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Commercial Sector

2nd issue

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Executive summary

1 Executive summary

MERGER NOTIFICATION

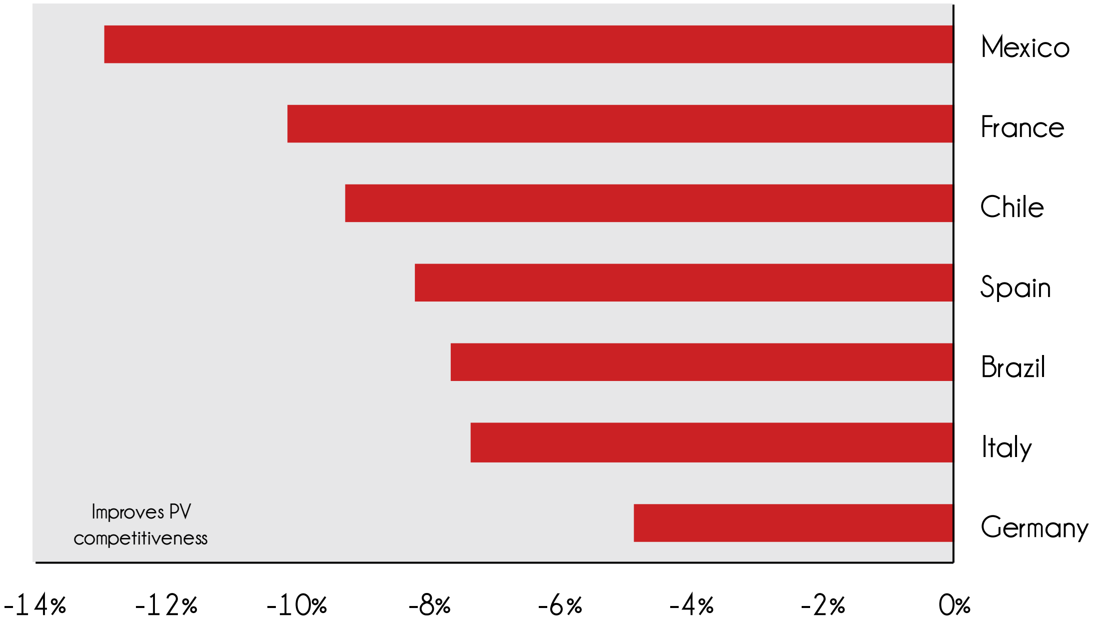
In January 2014, Creara and Eclareon (Spain) merged their business to form Creara Energy Experts (from now on CREARA) and consolidate their leadership in sustainable energy services.

This is the second issue of the Grid Parity Monitor to focus exclusively on the commercial segment (30 kW PV systems). As such, it analyzes PV competitiveness with electricity prices for commercial consumers and assesses local regulation for self-consumption in seven different countries: Brazil, Chile, France, Germany, Italy, Mexico, and Spain.

Retail electricity prices for a commercial electricity consumer can be complex, combining diverse charges such as energy and capacity costs. The GPM only considers the costs associated to energy consumption (generally, this equates to the energy charge) to compare against the LCOE, but the reader must bear in mind that if self-consumption results in a change on the consumption pattern of the user, the additional avoided costs (e.g. capacity costs) should also be accounted for.

The results of the analysis show that the main driver of PV grid parity is the decrease in PV system prices, one of the main parameters that determine LCOE.

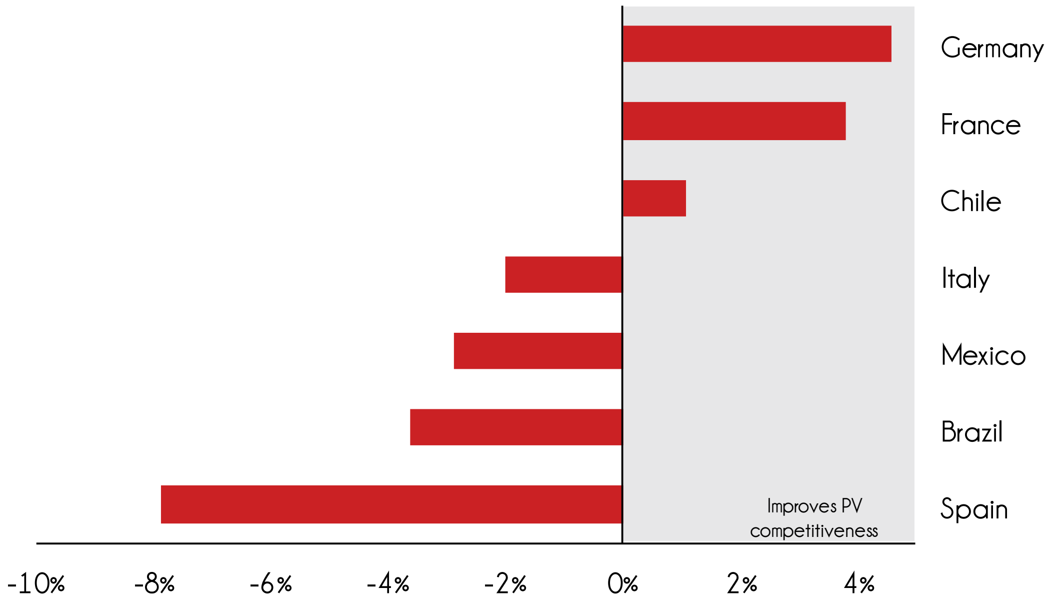
Figure 1: Compound Annual Growth Rate (CAGR) of LCOE (2nd half 2012 to 1st half 2015)



Source: CREARA Analysis

In addition, the analysis shows that only in Germany, France, and Chile retail electricity prices for commercial consumers have been increasing on average.

Figure 2: Compound Annual Growth Rate (CAGR) of retail electricity rates for commercial consumers from 2nd half 2012 to 2nd half 2013

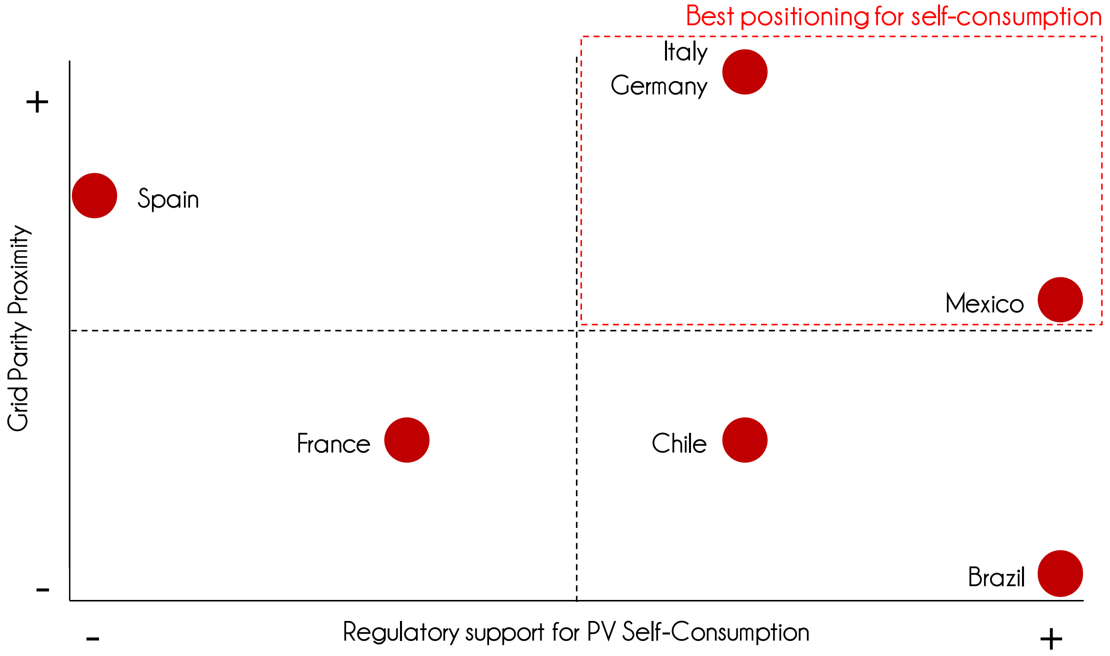


Note: The average CAGR was used for those countries with TOU rates
Source: CREARA Analysis

Those countries with a competitive LCOE and relatively high electricity rates are already at grid parity in the commercial segment. However, grid parity by itself is no guarantee of market creation. PV self-consumption will only be fostered if grid parity is combined with governmental support.

The Figure below illustrates the positioning of each country in terms of these two variables ("Grid Parity Proximity" and "Regulatory support").

Figure 3: Positioning Matrix of the countries analyzed (commercial segment)



Note: Data from the 1st half of 2015
Source: CREARA Analysis

The following main conclusions can be drawn from the above Figure:

- In Brazil, high installation prices and a high discount rate still prevent PV from being competitive against grid electricity, but the regulatory support (an attractive net metering system) is a good example of an effective incentive for market creation.
- Chile remains far from grid parity, mainly due to high installation prices, a high discount rate, and low electricity prices.
- In France, high irradiation levels (in the South) do not compensate for low electricity rates in the commercial sector and and the high installation prices for BAPV systems.
- In Germany and Italy, low PV installation prices, a low discount rate, and high retail electricity prices all contribute to reach full grid parity.
- In Mexico, certain commercial electricity consumers (“Tarifa 2”), have reached grid parity. For other consumers, low electricity tariffs still represent a barrier.
- In Spain, grid parity has been reached, owing to high irradiation and competitive system prices, but poor regulatory support[1] is a barrier for market creation.

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[1] The recent draft law on self-consumption, which includes a fee on self-consumption, has not been considered in the LCOE analysis (neither has been the tax on electricity generation).

2

Introduction

2 Introduction

The Grid Parity Monitor (GPM) Series was conceived to analyze PV competitiveness in order to increase awareness of PV electricity self-consumption possibilities. On-site PV self-consumption is a means of reducing the increasingly expensive electricity bill in an environmentally friendly way.

To assess the competitiveness of PV systems against grid electricity prices, this Study calculates PV grid parity proximity. Grid parity is defined as the moment when PV Levelized Cost of Electricity (LCOE) becomes competitive with grid electricity prices. Once PV grid parity is reached, electricity consumers would be better off by self-consuming PV-generated electricity instead of purchasing electricity from the grid.

Caveat for a fair grid parity analysis

When analyzing cost-competitiveness of PV technology against grid electricity, the reader 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.

However, one should note that while by definition PV LCOE is fixed as soon as the PV system is bought, future grid electricity prices are likely to change.

In contrast to other GPM issues, this one only addresses the commercial sector (30 kW systems).

Distinctive features of commercial consumers

This issue analyzes grid parity proximity for the commercial segment, which differs from the residential segment in several ways:

- For a commercial electricity consumer (private corporation), income taxes are relevant costs, as they affect cash flows.
    - This analysis calculates after-tax costs and includes the impact of depreciation for tax purposes: the PV Levelized "After-Tax" Cost of Electricity (simply, LCOE) is compared to the after-tax cost of grid electricity.

- Retail electricity prices for a commercial electricity consumer can be complex.
    - The structure of the utility rate can combine diverse charges: energy costs, capacity costs, costs that vary with the time of the year (TOU rates), or with the amount of electricity purchased (tiered rates), among others.
    - In this Study, only the energy charge is compared to LCOE (capacity charges are excluded), because for a commercial consumer it is not easy to save on capacity costs on a given month (although it is possible).

