FINANCING FOR SOLAR PHOTOVOLTAIC DISTRIBUTED GENERATION

Brazilian Federation of Banks – FEBRABAN
Center for Sustainability Studies at Getúlio Vargas Foundation – FGVces

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Improving lives

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STUDY

Financing for Solar Photovoltaic Distributed Generation

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Contents

List of figures

List of tables

List of acronyms

ABDE – Brazilian Association of Development

ABNT – Brazilian Association of Technical Standards

ABSOLAR – Brazilian Photovoltaic Solar Energy Association

ANEEL – Brazilian Electricity Regulatory Agency

IDB – Inter-American Development Bank

BNEF – Bloomberg New Energy Finance

CGHs – Hydroelectric Power Plants

Confaz – National Finance Policy Council

CRSS – Social Responsibility and Sustainability Committee

CVM – Brazilian Securities and Exchange Commission

FEBRABAN – Brazilian Federation of Banks

FGVces – Center for Sustainability Studies of the Getulio Vargas Foundation

FIT – feed-in-tariff

GW – gigawatt

ICMS – State Value-Added Tax
IEA – International Energy Agency
kW – kilowatt
kWp – kilowatt peak (energy power measurement)
LAB – Financial Innovation Lab
MME – Ministry of Mines and Energy
MW – megawatt
MWh – megawatt hour
NA – Not available
NDC – Nationally Determined Contributions
SFN – National Financial System

Presentation

The Brazilian Federation of Banks (FEBRABAN) and the Center for Sustainability Studies at Getulio Vargas Foundation (FGVces) have established a partnership that is in its fourth cycle of activities (2017-2018), to analyze possible ways to leverage the transition toward a Green Economy in Brazil using resources intermediated by the National Financial System (SFN).

In the last cycle, four studies were conducted, three of which give continuity to the studies started in 2016. The first one analyzes the implications of the physical incidence of deforestation in the supply chains of livestock, soybean, timber products and palm oil for the risk management of financial institutions. The second evaluates the economic-financial feasibility of bank financing models for forest restoration, considering the economic exploitation of Legal Reserve areas. The third study deals with the management of climate risk by banks and companies, examining the possible impact on financial institutions of the adoption of carbon pricing systems in Brazil, particularly in the relevant economic sectors in the banks' financing portfolio. Finally, the fourth study, which is the subject of this report, analyzes the economic and financial feasibility of adopting micro- and mini- solar photovoltaic distributed generation systems in Brazil, for purposes of this report "distributed generation", in order to examine the scalability of bank financing for these projects.

This study was conducted in partnership with the Brazilian Photovoltaic Solar Energy Association (ABSOLAR) and the Inter-American Development Bank (IDB).

It is worth highlighting the cooperation of ABSOLAR, which contributed with market data, facilitated valuable discussions with its members for the definition and validation of the financing models and offered important institutional support to this work. The contributions of the IDB are also worth highlighting, as they contributed not only by bringing in the experience of other countries in the subject, but also to the formulation of new collateral mechanisms and technical requirements for the projects, among other things.

Strategic partnership between FEBRABAN and ABSOLAR

In 2017, ABSOLAR, a national entity representing companies and professionals in the Brazilian solar photovoltaic sector, and FEBRABAN signed a Cooperation Agreement with the objective of establishing a strategic partnership between the two entities. This collaboration brings closer and strengthens the ties between the solar photovoltaic sector and the financial sector with the purpose of diversifying the supply and increasing the scale of bank financing for solar photovoltaic power, contributing to the democratization of this renewable energy source in Brazil.

The partnership includes the exchange of experiences, knowledge, data and strategic information, with the development of joint initiatives with members, such as meetings and workshops. One of the outcomes of this positive collaboration is this timely and relevant study, which relied on the sum of efforts of ABSOLAR, FEBRABAN, FGVces and the IDB, that allowed for an in-depth analysis of the opportunities and mechanisms for financing micro- and mini- solar photovoltaic distributed generation systems. It is therefore a relevant contribution to the Brazilian solar photovoltaic sector.

The financing of solar photovoltaic distributed generation is a strategic pillar for the development, growth and democratization of this renewable, clean, sustainable, versatile and increasingly competitive technology in Brazil. For this reason, ABSOLAR has been working on the subject since its foundation in 2013, given the need to expand the number of credit lines and the volume of resources available to meet the country's growing demand for this technology. For this purpose, ABSOLAR promotes dissemination, education and awareness actions among financial entities about the characteristics and benefits of solar photovoltaic power, mobilizing and motivating the merging of efforts with the solar photovoltaic sector, for the development and improvement of financial products, in tune with the reality of the sector and the market.

