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Utility-scale

2nd issue

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Executive summary

1 Executive summary

MERGER NOTIFICATION

In 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 ninth issue of the Grid Parity Monitor and the second one to exclusively focus on the utility-scale segment (50 MWp PV plants with a single-axis tracking system). This report analyzes PV competitiveness in wholesale energy markets and provides an outline of the electricity regulation in eight different countries (Chile, Honduras, Italy, Mexico, Morocco, South Africa, Turkey and USA (Texas)).

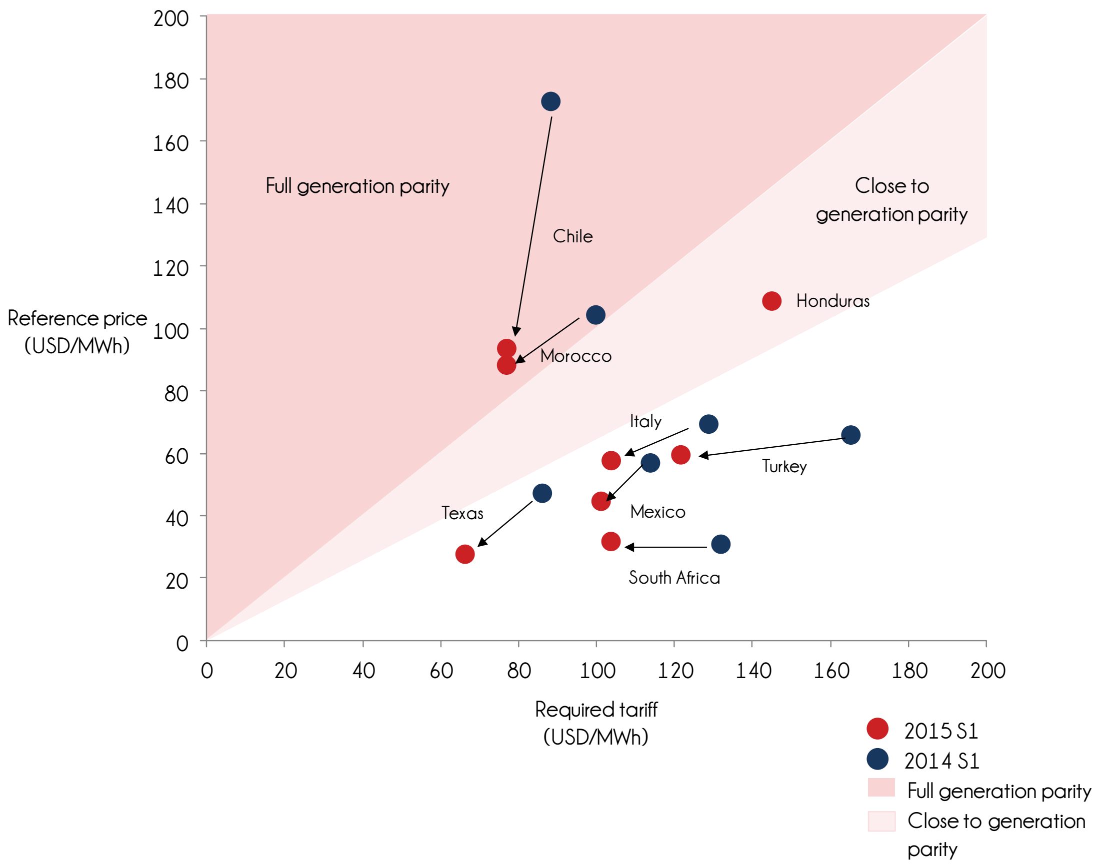
Like the first edition of the GPM utility-scale, this GPM issue applies a methodology which differs from the one used in previous GPM reports, which were centered on residential and commercial customers operating under a net metering scheme. Thus, while for residential and commercial clients the LCOE is calculated to analyze so-called *grid parity* proximity, the analysis of the utility-scale issues focuses on *generation parity*. In doing so, the report determines a theoretical tariff which fulfils profitability requirements for investors. This *required tariff* is compared to local wholesale prices in order to determine if *generation parity* exists in the country.

The *required tariff* is calculated based on the economics of the PV plant under a project finance scheme, since this is currently the most common form of financing. Other financing possibilities that could significantly improve *generation parity* results have not been analyzed in this report[1].

The results of the GPM analysis (summarized in the Figure below) show that Chile and Morocco are in a full *generation parity* situation, Honduras is close.

[1] That is the case of bond-financed plants, commonly used by utilities and which could lower *required tariffs* by 30% to 40%.

Figure 1: Generation parity proximity in the countries analyzed



Source: CREARA analysis

The following conclusions on the utility-scale segment (50 MWp plants) can be drawn from the analysis:

- In Chile, high electricity prices and irradiation levels still provide *generation parity*, although the margin to protect against additional falls in market prices has decreased significantly.

- Honduras is relatively close to generation parity with the *required tariff* being around 30% higher than the *reference price*. Attractive irradiation levels can be found and the reference price is high, although high CPI rates and capital costs influence the result negatively.

- *The generation parity* situation in Italy has not changed in the last two semesters. After a a sharp decrease in wholesale prices in the second semester of 2013, the reference price has not changed significantly since.

However, the volatility of the Italian market advises to monitor this country recurrently.

- Mexico is still undergoing a major regulatory reform that affects generation activities and will presumably impact wholesale prices. The reference price has decreased significantly in the last years but as the Mexican *required tariff* presents reasonably attractive values, this market should be analyzed in the future.

- Morocco has reached *generation parity*, although the *required tariff* is only slightly lower than the *reference price*. The increase in electricity prices foreseen for the coming years should increase the attractiveness of this country for utility-scale PV generation.

- South Africa is still very far from generation parity. Even though high irratiation levels can be found, the reference price is too low to compete for now.

- High capital costs (both for equity and debt) and high CPI rates hinder *generation parity* in Turkey. Nevertheless, electricity is relativeley expensive and the *required tariff* is decreasing.

- Although Texas shows the lowest *required tariff* of this GPM analysis, wholesale market rates are not attractive enough to allow for *generation parity*. Both the required and the reference price have shown a decreasing trend in the last two semesters.

For all countries initial equity investment costs (considered in dollars) have decreased in the last semesters, but the strong dollar has eliminated the impact on the final results.

The fact that generation parity has not been reached in a country does not imply that utility-scale PV plants will not be built. Other reasons may trigger such an investment, for example:

- A RPS (Renewable Portfolio Standard) system is in place

- A FiT exists

- A convenient PPA scheme has been granted to the investor

2

Introduction

2 Introduction

The Grid Parity Monitor (GPM) series was conceived to analyze PV competitiveness in order to increase awareness of PV electricity generation possibilities. This edition of the GPM takes the perspective of large installations selling energy to wholesale markets.

This document presents the second edition of the GPM utility-scale series and deals with installations with a capacity of 50 MWp using a single-axis tracking system. Within the GPM series non-utility-scale GPM issues focus on residential (3 kW) and commercial (30 kW) PV installations for self-consumption.

PV investors already consider PV as a credible technology to compete in the wholesale market in certain regions. For example, in Chile PV installations with capacities of over 70 MW are already operating as merchant plants. Currently a new project with a capacity of 80 MW is being developed (to be completed in 2016) and once finished will represent the largest merchant plant built so far. However, given the volatility wholesale markets may present and the fast decline of PV prices (much higher than in residential or commercial segments), PV utility-scale competitiveness is a phenomenon that should be monitored overtime.

To assess the competitiveness of large PV plants, this study estimates the so-called *PV generation parity* proximity. *Generation parity* is achieved when profitability requirements of PV investors are completely fulfilled with wholesale electricity prices[2].

Methodology for the generation parity analysis

- In order to evaluate generation parity proximity, the economics (P&L and cash flows) of a PV utility-scale plant have been analyzed, always from an investors' perspective. For that purpose, a project finance structure has been modelled, taking into account all relevant economic considerations.

[2] Without considering any specific financial incentives on PV production, such as FiT

- A theoretical tariff has been calculated based on investors' requirements for this type of projects. This *required tariff* is such that the IPP would achieve at least the minimum profitability sought in order to build the PV plant[3].

- As most PPA contracts, it has been considered that the theoretical tariff increases over time. An annual rate of 2% has been taken into account. This assumption is reasonable given that market prices are also expected to grow in the long term.

- This investor's *required tariff* has been compared to wholesale market prices in order to determine the generation parity proximity within the analyzed locations.

This report analyses the economics of a PV plant financed under a project finance scheme. This option was chosen because it is currently the most abundant case. However, it is important to bear in mind that PV plants are sometimes financed (mainly by utilities) by corporate debt, which is significantly cheaper[4]. The values of the *required tariff* under this assumption can well be 30% to 40% lower than the ones shown in this report.

In order to get full understanding of PV generation parity proximity, an outline of the electricity market is needed. This allows identifying which electricity prices must be chosen to evaluate PV generation parity and which are the main difficulties a PV plant faces in the considered market. This GPM report provides an abstract of the market situation of each country assessed.

It is important to remark that this GPM issue does not intend to serve as a detailed investment guide for PV utility-scale plants. The expected outcome of this report is a realistic overview of utility-scale PV competitiveness but in a theoretical framework. For instance, it could be possible to report a PV generation parity situation in a specific market where utility-scale PV plants are not allowed to operate.

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[3] Please note that this approach is considerably different from past GPM's methodologies, where LCOE was calculated (see Commercial and Residential issues: http://www.leonardo-energy.org/photovoltaic-grid-parity-monitor)

[4] The cost of corporate bonds from large utilities can be in the range of 2-3%

A note on Reference prices

Given the goal of this study, it is necessary to determine a *reference price* that will serve as a benchmark of the potential income that a PV IPP could obtain from the market. This *reference price* should not include specific economic incentives for renewable energy generation (such as FiTs or technology specific auctions) but represents actual competitiveness with the market.

Some defend that competitiveness should be defined comparing PV generation cost against CCGT generation plants (Combined Cycle Gas Turbine). However, this GPM analysis has been built considering PV as the only generation technology to be assessed. Therefore, the hypothetical investor has to decide whether to invest in a utility-scale PV plant or not. Investing in other technologies is not an option under the GPM framework.

In order to determine if the analyzed market presents generation parity, the following market *reference prices* can be considered as a good reference:

- Marginal prices of the day-ahead market in a power exchange: uniform or locational prices, depending on the dispatch model.
- Price of PPA contracts that are negotiated freely in a liberalized market (granted by large consumers or electric utilities).

PPA prices are not always easy to obtain, as many of these contracts are private agreements and no public information is available. Therefore, as a practical simplification, the GPM report selects between these two alternatives:

- A marginal price, where possible.
- A regulated tariff for large consumers: in countries where no spot market exists, the national utility rate for large consumers has been selected as a theoretical upper boundary of a PPA contract as a working hypothesis[5].

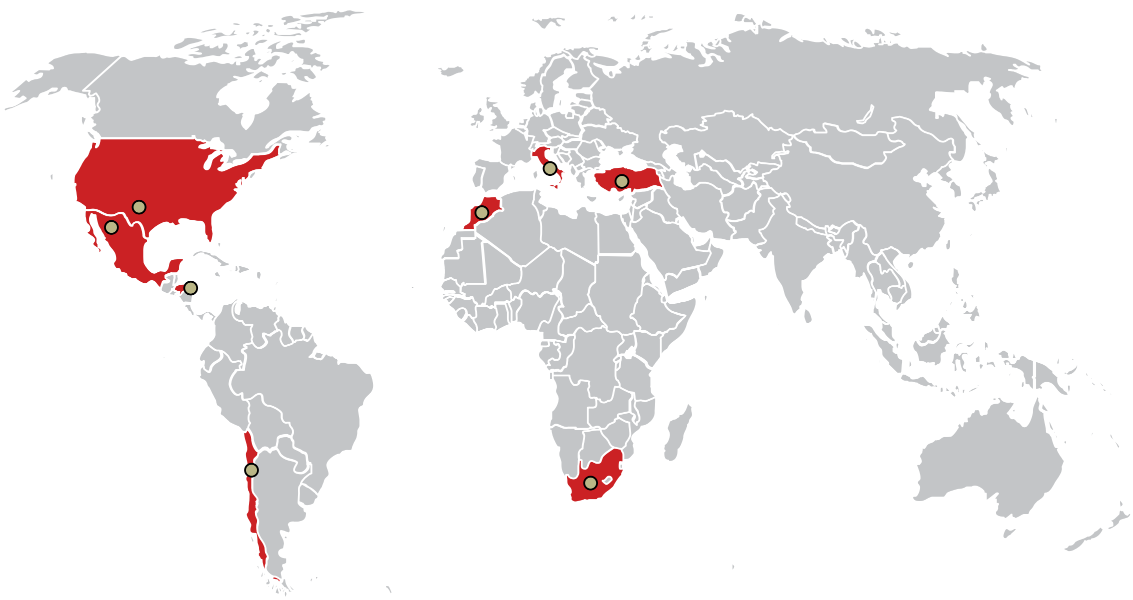
[5] In this GPM issue, regulated tariffs are used in the cases of Morocco and South Africa, and for Honduras when a regulated minimum cost of generation exists

The actual prices considered in this GPM report will correspond to those matching the period when PV can actually feed energy into the system, i.e. during daylight hours (assuming that there is no storage capacity).

It should be remarked that fast declining PV costs and changing electricity prices advise to monitor PV competitiveness overtime.

