Project

Promoting the use of Smart Meters and PV technology to reduce energy costs in low income households in Mexico

Document

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Document Revisions

Version	Date Approved	Approved by	Document Name	Brief Description
1.00	26/09/2015	MAH	Draft Final	Introduction of New Model according to new regulations in Mexico.

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1 Regulatory Overview

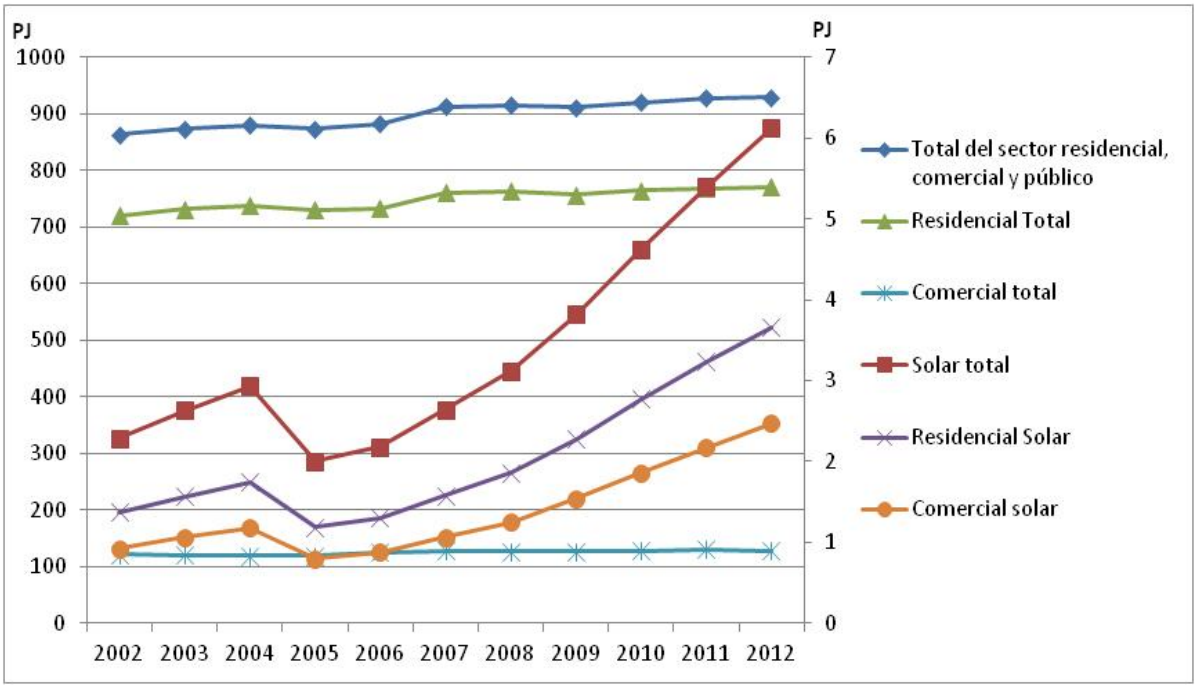
1.1 Solar Energy Market in Mexico

In the National Energy Balance 2012, the Energy Secretariat (SENER) presents the solar energy contribution provided to the National System. The energy consumption of the industrial sector supplied by solar energy was 0.3 PJ for 2012, an increase of 13% compared to 2011.

Energy consumption in the residential, commercial and public sectors for the years 2002-2012 is presented in Exhibit 1 . In 2012 these three sectors had a consumption of 928.94 PJ, showing an increase of 0.07% from 2011. The residential sector consumed 771.33 PJ which is an 83.03% of the total consumption of the three sectors, whilst the commercial sector consumed 127.41 PJ (13.72%). The solar energy contribution to all three sectors in 2012 was 6.12 PJ (0.66%). Breaking down the solar production, the residential sector consumed 3.6 PJ (59.71% of the total solar production) while the commercial sector consumed 1.94 PJ (40.29%).

According to Exhibit 1, it can be seen that the total energy consumption of the residential, commercial and public sectors has experienced from 2002 until 2012 an increase of 7.06%. For the residential sector only, the increase was 6.68%, whilst for the commercial was 4.44%.

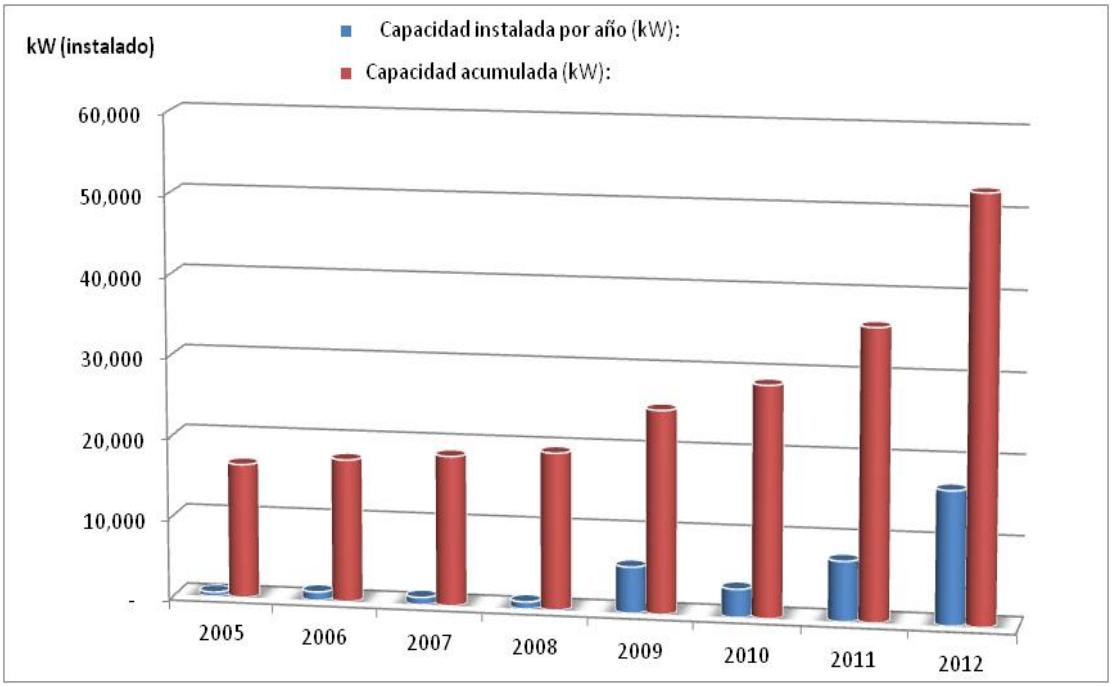
Exhibit 1 – Energy consumption 2002-2012



Source: National Energy Balance 2012 - SENER

The installation of PV systems is increasing faster and faster. According to the National Energy Balance, by 2012, 52,653kW of PV capacity was installed; only from 2011 to 2012there was an increase of 16,582 kW (46%). From 2006 until 2008 there was an increase of approximately 900 kW per year but in 2009 the annual installed capacity was 5,712 kW, an increase of 655% from the 2008 installed capacity (872 kW). This trend was maintained the following years as shown in Exhibit 2.

Exhibit 2 – Total installed capacity



Source: National Energy Balance 2012 - SENER

Table 1 – Energy consumption 2002-2012

	2008	2009	2010	2011	2012	Variation (%) 2012/2011
Total Residential, commercial and public	915.98	912.12	921.22	928.28	928.94	0.07%
Solar total	3.12	3.82	4.63	5.4	6.12	11.76%
Residential Total	763.9	757.47	765.21	768.57	771.33	0.36%
Residential Solar	1.86	2.28	2.77	3.23	3.66	11.75%
Commercial total	126.62	126.56	128.2	130.59	127.41	-2.50%
Commercial solar	1.25	1.54	1.86	2.17	2.47	12.15%

Source: National Energy Balance 2012 - SENER

1.2 Regulatory framework before the Energy Reform for residential PV projects

The first energy reform was introduced in Mexico in 1992. The main objective of this reform was to allow the participation of the private sector in the generation through the following figures: self-consumption, independent producer, small-scale producer, cogeneration, exporter and importer.

The second energy reform was developed during the period 2006-2012. From the provisions resulting from the reform (the enactment of new laws) different planning tools were developed such as the National Development Plan 2007-2012, the National Infrastructure Program 2007 - 2012, the Energy Sector Plan 2007 - 2012, the National Strategy for Energy Transition and Sustainable Use of Energy, the Special Program for the Use of Energy Renewables and the Special Climate Change Program 2008-2012. In addition, new legal provisions were issued, such as the Law on the Use of Renewable Energies and Financing of Energy Transition and its Regulations, which allow individuals (small producers) to have administrative licences to install photovoltaic systems. Permits allowed both renewable energy sources and cogeneration systems in small to medium scale and also the possibility of an interconnection contract with the Federal Electricity Commission (CFE). In 2010 this model of contract was extended under the concept of net metering introducing on one hand the new renewable energy sources and cogeneration and also medium-scale producers.

The contract for households and small producers started being developed in 2011, when the CFE requested the Energy Regulatory Commission (CRE) to address some concerns of housing developers about the need for a standard contract to be applied particularly in multifamily buildings with a common renewable generation source, so that a set of individuals or corporations share equitably rights and obligations arising from its operation.

CRE sent the CFE comments and suggestions for the development of a new interconnection agreement model for application to any type of collective renewable energy or efficient collective system of small-scale cogeneration. Based on this, the CFE proposed an interconnection agreement for collective renewable energy or efficient collective system of small-scale cogeneration, requesting approval by the CRE.

The contract model was issued in August 2012, and it is suitable for properties consisting on several single-family households (apartment blocks for example) or a set of small business (a mall) in which users cannot have their renewable generation set in their house or office for physical reasons (no access to sun or wind, or space or nor connection point to the electrical grid). Thus, they need to make use of community spaces (such as a rooftop or patio) and the commonly used building interconnection to the grid. The model contract is designed so that several inhabitants of the building can use, either equally or not, the renewable installation using common components.

