miriam@emapmontagens.com.br |
| Contact Name | Miriam Penna Diniz |
| **Chile** | |
| **Heliplast** | |
| Address | Luis Thayer Ojeda 0180 oficina 904, Providencia Santiago, Chile |
| Tel. | (0056)- 23340800 |
| Web | http://www.heliplast.cl/ |
| Email | christof.horn@heliplast.cl |
| Contact Name | Peter Horn |
| **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)- 298724724 |
| 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)- 222453013 |
| Web | http://www.aquitosolar.cl |
| Email | fcosmelli@aquitosolar.cl |
| Contact Name | Francisco Cosmelli Echeverría |

| 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)-467587601 |
| Web | http://www.gensun.fr |
| Email | info@gensun.fr |
| Contact Name | M. Martial Benazet |
| **Aguisol** | |
| Address | 22 Rue Des Iris, 68000 Colmar |
| Tel. | (0033)- 3 66 72 34 75 |
| Web | http://www.aguisol-68.com/ |
| Email | info@aguisol.fr |
| Contact Name | |
| **OFAEnR** | |
| Address | Scharnhorststr. 34-37 D-10115 Berlin |
| Tel. | 49 30 18 615 7427 |
| Web | http://www.bmwi.de/ |
| Email | nils.eckardt.extern@bmwi.bund.de |
| Contact Name | Nils Eckardt |
| **Rosaz-energies** | |
| Address | ZI le domaine, b.p.21, 73250 Saint Pierre d'Albigny |
| Tel. | (0033)-479842913 |
| Web | http://www.mctsolaire.com |
| Email | Eric.BAFFERT@rosaz-energies.fr |
| Contact Name | Eric Baffert |
| **Germany** | |
| **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 |
| **OFAEnR** | |
| Address | Scharnhorststr. 34-37 D-10115 Berlin |
| Tel. | 49 30 18 615 7427 |
| Web | http://www.bmwi.de/ |
| Email | nils.eckardt.extern@bmwi.bund.de |
| Contact Name | Nils Eckardt |
| **Israel** | |
| **TIV SOLAR ISRAEL** | |
| Address | Hamasger 2 Ashkelon Israel |
| Tel. | (00972)- 547775662 |
| Web | - |
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[47] Despite having its office in Texas, SRE gave quotation for a PV system in California.

# 6
# Annex: Acronyms

# 7 Annex: Acronyms

*Table 30: 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 |
| PVPC | Tariff of Voluntary Price for Small Consumers (Spain), acronym in Spanish |
| 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

# 8 Annex: References

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