Recently, PV cost-competitiveness has improved considerably —mainly due to dramatic cost reductions— causing PV systems to be profitable *per se* in certain markets. This economic reality, when combined with governmental support (i.e. net metering/net billing or equivalent mechanisms), has encouraged the introduction of subsidy-free distributed generation in many countries[2].

As seen recently in several countries, the rising penetration of distributed generation is beginning to pose new challenges with an impact on grid parity:

- To cover the fixed costs of DSO, countries such as Belgium (in the region of Flanders) imposed a specific fee per kW of installed solar[3], as did States such as Arizona and Idaho in the US.
- To compensate for the reduction in tax revenues[4] earned by the government, countries such as Spain have imposed a tax on electricity generation.

Even if Grid Parity (defined as the moment when PV LCOE equals retail electricity prices) becomes a reality, regulatory cover[5] is still necessary to foster the PV self-consumption market.

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[2] For instance, according to SEIA/GTM, in the US a solar project is installed every four minutes without subsidies at all.

[3] This fee was subsequently cancelled and is currently under discussion.

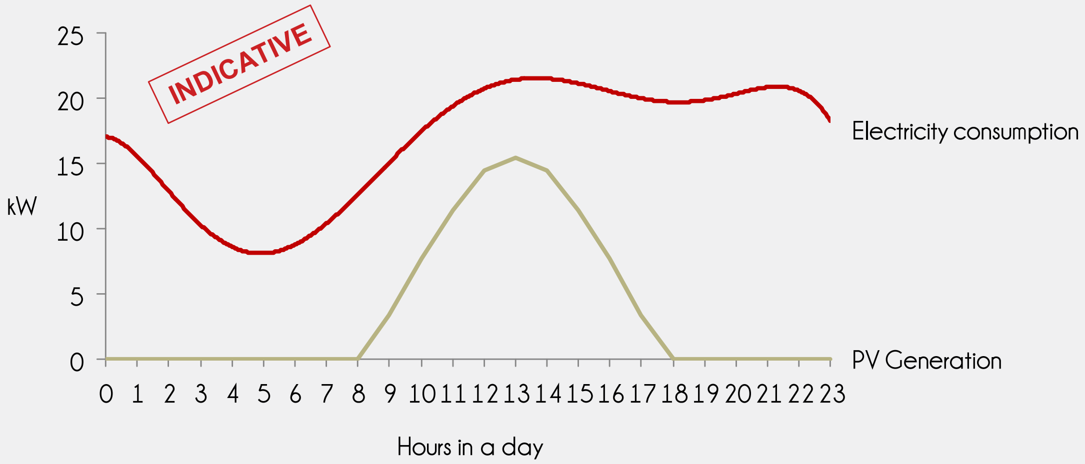
[4] Reduced revenues from taxes associated to the electricity that was previously bought from the utility but is now replaced by PV generated electricity.

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

Simplifying assumptions

To simplify the analysis, it is assumed that 100% of the electricity is self-consumed on-site, which is technically feasible when a good match between electricity consumption and PV generation is achieved. This case is illustrated in the following Figure:

Figure 4: Daily electricity *consumption* and PV generation (indicative)



In order to assess the magnitude of self-consumption possibilities worldwide, the current issue of the GPM analyzes some of the main current and potential markets. The Study includes only one city per country (located in a relatively sunny and populated area):

Figure 5: Countries included in this number of the GPM

As the above Figure shows, one city of 7 different countries is included in the analysis.

The PV Grid Parity Monitor consists of two main sections:

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

3

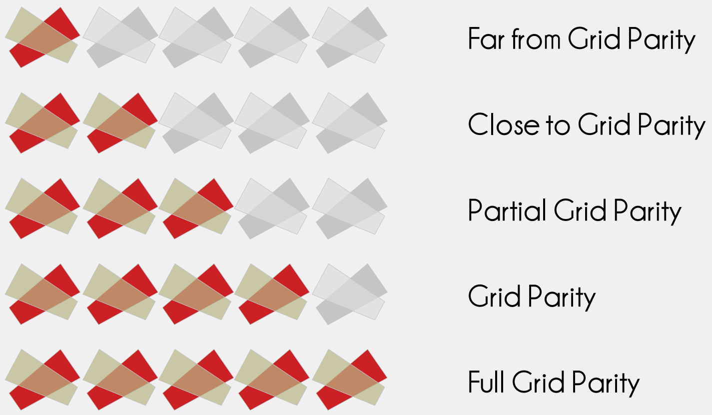
PV GPM results

3 PV Grid Parity Monitor Results

In this section, the PV Grid Parity Monitor compares the current PV LCOE to retail electricity prices for the commercial sector and assesses PV Grid Parity proximity in each location according to the following criteria:

Criteria used to asses PV Grid Parity proximity

Figure 1: Qualitative scale for the assessment of Grid Parity proximity



Where:

- Far from Grid Parity: The lowest PV LCOE is 50% above the highest grid electricity rate.
- Close to Grid Parity: The lowest PV LCOE is equal to or up to 50% above 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 existent incentives/barriers for the self-consumption market.

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

Figure 2: 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[6], 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.

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[6] 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 Brazil

3.1.1 Grid Parity Proximity

Figure 6: Comparison of grid electricity prices for the commercial segment and PV LCOE in Salvador, Brazil

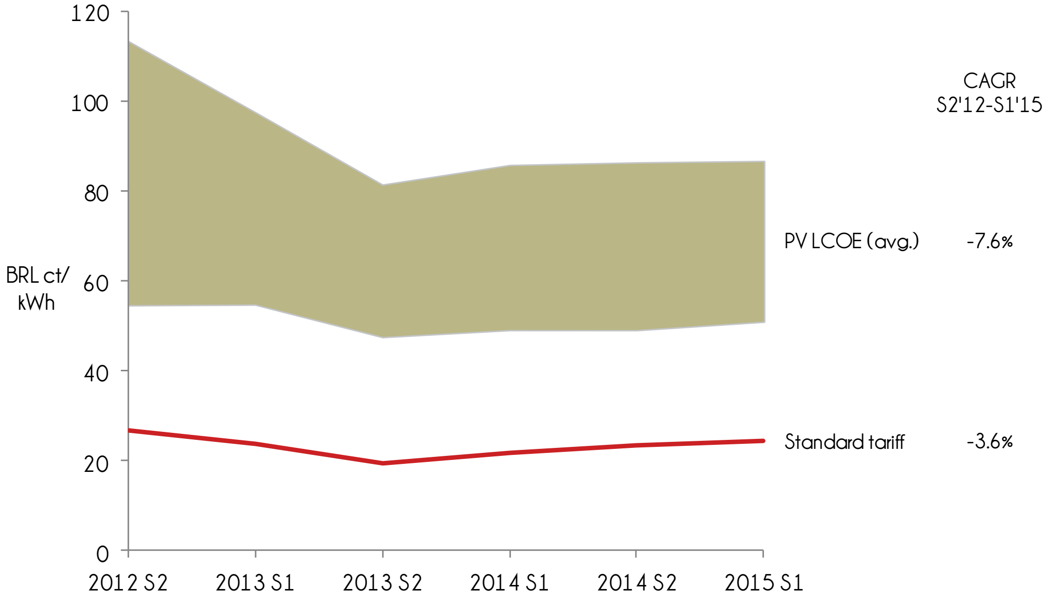


Figure 7: Salvador's Grid Parity Proximity

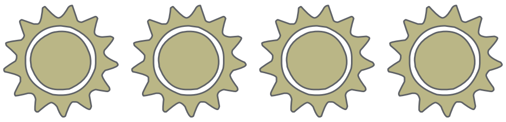
- In Salvador, PV technology is still far from being competitive against grid electricity, as the LCOE of the most competitive quotations remains ~3 times higher than grid electricity prices.
- In January 2013, the Brazilian Electricity Regulatory Agency (ANEEL, acronym in Portuguese) implemented a reduction of commercial electricity tariffs.
  - As a result of this measure, PV grid parity is being pushed further away.
- 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 custom duties levied on PV equipment and by the immaturity of the PV market, which allows for 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.
  - The depreciation of the Brazilian real, which raises the price of the PV system in nominal terms.

3.1.2 Regulatory support to PV self-consumption

- A net-metering regulation (Sistema de Compensação de Energia), proposed by ANEEL, for renewable energy systems up to 1 MWp is in place since January 2013[7]; with the following main characteristics:
  - Users will only pay for the difference between the energy consumed and the one fed to the grid.
  - Compensation will be held within the same rate period (peak - peak / off-peak - off-peak).
  - Energy surpluses can be compensated during a 36-month period or in other consumption units (other buildings) as long as they belong to the same owner and are located within the geographical scope of the utility (remote net metering).

Figure 8: Assessment of regulatory support to PV self-consumption



3.1.3 Other relevant developments for grid parity

- Although there is no other support for PV generation in Brazil as significant as the net metering system, the market outlook has improved since the last number of the GPM:
  - For the first time, the Energy Agency of Brazil (EPE, acronym in Portuguese) has accepted PV projects in its energy auction for new power producers.

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[7] The net-metering regulation was approved on April 17 2012, but distribution companies had 8 months to adapt their technical standards and products.

- The Brazilian Parliament intends to examine a proposal for the mandatory installation of PV and solar thermal systems on public buildings.
- The Brazilian Senate's commission for infrastructure is discussing legislation to reduce the tax rate charged on PV modules throughout the country.
- The local Government of Minas Gerais has introduced a new renewable incentive program aimed at promoting energy systems by applying a different tax criteria and offering financial support.

3.2 Chile

3.2.1 Grid Parity Proximity

Figure 9: Comparison of grid electricity prices for the commercial segment and PV LCOE in Copiapó, Chile

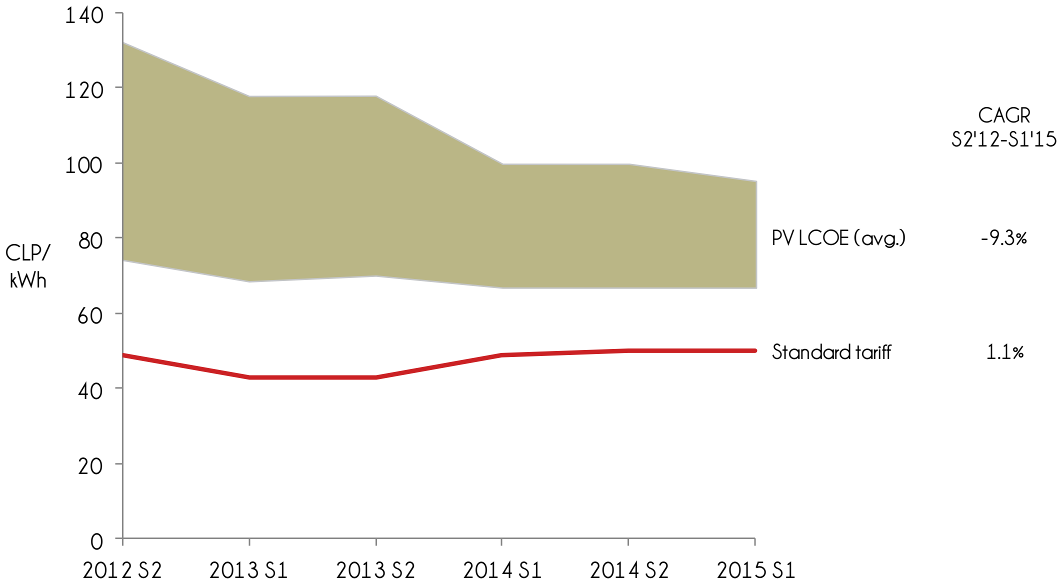


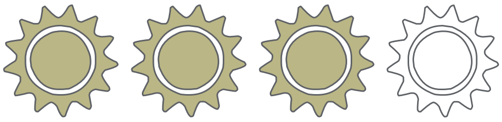
Figure 10: Copiapó's Grid Parity Proximity

- Despite relatively high irradiation levels in Copiapó, PV technology is still far from being competitive against grid electricity.
- The main factors impeding Grid Parity are the following:
  - Low variable electricity prices for the commercial segment, partly due to a tariff structure that places a significant weight on the fixed component of the electricity price.
  - High PV installation prices, which remain well above international competitive price levels.
  - A relatively high discount rate, which reflects the return required by equity and debt holders.