In order to assess the magnitude of utility-scale competitiveness, the current issue of the GPM analyzes some of the main current and potential markets for large plants. The study considers only one location per country in a region with a relatively high irradiation level and with existing transmission grid nearby:

Figure 2: Countries included in this issue



The report is structured in two main sections:

- Results Section, where *required tariffs* are quantified for each of the locations under study and PV generation parity proximity is analyzed.
- Methodology Section, which includes a thorough explanation of the main assumptions and inputs considered in the analysis.

3

PV GPM results

3 PV Grid Parity Monitor Utility-scale Results

In this section, the GPM Utility-scale (GPMU) compares the *required tariff* for a PV investor with electricity prices in order to assess the PV Generation Parity proximity in each country.

Criteria used to assess PV Generation Parity proximity

Figure 3: Qualitative scale for the assessment of Generation Parity proximity

Far from Generation Parity

Close to Generation Parity

Partial Generation Parity

Generation Parity

Full Generation Parity

Where:

- Far from Generation Parity: The *required tariff* is more than 50% above the *reference price.*
- Close to Generation Parity: The *required tariff* is equal or up to 50% above the *reference price.*
- Partial Generation Parity: The *required tariff* has been lower than the *reference price* in the last 2 years, but it is currently above that value.
- Generation Parity: The *required tariff* is currently lower than the *reference price*, but in the last 2 years generation parity was not clearly achieved.
- Full Generation Parity: All reference wholesale prices are above the *required tariff.*

3.1 Chile

3.1.1 Wholesale market and reference price in Chile

The situation of the Chilean power market has been reviewed and no significant differences have been detected with respect to what was stated in the previous issue of the GPMU. Thus, Chile has a liberalized and privatized power market with two main interconnected systems (four interconnected systems in total): the Interconnected System of the North (SING: Sistema Interconectado del Norte Grande, Spanish acronym) and the Interconnected System of the Centre (SIC: Sistema Interconectado Central, Spanish acronym). Each of them has its own trading platform. Nonetheless, a draft law revising the structure of the transmission system is being examined. Furthermore, an interconnection structure between both systems (SING and SIC) is expected to be available by 2018.

During the last semesters, competition has increased in the generation market. This trend should continue as ENAP (Empresa Nacional de Petróleo), a state-owned company, is expected to be allowed by law to enter the electricity generation market, which is currently occupied by private companies only. This could have an impact on the electricity price in the coming months and the reference price should therefore be revised.

Wholesale trading activities are carried out in a financial and/or a physical market:

- The financial market is based on bilateral contracts between generators and other private parties (generators, distribution companies[6], non-regulated consumers, etc.). An important way to establish contractual agreements are public auctions organized by distribution companies, which are obligatory to assure the supply to regulated consumers[7].

- The spot market is where physical energy transactions take place. It is operated by CDEC (Centre of Economic Dispatch or *Centro de Despacho Económico de Carga* in Spanish) in each interconnected system (CDEC-SIC and CDEC-SING). Each CDEC determines the efficient economic dispatch of the system, according to generation costs. This market is exclusive for the

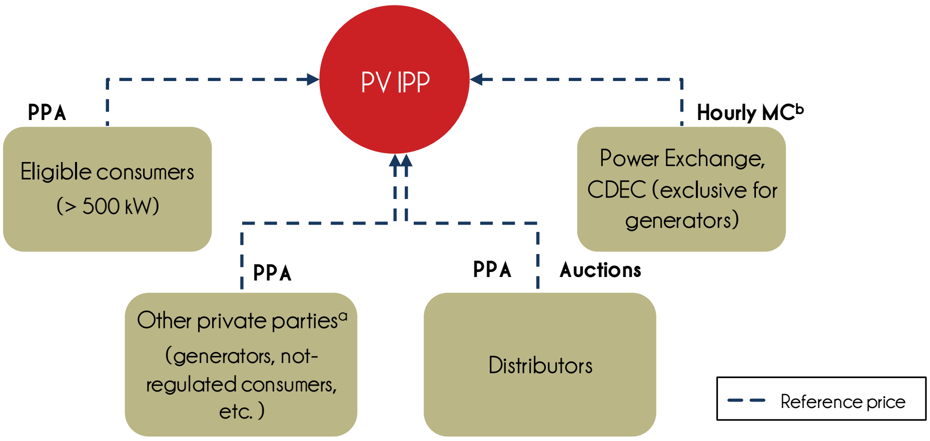
[6] In Chile, distribution companies are regional monopolies that are also in charge of power supply

[7] Unlike in the first issue, PV producers can now participate in this process since auction rules have been modified allowing bidders to apply to only sell their energy during the desired time block

participation of generators, who offer their excess generation or acquire electricity in case of deficit, according to their (financial) procurement agreements. A generator sells/purchases electricity at the nodal spot price, which is based on the hourly marginal cost of generation calculated by CDEC.

The next figure synthesizes the specific channels that a PV producer can use to sell its electricity production in Chile.

Figure 4: Trading channels for a PV Producer in Chile



Note: [a] It is important to note that Chile has established renewable energy obligations for the commercialization of electricity; the scheme envisions to reach 20% of the supplied energy coming from renewable energy sources by 2025

[b] Nodal marginal cost defined by the dispatch of CDEC in each of the interconnected systems

Source: CREARA Analysis

The analysis for Chile is carried out as if the PV producer were operating in the SIC system and the installation were situated in the region of Diego de Almagro, feeding energy into the node with the same name. The IPP is assumed to sell its total production on the spot market (CDEC-SIC). Therefore, the *reference price* in the study corresponds to the hourly nodal marginal cost at the node Diego de Almagro of CDEC-SIC, during daylight hours[8] [9].

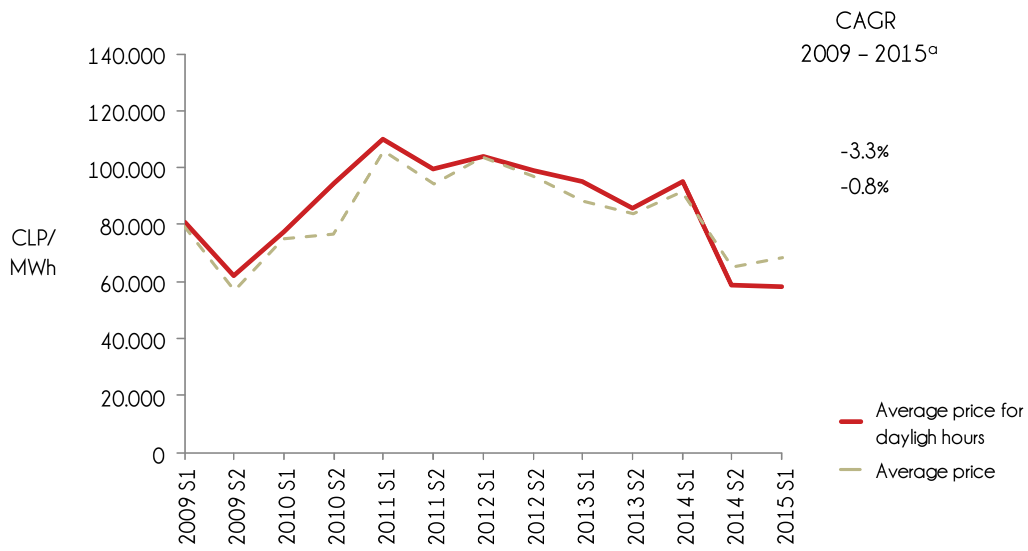
The CDEC-SIC market has presented a high volatility along the past decade, reaching variations of more than 110 USD/MWh from one year to another (considering average

[8] Daylight hours correspond to the period from 8:00 to 18:00, on average throughout a year in the zone of Diego de Almagro

[9] Furthermore, a producer could receive additional payments for other concepts (such as capacity payments) but for this study only the hourly marginal cost of the spot market is considered

prices). The SIC greatly relies on hydro generation, thus there is some seasonal variation which is highly correlated with hydrological conditions of each year. Besides this, a general increase in prices in the last decade has been influenced by supply shortages of Argentinean gas. More recently the prices have fallen (39% since the last issue, considering average prices), reaching 0 during some hours of several days. This low price was the result of large supply and low demand in the region that is not sufficiently interconnected with other regions for selling the electricity outside of the system. The next chart depicts the evolution of marginal costs for the node Diego de Almagro.

Figure 5: Evolution of average nodal prices at Diego de Almagro node[10]



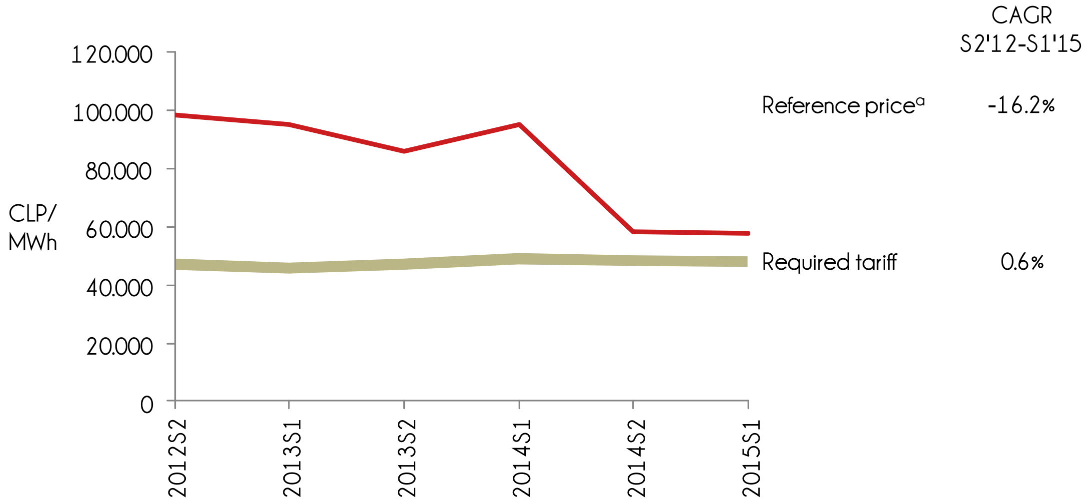
Note: ª Year 2015 includes data until July
* Prices have been adjusted with average exchange rates per semester
Source: CDEC-SIC; CREARA Analysis

3.1.2 Generation parity proximity

The assessment of PV generation parity in Chile is performed for a site near the region of Diego de Almagro, participating in the CDEC-SIC market (during daylight hours).

[10] Average hourly marginal costs in Diego de Almagro per semester, in the daily market of the CDEC-SIC: continuous line is based on daylight hours; dotted line is based on the 24 hours of a day

Figure 6: Comparison of hourly marginal cost of spot market and the required tariff for a PV investor in Chile under a project finance structure (Diego de Almagro)



Note: [a] *Reference price* corresponds to hourly spot prices of the daily market of CDEC-SIC for daylight hours

* Prices have been adjusted with average exchange rates per semester

Source: CDEC-SIC; CREARA Analysis

Figure 7: Chile's Generation Parity Proximity

- *Reference prices* are above the *required tariff* for a PV investor, which implies that full *generation parity* still exists in Chile for a large PV producer. Nonetheless, the *reference price* has decreased considerably from the previous issue.
    - The extraordinary irradiation levels contribute to this situation of PV parity in this Chilean region.
    - Even if the reference price has decreased, it still represents relatively high prices.
- Although SIC market has presented high volatility rates in the past decade, including the sharp decrease in the last year, PV tariff still offers some margin to absorb potential further decreases in the spot market, although this margin has decreased significantly and should be therefore revised for future editions.
- Initial investment costs have decreased in Chile in the last semesters (by more than 10%), but the strong dollar has eliminated the impact on the final results.

3.2 Honduras

3.2.1 Wholesale market and reference price in Honduras

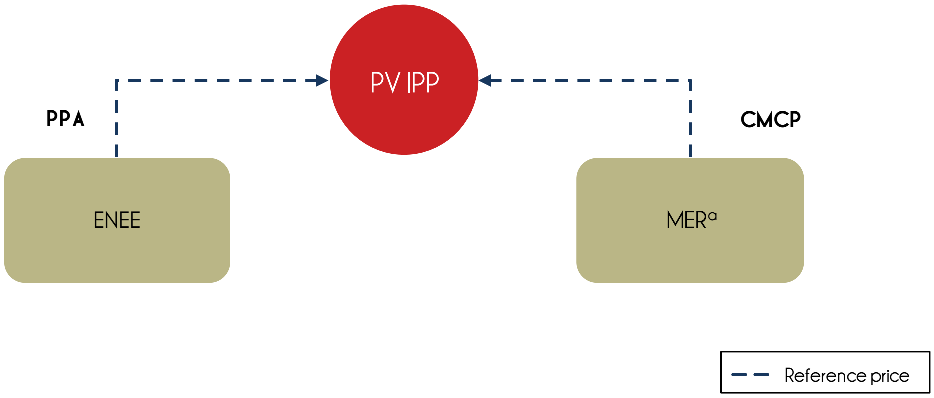
Although the Government promulgated a new Electricity Law (Ley Marco del Subsector Eléctrico) in 1994 in order to enhance the competitiveness of the power market, enabling private parties to participate in generation, transmission and distribution, the ENEE (Empresa Nacional de Energía Eléctrica, Spanish acronym) continues operating as a vertically integrated company. As a consequence, private entities only take part in generation, whereas transmission and distribution are still under ENEE's control, which acts, furthermore, as the sole power purchase. ENEE controls the majority of the country's generation capacity which requires significant investment.

