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INSTITUTE FOR TECHNOLOGY AND RESOURCES MANAGEMENT IN THE TROPICS AND SUBTROPICS

ANALYSIS OF THE CURRENT PHOTOVOLTAIC ENERGY SITUATION WITHIN NET METERING POLICY IN BRAZIL AND MEXICO: DEFINITION OF BARRIERS AND RECOMMENDATIONS FOR FURTHER ADOPTION

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Abstract

During the last years distributed solar photovoltaic (PV) energy have had an important development around the world, nevertheless its growth in countries like Brazil and Mexico have been small compared to this source potential. Public policies, economical, social and environmental factors play an important role in the further implementation of small scale PV systems. This research project describes the current situation of PV sector within the Net Metering policy in Brazil and Mexico, defining its barriers at different application levels. The methodology is based in a mixed method approach: quantitative questionnaire analysis, qualitative interviews and literature review. As study case, the projects coordinated by IDEAL Institute "50 telhados" and "Fundo Solar" are analyzed from the users point of view in Brazil. The Brazilian PV market evolution is analyzed throughout the 2013 and 2014 IDEAL market studies. An approach from the users and PV market point of view in Mexico is analyzed through qualitative interviews with some of the main stakeholders. One of the principal outcomes this research has is to set recommendations for each of the identified barriers. The investigation also aims to provide a new comprehension about the contribution that distributed PV energy can have for the renewable energy targets defined by each country in the path of energy transition.

Key words: Renewable energy, net metering policy, distributed PV generation.

Resumen

Durante los últimos años, la energía distribuida fotovoltaica (FV) ha tenido un desarrollo importante alrededor del mundo, sin embargo su crecimiento ha sido menor en países como Brasil y México en comparación con el potencial que este recurso tiene. Las políticas públicas y los factores económicos, sociales y medio ambientales juegan un rol importante en la futura implementación de sistemas FV a pequeña escala. Este proyecto de investigación describe la situación actual del sector FV dentro de la política del Net Metering en Brasil y México, definiendo sus barreras en diferentes niveles de aplicación. La metodología está basada con un enfoque mixto: análisis de cuestionarios cuantitativos, entrevistas cualitativas y revisión literaria. Como casos de estudio en Brasil, los proyectos coordinados por el Instituto IDEAL "50 telhados" y "Fundo Solar" son analizados desde un punto de vista de los usuarios. La evolución del mercado FV Brasileño es analizado con los estudios del mercado realizados por IDEAL en 2013 y 2014.El enfoque por parte de los usuarios y el mercado FV en México es analizado a través de entrevistas cualitativas con algunas de las principales partes interesadas. Uno de los resultados principales que esta tesis tiene es la de establecer recomendaciones a cada una de las barreras identificadas. La investigación tiene también como objetivo la de proveer un nuevo entendimiento acerca de la contribución que la energía distribuida proveniente de sistemas FV puede ser para los objetivos establecidos por cada país en el camino hacia la transición energética.

Palabras clave: energía renovable, net metering, generación FV distribuida.

Zusammenfassung

Während der letzten Jahre gewann die dezentrale Energie aus Photovoltaik (PV) weltweit zunehmend an Bedeutung. Jedoch war der Zuwachs in Ländern wie Brasilien und Mexiko gering verglichen zum Potential dieser Ressource. Politische, wirtschaftliche, soziale und Umwelt-Faktoren spielen eine wichtige Rolle bei der zukünftigen Installation von PV-Anlagen im kleinen Maßstab. Diese Masterarbeit beschreibt die aktuelle Situation des PV-Sektors innerhalb der Net Metering Politik in Brasilien und Mexiko und definiert seine Grenzen auf mehreren Anwendungsebenen. Dabei wurden Fragebögen für die quantitative, Interviews für die qualitative Datenerhebung und Literaturrecherche beschreiben genutzt. Als Fallstudie wurden die Projekte, welche vom IDEAL Institut "50 roofs" und "Fundo Solar" koordiniert werden, vom Standpunkt des Verbrauchers in Brasilien analysiert. Die brasilianische Marktentwicklung wurde mittels IDEAL Marktstudien der Jahre 2013 und 2014 analysiert. Ein Ansatz von dem Standpunkt der Verbraucher und des PV Marktes in Mexiko, wurde durch qualitative Interviews mit einigen der wichtigsten Stakeholder analysiert. Eines der Hauptziele dieser Arbeit ist, Empfehlungen für jede identifizierte Grenze zu geben. Die Untersuchung soll zudem verdeutlichen, welchen Beitrag die dezentrale Energie aus PV im Zuge der Energiewende für die Erreichung der Ziele zu erneuerbaren Energien verschiedener Länder leisten kann.

Schlüsselwörter: Erneuerbare Energien, Net Metering, dezentrale PV Generation

Chapter 1. Introduction

Renewable energies at the global scene.

According to the IEA (International Energy Agency) the renewable energies (RE) technologies have been diploid by governments and consumers for three main reasons:

1. To improve energy security;
2. To encourage economic development and high-tech manufacturing;
3. To protect the climate and the wider environment from impacts of fossil fuels use.

Energy security is linked with the availability, affordability and sustainability of the resource, and it is define as the provision of sufficient and reliable energy supplies to satisfy demand at all times at affordable prices, while also avoiding environmental impacts (IEA, 2011).

Nowadays the diversification of energies sources is important to accomplish the availability of it. Making a comparison between the conventional fuels and RE such as solar, we observe that the first ones depend more on its storage, require extraction (finite reserves) and require large infrastructure and transportation, being a centralized source; meanwhile RE are freely available, constantly replenished and do not need extraction since they are a decentralized source and are focused at the medium and micro levels.

The affordability depends mainly on two variables: the price volatility and the price uncertainty (Müller, Brown, & Ölz, 2011). The first one refers to the degree of deviations from the average price that tends to occur; the second one means only the variation of the average price. The fossil energies depends on fuel and its behavior on the market, this is why they are susceptible to the volatility and uncertainty of the resources like oil and coil. RE do not depend on fuels (water, sun, wind) so they are not exposed to these aspects and have the proficiency to keep their market more stable than the first one.

A source of energy that delivers cheap prices but endanger the future of the nations cannot be seen as a secure source. The current patterns of global energy consumption and production are unsustainable due to their dependence on fossil energies and the degradation they cause to the environment such as climate change. RE can make the difference in the short and long term making reductions of the CO_2 emissions.

We are now in the period that some governments called "energy transition", where the nations attempt to depend less on fossil fuels and more in renewable energies. In Mexico and Brazil this transition has still a long way to go to be completed, but the implementation of new public policies including sustainable terms has initiated this transition. Renewable energy targets have emerged as a popular mechanism to set national and regional economies on the path towards a more secure and sustainable energy future (IRENA, 2015).

Within these ideas of energy security, economic development, and energy transition, the contribution of RE at small scale represents a possible solution. Brazil and Mexico have recently added Net Metering policy in order to increase the participation of RE at this scale. From this, PV systems have been the most widely spread among the residential and commercial establishments. During the first years of implementation, where the policy, market and society are playing an important role on the development of it, a number of challenges have appeared hindering the full potential both countries have to completely avail this source as a solution to energy transition.

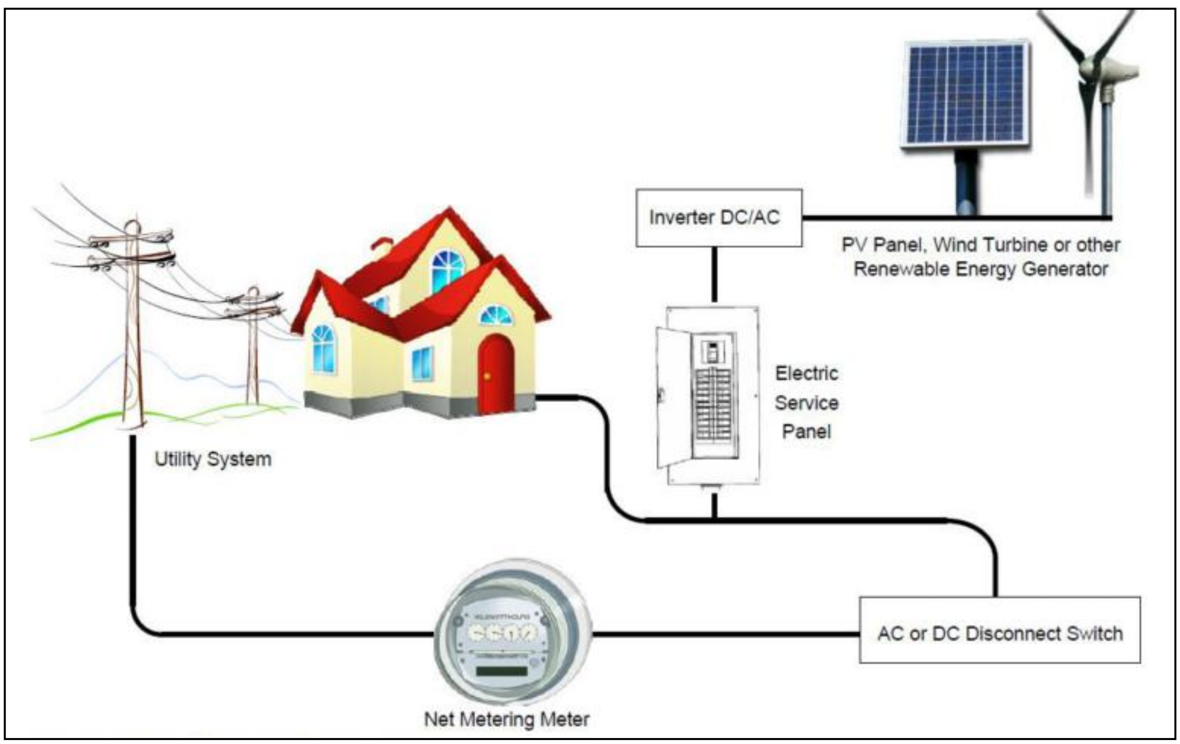
Net Metering implications

Current literature and studies present how RE have been implemented in different countries and the policies used to encourage them. The main international agencies related to these topics include in their annual reports the improvements the sector has, but few of them focus on small scales application and their barriers for further expansion. Nevertheless most of them coincide in the same aspects when referring to the energy policies, where initiatives confront political, economical, scientific, and technological challenges, with far-reaching implications on each of these areas (Carley & Miller, 2012).

From the main energy policies used to encourage self dependence in home power, the Net Metering is one of the most common appliances in different countries, but this wide range of places also tend to vary according to each case, influencing the economics and utility accounts.

Net Metering is a special metering and billing arrangement between a utility and customers (Image 1) who choose to install renewable generation systems like wind turbines and PV panels and interconnect them to the utility (Stadler, Bhandari, & Madeiro, 2010). It allows a better energy proficiency by using first the energy provided by the renewable source and then by balancing the billing for the energy still needed. In the case where exceed energy is produced, this is used as credit for next requirements in most of the cases.

Image 1: Net Metering scheme



Source: (Stadler et al., 2010)

Policies such as Net Metering promote the usage of renewable energies specially PV systems. One of the implications considered for its development are the economic factors such as investment and its return of investment, which determine the economic feasibility of the small scale renewable project (Starrs, 1996). Even if constraints like capacity building, promoting RE, policy framework, and demand for RE technologies are removed, the up-front investment costs will still be higher in most of the cases than the conventional technologies (Stadler et al., 2010). These factors make the market function dependant on the competitiveness and new technology releases at low costs, improvements that PV systems have nowadays and become a more common source of energy.

Non economic factors can also have an important impact on the deployment of RE and Net Metering such as government energy policies against RE and high administrative burdens (Müller et al., 2011). Examples as split incentives policies, large number of permits required when installing renewable sources of energy, bottlenecks in the nation energy legislations and irregularities on the annual budget investment on renewable energies, are just some of the documented barriers by IEA (Müller et al., 2011), but there could be much more yet to explore. The diffusion on information about energy policies within the society, bank or institutions credit financing, new technologies and environmental consciousness are also topics considered in this research.

Objectives

The principal aim of this thesis research is to analyze the current photovoltaic energy situation within Net Metering policy by defining barriers that other authors and the study case have found. Once they are defined, a list of recommendations is given in order to increase the participation of distributed energy with PV systems inside the energy matrix on each country.

The relevance of analyzing the current PV energy situation is to do a link between political, economical, social and technical aspects, understanding them at the macro (national) and micro (PV users and suppliers) scales. Each of these factors impact directly or indirectly in the application of distributed energy within Net Metering policy.

The idea of analyzing these aspects in Brazil and Mexico is to expose how each country have implemented and develop this policy, remarking on the similarities and differences they have. At micro scale, users and PV suppliers apply this policy and from them it is possible to obtain experiences that can be used as an asset for the improvement of it. With all of these aspects included, this research aims to provide a new comprehension about Net Metering and the benefits PV systems at small scale would offer to its users and suppliers, and in general, to achieve a more decentralized generation of energy.

Governmental and non-governmental institutions in Brazil and Mexico are already taking steps to ensure that for the next year's electric energy generation become more sustainable, thus this investigation purpose is to be used as reference for the main stakeholders involved and for further investigations on the topic of distributed energy.

Research approach levels

Macro level analysis

The macro level analysis is attempted to describe the upper level of decision makers. In this part the focus is on the countries exposed in the thesis, Brazil and Mexico. Each country present different approaches on the topics of public policies, economy, technology, social and environmental aspects that will be exposed in order to understand their current overall situation and set possible limitations that both countries have and may impact at small scale.

The economic analysis at the macro level approach searches for the understanding of how economical decisions at this level may impact in the development of PV systems at small scale. Concepts such as economic growth, consumed energy and future energy scenarios are described to understand how the governments act in order to increase the generation of energy trough RE.

The concept analyzed within the technology aspect at the macro level is mainly based on the installed capacity on each country. The study of centralized and decentralized energy generation is also an important factor inside this topic to consider the principal way of supplying the energy to the final consumers.

Political factor is contemplated by describing the main energy policy framework in both countries, understanding how the main energy institutions administrate the energy generation and distribution. The Renewable Energy Targets (RET) established by each government are also explained in this point.

The expected output at this level is to propose recommendations in each topic that might be useful for decision makers, trying to overcome the main barriers that nowadays limit the development of PV systems under this level. These aspects will be reflected at the micro level analysis as well, as a top down approach.

Micro level analysis

The concept studied inside the legal framework is Net Metering policy that has been already applied in both countries with some differences in each one. The evolution and changes implemented to this policy are described in order interpret the current function situation.

The micro level analysis also pretends to study the application of this policy at the final energy consumer sector such as householders and small businesses. In the other hand, private sector and PV suppliers are also taken into account. This level will be analyzed with the same framework as in the macro level analysis but considering different concepts regarding only in this level, focusing on the policy procedures, contracts and time. Another important aspect to analyze is the contribution of this scale in the total electricity generation, understanding the importance and reach the Net Metering have in each country.

Study case

Two projects are analyzed under the perspective of PV users in Brazil: “50 telhados” and “Fundo Solar”. For the PV suppliers’ point of view, the studies done by the IDEAL Institute in 2013 and 2014 are taken into account. The case of

Mexico is revised through interviews with some of the main stakeholders involved in the topic. Further information of the methodology is described in chapter 4.

The prime objective for this analysis is to find the main barriers final users and PV suppliers are having with the implementation of Net Metering at the different aspects such as economical, procedural, and technological. The expected output on this level is to propose recommendations based on the experiences reported by this sector that may improve the general application of this policy. A schematic representation of the thesis research is exposed on Figure 1.

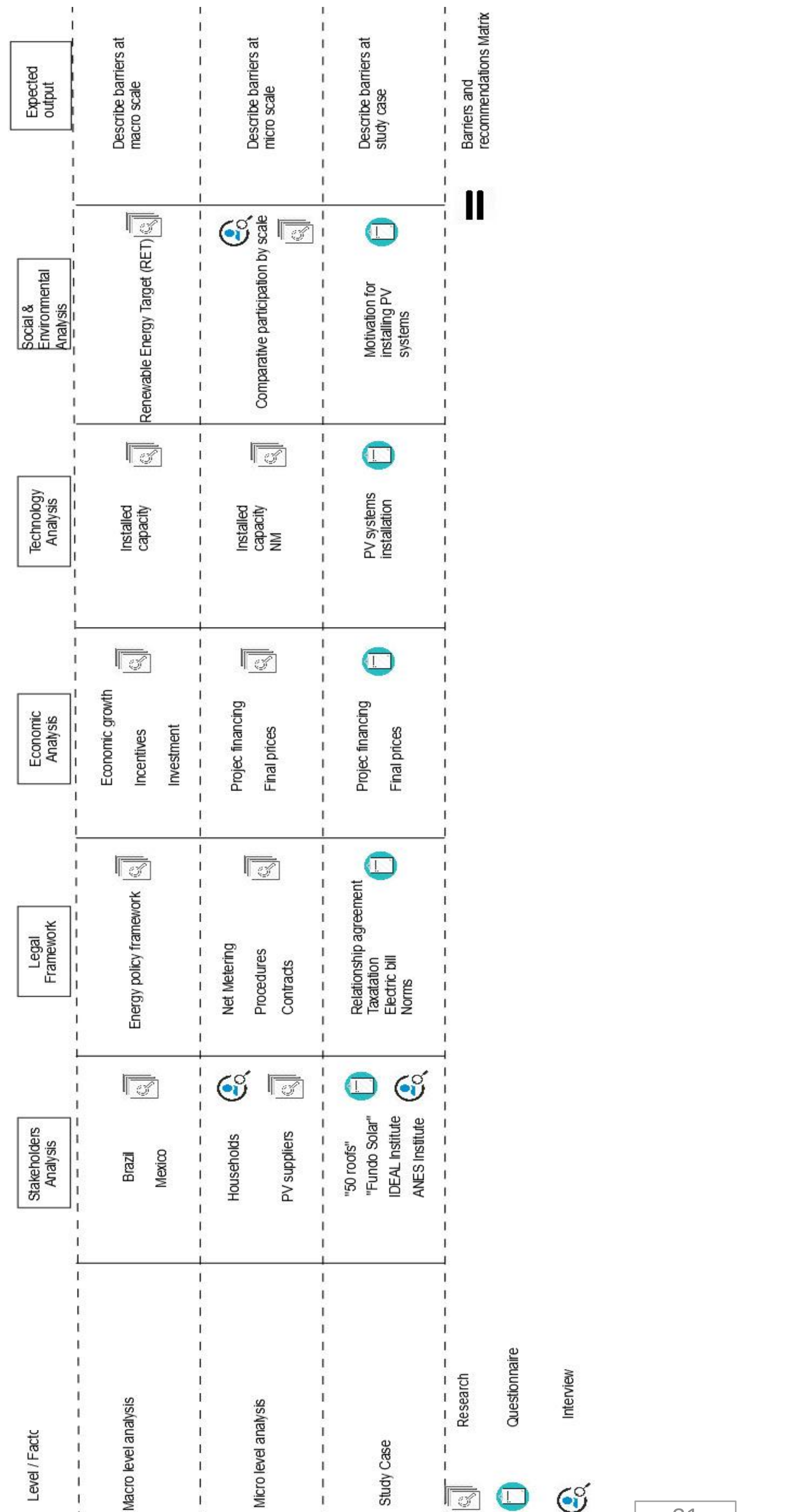


Figure 1: Research approach

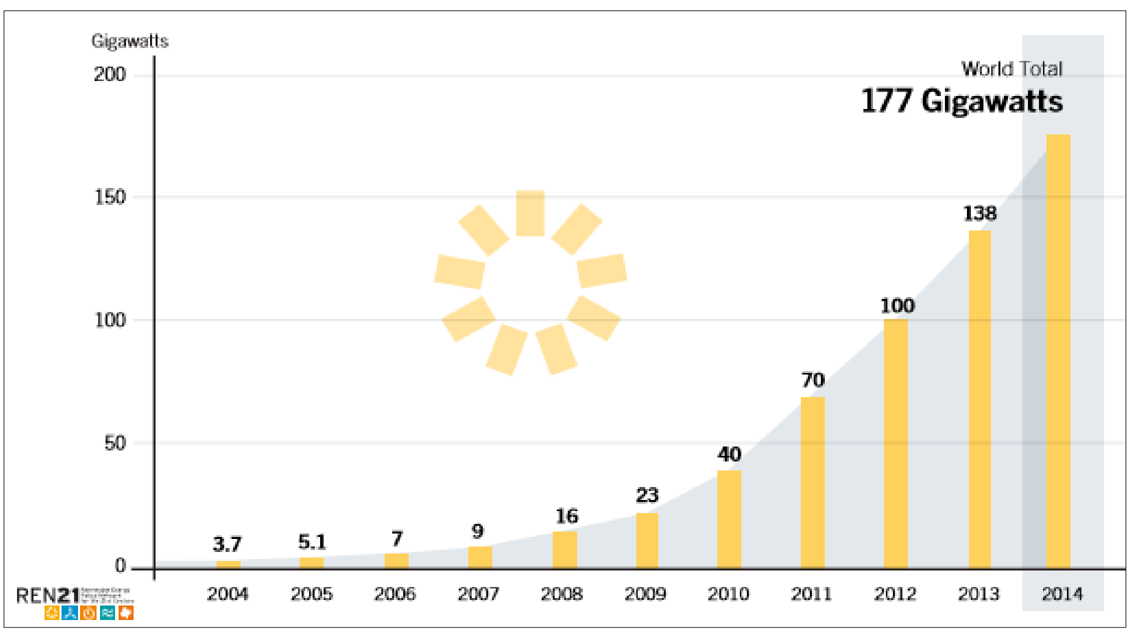
Chapter 2. Macro-level analysis

International perspective in the photovoltaic energy supply.