1.2.1 Types of interconnection agreements

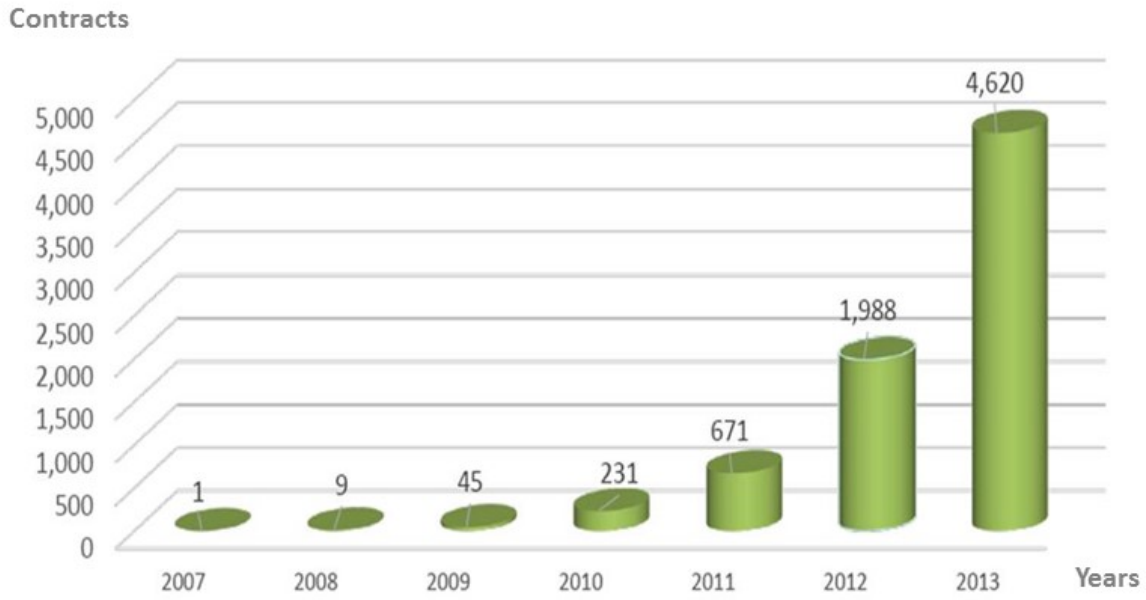
Before the energy reform there were three types of interconnection agreements:

- Small scale
- Medium scale
- Generation and transport

In small scale projects the maximum capacity is 30 kW and for medium scale the maximum capacity is 500 kW. Providing that in both cases the installed capacity is lower than 500 kW there was no requirement for a license for power generation. It is noteworthy to mention that in order to make an interconnection to the grid of the CFE it was mandatory to sign a small s-scale interconnection agreement which is an annex to the standard agreement for energy supply.

Exhibit 3 shows the evolution of the interconnection of small and medium scale agreements until 2013 when CFE had 4,620 interconnection agreements. It can be seen that in 2007 there was only one agreement and the number has been gradually increased. The number of agreements increased especially during the years 2011, 2012 and 2013 with an increase of 688%.

Exhibit 3 – Evolution of interconnection contracts in small and medium scale



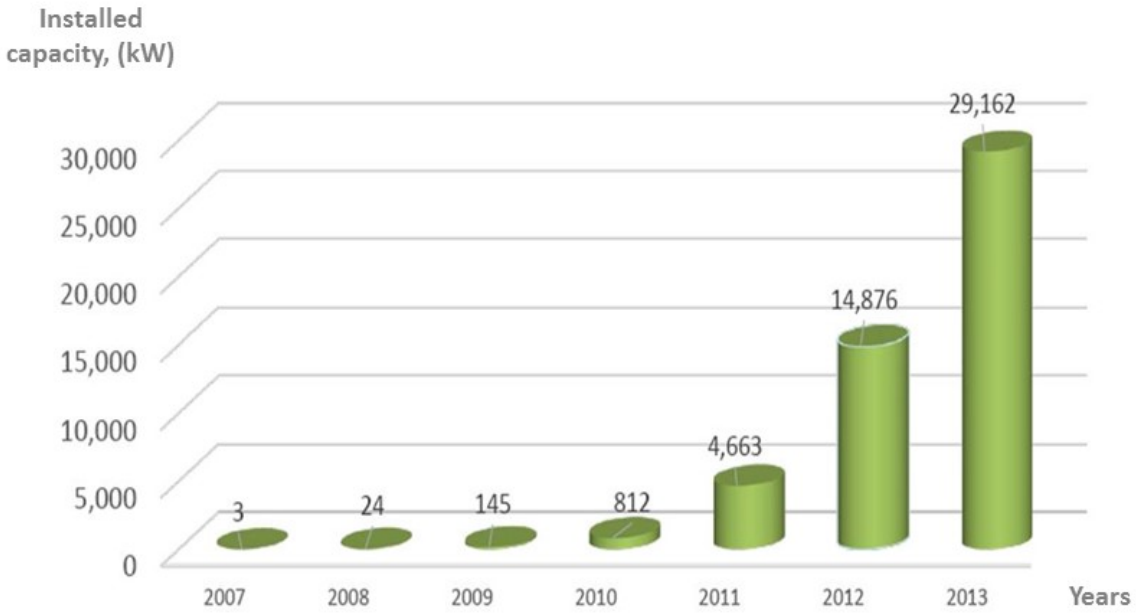
Source: Annual Activity Report 2013 - CRE

1.2.2 Installed capacity

In terms of installed capacity in small and medium scale (see Exhibit 4) the installed capacity in 2007 was only 3 kW. From 2009 onwards there is a substantial increase with 145 kW in

2009, 812 kW in 2010 (560% annual increase), 4,633 kW in 2011 (319% annual increase), 14,976 kW in 2012 and 29,162 kW in 2013.

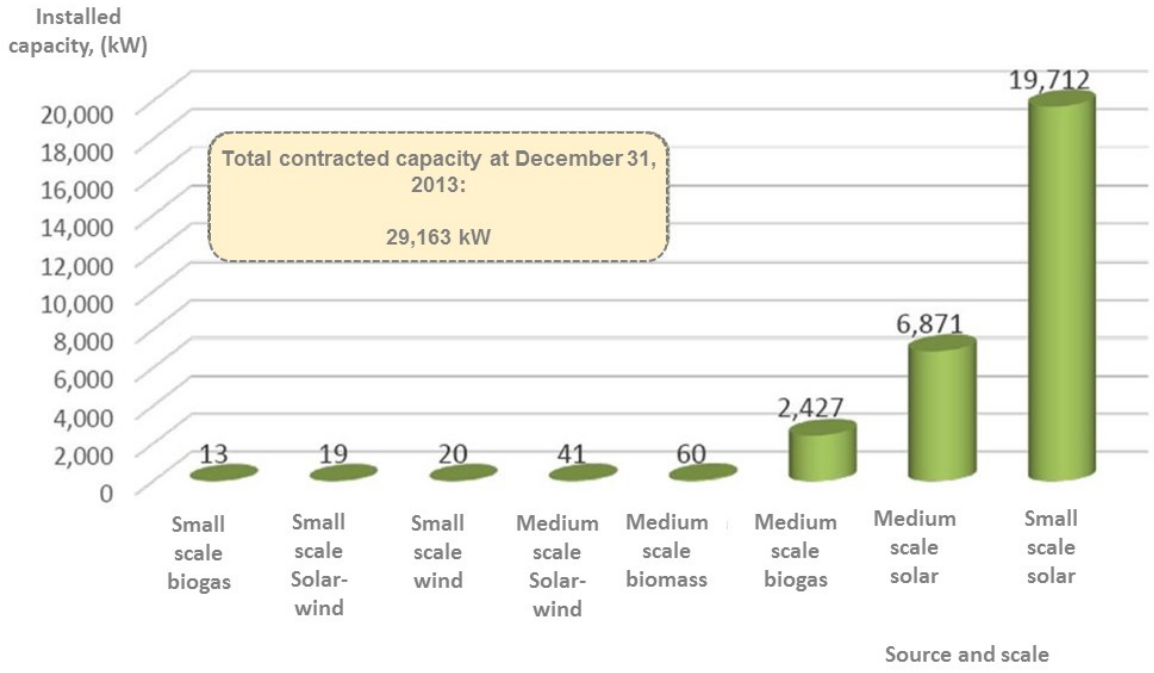
Exhibit 4 - Evolution of installed capacity in small and medium scale



Source: Annual activity report 2013 - CRE

Agreements awarded in small and medium scale were 4,620 (until December 31, 2013) and its installed capacity reaches 29,162 kW. Exhibit 5 shows the installed capacity of all the energy sources in small and medium scale.

Exhibit 5 – Capacity by source and scale



Source: Annual activity report 2013 - CRE

It can be seen that the installed capacity of solar small scale is much higher compared to the rest of medium and small-scale installations.

1.2.3 Interconnection agreements issued

Complementing the above information, Exhibit 6 shows the interconnection agreements in terms of installed capacity in December 2013. It can be observed that there are 4,249 agreements (91.96% of the total) with less than 10 kW, representing an installed capacity of 12,932 kW. This is on average 3.04 kW per agreement.