3.2.2 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 a 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 power generating companies to have at least 5% of their annual sales of electricity to end customers (either regulated or non-regulated) 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).
    - Generating companies can produce their own renewable energy; buy it from other energy producers such as self-consumers or buy the "ERNC certificate" from a non-conventional renewable energy generator.
    - This could encourage utilities to support the development of the PV self-consumption market.

Figure 11: Assessment of regulatory support to PV self-consumption



3.2.3 Other relevant developments for grid parity

- Utilities can produce their own renewable energy or buy it from other energy producers such as self-consumers (regulated through Law 20571, which regulates the payment to residential generators and describes the NCRE certificates that can be sold to companies).
    - Utilities can produce their own renewable energy or buy it from other energy producers such as self-consumers (regulated through Law 20571, which regulates the payment to residential generators and describes the NCRE certificates that can be sold to companies).

3.3 France

3.3.1 Grid Parity Proximity

Figure 12: Comparison of grid electricity prices for the commercial segment and PV LCOE in Marseille, France

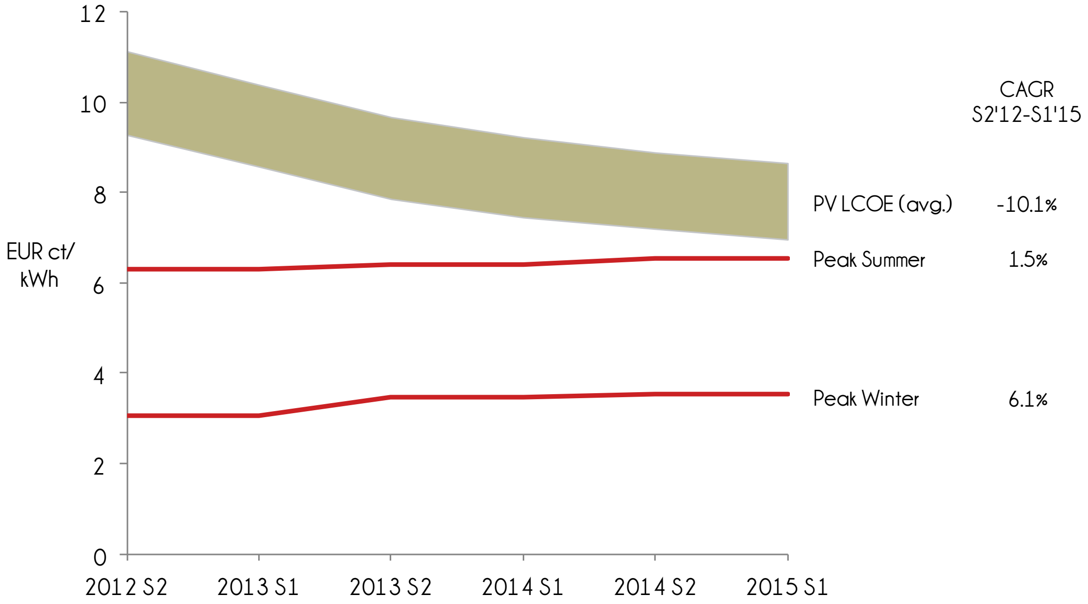


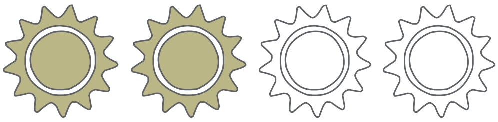
Figure 13: Marseille's Grid Parity Proximity

- Despite relatively high solar irradiation in Marseille, grid parity has not been reached yet. This is explained by two main factors:
  - Low electricity rates for commercial consumers.
  - High installation and grid connection costs for PV systems.
- However, with an estimated annual decrease of PV LCOE over 10%, grid parity could be a reality in the medium term.

3.3.2 Regulatory support to PV self-consumption

- In France, commercial PV systems can receive a Feed in Tariff (FiT) that compensates for the excess electricity fed into the grid[8].
    - For the first quarter of 2015, the FIT for simplified BIPV systems up to 36 kW amounts 13.46 cts€/kWh (12.79 cts€/kWh from 36 to 100 kW), which is above the price of retail electricity.
- Given that FiTs for BIPV systems are still higher than the retail price of electricity, self-consumption is not being incentivized.
- However, there is great uncertainty about the future of the FiT scheme as French Minister of Ecology, Sustainable Development and Energy recently announced that it could be modified in line with the European guidelines for State support[9].

Figure 14: Assessment of regulatory support to PV self-consumption



3.3.3 Other relevant developments for grid parity

- The extinction of the regulated "tarif jaune" will likely increase interest for self-consumption solutions.
- Moreover, the Ministry is actually working on a self-consumption support scheme for commercial/industrial installations, probably via a call for tender.

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[8] These are lowered every quarter and guaranteed for 20 years.

[9] It could be replaced by direct selling of the produced electricity encouraged by a supplemental remuneration. Small and immature technologies will still benefit from the FiT scheme.

3.4 Germany

3.4.1 Grid Parity Proximity

Figure 15: Comparison of grid electricity prices for the commercial segment and PV LCOE in Munich, Germany

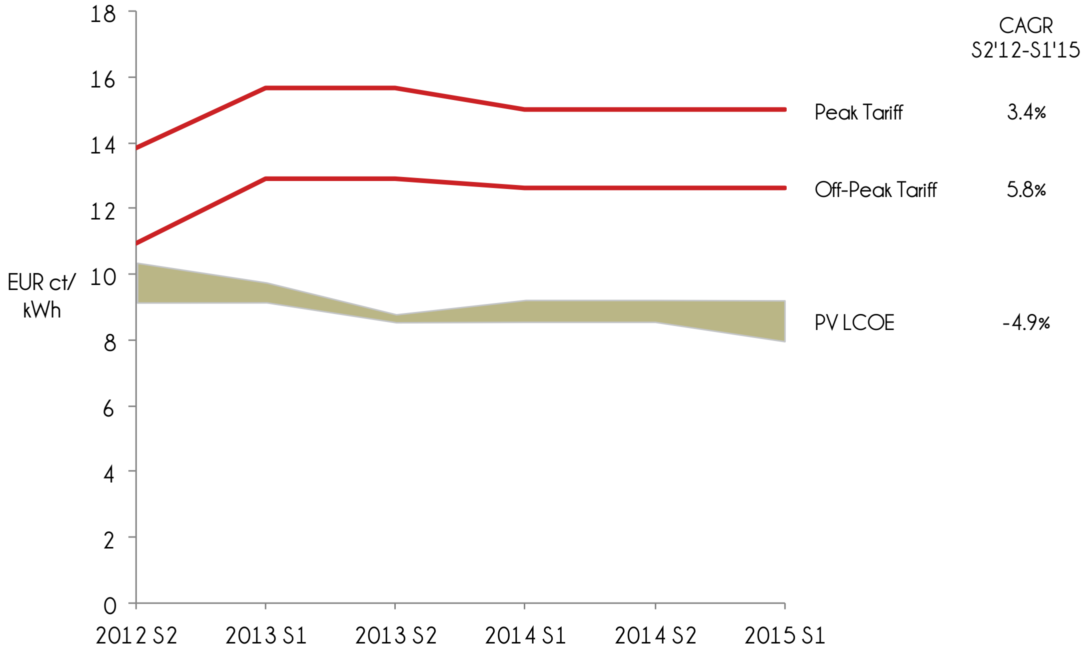
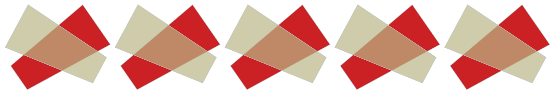


Figure 16: Munich's Grid Parity Proximity

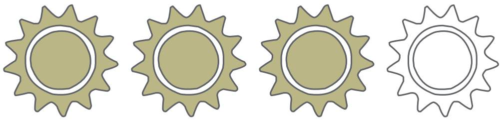


- Despite the relatively low irradiation levels in Germany, full grid parity has already been reached in Munich for commercial consumers, and it was driven mainly by the following factors:
  - The competitive system prices in the country, which are among the lowest quotations received.
  - The low discount rate used for the calculation of LCOE, which reflects the minimum return a German electricity consumer would require from the investment.
  - The high retail electricity prices charged to commercial consumers.

3.4.2 Regulatory support to PV self-consumption

- Germany's EEG FiT program fosters the self-consumption market in an efficient way, as the tariff for the excess electricity is lower than the price of electricity from the grid.
- Moreover, the country is reducing the level of incentives every month.
    - Current FiT cuts for medium-scale PV installations are set at 1.4% per month.
    - For a commercial consumer, FiT levels reached 12cEur/kWh on July 2015 (lower than retail electricity prices from the utility).
- However, a grid charge on self-consumption has been recently introduced for consumers with systems above 10 kWp who self-consume more than 10 MWh PV-generated electricity (30% surcharge in 2015, 35% in 2016, 40% in 2017 and onwards).
    - This measure has a negative impact on the attractiveness of PV for self-consumption.

Figure 17: Assessment of regulatory support to PV self-consumption



3.4.3 Other relevant developments for grid parity

- Germany has introduced an energy storage incentive program that provides PV owners of systems up to 30 kW with a 30% rebate and low interest loans from KfW (German development bank).

3.5 Italy

3.5.1 Grid Parity Proximity

Figure 18: Comparison of grid electricity prices for the commercial segment and PV LCOE in Rome, Italy

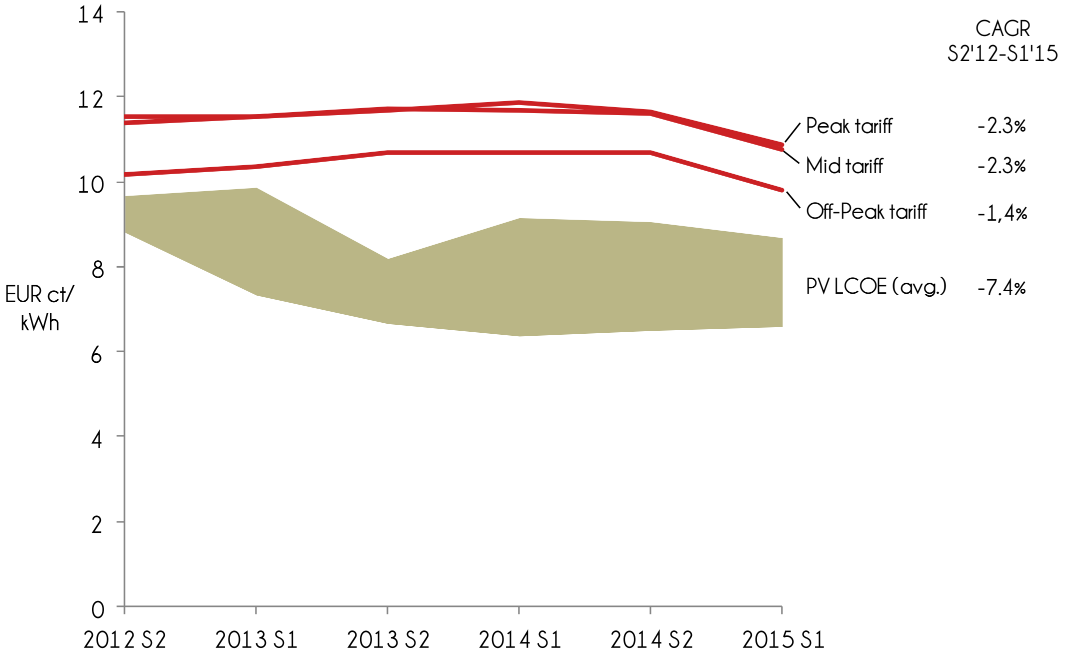


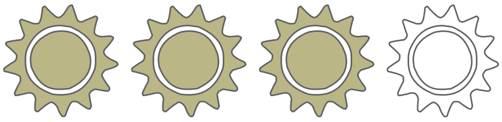
Figure 19: Rome's Grid Parity Proximity

- Full PV Grid Parity has been reached in Rome. This is mainly due to the following factors:
  - Cost-competitive PV system installation costs.
  - High irradiation levels in comparison to those in most other European countries.
  - Relatively expensive 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).