PV Installed Capacity.

Solar PV worldwide installation has increase an estimated of 40 GW in the year 2014 reaching the total global capacity amount of 177 GW (REN21, 2015). The increase of installed capacity in the last years has been unequal around the world, being Germany, China, Japan, Italy and United States the top five countries with more PV capacity. Between the years 2003 and 2013, cumulative installed capacity has grown at an average rate of 49% per year, taking into account small grid and off-grid PV systems, which become few KW into hundreds of MW; and at the opposite, plants over 100 MW capacity mostly in China and United States, providing high amounts of energy (IEA, 2014b). Latin America countries have the fastest growing market, although growth is uneven from country to country, with Chile at the head of the region´s installation and other countries like Mexico and Brazil that saw a substantial growth in the 2014 (REN21, 2015).

Figure 2: Solar PV Global capacity, 2004-2014



Source: (REN21, 2015)

PV economics

The prices in the production of PV modules have decrease in recent years due to the large competition with Asian market. The average prices with multicrystalline silicon module lowered about 14% year-over-year to USD 0.6/Watt (REN21, 2015). This price is found in China but in some other countries the prices might vary between USD 0.67-0.79/W (IEA, 2014b). The PV module is the part with larger price decrease in the PV systems, and other parts (inverters, support structures, cables etc.) have had a slower price decrease (IEA, 2014b). Final PV systems prices have declined an average of 6% to 7% per year from 1998 to 2013 at residential (<10KW) and large commercial (>100KW) scales in the United States (Feldman et al., 2014); but price differences can be found among countries even for similar types, especially for the smaller systems, which are dependent on customer acquisition, inspection and interconnection, installing labor and financing costs (IEA, 2014b). At utility scale the prices are smaller and have less differences between countries, reaching in 2013 the cheapest price of USD 1.5/W, something expected to happen until 2017 at the earliest (IEA, 2014b).

Levelised cost of electricity (LCOE) has also fallen in PV systems becoming each day a more competitive source of energy in several countries. LCOE varies depending on the global horizontal irradiation (GHI), in places with high GHI (>14500 Kwh/m2/Y) and assuming same system costs the LCOE 2013 was under EUR .12/KWh for all PV power plant types (IEA, 2014b). Some examples can be found in South Spain (1800 kWh/m2/Y) or Middle East and North African (MENA) countries (2000 kWh/m2/Y) where LCOE fell from 0.10 to 0.06 Euro/kWh, while in countries like France (1450 kWh/(m2/Y) the LCOE lies at approximately 0.08 to 0.12 Euro/kWh (KOST et al., 2013). In other places where PV is at his first developing stages, LCOE may be significantly higher, preventing PV from being immediately competitive (IEA, 2014b).

PV policies

Policy options for developing different PV energy scales have increase in the latest years. According to IEA this variety have differences depending on the world regions and the scale it is focused on. For utility-scale PV plants, feed-in tariffs (FiTs), feed-in-premiums (FiPs) and auctions have been used mainly in the European countries, Canada and Japan. Long -term-power-purchase agreements (PPA) have been signed by utilities to respond to renewable energy portfolio standards (RPS) in the United States. In emerging economies auctions are commonly used in countries like in Brazil and South Africa. For distributed PV, FiTs are also used in Europe and Asia, and net energy metering (NEM), notably in the United States and recently in other countries. Both policies have been so far the most widely used, often in combination with various fiscal incentives such as investment tax credits (ITC) or production tax credits (PTC). In some other countries, renewable energy certificates (REC) or solar REC (SREC) are strategies used also in the developing of RE (IEA, 2014b).

In this topic, energy policies developed in Brazil and Mexico are similar in terms of cuantity, only Brazil has recently adapted FiTs and some other mandates in the field of biofuels and heat; Mexico has also implemented Clean Energy Certificates (CEC) with similar performance as Renewable Energy Certificates (REC) but considering some low-impact fossil fuels like natural gas. The application of these policies in time have been also similar in both countries following international patterns. In Table 1 the regulatory policies, fiscal incentives and public financig are listed, as well as the year to reach the each one according to 2013 REN21 report.

Table 1: RET, policies and incentives in Brazil and Mexico

		Mexico		Brazil	
RET*	Renewable energy target	Exists	2020	Exists	2022
Regulatory Policies	Feed in tariff / Premium payment			Exists	2012
	Electric utility quota obligation / RPS				
	Net Metering	Exists	2007	Exists	2012
	Tradable REC				
	Tendering	Exists		Revised	
	Heat obligation / Mandate	Exists		Exists	
	Biofuels obligation / Mandate			Exists	
Fiscal incentives and public financing	Capital subsidy or rebate			Proposed	2020
	Investment or production tax credits	Exists	2012	Exists	2012
	Reduction in sales, energy, CO2, VAT or other taxes				
	Energy production payment				
	Public investment, loans, or grants	Exists	2009	Exists	2012
	Public competitive bidding	Exists	2012	Exists	2013

Source: (Ren21, 2013)

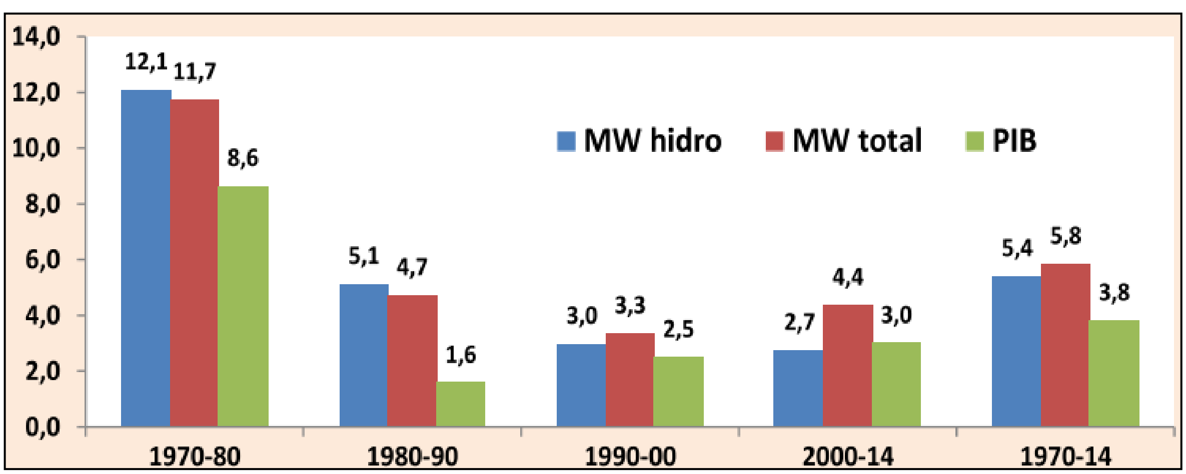
Brazil and Mexico are the largest emerging economies in Latin America. Both countries have experimented in the last years an important GDP increase, industrial investment and population growth that come along with more energy consumption. This relationship between electricity consumption and income, together with a more efficient energy development, requires the financial support of a strong economy (Pao & Fu, 2013). In the next part, an analysis of each country is done in order to understand how national macro-level aspects have impacted on the development of PV energy.

Macro-level aspects in Brazil

Brazil energy scenario.

Brazil GDP had a constant growth during the last years of the 90's decade and until 2008 experimented a stable growth mainly because of the global demand for Brazilian commodities. The global economic crisis and the fall for Brazil's commodity-based exports and foreign credit made 2009 GDP shrank by 0.2%. Next year Brazil have increased its growing rate reaching a historical growth of 7.5%, after that, a slower growth has been seen with an average of 2.1% annually from 2011 to 2013 (Focus Economics, 2015).

Figure 3: Brazil installed capacity and PIB



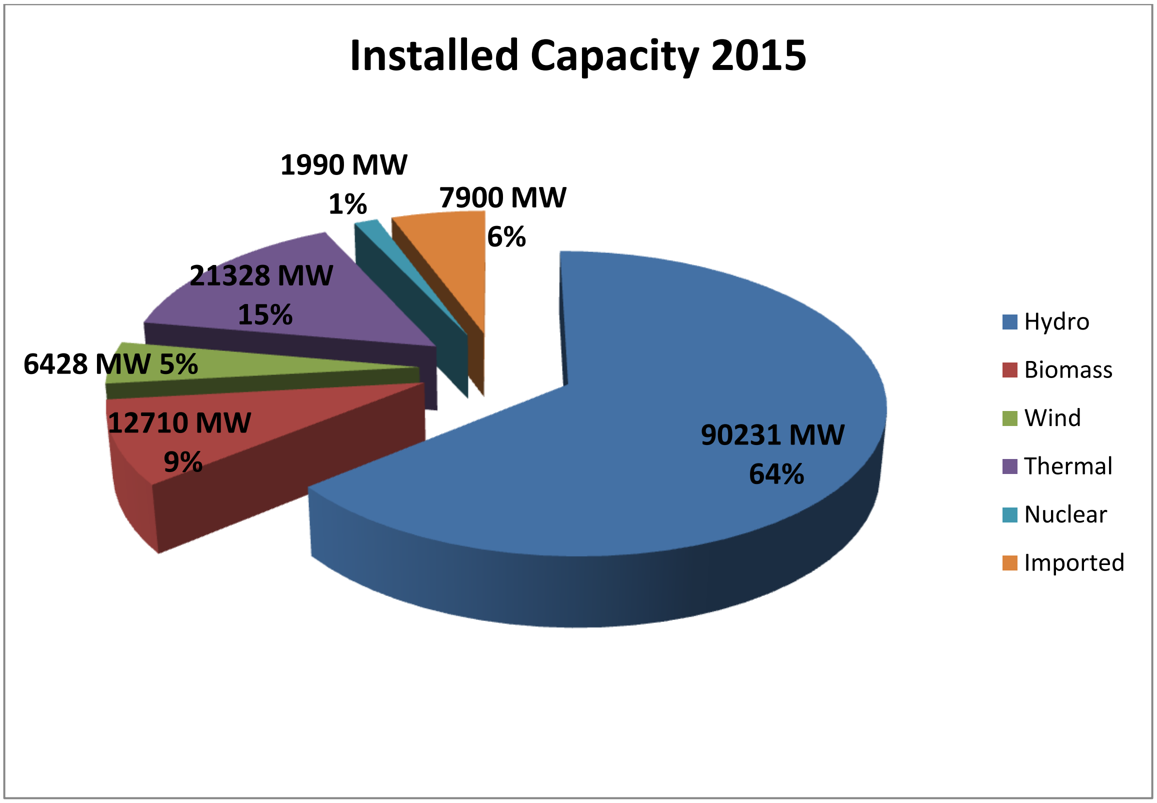
Source: (MME, 2015)

According to Figure 3, electric energy installed capacity have increased with an average 5.8% per year between 1970 and 2014 going from an installed capacity of 11GW to 133.9 GW, compared with a 3.8 yearly GDP growth in the same period of time. Hydro power is the energy source with the biggest rate of growth in Brazil in comparison with other sources, having an annual increase of 5.4% in this period (MME, 2015). The residential energy consumption experimented an average 6.3% growth, while industrial sector 4%; this means that energy had a more social use (Filho, 2013). Also related to this, there have been in past decades a high rate of population growth in Brazil with an increase of more than twice its population since 1970, going from 96 million inhabitants to 200 million in 2013 according to The World Bank; nevertheless this rate is reducing in recent years, expecting to have an 0.7% growth rate per year until 2023 and increasing the population to 216 million (World Bank, 2015).

Future scenario considered by PDE (Decennial Energy Expansion Plan) expect an annual energy consumption rate of 4.0% growth between 2013 and 2023 in the grid, with major participation from the commercial sector (5.5%), followed by residential (4.3%) and industrial (3.4%) (MME, 2014).

The installed capacity in 2015 for electric generation according to Figure 4 has a total of 146,014 MW. Hydro power is the largest source of energy with 90.2 GW of installed capacity representing a 64% from the total amount. Other sources have a much smaller installation compared to Hydro, being Thermal and Biomass energy the second and third largest sources with a 21.3 GW and 12.7 GW of installed capacity respectively.

Figure 4: Brazil Installed Capacity in 2015



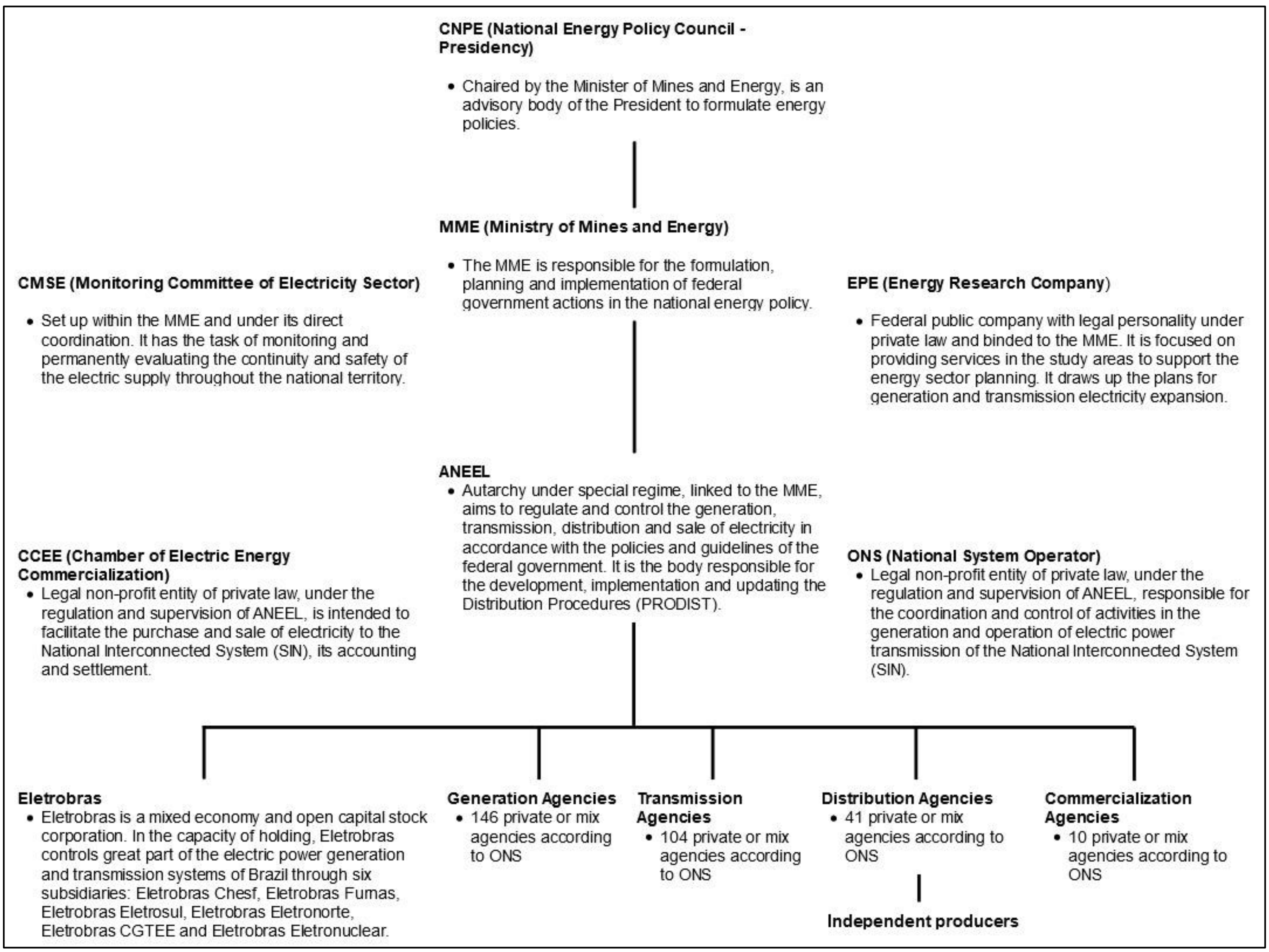
Source: (ANEEL, 2015d)

Hydro power is a very cost effective source of energy, nevertheless according to REEEP Policy database in 2001 droughts caused power shortages and energy rationing attributing it to the lack of investment within the sector and resulting in major economic consequences having a cost of rationing close to 3% of the GDP. A more recent case in February 2014, the reservoir levels in the Southeast and Central West regions of the country had not the expected levels, resulting in 6,260 MW of additional thermal capacity being put onto the grid in that region(REEEP Policy Database, 2014). A centralized energy system like the Brazilian case, produce a strong dependency in one energy source such as Hydro having high transmission losses and becoming the Brazilian energy market vulnerable (Barth et al. 2014). Under this situation, the introduction of new energy sources that decentralized and diversify the incoming electricity befall an important challenge within this sector.

Regulatory framework in Brazil

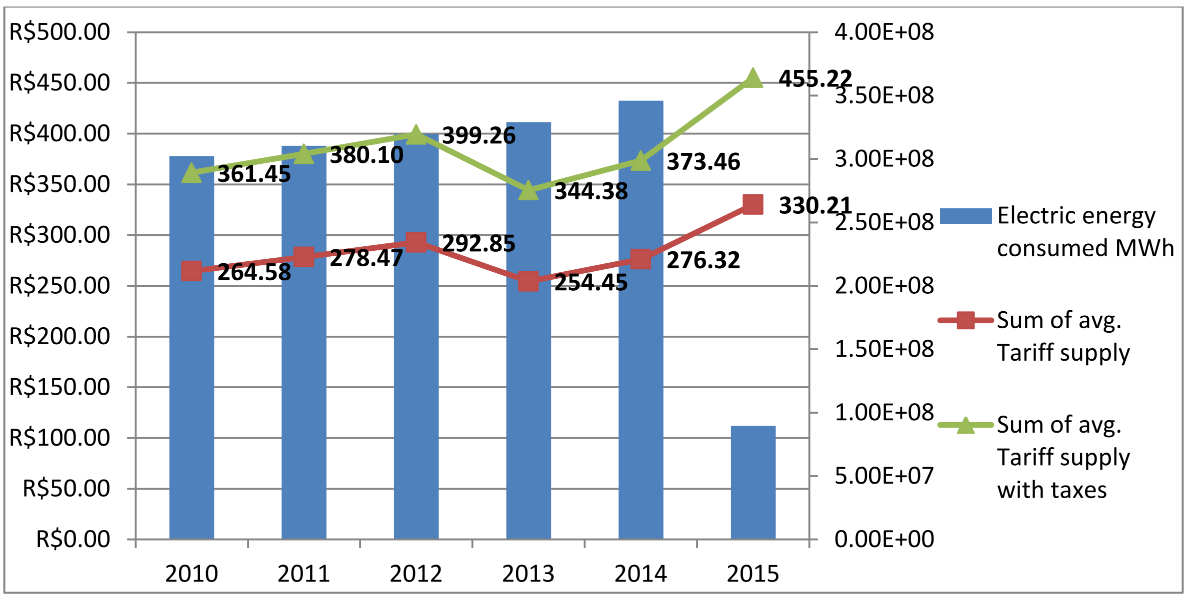
Brazil has seen two important political reforms recently, the first occurred in 1996 in which the whole energy sector was controlled by vertically integrated state-owned companies. The second reform occurred in 2004, after the country passed through energy rationing in 2001 and 2002, leading to an energy sector with public and private companies divided into generation, transmission and distribution together with two systems of selling electricity, that could be a free market with bilateral contracts between seller and buyer or it can be sold in the regulated market via auctions (ECOFYS, 2009). The main energy regulatory Institutions in Brazil and its main activities are explained in Figure 5.

Figure 5: Energy Institutions in Brazil



The electricity consumers pay through received accounts established by the distribution agencies, a price that corresponds to the amount of electricity consumed in kWh multiplied by a unit value in R$/kWh. The distribution agencies are regulated by ANEEL who set tariffs to ensure consumers pay a fair price. This rate set by ANEEL for distribution agencies is done throughout annual adjustments and periodic reviews, including items that are part of the electric bill such as energy, transmission, distribution, regulatory charges and taxes. Figure 6 explains the evolution of electric energy tariffs and electric consumption from 2010 to the first months of 2015.

Figure 6: Evolution of electric energy consumption and tariffs in MWh



Source: (ANEEL, 2015c)

From 2015 the bills began measuring the Flags System tariffs. The green, yellow and red flags indicate whether the energy cost more or less depending on the conditions of electricity generation. The green flag means the conditions were favorable for power generation and the rate does not suffer any increase. The yellow flag means less favorable generating conditions, thus the rate suffers an increase of R$0.025 for every kilowatt hour (kWh) consumed. The red flag applies for the most expensive generation conditions in which the rate increase R$0.055 for each kilowatt-hour kWh consumed (ANEEL, 2015a).

ANEEL establishes a different rate for each distributor depending on the concession peculiarities that should ensure quality energy supply as well as revenues to the service providers. Other factors that make the energy bill vary are the consuming rates depending on the voltage level consumers are connected to the grid. This rate divides consumers into groups A greater than 2.3 kV (for example large industries) and B less than 2.3 kV (for residential consumers). Consumers in Group A have rates set for peak hours and off-peak (ANEEL, 2015f).

Regarding taxes and other elements that are part of the electricity bill, some of the next aspects could be found: ICMS (Tax on Goods and Services), state tax at rates that vary on each region; PIS/PASEP (Social Integration Program / Public Service Formation Patrimony Program) and COFINS (Contribution to Social Security Financing); COSIP/CIP (Social Contribution for Public Lighting)(ANEEL, 2015f).