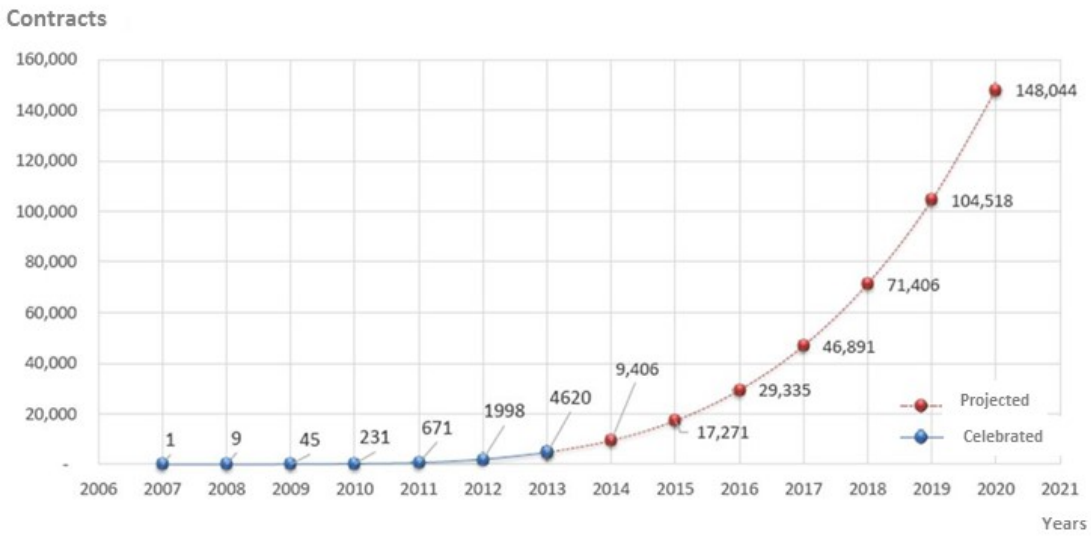
Exhibit 6 – Interconnection agreement issued

Source: Annual activity report 2013 - CRE

Based on the information described above and on CRE's projections[1], it is expected an uptrend in small and medium scale contracts, as illustrated in Exhibit 7. It is expected that in 2015 there will be 7,865 new contracts, 17,271 in total. The same exhibit shows that it is expected to have 148,044 contracts by 2021, which is an increase of 3,200% from 2013. CRE estimated this trend based on the growth of contracts issued in previous years.

[1] Statistics - Interconnection contracts for small and medium scale. CRE, 2014

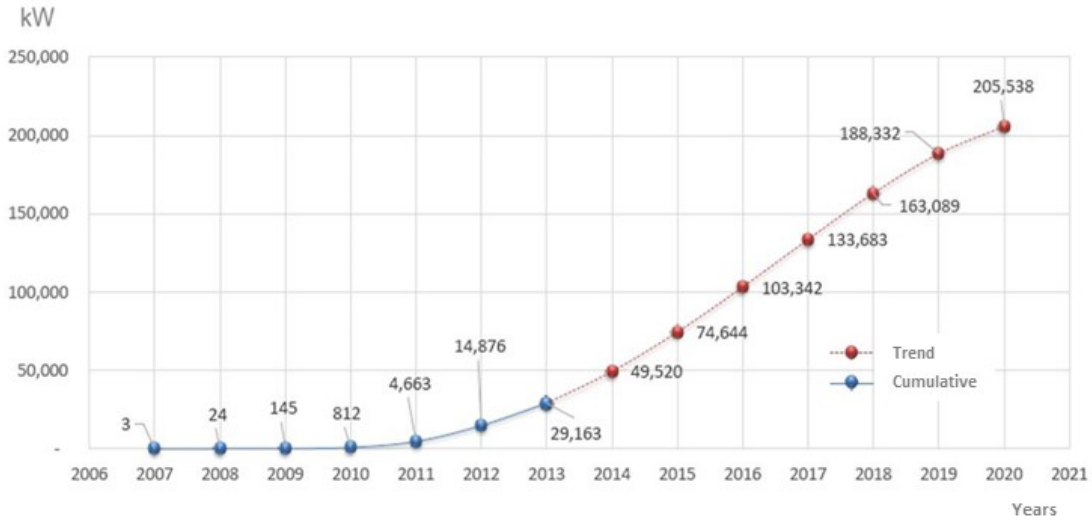
Exhibit 7 – Trend of issued agreements



Source: Interconnection contracts for small and medium scale. CRE, 2014

Exhibit 8 shows the trend in installed capacity which is proportional to the increase of number of contracts.

Exhibit 8 – Trend of installed capacity



Source: Interconnection contracts for small and medium scale. CRE, 2014

In terms of installations over 500 kW, in 2014 787 licenses were issued, of which 73 correspond to PV. Seven of them are operating, 20 under construction and 46 have not started the construction yet (see Table 2 – Licenses for installations over 500 kW issued).

Table 2 – Licenses for installations over 500 kW issued in 2014

Status	Installations	PV installations
Operating	559	7
Under construction	133	20
Not under construction	91	46
Pending	4	0
Total	**787**	**73**

Source: CRE

In terms of installed capacity, 35,915 kW were installed, with a generation of 217,247 GWh (see Table 3) in 2014. The authorized capacity for PV systems is 2,159 MW; this represents 6% of the permits for installations over 500 kW issued by the CRE (see Table 4). From the capacity authorized for PV in 2014, 49.92 MW are already installed and generated 127.45 GWh during 2014, representing an investment of USD 174,734,280.

Table 3 – Status of the 2014 licenses for installations over 500 kW

Status 2014	MW	GWh	Investment (Thousands of USD)
Total Generation	33,888.23	203,467.10	44,935,062.62
Total Import	290.51	1,709.40	$ 17,680.00
Total Export	1,737.17	12,070.99	$ 2,241,225.11
Total Authorized	35,915.91	217,247.49	$47,193,967.72

Source: CRE

Table 4 –Status of licenses for solar power installations over 500 kW

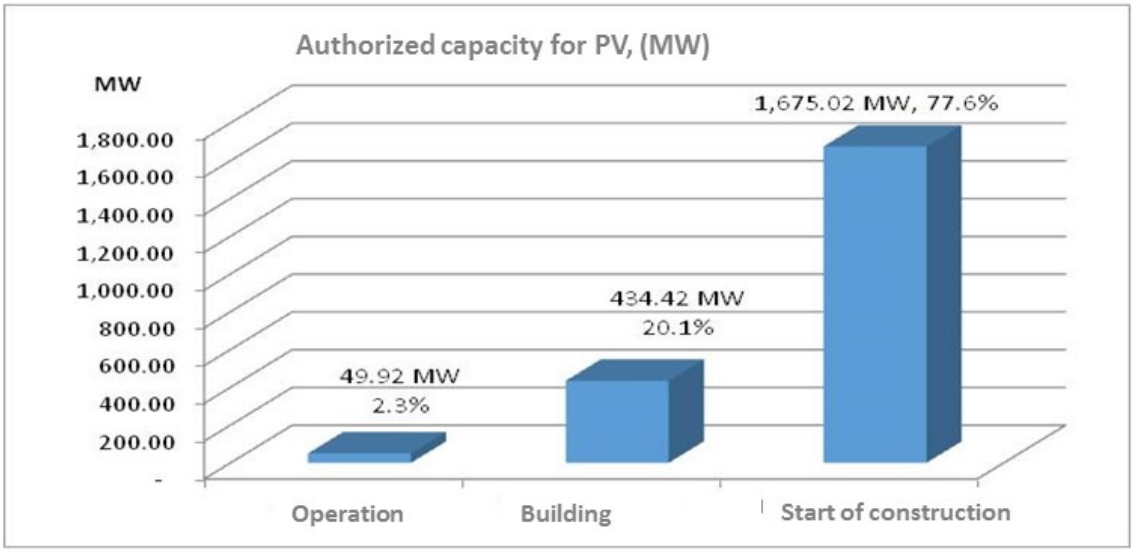
Status 2014	Authorized Capacity (MW)	Authorized Energy Generation (GWh/año)	Investment (Thousands of USD)
Operating	49.92	127.45	$ 174,734.28
Under construction	434.42	945.08	$ 1,520,486.80
Not under construction	1,675.02	3,775.51	$ 5,862,587.08
Total	**2,159.37**	**4,848.05**	**$ 7,557,808.16**

Source: CRE

From the capacity authorized for PV in 2014, 434.42 MW are currently under construction (20.1% from the total), with a potential generation of 945 GWh per year and an investment of USD 1,520,486,800. Finally there are 1,675 MW (77.9%) that have been authorized but

that haven't been installed, with an estimated annual generation of 3,775 GWh and an investment of 5,862,857,080 USD (Exhibit 9).

Exhibit 9 – Authorized capacity for PV installations over 500 kW in 2014



Source: CRE Webpage

1.3 Present Regulatory Situation

1.3.1 Types of contracts

There are three different types of contracts for PV installations; small scale, medium scale and collective.

1.3.1.1 Small scale contracts

Small-scale contracts in either residential or business mode apply:

- Residential with a maximum capacity of 10 kW;
- Business with a maximum capacity of 30 kW.

In both cases they will be interconnected to the grid at less than 1 kV.

- If the generation is higher than the consumption the energy balance is kept and compensated within 12 months
- If the generation meets the consumption only the minimum normal service is paid
- If the consumption is higher than agreed, the difference must be paid using the current CFE tariffs

The same considerations apply for medium scale contracts.

CFE provides the following documents for interconnection contracts:

- Request for connection;
- Technical Specifications small scale;

- Characteristics of the measuring equipment;
- Contract for small scale interconnection

1.3.1.2 Collective small-scale contracts

This contract comprises:

- Installations of renewable energy or cogeneration for residential with an installed capacity lower than 10 kW per user.
- Installations of renewable energy or cogeneration for general use with an installed capacity lower than 30 kW

The main difference between these systems and the small-scale is the voltage level; in this case the voltage level must be between 1 kV and 69 kV, and the energy accounting.

This contract has the following considerations for billing and payments:

- If the difference is negative, it will be considered as a credit in favour of the producer which can be compensated within the following twelve months. If there is no compensation the credit will be cancelled.
- If the difference is positive, it will be considered as a credit in favour of the supplier and it will be charged using the corresponding tariff.
- If the difference between the delivered energy and the received energy by the collective renewable energy source at the interconnection point is negative, it will be considered as a credit in favour of the supplier and will be added, in the same proportion assigned by the representative, to the energy consumed by the load of the producer using the corresponding tariff.