In order to operationalize these activities, ABSOLAR has a permanent Financing Working Group, exclusively focused on the subject, which contributed to the success of this project. Through coordinated and participative actions, ABSOLAR and its associates collaborate with national and international, public and private financial institutions, developing proposals and recommendations to improve access to financing for individual and legal persons interested in purchasing solar photovoltaic power systems, making financing a driving tool for renewable, sustainable, modern, competitive solutions that are integrally aligned with the aspirations of the Brazilian society.

FEBRABAN and IDB strengthen their goals by working together

The Inter-American Development Bank (IDB) works to improve the quality of life in Latin America and the Caribbean, financially and technically supporting countries and institutions in areas such as health, education and infrastructure, seeking to reduce poverty and inequality. Our goal is to achieve development in a sustainable and ecological way.

With FEBRABAN, the main representative body of Brazilian banks, the IDB enhances the achievement of its objectives. Together, the institutions have complementary forces that can change the *status quo* of financial services in Brazil, incorporating socio-environmental principles and criteria in the decision-making structure of the investment and financing chain in Brazil.

In one of the initiatives with FEBRABAN, in which the institution sought to strengthen the investment chains related to Distributed Solar Power Generation, the IDB aimed at fulfilling one of its main strengths: cooperation. With technical knowledge, innovative structures of financing and institutional relations, we seek to bring a new financing paradigm to financial institutions; the investment projects refer to risks of low potential impact and, for that reason, they must be treated differently when the operation risk analysis is performed.

With the excellent work developed by FEBRABAN and its partners, the IDB has connected different banks associated with FEBRABAN considering the dissemination of knowledge, the testing and the adoption (risk analysis tool) by institutions, has disseminated learnings and will support pilot projects. The results were presented at the 55^{th} Coffee with Sustainability, which, in addition to strengthening the partnership, could demonstrate the application of the risk analysis tool of solar photovoltaic distributed generation projects, thus facilitating the understanding of the business model.

Introduction

The development of this study, which gives continuity to the report published in 2016 – "Sustainable buildings and energy efficiency" – was driven by some factors, especially:

(1) **Projected growth in the use of distributed solar photovoltaic power in Brazil in the upcoming years:** According to data from ABSOLAR and projections of the Brazilian Electricity Regulatory Agency (Aneel), the micro-and mini-solar photovoltaic distributed generation installed capacity in residences, businesses, factories, rural producers and public buildings will increase from 182.6 MW in 2017[1] to 3.2 GW in 2024.[2] In addition, estimates made by Bloomberg New Energy Finance (BNEF) indicate that, in 2040, distributed solar photovoltaic power will account for 20% of the country's electricity supply.[3]

(2) **The country's commitment to increasing the use of non-hydropower renewable energies:** Through its Nationally Determined Contributions (NDCs), Brazil has set as a goal that, by 2030, 45% of the Brazilian energy matrix will be composed of renewable energies and that the share of non-hydropower renewable energies in the supply of electricity will increase to at least 23%.

(3) **Few financial products aimed at financing distributed solar photovoltaic generation power:** The market perception (later corroborated by the survey of financial products carried out in this study – Appendix I) shows that there is a low volume of resources and a limited number of financial products dedicated to the financing of solar photovoltaic power projects, which may compromise the attainment of the Brazilian NDCs.

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1 (ABSOLAR, 2018)

2 (Aneel, 2017a)

3 (BNEF, 2018)

Therefore, this study's main objectives are:

- To analyze the feasibility of financing distributed solar photovoltaic power projects, examining: design of financing models, improvements in the collateral offered and certification of implementers and installations; and
- To discuss proposals to enable the scalability of financing distributed solar photovoltaic power projects in the following segments:

Individual

- Installation of a solar photovoltaic power generation system in a household for consumption near the charging device;
- Installation of a solar photovoltaic power generation system in a property, with the possibility of offsetting electricity credits, under the remote self-consumption modality, by other properties of the same owner, provided that they are served by the same utility company.

Cooperatives

- Intermediation for the installation of a solar photovoltaic power generation system and remote compensation for members of the cooperative, under the shared generation modality.