RET in Brazil and expected impact in 2023.

Brazil renewable energy target to 2023 is to produce 42.5% of primary energy supply and 86.1% of electric energy trough renewable sources (IRENA, 2015a) including large hydropower which is estimated to increase from 79.9 GW of installed capacity to 112.17 GW in 2023 (MME, 2014). The main source of electric energy generation will still be large hydropower, but the strategies also intend to increase renewable sources such as small hydro, wind, bio-fuels and solar with a 24.1% of electric energy participation coming from them in 2023 (MME, 2014).

Wind is expected to be the largest installed capacity from RE sources in 2023 with 22.4 GW (See Annex 1). Biomass will contribute with 13.98 GW, small hydro (PCH in the figure) with 7.3 GW and in the case of solar the forecasts foreseen an installed capacity of 3.5 GW in 2023 (MME, 2014).

Brazil is part of the United Nations Framework Convention on Climate Change (UNFCCC) and has established targets in order to reduce greenhouse gas emissions (GHG) even when is not obligated by the Kyoto protocol. According to the World Resources Institute (WRI) GHG emissions from Brazil are 1012.6 Mt CO_2e (excluding land use and forestry) that represents a 2.34% of the total global, and from them 469.7 Mt CO_2e (46.3%) come from energy supply (WRI, 2015). In relation to this, since December 2009 in the COP-15 in Copenhagen, Brazil established the voluntary goal to reduce GHG emissions between 36.1% and 38.9% in 2020. Since then the Decennial Energy Plans (PDE) have within their objectives to achieve that goal, defined in the Law n° 12.187/09 and Decree n° 7.390/10. Thus the GHG emissions should not surpass the 680 Mt CO_2e by 2020 (MME, 2014).

Evolution of photovoltaic energy and installed capacity in Brazil

Photovoltaic energy represents a small percentage in the electric energy generation in the country, nevertheless the implementation of new governmental programs have helped with the objective of increasing RE contribution. One example is the project "Light for all" implemented in 2003 in order to bring electric energy to 10 million people in rural areas until 2008. A second stage was implemented in which solar energy, among others, was a form to generate energy for rural areas while promoting PV systems (LPT, 2015). According to ABSOLAR around 30 MW of cumulative off-grid PV capacity is installed in Brazil (Barth, Mayer, Trennepohl, & Brückmann, 2014).

For utility scales the implementation of auctions has been a new alternative for PV promotion. The first solar auction was done in October 31st 2014 and after this a change in the PV installed capacity is expected. According to the Generation Information Bank (BIG) to the month of July 2015 a total of 15.2 MW of installed capacity is currently connected to the grid and 1.07 GW are projected to start construction (ANEEL, 2015b). The funding options for PV energy auctions are based on national and international programs. The Brazilian National Bank for Economic and Social Development (BNDES) is a fund for participants in solar auctions which interest rates are specified under BNDES Finem and Fundo Clima guidelines, with a minimum funding of R$20 million and R$3 million respectively (BNDES, 2015).

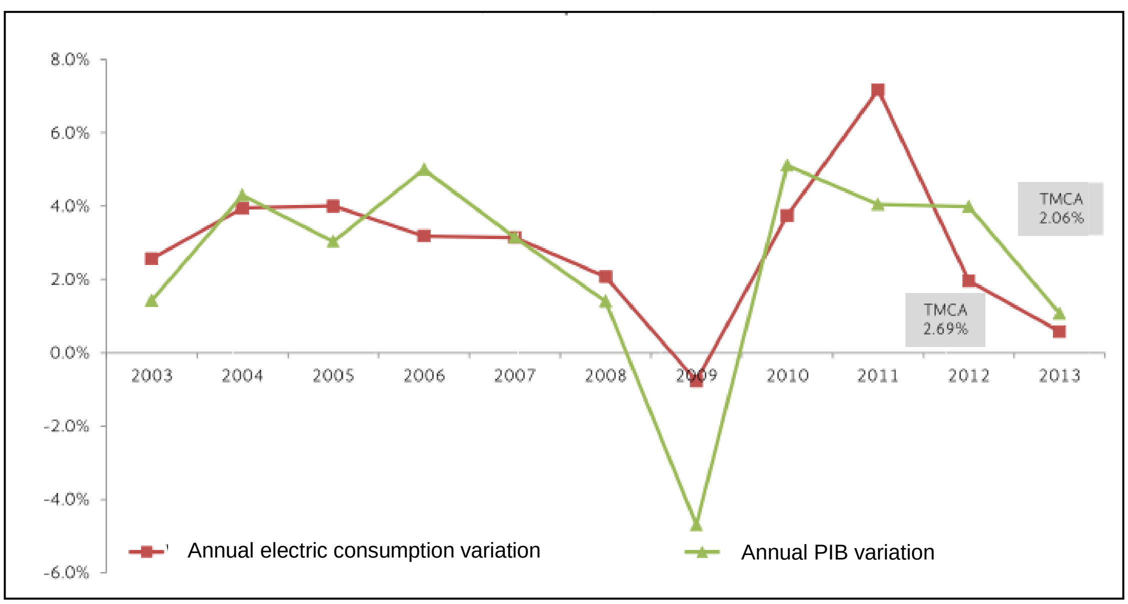
Macro-level aspects in Mexico

Mexico energy scenario.

After a faster economic growth in the 60's and 70's decades, the GDP per capita in Mexico has experienced a decrease due to a several macro economic crisis, having an annual rate of 0.6% since 1980 until now (OECD, 2015). The entry of Mexico to the North America Free Trade Agreement (NAFTA) in 1994 has transformed the economy of the country by liberalizing the market, increasing the amount of exportations mainly to the USA. In recent years Mexican economy has experienced a moderate growth, increasing 1.4% and 2.1% in 2013 and 2014.

Electric generation, distribution and transmission have been since many years a responsibility of Federal Electricity Commission (CFE). By the year 1971 the electric energy installed capacity reach the amount of 7,874 MW due to the big public inversion in previous years. In the next decade the installed capacity growth continued until the 90's decade in which the rate of expansion decreased having in 1991 an amount of 26,797 MW. By 2000 this amount increase to 38,385 MW having a 94.7% of national coverage (CFE, 2015). According to the World Bank the energy consumption have increase since the year 1990 to 2011 a rate of 5.5% per year making difficult to provide electricity to the total population in the country.

Figure 7: Annual electric energy and GDP variation



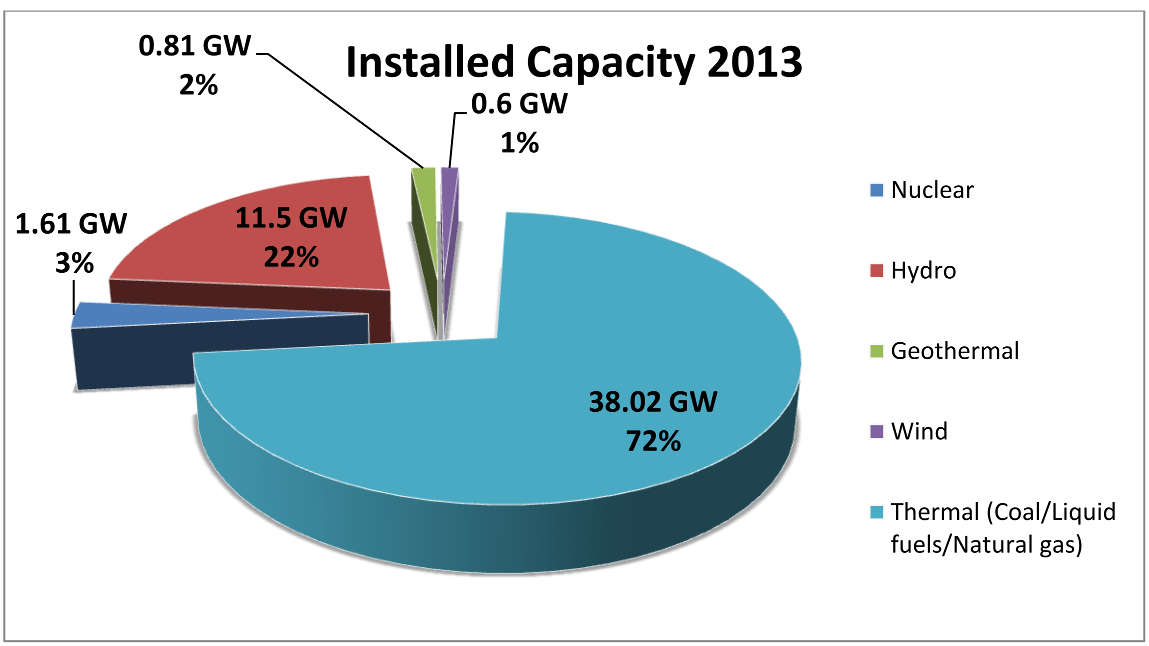
Source: (SENER, 2014)

According to Figure 7 there is a close relationship between economic growth and electric energy consumption, an example of this is how the economic recession in 2009 had an impact in electric consumption in the country (SENER, 2014).

In a deeper analysis, electric energy consumption in Mexico has experienced an important growth in social aspects as well in Brazil. From 2003 to 2013 the services sector had an annual growth of 3.9%, followed by medium companies and residential sectors with 2.9% and 2.8% respectively (SENER, 2014). Future scenarios expected by SENER are an annual increase of 3.5% in the GDP and 4.4% in the electric consumption from 2014 to 2028 (SENER, 2014).

Electric energy installed capacity in 2013 in Figure 8 shows the dependency on fossil fuels that Mexico has to produce electricity. 72% of the installed capacity comes from thermal power plants and from them 40% from Natural gas with 15.37 GW of installed capacity. The second largest source is hydro plants with 11.5 GW of installed capacity and representing 22% of the total amount. Other sources such as nuclear (1.61 GW), wind (0.6 GW) and geothermal (0.81 GW) represent a small percentage in the total amount of 52.54 GW.

Figure 8: Installed Capacity in Mexico 2013



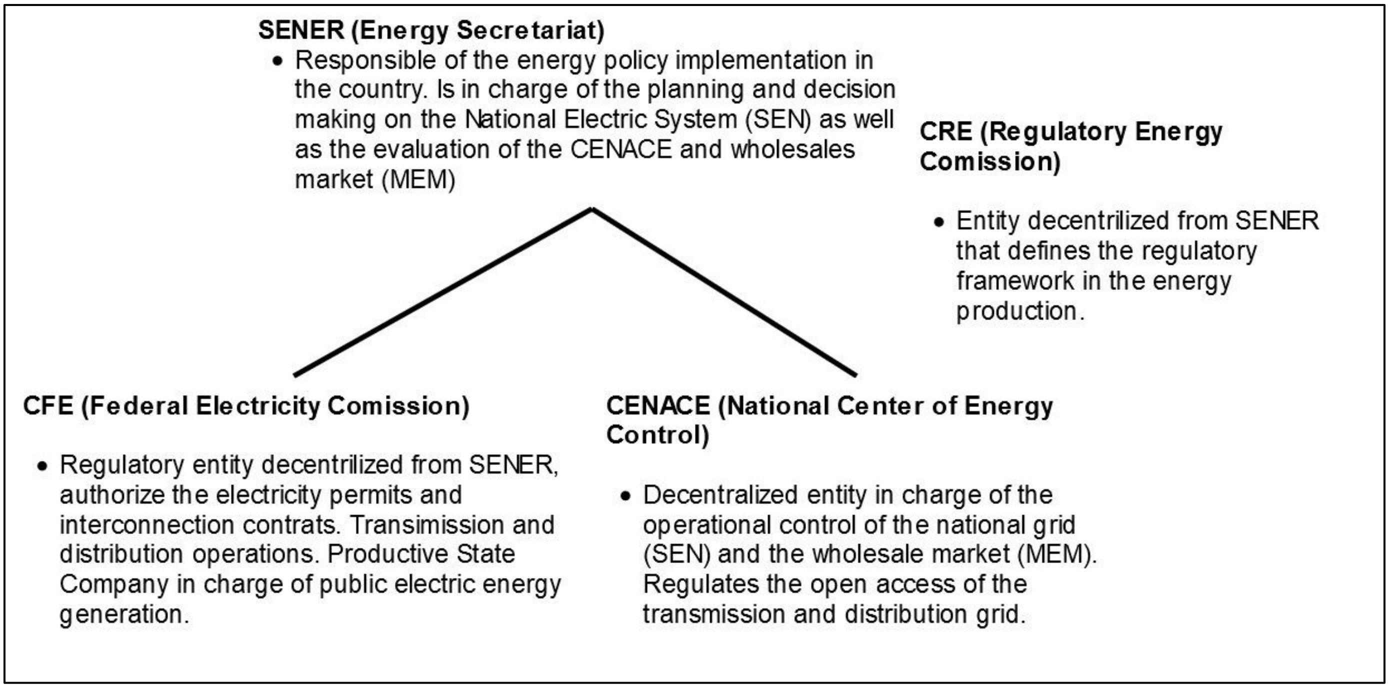
Source: (IEA, 2014a)

Mexico's plan for electric generation expansion in future years has a new approach by letting private companies to incur in this sector. There has been a recent change in this aspect with the Energy Reform implemented in 2013, in which the sectors known before as "self supplying" and "co-generation" are now consider as particular projects. Next year's particular projects will become one of the major sources of generation with natural gas as the main fuel. From 2019 until 2028 is expected to increase 2 GW of installed capacity coming from RE specially wind energy.

Regulatory framework

Mexico regulatory framework has been reformed impacting on all the levels of energy generation. According to SENER this reform will strength the competiveness in the generation sector by creating a wholesale market and enabling new suppliers to incur in the power supply system. In the case of electricity the main institution CFE has been renewed in tasks by the Electricity Industry Law (LIE) and the Federal Electricity Commission Law (LCFE), with this CFE changes from being a decentralized company to a productive company owned by the state; the transmission and distribution activities are constructed and operated still by CFE with the option to hire third parties. The Figure 9 explains the regulatory framework implemented, other regulatory institutions related in the energy regulations and research are not included due to recent changes in the system.

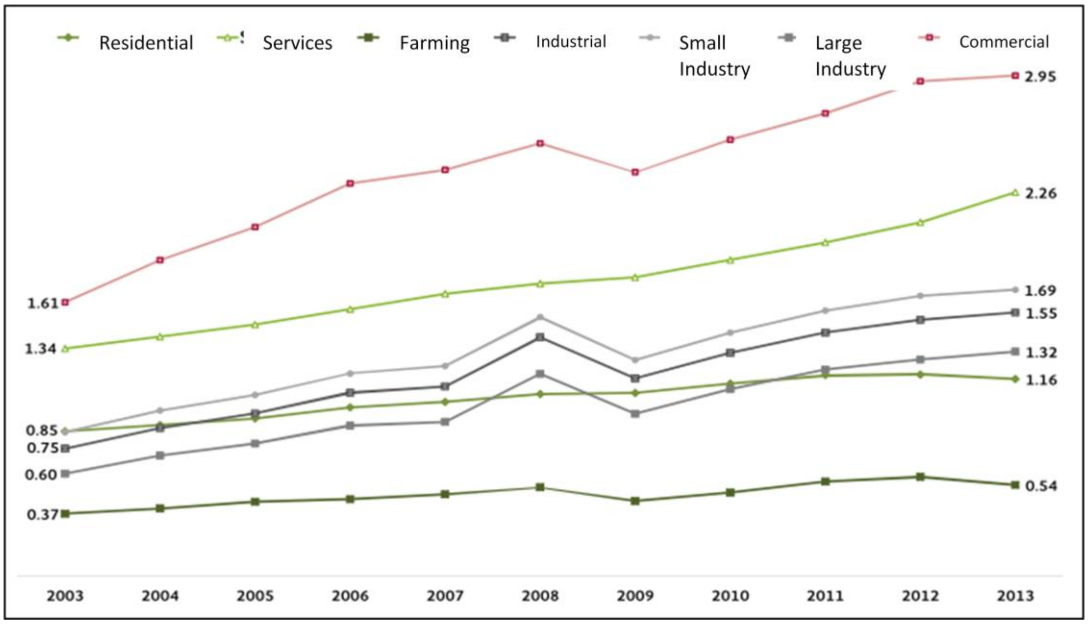
Figure 9: Energy Institutions in Mexico



The CENACE is in charge of the wholesales market (MEM) in which generation qualified companies that participate in the energy transactions are regulated by the market rules. The prices of the transactions will be calculated based on the received offers(PwC, 2015). As well as the generation, energy commercialization will become a free competition establishing two main types of users, "qualified" and "basic supplier" according to Electricity Energy Law. CRE acredites the qualified users to participate in the MEM without any type of representative, in the other hand, "basic suppliers" will need a representative or "supplier" (CFE) in case of energy transaction (PwC, 2015). This point is explained in a deeper way in chapter 5, where users under Net Metering scheme are still not regulated by this Law.

Energy tariffs are calculated by CFE depending on the sector the electric energy is supplied and the voltage the interconnection point has. According to Figure 10, from 2004 until 2013 the average price in $Pesos/KWh on each of the different sectors has a fluctuation depending on fuel costs, subsidies and inflation(SENER, 2014). The commercial and service sector have the highest prices while residential average price have maintained the lowest.

Figure 10: Average electricity price in Mexico in Pesos/KWh 2003/2013 by sector



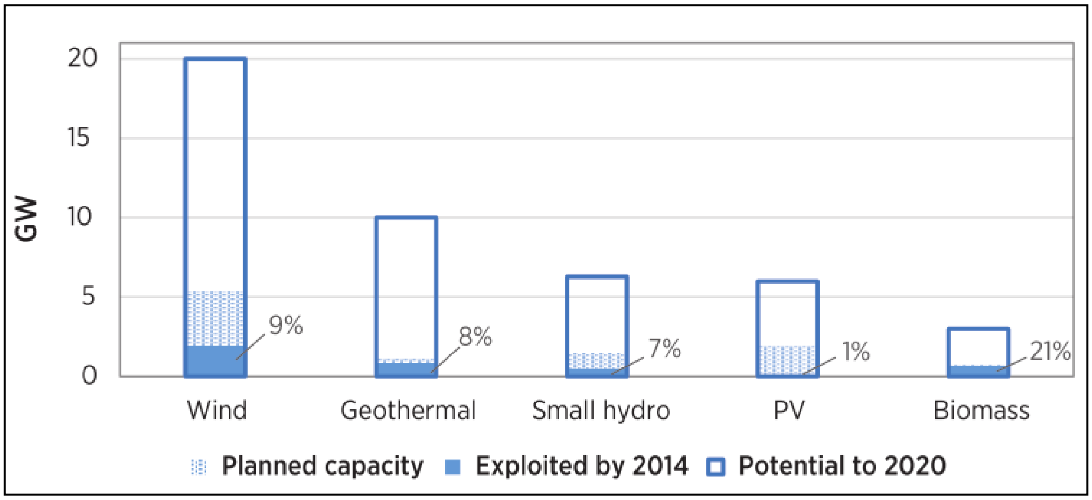
Source: (SENER, 2014)

RET in Mexico: expected impact in 2024

In the case of Mexico, the law for Renewable Energies Exploitation and Energy Transition Funding LAERFTE (Ley para el Aprovechamiento de Energías Renovables y el Financiamiento de la Transición Energética) committed to reach 35% of the electric energy generation in 2024 through renewable energies. If by 2018, 29% is already accomplish from this target, the equivalent 2% of 2011 GDP would increase in this year, 147,000 new employments will be created and 21MtC02 will be reduced in energy generation (PwC, WWF, IMERE, & CWF, 2013).

According to Figure 11 the expansion for RE in Mexico is expected to start increasing in 2020, year in which renewable energies are theoretically measured by SENER with the next potential of installed capacity for the following years: wind (20 GW), geothermal (10 GW), small hydro (6.5 GW), solar PV (5.6 GW), Biomass (2.8 GW) (IRENA & SENER, 2015).

Figure 11: Renewable energy economic potential for power generation by 2020 in Mexico



Source: (IRENA & SENER, 2015)

In terms of photovoltaic energies, the target is set for 2020, expecting to increase the total installed photovoltaic capacity to 1.5 GW (SENER 2012a). With this strategy Mexico would be looking for an economic development of 0.24% 2011 GDP reflected in 2020, creating 12,400 new jobs, reducing 1.4 MtC02 emissions and 4% of energy loses in transportation and distribution, as well as reducing the peak demand in some parts of the country (PwC et al., 2013).

According to WRI Mexico´s total GHI emissions are 723.9 Mt CO2e (excluding land use and forestry) contributing with 1.67% from the world total. Energy emissions contribute with 490.7 Mt CO2e (67.7% from the total), thus the sector with larger participation in reducing GHI from Mexico is the energy sector (WRI, 2015). According to INDC (Intended Nationally Determined Contribution) established by the Mexican government: "Mexico is committed to reduce 25% of its GHG emissions for the year 2030. This commitment implies a reduction of 22% of GHG and a reduction of 51% of Black Carbon. This commitment implies a net emissions peak starting from 2026, decoupling GHG emissions from economic growth: emissions intensity per unit of GDP will reduce by around 40% from 2013 to 2030 (Gobierno de la República, 2014)", becoming the first developing country in setting INDC plans for the COP21.

Evolution of photovoltaic energy and installed capacity in Mexico.