The community is in charge of the operation and maintenance of the collective energy source. The community will be responsible of any damage caused to the supplier by the collective renewable energy source.

The requirements to perform an interconnection contract with CFE in small-scale are:

• To have a normal supply contract for low voltage;

• The facilities comply with the Mexican Official Standards and specifications issued by the CFE;

• The power source does not exceed 10 kWp

The steps that must be followed for processing an interconnection agreement are:

1) Request interconnection for houses. The application must be completed and submitted by the subscriber of the regular contract with the CFE and must present an official ID.

2) Request interconnection for businesses. In case of a business, the legal representative of the company must complete and submit the application and provide legal documentation regarding the articles of incorporation of the company. .

After the CFE has given an application number to track the process of interconnection:

3) Letter and sketches. A letter with general information for interconnection and a sketch of the installation and the number of panels

4) Installation check. CFE technicians check the photovoltaic solar system at home to verify that it meets the technical requirements. Then the results will come.

5) Interconnection agreement. After approving the installation, the interconnection agreement will be signed at the CFE offices. A bidirectional meter will be installed without any additional cost.

These medium and small scale contracts are permanent. In order to terminate the contract the owner should notify CFE at least 30 days prior to the desired disconnection date.

1.3.1.3 Residential Electricity tariff

The CFE considers eight tariffs for domestic use, of which seven (1, 1A, 1B, 1C, 1D, 1E and 1F) are applied to different regions of the country, in accordance with the minimum ambient temperature of the region. In warmer regions, the rate is lower, because places with higher temperatures use more electricity for cooling devices (these areas have higher subsidy). The eighth rate of domestic consumption is called (DAC), and it is applied when the average bimonthly consumption registered for the last 12 months exceeds the limit set for that location.[2]

The cost in electric power considers three elements: the rate, the season, and consumption of kilowatts per hour (kWh). The summer rate is applied during the warmer months. Therefore, in warmer regions this rate applies from April to September. If the property is placed in areas where high temperatures are recorded in summer, the summer rate will be applied to provide housing benefit corresponding to the region and thus to maintain its consumption in the range in which this rate applies and you can access the benefit. Otherwise, the bimonthly account could even quadruple during the summer if you do not have subsidized rates.

Table 5 – Residential electricity tariff

Tariff normal	Description	Maximum consumption to rate DAC[3] tariff
Tariff 1	It is for basic consumption, the cost will be 0.809 pesos for each of the first 75 kilowatt-hour; 0.976 pesos for each of the next 65 kilowatt-hour; and consumer surplus, 2,859 pesos for each additional kilowatt-hour earlier.	250 kWh/ month
Tariff 1A	It includes domestic service for locations with minimum average summer temperature of 25 degrees Celsius, equivalent to 25 kilowatt-hours. In summer the cost of basic consumption will be 0.711 pesos for each of the first 100 kilowatt-hours; intermediate, 0.839 pesos for each of the next 50 kilowatt-hours and consumption surplus will pay 2,859	300 kWh/ month

[2] http://www.cfe.gob.mx/casa/4_Informacionalcliente/Paginas/Tarifa-DAC.aspx

[3] When the average monthly consumption recorded in the last 12 months exceeds a maximum amount of kWh/month, the service will be reclassified in Domestic Consumption Rate High (DAC) that corresponds according to the area.

Tariff normal	Description	Maximum consumption to rate DAC[3] tariff
	pesos for each additional kilowatt-hour earlier.	
Tariff 1B	In summer, with consumer staples will be of 0.711 pesos for each of the first 125 kilowatt-hours; intermediate, of 0.839 pesos for each of the next 100 kilowatt-hour, and over consumption of 2,859 pesos for each additional kilowatt-hour earlier.	400 kWh/ month
Tariff 1C	For locations with minimum average summer temperature of 30 degrees Celsius, apply charges for the energy consumed depending on the season. During the summer it will cost from baseline of 0.711 pesos for each of the first 150 kilowatt-hours; through consumption low, 0.839 pesos for each of the next 150 kilowatt-hours; 1,071 overlooked intermediate weights for each of the next 150 kilowatt-hours and consumption over the fee is 2,859 pesos for each additional kilowatt-hour earlier.	850 kWh/ month
Tariff 1D	It includes service in areas with low average summer temperature of 33 degrees Celsius. The following rates will apply: for basic consumption, 0.595 pesos for each of the first 300 kilowatt-hours; through consumption low, the cost will be 0.741 pesos for each of the next 900 kilowatt-hours; intermediate high 1,804 pesos for each of the next 1,300 kilowatt-hours; by consumption surplus will be of 2,859 pesos for each additional kilowatt-hour earlier.	1,000 kWh/ month
Tariff 1E	For locations with minimum average summer temperature of 31 degrees Celsius, energy consumption charges apply depending on the season. For basic consumption: 0.711 pesos for each of the first 175 kilowatt-hours; by Low Intermediate: 0.839 pesos for each of the next 225 kilowatt-hour, while for upper intermediate: 1,071 pesos for each of the next 200 kilowatt-hours.	2,000 kWh/ month
Tariff 1F	It corresponds to service in areas with low average summer temperature of 32 degrees Celsius. For basic consumption rate is 0.595 pesos for each of the first 300 kilowatt-hours; intermediate consumption under 0.741 pesos for each of the next 450 kilowatt-hours; the upper intermediate 0.967 pesos for each of the next 150 kilowatt-hours, and surplus 2,859 pesos for each additional kilowatt-hour earlier.	2,500 kWh/ month

Source: CFE Webpage

Residential electricity tariff is the most expensive in Mexico, however, users consuming less than 500 kWh bimonthly have a discount (subsidy) of 80% on average, users exceeding 500 kWh bimonthly rate will be in DAC (high consumption), this rate is the highest with an average cost of $ 3.60 / kWh (varies on the season), DAC tariff applies for the following consumers:

- Demand greater than 500kWh bimonthly
- Consumption higher than 3000 kWh during an annual period
- In order to leave DAC tariff the average consumption must be less than 500kWh for the last 6 bimonthly;

- If the subsidy tariff is passed there is no right to governmental contribution

It should be noted than the DAC tariff varies depending on the city and the season.

1.4 The Energy Reform and Distributed Generation

The Law of the Electricity Industry (LIE) was enacted in August 2014 and aims to promote the sustainable development of the electricity industry and ensure its continuous efficient and safe operation for the benefit of users and compliance PSOs and universal service, clean energy and reducing emissions. The elements of the National Electricity System (SEN) as the defined by the LIE are:

- The National Transmission grid;
- General distribution grids;
- Power plants providing electricity to the national transmission grid or general distribution grids;
- The equipment and facilities CENACE uses to perform operational control of the National Electric System

It defines that the wholesale electricity market will be operated by the CENACE in which market participants can make the transactions mentioned in Article 96. These rules are integrated by the Electricity Market Rules and the operative provisions of the Market, which together govern the wholesale electricity market.

The Electricity Market Rules are administrative provisions containing general principles of design and operation of the wholesale electricity market, including auctions.

Power plants with capacity greater than or equal to 0.5 MW and power plants of any size represented by a generator in the wholesale electricity market require a permit granted by the CRE to generate electricity in the country. Exempted Generators do not require special permits. If exempted generators sell their electricity and associated products through a Supplier of Basic Service, the CRE will issue contract models and calculation methodologies, criteria and bases for determining and updating the applicable considerations which reflect the economic value produced by the Supplier. Exempted Generator may also sell electricity and related products through a Qualified Service Supplier, provided the Power Plants do not share their measurement with the load centre of a User Basic Supply.

There are also two extra Supplier agreements for exempted generators:

- Qualified Service provider: Concessionaire offering Qualified Supply to qualified users and can represent to exempt generators on a competitive basis in the wholesale electricity market.
- Supplier of Last Resort: Concessionaire offered the Last Resort Supply to qualified users and represent in the wholesale electricity market to exempt generators that require it. The CRE will establish the mechanisms for allocating and Qualified Users Exempted Generators to the suppliers of last resort.

An obligation of Exempted generators is to provide power and related services in an emergency to the national grid facilities. In this case, the Generators and exempted Generators will have the right to receive compensation according to Market Rules.

A central point in the LIE on the marketing side is notwithstanding to be subject to the measurement requirements laid down in the general conditions for the provision of the Public Service Transmission and Distribution of Electric Power or the Market Rules, the sale of electricity from a third party to an End User if the energy is produced inside of the facilities of the end user. In this case, it cannot be considered within the Market rules and therefore it does not require permit or registration.

Another relevant definition of the energy reform is the distributed generation as the generation of electricity that is produced by an Exempted Generator or produced at a power plant that is interconnected to a distribution circuit containing a high concentration of Loads.

The distributed generation has one advantage, it will have open access and not discriminatory to the open market of the standard distribution grids, as well as the markets where its production can be sold. For this purpose, the Development Program of the National Electric System consider the expansion and modernization of the public distribution systems required for interconnecting distributed generation. Besides the general technical specifications required for the interconnection of new power plants include specific provisions for distributed generation, so that, in typical cases, requests for interconnection of these power plants do not require studies to determine the specific characteristics of the infrastructure.

The general conditions for the provision of electrify supply will ensure the commercial processes in order to facilitate the sale of energy and related products through distributed generation.

Another advantage for the development of solar energy are the obligations that LIE set to acquire “Clean Energy” certifications that the must comply suppliers, qualified stakeholder of the market and the end users that receive energy from isolated supply, as well as holders of interconnection agreements, associated with consumption of the represented or included load centres.

CRE will promote the training of companies and their staff, as well as independent professionals and technicians for the installation of clean distributed power plants.