3.5.2 Regulatory support to PV self-consumption

- The Scambio Sul Posto (SSP) net-metering 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.
    - The amount of the SSP grant includes an "Energy Quota" that varies with the value of energy exchanged and a "Service Quota", updated regularly, that depends on the cost of services and the energy exchanged.
    - Net metering is only possible when the owner of the PV system and the self-consumer are the same entity (i.e. it is not possible to have net metering when the plant's owner is a third party).
- It should be noted that this mechanism is currently under discussion among Italian regulators.
    - The nominal power limit has already been cut and it is uncertain whether the SSP will be maintained in the future.
- As for the Conto Energia (FiT scheme) and the self-consumption premium, these were eliminated last summer, as the set budget was reached.

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



3.5.3 Other relevant developments for grid parity

- The law on PPA (SEU, Sistema Efficiente di Utenza) allows the direct sale of electricity to the final consumer in the residential and commercial sector, although in most cases the excess PV electricity will be fed to the grid and receive a much lower price than the retail price of electricity.

3.6 Mexico

3.6.1 Grid Parity Proximity

Figure 21: Comparison of grid electricity prices for the commercial segment and PV LCOE in Hermosillo, Mexico

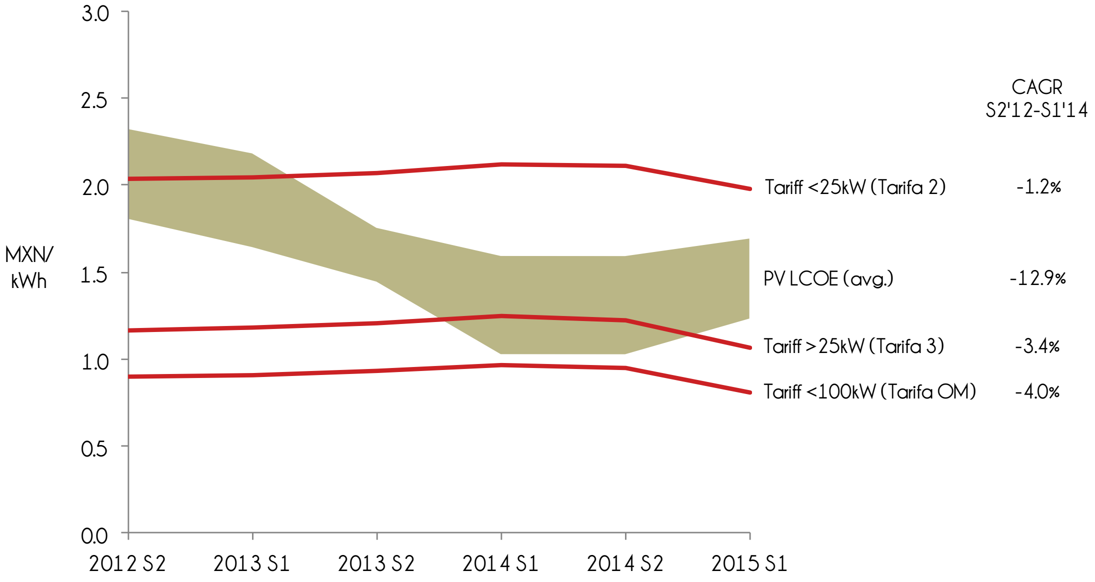
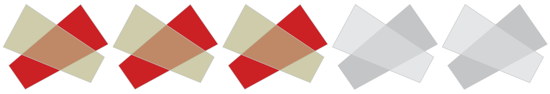


Figure 22: Hermosillo's Grid Parity Proximity[10]



- In Hermosillo, only commercial consumers with contracted power below 25 kW have reached full grid parity.
    - For other consumers such as those under "tarifa 3" and "tarifa OM", high irradiation levels do not compensate for the low electricity prices from the grid, which make buying electricity from the Comisión Federal de Electricidad (CFE, the National utility) more economical than PV self-consumption.
- The fact that the Mexican Peso (MXP) depreciated with respect to the US Dollar (USD) negatively affected grid parity proximity, as PV system prices depend on a great extent on international prices.

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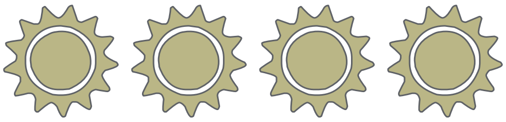
[10] This reflects the average situation for commercial consumers

  - This trend caused consumers under "tarifa 3" to move out of grid parity in 2015.

3.6.2 Regulatory support to PV self-consumption

- In Mexico, a net-metering mechanism (Medición Neta) was created in June 2007 for renewable energy based systems under 500 kW.
  - It allows users to feed into the grid part of their electricity and to receive energy credits (in kWh) for it, used to offset their electricity bill.
- Moreover, the National Fund for Energy Savings finances PV systems for commercial and industrial consumers, with a 5 year repayment term, at lower interest rates than commercial banks do.
- In addition, companies can depreciate 100% of the capital investment on the first year and can benefit from a reduced rate for power transmission services.
- 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 2015/2016. 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 23: Assessment of regulatory support to PV self-consumption



3.6.3 Other relevant developments for grid parity

- An eventual regulatory change that modifies the recognition process of injected power by utility-scale PV systems would benefit these generators.

- Moreover, if distributed PV generation is included in this legislation, it would allow self-consumers to attain savings from the fixed component of the retail electricity tariff, in addition to the avoided costs per kWh from the grid.

3.7 Spain

3.7.1 Grid Parity Proximity

Figure 24: Comparison of grid electricity prices for the commercial segment and PV LCOE in Las Palmas, Spain

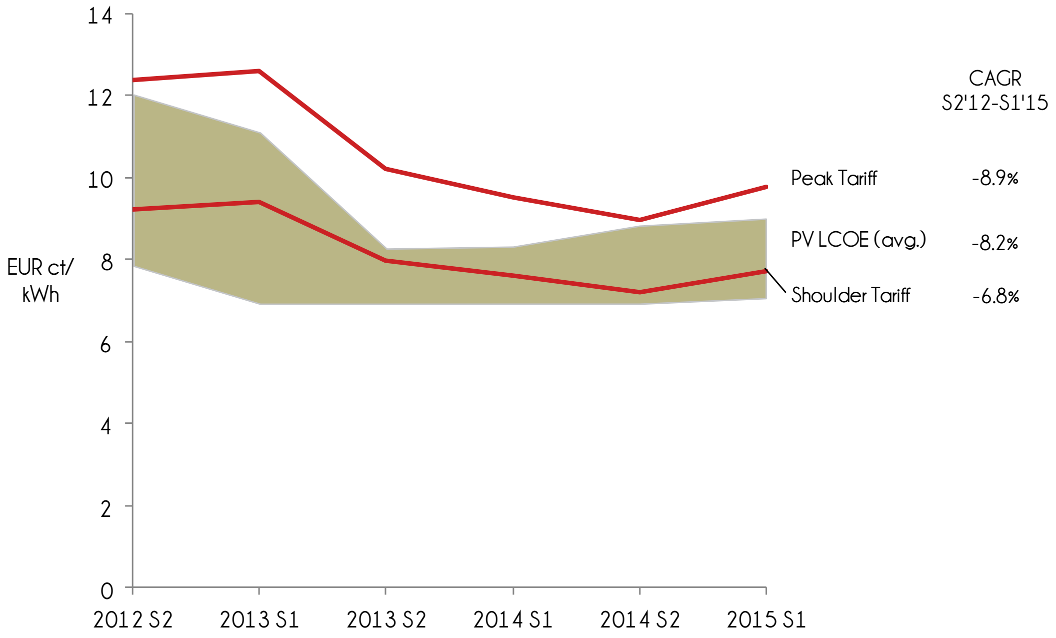


Figure 25: Las Palmas's Grid Parity Proximity

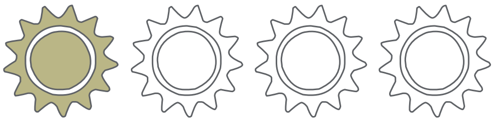
- In Las Palmas, PV is already competitive against retail electricity prices for the commercial sector, which has been driven by two main factors:
  - The important decrease experienced by PV system prices.
  - The relatively high irradiation levels in Las Palmas.
- However, PV competitiveness was negatively affected by the major change in the electricity tariff structure that reduced the variable component (energy charge) and increased the fixed component (capacity charge).
- In addition, 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[11]. 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.

3.7.2 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.
- On the other hand, the latest law proposal for the self-consumption market de-motivates the installation of these PV systems. The measures designed by the Government, which could go into effect this year, include:
  - No compensation allowed for the excess PV generation fed into the grid.
  - A fee charged for every kWh of PV self-consumption.
- 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.
  - Prosumers located outside the Peninsula could be exempt from paying the proposed fee on self-consumption.

Figure 26: Assessment of regulatory support to PV self-consumption



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[11] A system with energy injections requires prosumers to sell the excess electricity in the spot market through a market representative, which is generally not economically viable for commercial consumers.

4

Methodology

4 Methodology

This Section includes an explanation of the calculation methodology of LCOE, clarifies the main assumptions of the analysis, and justifies the inputs used in the financial model. The investment considered is a 30 kW rooftop on-grid PV system without storage, in one sunny city in each of the seven countries under study. In addition, electricity prices for each city are explained.

4.1 Calculation of PV LCOE

The purpose of this analysis is to evaluate grid parity proximity from the perspective of a commercial electricity consumer, who buys electricity from the grid at retail prices. With this aim, the cost of generating PV electricity is compared against the cost of electricity from the grid, assuming 100% PV self-consumption[12].

The cost of PV-generated electricity is here represented by the PV LCOE, which is defined as the constant and theoretical cost of generating one kWh of PV electricity, whose present value is equal to that of all the costs associated with the PV system over its lifespan. As such, it includes all relevant costs that influence the decision of whether to self-consume PV electricity or to buy it from the utility.

Relevant costs from the viewpoint of a commercial consumer

For a commercial electricity consumer that is a private corporation, income taxes are relevant costs, which affect cash flows, and therefore have an impact on the investment decision. Therefore, after-tax costs and depreciation for tax purposes are included in the economic analysis.

After-tax cost flows are calculated to compute the PV Levelized "After-Tax" Cost of Electricity (referred to as LCOE throughout this document), which will then be compared to the after-tax cost of grid electricity.

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[12] This is technically feasible for such a consumer.