Solar resources such as PV have been barely exploited in Mexico on any large-scale or commercial basis (IRENA & SENER, 2015). In the year 2013 there were 39 MW of installed capacity in the country coming from private users (utility scale) within the past regulatory framework and CFE installed projects. This amount has increased to 66 MW according to the most recent numbers in the National Renewable Energies Inventory in México, only counting utility scale projects (INERE, 2015).

Chapter 3. Micro level analysis

Net Metering in Brazil

ANEEL (National Agency for Electric Energy) resolution RN 482/2012 was the first one to establish a compensation scheme for distributed generation (Barth et al., 2014). In the Brazilian case the Net Metering can be used with hydraulic, solar, wind, biomass and qualify cogeneration sources. Nowadays the PV panels are the most common application within Net Metering scheme among these sources in Brazil (see Annex 2).

During the last two years ANEEL has modified, implemented and restructured some of the conditions established in the first resolution RN 482/2012. The main objectives for these alterations are in favor of improving and clarifying the process relationship between distributor and consumer. The main modifications to the resolution are the next (ANEEL, 2015e):

- Normative Resolution No. 517: Modification of PRODIST Module 3 to clarify that the concept of "free loan" is not as a process of purchase-sell between the consumer and the distributor. This resolution also limits the compensation energy system scope to the consumers with the same CPF and CNPJ (Individual or company cadastre).
- CONFAZ-ICMS agreement: CONFAZ applied the ICMS tax to all consuming unit coming from the distributor. ICMS is applicable to all energy consumed during the month.
- Dispatch nº 720 PRODIST S 3.7 M 3: DSV electricity meter does not need to be installed when generators already have an inverter connected to the grid.
- Ordinance INMETRO nº 357/2014: Inverters with power up to 10KW in PV systems connected to the grid have to be accredited by INMETRO laboratories.

- Oficio Circular n° 0015/2015-SRD/ANEEL: Distributors have to present the certificates (national or international) or manufacturer's declaration to the inverters submitted by consumers who requested access.

According to RN482/2012 the size limit permition for Net Metering is divided into two different scales (ANEEL 2012a):

1. Micro generation: central power generator with installed capacity less than or equal to 100 kW and using sources based on hydropower, solar, wind, biomass or qualified cogeneration, as regulated by ANEEL, connected to the distribution network through units facilities consumers.
2. Mini generation: central power generator with an installed capacity greater than 100 kW and less than or equal to 1 MW to sources based on hydropower, solar, wind, biomass or qualified cogeneration, as regulated by ANEEL, connected to the distribution network by consumer units plants.

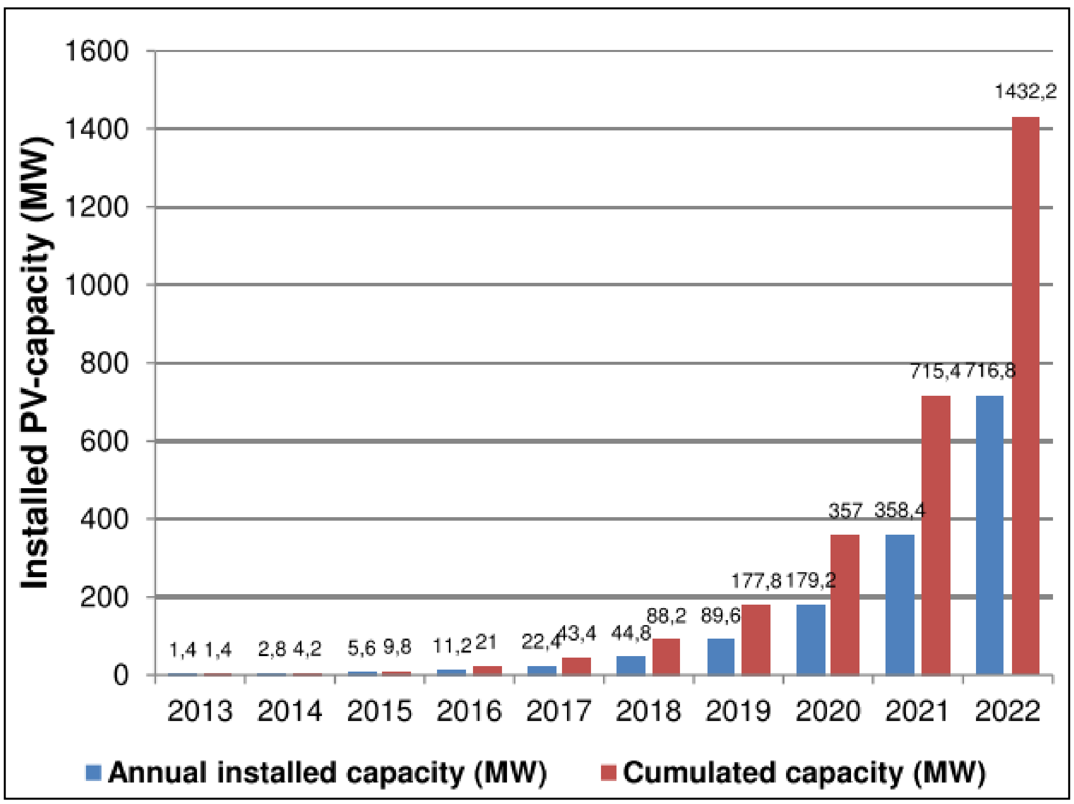
The bill issued under Net Metering scheme in Brazil has the agreement of reducing the injected energy to the consumed energy coming from the grid with the same tariff. In the case that the energy generated is more than the demanded from the consumer, this over production will be discounted during the next months with the same tariff. In the case of having different generation units with the same holder, this over production can be used to supply them too within 36 months.

Besides the metering on the energy consumption, the Brazilian electricity rates have a minimun consumption amount in order to pay for grid availability to the consumers. This value is categorized in three different rates: residential customer using a single phase connection pays for a minimum consumption of 30 kWh per month, a customer using a two-phase connection pays for a minimum consumption of 50 kWh per month and a customer using a three-phase connection pays for a minimum consumption of 100 kWh per month, even if in reality the consumption is lower (Barth et al., 2014).

The distribution procedures and regulations are given by the PRODIST (Procedimentos de Distribuição de Energia Elétrica no Sistema Elétrico Nacional) that give the process requirement for the installation of power generators that will be connected to the grid under NM scheme. The basic steps (Annex 3) for interconnection system are: 1) grid connection application, 2) utility application review, 3) installation and commissioning, including determining the connection point, and 4) connection of the PV system, including an interconnection agreement (Barth et al., 2014).

The implementation of the ANEEL resolution n° 482/2012 for Net Metering in the year 2012 has been the main policy for encouraging the use of PV system expecting to increase the participation of mini and micro generation. The evolution of mini and micro PV installed capacity in Figure 12, will increase from 1,4 MW in 2013 to 1432,2 MW in 2022 according to (Preiser, Kissel, & Krenz, 2014) and cited in (Barth et al., 2014).

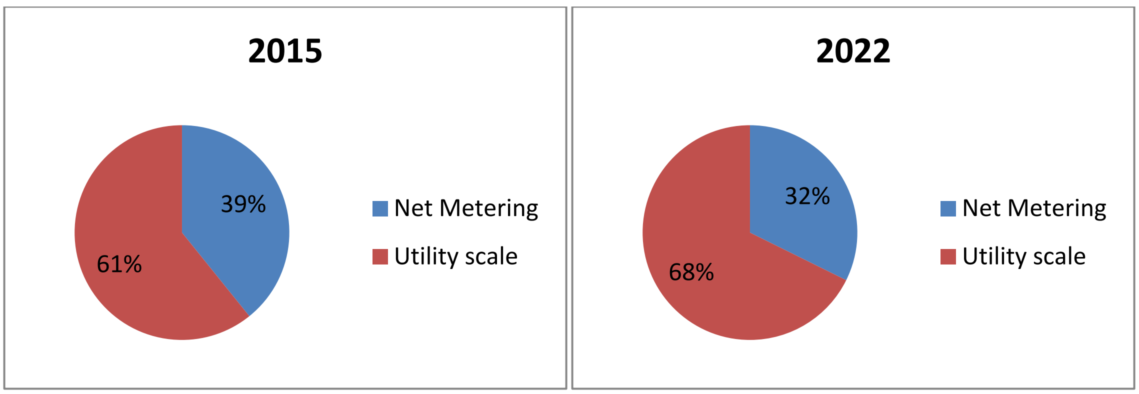
Figure 12: Installed PV capacity 2013 to 2022 under Net Metering



Source: (Barth et al., 2014)

According to the previous graph there is approximately 9.8 MW of installed capacity coming from PV sources under Net Metering scheme by the end of 2015. Taking into account 15.2 MW of installed capacity coming from utility scale power plants, the current share of participation in Figure 13 by each scale in the photovoltaic installed capacity in Brazil is 39% for the Net Metering and 61% for the utility scale. Future seven year scenario in 2022 will represent a decrease in the share of participation of Net Metering with 32% and utility scale with 68%.

Figure 13: Net Metering current and future participation share



Source: (Barth et al., 2014) & (ANEEL, 2015b)

Net Metering in Mexico

The Energy Secretariat (SENER) in Mexico is the public agency that established Net Metering for the first time in 2007. At the beginning this resolution was made for PV systems only, but after its reform in 2010 it allows also other types of energy sources to be connected to the grid. This last resolution is at the present time in application under the name RES/054/2010. In addition there is one more resolution implemented in 2012 for collective generation systems under the name RES/249/2012. The following description of this policy is in accordance to the last resolution mentioned above, but recent changes in the energy normative framework have impact on the application of it. The main changes are described in chapter 5.

As well as the Brazilian case, Mexico permits any type of renewable energy to be connected to the grid. Small and medium solar PV is the majority type of contracts under Net Metering scheme, followed in much less amount by biogas, biomass and hybrid systems (see Annex 4).

In terms of system size for the grid interconnection the division is made in three different scales:

1. Small scale: is sub divided for households and general use. In the first case the installed capacity must be less or equal than 10 KW. General use means the installed capacity can be up to 30 KW and it is focus in business or companies. In both cases the installation to the grid must have a voltage lower than 1KV.
2. Medium scale: the maximum installed capacity of the generator must be equal or under 500KW with voltage above 1KV and under 69KV.
3. Collective scale: with this contract it is allowed to have several units interconnected to the grid. The collective scale is an adaptation to the small scale, if the installation of the units is for residential use these cannot surpass the 10KW limit each one, and if they are for general the limit is 30KW. The total amount of installed capacity must be less than 500 KW as well, but the voltage has to be maintained under 1KV.

The metering in Mexico follows almost the same rules that in Brazil, making a subtraction between the energy injected and energy consumed. In the case of having a energy production larger than the consumed, the surplus will be hold like a credit for the next months. In this case the extra energy can be consumed from the grid only within the next 12 months[1].

In the collective mode the metering is done in a different way due to the energy generation that comes from a number of units that may produce different quantities of energy. A dual metering device is connected to the grid and it measures the total amount of energy injected by all the generators to the grid as well as the consumed. An individual metering device is connected to each of the units, measuring the percentage of participation of each one, with this the final billing will

[1] This aspect has changed according to the new Electric Industry Law (See chapter 5)

be issued individually depending on the participation percentage (Sitio Solar, 2013).

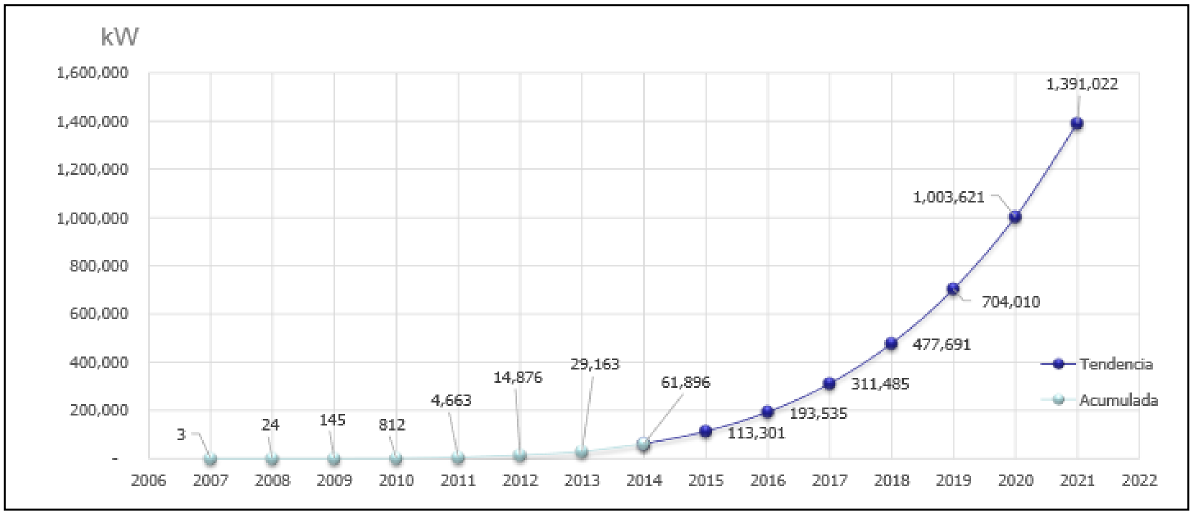
Because the energy has different fees depending on the time and month in which it was generated, the compensation must convert the energy stored from previous months KWh currently equivalent, considering the order fee and hour period (SENER, 2010).

The procedure in order to install a renewable energy generator is given by the CFE. The contracts are depending on the scale mentioned before with some differences between them. The medium scale main steps are (Sitio Solar, 2013): interconnection feasibility study done by CFE, port study, interconnection contract, agreement of sale of surplus energy (Optional), convention transmission (only if applicable), backup contract (Optional).

According to CRE by December 2014 a total of 58.2 MW were connected to the grid, 39.3 MW from small scale and 18.9 from medium scale (CRE, 2015). This amount represents the 94% of the total amount of installed capacity under Net Metering scheme. The other 6% is represented by biogas, biomass, wind and hybrid power systems. Considering this, the Annex 5 shows the total amount of interconnection contracts under net metering scheme with all renewable sources. It can be observed that the majority of the contracts are below the 10KW of installed capacity.

Future scenario in Figure 14 shows the upward tendency in the installed capacity of this type of interconnection, expecting to have a cumulative amount of 1.39 GW by 2021. If the same 94% is still coming from PV systems, it would mean that 1.3 GW will come from this source.

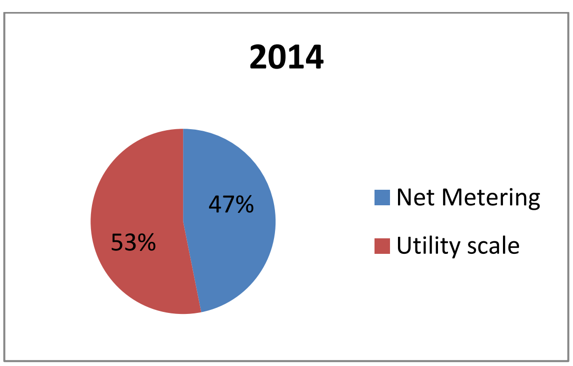
Figure 14: Net Metering installed capacity 2006 to 2022.

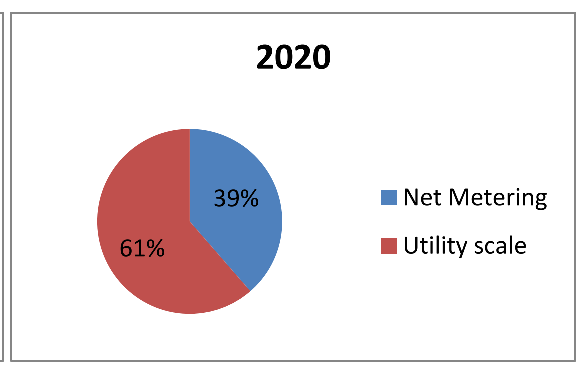


Source: (CRE, 2015)

According to the numbers exposed in Figure 15, current share of participation by each scale in the photovoltaic installed capacity in Mexico is 47% for the Net Metering and 53% in the other scales (mainly represented by utility scale). Future five year scenario in 2020 will represent a decrease in the share of participation of Net Metering with 39% and other scales with 61% of installed capacity. The IRENA renewable energy prospects considered an increase in solar PV capacity of 5.6 GW by 2030, of which around 60% is utility-scale and the remaining is rooftop solar (IRENA & SENER, 2015), similar numbers as the calculations done.

Figure 15: current and future net metering and utility scale share of participation in Mexico





Source: (CRE, 2015) & (INERE, 2015)

Chapter 4. Methodology

The investigation methodology is based on a pragmatic approach, where the final output is result oriented. A mixed research design is focused on obtaining data from quantitative and qualitative methods (Creswell, 2003), such as questionnaires and interviews. This research final aim is to have an overall understanding of the system, main reason of analyzing it at the different levels exposed before: macro, micro and study cases.

Final expected output is to get a list of barriers and recommendations in each country, having the opportunity to define similarities and differences. For this the next research methods were used: literature review on similar studies, quantitative questionnaires and qualitative interviews.

The main reason to execute the research project with these three different methods is to obtain data seen from different points of view, statistical, empirical and theoretical. To conduct quantitative and qualitative methods at the same time, the likelihood of unanticipated outcomes is multiplied (Bryman, 2009). Together the qualitative, quantitative and literature review will result in a vast whole for a better analysis during the research and fulfill the aims of the investigation.

Similar studies have already defined some of the barriers RE and Net Metering have presented in both countries in recent years. These studies realized by public (ANEEL, SENER) and private institutions (IDEAL, ANES, PwC, IRENA) can be used as reference to expand the knowledge of upcoming results obtained from questionnaires and interviews. A deeper analysis is done comparing results obtained from past studies and current ones.

Study case questionnaires and interviews

Brazilian PV users approach.

The research "Pesquisa sobre o mercado de sistemas fotovoltaicos conectados à rede" (Questionnaire about the photovoltaic system market connected to the grid see Annex 6) were conducted together with Ideal Institute within the projects "50 Telhados" (50 roofs) and "Fundo Solar" (Solar Fund), which objectives are to promote the distributed energy generation from PV systems, giving support and incentives to the participants. A description of each program is explained in the Table 2: Project description.

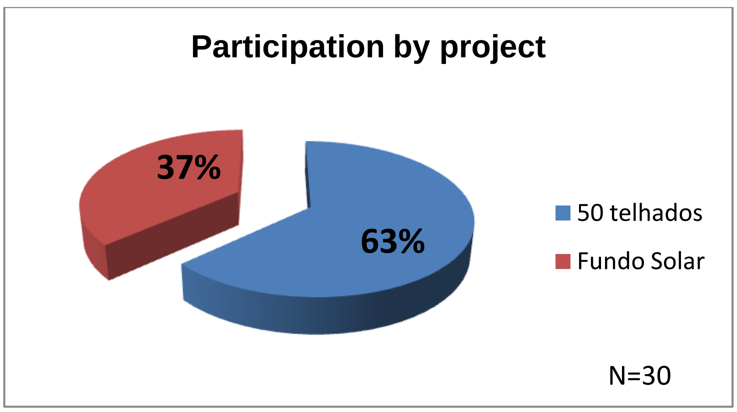
Table 2: Project description

Project	Description
50 Telhados	The Rooftops Project 50 was launched in order to promote distributed generation based on photovoltaic power. Coordinated by Ideal Institute, the project is run locally by installation companies that, by December 2015, should achieve the goal of installing 50 photovoltaic roofs of 2 kWp (or 100 kWp total installed power). Thus, the estimated annual generation would be around 130 MWh in each city. The goal of Ideal is implementing the project in at least 20 cities in Brazil during 2014. By December 2014, the project was already in 32 cities. Any engineering and installation of grid -connected photovoltaic systems can participate in the project as an executing company , provided it is approved by Ideal Institute based on the Guidelines Criteria (IDEAL, 2015)
Fundo Solar	Solar Fund is a financial support for residential and business people who want to install PV systems up to 5kW of power. To gain the benefit, the system must be connected to the grid, be integrated into a building and be under Net Metering scheme (as provided in the resolution 482 by ANEEL). The value of the available resource varies between R$ 1000 and R$ 5000 (€250 to €1450 according to 07/07/15 currency exchange), depending on the location where the micro-generator will be installed and the total investment cost (IDEAL, 2014).

An online survey was sent in April 26th 2015 to 114 customers with PV systems connected to grid that participated in one of these two projects mentioned before, inviting them to answer a whole of 25 questions about their experience in the process of PV system implementation, beginning from the reasons that motivated them to start a new project until the final system installation and performance. The main topics to analyze are related to energy consumption, financing options, final billing, and user's relationship processes with the PV installer and distributor facility.

The deadline to participate on the survey was May 21th and, a total of 30 customers had completed the survey (26% of the total invited to participate). The Figure 16 shows the participation by project, compiling on one hand a sum of 19 customers that complete the survey and participated on the project "50 telhados", in the other hand a total of 11 customers were part of "Fundo Solar".

Figure 16: Participation by project



It is important to clarify that the owners within the project "50 telhados" have cover the 100% project budget with their own money resources (with only one exception), on the contrary to participants from "Fundo Solar", which received a percentage of the project final budget.