The new Law (Ley General de la Industria Eléctrica) approved in January 2014 pretends to reform the electric sector completely. Thus, the ENEE is going to be divided into three new companies that will compete with private entities in the generation, transmission and distribution of electricity. Although the new Law is currently in force, secondary regulation has to be launched to clearly determine how the electricity sector will be structured in the coming years. As a consequence, the reference price should be reviewed once the secondary legislation, which is expected to be issued by 2016 (according to interviews carried out with market players), has established the concrete conditions of the new market in Honduras.

Thus, IPPs can supply ENEE through a PPA. Alternatively they can sell the energy in the regional spot market (MER, Mercado Eléctrico Regional) at the short-term marginal cost (CMCP). The regional spot market has been set up by six Central American countries (Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica and Panama).

The following chart depicts the available alternatives for PV producers:

Figure 8: Trading channels for a PV producer in Honduras



Note: [a] It is important to note that the regional spot market has been set up by six Central American countries (Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica and Panama) and does not constitute a manner to sell energy inside Honduras.

Source: CREARA Analysis

The selected reference price for Honduras corresponds to the variable part of the Marginal Short-term Generation Cost (Costo Marginal de Corto Plazo de Generación) established as a minimum to be paid by law. This variable part is represented by the marginal energy cost:

Table 1: Minimum marginal energy cost by season and hourly block, 2014

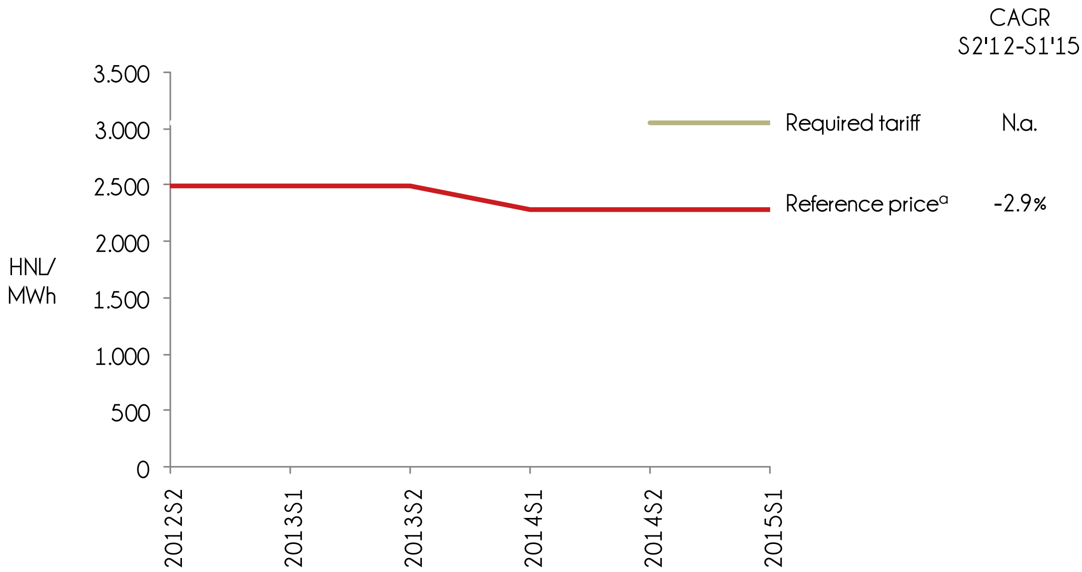
Hourly block	Dry season (December-May)	Rainy season (June-November)
Peak	136.25 USD/MWh	130.41 USD/MWh
Standard	126.53 USD/MWh	108.69 USD/MWh
Off-Peak	105.68 USD/MWh	89.52 USD/MWh

Source: La Gaceta de la República de Honduras

3.2.2 Generation parity proximity

PV Parity in Honduras is calculated for the zone of Nacaome (Valle), considering a merchant plant selling to ENEE.

Figure 9: Comparison of Marginal Short-term Generation Cost and the required tariff for a PV investor in Honduras under a project finance structure (Nacaome)



Note: [a] *Reference price* corresponds to marginal energy cost of generation and represents average prices for daylight hours

* Prices have been adjusted with average exchange rates

Source: La Gaceta de la República de Honduras; Creara Analysis

Figure 10: Honduras' Generation Parity Proximity

- In Honduras, PV utility-scale generation is not competitive with the refernce price at this moment, although the *required tariff* can be considered close to *generation parity* (about 30% above the *reference price*).
  - Attractive irradiation levels can be found, although high CPI rates and capital costs influence the result negatively.
- In order to promote the installation of solar capacity, the government offered an incentive of 3 USD c/kWh (to be added to the negotiated PPA with the government) for those installations that were connected by the end of August 2015.
  - This additional income would allow the *required tariff* to be less than 6% above the *reference price* and *generation parity* could be considered to be very close.

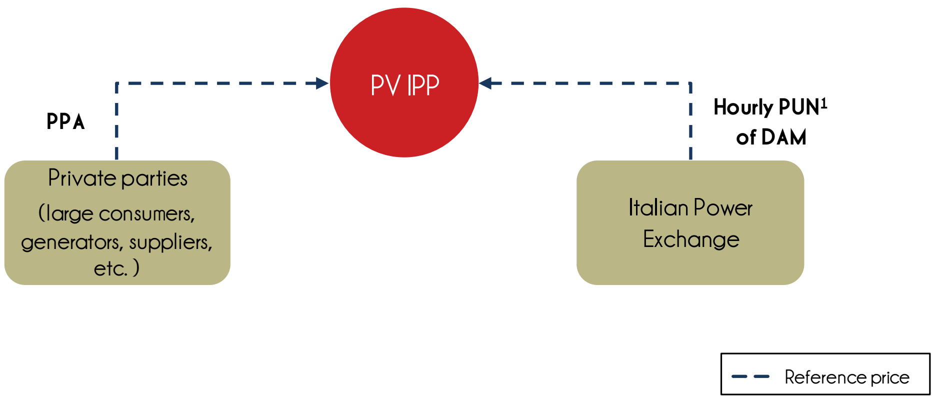
3.3 Italy

3.3.1 Wholesale market and reference price in Italy

The Italian power market has not experienced any significant change during the end of 2014 and the beginning of 2015 and, therefore, the situation described in the first issue of the GPMU remains in force. The Italian power market is fully liberalized. Wholesale electricity sales are carried out through two different channels: the spot electricity market (representing around the half of electricity trade) and the bilateral market, where contracts are freely negotiated among agents (generators, suppliers, consumers, etc.)

With regards to specific trading options for a PV producer, the next scheme summarizes the selling alternatives available:

Figure 11: Trading channels for a PV Producer in Italy



Note: [1] Marginal Price for Italy (PUN -National Single Price, uniform in all the country except for the regions of Sicily and Sardinia due to constraints in transmission capacity)

Source: CREARA Analysis

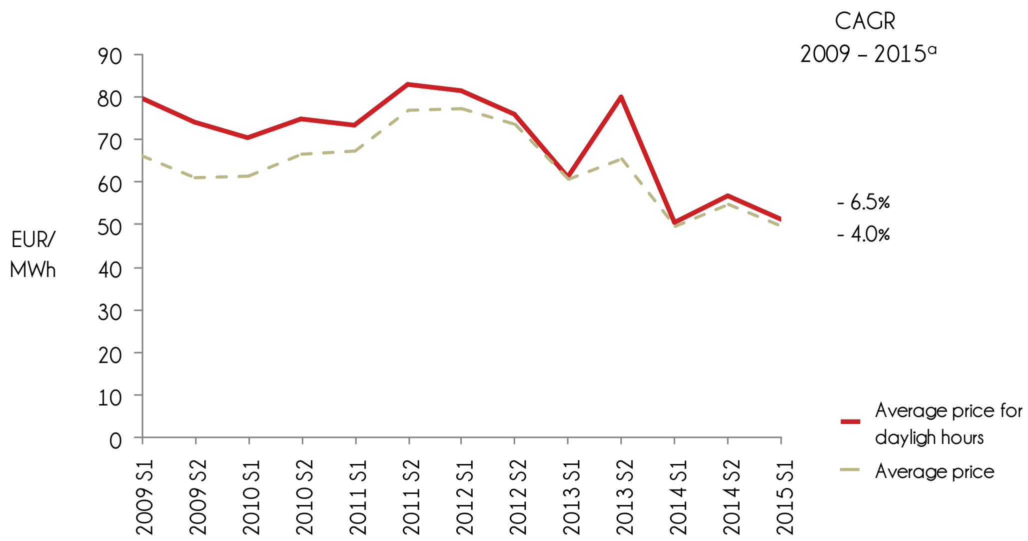
The selected *reference price* in this study is the one corresponding to the remuneration received by a generator in the spot market, i.e. the hourly marginal price of the day-ahead market for daylight hours[11].

The chart below shows the evolution of marginal prices in the IPEX (Italian Power Exchange or *Gestore del Mercato Elettrico* in Italian). Spot prices have been decreasing significantly in the last years. This is correlated to the large penetration of renewable energy (hydro and

[11] Daylight hours correspond to the period from 7:00 to 18:00, on average throughout a year in the zone of Pomezia

solar), which has caused a decrease of gas-fired generation in the mix and to lower prices in the Italian PSV hub.

Figure 12: Evolution of average spot electricity prices in Italy[12]



Note: ª Year 2015 includes data until July
Source: IPEX; CREARA Analysis

The integration of renewable energy is facilitated by system rules favouring the development of renewable energy, including:

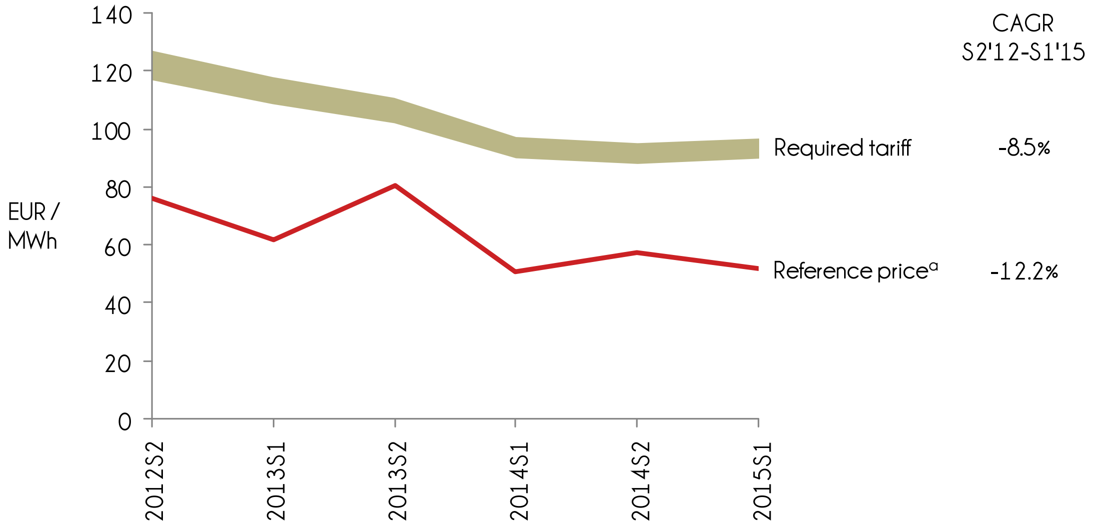
- Priority access and dispatch for electricity from renewable energy sources.
- Enabling the request for network expansion to allow the connection of renewable energy when needed.

3.3.2 Generation parity proximity

PV Parity in Italy is calculated for the zone of Pomezia (Rome), considering a merchant plant selling to IPEX.

[12] Average hourly spot prices (Single National Price, PUN) of day-ahead market per semester: continuous line is based on daylight hours; dotted line is based on the 24 hours of a day

Figure 13: Comparison of hourly day-ahead market prices and the required tariff for a PV investor in Italy under a project finance structure (Pomezia)



Note: [a] *Reference price* corresponds to hourly spot prices of day-ahead market in IPEX during daylight hours

Source: IPEX; CREARA Analysis

Figure 14: Italy's Generation Parity Proximity

- In Italy, PV utility-scale generation is not currently competitive in the spot market since the *required tariff* for a PV investor is significantly higher than the *reference price.*
  - Spot prices have decreased 12% annually over the past 3 years.
  - The depreciation period for assets has been increased to 25 years starting from 2014, which worsens the impact of depreciation for tax purposes.
  - Moreover, a high cost of equity and specific taxes for electricity generation and land renting are barriers to reach generation parity.
- However, the appetite of financial institutions in the Italian market is recovering after past years' financial crisis, which is improving market conditions for this type of utility-scale infrastructures and will help the *required PV tariff* to decrease.
- PV investment costs have decreased in the last semesters. As these are considered in dolars the impact on the final results has been reduced because of the unfavorable exchange rate.

3.4 Mexico

3.4.1 Wholesale market and reference price in Mexico

Mexico is undergoing a major Energy Reform that liberalizes generation activities and opens the retail and wholesale markets to competition. As secondary legislation is still pending to complete the transition towards the new market structure, currently the participation of private parties remains restricted. Therefore the current regulatory framework will be considered to analyze the market and to establish the *reference price* for the generation parity analysis.

The power system (prior to the Energy Reform) is structured around a state-owned monopoly, CFE (*Comisión Federal de Electricidad*, Spanish acronym), that manages all the activities of the power chain. Under this framework, the commercialization of electricity to final consumers (at any level, wholesale or retail) is almost exclusively conferred to the CFE[13].