Clean Energy Certification: certificate issued by CRE that certifies the production of a certain amount of electrical energy from clean energies, valid to meet the requirements associated to the consumption of the load centres.

1.4.1 The rules of the Electricity Market

The wholesale Electricity Market consists of the following markets:

I. A short-term energy market, which is comprised of:
    a. Day-ahead
    b. Hour-ahead
    c. Balancing market
II. A Market of Clean Energy certificates
III. Auctions of financial transmission rights

Moreover, CENACE will carry out auctions in order to assign short and medium term Electric hedge contracts.

The rules of the Market are structured following the following hierarchy:

I. **Basis of the electricity market**: It is the document where are reflected the provisions of higher hierarchy within the rules of the electricity market. It sets the principles for designing and operating the wholesale electricity market.
II. **Market Operating Provisions**: Documents that define business processes of the wholesale electricity market.
III. **Market Practices Manuals**: Operative provisions of the Market which establish the principles of calculation, instructions, rules, guidelines, examples and procedures for the management, operation and planning of the wholesale electricity market.
IV. **Operational Guidelines**: Market Operational provisions that establish formulas and procedures that for their complexity and specificity are contained in different documents of Market Practices manuals.
V. **Criteria and Operational Procedures**: Operative provisions of the market, establishing specification, technical notes and operating criteria required for the implementation of the Electricity Market Rules, the Market Practices Manuals or the Operational Guidelines, for designing software or daily operation.

The expected roadmap for the implementation of the wholesale electricity market is:

- Short-term energy market:
    a. First stage tests: September 2015
    b. First stage: December 2015
    c. Second stage: 2017-2018

- Long term auctions:
    a) Bidding documents : October 2015
    b) Procurement: first quarter 2016

- Financial Transmission Rights assignment: October 2015

- Financial Transmission Rights auction:
    a) First stage tests: September 2016
    b) First stage: November 2016
    c) Second stage: January 2017

- Balancing markets
    a) First stage tests: October 2016
    b) First stage: February 2017

In the area of distributed generation the following provisions shall apply in order to define a distribution circuit with a high concentration of load centres, the following criteria shall apply:

- At the time of the interconnection of the power plant or the evaluation of it, it must meet at least one of the following conditions:
    a) The installed capacity of the Power Plant should always be lower than expected demand load canters in the distribution circuit where is connected, or

b) The installation of the power plant must reduce or not to have any impact to the maximum load of every single element of the distribution circuit.

- The distribution circuit includes all distribution equipment between the power plant and distribution substations belonging to the public distribution

- All the plants with a capacity lower than 500 kW connected to the general distribution grid shall comply with all the before mentioned criteria.

Moreover, Central Power Units, load centres and the interconnection between the Private grid and the National Electric System must be measured separately if the private grid is going to be connected to the National Electric System. When installation is considered as Distributed Generation, measuring the net energy delivered or received is permitted; measurement processes and liquidations corresponding generation and consumption estimates are made separately. It is noteworthy to mention that the owner of the private grid must request CENAE in order to open or close the interconnection to the national system.

Having said that, when the Private grid is operating connected to the National System, all the generation and load must be offered in terms of wholesale market. In particular the following conditions are applied:

- Power Plant Units within the isolated production must be included in the corresponding interconnection agreement and comply with Market Rules and other applicable provisions. They must be represented by a generator if they have a capacity greater than 0.5 MW or smaller capacity and choose to get a generation permit. They must be represented by supplier if they have a capacity lower than 0.5 MW and do not choose to get a generation permit.

- Load centres within the isolate generation must be included in the connection contract and subject to the Market Rules and other applicable provisions. They must be represented by a supplier.

- Each particular grid used in the isolation generation can only have one active point to the National Transmission Grid or to the Distribution Grid, and such interconnection cannot be performed when the particular grid has interconnection with other electrical system. Only if the installation is not considered as distributed generation, the measurement of Power Plant Units or load centre is required separately.

As mentioned in the LIE, suppliers must obtain permission from the CRE to provide power or represent Exempt Generators. CENACE verifies the validity of the permit before assigning the load centres to a supplier.

The procedures for interconnection shall be defined within the Manual of Market Practices, which will define the registration process of new applications, tracking, time, modification, cancellation requests and retention interconnection guarantees for power plants and connection Load centres, including increases in the capacity of power plants, increase of demand in Load Centres, and changes in interconnection points or connection. CENACE shall

develop a website for recording and tracking of requests for interconnection and connection to reduce the number of communications through physically delivered printed documentation, make the process transparent and reduce the time to notify applicants.

1.4.2 Actions to be taken in order to develop PV project in houses

Currently, the market potential for photovoltaic solar projects in the residential sector are in high consumption (DAC) and 1F tariff. Where the photovoltaic system converts solar energy into electricity, on their hospitality to the residence, which allows the housing lower consumption and therefore pass rate DAC to the next lower tariff.

Significantly, the DAC presents a cost rate 400 % higher compared to normal residential rates. The first project of this type was "the Valley of the Missions", with this interconnection network are authorized and installation of bidirectional meters began, where the surplus power generation that does not consume the residence is stored on an exchange of energy that accounts for the meter, so that the housing use at another time the PV system is not generating.

One of the barriers for PV projects in housing is the lack of this technology by the general population. Another barrier is the lack of dissemination of photovoltaic technology and its benefits.

The most serious barrier is that the electricity in the residential sector has a high subsidy, which discourages market, especially at rates that are not DAC.

Short term

- CRE still has to provide calculation methodologies, criteria and bases for determining and updating the considerations applicable to exempt generators and users with basic supply and controlled demand if they want to sell their production to a supplier.
- Set the mechanisms for the assignment of qualified users and exempt generators to last resort suppliers
- To develop a Market Practices Manual on interconnection and connection;
- Issue interconnection contract models for power plants, connection to load centres, trading of exempt generators, trading by users with basic supply and controlled demand.
- Issue the standards, guidelines, methodologies and other administrative provisions to regulate and promote the generation of electricity from clean energy, in accordance with the provisions of this Act, based on the energy policy established by the Secretariat.

Medium term

- Regulate, supervise and implement the standardization process and standardization in the national electricity system;
- Prepare the Grid Code for Small Power Systems in Micro-Grids
- Develop Market Practices Manual for small electrical systems;

- Issue regulations, directives and other administrative provisions for Smart Grids and Distributed Generation;
- Develop regulation in efficiency, quality, reliability and security of distributed generation,
- Develop regulations to authorize specialized inspection units in Distributed Generation Power Plants that will exert the function of Article 33, section IV of this Act
- Develop mechanisms for financing Power Plants Clean Distributed Generation.
- Regarding the energy certificate develop:
    a) Regulation to validate the ownership of the energy certificate;
    b) Verify compliance with the requirements for the energy certificate;
    c) Issue efficiency criteria used in the definition of clean energy;

2 Proposed Business Model Description

2.1 Relationships

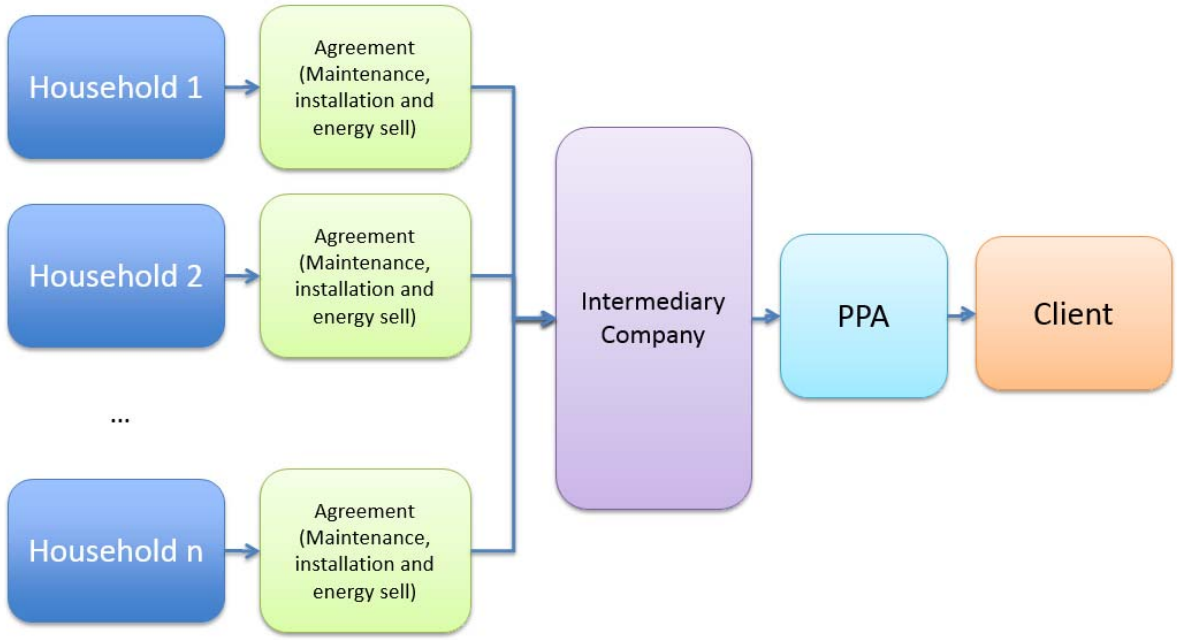
The model proposes the installation of photovoltaic panels on the rooftop of individual households. These individuals shall establish an agreement with an intermediary company for selling the exceeding energy produced by the PV panels. This agreement shall comprise two main variables:

- Percentage of the PV panel owned by the household and the intermediary
- Percentage of self-consumption related to the demand of the household when the PV panel is generating energy

The installation and maintenance of the panels will be carried out by the intermediary being the cost of these services covered proportionally by the household and the intermediary according to the percentage of the panel owned by each agent.