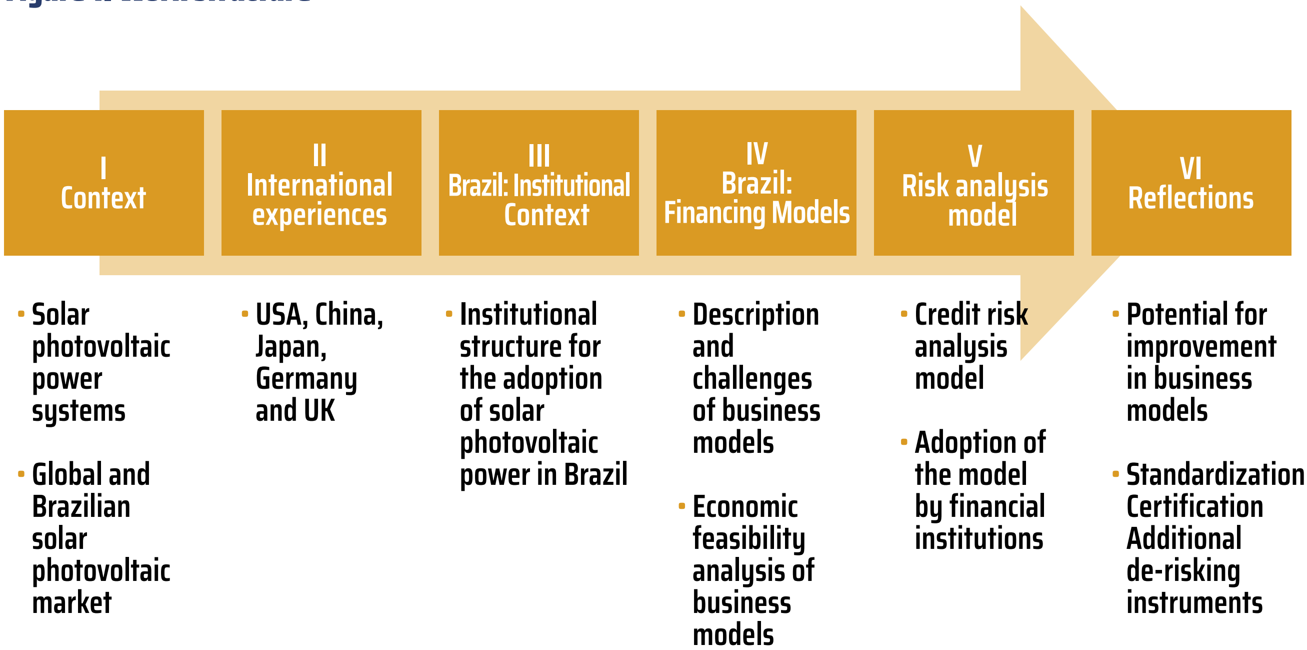
Legal Entity (small and medium-sized enterprises)

- Installation of a photovoltaic solar power generation system in a company for consumption near the charging device;
- Installation of a photovoltaic solar power generation system in a property, with the possibility of off setting electricity credits, under the remote self-consumption modality, by other properties of the same owner, provided that they are served by the same utility company.
- Installation of a solar photovoltaic power generation system by the system implementer that creates a consortium for the generation and shared supply to two or more companies;
- Construction or implementation of a mini power plant for the generation and shared supply to several companies.

It is worth highlighting that technological evolution and market scalability have systematically reduced the costs of solar photovoltaic power projects. The variation of investments in these projects depends on their size.

To meet the objectives of the study, this report is structured in six parts.

Figure 1. Work structure



Source: FGVces

The first part provides the definition of solar photovoltaic power and classifies the different types of photovoltaic systems. It also provides an overview of the current and projected market for solar photovoltaic power in Brazil and worldwide.

The second part identifies the incentives and mechanisms that have been adopted by the governments of selected countries (United States, United Kingdom, Japan, China and Germany) to encourage the production of solar photovoltaic power.

The third part examines the Brazilian regulatory environment for solar photovoltaic distributed generation.

The fourth part describes the different models of financing photovoltaic systems, analyzing the economic and financial feasibility of these models and examining the challenges for financing each one.

The fifth part proposes an integrated risk analysis model (project risk + customer risk) that financial institutions can adopt to evaluate photovoltaic projects of legal entities in the medium-sized and mini power plant modalities. It also describes the main results of the IDB and FEBRABAN's initiative, in which a sample of financial institutions analyzed the proposed analysis model.

The last part concludes and provides recommendations to FEBRABAN and financial institutions.

Methodology

The study was developed through:

✓ Literature review of technical studies of the sector, and analysis of federal and state regulations to assess the size of the national and international solar photovoltaic power markets, as well as the Brazilian institutional framework;

✓ Interviews with 12 companies associated with ABSOLAR to identify which models for financing solar photovoltaic power exist in Brazil as well as the challenges of the industry companies in accessing financing;

✓ Interviews with the nine financial institutions participating in FEBRABAN Solar Power Working Group to identify which financial products the banks offer to finance solar photovoltaic projects, as well as to analyze which factors hinder the growth of supply of this type of product;

✓ Based on data on photovoltaic systems provided by the IDB and tariff data from electric power utility companies, the FGVces team structured a model to analyze the financial feasibility of the financing models of photovoltaic systems.