Equation 1 shows the resulting identity for the computation of LCOE from the perspective of the project as a whole:

Equation 1: LCOE Calculation (1)

$$\sum_{t=1}^{T}\left(\frac{\boldsymbol{LCOE}_{t}}{(1+r)^{t}} \times E_t\right) = I + \sum_{t=1}^{T}\frac{C_t \times (1-\mathrm{TR})}{(1+r)^{t}} - \sum_{t=1}^{T}\frac{DEP_t \times \mathrm{TR}}{(1+r)^{t}}$$

Table 3: LCOE Nomenclature

Nomenclature	Unit	Meaning
LCOE	*MU*[13]*/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[14]
E_t	*kWh*	PV electricity generated on year t
I	*MU*	Initial investment
r	*%*	Nominal discount rate (WACC)
TR	*%*	Corporate Tax rate per country
DEP	*MU*	Depreciation for tax purposes

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

Equation 2: LCOE Calculation (2)

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

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

- Average PV system lifespan (T)
- Initial investment (I)
- O&M costs and other operating costs (C_t)
- PV-generated electricity over the system's lifespan (E_t [15])

---

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

[14] These costs include the replacement of the inverter.

- Discount rate (r)
- Depreciation for tax purposes (DEP)
- Corporate tax rate (TR)

For a given PV system, the rate used to discount back the factors of LCOE (left side of Equation 1) will define whether LCOE is 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 this analysis, nominal LCOE is calculated.

4.2 Inputs from Primary Sources

In order to perform a thorough cost analysis, local PV installers were consulted on the total cost of installing, insuring, operating and maintaining a commercial PV system over its economic lifetime in the analyzed countries. Contact details of the collaborator companies are shown in the Annex: PV GPM collaborators.

In addition to this, CREARA has been supported by national PV Associations, which validated the input information and assumptions for their respective countries.

Table 4: Collaborating associations

Country	Association
Chile	Asociación Chilena de Energías Renovables (ACERA)
France	Association professionnelle de l'énergie solaire (ENERPLAN)
France/Germany	French-German Office for Renewable Energies (OFAEnR)
Germany	Bundesverband Solarwirtschaft (BSW)
Mexico	Asociación Nacional de Energía Solar (ANES)
Spain	Unión Española Fotovoltaica (UNEF)

---

[15] Go to Section 4.3.8 for a complete explanation of how the PV electricity generated in a given year (E_t) is derived.

4.2.1 Investment cost

Investment costs include all costs related to the PV system: equipment purchase and installation, as well as costs for permitting and engineering. Within each of the analyzed countries, PV installers shared the turnkey price of a PV system of 30 kW (without a storage system), assuming:

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

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.

4.2.2 O&M Costs

A commercial rooftop PV system can be broadly considered maintenance free, requiring just a few hours of work per year. The main maintenance costs essentially cover cleaning of the PV modules, monitoring of inverters, controlling the electric system, among other tasks.

In addition, 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).

This analysis considers an average of four hours of maintenance per year, valued at the corresponding local labour cost per hour[16].

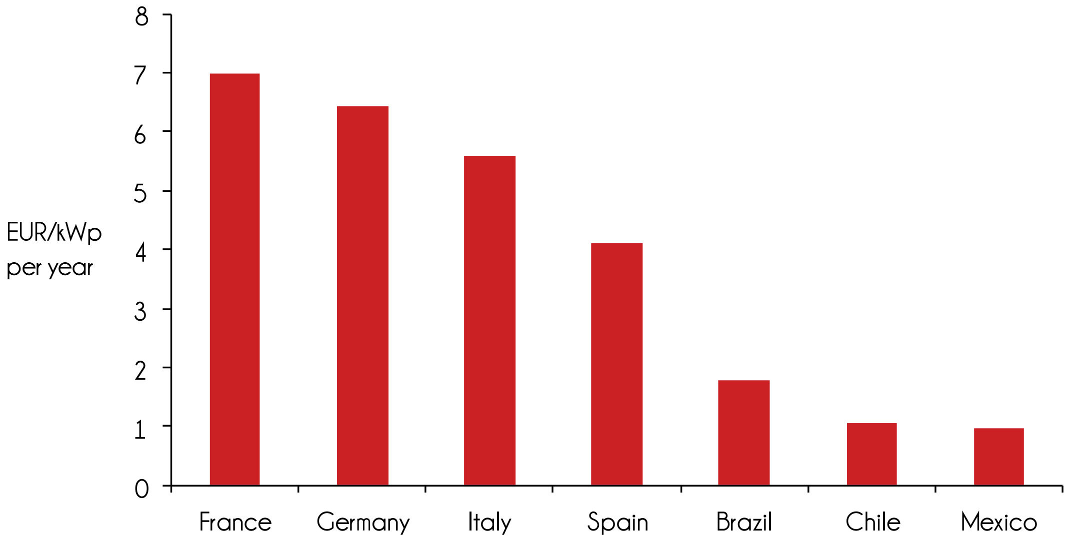
In addition, a mark-up for the O&M service is added to the local hourly compensation. According to several sources from the European PV market, O&M mark-ups range from 20% to 60% for commercial PV installations. With the aim of using conservative values for inputs, a 60% mark-up is considered.

---

[16] 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.

Updated O&M costs per kW for commercial PV systems are as follows:

Figure 27: Estimated O&M costs in 2015



Source: U.S. Department of Labor; Eurostat; Instituto Nacional de Estadisticas de Chile; CREARA analysis

4.2.3 Inverter Replacement

The European Photovoltaic Industry Association (EPIA) assumes a technical guaranteed lifetime of inverters of 15 years in 2010 to 25 years in 2020. For this analysis, an inverter lifetime of 15 years is assumed. This means that the inverter will be changed once during the 30-year PV system lifetime.

In order to estimate the cost of replacing the inverter, the learning factor, which measures the average cost reduction for each doubling of the total number of units produced, has been considered and is assumed constant.

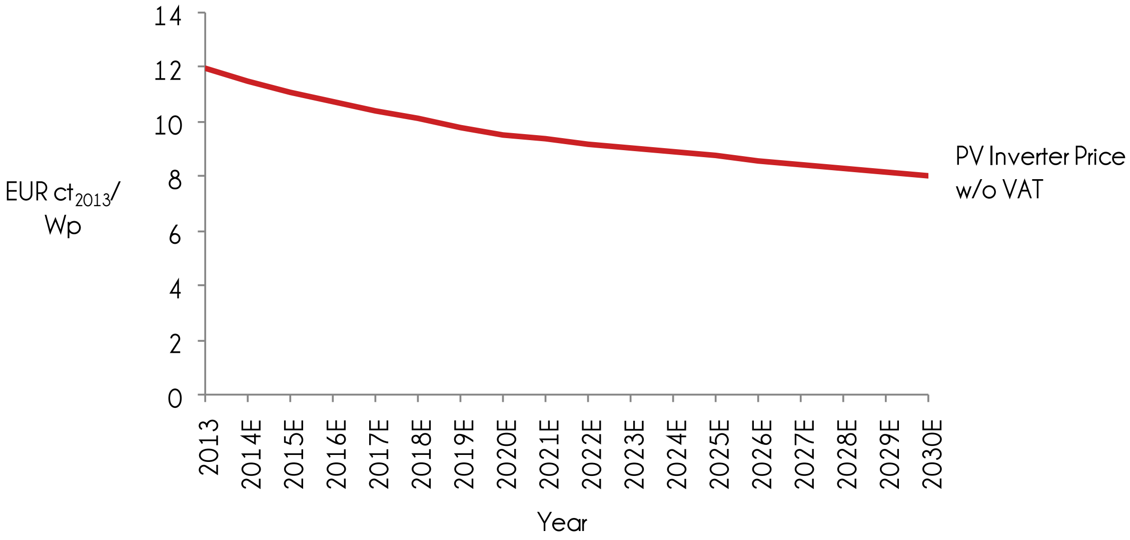
On the basis of sources such as EPIA[17], a 10% learning factor has been assumed for inverters within the commercial sector. Moreover, the current cost of replacing a PV inverter was derived from collaborator companies from the German market, as Germany is considered a mature PV market towards which 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 Wp, the current cost of an inverter has been converted to each country's local currency if different from the Euro.

---

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

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[18] as shown in EPIA/Greenpeace Solar Generation VI. With a 10% learning factor as mentioned above, future inverter prices were calculated.

Figure 28: Historical PV Inverter Prices and Learning Curve Projection 2013-2030



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

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 4.3.5 for more information on inflation rates).

4.2.4 Insurance Cost

According to contacted sources, insurance quotations for a 30 kW PV system approximately range from 0.1% to 2.0% of the total system cost per year. In order to maintain a conservative estimate, an insurance cost of 2% of the total system cost adjusted for inflation will be considered.

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.

---

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

- 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 Corporate Tax Rate

As mentioned before, after-tax cost flows will be used to compute LCOE, which will be compared to the after-tax cost of electricity from the grid. With this aim, corporate tax rates for each of the analyzed countries were used:

Table 5: Corporate Tax Rates (2015)[19]

Country	Corporate Tax Rate
Brazil	34.0%
Chile	20.0%
France	33.3%
Germany	29.6%
Italy	31.4%
Mexico	30.0%
Spain	28.0%

4.3.2 Salvage Value

The salvage value of a PV system is the value of the asset at the end of its useful life, which affects taxable income in different ways depending on the situation:

- If the equipment is sold or recycled, an inflow that increases taxable income should be accounted for.
- Alternatively, if costs are to be incurred in order to dismantle the installation, an outflow should be reported.

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[19] Source: KPMG; Local Websites

Although usually some positive value is recognized as pre-tax income at the end of the life of the PV system, this analysis considers no salvage value in order to use conservative estimates.

4.3.3 Depreciation

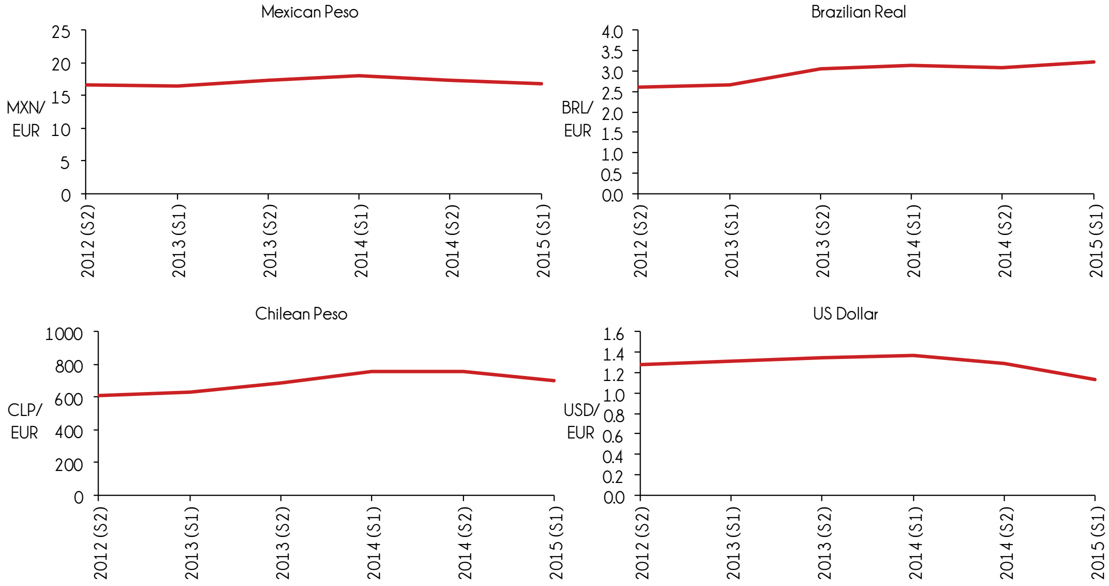
Depreciation for tax purposes is a means of recovering some part of the cost of the investment through reduced taxes. The method used (e.g. straight line or declining balance) and the depreciation period will affect LCOE: all else being equal, a shorter depreciation period and a greater depreciation amount in the earlier years are preferred.