On the generation side, IPPs can supply CFE signing PPAs that can be established either through regulated tenders (*Productor Independiente*) or through the SPP generation scheme (Small Power Producer or *Pequeño Productor* in Spanish). The latter is accessible for private parties with renewable installations <30 MW. The SPP would sign a PPA with a price that is equivalent (for the case of renewable generation) to 98% of the nodal cost at the connection point. This nodal cost is the CTCP (Short-term Total Cost or *Costo Total de Corto Plazo* in Spanish) that results from the dispatch of the power system.

Besides this, another alternative for renewable electricity generation is the "autoabastecimiento" scheme (installations >500 kW). In practice, it may be similar to a PPA contract between the project developer and the end customer (both co-owners of the project). This is allowed for on-site generation or in a location that is different from that of the demand. Until now this generation scheme has presented some attractive features which will be eliminated through the Energy Reform:

- Postage stamp tariff that enables the prosumer to wheel electricity over the transmission grid at standard tariffs that are subject to the voltage connection level (i.e. HV, MV or LV).

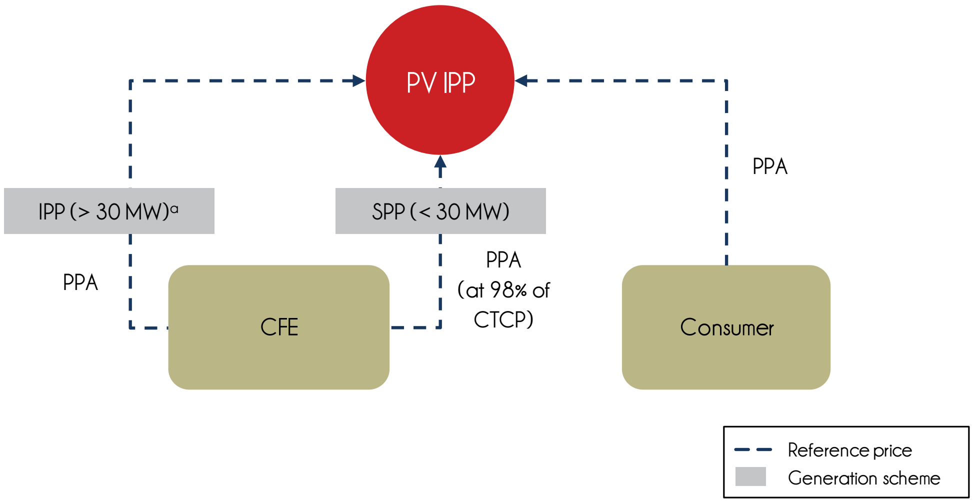
[13] In practice, under the "autoabastecimiento" scheme IPPs can sell electricity directly to private consumers

- Energy bank for excess energy: Recognition of injected power by PV systems, that translates into energy credits for future consumption or to be sold to CFE (energy excess can be bought at a rate of 85% of the CTCP on the injection node).

Further, regulation foresees that a wholesale market will be established where electricity can be bought and sold on a spot and a day-ahead market. Although, until the needed mechanisms have not been implemented this option cannot be analyzed in detail and is therefore not considered for this issue.

The next figure depicts the current alternatives of a PV IPP to enter the system in Mexico.

Figure 15: Trading channels for a PV Producer in Mexico



Note: Existing scheme, prior to Energy Reform
[a] Theoretically, a PV IPP > 30 MW could supply CFE with this type of contract although this situation has never been taken place

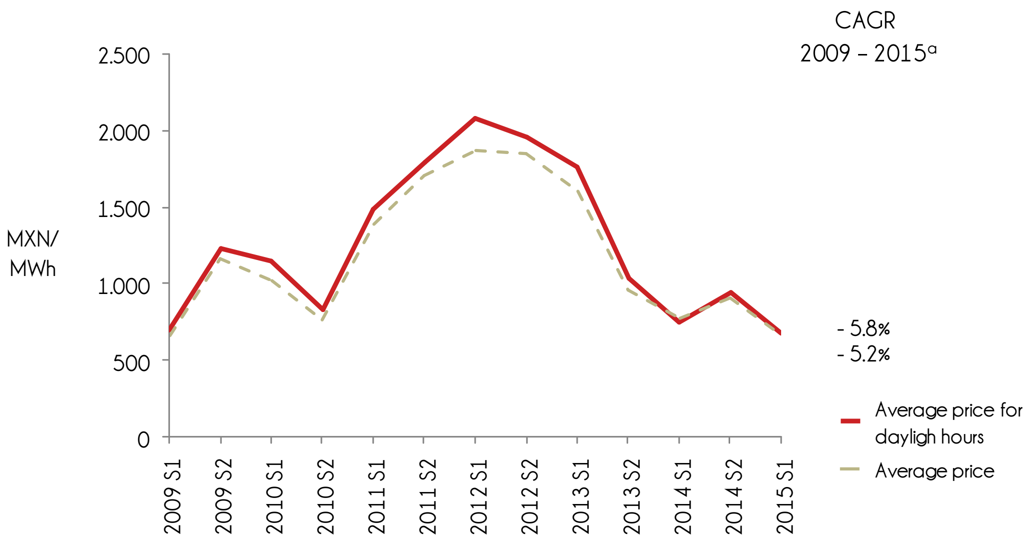
Source: CREARA Analysis

Given the existing and expected market structure, the *reference price* for this study will be set on the basis of the current remuneration for a SPP. This has been selected, as the CTCP is representing the actual costs of system's dispatch. Moreover these prices can be assumed as a proxy for the spot prices expected in the power exchange to be in place (following the Energy Reform), at least in the short term[14].

[14] In any case, one should bear in mind that this is a theoretical reference as, under the current framework, an installation of 50 MWp (as the one under study), could not apply for the SPP scheme

As the case study considers the PV plant to be located in the zone of Santa Ana (in the state of Sonora), it is assumed that it would be feeding electricity in the node of *Sonora Norte*[15]. Consequently, the *reference price* corresponds to the 98% of the hourly CTCP for daylight hours at this node[16]. The next chart shows the CTCP values in the node of Sonora Norte since 2009.

Figure 16: Evolution of average short-term nodal costs in the node of Sonora Norte in per semester[17]



Note: ª Year 2015 includes data until the month of July

Source: CFE; CREARA Analysis

3.4.2 Generation parity proximity

As previously stated, the generation parity in Mexico is assessed for the city of Santa Ana in Sonora, for a PV producer receiving a remuneration corresponding to 98% of the CTCP in the node of *Sonora Norte* (during daylight hours).

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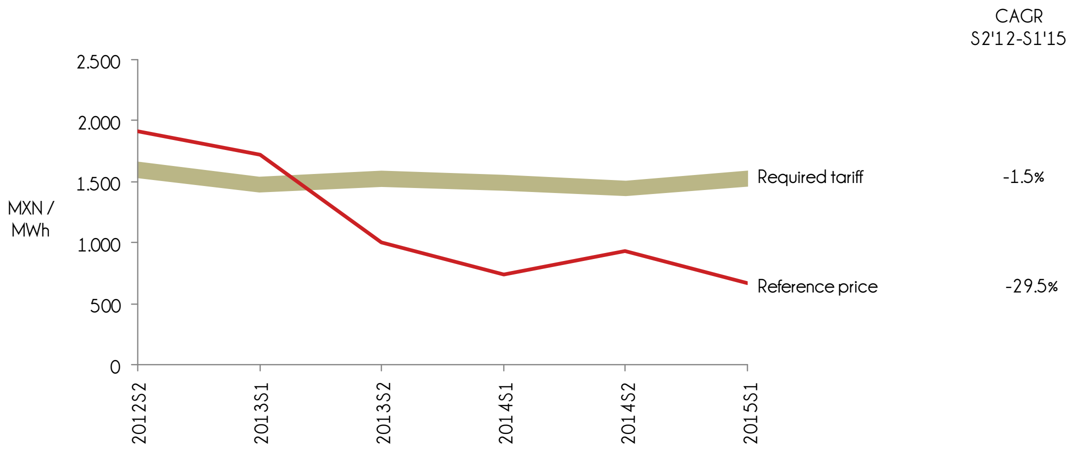
[15] One of the 42 nodes of the simplified model representing the power system in Mexico

[16] Average daylight hours throughout the year in Santa Ana go from 7:00 to 18:00

[17] Average hourly short-term nodal cost (CTCP) at *Sonora Norte* node per semester: continuous line is based on daylight hours; dotted line is based on the 24 hours of a day

Figure 17: Comparison of CTCP-based remuneration and the required tariff for a PV investor in Mexico under a project finance structure (Santa Ana, Sonora)



Note: [a] *Reference price* corresponds to 98% of hourly CTCPs in the node of *Sonora Norte* during daylight hours

* Prices have been adjusted with average exchange rates per semester

Source: CFE; CREARA Analysis

Figure 18: Mexico's Generation Parity Proximity

- In Sonora, generation parity was reached in 2012 and S1 2013 with electricity prices clearly higher than the *required tariff* for a PV investor.

- However, despite PV tariffs falling at an annual rate of 1.5% on average, a major decrease in wholesale market prices has turned the situation upside down.

- With an energy reform underway, the evolution of wholesale market prices (and thus generation parity) is uncertain. It will be interesting to analyze what the picture looks like in 2016 once the energy reform is in place.

- As in the other countries, the PV investment costs (considered in dollars) have decreased in Mexico in the last semesters, but the strong dollar has eliminated the impact on the final results.

3.5 Morocco

3.5.1 Power system and reference price in Morocco

The situation of the power market in Morocco has been revised and no significant differences have been detected with respect to the circumstances described in the previous GPM issue. Moroccan electricity system is organized around the state-owned utility ONEE (Office National de l'Electricité et de l'Eau potable, French acronym) that is vertically integrated along the power system. ONEE is a key player in the wholesale market, possessing its own generation park and acquiring a share of its power needs from IPPs which are granted with concession contracts.

Since 2010, generation and commercialization are open to competition for IPPs producing electricity from renewable energy sources. The framework in place allows Renewable Energy IPPs to contract with eligible consumers, which are those connected to MV (Medium Voltage)[18], HV (High voltage, 60kV) and VHV (Very High Voltage, 150 and 225 kV) levels.

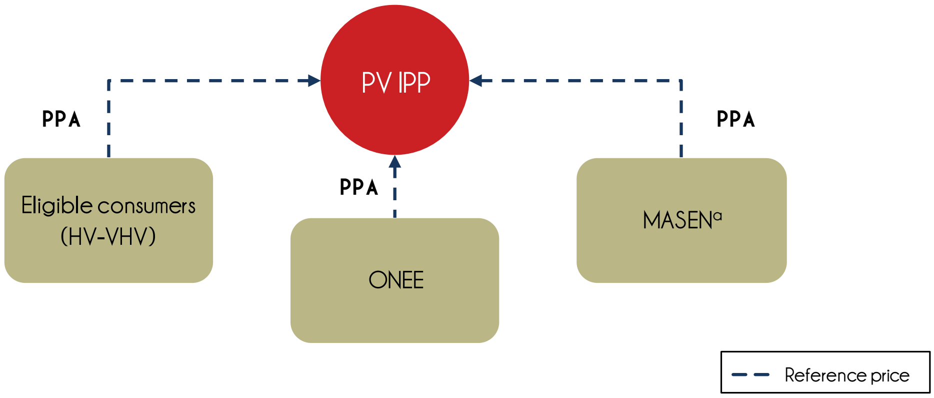
Besides contracting with large consumers and ONEE, a PV IPP could enter the power system through the organized solar tenders of MASEN (Moroccan Agency for Solar Energy)[19].

The following diagram shows the possible trading channels that a PV IPP could envision in Morocco.

[18] However, it is not specifically regulated under which conditions an IPP can be connected on the MV voltage and thus grid connection is subject to negotiation with ONEE

[19] MASEN was created to implement the Moroccan Solar plan pursuing to install 2 GW of solar capacity by 2020 (including CSP and PV)

Figure 19: Trading channels for a PV Producer in Morocco



Note: ^{a} A PPA with MASEN would be granted through a specific tender, as part of the National Solar Plan
Source: CREARA Analysis

The *reference price* to be used for the analysis in Morocco will be based on the energy charge of standard electricity tariffs for the industrial sector (consumers connected to HV-VHV)[20]. These tariffs have been in place since 2009 and have been kept constant since then. However, a scheme of tariff increases was implemented in order to eliminate the subsidies internalized in the tariffs. The increase is split in 4 different steps: August 2014, January 2015 and along 2016 and 2017[21].

Table 2: Electricity tariff for large consumers in Morocco (Grands Comptes, HV-VHV)[22]

Tariff	Rate Periods	Charges
Capacity charge	-	361.04 MAD/kVA/year
Energy charge	Heures de pointe (Peak)	1.14 MAD/kWh
	Heures pleines (Valley)	0.81 MAD/kWh
	Heures creuses (Off-Peak)	0.53 MAD/kWh

Source: ONEE

[20] Only the energy charge is used in the comparison as it is assumed that the contracted capacity stays the same; there are other optional tariff classes existing for HV-VHV consumers but the standard ones have been chosen as the most representative

[21] Depending on the tariff class and the daytime of consumption, the increase will differ; the first two increases have not affected the reference price used for this analysis. Although, for 2017 a total increase of about 5% for HV-VHV standard tariff (*Heure pleine - tariff général*) and 25% for MV standard tariff (*Heure pleine - tariff général*) is expected

[22] Tariff scheme January 2015: *Tariff Général*, without VAT (14%)

The next table presents the consumption periods applicable during the day and for each of the two seasons along the year.