Brazilian PV suppliers approach

The study case: “O mercado brasileiro de geração distribuída fotovoltaica em 2014” (Brazilian market of distributed photovoltaic generation in 2014), is the second annual report done by IDEAL Institute once the normative resolution 482/2012 was implemented. For the relevance of this thesis investigation, only some key aspects are taken into account from the report delivered to ANEEL in the public audience № 26/2015. The report delivered by Ideal Institute is, to the date 07th of July 2015, a preliminary result from the final article; nevertheless, the data analysis is already concluded. The purpose of this section is to analyze the

Brazilian PV market in 2014, remarking on the development of it in comparison with 2013 similar study regarding the next topics:

1. Installed systems
2. Time process in installing a PV system
3. Energy prices
4. PRODIST, INMETRO and Distributor agency perceptions according to PV installation companies.
5. Process difficulties

The methodology used to do the study is through an online questionnaire using the Question Pro (HTTP://www.questionpro.com) platform. The survey was sent to the companies registered in the Photovoltaic Sector Companies Map (http://www.americadosol.org/fornecedores) in May 2015, which add a total of 504 companies. The time to respond the questionnaire was 34 days. From the total of the registered contacts, 172 (34%) started the questionnaire, from which 107 (21%) answered all of the questions. Thus, the responses considered valid for this study were only the ones who completed the questionnaire. To avoid the possibility of ambiguity regarding the installer understanding, the questions were revised from the past edition researched in 2013 (Instituto IDEAL, 2015).

With the data compiled during the analysis from the previous topics, some relevant aspects are given in order to define opportunity areas and recommendations to the main entities involved within each topic.

Mexico's approach

The study case in Mexico is analyzed from the Dr. Valdés point of view, current president of the ANES (National Solar Energy Association) and one of the most involved persons in the topic of photovoltaic market development in the country.

A qualitative semi-structured interview was done to Dr. Valdés the 23th of June 2015 via Skype. The interview aims are to have a general approach on the current photovoltaic energy situation in Mexico as well as the Net Metering regulatory norm development in the country. The idea of interviewing an association like ANES is to present a different perspective from the official government point of view mainly exposed on the legal aspects showed in chapter 3. The main points discussed within the interview are divided into 3 main topics: PV different scales generation and Net Metering current situation, main barriers in the development of PV systems and social perspective.

ANES is as Mexican nonprofit civil association whose objectives are to provide a forum for the discussion of ideas, to compare and exchange results and, in general, to disseminate and promote the use of solar energy; by attempting to influence in a firm and definite way, with technical and scientific grounds, on the governmental agencies that shape the country's energy policy; as well as with awareness of the important role that different forms of solar energy have in the future development of Mexico. ANES is also part of the International Solar Energy Society (ANES, 2015). According to Dr. Valdés, in the most recent years, this association has focus on the development of the industrial PV sector more than the academic one due to the second one is already very solid with the past years research in were the development of the technology was a more relevant topic.

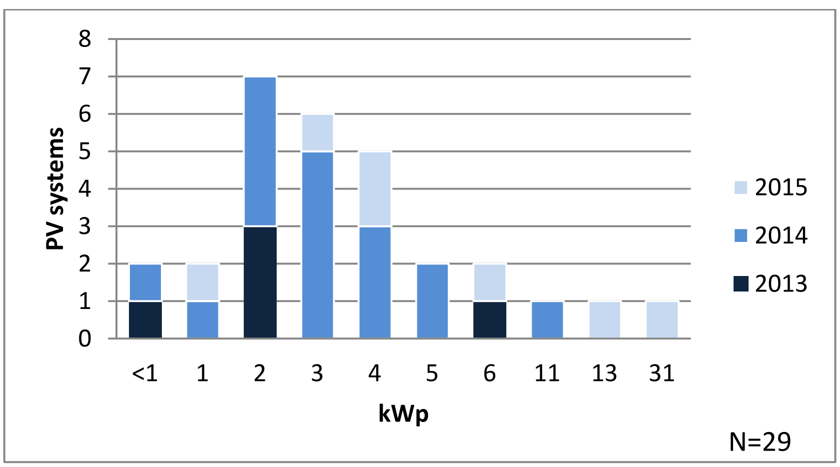
Chapter 5. Study Case

Brazil study case: Questionnaire about the photovoltaic system market connected to the grid

Users PV system size

The user's system sizes in kWp are mainly concentrated in micro generation for residential use between 2 and 4.9 kWp with 60% of the users inside this category (Figure 17). The other sizes rated less than 6 kWp are similarly distributed, having two systems on each category. There were also three participants with larger systems above average, with 11, 13 and 31 kWp respectively. One user was not considered in this information due to his answer was not inside the Net Metering terms, that is to be connected to the grid with a system under 1 MWp. In relation to the PV system connection date to the grid by the distributor agency, it was found that 5 systems were connected during 2013, 17 in 2014 and 7 in 2015.

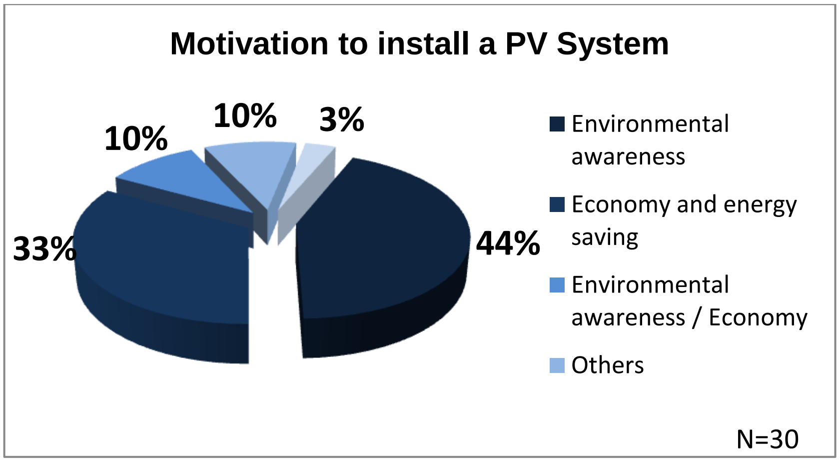
Figure 17: PV holder's system size in kWp



Motivation for installing a PV system

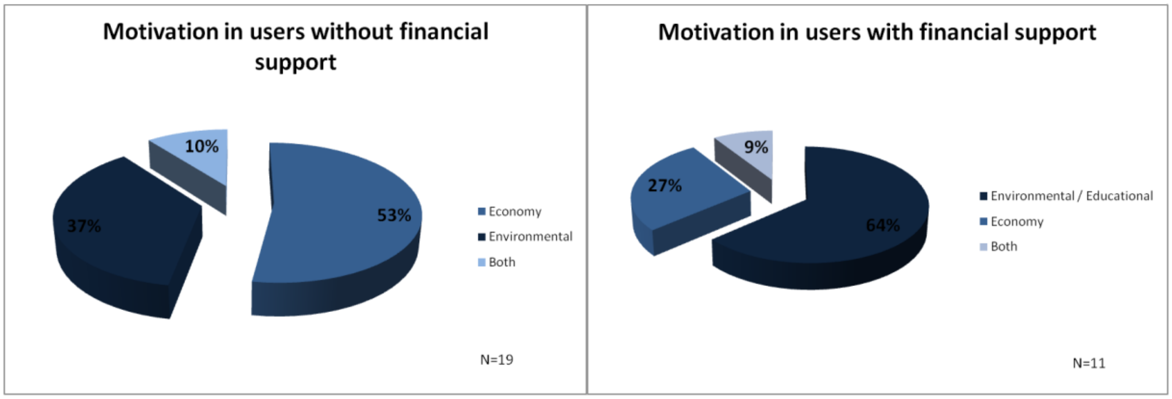
Within the answers for what have motivated the users in installing a PV system, it was found (Figure 18) that environmental awareness is the main reason among the participants with a 44% of the total result. In second place, economy and energy savings are the drivers for installing a PV system with a 33%. 10% responded that the motivation were both economical and environmental. Other 10% of the answers were classified in "other" depending on different goals each user had. Also, one user representing the 3% was driven by educational purposes due to the project has been installed in a school.

Figure 18: Motivation for installing a PV system



If the two answers with larger percentage are compared (Figure 19), the general idea is that the final purpose for the participants, in this study case, is to have a major participation in environmental related topics. However, if it is also considered the financial support given to the users, a different panorama can be seen. The users that had a financial support (for this case, financial support is considered as an incentive more than a credit) answered with a 64% that environmental and educational reasons were what motivated them to install a PV system. The other 27% responded that the economy factor was the main driver for their installation project. The final 9% were motivated for both reasons with an equal importance. On the other hand, 53% of the users that did not have a financial support answered that their PV installation project was oriented to an economic reason. The other 37% were motivated for environmental awareness and 10% came to a decision for both reasons with an equal importance.

Figure 19: Motivation for installing a PV system (with and without financial support)



It is important to mention that among "economic reasons" there were classified other similar motivations for which the final goal was an economic improvement such as: building a laboratory for further systems development in a selling company, installing a pilot system in a company and having independency from a distributor agency.

Another topic surveyed amongst the users is about how they got informed of the possibility to generate their own energy and connect their PV system to the grid. From the total, 11 users received the information through the media (internet, TV and radio) whether by their own research or commercial and public spots; the same amount of users received the information directly through their PV supplier. From the rest of the users, 3 worked in the field of RE, 2 got informed directly by a distributor agency or ANEEL, and 3 more by different personal sources (see Annex 7).

Process steps difficulty analysis according to the users.

The users were asked to express the level of difficulty during the next processes:

Project financing

1. Qualified PV supplier selection
2. Access request to the distributor's grid
3. Technical PV system installation

4. Relationship agreement signed with the distributor
5. Information given in the electricity bill.
6. Information given in the electricity bill.

The question was formulated in a tabular format, where users could see the 6 process options simultaneously and therefore, there could be an influence on the value given on each one. These steps include the main aspects were users are involved within the implementation of a PV project. The user's perspective in these topics is relevant in the understanding of the main opportunity areas in the further adoption of PV systems.

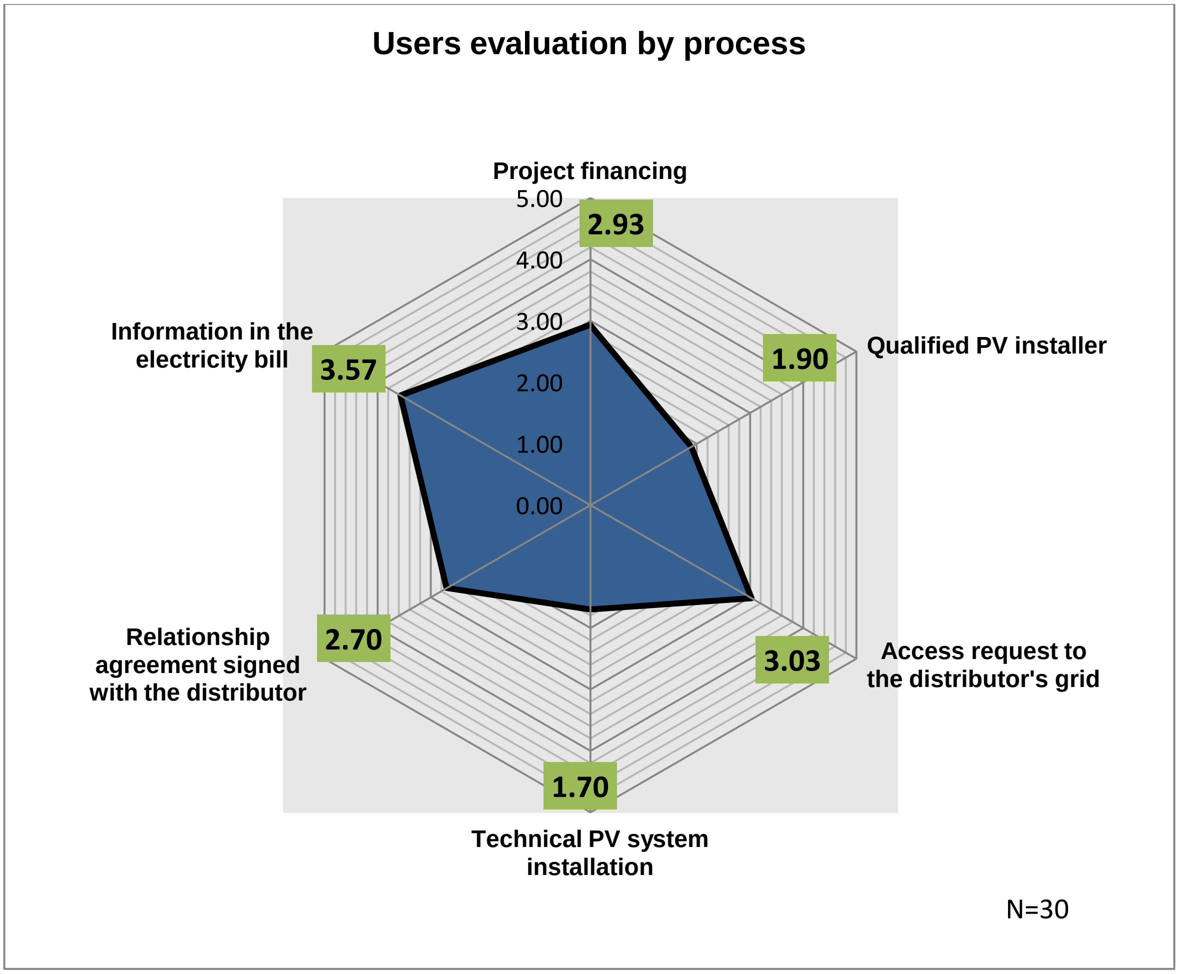
A system grade between 1 and 5 was given, where 1 stands for "without any difficulty" and 5 for "very difficult" during the implementation of the step. An average value was obtained with the 30 answers of each step. This value aim is only to be used as a comparative number between the different processes.

A summary of the values is shown in Figure 20 , in which can be seen that there is a difference between the level of difficulty depending on the entity with whom the user have to do the process. The steps are arrange going from the most difficult step to the easiest: Information given in the electricity bill, access request to the distributor's grid, project financing, relationship agreement signed with the distributor, qualified PV installer and technical PV system installation.

The first two processes are performed by the distribution agencies, which mean that the most difficult steps are carried out by these institutions. In a second place of difficulty level, during the project financing, there is not a specific entity to pin the responsibility for this step; nevertheless the lack of financing opportunities is generally a topic that falls into the absence of governmental programs. The less two difficult processes are related to the relationship between PV installers companies and users in which performance is well perceived according to the grades given.

This general panorama might give the suggestion that processes carried out by public agencies are still not regulated nor implemented well enough according to users' point of view.

Figure 20: Users evaluation by process



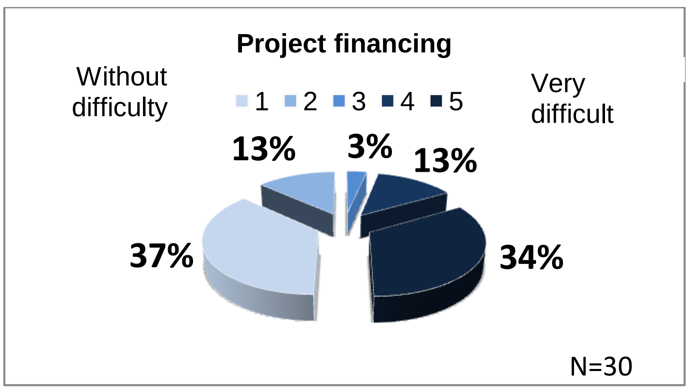
A deeper analysis is done inside each process. The objective for this is to have a better understanding, not taking into account the average value, but the complete range of answers as well as the individual comments on each one.

<u>Project financing</u>

Project financing refers to the action of finding an incentive, bank credit or any other type of income that helped the user to pay for the project budget. In this study case it is found three different scenarios in terms of financing: the first refers to the majority of the surveyed users coming from "50 telhados" project which financed their project with their own income. The second scenario is related to the users that were funded by "Fundo Solar"; this fund has different amounts of incentive depending on each project. The third scenario has only one user who looked for a bank credit in order to finance his project, approximately 80% of the final budget.

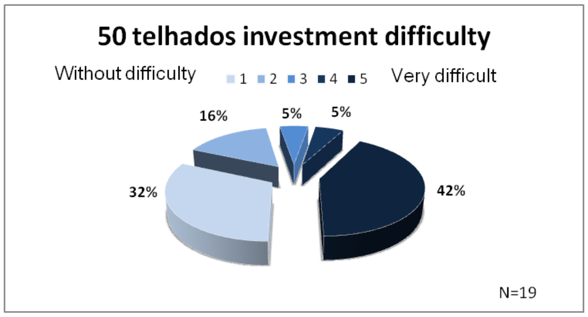
The answers related to this section in the Figure 21 are contrasting, being that 37% of the total surveyed users gave a grade of "without difficulty", in comparison with the almost same amount of users (34%) that answered completely the opposite, stating a "very difficult" financing process. The final 29% of the users are also similarly arrange in the grades 2 to 4 with a 13%, 3% and 13% respectively.

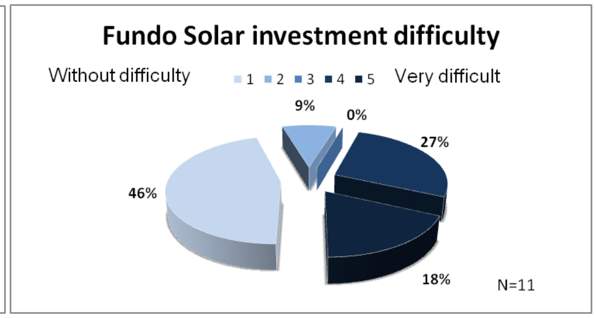
Figure 21: Difficulty financing a PV system project.



A different perspective can be seen if the answers are divided according to the project in which they participate in Figure 22. If the project "50 telhados" answers are taken separately, the perception of difficultness increases among the participants, in which 42% stated it as “very difficulty”. On the other hand, project “Fundo Solar” answers lean more towards “without difficulty” process, this obtained 46% from the total participants within the survey. This difference between projects is relevant due to the characteristics of each program where users with financial incentive found the financing difficulty level easier that the users without it, and for this case, the users might be in reality grading the incentive program more than the process itself. Finding a public or bank program to help during the financing process is also a common comment on final notes section, which is mention further on.

Figure 22: Difficulty level of Investment by project

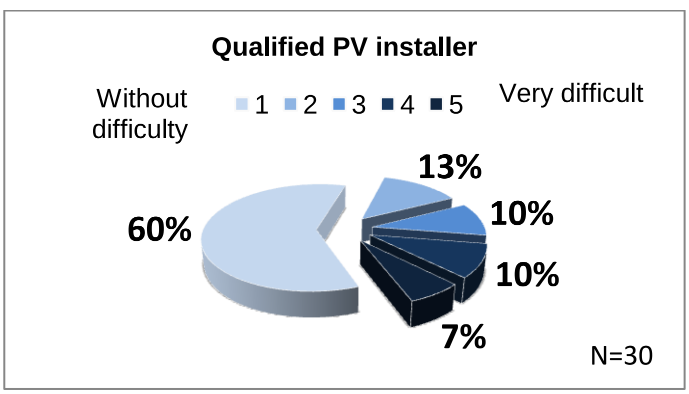




<u>Qualified PV supplier selection</u>

The process selection for a qualified PV supplier is relevant because most of the times it is the installer company itself who takes the role of informing the customer about the procedures, both in regulatory and technical aspects. The grades obtained for this step in Figure 23 show that most of the surveyed users answered "without difficulty" with a 60% of the total. The other grades are more or less similarly distributed, being the grade "very difficult" the lowest answered option with only 7% from the total. These values obtained for this step process express that the users within the study did not have major problems to choose a qualified PV supplier, and also symbolize the users' experience lived grading them as qualified suppliers.

Figure 23: Qualified PV installer

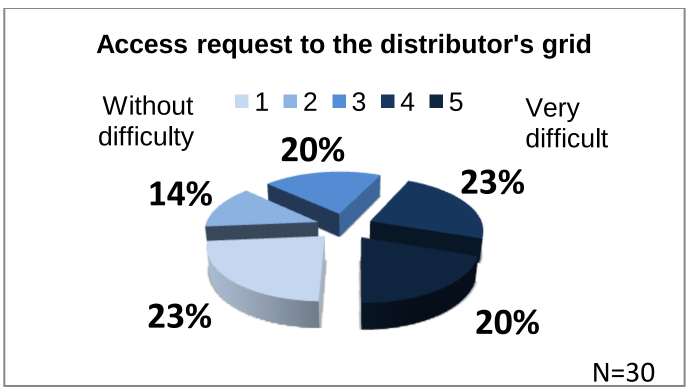


<u>Access request to the distributor's grid</u>

In this step the users request the distribution agent to have access to the grid, who has 30 days to issue an opinion. In case of mini-generation (>100 kWp), this period is increased to 60 days in accordance with the RN 482/2012. The executing time achievement in this process is analyzed in the second questionnaire; nevertheless the grade issued by the users is closely related to the time and has the same relevance as the administrative processes.

In the answers received in this step in the Figure 24, the customers expressed unconformity being that 43% of the participants qualified the process as "difficult" or "very difficult". 37% of the respondents stated that this step was without or only few difficulties. The rest 20% found the process moderately difficult. The main comments expressed within the answer "very difficulty", affirmed this situation happened mainly because of the distributor's lack of experience, little knowledge on the topic and long periods of time for process completion.