In Mexico, the cost of the investment can be deducted in full that same year, therefore accelerated depreciation is used (the investment becomes an expense on year 1). For all other countries, the straight-line depreciation method is used and a depreciation period of 20 years is assumed.

4.3.4 Exchange Rate

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 6: Exchange Rates - Foreign Currency Units per Euro



Source: OANDA; quarterly-averaged data

4.3.5 Inflation Rate

The estimated inflation rate is taken into account when calculating O&M and insurance costs of a PV system over its entire lifetime in each country. It is estimated as follows:

- Until 2015, the yearly average percentage change of household prices (Consumer Price Index, CPI) in the past eight years (2007-2014).
- From 2015 onwards, the estimated future inflation of each country[20], when applicable.

The following Table shows the inflation rates used for each of the countries analyzed:

Table 7: Average Inflation per Country[21]

Country	Historical Inflation Rate	Estimated Future Inflation Rate
Brazil	5.5%	7.0%
Chile	3.5%	4.0%
France	1.4%	2.0%
Germany	1.6%	2.0%
Italy	1.8%	2.0%
Mexico	4.2%	5.0%
Spain	1.9%	2.0%

4.3.6 Discount Rate (r)

It should be noted that to evaluate the economics of the project, our analysis is performed from the point of view of the project as a whole (including debt and equity holders), i.e., for the LCOE calculation, project cost flows and the Weighted Average Cost of Capital (WACC) as discount rate are used.

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[20] It should be noted that these estimations were based on the survey approach and, as such, in some cases these rates are above the country's long-term target inflation rate.

[21] Source: OECD; European Central Bank; Focus-economics; Creara Research, Creara Interviews.

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 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.

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 on equity have been simplified and defined as follows:

- An inflation premium, which compensates investors for expected inflation and reflects the average inflation rate expected over the lifetime of the investment in a particular market.
- A country risk premium, which reflects the perception of the investor about the risk of investing in a particular market/country, excluding inflation risk.
- An investment-specific risk premium, which is the incremental return that the investor will require above the country-specific premiums (inflation plus country premium) in order to invest in a commercial PV system for self-consumption.

Moreover, it is assumed that 30% of the investment is financed with equity, while the remaining 70% is financed with debt, which is tax deductible.

As a result, the calculation of the discount rate is set as follows:

Equation 3: Discount Rate

$$\boldsymbol{r_c = [30\% \times (IP_c + CP_c + IR)] + [70\% \times i_c \times (1 - TR_c)]}$$

Table 8: Discount Rate Nomenclature

Nomenclature	Unit	Meaning
r_C	%	Discount rate (required return)
IP_C	%	Inflation premium (country-specific return)
CP_C	%	Country premium (country-specific return)
IR	%	Investment premium (investment-specific)
i_C	%	Interest rate (cost of debt)
TR_C	%	Corporate tax rate

4.3.6.1 Cost of Equity

To derive the required return on equity for each country, each risk component is defined in the Sections below.

4.3.6.1.1 Inflation Premium (Country-Specific)

Without accounting for the time preference for current consumption over future consumption, 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.

Historical inflation rates, as well as long-term targets, vary considerably between countries. As a result, these differences should be incorporated on expectations on the inflation rate over the total lifetime of the PV system and each country should be analyzed separately.

Taking into consideration the above facts, interviews to local professionals have been conducted to estimate the average inflation rate expected throughout the lifetime of the asset. The results are as follows:

Table 9: Estimated Expected Inflation[22]

Country	Inflation Premium
Brazil	7.0%
Chile	4.0%

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[22] Source: Creara Interviews; Creara Analysis

Country	Inflation Premium
France	2.0%
Germany	2.0%
Italy	2.0%
Mexico	5.0%
Spain	2.0%

4.3.6.1.2 Country Premium (Country-Specific)

The country premium intends to reflect the additional risks that the investor has to face when investing in a specific country. These risks are determined by factors such as the following ones:

- Health and predictability of the economy.
- Reliability and amount of information available to investors, which influences investors' confidence.
- Cathastrophic events: the risk perceived by the investor of having to face the consequences of a very infrequent, albeit dramatic, events (e.g. government default).
- Degree of uncertainty about government policy.

The country risk was estimated using a melded approach[23] that considers each country's sovereign rating adjusted for market-specific volatility:

- Based upon the rating[24] assigned by Moody's to each particular market, a default spread was used to measure country risk above the risk of "Aaa countries" (e.g. Germany).
- Then, a multiplier was used on the default spread of emerging markets (i.e., Brazil, Chile, and Mexico) to reflect the relative volatility of the equity market in each country[25]:

---

[23] Based on Aswath Damodaran's paper: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2027211

[24] Ratings as of January 2014. The rating measures default risk and is affected by expectations on economic growth and the robustness of the political system, among other factors.

The following Table shows the input parameters and the resulting country risk premium:

Table 10: Country risk derivation

Country	Default spread	Multiplier	Country Risk
Brazil	1.9%	1.7	3.3%
Chile	0.6%	1.8	1.1%
France	0.4%	1.0	0.4%
Germany	0.0%	1.0	0.0%
Italy	1.9%	1.0	1.9%
Mexico	1.6%	1.6	2.6%
Spain	2.2%	1.0	2.2%

4.3.6.1.3 Investment Risk Premium (Investment-Specific)

In general, the required compensation for bearing the risk of investing in a PV system for self-consumption will be higher than that required solely to compensate for country-specific risks.

As expected, the investment risk (IR) 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 systems?
  - Considering a 30-year investment, how does the investor perceive the risks associated with such timeframe?
- 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?

---

[25] It consists on dividing the standard deviation in the equity index by the annualized standard deviation in the country's dollar denominated 10-year bond.

- 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 based on a combination of answers to questions such as the ones rose 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 and country 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 commercial investors are reasonably compensated for taking the uncertainty of investing in a PV system for self-consumption if they receive a 5% return above the inflation and country premium. This matches the cost of equity found in all countries analyzed.

4.3.6.2 Cost of debt

It is considered that the investment is financed through a corporate loan and that the resulting debt-equity ratio is 70/30. The interest rates for a loan in each country´s national currency were included in the analysis:

Table 11: Interest Rates (pre-tax) [26]

Country	Interest Rates
Brazil	12.5%
Chile	9.5%
France	3.5%
Germany	3.0%
Italy	4.0%
Mexico	11.0%
Spain	4.7%

As a result of the above inputs and assumptions, the discount rate used for each country is as follows:

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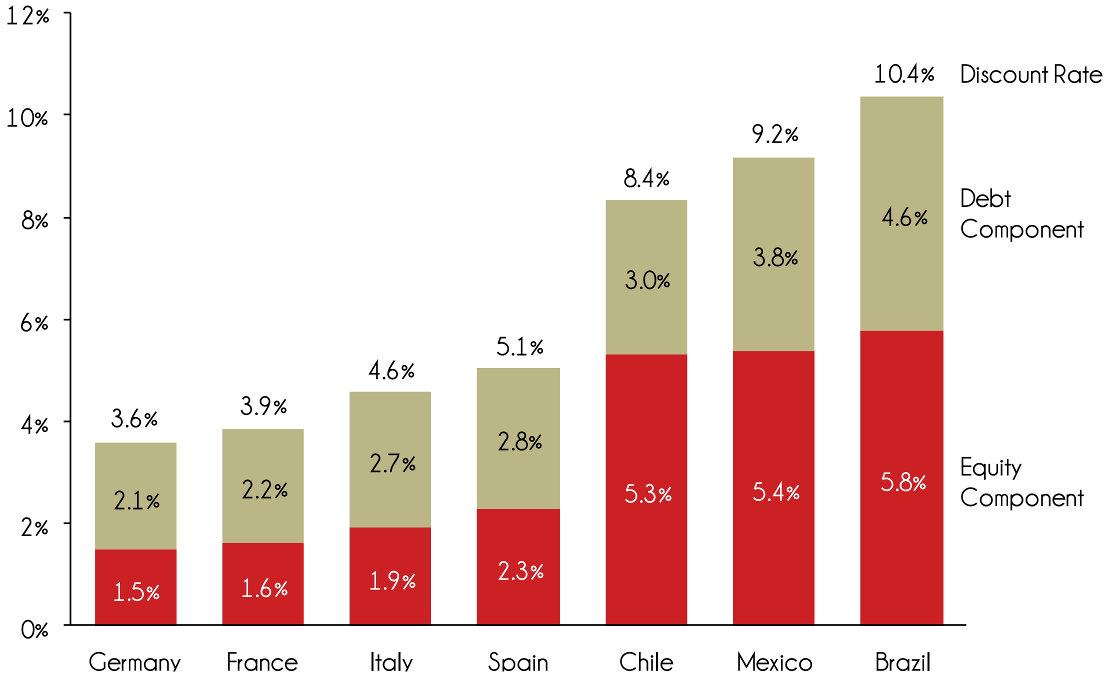
[26] Source: CREARA Interviews; Reuters; Bundesbank; Banque de France; Aswath Damodaran.

Figure 29: Discount Rate (WACC) per country



Source: Aswath Damodaran; Reuters; Banco do Brasil; Gobierno del Estado de Sonora; Banco Estado; Banque de France; Bundesbank; Bloomberg; CREARA Analysis

The above discount rates are reasonable required returns for such an investment and in line with those actually taken into account by investors with a similar debt-equity ratio, albeit under a relatively favourable scenario.

4.3.7 PV System Economic Lifetime

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

- Most of the reports consulted[27] consistently use 25 to 35 years for projections.
- Moreover, PV Cycle[28], European association for the recycling of PV modules, estimates the lifetime of a PV module at 35 years.

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

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

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.

4.3.8 PV Generation

As explained above, the LCOE is a measure of the cost per unit of PV electricity generated by the system, which is calculated as follows:

Equation 4: PV Generation on year t

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

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

Table 12: 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, in order to estimate the annual PV generation of a 30 kW rooftop installation in each of the 7 cities, the following variables were defined:

- Local solar irradiation
- Degradation rate
- Performance ratio

4.3.8.1 Local Solar Irradiation

Solar resource estimates used in the analysis are summarized in the following Table:

Table 13: Irradiation on a plane tilted at latitude (kWh/m^2/year)

Country	City	Irradiation
Brazil	Salvador	1,918
Chile	Copiapó	2,154
France	Marseille	1,691
Germany	Munich	1,267
Italy	Rome	1,611
Mexico	Hermosillo	2,486
Spain	Las Palmas	2,008

These estimates were obtained from two sources:

- Mexico (i.e. Hermosillo) data was obtained, following ANES recommendation, from SIGER (Geographic Information System for Renewable Energies) and UNAM´s Geophysics Institute Solar Observatory.
- For the rest of locations, the irradiation estimates were obtained with SolarGIS' pvPlanner, an online tool developed by GeoModel Solar, which is used for long-term photovoltaic power estimation. 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.

  SolarGIS solar resource database is developed from global satellite and atmospheric high-resolution time series data. The tool exploits solar resource and air temperature database at spatial resolution of 250 meters, which is aggregated from 15 and 30-minute SolarGIS time series covering a history of up to 20 years[29].

Worldwide, the global in-plane irradiations estimated with a satellite-based methodology have an uncertainty of approximately 5-6% depending on the site, due to factors such as quality of inputs regarding atmospheric conditions[30], simulation accuracy of cloud transmittance derived from satellite data, geographical conditions of the site, etc.