Table 3: TOU consumption periods in Morocco

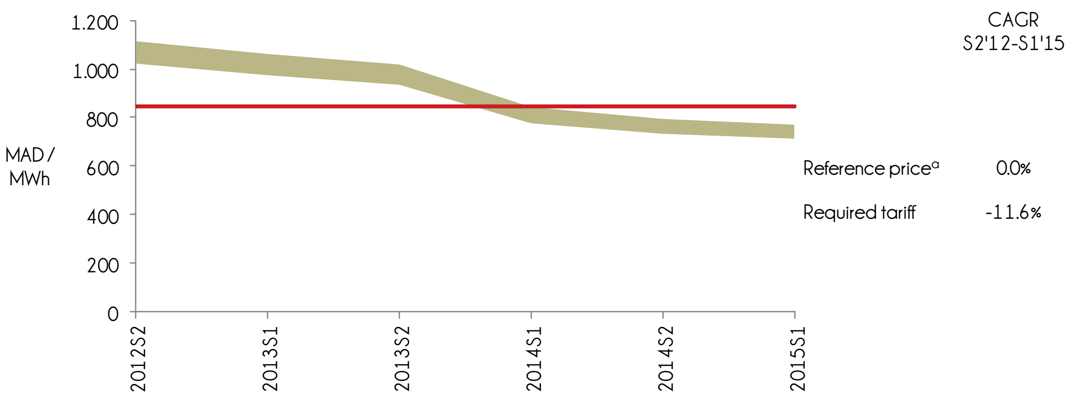
Rate Periods	Winter (October-March)	Summer (April-September)
Heures de pointe (Peak)	From 17h to 22h	From 18h to 23h
Heures pleines (Valley)	From 7h to 17h	From 7h to 18h
Heures creuses (Off-Peak)	From 22h to 7h	From 23h to 7h

Source: ONEE

3.5.2 Generation parity proximity

The evaluation of PV parity is done for the region of Ouarzazate, comparing with industrial (HV-VHV) electricity tariffs.

Figure 20: Comparison of electricity tariffs for industrial consumers (HV-VHV) and the required tariff for a PV investor in Morocco under a project finance structure (Ouarzazate)[23]



Note: [a] The reference price represents the compound average according to TOU tariffs during daylight hours

* Prices have been adjusted with average exchange rates per semester

Source: ONEE; CREARA Analysis

[23] For Morocco, the comparison has been performed against a regulated tariff, instead of the market. Therefore, a lower cost of equity has been assumed (See Cost of equity)

Figure 21: Morocco's Generation Parity Proximity

- Morocco has reached generation parity, as the *required tariff* for a PV investor is below than *reference prices* for industrial consumers.
    - High irradiation levels and the continuous decrease in PV prices have compensated for the subsidized rates.
- The foreseen tariff increases until 2017 should push *generation parity* proximity significantly.
- The initial PV investment costs have decreased significantly in Morocco since the last issue. If the exchange rate had been more favorable, the impact on the final result would have been stronger.

3.6 South Africa

3.6.1 Wholesale market and reference price in South Africa

The power system in South Africa is operated by the vertically integrated state-owned monopoly, ESKOM. The market is open for the participation of private investors through the options explained below:

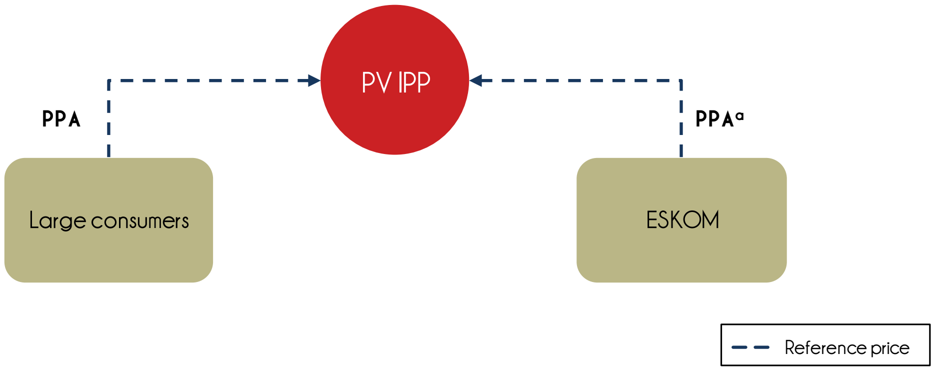
- National utility: ESKOM can contract with private generators to cover part of its electricity procurement needs.
- Bilateral market: Where IPPs can arrange energy transactions with large consumers.
- REIPPPP program: The REIPPP program (Renewable Energy Independent Power Producer Procurement Programme) has been designed to contribute to the target of South Africa to achieve 3.7 GW of renewable energy, of which 1,450 MW are dedicated to PV. The capacity is allocated through technology specific tenders driven by the DoE (Department of Energy). A generator winning the bid is granted a 20 year contract with ESKOM.

It is important to mention that there are some regulatory provisions applicable for any IPP entering the system, what facilitates the penetration of large-scale renewable energies, including PV. These include:

- Net-metering, allowed for on-site self-consumption for clients connected at MV (Medium Voltage) level and above.
- Wheeling services, to provide access between a generator and an off-taker to facilitate energy trading (limited for installations <300 MW).
- Energy bank, to recognize occasional surplus between generation and consumption than can be used as energy credits for future supply by ESKOM (banking arrangements are agreed on a case-by-case basis).

With this framework in mind, the next diagram synthesizes the specific trading channels available for a PV IPP.

Figure 22: Trading channels for a PV Producer in South Africa



Note: ª PPA contracts with ESKOM can arise from the initiative to cover its procurement needs or allocated through REIPPPP tenders

Source: CREARA Analysis

Due to the complexity of having information on the very few contracts signed by ESKOM with private generators, the *reference price* for this case study has been defined as the regulated WEPS tariff (Wholesale Electricity Pricing System). WEPS rates are equivalent to the active energy charges of regulated tariffs for large consumers connected to high voltage (the so-called Megaflex tariff) adjusted for losses and reliability service charges.

The next table shows TOU electricity tariffs relevant for wholesale trade.

Table 4: TOU electricity tariffs for wholesale in South Africa (WEPS)

Rate Periods	High season (June-August)	Low season (September-May)
Peak	217.77 ZAR c/kWh	68.70 c/kWh
Standard	63.53 ZAR c/kWh	46.18 c/kWh
Off-Peak	32.91 ZAR c/kWh	28.03 c/kWh

Source: ESKOM

Table 5: Hour periods for TOU tariff in South Africa

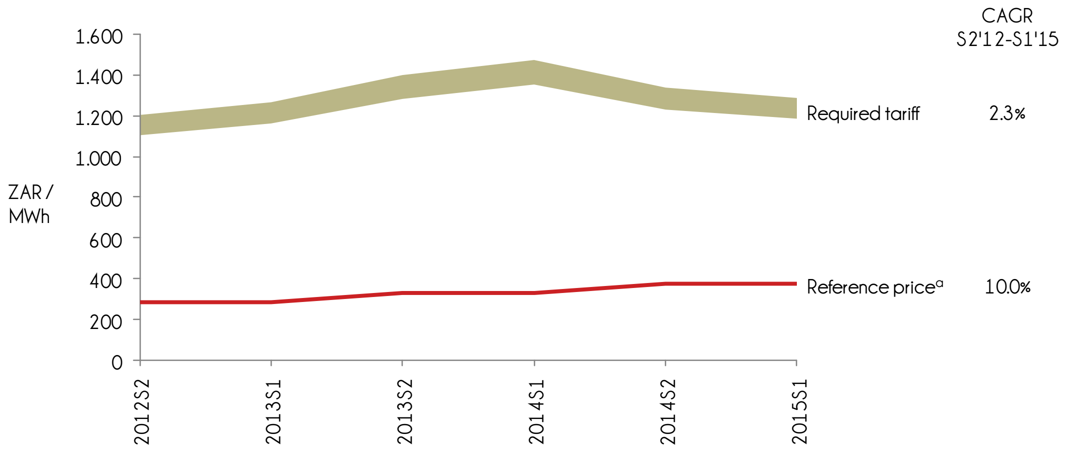
Rate Periods	Hour period
Peak	7:00-10:00, 18:00-20:00
Standard	6:00-7:00, 10:00-18:00, 20:00-22:00
Off-Peak	22:00-6:00

Source: ESKOM

3.6.2 Generation parity proximity

The case of PV parity in South Africa considers a PV installation near the zone of Aggeneys (Northern Cape). The *required tariff* is compared with wholesale electricity tariffs.

Figure 23: Comparison of large consumer tariffs and the required tariff for a PV investor in South Africa under a project finance structure (Aggeneys, Northern Cape)



Note: * Prices have been adjusted with average exchange rates per semester
Source: ESKOM; CREARA Analysis

Figure 24: South Africa's Generation Parity Proximity

- Despite high irradiation levels and a favorable asset depreciation scheme (3 years) the *required tariff* does not reach generation parity in South Africa, driven mainly by the low wholesale electricity prices (less than 3 c EUR / kWh).
  - Since the beginning of 2014, there has been a decreasing trend in the *required tariff* rate though and the reference price is increasing by 10% per year on average.
- As in the other countries, CAPEX has decreased in South Africa in the last semesters (by over 20%), but the strong dollar has eliminated the impact on the final results.

3.7 Turkey

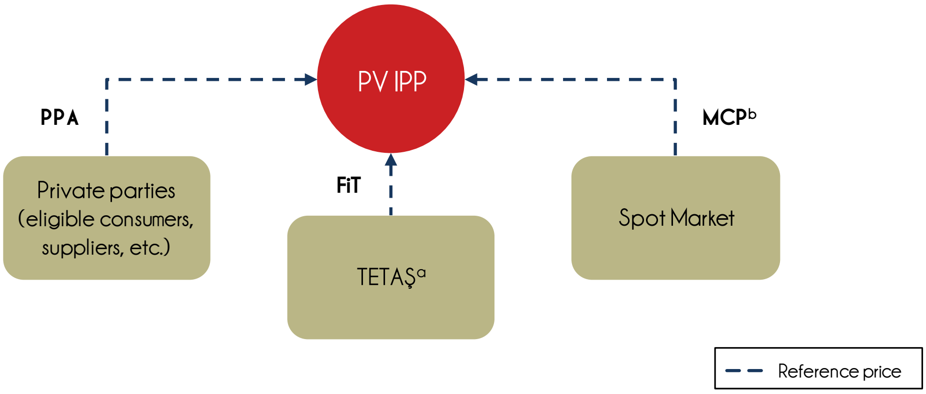
3.7.1 Wholesale market and reference price in Turkey

The power system in Turkey has undergone a series of structural changes in the last three decades, towards a liberalized and privatized sector. At present, competition exists in all activities of the power market.

Wholesale electricity trading in Turkey is carried out through the power exchange (representing a low share of electricity commercialization, around 15%) or the OTC market. In the latter, private and public agents negotiate on a bilateral basis[24].

For a PV IPP, the potential sales channels are summarized in the figure below:

Figure 25: Trading channels for a PV Producer in Turkey



Note: ᵃ The contract that an IPP would establish with TETAŞ would be based under the FiT scheme
ᵇ Market Clearing Price of day-ahead market

Source: CREARA Analysis

- At present, a series of regulatory and economic schemes are in place to boost the penetration of renewable energy. One of the most important ones is the FiT that is granted to renewable IPPs during 10 years (ex-post to having access to the grid[25]). The scheme is accessible for projects in operation before the end of 2015. The FiT for solar is 13.3 USD c/kWh. A premium based on local content (up to 6.2 USD c/kWh) is also given on top of the FiT.

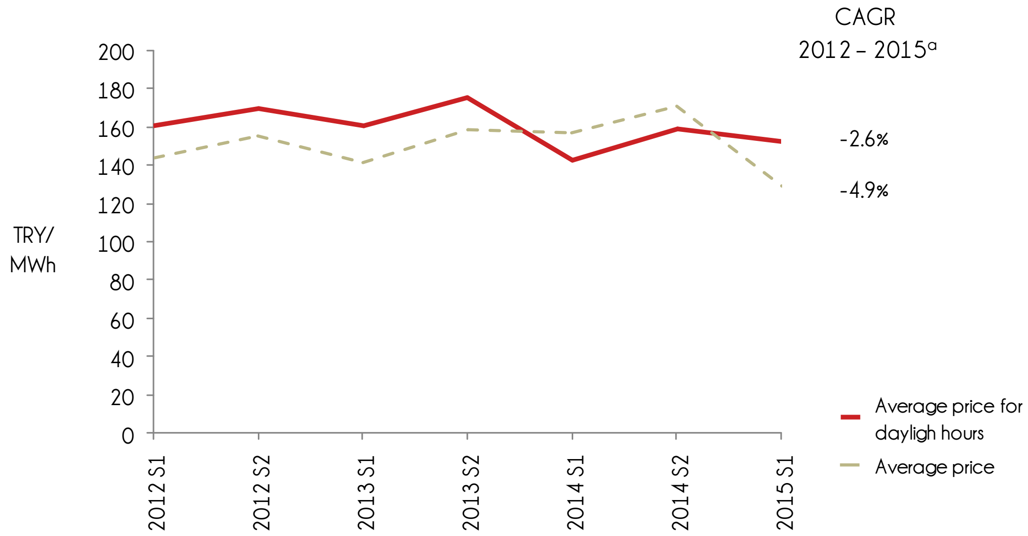
[24] Regarding pubic agents, TETAŞ is the state-owned wholesale company operating in the market

[25] Generation is granted based on the existence of a permit for grid connection

The *reference price* chosen for this analysis is based on the hourly MCPs (Market Clearing Price) of the day-ahead market during daylight hours[26]. One should bear in mind that this is deemed as *reference price* to perform the assessment of PV generation parity, without considering specific economic incentives. In reality, a PV investor would intend to participate in the FiT scheme that is above spot prices of the day-ahead market.