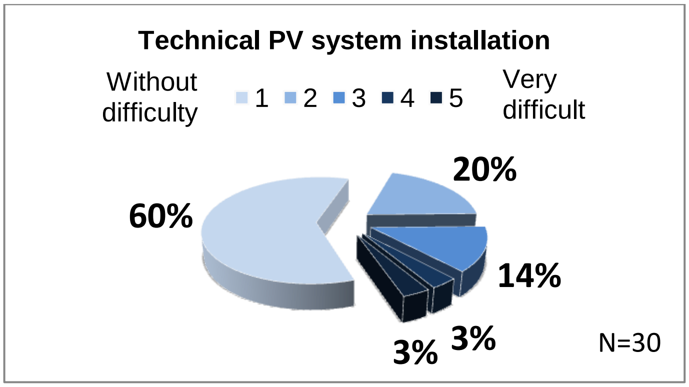
Figure 24: Difficulty level during grid access request.



<u>Technical PV system installation</u>

Technical PV system installation refers to the process in which the suppliers do the PV implementation in order to start the energy generation. The answers given to this step got a good level of approval among the users according to Figure 25, in which 80% responded that the process was without or only a small grade of difficulty. From the remaining 20%, only two users claimed having a “difficult or very difficult” installation process due to an incorrect PV angle placement and low energy generation performance after installation. The final values obtained can be considered as a step with a non representative difficulty among the users surveyed.

Figure 25: Difficulty level during technical PV system installation.

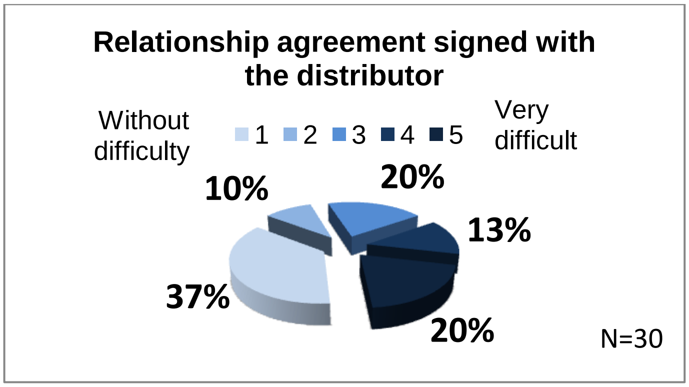


Relationship agreement signed with the distributor

After the process of installation the distributor agency does an inspection for 30 days, and after this, it has 15 days to issue a technical report (Barth et al., 2014). In case all technical aspects are approved, the users request a connection point and sign an agreement with the distributor agency, which approves and connects the installation within the following 7 days (Barth et al., 2014). Just as the step of requesting access to the distributor's grid, the time is a key factor to consider in the grade given as well as the administrative process.

The difficulty level obtained from this step in Figure 26, shows that 47% of the respondents did not find difficulties during the process. 33% came across with some difficulties that stalled this step; the final 20% of the respondents referred to the process as moderately difficult. The values obtained from the users express a medium to low difficulty. The main reasons described among the users who answered a high level of difficulty are related to the long periods of time between system installation and inspection performed by the distributor.

Figure 26: Difficulty level during relationship agreement.

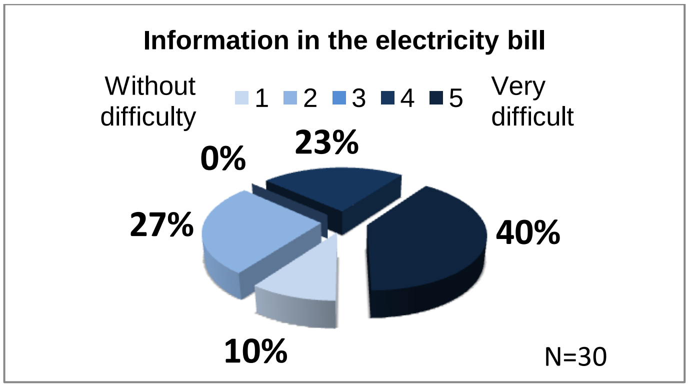


<u>Information given in the electricity bill.</u>

After the PV system installation and connection to the grid comes the metering and billing processes of energy generated. Many users include some of the "after-connection" aspects in this step even ought they were not specifically asked in this question. Because of this, in the section of open comments many users explained their main unconformities helping to add value to the difficulties found in this step that entails a close relationship between the distributor entities and the clients.

According to the answers obtained in Figure 27, this is the step with more difficulties in the hole project for the users, with 63% of the participants expressing disagreements and grading this process as “difficult or very difficult”. The other 37% of the respondents stated that the process was “without or only few difficulties”, but from this percentage, only 10% are completely pleased by their electricity bill. The values obtained reveal that the process has in overall a medium to high level of difficulty to the users surveyed. Some of the comments given by them are: an unclear bill invoice format, unaccredited energy generation and ICMS taxation.

Figure 27: Difficulty level during electricity billing.



Brazil study case: Brazilian market of distributed photovoltaic generation in 2014.

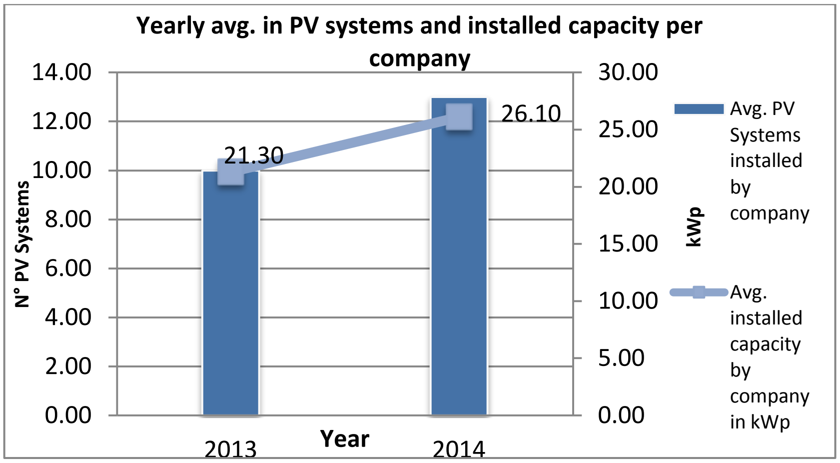
Systems installed and process time

From the surveyed installers (107) 50 companies expressed that they have installed a PV system during 2014 under the Net Metering scheme. The amount of PV systems installed by them increased to 252 (See Annex 8). The sum of 250 from those installed projects[2] give an approximately amount of 1253 kWp installed power capacity, which represents an significant value (54%) compared to the total amount registered by ANEEL data base, in which to the date, 15/07/2015, were registered 466 PV systems. In the 2013 study the amount of PV systems installed were 90 with an installed power capacity of 788 kWp.

According to Figure 28, an average of 10 PV systems was installed by the surveyed companies in 2013 in comparison with 13 systems in 2014. From these projects, an increase from 21.30 kWp average of installed capacity by each company to 26.1 kWp represents that the market continues with an upward trend on their installation projects.

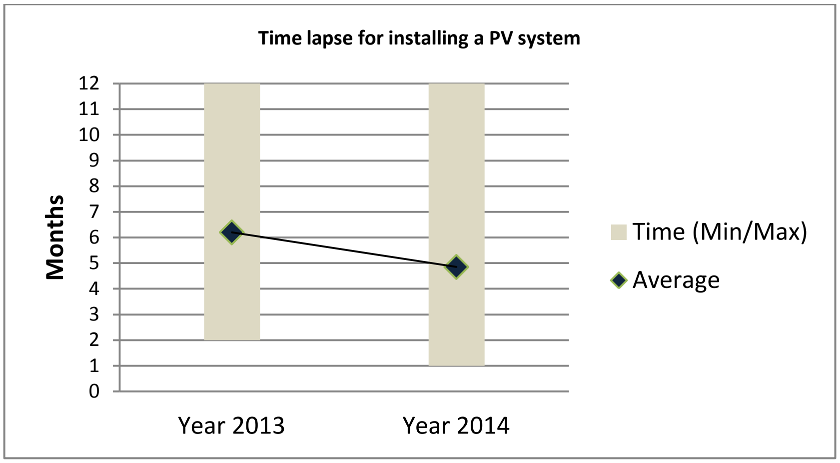
[2] The 2 remaining projects are not considered due to unclear information given by the distributor

Figure 28: Yearly average in PV systems and installed capacity per company.



As established in Module 3 section 3.7 Distribution Procedures (PRODIST), the maximum amount of time that the distributor has to perform its activities in relation to mini generation (issue the approval to access the grid, the inspection of the facility, delivery of the inspection report, approval and effectiveness of the connection) is equal to 112 days (IDEAL 2014). In terms of the time taken in order to achieve the complete process of PV installation, the results exposed in the 2013 and 2014 studies, show an improvement in time lapses. The time considered within this time lapse is from the contract signature between the installer and the user until the effective connection of the PV system to the grid. According to Figure 29, while in 2013 the PV companies had an average of 6.2 months for installing a PV system, in 2014 companies improved project time to an average of 4.8 months, which means a significant progress. A second important fact is the decrease of minimum time, which in the year 2014 one company could complete a PV installation in one month. Regarding the maximum time average, it has been maintained due to the question option maximum value is 12 months.

Figure 29: Time lapse for installing a PV system.

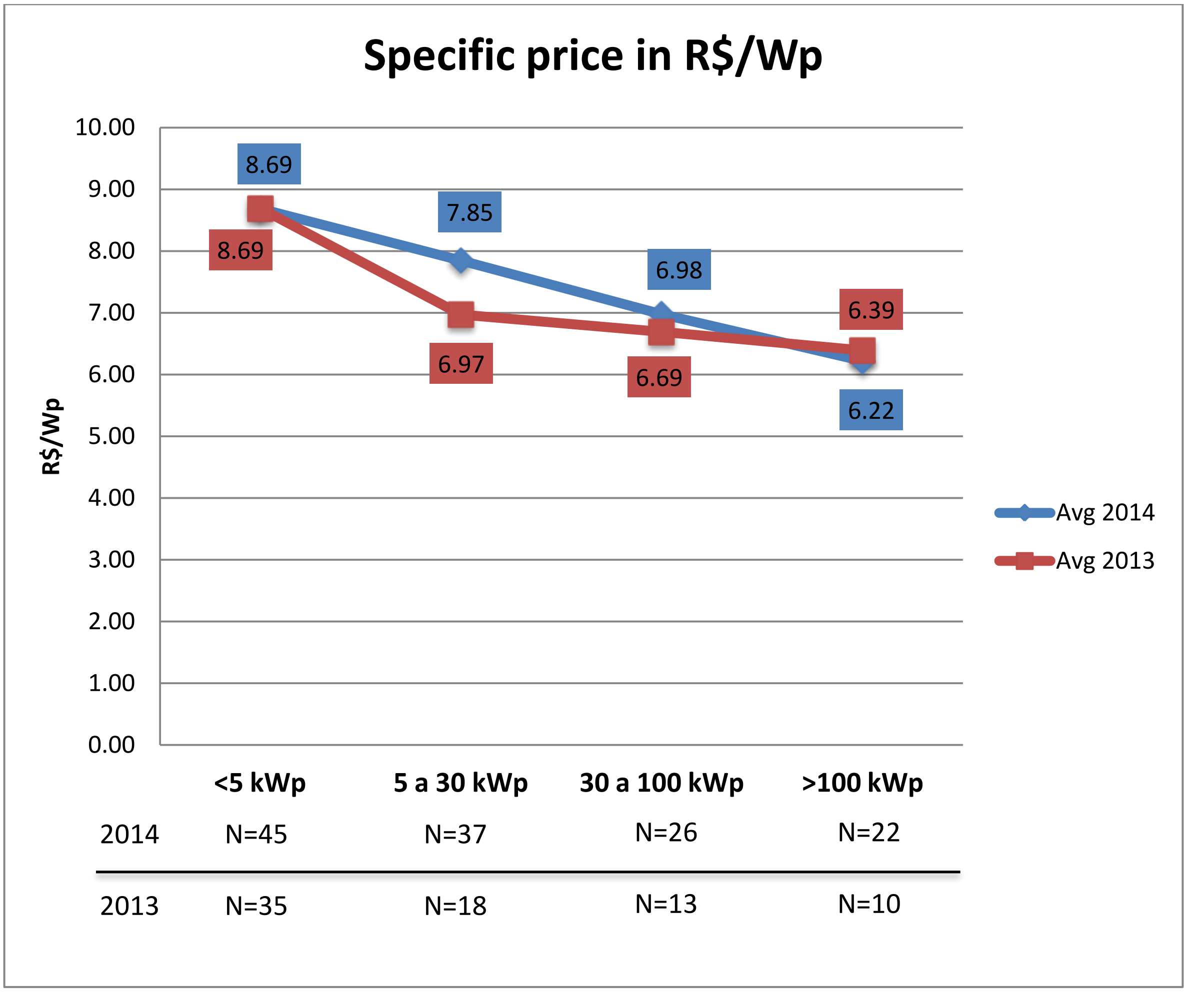


Final prices by kWp

The specific price in R$/Wp refers to the average price for PV systems installed on each of the nominal power categories in Wp connected to the grid with RN482/2012 norm. The price considered by the installers included technical equipment and work labor. The installers did not report any price in 2014 study in the case that they did not installed any system within a category, on the other hand on 2013 study, some installers estimated the final price without having conclude a project in that category (IDEAL 2014). It is important to consider this difference between the two studies and some of the data given mainly in bigger categories.

According to Figure 30, the most common category within the range of PV systems installation is under 5 kWp. In this rank the final price has continued been the same in both studies even when 2014 survey contemplated a larger number of installers. Other panorama can be seen in other categories where the final average prices have grown according to 2013 prices. In the category 5 to 30 kWp, an increase of 0.88 R$/Wp is seen, but a difference of 19 installers data between the two studies is also an important fact. In the final two categories a smaller difference can be seen, in the rank from 30 to 100 kWp there is an increase of 0.29 R$/Wp, and in the rank above 100 kWp, a decrease of 0.17R$/Wp. According to these numbers, the specific price has been maintained similar during 2014 in comparison with 2013 data.

Figure 30: Specific price in R$/Wp

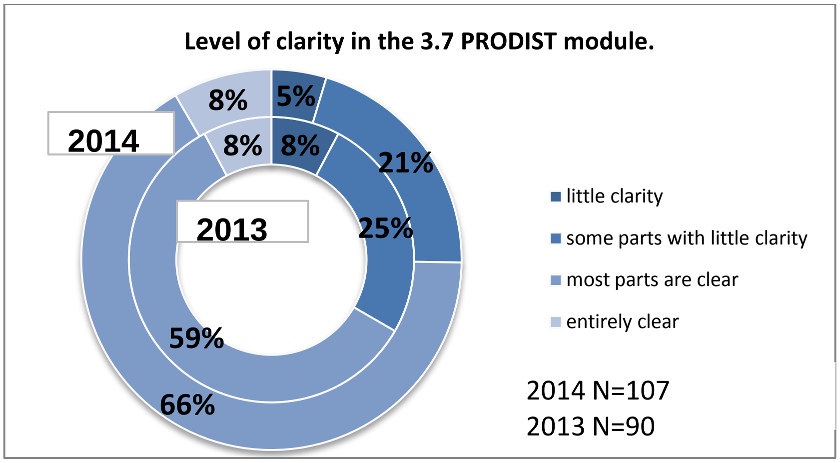


PRODIST, INMETRO and Distributor agency perceptions

One important part of the studies is related to the installers' perception regarding topics such as regulatory procedures, norms and time lapses which were describe in chapter 3 and 4. This points are mainly executed by the distribution agencies and ANEEL inside the regulatory framework of PRODIST and INMETRO. The main objective in this section is to observe the changes in the perception of the installers and find out which aspects might be the drivers for these.

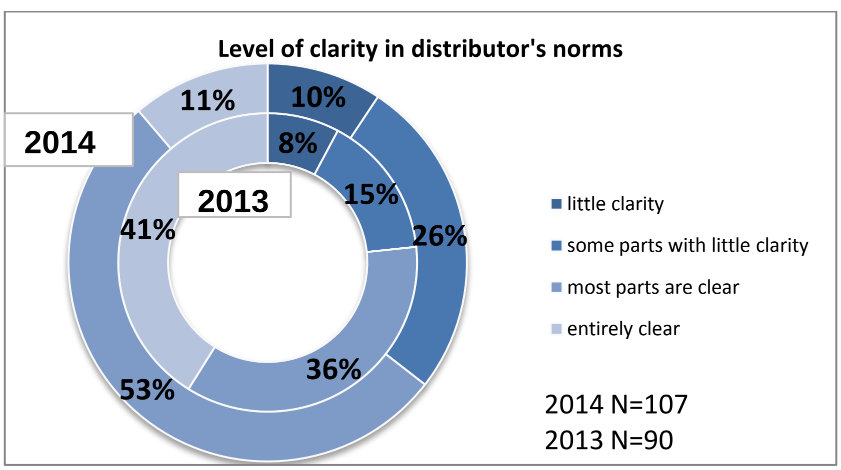
Regarding the evaluation of the clarity level in the 3.7 PRODIST module about distribution procedures in Figure 31, the installers perception improve according to 2013 study. While in 2013 survey 33% of the installers found that part or the complete section with little clarity, in 2014 this amount has been reduced to 26%, this including a larger amount of asked companies. The rest 67% and 74% in 2013 and 2014 surveys respectively, found the procedure most or entirely clear, which means a improvement either on the clarity level of PRODIST or in the experiences of the installers working with it.

Figure 31: Level of clarity in the 3.7 PRODIST module.



Another aspect evaluated is the level of clarity in the distributors' norms, which did not have an improvement as in the PRODIST perception. According to Figure 32, the evaluation sum of the answers "little clarity" and "some parts with little clarity" has increase from a 23% to 36% among the surveyed installers; while the evaluation sum of the answers "most part are clear" and "entirely clear" has decrease from a 77% to 64%. The most important decrease can be seen specifically in the answer "entirely clear", in which a decrease of 30% among the surveyed installer reflects deterioration in the perception of clarity that installers have regarding the distribution norms.

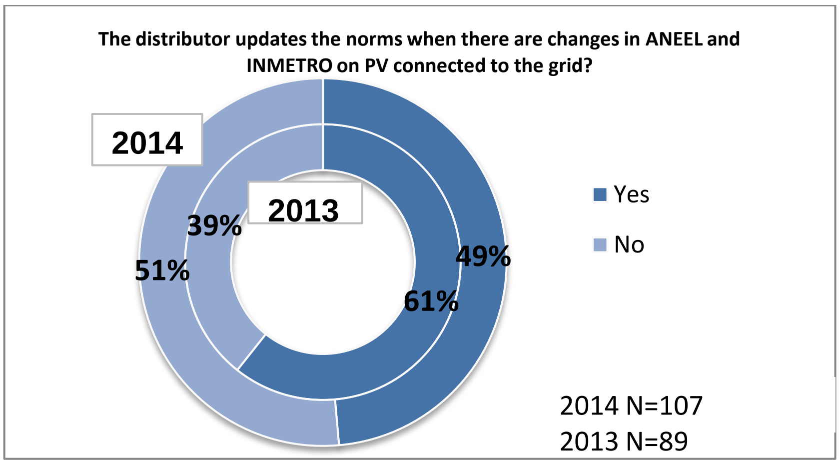
Figure 32: Level of clarity in distributor's norms



The coherence between the national and specific norms from each distribution agency is also an aspect that must be considered in the evaluation of new implemented procedures. This is the reason why, the installers were asked if the distributor agencies update the norms when ANEEL and INMETRO do normative changes related to PV mini and micro generation(IDEAL 2014) .

According to Figure 33, there is a decrease in the perception of the norms updating by the distributor agencies from 61% to 49% according to years 2013 and 2014 surveys. This means that almost half of the PV companies believe that distributors do not revise or implement with enough time the necessary adjustments when there is a change on the national regulatory frame.

Figure 33: Perception in the norms updating.



Process difficulties

Another aspect raised within the survey is the satisfaction level during the process implementation with the distributor agency. According to the studies in 2013 a 51% of the surveyed installers affirmed they were dissatisfied or little satisfied with the distributor agency process. In 2014 this number increased to 58% of the surveyed installers, which reflects a deterioration of the relations between installers and distributor agencies in this period.

After having an evaluation in the satisfaction level, a question regarding the main reasons for the companies who answered "dissatisfied" or "little satisfied" was done, in which some aspects have increased according to 2013 evaluation. According to Figure 34, the reasons that show larger increases are A and D with a raise of 4% on each one. This means that the processes of documentation analysis by the distribution agencies and the achievement of deadlines according to RN 482/12 have not been well regulated or improved in the period between 2013 and 2015, and on the other hand, they have become a more important reason for PV suppliers’ dissatisfaction. The other aspects have more o less been maintained with the same percentage amount, which means meanly that they keep being an important factor for dissatisfaction.

Table 3: Main reasons PV suppliers are dissatisfied or little satisfied.

A	The documentation analysis of PV generator varies depending on the technical agent.
B	The technical team, at different stages during the application process, does not have enough knowledge on photovoltaic generation.
C	The technical team, at different stages of the application process, do not know all the details about the RN 482/12
D	The process have delays or deadlines according to RN 482/12 are not met
E	Others

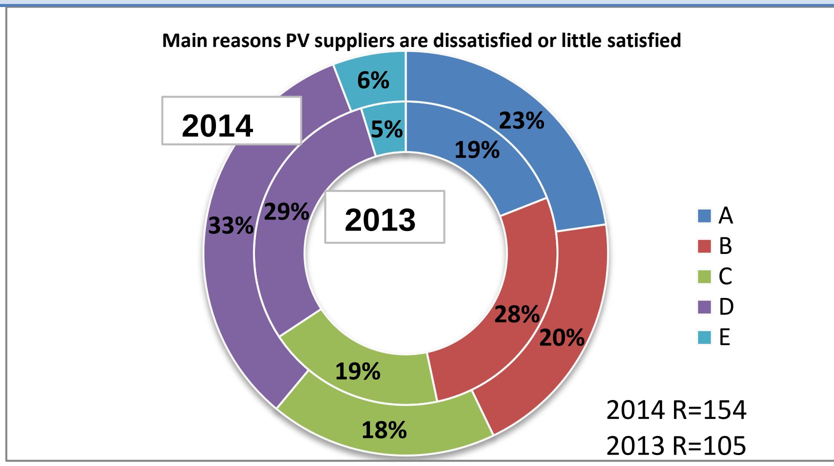


Figure 34: Main reasons PV suppliers are dissatisfied or little satisfied.