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[29] SolarGIS database and pvPlanner are available online at http://solargis.info

[30] Regionally, the solar resource predictions may have a larger uncertainty because resource estimates are particularly problematic in areas with a high concentration of atmospheric aerosols, see: http://www.solarconsultingservices.com/Gueymard-Aerosol_variability-SolarPACES2011.pdf

4.3.8.2 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 to use as input on their financial models.[31]
    - Analyses of PV systems after 20/30 years of operation show that the average degradation rate of crystalline silicon (c-Si) modules reached 0.8% per year[32].
    - More recent research concludes that currently c-Si annual degradation rate is near 0.5%[33].
- In addition, module manufacturers warrant an annual degradation lower than 1% (e.g., SunPower warrants that the power output at the end of the final year of the 25 year warranty period will be at least 87% of the Minimum Peak Power rating[34]).

Taking into account these facts, an annual degradation of 0.5% per year has been considered for the analysis.

4.3.8.3 Performance Ratio

The Performance Ratio (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[35] the PR of more than 100 PV system installations.

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[31] K. Branker et al. / Renewable and Sustainable Energy Reviews 15 (2011) 4470– 4482 (Tabla 1); SunPower / The Drivers of the Levelized Cost of Electricity for Utility-Scale Photovoltaics; IFC (Banco Mundial) / Utility Scale Solar Power Plants.

[32] Skoczek A, Sample T, Dunlop ED. The results of performance measurements of field-aged crystalline silicon photovoltaic modules (citado en K. Branker et al.).

[33] Dirk C. Jordan, NREL, 2012. Technology and Climate Trends in PV Module Degradation.

[34] SunPower Limited Product and Power Warranty for PV Modules

  - 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.[36]

4.4 Retail Electricity Rates

The value and structure of the electricity rates in each location will have an impact on the economic decision of self-consuming PV electricity or buying electricity from the utility.

The structure of a utility rate can range from a simple flat charge to a complex combination of charges that depend on various factors:

- Energy costs, which increase with electricity demand (kWh).
- Capacity costs, which vary with peak power demand (kW).
- Availability of rates that vary with the time of the day and/or month within a year (i.e. TOU rates).
- Availability of rates that increase with the amount of electricity purchased (i.e. tiered rates).

Generally, PV self-consumption will be attractive whenever LCOE is lower than the energy costs charged by the utility for each kWh consumed from the grid. Moreover, if PV self-consumption results in a change on the consumption pattern of the user, the additional avoided costs should also be accounted for within the LCOE calculation.

In this regard, capacity costs can decrease as a result of a reduction of peak demand from the grid. However, for this to happen, several conditions must be met. The illustration in Figure 30 exemplifies this situation.

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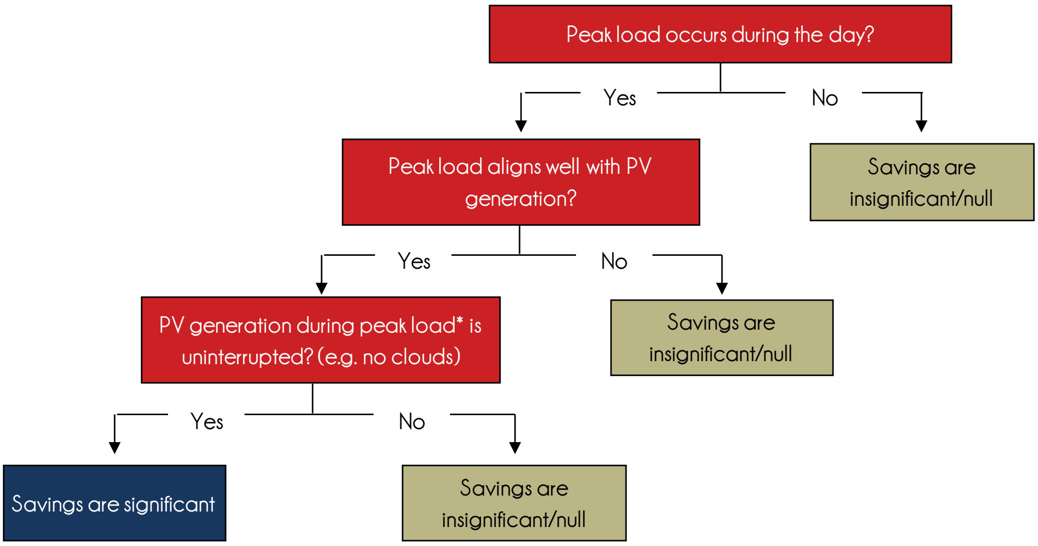
[35] Performance ratio revisited: is PR>90% realistic?, Nils H. Reich, et.al., Fraunhofer Institute for Solar Energy Systems (ISE), and Science, Technology and Society, Utrecht University, Copernicus Institute

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

Figure 30: Illustration of the conditions to attain capacity charge savings on a given month



Note: * Each day in the month, during an interval of 15 minutes
Source: CREARA Analysis

As the above Figure shows, for a commercial consumer it is not easy to save on capacity costs on a given month. This is due to the following reasons:

- On some months, PV generation is interrupted by the presence of clouds.
- On other months, peak load reduction is limited by the magnitude of the (second highest) peak demand, which does not coincide with PV generation.

In this analysis, the capacity charge will not be included, but the reader should bear in mind that throughout the lifetime of the PV system it is possible that some savings of capacity charges can be reached, albeit small.

A note on Storage

There are several alternative solutions for storing generated electricity for self-consumption, predominantly Lithium-ion and lead-acid based technologies. Such storage systems can guarantee backup power needs and energy reliability (for instance, during peak load), contributing to the reduction of capacity charge.

As soon as these storage technologies for the application under study become economical, the possibility of attaining savings from the fixed component of the electricity bill will be put into reality.

4.4.1 City of Salvador (Brazil)

In Brazil, commercial electric rates are regulated and published by ANEEL every year. The country is divided into 63 concession areas, where one or more utilities are in charge of electricity distribution. The city of Salvador is within COELBA distribution area.

It should be noted that electricity price levels vary considerably within Brazil. Those considered herein reflect the ones applicable only in the analyzed city, without precluding commercial consumers from paying higher or lower electricity prices in other parts of the country.

The main characteristics of the electricity tariff considered for Salvador are as follows:

Table 14: Characteristics of the "Tarifaría B3"

	Brazil (Salvador)
Tariff	Tarifa B3
Voltage	Low voltage < 2.3kV
Contracted Power	<300kW
Structure of tariff	• Energy charge • No capacity charge From 2013, two options are available: • Tarifa Convencional B3 (non-TOU, no tiers) • Tarifa Branca B3 (TOU, no tiers)

Tariffs in Brazil are the sum of two different concepts:

- TUSD: Accounting for the usage of the electricity distribution system.
- TE: Accounting for the energy costs.

Since mid 2013, ANEEL has introduced a system called *"Bandeiras Tarifarias"* (literally, tariff flags) that are meant to reflect energy generation costs in the different electricity tariffs. There are three tariff flags, fixed by ANEEL every month, that modify the TE:

- Green, when the conditions of energy generation are favourable. No modification in TE associated.
- Yellow, when they are less favourable. TE is increased by 1.5 BRL per kWh.
- Red, when energy generation is more expensive. TE is increased by 3.0 BRL per kWh.

For the GPM analysis, the tariff *"Tarifa Convencional B3"* has been selected. The TOU version (*"Tarifa Branca"*) has not been used due to its price structure: Peak happens between 19 and 21. Regarding the tariff flags mechanism, and considering its minor influence over the final energy price, only the intermediary option (yellow flag) has been used in the final model.

4.4.2 Copiapó (Chile)

In Chile, the electricity market for commercial consumers is regulated by more than 30 private distribution companies, that are private companies operating within the regulatory framework established by the State's *Comisión Nacional de Energía* (CNE). Prices are fixed by the CNE every month.

As was the case in Brazil, there is a considerable variation between electricity price levels throughout the country. Those considered herein reflect the one applicable only in Copiapó (i.e. EMELAT distribution), without precluding commercial consumers from paying higher or lower electricity prices in other parts of the country.

The main characteristics for the electricity tariff considered are highlighted in the Table below:

Table 15: Characteristics of "Tarifa BT 2" in Copiapó

	Chile (Copiapó)
Tariff	Tarifa BT 2/3
Voltage	Low voltage < 0.4kV
Contracted Power	>10kW
Structure of tariff	• Energy charge (non-TOU, no tiers) • Capacity charge • Fixed charge per client

4.4.3 Marseille (France)

In France, electricity prices can be either regulated by the Government or set freely by the utilities; however, most of the consumers remain under the regulated market. Given that the main utility is the state-owned *Electricité de France* (EDF), their commercial tariffs were taken into consideration. Electricity tariffs are divided into three categories depending on the voltage range (low or high) and the contracted power (Bleu, Jaune, Vert).

The main characteristics of the tariff chosen for France are presented in the following Table:

Table 16: Characteristics of the "Tarif Jaune" electricity tariff in Marseille

	France (Marseille)
Tariff	Tarif Jaune
Voltage	Low voltage < 1kV
Contracted Power	Between 42 and 240 kVA
Structure of tariff	• Energy charge (TOU, no tiers) • Capacity charge

Electricity rates vary depending on the season and the time of the day. For Marseille area (and depending on the town or district) five different off-peak (*"heures creuses"*) periods are available:

- Option 1 : 11 PM - 7 AM
- Option 2 : 2 AM - 7 AM; 2 PM - 5 PM
- Option 3 : 2 AM - 7 AM; 1 PM - 4 PM
- Option 4 : 10:30 PM - 6:30 AM
- Option 5 : 12 AM - 5:30 AM; 2:30 PM- 5 PM

It is assured that PV users would select options 1 or 4 (so the off-peak happens when the PV system is not generating energy). Therefore, the off-peak price will not be included in the grid parity analysis.

4.4.4 Germany (Munich)

Stadtwerke München (SWM) is the municipal utility that serves electricity customers in Munich. For commercial clients, electricity tariffs vary with the annual consumption of each consumer in three categories and within these categories, electricity prices vary with the contracted power.

The main characteristics of the tariff are shown in the following Table:

Table 17: Characteristics of the "M-Strom" electricity tariff

	Germany (Munich)
Tariff	M-Strom
Consumption	Below 100 MWh/year
Contracted Power	>30 kW
Structure of tariff	• Energy charge (TOU) • No capacity charge • Fixed charge per client

The peak tariff is applicable during the week and the off-peak tariff mostly on weekends, as summarized in the Table below:

Table 18: Rate Periods in Munich

Season	Rate Periods	Time Periods
All	Peak	Monday to Friday from 6 AM to 9 PM
	Off-Peak	Monday to Friday from 9 PM to 6 AM Weekends

4.4.5 Italy (Rome)

In Italy, electricity tariffs vary with the voltage level (low, medium, high, very high) and the contracted power. Prices are the same throughout the country.

The main conditions of the electricity tariff considered are the following:

Table 19: The Italian BTA 6 electricity tariff

	Italy (Rome)
Tariff	BTA 6
Voltage	Low voltage < 1kV
Contracted Power	>16.5kW
Structure of tariff	• Energy charge (TOU) • Capacity charge

The following time periods will be considered in the analysis:

Table 20: Rate Periods in Rome

Season	Rate Periods	Time Periods
All	*Punta* (Peak)	Monday to Friday from 8 AM to 7 PM
	Intermedia (Shoulder)	Monday to Friday from 7 AM to 8 AM and from 7 PM to 11 PM Saturday from 7 AM to 11 PM
	Fuori punta (Off-Peak)	Monday to Saturday from 11 PM to 7 AM Sunday and bank holidays

4.4.6 Mexico (Hermosillo)

In Mexico, electricity tariffs are fixed every month by the national utility CFE. This analysis considers the tariff applicable to commercial consumers with contracted power over 25 kW ("*Tarifa 3*") and below 25 kW ("Tarifa 2") for low voltage and below 100kW ("Tarifa OM") for medium voltage.