The next figure shows the evolution of MCPs of the day-ahead market in the power exchange, which is in operation since December 2011.

Figure 26: Evolution of MCP prices in Turkey[27]



Note: ª The CAGR for 2015 includes MCPs until the month of July

Source: PMUM; CREARA Analysis

An additional feature of the system to take into consideration is that the connection of utility-scale PV (or any other technology) is limited by the available network capacity determined by the TSO, TEİAŞ[28]. If the demand for connection capacity in a specific substation exceeds

[26] Daylight hours correspond to the period from 7:00 to 17:00, on average throughout a year in the zone of Karaman

[27] Average hourly MCPs of the day-ahead market per semester: continuous line is based on daylight hours; dotted line is based on the 24 hours of a day

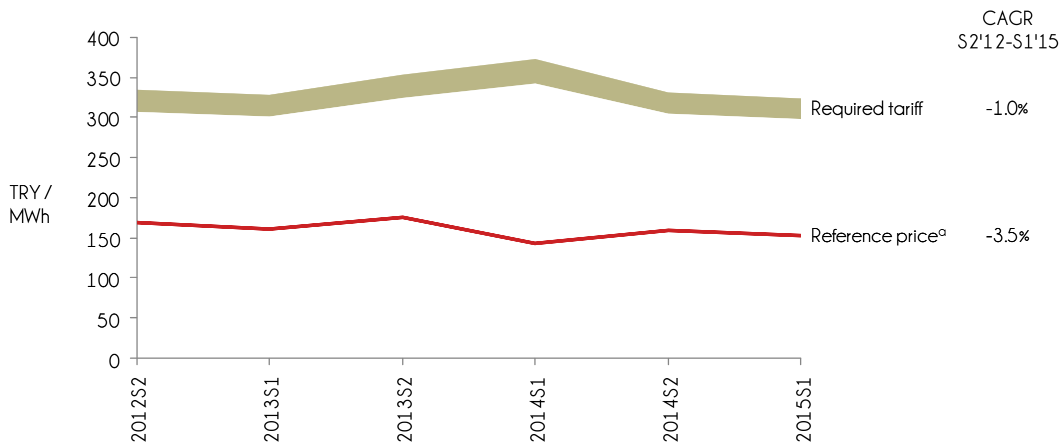
[28] Connection capacity for 2013 was 600 MW, of which only two connection licenses for installations of 5 MW and 8 MW have been assigned

the available capacity, an auction would be held among applicants. Renewable energy benefits from priority of connection.

3.7.2 Generation parity proximity

Generation parity in Turkey is assessed for the zone of Karaman, comparing against spot market prices.

Figure 27: Comparison of hourly DAM prices of the spot market and the required tariff for a PV investor in Turkey under a project finance structure (Karaman)



Note: [a] *Reference price* corresponds to the MCPs of the day-ahead market for daylight hours
* Prices have been adjusted with average exchange rates per semester

Source: PMUM; CREARA Analysis

Figure 28: Turkey's Grid Parity Proximity

- In Turkey, PV technology is far from being competitive in the utility scale segment although wholesale electricity prices are not low:
  - Despite of the significant decrease of PV investment prices, the required tariff is far from the selected reference price.
  - Turkey presents a high CPI rate, which is expected to continue at similar levels in the midterm and hinders the investment case.
  - A relatively high discount rate (which reflects the high return required by equity holders) is also a barrier to reach PV generation parity.

- Initial investment costs (considered in dollars) in Turkey have decreased significantly in the last semesters. Although the impact on the final results has been reduced, give the strong position of the dollar.

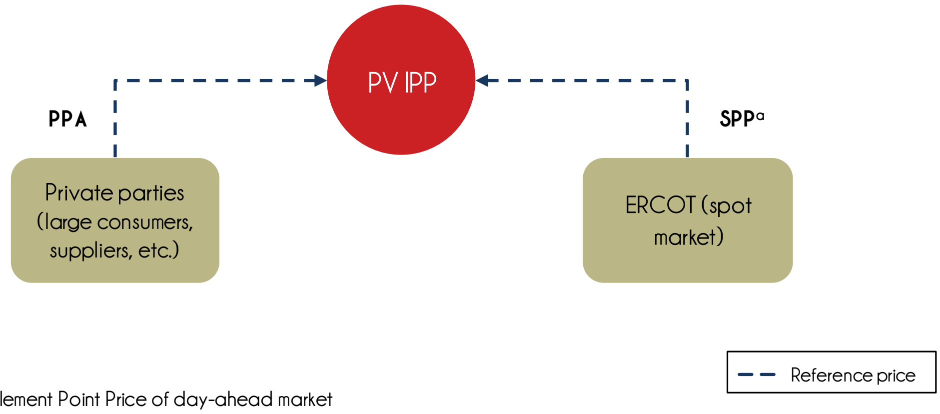
3.8 USA

3.8.1 Wholesale market and reference price in USA

The US power system has specific characteristics depending on the state that is being analyzed. For this study, the case of Texas will be evaluated, specifically the region corresponding to the ERCOT market.

The Texas market is liberalized so that private actors can trade energy freely through bilateral contracts and also through the spot market. The specific trading options for a PV IPP are shown in the figure below.

Figure 29: Trading channels for a PV Producer in Texas



Note: [a] Settlement Point Price of day-ahead market
Source: CREARA Analysis

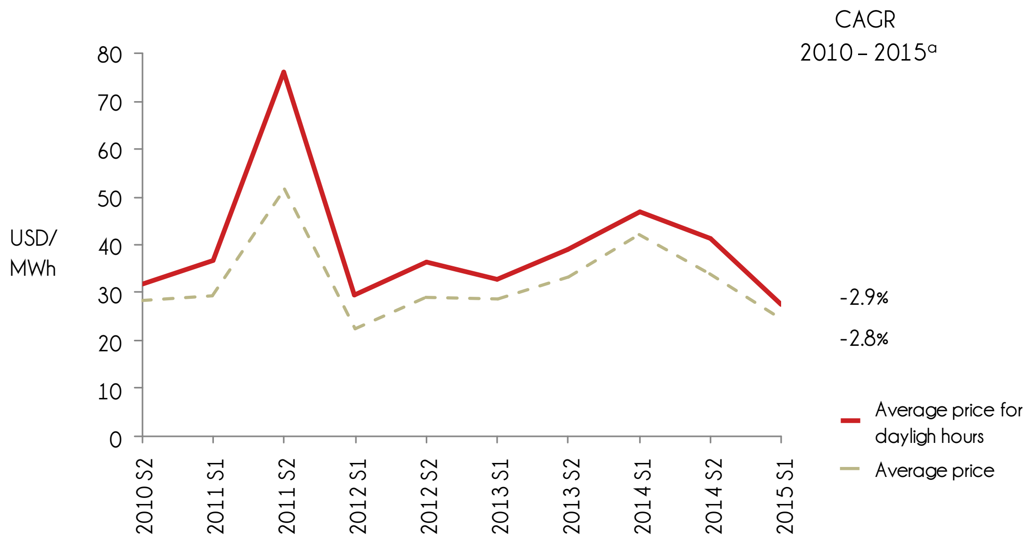
There are renewable-energy-specific incentives that promote the adoption of clean technologies in the energy mix. Some of these are state-based incentives, while others are applicable at the federal level. For the latter case, one of the main ones is the Investment Tax Credit (ITC) that grants corporate tax credits equal to 30% of expenditures[29].

The chosen sales channel for the PV IPP of the case study is the spot market. This market is dispatched based on a model that draws LMPs (Location Marginal Prices), which are later aggregated by zone, the so-called SPPs (Settlement Point Prices). The selected zone to assess the *reference price* corresponds to the region of Midland, therefore the *reference price* is the hourly SPP of the day-ahead market that is aggregated for the West Hub. As in the previous cases, the values that match daylight hours are taken.

[29] The 30% credit is available for PV plants starting operation by the end of 2016 at the latest. After this date, it will be reduced to 10%

The next chart shows the evolution of these prices for the West Hub since the beginning of the functioning of the day-ahead market (December 2010). It shows that in the second semester of 2011 there was a price spike driven by a prolonged heat wave that occurred during August combined with the shortage of operating reserves. This was reflected in the spot prices of the day-ahead market in the West Hub that reached over 2,000 USD/MWh for some hours along that month. During the last two semesters of this analysis, prices have decreased.

Figure 30: Evolution of day-ahead SPP prices in the West-Hub of ERCOT market[30]



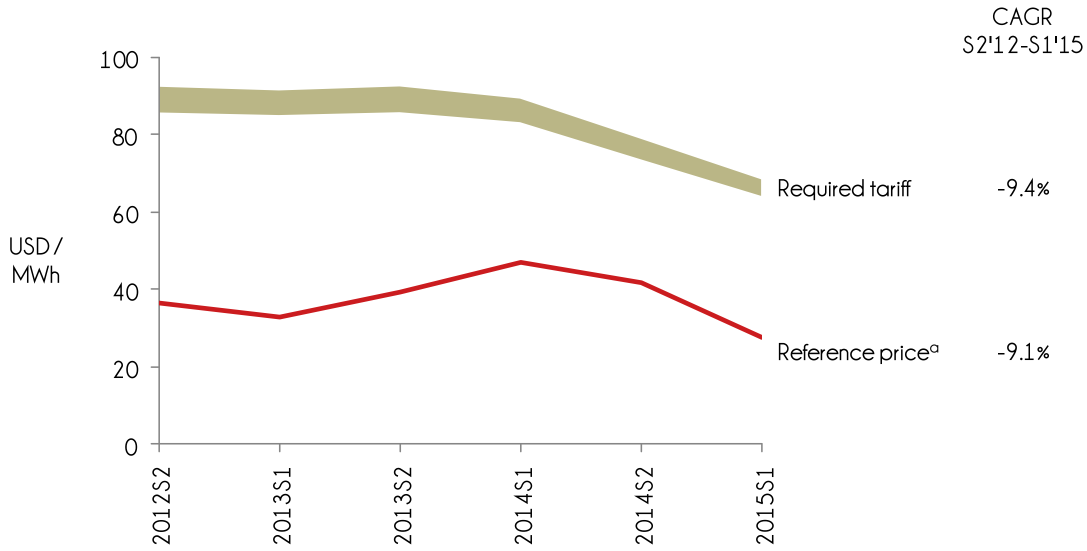
Note: ª The CAGR covers from December 2010 (start of operation of ERCOT's DAM) until the month of July 2015
Source: ERCOT; CREARA Analysis

3.8.2 Generation parity proximity

PV Parity in Texas is calculated for the zone of Midland, considering a merchant plant that is selling 100% in the ERCOT.

[30] Hourly SPP (Settlement Point Prices) of the West Hub in the day-ahead market of ERCOT: continuous line is based on daylight hours (average along a year from 7:00 to 19:00); dotted line is based on the 24 hours of a day

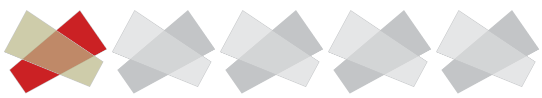
Figure 31: Comparison of hourly day-ahead market prices of ERCOT's spot market and the required tariff for a PV investor in Texas under a project finance structure (Midland), USA



Note: [a] *Reference price* corresponds to hourly DAM prices of ERCOT's spot market for daylight hours

Source: ERCOT; CREARA Analysis

Figure 32: Texas' Generation Parity Proximity



- Although the *required tariffs* for a PV investor in Texas has been below 100 USD/ MWh in the last years, which represents one of the lowest PV rates analyzed in this study, and is further decreasing, PV generation parity is still distant.
  - The positive impact of ITC and low discount rates do not compensate medium irradiation levels and low wholesale electricity prices in the ERCOT market.
- The increasing trend in electricity rates which was identified in the last issue could not be seen in the last semesters where electricty rates have decreased balancing out the clear decrease in the required PV tariffs.
  - Even though PV utility-scale is not competitive in the spot market, this PV rate may allow achieving PPA contracts with large consumers or utility companies willing to secure electricity prices in the long term.

4

Methodology

4 Methodology

This Section includes a description of the main assumptions of the analysis and justifies the inputs used in the financial model. The methodology is identical to the one used in the issue of the GPMU. The case under analysis is based on a 50 MWp on-grid PV system without storage. For each of the eight countries, the analyzed location corresponds to a zone with high irradiation and with existing transmission network in proximity.

The purpose of this study is to evaluate PV generation parity proximity. This assessment is carried out from the perspective of an IPP selling electricity to a pertinent off-taker (e.g. the power exchange or an industrial consumer), according to the structure and characteristics of the power system.

The electricity sold by the IPP would be valued at a *reference price*[31] that corresponds to the one that any other entity selling electricity under similar trading conditions would charge (and without any specific economic support scheme such as a FiT). It is assumed that 100% of the electricity is sold under the chosen trading scheme, i.e. the day-ahead market (or equivalent) of the power exchange or large consumer tariffs.