Regarding the process difficulties during the whole process of PV implementation, it was asked if their company has faced any difficulty that hindered, delayed, or prevented from ending the project. While in 2013 64% of the surveyed companies answered affirmatively, in 2014 this percentage increased to 75%. This means that companies perceive more difficulties in the process due to different aspects. Another relevant factor could be that some of the surveyed companies are new on the market and this could affect their perception on this process.

A list of the main steps was given to the installers who answered affirmatively to the past question in order to find out which one of them have been the most frequent. In this case, the "access request permission" and "operational relationship agreement signature between client and distributor agency" steps have been the phases in which most of the PV installers found out difficulties that triggered time delay. In the access request permission the percentage has increased considerably from a 29% to a 40%, while the operational agreement signature has increased from 18% to 21% between periods of these studies. The other phases have more or less improved regarding their past percentage; nevertheless this still means that there were dissatisfy during these processes.

An important fact within these numbers is the observation that steps B and C have a relationship between installer (or user) and distributor agency. This means that most of the processes that triggered a time delay, according to the installers, are responsibility of the distribution agencies.

Table 4: Project phase that triggered time delay.

A	Project planning
B	Access request permission
C	Operational relationship agreement signature between client and distributor agency.
D	PV system installation
E	Commissioning
F	Operation
G	Billing

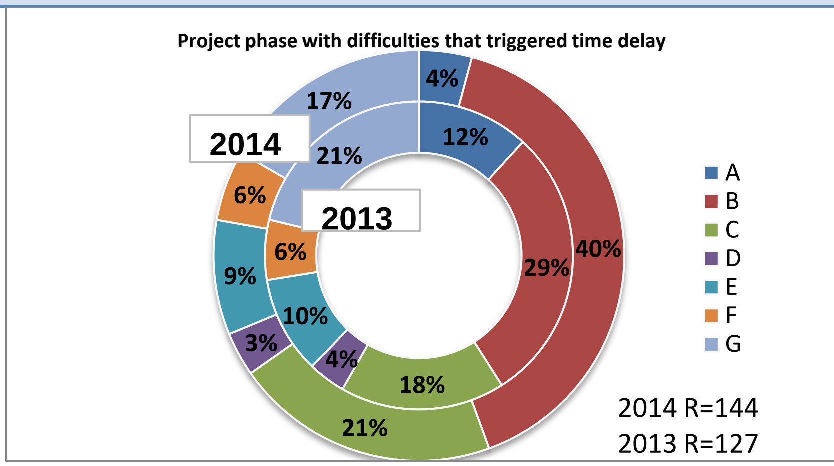


Figure 35: Project phase that triggered time delay

Another important aspect is that 38% of the companies claimed these difficulties make an impediment to connect the PV system to the grid in 2013, but a slightly improvement is seen in 2014 in which 35% of the installers expressed the project was not connected to the grid.

Chapter 6. Identified barriers and recommendations.

Brazil

There has been an increase of PV projects installations in comparison with previous years before the Net Metering policy, tendency that will continue in the next years. Because of this increase in the PV systems demand, the market has a good opportunity to expand itself and create competitiveness among the suppliers. The first years of the Net Metering policy in Brazil are important in order to shape the base in which further development will be implemented as it was presented in Chapter 3, in which according to the high expectations, they depend on a good execution of the different norms.

There have been positive examples within the 2013 and 2014 studies such as the improvement in projects' finalization time. On the other hand the prices have not decreased in comparison with 2013, but they have also not increased in a significant way that enacts in a major difficulty for users. In the coming years the PV system prices could present a decrease if the market continues with a constant development.

In this chapter are described the main barriers found within the study cases, giving a point of view from PV users and installers. In order to find a relationship between the values given and the possible reasons for them, some open commentaries are also given from the PV users' point of view. The users' opinion about the satisfaction level regarding the project initial expectations (economic and non economic) in addition to the barriers found in the PV supplier studies, give a general panorama of the current situation in Brazil about Net Metering policy.

Some of the barriers concerning net metering policy in Brazil have been also exposed in the studies "Framework Assessment for the photovoltaics Bussiness Oportuninities in Brazil" and “Experiências do Fundo Solar: Recomendações para a revisão da RN 482/2012” in order to review and evaluate the actual market in the country, giving similar points of view on the topic that complement the research. The main barriers founds and recommendation proposed are described next.

Internal process bureaucracies & distributor inexperience

Bureaucracies related to documentation and extensive approval times during the different processes have created a perception among the users of a general lack of interest from the distributors to improve the whole system procedures, likewise a deficiency in the standardization and regulation processes by ANEEL. Internal processes have not been properly set up yet to guarantee a streamlined execution of interconnection requests by small distributed generators (Barth et al., 2014). In accordance to this, the access requesting to the distributor's grid process and relationship agreement signed with the distributor process are graded by the users with a medium to high difficulty and medium to low difficulty respectively.

Some of the comments given by the PV holder regarding this aspect are the next:

1. *"Distributor lack of experience of the distributor...causing excessive delay and requisition of unnecessary documents."*
2. *"The distributor was little adapted to the PV systems connections"*

The non-compliance of times established by the RN 482/2013 is also the most frequent aspect according to the PV suppliers to be dissatisfied with the distributors. These procedures carried out by the distributors represent an important field to improve the overall situation. The most mentioned processes within this topic in 2013 and 2014 studies are the access request permission and the operational relationship agreement signature between client and distributor agency. These two points match with what PV users mentioned in the survey presented before, in which they classified these processes as the most difficult ones only under the billing procedure.

Little knowledge by the agencies regarding connection norms and processes could encounter in time delays and the customers viewing the process of PV installation as exhausting. Nevertheless, the information given by the suppliers expressed an improvement in the time to finalize PV projects, which could mean that distributors’ learning curve must be taken into account hoping to continue improving in coming years.

There are still some aspects to improve also in the level of clarity, mainly in the distributors' norms. While PRODIST procedures about RN 482/2012 are not considered as a problem to the installers, the application of it through distributors' norms could difficulty the processes. This decrease in level of clarity in the distributors' norms respecting 2013 and 2014 studies could have two reasons; one is that many of the surveyed installers in 2014 have fulfilled only one or few PV projects under Net Metering scheme and have little experience on the topic and application of the norms. A second reason could be that in reality the distributors agencies have not clarify terminologies and procedures, breaching the times established by RN 482/2012.

An absence of qualified and experienced technicians and attendants are also one of the most current answers and perspectives among the users surveyed. Lack of qualified and experienced installation technicians, project managers and engineers with knowledge and background in the solar industry is posing a great challenge in workforce recruitment. There is a need for education programs in solar installations that can be managed by certified training organizations or even stakeholder associations maybe supervised by foreign competence (Barth et al., 2014).

The conclusion for this point is that customers need to be previously informed about the different procedures. In addition, an adequate training to distributors' employees would be a positive improvement in the system's procedures and the overall time for the interconnection process. A point suggested by the respondents is the need for training programs, standardization and supervision on the distributor companies, something that could be conducted by ANEEL. Different distribution companies can enhance the process significantly if they coordinate the streamlining and thereby create similar processes. Such coordinated processes will make the connection procedures for PV developers more predictable (Barth et al., 2014).

Billing process

The proper understanding on the final billing has been an issue exposed by the users. One of the problems reported by them is the little comprehensibility on the definition of energy consumption and injection done by the distributors, making it difficult for the customers to claim any possible mistake in the billing invoice. The values given become this step with the unconformity level greater among all the project procedures. Some of the examples given also include doubts regarding the collection of the availability cost and previous credit balances, here is an example:

1. *-"It is difficult to understand the electricity bill: the terms are unclear between generation and injection. I had doubt whether the Additional Red Flag on top of the cost of availability will be charged..."*

According to this, the modification in RN482/2012 proposed by ANEEL (Art. 4º § IX on the new regulation draft) which includes a series of obligatory information on the energy bill) should be well received because it is an issue raised by the PV holders during the survey. Besides the addition of information, it is also important to clarify the terms and conditions of each one of them in order to set a positive relationship between users and the distributor agencies.

Financing options & incentives

Currently, most residential customers installing a small PV system under the RN 482/2012 can afford to do so as they have enough money in the bank and do not need a loan (Barth et al., 2014). This aspect is mentioned by the customers in several occasions, exposing the fact that there are few financing options as well as incentives by public agencies in order to expand this technology. Some of the examples given are:

1. *"Few banks or government credit lines ...it is the public agencies obligation to give example in this initiative of micro generation."*
2. *"...implement projects that reduce the amount paid for IPTU as a way of encouraging the use of renewable energies..."*
3. *"To have more government incentives in order to acquire PV systems with a minimum financial period of 60 months."*

One example that could show the few amount of incentives, is that from the total users participating in the "50 telhados" project, only one person used a bank credit in order to do the installation of the PV system. Therefore, in order to increase access to PV distributed generation to different social sectors it would be necessary to develop better financing conditions for small residential systems as well as governmental incentive initiatives.

Taxation

Excess PV electricity that is not self-consumed but fed back into the grid for gaining net metering credits, is burdened with a numerous amount of taxes and surcharges. Consequently, excess PV kilowatt-hours do not compensate grid kilowatt-hours on a 1 to 1 basis, since the value of the injected PV kWh is decreased financially(Barth et al., 2014). Even when this point was not taken into consideration during this survey, the users expressed their opinion regarding the topic. ICMS tax is repeatedly mentioned by the surveyed users as the main obstacle for this technology electricity generation. The amount of time these investments take to payback increases due to this tax and the pursuing of legal action towards the misappropriation of ICMS on produced energy are only some of the examples given by the respondents:

1. *"The improper collection of taxes because of the energy entering the house, even when it is returned or produced with surplus".*
2. *"Once the system was installed we find out that the government does not exclude the taxes on solar generation, increasing the return of investment".*
3. *"The taxes on my state make the energy generation more expensive by 50.72% ... I receive a cost for energy generated of R$ 0.3450 and paid R$0.52".*

Despite that the process of electric generation and injection to the grid is not considered as a purchase and sells one; it is still unpractical since the CONFAZ approved the ICMS tax in 2013 fall on all energy consumed during the month by the consumer. PIS and CONFIS are two more taxes added by the distributor agencies which do not have a legislation support by the Federal treasury (RFB). ANEEL proposition is to apply these taxes only when the generation surpass the consumption and it should be just the value of availability cost (depending on limits fixed during the connection to the grid) (ANEEL, 2015e).

It is still unclear to the customers the reasons of this taxation and further efforts to settle better solutions for it are needed. An option to avoid this is when planning a PV installation, the PV self-consumption should be lower than the residual off take from the grid below the threshold of the current ICMS rate, if applicable in that federal state (Barth et al., 2014).

Other barriers

Next are presented some other barriers found in the study cases, that are also important to the topic.

Structure retail rates: Residential customers using a single phase connection pay for a minimum monthly consumption of 30 kWh, even if their real consumption is lower. Customers using a double-phase connection pay for a minimum consumption of 50 kWh, and customers using a three-phase connection pay at a minimum for 100 kWh. Therefore, there is little economic appeal to increase energy efficiency or decrease electricity consumption by means of installing a net-metered PV system and generating electricity on-site. Consequently, PV installations will be dimensioned smaller than the self-consumption optimum but relatively expensive at the same time. Consider accurately the existing ratemaking of the customer in order to maximize his / her net-metering-profit out of self-consumption. Regulators should review the rate making structure and promote structural changes in favor of energy efficiency measures and distributed generation in form of small-scale PV systems (Barth et al., 2014).

Custom duties on imports: Since most PV equipment is imported, national import taxes arise. A rate of 12% occurs for photovoltaic modules and 14% for inverters, except for members of the Common Market of the South MERCOSUR. It should be consider procuring locally produced components as long as market demand does not accept the resulting price differences for imported products (Barth et al., 2014).

Certification of inverters: National Brazilian codes and standards have been set up. They typically are very ambitious, mainly based on German and Italian standards but enhanced by Brazilian specifications. Furthermore, according to a project developer, Brazilian laboratories are not mostly equipped yet to carry out the needed tests. In addition, the know-how regarding testing is often missing. Inverter manufacturers need to become acquainted with the national and regional certification requirements before offering their products. Complying with the international standards is a prerequisite, but further certification might be necessary (Barth et al., 2014).

Mexico

Current policies in Mexico are focused in larger power generation plants, which do not mean that distributed generation is going to stop but maybe it will not grow with the expected rate as thought (Valdés,2015). Regarding the situation with larger PV generation scales, what in Mexico is known as self sufficiency in power plants larger than 0.5 MW, the new Electric Industry Law contemplate them as certified users trough the new implemented Clean Energy Certifications (CEC); which are nowadays an important topic in Mexico due to its relevance regarding the possibility of being contemplated as an energy incomer source by the CFE. They are described as an instrument to promote new clean energy inversion by letting individual obligations transform into national goals of clean energy generation (SENER, 2015). The main objective of the CEC's is to establish a percentage of clean energy in which energy producers within the Law of Electric Industry have to fulfill by 2018.

Nowadays there are around 238 authorized projects that sum 3.8 GW installed capacity (Valdés,2015), a number larger than the goal established by the government. These certified power plants are considered as wholesalers and will be able to set spot prices at the correspondent hours. The only observation established by the main stakeholders within this sector is the increase of contract time which now is 10 years, but according to them, a period of 15 to 20 years is needed in order to have an inversion certainty (Valdés,2015).

A different panorama in comparison with the large generation plants can be seen in distributed PV energy in Mexico. According to Dr. Valdés, to this day high electric consumers (domestic or commercial) were the ones who triggered the use of distributed PV energy generation and for this reason it is important to analyze current legal situation in this topic to understand the possible ways the new legislation is closing the door to Net Metering. The main barriers presented next in Net Metering are also due to technical and economical factors, recommendations to these are also given.

Normative changes & internal CFE processes

The first discussed topic is the current Net Metering situation, in which the new Law of the Electric Industry, issued on February 24th 2015, is describing new parameters for electric generation. ANES, together with other institutions, has set several observations regarding the parameters and changes Net Metering is being submitted within this new Law. According to Dr. Valdés, one of the main observations that are currently concerning this energy sector is the fact that Net Metering is not contemplated in the new Law of the Electric Industry (Valdés,2015):

1. *"Net Metering is not contemplated within the Law of the Electric Industry, not as interconnection mechanism nor anything similar. The interconnection Law released, that is about interconnection requirements, are mainly technical and nobody opposed that, to the contrary, they are fine; but there isn't still a way in which various aspects are recognized that we thought they were already overcome, including Net Metering, which had been introduced since LAERFTE Law."*

Since PV energy producers under Net Metering scheme are not contemplated by this Law as wholesalers, they cannot have access to clean energy certifications. This means that they have to be endorsed to CFE under conditions still unclear. The connection of a PV system have a regular process as described in chapter 3, but with the release of the new Law, this steps are no further contemplated or still unclear of their continuity. If a new arrangement is done between CFE and a consumer below 0.5 MW, a possible new negotiation will be done, in which energy surplus would be bought by CFE under the price of the current time generation rate, in the case of PV systems during mid day when electricity prices are at its lowest. In words of Dr. Valdés:

2. *"It is like consumer starts to buy and sell dollars to the same bank".*

Meaning that there is no longer an energy exchange but a product of energy that in this case will be in terms of money; under this scenarios consumers could be discourage to continue or even install a PV system. It is because of these reasons that main companies involved in the PV market are worry about SENER and CRE not maintaining current Net Metering scheme as today's and if the contrary happens, an unclear panorama for the development of PV energy production is predicted. In the case of already installed PV systems, previous contracts are being respected by CFE.

If this new scenario is implemented the best possible action to do, according to Dr. Valdés, is to keep the high consumption energy tariff as its current price which is around 4 Mexican pesos per kWh and not the price of the subsidy energy around 1.5 Mexican pesos per kWh. These expectations are low due to the decrease of national energy generation prices to a 30%, impacting mainly in the return of investment (ROI) a PV project would have, increasing approximately from 6 to 8 years and also discouraging possible bank credits now that the ROI takes longer (Valdés,2015).

The large amount of formalities to achieve the implementation and the extent contracts have become a problem among users. CFE processes to install a PV system under Net Metering have to be simplified as well in order to continue with the expansion of generation systems. Another key point is to improve the technical norms for constructing, operation and maintenance of distributed energy systems (Gallegos & Rodriguez, 2015).

Another barrier found in minority express the few human capital and the need of training that shape new technicians in the fields of design, construction, management and operation.

PV competitiveness & Subsidies

The PV competitiveness is another factor to contemplate with the new open market system brought by the new Energy Reform, in which private energy wholesalers will be able to sell their energy production and will establish a difficult competition system for renewable energies. It is contemplated that with the implementation of CEC's a bigger promotion of RE is done, but the 5% established for next 2018 takes into account clean energies as well, considering within this category the production of energy through natural gas. The levelized cost of energy (LCOE) of PV systems compared to the new fossil resources exploitation will still be hard to reach according to Dr. Valdés. Putting into perspective, the called "natural gas last generation" is around 3 EUR cents per kWh generation, but a PV plant of 20 to 30 MW LCOE is around 10 or 11 cents, and a small residential producer would have a 20 cents LCOE, explains Dr. Valdés; from his point of view the RE technology prices are not necessarily the problem but the competition market in which they are involved produce them not to be included, affecting the suppliers that depend on this type of business (Valdés,2015).

The subsidy electric energy tariffs in Mexico have made PV systems not economically viable in some cases, enclosing the market to only high electric energy consumers. This barrier could be also seen as an opportunity, if the money for subsidies is used to finance the installation of PV projects. According to IMCO (Mexican Institute for Competitiveness), with the amount of money used for subsidies in 2012, around 2,763 MW of installed capacity for distributed PV could be implemented, that would imply 5% of the total installed electric capacity in Mexico (Gallegos & Rodriguez, 2015).

Incentives & information

According to Dr. Valdés, PV systems are mostly seen from an economic point view by the users, in which electricity prices do not motivate the inversion in this type of technology and other benefits are excluded. One of the main drivers for solar energy development is not PV systems itself, but the up growth of solar thermal technologies around the country. According to Dr. Valdés, the more accessible price, around 15 000 pesos for a 4 members family house, and the entry of new projects in low income housing, is bringing people's attention. PV systems are closely link to the solar thermal ones by the companies that distribute both types of technologies and also inform the possible users. The difference in price, around 100 000 pesos for a 4 members family house system, make the sector that is interested in PV technology smaller, but already familiar to it (Valdés,2015).

In order to overcome lack of information, new communication channels and plans are needed to break actual paradigms in PV energy, compiling the benefits, potential and technologic evolution that the sector has. At larger scales within distributed energy, the level cost of methodology should include the environmental benefits in terms of energy security and sustainability; the level of remuneration should also establish a model with associated tariffs that detonate this source potential (SENER, 2012).

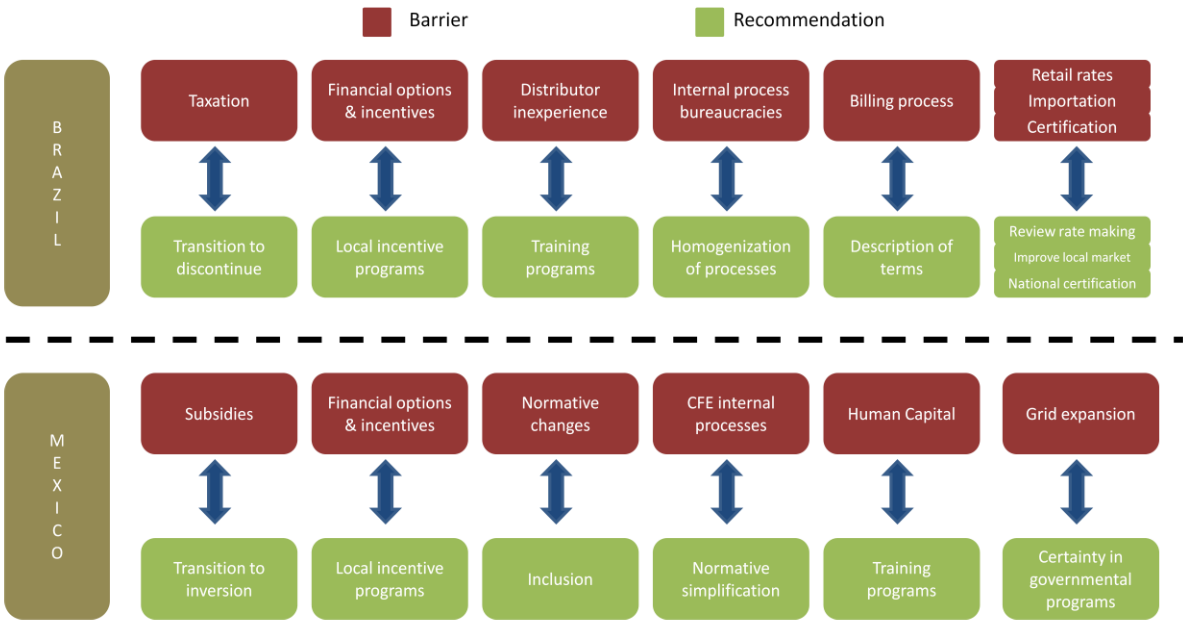
Institutional and governance issues at municipality level has been an obstacle for the development of RE systems, this is why the importance of creating incentives for distributed energy in municipalities that promote RE sources. Well established business models, considering the whole supply chain of the project such as technology, required training and stakeholders' income; would also guarantee reliable models for further implementation(Gallegos & Rodriguez, 2015). Finally, financial schemes for small generation users coming from private banks are needed for the users' motivation.