The intermediary company shall establish a PPA (Power Purchase Agreement) in order to sell the exceeding energy form the PV. These relationships are summarized in the exhibit below.

Exhibit 10 – Relationships in the proposed model



Source: Own elaboration

2.2 Energy Flow

PV panels shall be installed on the low-income customer's rooftops or properties. The household could use the energy produced by the PV panels in order to cover the agreed

percentage of demand of this moment. However, it is important to note that there is no longer a physical relationship with the Grid but only economical. In this way, there is no longer a bank of energy so the self-consumption must be instantaneous and at the same time as it is produced. In other words, there is no possibility to use the Grid as a warehouse for energy where the exceeding energy can be injected and used later on.

The exceeding energy is thus:

$$Exceeeding\ Energy\ Annual = \sum_{d=1}^{365} \sum_{s=0}^{86,400} Energy\ produced\ by\ PV_{sd} - Self consumption_{sd}$$

Based on irradiance data, sunrise and sunset time and load curves for households of Baja California it is expected that around 43% of the energy consumed during the winter and 53% during the summer can be provided by the Solar Plant. The rest of the demand of the household shall be supplied by CFE and the rest of the production of the Solar Plant shall be injected in the Grid.

2.3 Cash Flow

As mentioned before, the cost of installation and maintenance of the panels will be covered proportionally by the household and the intermediary according to the percentage of the panel owned by each agent. Besides it, the intermediary company shall pay a fixed rent for the rooftop per month to the household based on the percentage of the panel owned by them.

In terms of energy, these two agents shall receive the money of the sales of energy proportionally to the ownership of the panel. The household shall pay CFE the energy demand minus the self-consumption.

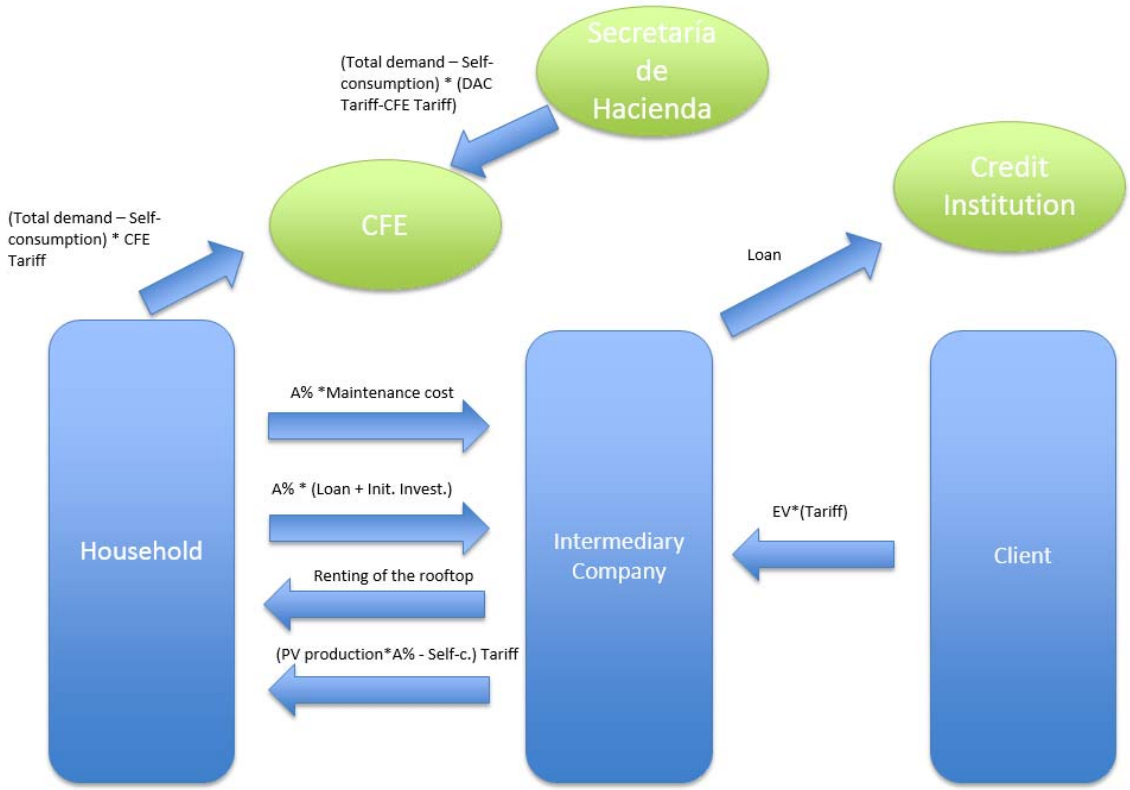
The intermediary company shall manage all the processes with the credit institute in order to finance the acquisition of the PV panels. The initial payment and the loan shall also be paid proportionally to the ownership of the panel.

Tariffs for residential customers are highly subsidized by the Government. Therefore, a collateral effect of the implementation of PV panels is the reduction of subsidies for the energy self-generated and self-consumed by the residential consumers. This saving can constitute an important amount depending on the penetration of the PV panels.

Though it is difficult to estimate the tariff without subsidy by segment, it can be used as proxy the value of DAC tariff that is residential, low voltage and without any subsidy.

The Economic flow is summarized in the Exhibit below.

Exhibit 11 – Economic flow



Source: Own elaboration

3 Economic and Financial assessment

The objective of this section is to model and analyse the financial and economical results of the PV system installation. To do this, it is necessary to estimate the current cost of energy for the type of customer under study, and the same costs after the PV system is commissioned and possible benefits derived from it.

For the sale of energy by the households and intermediary as a demand consumption profile of a T2 tariff customer has been created based on historical data and, to calculate the current energy costs, monthly tariffs of 2015 defined by CFE have been used.

The customer group to be analysed is the Residential. Given the suggested location, Baja California, to implement the model, the appropriate tariff is 1D. In order to do perform the analysis, a demand consumption profile for a standard residential customer has been created based on historical data. To calculate the current energy costs monthly tariffs of 2015 defined by CFE have been used.

Costs and benefits depend directly on different variable and conditions, as the capital costs of the PV system, the conditions of the loan granted to the customer, variation on the tariffs, % of self-consumption, % of the panel owned by the household etc. This variables and conditions are explained in detail in the following subsections.

All the figures referring to money are expressed in $ MXN.

3.1 Model

It is considered the installation of a PV panel of 10 kW which correspond to a 66.6 m2 rooftop. The key parameters of the panels are presented in the Table below. Global irradiance is considered to be in average of 5.74 kWh/m2/day in Baja California.4

Table 6 - PV panel key parameters

Parameter	Unit	
PV System Efficiency	%	16%
Combined PV system Losses	%	30.7%
Global PV System Efficiency	%	11.1%
Peak Power/ m^2	kw/m2	0.15
Capital Cost[5] (PV)	$ (MXN)/kW	28,800

To be able to economically analyse the consequences of installing PV panel in these customers, a standard monthly consumption profile has been created. This, together with the electricity tariffs and the percentage of self-consumption allows calculating electricity monthly

[4] Source: Southwest Tech. Development Institute

[5] This is the cost considered for the Base Case further in the report as it is within the current range of residential PV systems in Mexico.

costs. For this analysis it is considered that clients shall 100% supply its electricity needs from the PV Panel during the hours that the PV panel is producing energy.

With the monthly energy produced by the panel the energy and tariff savings can be estimated. This process is shown in the following table.

All the figures referring to money are express in $ MXN

Table 7 – Calculations for the energetic/economic model

Residential Tariff Customer	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Tariffs 20015												
Basic Consumption up to 75 kWh	0.809	0.809	0.809	0.809							0.809	0.809
Basic Consumption between 76 - 200 kWh	0.976	0.976	0.976	0.976							0.976	0.976
Exceeding Consumption over 200 kWh	2.859	2.859	2.859	2.859							2.859	2.859
Low-Intermediate Consumption 0-300 kWh					0.711	0.711	0.711	0.711	0.711	0.711		
High-Intermediate Consumption 301 - 1200 kWh					0.839	0.839	0.839	0.839	0.839	0.839		
High Consumption 1201- 2500 kWh					1.071	1.071	1.071	1.071	1.071	1.071		
Exceeding Consumption over 2500 kWh					2.859	2.859	2.859	2.859	2.859	2.859		
Baseline												
Current Demand kWh/mes	215.1	195.5	179.4	199.8	265.1	452.9	662.8	769.0	745.8	587.2	352.4	235.0
Current Electricity charge $	**$225.91**	**$178.28**	**$162.57**	**$182.46**	**$188.51**	**$341.55**	**$517.67**	**$606.82**	**$587.36**	**$454.25**	**$618.28**	**$282.75**
El. Charg without subv.	$784.98	$695.96	$631.12	$684.24	$761.22	$1,293.37	$1,873.00	$2,169.45	$2,116.69	$1,731.03	$1,202.79	$796.65
Subvention	$559.07	$517.68	$468.55	$501.79	$572.70	$951.82	$1,355.33	$1,562.63	$1,529.33	$1,276.78	$584.51	$513.90
With Photovoltaic System												
Energy generated PV (kWh/month)	1008.27	1138.37	1374.91	1463.62	1489.49	1463.62	1443.66	1420.74	1308.38	1329.08	1086.62	962.44
Energy generated PV * Tariff T2 ($)	$2,881.6	$3,221.7	$3,798.1	$3,949.3	$3,999.2	$3,888.4	$3,827.6	$3,790.0	$3,621.0	$3,629.8	$2,942.3	$2,587.9
Max % of Energy covered by PV	43%	43%	43%	43%	53%	53%	53%	53%	53%	53%	43%	43%
Max energy covered by PV (kWh/mes)	92.4	83.9	77.0	85.8	140.7	240.3	351.6	408.0	395.7	311.5	151.3	100.9
Self Consumption (kWh/month)	92.4	83.9	77.0	85.8	140.7	240.3	351.6	408.0	395.7	311.5	151.3	100.9
Self Consumption (kWh/month) * Tariff T2 ($)	$221.18	$196.57	$173.82	$191.37	$335.86	$600.08	$897.73	$1,055.62	$1,061.85	$814.77	$369.42	$229.65
Final Consumption from the Grid (kWh/month)	122.75	111.55	102.36	113.99	124.47	212.60	311.14	361.03	350.14	275.66	201.05	134.09
Electricity Charge CFE	**$107.3**	**$96.3**	**$87.4**	**$98.7**	**$88.5**	**$151.2**	**$222.6**	**$264.5**	**$255.4**	**$196.0**	**$185.7**	**$118.3**
Savings in Electricity	**$118.6**	**$81.9**	**$75.2**	**$83.7**	**$100.0**	**$190.4**	**$295.0**	**$342.3**	**$332.0**	**$258.3**	**$432.6**	**$164.4**
Electricity Charge without subv.	$447.9	$397.1	$360.1	$390.4	$357.4	$607.2	$879.3	$1,018.5	$993.7	$812.6	$686.3	$454.6
Subvention	$340.6	$300.8	$272.7	$291.7	$268.9	$456.0	$656.6	$754.0	$738.3	$616.6	$500.6	$336.2
Final Delivery to the retailer (kWh/month)	915.89	1054.42	1297.88	1377.83	1348.82	1223.35	1092.03	1012.73	912.68	1017.55	935.31	861.52
Final Delivery to the retailer * Tariff T2 ($)	$2,613.10	$2,980.50	$3,582.61	$3,715.07	$3,617.19	$3,242.62	$2,884.21	$2,688.38	$2,511.46	$2,767.94	$2,526.09	$2,311.63