Generation parity will be achieved when the aforementioned *reference price* is equal to the theoretical tariff that meets the investor's requirements. In order to invest his capital, the IPP will demand that the profitability of the PV project equals at least his equity requirements for that specific project and location. This *required tariff* is calculated based on the main financial statements (P&L and cash flows) of the PV installation. The PV project is considered under a project finance structure. We assumed that this required tariff will increase 2% annually.

The variables that are paramount to derive the *required tariff* are the following:

- Average PV system lifespan
- Initial equity investment
- O&M costs
- Income taxes
- Loan payment

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[31] Refer to *Introduction, A Note on Reference Prices*

- PV-generated electricity over the system's lifespan
- Cost of equity

For a given PV system, the rate used to discount back the economic factors will define whether it is expressed in nominal or real terms:

- Nominal terms: when constant values in nominal currency are used (each years' number of current Dollars, or the applicable local currency if different from Dollar), unadjusted for the relative value of money.
- Real terms: when using a constant value expressed in the local currency corrected for inflation, that is, constant currency of one year in particular.

In this analysis, nominal terms are considered.

The research of the study has been completed with the collaboration of local experts[32]. Additionally, CREARA has been supported by national solar associations that have validated the economic and financial information used as model input and assumptions for their respective countries.

Table 6: Partner Associations

Country	Association
Chile	ACERA - Chilean Renewable Energy Association (Asociación Chilena de Energías Renovables)
Mexico	ANES - Mexican Solar Energy Association (Asociación Nacional de Energía Solar)
Mexico	ASOLMEX – Mexican PV Energy Association (Asociación Mexicana de Energía Solar Fotovoltaica)
Honduras	AHPER – Honduran Renewable Energy Association (Asociación Hondureña de Productores de Energía Renovable)

[32] Refer to Annex: PV GPM Utility-scale collaborators

4.1 Inputs from Primary Sources

In order to assess the investment and O&M costs for a large scale PV plant, a group of PV EPC companies operating in the countries subject to analysis was consulted.

4.1.1 Investment cost

Investment costs correspond to those that would be incurred by an EPC (Engineering Procurement and Construction) company developing an on-grid 50 MWp PV plant. These include mainly: equipment costs (PV modules and BOS elements), site preparation, civil work, installation, interconnection, logistics, workforce, project development, engineering, etc. The main project specifications that consulted EPC companies have been asked to consider include:

- Typical installation components (c-Si modules, inverters, structures, metering and monitoring devices, etc.).
- Single-axis tracking, inclined axis system.
- Transmission interconnection (assuming a reasonable distance to the substation for connection[33] and that there are no costs related to expansion or reinforcement of the grid).
- Project development (technical studies, permits, etc.).
- Structuring costs of project finance (advisors, bank fees, etc.).
- Self-development through an integrated EPC contract[34].

It is worth mentioning that the prices collected in the consultation are real and reflect a competitive situation, but they are not intended for aggressive pricing strategies.

[33] The distance until the interconnection point is assumed to be lower than 7 km for all the countries except for Italy, where the distance is lower than 3 km

[34] This implies that the EPC developer is not intending to sell the plant to a third party but to own and operate the plant itself, thus no market standard margin from the EPC development has been included

For each location, inputs on the investment cost vary depending on two different scenarios: a best-case scenario, with the lowest quotation received; and a worst-case scenario, with the highest quotation received. Both scenarios define the *required tariff* range which is shown for each country.

4.1.2 O&M Costs

O&M costs relevant to run a large scale PV plant over its lifetime are included; these are recurring costs, which consist mainly of:

- Cleaning of PV modules
- HV-MV maintenance
- Insurance
- Land leasing
- Monitoring
- Preventive and corrective maintenance

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).

There are other costs associated to operating the PV plant within a power system or related to the participation in a wholesale market which are not considered in the analysis, such as use-of-transmission-system rates, power exchange fees and system operation costs (management of congestion, losses, reserves, reactive power, etc.)[35].

4.1.2.1 Inverter Replacement

The European Photovoltaic Industry Association (EPIA) (now SolarPowerEurope) 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.

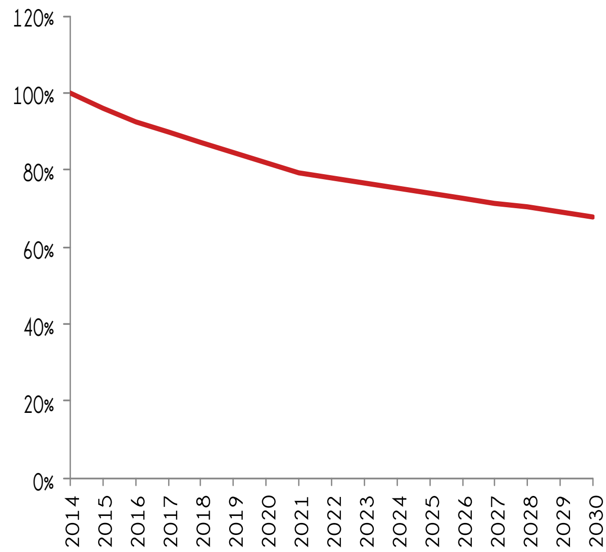
[35] Although no specific consideration has been done for these charges, it should be noted that some of these, as losses and congestion, might be embedded in market prices with a system dispatch considering other economic and system constraints (e.g. nodal prices)

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[36], a 10% learning factor has been assumed for inverters within the utility-scale sector.

The current cost of replacing a PV inverter was derived from collaborating EPC companies as part of the requested O&M costs.

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[37] as shown in EPIA/Greenpeace Solar Generation VI. As mentioned above, the evolution of inverter prices was calculated with a 10% learning factor.

Figure 33: Current PV Inverter Price and Learning Curve Projection 2015-2030



Source: CREARA Analysis

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, USA's estimated annual inflation rate was applied (go to Section 4.2.5 for more information on inflation rates).

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36 EPIA (2011), *Solar Photovoltaics Competing in the Energy Sector – On the road to competitiveness*

37 Three scenarios were estimated: Reference (worst), Accelerated (average), and Paradigm (best)

4.2 Other inputs and assumptions

4.2.1 Income taxes

Income taxes are a capital issue to take into account in this analysis. When modeling a utility-scale PV project, income taxes are not regular along the project's life. This type of taxes depends on yearly earnings and operation costs, interest expenses, depreciation for tax purposes and tax losses of past years. Especially in the first years of operation, accelerated depreciation schemes can be particularly relevant.

In order to estimate the right income taxes for each country, actual cash flows were estimated under a project finance structure. The main variables impacting the income taxes model are explained below.

4.2.1.1 Corporate tax rates

Nominal corporate tax rates for each of the analyzed countries:

Table 7: Corporate Tax Rates (2015)[38]

Country	Corporate Tax Rate
Chile	22.5%
Honduras	30.0%
Italy	31.4%[39]
Mexico	30.0%
Morocco	30.0%
South Africa	28.0%
Turkey	20.0%
USA (Texas)	35.0%

[38] Source: KPMG and GSE

[39] I"Robin Hood tax" of 6.5% has been eliminated

4.2.1.2 Depreciation

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

Each of the countries under analysis present different accounting rules regarding depreciation of assets. Some of them have implemented fiscal provisions that allow depreciating investments in a shorter time and in some cases[40], following a declining balance method. Thus, the depreciation period for tax purposes for each country is as follows:

- Chile: It is possible to apply a linear depreciation for a reduced period of 3 years.
- Honduras: A standard machinery depreciation period of 10 years has been applied (PV-specific depreciation terms have not been published so far).
- Italy: The depreciation is evenly spread over a 25-year period.
- Mexico: A fiscal incentive for renewable energy allows to use accelerated depreciation for renewable energy investments; 100% of modules' investment cost can be deducted in year one. The rest of investment costs are deducted in 20 years.
- Morocco: Straight-line depreciation method is used over a period of 20 years.
- South Africa: An accelerated depreciation allowance (50% rate to apply in the first year, 30% in the second and 20% in the third) is available for photovoltaic generation. Moreover, this depreciation allowance is expected to be increased in the coming years.
- Turkey: A linear depreciation applies typically over a period of 10 years.
- USA: Under the federal MACRS (Modified Accelerated Cost-Recovery System), businesses may recover investments in renewable energy technologies through

[40] Some of these are applicable for renewable-specific investments

depreciation deductions. The depreciation is applied for the case under analysis at the following rates[41]: 35%, 26%, 15.6%, 11.01%, 11.01% and 1.38%.

4.2.1.3 Tax losses

A tax loss is defined as a loss suffered by a corporation that can be set against future profits for tax purposes. Depending on the country and the company's decision, tax losses can be carried forward for future years or carried back and be used to claim it against a tax liability from a previous year. In the GPM study, only the case of carrying tax losses forward has been considered.

Depending on the country, tax losses can be carried forward during a specific period of time:

Table 8: Tax Loss Periods (2015)[42]

Country	Period (years)
Chile	Unlimited
Honduras	3
Italy	Unlimited[43]
Mexico	10
Morocco	4
South Africa	Unlimited
Turkey	5
USA (Texas)	20

4.2.2 Cost of debt

It is considered that the investment is financed through project finance and that the debt-equity ratio is 70/30. The loan is based on constant payments and a constant interest rate and has a tenor of 15 years. The interest rates for each country´s national currency were included in the analysis:

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[41] Depreciation rates depend on the start of operation with respect to the year; for the analysis it has been assumed that the plant starts operating at the beginning of the year, i.e. first quarter

[42] Source: KPMG and GSE

[43]Although Italy presents important particularities on tax losses, they are not applicable to this GPMU's Italian case according to its P&L result and estimated cash flows

Table 9: Interest rates (pre-tax) S1 2015 [44]

Country	Interest Rates
Chile	7.3%
Honduras	11.1%
Italy	4.2%
Mexico	9.4%
Morocco	8.0%
South Africa	11.0%
Turkey	10.0%
USA	5.4%

4.2.3 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.

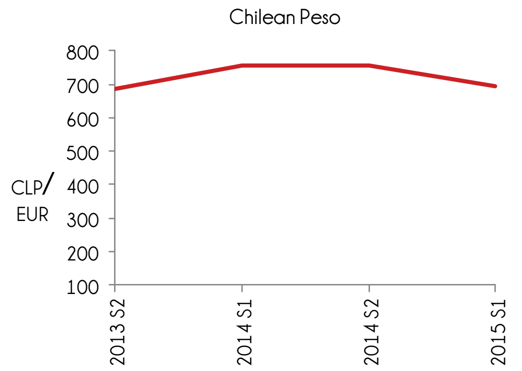
Although usually some positive value is recognized as pre-tax income at the end of the life of the PV system, this analysis considers no salvage value in order to use conservative estimates.

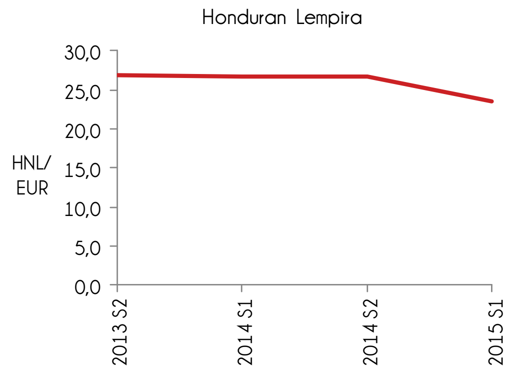
4.2.4 Exchange Rate

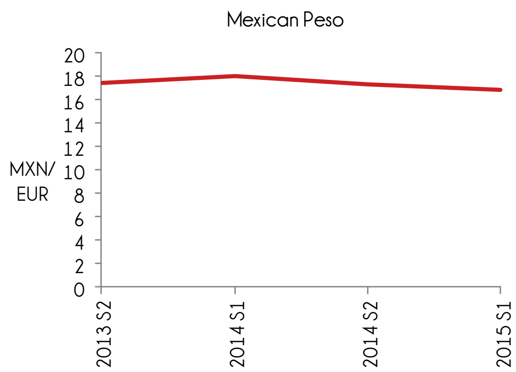
In this report, all costs are expressed in each country's national currency. When necessary, the following exchange rates (number of foreign currency units per Euro) were used in the analysis:

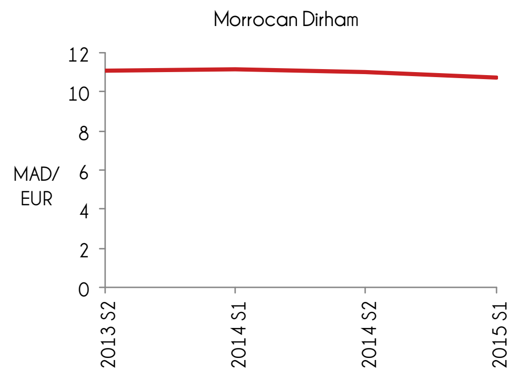
[44] Source: CREARA Interviews; Central bank and monetary authorities

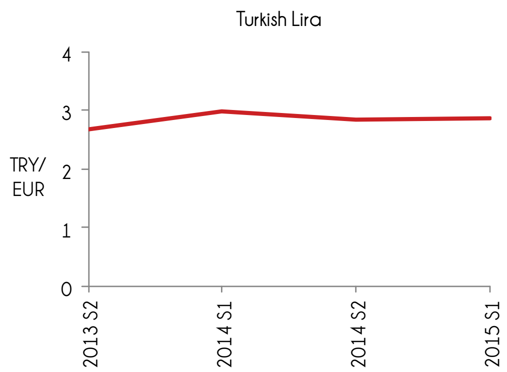
Table 10: Exchange Rates – Foreign Currency Units per Euro[45]

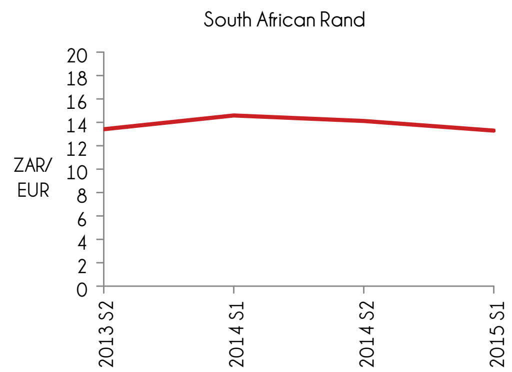


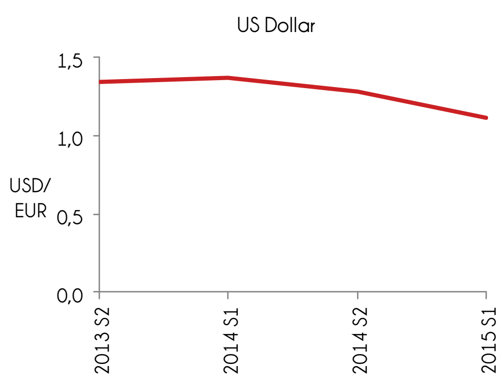












[45] Source: OANDA

4.2.5 Inflation Rate

The estimated inflation rate is taken into account when calculating O&M costs for the 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, when applicable.