Table 21: Conditions of the Mexican "Tarifa 2/3/OM"[37]

	Mexico (Hermosillo)		
Tariff	*Tarifa 2*	*Tarifa 3*	*Tarifa OM*
Voltage	Low voltage < 1kV	Low voltage < 1kV	Medium voltage
Contracted Power	<25 kW	>25kW	<100kW
Structure of tariff	• Energy charge (non-TOU, three tier) • No capacity charge • Fixed charge per client	• Energy charge (non-TOU, no tier) • Capacity charge	• Energy charge (non-TOU, no tier) • Capacity charge

The rates included in the analysis are the electricity prices for the commercial sector as indicated by the Federal Electricity Commission (CFE, Spanish acronym) for the northern region of Mexico.

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[37] CFE (accessed 2014)

4.4.7 Spain (Las Palmas)

In Spain, commercialization of energy is a liberalized market[38]; and as such electricity tariffs are not set by the Government but rather negotiated between the parties.

Utility tariffs are divided into three categories according to voltage level (low, medium and high) and according to the contracted power. This analysis considers the tariff applicable to low voltage consumers with contracted power over 15 kW (3.0A tariff), whose main characteristics are summarized in the Table below:

Table 22: Conditions of the Spanish "Tarifa 3.0 A"

	Spain (Las Palmas, Canary Islands)
Tariff	*Tarifa 3.0 A*
Voltage	Low voltage < 1kV
Contracted Power	>15kW
Structure of tariff	• TOU energy charge • Capacity charge

PV LCOE will be compared to peak and shoulder tariffs, according to the following time periods:

Table 23: Rate Periods in Las Palmas

Season	Rate Periods	Time Periods
Winter	*Punta* (Peak)	6 PM to 10 PM
	Llano (Shoulder)	10 PM to 12 AM and 8 AM to 6 PM
	Valle (Off-Peak)	12 AM to 8 AM
Summer	*Punta* (Peak)	11 AM to 3 PM
	Llano (Shoulder)	8 AM to 11 AM and 3 PM to 12 AM
	Valle (Off-Peak)	12 AM to 8 AM

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[38] Except for the Tariff of Last Resort (in Spanish, TUR), a regulated tariff available for residential consumers with contracted power lower than 10kW.

5

Annex: PV GPM collaborators

5 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 medium-scale (33 kWp) PV system for a grid-connected 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 24: Grid Parity Monitor Collaborators

Collaborators per Country	
Brazil	
BR Solar	
Tel.	(0055) 21 2512 1260
Website	http://www.brsolar.com.br
Contact Name	Ruberval Baldini
Efficienza - Automação e Energia	
Tel.	(0055) 41 3292 5603
Website	www.efficienza.eng.br
Contact Name	Vinícius Cardoso de Vargas
Emap Solar	
Tel.	(0055) 31 3223 1430 / (0055) 31 9632 2511
Website	www.emapsolar.com.br
Contact Name	Miriam Penna Diniz
Insole Tecnologia Ambiental	
Tel.	(0055) 81 3076 1423
Website	www.insole.com.br
Contact Name	Jordi Ribas
Solaria	
Tel.	(0055) 11 3062 0258 / (0034) 91 564 42 72
Website	http://www.solariaenergia.com/
Contact Name	Fernando Rodríguez
Sollaric	
Tel.	(0055) 11 4153 3726
Website	http://www.sollaric.com.br
Contact name	Paulo Hornyansky

Chile	
Aquea Energy	
Tel.	(0056) 9 9538-8823
Website	www.aqueaenergy.com
Contact Name	Santiago Valentini
Aquito Solar	
Tel	(0056) 2 2245 3013
Website	http://www.aquitosolar.cl/
Contact Name	Mauricio Contreras
Ecoditec	
Tel.	(0056) 2 2335 1957
Website	http://www.ecoditec.cl/
Contact Name	Italo Mazzei
Enersafe	
Tel.	(0039) 961 757 4841
Website	http://www.enersafe.it/
Contact Name	Alessandro Mascaro
Lumisolar	
Tel.	(0056) 2 2415 2774
Website	http://www.lumisolar.cl/
Contact Name	Arturo Letelier
Solener	
Tel.	(0056) 24 537 687
Website	http://solener.cl/
Contact Name	Alejandro Pinto
France	
Canopy	
Tel.	(0033) 1 53 00 40 96
Website	http://www.canopy-energy.com/
Contact Name	Francesco Paolo Oddo
KiloWattsol SAS	
Tel.	(0033) 4 27 86 82 47
Website	http://www.kilowattsol.com/
Contact Name	Xavier Daval
Krannich Solar	
Tel.	(0033) 3 60 53 80 01
Website	http://fr.krannich-solar.com/
Contact Name	Alexis Veigel

Solorea	
Tel.	(0033) 4 81 92 60 71
Website	http://www.solorea.com/
Contact Name	Patrick Martinet
Enerplan. Syndicat des professionnels de l'énergie solaire	
Tel.	(0033) 4 42 32 43 23
Website	http://www.enerplan.asso.fr/
Contact Name	Sylvain Roland
Germany	
A&M Photovoltaikanlagen	
Tel.	(0049) 793 0993 96 40
Website	http://www.am-photovoltaikanlagen.de/
Contact Name	Stephan Steigmieir
BSW - Bundesverband Solarwirtschaft e.V.	
Tel.	(0039) 030 29 777 88 37
Website	http://www.solarwirtschaft.de/
Contact Name	Jan Knaack
Office franco-allemand pour les énergies renouvelables (OFAEnR) Deutsch-französisches Büro für erneuerbare Energien (DFBEE)	
Tel.	(0049) 30 18 305 4681
Website	www.ofaenr.eu / www.dfbee.eu
Contact Name	Nils Eckardt
SunEnergy Europe	
Tel.	(0049) 40 520 143 290
Website	http://www.sunenergy.eu/
Contact Name	Florian Kubitz
Italy	
Alet Taldea	
Tel.	(0034) 669 366 953
Website	http://www.alet-taldea.com/
Contact Name	Mikel Almorza Aranguren
Enersafe	
Tel.	(0039) 096 881 8836
Website	http://www.enersafe.it/
Contact Name	Alessandro Mascaro
I.A.T.	
Tel.	(0039) 06 440 3340
Website	http://www.iatroma.com/
Contact Name	Giuseppe Cherubini

Medielettra	
Tel.	(0039) 09 194 1804
Website	http://www.medielettra.it/
Contact Name	Angelo Badalamenti
Saccomandi & Brilli Elettroimpianti	
Tel.	(0039) 05 4185 7272
Website	http://www.saccomandiebrilli.com/
Contact Name	Eduardo Bianchini
Mexico	
Baja Solar	
Tel.	(0052) 222 211 6111
Website	http://baja-solar.mx/
Contact Name	Alfonso Lazcano
Butecsa	
Tel.	(0052) 555 594 0341
Website	http://www.butecsa.com/
Contact Name	Rodolfo Martínez Strevel
Conermex	
Tel.	http://www.conermex.com.mx/
Website	(0052) 55 5384 5130
Contact Name	Jessica Montalvo
Ergo Solar	
Tel.	(0052) 22 2211 6111
Website	http://www.ergosolar.mx/
Contact Name	Luis Gerardo Sánchez Stone
Grupo Simosol SA DE CV	
Tel.	(0052) 6144340242
Website	http://www.simosol.mx/
Contact Name	Xavier Loya
Soluciones de Energías Alternas SA DE CV / Energy Solar	
Tel.	(0052) 44 4833 4457
Website	http://www.energysolarslp.com.mx/
Contact Name	Gerardo Morales Loyde
Spain	
Endef	
Tel.	(0034) 976 36 58 11
Website	http://endef.com/
Contact Name	Carlos Herrando

Energon Renovables	
Tel.	(0034) 644 42 43 36
Website	http://www.energonrenovables.es/
Contact Name	-
Enerpal	
Tel.	(0034) 979 745 042
Website	http://www.enerpal.es/
Contact Name	José Antonio Gutiérrez
Genia Global	
Tel.	(0034) 963 63 61 47
Website	http://geniaglobal.com/
Contact Name	Gabriel Butler
Sud Energies Renovables (SunPower Authorized Partner)	
Tel.	(0034) 93 886 69 48
Website	http://www.sud.es/
Contact Name	Alfred Puig
TFM (grupo Comsa Emte)	
Tel.	(0034) 935 753 666
Website	http://www.tfm.es/
Contact Name	Óscar Aceves
Tudela Solar S.L.	
Tel.	(0034) 948 848 776
Website	http://www.tudelasolar.com/
Contact Name	Marian Orta
Solaria	
Tel.	(0034) 91 564 42 72
Website	http://www.solariaenergia.com/
Contact Name	Fernando Rodríguez

6

Annex: Acronyms

6 Annex: Acronyms

Table 25: Acronym Glossary

Acronym	Meaning
ABINEE	Brazilian Electrical and Electronics Industry Association
ACERA	Asociación Chilena de Energías Renovables
AEEG	Regulatory Authority for Electricity and Gas, acronym in Italian
ANEEL	Brazilian Electricity Regulatory Agency
ANES	Asociación Nacional de Energía Solar
BRL	Brazilian Real
BSW	Bundesverband Solarwirtschaft
CAGR	Compound Annual Growth Rate
CFE	*Comisión Federal de Electricidad*
CLP	Chilean Peso
CNE	*Comisión Nacional de Energía*
CPI	Consumer Price Index
c-Si	Crystalline Silicon
DEP	Depreciation for tax purposes
DSO	Distribution System Operator
EDF	*Electricité de France*
EEG	German Renewable Energy Act, acronym in German
EPE	Energy Agency of Brazil
EPIA	European Photovoltaic Industry Association
EU	European Union
EUR	Euro
FiTs	Feed in Tariffs
IFC	International Finance Corporation
GPM	Grid Parity Monitor
GTM	Green Tech Media
INEGI	Instituto Nacional de Estadística y Geografía
ISE	Institute for Solar Energy Systems
ITC	Investment Tax Credits
KfW	German development bank
kV	Kilo Volt
kVA	Kilo Volt Ampere
LatAm	Latin America
LCOE	Levelized Cost Of Electricity
LV	Low Voltage

Acronym	Meaning
MU	Monetary Unit
MV	Medium Voltage
MXN	Mexican Peso
NREL	National Renewable Energy Laboratory
NCRE	Non-Conventional Renewable Energy
O&M	Operation and Maintenance
OFAEnR	French-German Office for Renewable Energies
OMIE	*OMI-POLO ESPAÑOL, S.A.*
PR	Performance Ratio
PV	Photovoltaic
REE	*Red Eléctrica Española*
RP	Risk premium
SEIA	Solar Energy Industries Association
SIGER	Geographic Information System for Renewable Energies
SSP	*Scambio Sul Posto*
SWM	*Stadtwerke München*
TOU	Time-of-use
TR	Tax Rate
TUR	Tariff of Last Resort
UNAM	*Universidad Nacional Autónoma de México*
UNEF	*Unión Española Fotovoltaica*
US	United States
VAT	Value Added Tax

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