Grid expansion

Another point raised by Dr. Valdes is in the technical aspect, in which in order to install a PV system in a residence or commercial establishment, an additional grid is needed. This situation produces an extra cost for the user that would increase the final project price. A second technical point is that the national electric grid in Mexico is old and does not provide the necessary arrangement that an intelligent grid would do instead. This means that the electricity provided mainly during mid day by different generation systems produces imbalances in the grid (Valdés,2015). The installed capacity and generation associated to PV systems need a better grid infrastructure for its development, as well as developing certainty for future expansion grid projects.

Chapter 7. Conclusions

Image 2: Identified barriers and recommendations



The identified barriers and recommendations are summarized in the Image 2. Some similarities and differences can be seen in both countries that have adapted Net Metering as strategy to increase the participation of RE electric generation. In Brazil this policy has few years of being implemented and many aspects have risen as it would be expected when a new policy is introduced in any country. The responds to these have been well intervened in their majority and institutions have contributed in the follow up of it, adapting this practice to the Brazilian system needs. On the other hand, Mexico has already gone through these first years of implementation and few modifications have been seen in the policy in past years until now, when the macro level policies are in a reform process, and new secondary laws are still in the way of changing several factors, Net Metering included.

Brazil energy regulation has an open distribution system in which different agencies apply, under the same law, the Net Metering practice. Therefore, problems with the standardization of processes among them have been detected. A different panorama can be seen in Mexico, where only one distribution agency is allowed to do contracts (CFE). This does not necessarily means a better a strategy, inasmuch that the company has been encumbered with unnecessary procedures that need to be simplified. Experiences from both sides can be learned in this topic, such as the control CFE has about generation procedures with distributed energy, and the larger participation distribution companies have in Brazil, scenario that could be seen in Mexico within few years. Another experience that could be implemented in a cross way, is how Brazil has enlarge the system size permit under Net Metering to 1 MW while Mexico has implemented the collective scale, both cases to promote a higher participation of RE.

Another regulatory similarity can be found in both countries. On one hand in Brazil, the energy generation is burdened with taxes under certain conditions, which had difficult the expansion of PV systems; while on the other hand in Mexico, the subsidies to energy tariffs have slowed the participation of them. The government's strategy is not clear in any of both countries in order to overcome these topics, but new suggestions from different organizations could be used. Furthermore, few incentives and financial options are commonly repeated in both countries as part of the barriers to increase the PV participation. The answer seems to be in the involvement of local entities, sometimes supported also by international organizations. Examples as the "Fundo Solar" project in Brazil and successfully municipality cases in Mexico encouraging collective distributed energy, should be deeper studied in order to be used as reference cases for further application.

The Net Metering policy development is an interesting topic in both countries, nevertheless, from a personal point of view, it is still not especially considered by national or local governments in their energy future generation plans. As it has been exposed, the current and future generation participation share of PV systems within this practice is and will continue being a fundamental part of the generation in this technology. Despite of this, a larger number of programs and reports are done for utility scale power plants, and possibly missing the vast opportunity decentralized energy has among micro and mini producers to achieve today's energy targets.

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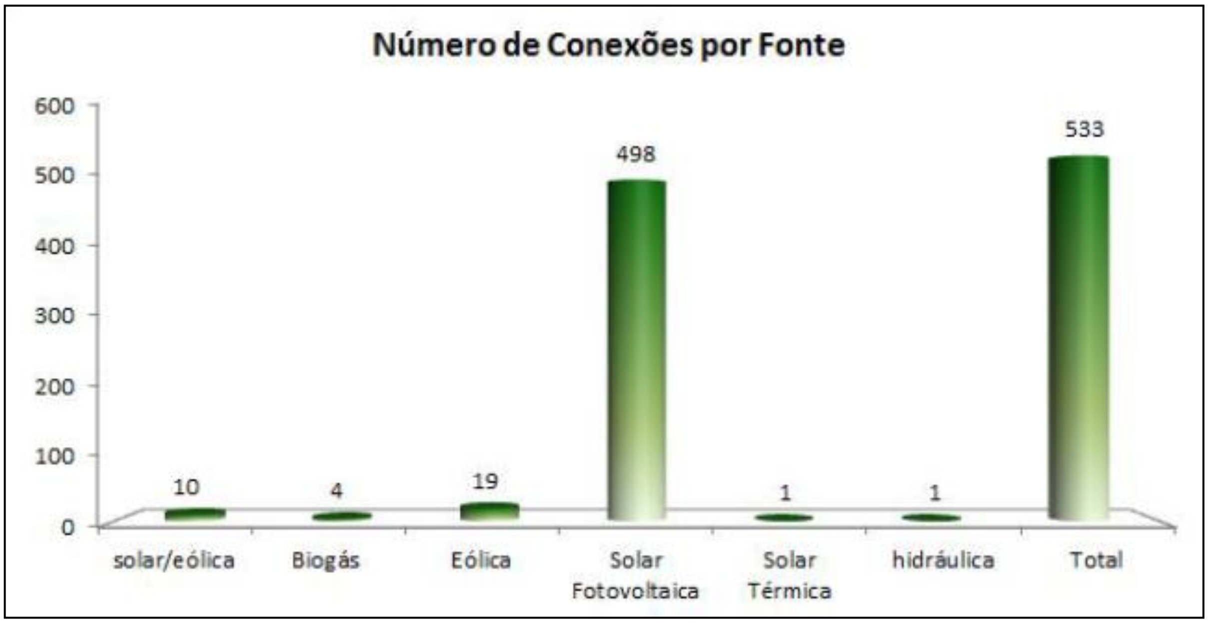
Annexes

Annex 1: Installed RE capacity 2013/2014 in Brazil Source: (MME, 2014)

FONTE	2013[c]	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
						MW					
RENOVÁVEIS	**103.399**	**110.335**	**118.653**	**125.444**	**133.193**	**142.849**	**146.046**	**149.740**	**154.472**	**158.947**	**164.135**
HIDRO[a]	79.913	82.629	87.183	92.193	96.123	100.935	101.874	103.344	106.167	108.941	112.178
IMPORTAÇÃO[b]	6.120	6.032	5.935	5.829	5.712	5.583	5.441	5.285	5.114	4.925	4.716
OUTRAS	17.366	21.674	25.535	27.422	31.358	36.331	38.731	41.111	43.191	45.081	47.241
PCH	5.308	5.538	5.671	5.701	5.854	6.289	6.439	6.619	6.799	6.919	7.319
EÓLICA	2.191	5.452	9.019	10.816	14.099	17.439	18.439	19.439	20.439	21.439	22.439
BIOMASSA	9.867	10.684	10.845	10.905	10.905	11.603	12.353	13.053	13.453	13.723	13.983
SOLAR	0	0	0	0	500	1.000	1.500	2.000	2.500	3.000	3.500

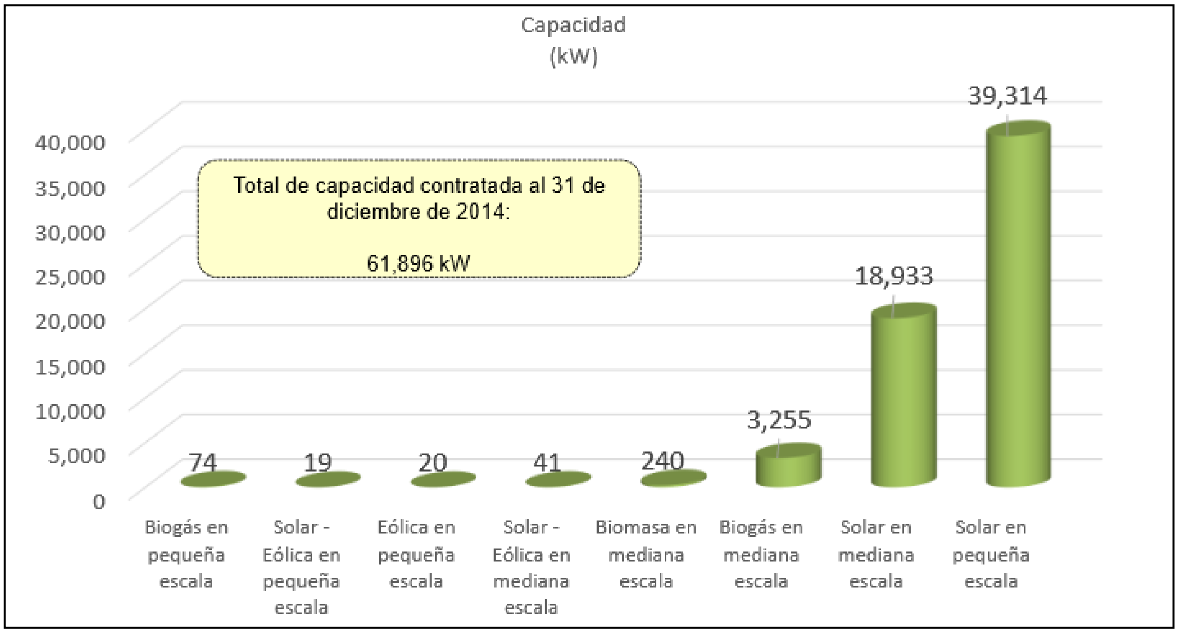
Annex 2: Net Metering contracts until March 2015 in Brazil Source: (ANEEL, 2015e)



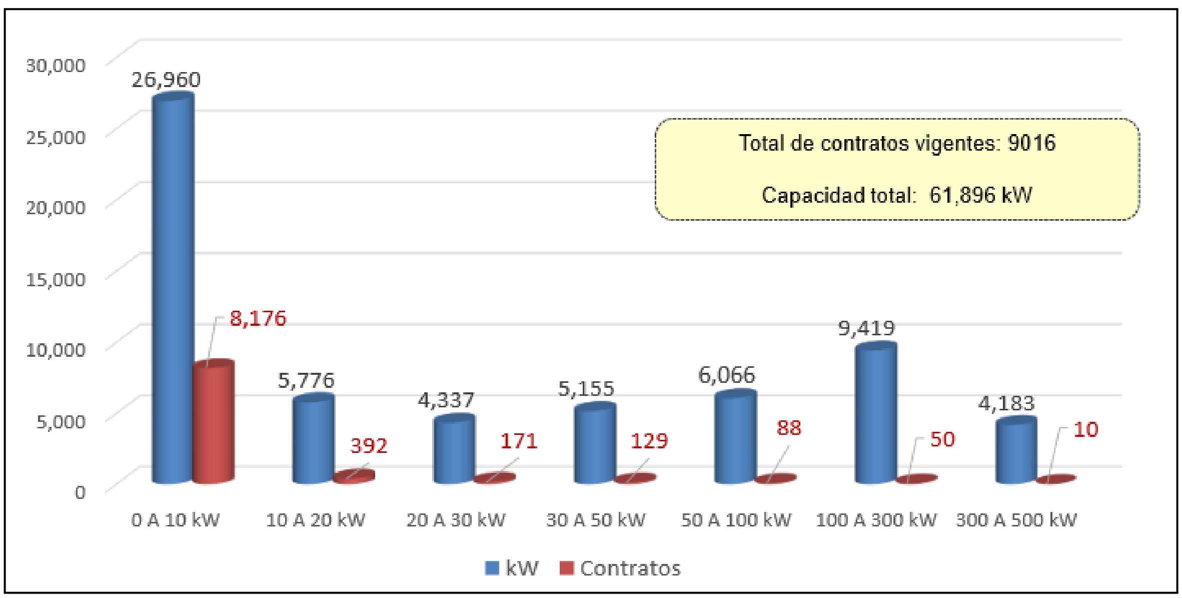
Annex 3: Net Metering steps Source: (Barth et al., 2014)

REQUEST TO ACCESS THE GRID	The consumer requests the distribution agent for access to the grid
PERMISSION TO ACCESS THE GRID	The distribution agent has 30 days to issue the opinion. In case of mini generation (>100 kWp) units or when additional work (e.g. construction) are required, this period is increased to 60 days
INSTALLATION OF GENERATION UNIT	The consumer acquires and installs the micro or mini generation unit (usually through specialized companies)
INSPECTION	The consumer (or the specialized company hired) requests for an inspection. The distribution agent has 30 days to do the inspection and, afterwards, has 15 days to issue a technical report.
REQUEST FOR CONNECTION POINT	The consumer requests a connection point. In case technical aspects need to be corrected, the consumer shall correct them prior to requesting for the connection point.
(APPROVAL OF CONNECTION POINT) / CONNECTION OF INSTALLATION	The distribution agent has 7 days to approve the connection point and connect the installation.

Annex 4: Installed capacity per RE source in Mexico under NM by December 2014 Source: (CRE, 2015)



Annex 5: Interconnection contracts and installed capacity by power ranks in Mexico by December 2014 Source: (CRE, 2015)



Annex 6: PV user's survey

Pesquisa sobre o mercado de sistemas fotovoltaicos conectados à rede.

Caro Senhor(a),

Nos últimos dias você recebeu um questionário sobre sua experiência no processo de contratação e instalação de um sistema fotovoltaico. Porém não tivemos sua participação ainda e ela é muito importante para nos ajudar a caracterizar o mercado de geração distribuída a partir da fonte solar fotovoltaica no Brasil.

Sabemos que seu dia é corrido, por isso, elaboramos perguntas simples e você não irá gastar mais do que 10 minutos para respondê-las.Você e/ou sua empresa não precisarão se identificar para responder ao questionário e os resultados serão publicados após a análise. Ele faz parte de uma pesquisa de mestrado realizada por Marcos Hidalgo na Universidade de Ciências Aplicadas em Colônia, na Alemanha (www.fh-koeln.de), e com o apoio do Instituto IDEAL (http://institutoideal.org), em Florianópolis.

Todos os participantes que deixarem um email de contato participarão do sorteio de um Kit do Instituto Ideal, que contém uma camiseta, uma sacola de compras de garrafa pet e cartilhas educativas sobre energia fotovoltaica.

Pedimos por gentileza que participe da pesquisa até o dia 15 de maio!

* Required

ideal INSTITUTO PARA O DESENVOLVIMENTO DE ENERGIAS ALTERNATIVAS NA AMÉRICA LATINA

Fachhochschule Köln
Cologne University of Applied Sciences

Participe e concorra a um kit Solar do IDEAL (deixe seu email no final da pesquisa)

Antes de iniciar o questionário, pedimos que tenha em mãos a sua última conta de luz.

Primeiramente gostaríamos de conhecer o seu consumo de energia elétrica. Veja na sua fatura de energia (conta de luz) qual foi o seu consumo no mês (em kWh) e coloque esse valor no primeiro campo abaixo. Depois, procure em sua conta de luz pelo histórico de consumo e informe os valores dos últimos meses que constam ali. Por favor informe apenas números: p.ex. 88. *

Abril 2015

[ ]

*

Março 2015

[ ]

*

Fevereiro 2015

[ ]

Janeiro 2015

[ ]

Dezembro 2014

[ ]

Novembro 2014

[ ]

Outubro 2014

[ ]

Setembro 2014

[ ]

Agosto 2014

[ ]

Julho 2014

[ ]

Junho 2014

[ ]

Maio 2014

[ ]

Qual é a potência do sistema fotovoltaico (FV) instalado em sua propriedade (em kWp)? *

Informe apenas números. Ex.: 2 ou 1,5

[ ]

Nos informe, por favor, quando a distribuidora realizou a conexão à rede do seu sistema FV. *

dd/mm/aaaa

Qual foi a principal razão para você instalar um sistema FV em sua propriedade? *

- Economia de energia ou financeira
- Consciência ambiental
- Propósitos educacionais
- Other:

Qual é a fonte do investimento financeiro feito para instalar um sistema FV em sua propriedade? *

- Recursos próprios
- Recursos próprios + Fundo Solar
- Recursos próprios + Financiamento bancário
- Financiamento bancário
- Financiamento bancário + Fundo Solar
- Parcelamento diretamente com o instalador

Qual é o nome da instituição com o qual o você fez o financiamento bancário?

Esta linha de financiamento bancário é específica para equipamentos de geração de energia a partir de fontes renováveis? *

- Sim
- Não

Qual o percentual do investimento total que foi financiado (%)?*
Informe apenas números. Ex.: 10, 50, 100.

Add item

After page 2 Continue to next page

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Como você soube da possibilidade de gerar sua própria energia e conectar seu sistema FV à rede elétrica?

- Site da ANEEL
- Site da Distribuidora
- Anúncio publicitário da ANEEL
- Anúncio publicitário da Distribuidora
- Site ou cartilhas do Programa América do Sol
- Notícia na internet
- Notícia na televisão ou rádio
- Notícia em jornal ou revista
- Foi informado pelo instalador
- Other:

Qual critério, dentre os relacionados abaixo, você acha que foi mais importante para a empresa instaladora no momento de projetar um sistema FV para sua propriedade? *

- ○ A demanda energética que aparece no histórico da sua fatura de eletricidade
- ○ Área disponível na sua propriedade
- ○ Sua limitação financeira
- ○ Equipamentos que a instaladora tinha disponível no estoque
- ○ Restrições arquitetônicas ou estruturais da edificação
- ○ Eficiência dos módulos FV

Qual critério, dentre os relacionados abaixo, você acha que deveria ser o mais importante no momento de projetar um sistema FV para uma propriedade? *

- ○ A demanda energética que aparece no histórico da sua fatura de eletricidade
- ○ Área disponível na sua propriedade
- ○ Sua limitação financeira
- ○ Equipamentos que a instaladora tinha disponível no estoque
- ○ Sim
- ○ Não

Add item

After page 5 Continue to next page

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Você poderia nos dizer porquê o sistema FV instalado não atendeu sua expectativa?

Agora avalie o grau de dificuldade em cada uma das etapas do processo de aquisição, instalação e funcionamento do seu sistema FV. *

Considere 1 como sendo sem dificuldade e 5 como muito difícil

	1	2	3	4	5
Financiamento do projeto	○	○	○	○	○
Escolha de um instalador qualificado	○	○	○	○	○
Solicitação de acesso à rede da distribuidora	○	○	○	○	○
Instalação técnica do sistema FV	○	○	○	○	○
Assinatura do Termo de Relacionamento com a distribuidora	○	○	○	○	○
Informação correta sobre o faturamento na conta de luz	○	○	○	○	○

Por favor, nos diga se você enfrentou algum outro problema que não tenha sido mencionado acima.

Você avalia ter feito uma boa decisão financeira?*

- Sim
- Não

Por favor, deixe um comentário ou sugestão sobre qualquer assunto que não tenha sido incluído nas questões anteriores.

Podemos contactá-lo para mais perguntas relacionadas ao tema desta pesquisa? *

- Sim
- Não

Add item

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Por favor, nos informe seu email de contato

Add item

After page 8 Continue to next page

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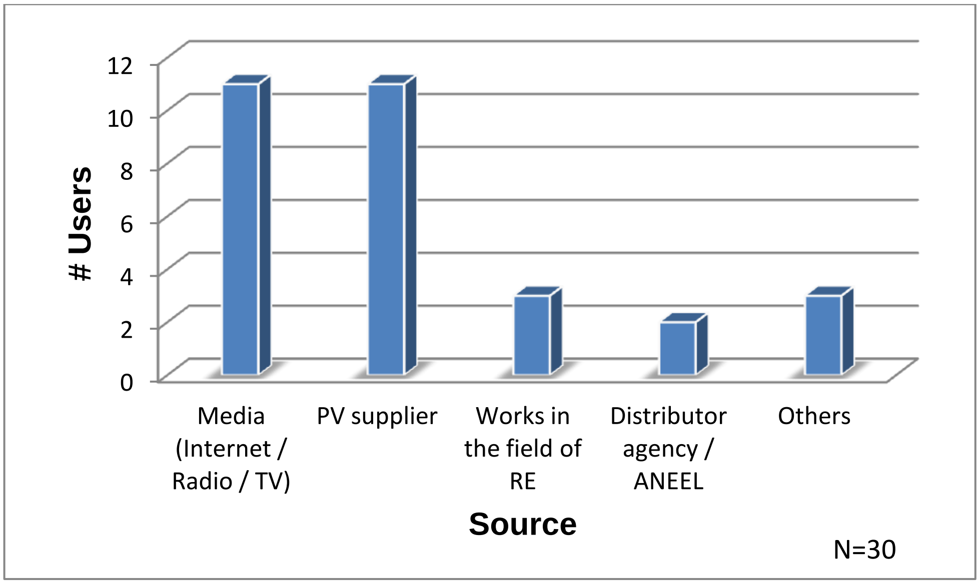
Muito Obrigado!

Qualquer dúvida ou comentário, por favor contate-me no e-mail: marcos.hidalgo.arellano@gmail.com

Add item

Annex 7: Sources of information



Annex 8: N° PV systems connected to the grid by company within the IDEAL survey 2014 Source: (Instituto IDEAL, 2015)