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

Table 11: Average Inflation per Country[46]

Country	Historical Inflation Rate (2007-2014)	Estimated Future Inflation Rate
Chile	3.4%	3.0%
Honduras	6.5%	5.3%
Italy	1.8%	1.8%
Mexico	4.2%	3.0%
Morocco	1.5%	2.0%
South Africa	6.3%	5.5%
Turkey	8.2%	6.0%
USA	2.0%	2.0%

4.2.6 Cost of equity

It should be noted that to evaluate the economics of the project, our analysis is performed from the point of view of an IPP investor; i.e., equity holder's cost flows and the cost of equity as discount rate are used.

There are many recognized methodologies to estimate the required rate of return of an asset (e.g., CAPM, dividend discount model or market return adjusted for risk). However, PV merchant plants are

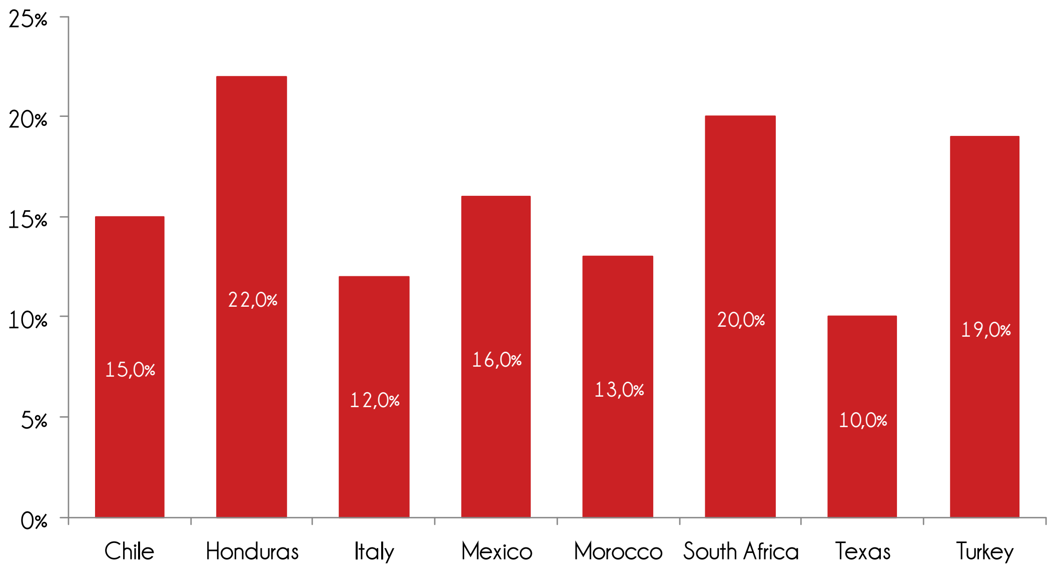
[46] Source: European Central Bank; Focus-economics; Trading Economics; Creara Research, Creara Interviews, IMF

a recent phenomenon and little reliable information is available to estimate or collect the required inputs which those methods need.

Therefore, a programme of interviews with PV and financial experts was conducted in order to collect actual values of cost of equity that PV investors would ask for when investing in a merchant plant in the analyzed countries. In the Moroccan case, as no spot market is available, the cost of equity which is required to invest in a PV plant intended to receive a PPA rate is considered.

The cost of equity values considered in this report is shown below:

Figure 34: Cost of Equity per country for a merchant PV plant[47] (S1 2015)



Source: CREARA Interviews; CREARA Analysis

4.2.7 Specific incentives

In Texas, renewable projects can make use of an Investment Tax Credit (ITC) which is granted by the Federal Government. The ITC is recognized as a one-time income tax credit which decreases current tax expenses at the investor level.

For the PV project analyzed in this GPM issue, the credit would be equal to 30% of the CAPEX expenditures, with no maximum limit in monetary terms. After the credit is computed, the basis for depreciation purposes of the PV plant is adjusted by reducing its value a 50% of the ITC amount. The generation asset must be operational within the year in which the credit is first taken.

[47] It should be noted that Moroccan cost of equity represented in Figure 34 is not estimated for a merchant plant but for a PPA contract

4.2.8 PV System Economic Lifetime

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

- Most of the reports consulted[48] consistently use 25 to 35 years for projections.
- Moreover, PV Cycle[49], European association for the recycling of PV modules, estimates the lifetime of a PV module to be greater than 30.

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.

4.2.9 PV Generation

In order to estimate the annual PV generation of a 50 MWp installation in each of the 8 locations, the following variables were defined:

- Local solar irradiation
- Degradation rate
- Performance ratio

4.2.9.1 Local Solar Irradiation

Solar resource estimates used in the analysis correspond to global in-plane irradiation for single-axis tracking with inclined axis and no backtracking. These are summarized in the following Table:

[48] (Not exhaustive) Studies quoted in K. Branker et al. (2011), *Renewable and Sustainable Energy Reviews 15*, 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

[49] http://www.pvcycle.org/pv-recycling/waste-prognosis/

Table 12: Irradiation on a plane tilted at latitude with single-axis tracking (kWh/m²/year)[50]

Country	Location	Irradiation
Chile	Diego de Almagro	3,669
Honduras	Nacaome	2.800
Italy	Pomezia (Rome)	2,366
Mexico	Santa Ana (Sonora)	3,162
Morocco	Ouarzazate	3,326
South Africa	Aggeneys (Northern Cape)	3.403
Turkey	Karaman	2,629
USA	Midland (Texas)	2,282

These 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[51].

Worldwide, the global in-plane irradiations estimated with this methodology have an uncertainty of approximately 5-6% depending on the site, due to factors such as quality of inputs regarding atmospheric conditions[52], simulation accuracy of cloud transmittance derived from satellite data, geographical conditions of the site, etc.

[50] Source: SolarGIS' pv Planner

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

[52] 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

4.2.9.2 Degradation Rate

The degradation rate (d) of the PV system, determined by the degradation of the PV module, 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[53].

- 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[54].

- More recent research concludes that currently c-Si annual degradation rate is near 0.5%[55].

- 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[56]).

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

4.2.9.3 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 or trackers, among others.

For this analysis, an average system performance ratio of 75% will be assumed in all locations, based on the following sources:

- The Fraunhofer Institute for Solar Energy Systems (ISE) investigated[57] the PR of more than 100 PV system installations.

[53] 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*

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

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

[56] *SunPower Limited Product and Power Warranty for PV Modules*

- Annual PR was between ~70% and ~90% for the year 2010.
  - SolarGIS' pvPlanner estimations range between 72% and 80% in the analyzed spots.
  - Moreover, experts of the sector, including EPC companies collaborating in the study were consulted, concluding that an average PR of 75% was a reasonable estimate for a large scale PV plant as the one considered.

[57] 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

5
Annex: PV GPM Utility-scale collaborators

5 Annex: PV GPM Utility-scale collaborators

As explained at the beginning of the Methodology section, the research carried out for the study has been completed thanks to the collaboration of local experts from the public and private sector, which have contributed especially for the assessment of the development of large scale PV and the regulatory framework in each of the countries.

The contact information of those collaborators which have agreed to be included in the report is summarized in the following Table.

The relationship between CREARA and these 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 13: GPM Utility-scale Collaborators

Collaborators per Country	
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ACERA – Chilean Renewable Energy Association	
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Contact	Carlos Finat
Website	www.acera.cl
ACESOL – Chilean Solar Energy Association	
Phone	+56 222 47 42 65
Contact	Verónica Munita
Website	www.acesol.cl
ACTIC Consultores	
Phone	+56 223 34 34 56
Contact	Cristian Hermansen
Website	www.actic.cl
ENNERA	
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Contact	Maurizio Colombo
Website	www.ennera.com
STV Investment	
Phone	+34 914 29 88 46
Contact	Luis Sainz
Website	www.stvinvestment.com

Honduras		
	AHPER – Asociación Hondureña de Productores de Energías Renovables	
	Phone	+504 2220 67 31
	Contact	Kevin Rodriguez
	Website	www.ahper.org
Mexico		
	ANES – Asociación Nacional de Energía Solar	
	Phone	+55 56 01 87 63
	Contact	anes@anes.org
	Website	www.anes.org
	ASOLMEX – Asociación Mexicana de Energía Solar Fotovoltaica	
Morocco		
	Dii - International Industrial Network for Desert Power	
	Phone	+ 49 89 340 77 05 - 0
	Contact	info@dii-eumena.com
	Website	www.dii-eumena.com
	RCREEE - Regional Center for Renewable Energy and Energy Efficiency	
	Phone	+20 224 15 47 55
	Contact	info@rcreee.org
	Website	www.rcreee.org
	MAROC RENEWABLES	
	Phone	+212 522 49 10 98
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6

Annex: Abbreviations

6 Annex: Abbreviations

Table 14: Acronyms

Acronyms	Meaning
ACERA	Asociación Chilena de Energías Renovables
AHPER	Asociación Hondureña de Productores de Energías Renovables
ANES	Asociación Nacional de Energía Solar
ASOLMEX	Asociación Mexicana de Energía Solar Fotovoltaica
BOS	Balance of System
CAGR	Compound Annual Growth Rate
CAPM	Capital Asset Pricing Model
CCGT	Combined Cycle Gas Turbine
CDEC	Centro de Despacho Económico de Cargo
CFE	Comisión Federal de Electricidad
CMCP	Costo Marginal de Corto Plazo
CNE	Comisión Nacional de Energía
CP	Country Risk Premium
CPI	Consumer Price Index
c-Si	Crystalline Silicon
CSP	Concentrated Solar Power
CTCP	Costo Total de Corto Plazo
DAM	Day-ahead Market
DEP	Depreciation for tax purposes
DoE	Department of Energy
DSO	Distribution System Operator
ENEE	Empresa Nacional de Energía Eléctrica
EPC	Engineering Procurement and Construction
EPIA	European Photovoltaic Industry Association
ESKOM	Electricity Supply Commission
EU	European Union
FiT	Feed in Tariff
GPM	Grid Parity Monitor
GTM	Green Tech Media
HT	Haute tension
HV	High voltage
IFC	International Finance Corporation
IPEX	Italian Power Exchange
IPP	Indepent Power Producer

Acronyms	Meaning
ISE	Institute for Solar Energy Systems
ITC	Investment Tax Credit
LCOE	Levelized Cost Of Electricity
LMP	Locational Marginal Price
LV	Low Voltage
MACRS	Modified Accelerated Cost-Recovery System
MASEN	Moroccan Agency for Solar Energy
MCP	Market Clearing Price
MER	Mercado Eléctrico Regional
MP	Market risk Premium
MU	Monetary Unit
MV	Medium Voltage
NREL	National Renewable Energy Laboratory
O&M	Operation and Maintenance
ONEE	Office National de l'Electricité et de l'Eau potable
OTC	Over-the-counter
PPA	Power Purchase Agreement
PR	Performance Ratio
PV	Photovoltaic
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
Rf	Risk free rate
RP	Risk premium
SEIA	Solar Energy Industries Association
SIC	Sistema Interconectado Central
SING	Sistema Interconectado del Norte Grande
SPP	Small Power Producer
SPP	Settlement Point Price
THT	Très Haute Tension
TOU	Time-of-use
TR	Tax Rate
US	United States
USA	United States of America
VAT	Value Added Tax
VHV	Very High Voltage
WACC	Weighted Average Cost of Capital
WEPS	Wholesale Electricity Pricing System

Table 15: Units

Unit	Meaning
CLP	Chilean Peso
EUR	Euro
HNL	Honduran Lempira
Km	Kilometer
kV	Kilovolt
kVA	Kilovolt ampere
kW	Kilowatt
kWh	Kilowatt hour
kWp	Kilowatt peak
MAD	Moroccan Dirham
MW	Megawatt
MWp	Megawatt-peak
MXN	Mexican Peso
TRY	Turkish Lira
USD	US Dollar
W	Watt
ZAR	South African Rand

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