Source: Own elaboration

Table 8 – Annual summary

Current Elect. Charge	$4,346.41
Annual Energy Savings (kWh/year)	2,439.18
Annual Tariff Savings ($/year)	$2,474.48
Annual Payment to CFE ($/year)	$1,871.93
Annual PV Energy (kWh/year)	15,489.20
Investment PV cost ($)	$288,000.00
Annual self-consumption (kWh/year)	$2,439.18
Annual Delivery to the retailer * Tariff 2 ($)	$35,440.80
Annual Self Consumption * Tariff 2 ($)	$6,147.91
Annual PV production * Tariff 2 ($)	$42,136.96
Subvention reduction ($)	$4,861.02

3.2 Estimation of costs

The cost and benefit analysis is carried out on 15 years' time. This analysis period is conservative compared to the life span of the panel, and it could even be extended to 20 years. This model considers the initial capital investment, i.e. the acquisition of the panel and additionally the costs corresponding to the operation and management of the equipment.

The main assumptions for the analysis of this model are:

- It is assumed that the intermediary request a credit to cover the 70% of the investment costs. Such credit has an annual interest of 12% with a re-payment period of 10 years.
- All calculations are made at a nominal value; however, considering a Mexico Bond 15Y of 5.88% and an inflation of 3.51%, the discount rate is 2.29%. With these numbers, investments and O&M costs and credit payments for 15 years are calculated to today values, as well as the energy generated by the panel during those years.
- The customer receive a subsidy of 40% for the acquisition of the equipment.
- The efficiency of the panel reduces 3% after the first year, and 1% each year for the rest of its useful lifetime.
- The renting of the rooftop is expected to be $ MXN 4800 a year

Table 9 – Main parameters for the base case

Base Case	
Subsidy	40%
Interest Rate	12%
Loan period	10 years
Tariffs	CFE 2015
PV Capital Cost	$288,000 MXN
PV Capital Cost with subsidy	$ 172,800 MXN

With the previous conditions, the estimated costs of this model for a Base Case are shown in the following table.

Table 10 – Estimated financial, O&M and renting cost for the model

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Investment Cash	51840															
Payment		21408	21408	21408	21408	21408	21408	21408	21408	21408	21408	0	0	0	0	0
O&M		1440	1440	1440	1440	1440	1440	1440	1440	1440	1440	1440	1440	1440	1440	1440
Rooftop Renting		4800	4800	4800	4800	4800	4800	4800	4800	4800	4800	4800	4800	4800	4800	4800

Source: Own elaboration

3.3 Financial Cash Flow

The economic flow described in section 2.3 has been modelled and the profit calculated using the inputs described in the previous sections. The stakeholders analysed in the economic flow are:

- Household
- Intermediary company
- Secretaría General de Hacienda

For the calculations it has been used a 50% of ownership of the panels for both household and intermediary. The intermediary company is expected to apply the household a 40% margin over the maintenance cost.

The results are summarised in the tables below.

Table 11 – Annual cash flows for households

	Household															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Renting (A)	$ -	$ 2,400.00	$ 2,400.00	$ 2,400.00	$ 2,400.00	$ 2,400.00	$ 2,400.00	$ 2,400.00	$ 2,400.00	$ 2,400.00	$ 2,400.00	$ 2,400.00	$ 2,400.00	$ 2,400.00	$ 2,400.00	$ 2,400.00
O&M (B)	$ -	$ -1,008.00	$ -1,008.00	$ -1,008.00	$ -1,008.00	$ -1,008.00	$ -1,008.00	$ -1,008.00	$ -1,008.00	$ -1,008.00	$ -1,008.00	$ -1,008.00	$ -1,008.00	$ -1,008.00	$ -1,008.00	$ -1,008.00
Payment of the panel (C)	$ -25,920.00	$ -10,704.00	$ -10,704.00	$ -10,704.00	$ -10,704.00	$-10,704.00	$ -10,704.00	$ -10,704.00	$ -10,704.00	$ -10,704.00	$ -10,704.00	$ -	$ -	$ -	$ -	$ -
Sales of Energy (D)	$ -	$ 14,920.57	$ 14,472.95	$ 14,323.75	$ 14,174.54	$ 14,025.33	$ 13,876.13	$ 13,726.92	$ 13,577.72	$ 13,428.51	$ 13,279.31	$ 13,130.10	$ 12,980.89	$ 12,831.69	$ 12,682.48	$12,533.28
Self Consumption * CFE Tariff (E)	$ -	$ 2,474.48	$ 2,400.25	$ 2,304.24	$ 2,189.03	$ 2,057.68	$ 1,913.65	$ 1,760.56	$ 1,602.11	$ 1,441.89	$ 1,283.29	$ 1,129.29	$ 982.48	$ 844.94	$ 718.20	$ 603.28
Profit (A+B+C+D+E)	$ -25,920.00	$ 8,083.05	$ 7,561.20	$ 7,315.98	$ 7,051.56	$ 6,771.02	$ 6,477.77	$ 6,175.48	$ 5,867.82	$ 5,558.40	$ 5,250.59	$ 15,651.39	$ 15,355.38	$ 15,068.62	$ 14,792.68	$14,528.56
NPV	$ -25,339.72	$ -17,614.54	$ -10,549.88	$ -3,867.37	$ 2,429.43	$ 8,340.35	$ 13,868.67	$ 19,021.01	$ 23,807.08	$ 28,239.26	$ 32,332.28	$ 44,259.93	$ 55,700.01	$ 66,675.13	$ 77,208.05	$87,321.33
NPV	$ 87,321.33															
IRR	29%															

Table 12 – Main results of the model for the household

Financial indicator	
NPV 15 years	$87321.33
IRR	29%

The annual cash flows are positive from the beginning which means that the benefits of selling energy plus the savings in energy are able to pay the loan of the PV panel. Total profit of the 15 years is brought to a nominal value with the same discount rate previously calculated. At the end of the analysis

the profits seen by the customer amounted to $87,321.33 MXN, and the inversion has an IRR of 29%. The IRR is quite higher than the 15Y Mexico Bond, and thus the investment can be considered as viable from the financial point of view

Table 13 – Annual cash flows for the Intermediary Company

	Intermediary Company															
Año	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	
Rentig (A)	$ -	$ -2,400.00	$ -2,400.00	$ -2,400.00	$ -2,400.00	$ -2,400.00	$ -2,400.00	$ -2,400.00	$ -2,400.00	$ -2,400.00	$ -2,400.00	$ -2,400.00	$ -2,400.00	$ -2,400.00	$ -2,400.00	$ -2,40
O&M (B)	$ -	$ -432.00	$ -432.00	$ -432.00	$ -432.00	$ -432.00	$ -432.00	$ -432.00	$ -432.00	$ -432.00	$ -432.00	$ -432.00	$ -432.00	$ -432.00	$ -432.00	$ -43
Payment of the panel (C)	$ -25,920.00	$ -10,704.00	$ -10,704.00	$ -10,704.00	$ -10,704.00	$-10,704.00	$ -10,704.00	$ -10,704.00	$ -10,704.00	$ -10,704.00	$ -10,704.00	$ -	$ -	$ -	$ -	$
Sales of Energy (D)	$ -	$ 21,068.48	$ 20,436.43	$ 20,225.74	$ 20,015.06	$ 19,804.37	$ 19,593.69	$ 19,383.00	$ 19,172.32	$ 18,961.63	$ 18,750.95	$ 18,540.26	$ 18,329.58	$ 18,118.89	$ 17,908.21	$17,69
Profit (A+B+C+D)	$ -25,920.00	$ 7,532.48	$ 6,900.42	$ 6,689.74	$ 6,479.05	$ 6,268.37	$ 6,057.68	$ 5,847.00	$ 5,636.32	$ 5,425.63	$ 5,214.95	$ 15,708.26	$ 15,497.58	$ 15,286.89	$ 15,076.21	$14,86
NPV	$ -25,339.72	$ -18,140.73	$ -11,693.46	$ -5,582.96	$ 202.60	$ 5,674.72	$ 10,844.53	$ 15,722.82	$ 20,320.06	$ 24,646.37	$ 28,711.60	$ 40,682.59	$ 52,228.62	$ 63,362.71	$ 74,097.52	$84,44
NPV	$ 84,445.35															
IRR	**27%**															

Table 14 - Main results of the model for the intermediary company

Financial indicator	
NPV 15 years	$84,445.35
IRR	27%

In the case of the intermediary company the cash flows are quite similar to the households. It is positive from the first year being the net present value positive from the fifth year. Total profit of the 15 years is brought to a nominal value with the same discount rate previously calculated. At the end of the analysis the profits seen by the customer amounted to $87,445.35 MXN, and the inversion has an IRR of 27%. The IRR is quite higher than the 15Y Mexico Bond, and thus the investment can be considered as viable from the financial point of view

Table 15 - Annual cash flows for Secretaria Genral de Hacienda (Treasury department)

Año	Secretaría General de Hacienda															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Subsidy panel	$ -115,200.00															
Reduction Tariff Sub.	$ -	$ 4,861.02	$ 4,715.19	$ 4,666.58	$ 4,617.97	$ 4,569.36	$ 4,520.75	$ 4,472.14	$ 4,423.53	$ 4,374.92	$ 4,326.31	$ 4,277.70	$ 4,229.09	$ 4,180.48	$ 4,131.87	$ 4,083.26
Total	$ -115,200.00	$ 4,861.02	$ 4,715.19	$ 4,666.58	$ 4,617.97	$ 4,569.36	$ 4,520.75	$ 4,472.14	$ 4,423.53	$ 4,374.92	$ 4,326.31	$ 4,277.70	$ 4,229.09	$ 4,180.48	$ 4,131.87	$ 4,083.26
NPV	$ -57,896.16															
IRR	-6%															

Table 16 – Main results of the model for Secretaria Genral de Hacienda (Treasury department)

Financial indicator	
NPV 15 years	-$ 57,896.16
IRR	-6%

In the case of “Secretaría General de Hacienda” (Treasury Department), there is a substantial reduction in subsidy of energy but on the other hand, there is a subsidy of the 40% of the cost of the PV panel. The total result gives an IRR of -6% and a NPV of -$57,896.16 MXN.

3.4 Sensitivity analysis

3.4.1 Base case

Cost-Benefit results directly depend on the ownership of the PV panels and the potential subsidy. Some conditions for this model are likely to change, and thus drive to different results and conclusions. It is convenient to perform a sensitivity analysis in order to observe the results when changing such conditions, and analyse other possible scenarios.

The following tables show the IRR when these two parameters are modified within a reasonable range.

Table 17 – IRR Sensibility analysis for households

IRR Household		Subsidy				
		0%	15%	30%	45%	60%
% Household Ownership	0%	-	-	-	-	-
	25%	6%	12%	23%	40%	71%
	50%	4%	10%	19%	35%	64%
	75%	3%	9%	18%	34%	62%
	100%	3%	9%	18%	33%	61%

Table 18 - IRR Sensibility analysis for the intermediary company

IRR Intermediary		Subsidy				
		0%	15%	30%	45%	60%
% Household Ownership	0%	3%	9%	17%	32%	59%
	25%	3%	9%	18%	32%	60%
	50%	3%	9%	18%	33%	61%
	75%	4%	11%	20%	35%	64%
	100%	-	-	-	-	-

Table 19– IRR Sensibility analysis for Secretaria General de Hacienda (Treasury department)

IRR Secretaria General de Hacienda		Subsidy				
		0%	15%	30%	45%	60%
% Household Ownership	0%	-	6%	-3%	-8%	-10%
	25%	-	6%	-3%	-8%	-10%
	50%	-	6%	-3%	-8%	-10%
	75%	-	6%	-3%	-8%	-10%
	100%	-	6%	-3%	-8%	-10%

As expected, the most favourable results (for Households and Intermediary) are obtained for the higher subsidy. It is also noteworthy to mention that the model is

profitable for the household and the intermediary company even without subsidy. There is also a case with low subsidy (15%) where the IRR is positive for all the stakeholders.

3.4.2 Level of incomes analysis

Cost-Benefit results also directly depends on the energy consumption of every household. In order to analyse the effect of changing the level of incomes of the households a sensitivity analysis based on this and the level of subsidy of the PV panel has been performed. For this purpose a "medium-high" income household and a "medium" household has been taken. The medium-high correspond to a household consuming a high amount of energy, close to the limit of being considered as a DAC consumer (no subsidy tariff). The medium correspond to the mean between the low income household and the medium-high[6].

The results of the sensibility analysis are shown in the table bellow.

Table 20 – IRR Sensibility analysis for households

IRR Household		Level of incomes		
		Low	Medium	Medium-High
% Subsidy	0%	4%	-4%	-13%
	15%	10%	1%	-9%
	30%	19%	9%	-3%
	40%	29%	17%	3%
	45%	35%	22%	8%

Table 21 - IRR Sensibility analysis for the intermediary company

IRR Intermediary		Level of incomes		
		Low	Medium	Medium-High
% Subsidy	0%	3%	3%	3%
	15%	9%	9%	9%
	30%	18%	18%	18%
	40%	27%	27%	27%
	45%	33%	33%	33%

Table 22– IRR Sensibility analysis for Secretaria General de Hacienda (Treasury department)

IRR Secretaria General de Hacienda		Level of incomes		
		Low	Medium	Medium-High
% Subsidy	0%	-	-	-
	15%	6%	16%	25%
	30%	-3%	4%	9%

[6] The monthly demand profile of each level of incomes is shown in Annex A

	40%	-6%	0%	5%
	45%	-8%	-2%	3%

As it can be seen, the IRR of the households decreases as the level of incomes increases. The main reason is the amount of energy self-consumed by the households. When the energy demand is higher, a bigger amount of energy is susceptible of being self-consumed and consequently less energy can be sold at T2 tariff. The expected IRR is therefore lower compared to low income households.

For Secretaria General de Hacienda (Treasury Department) the IRR is expected to be higher as the level of incomes increases. On one hand, the self-consumption shall be higher as explained before. This together with the fact that the tariff is divided in subsidy levels (being less subsidised the energy as the demand increases) makes the amount of energy subsidised byt Secretaria General de Hacienda lower and therefore it IRR higher.

3.4.3 Break-even scenario for Secretaria General de Hacienda

3.4.3.1 Low income households

The break-even scenario where the IRR is 0% for Secretaria General de Hacienda in the case of low-income houses is **23%** of subsidy. Under this condition the IRR for all the stakeholders is:

Table 23 - Break-even scenario results (Low income)

Stakeholder	IRR
Household	14%
Intermediary	13%
Secretaria General de Hacienda	0%

As it can be seen, the break-even scenario is reached with a subsidy of the price of the panel relatively low with a good result for both household and intermediary. For this scenario, the sensibility of the IRR to the subsidy is low. The reason for this is that the realtive weight of the sales of energy is much higher than the cost of the panel.

3.4.3.2 Medium income household

The break-even scenario where the IRR is 0% for Secretaria General de Hacienda in the case of low-income houses is **33%** of subsidy. Under this condition the IRR for all the stakeholders is:

Table 24 - Break-even scenario results (Medium income)

Stakeholder	IRR
Household	17%
Intermediary	27%
Secretaria General de Hacienda	0%

The break-even scenario is reached with a good result for both household and intermediary. For this scenario, the sensibility of the IRR to the subsidy moderate. The

reason for this is that the relative weights of the sales of energy and the panel are balanced.

3.4.3.3 Medium-high income household

The break-even scenario where the IRR is 0% for Secretaria General de Hacienda in the case of low-income houses is **55%** of subsidy. Under this condition the IRR for all the stakeholders is:

Table 25 - Break-even scenario results (Medium-High)

Stakeholder	IRR
Household	21%
Intermediary	49%
Secretaria General de Hacienda	0%

The break-even scenario is reached with a high level of subsidy. With an extremely good result for both household and intermediary. However, the sensibility of the IRR to the subsidy is extremely high, decreasing the IRR performance of the household very fast as the subsidy decreases. The reason for this is that the relative weight of the cost of the panel is higher than the benefits of selling energy.

3.5 Summary of the results

The results for the base case (40% of subsidy) are very good for households of low and medium level of incomes and not so good for medium-high households. For the intermediary company, the results are good and not dependent of the level of incomes of the houses. In the case of Secretaria General de Hacienda the IRR is negative for low incomes households, neutral for medium and good in the case of medium-high. The results are summarised in the table below.

Table 26 – Summary of the results for base case

Level of incomes	IRR household	IRR Intermediary	IRR Secretaria General de Hacienda
Low	29%	27%	-6%
Medium	17%	27%	0%
Medium-High	3%	27%	5%

From a household perspective, it is also interesting to see the annual savings in energy due to the installation of the PV panels. The results are shown in the table below.

Table 27 – Annual savings in energy

Level of incomes	Annual Savings (MXN)
Low	$2,474
Medium	$6,476

Medium-High	$9.075

As explained before, although the savings in energy are higher, the medium and medium-high households have worse results due to the lower amount of energy sold at T2 tariff.

The sensibility analysis has also shown that there are some scenarios for all the households with a fair result in IRR and a positive result for Secretaría General de Hacienda. These scenarios are:

Table 28 – Most favourable cases for Households -Secretaria General de Hacienda

Level of incomes	Subsidy	IRR Secretaria General de Hacienda	IRR Household
Low	15%	6%	10%
Medium	30%	6%	9%
Medium-High	42%	4%	6%

Annex A – Demand profile

Table 29 – Monthly energy consumption for each level of incomes

Level of incomes	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
"Medium-High" (kWh)	645	586	538	599	795	1359	1988	2307	2238	1762	1057	705
"Medium" (kWh)	430	391	359	400	530	906	1326	1538	1492	1174	705	470
"Low" (kWh)	215	195	179	200	265	453	663	769	746	587	352	235