✓ The risk analysis model was developed by the FGVces team and validated by the Institutional Relations team, FEBRABAN Solar Power Working Group, FEBRABAN Social Responsibility and Sustainability Committee (CRSS), the IDB, LAB and the companies associated with ABSOLAR.

✓ The recommendations presented in this report were jointly developed by FEBRABAN (Solar Power Working Group, CRSS and Institutional Relations), IDB, members of ABSOLAR and FGVces.

Part I. Overview of photovoltaic solar power generation systems

A photovoltaic solar power system generates electricity directly from solar radiation. Through the photovoltaic effect, photovoltaic cells convert solar radiation into electric power. The photovoltaic modules are composed by a group of photovoltaic cells, which, together with the other system's equipment such as the support structure, inverters, cabling and others, make up the photovoltaic system. Photovoltaic systems have a wide range of applications. They do not use fossil fuels, they do not have moving parts and, being composed of solid-state devices, they require less maintenance.[4]

Solar photovoltaic power can be generated by large power plants connected to the National Interconnected System, which is composed by an extensive network of transmission lines[5], or by distributed generation, characterized by the installation of small generators, connected to the electric power distribution system, located near the centers of power consumption.[6]

On the other hand, distributed solar photovoltaic systems can be classified according to how the generation or connection with the distribution system is made:

- **Autonomous systems (off-grid):** they have no connection with the power distribution network of the utility companies. They can be hybrid, working together with another power generation system (for example, with a diesel generator), or autonomous, having no other form of power generation. Both systems can have a power storage system.[7]

- **Systems connected to the grid (on-grid):** systems connected to the distribution network. Generally, they do not use power storage systems. As they use the distribution network of the utility companies for the flow of the generated electricity, they depend on conducive legislation.[8]

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[4] (di Souza, 2016)

[5] (Barbosa Filho & Azevedo, 2014)

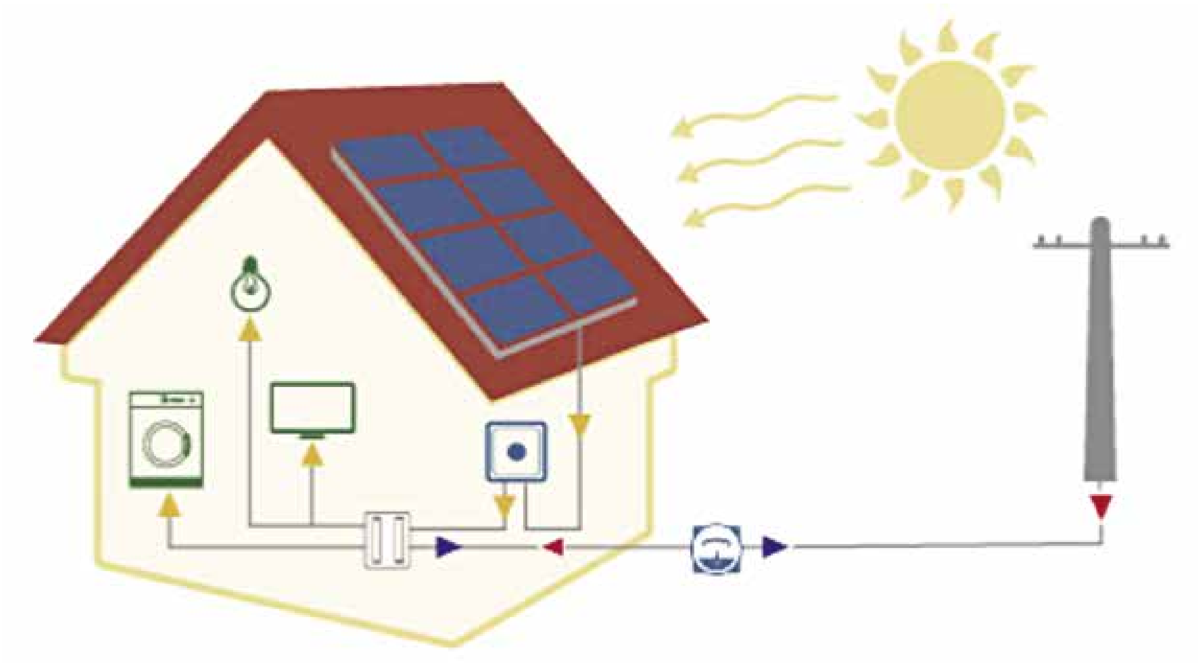
[6] (Aneel, 2016)

[7] (di Souza, 2016)

[8] (di Souza, 2016)

In general, a residential photovoltaic system works as follows:

Figure 2. Operation of a residential solar photovoltaic power system



1 - The modules capture sunlight and transform it into direct current
2 - The current passes through an inverter, where it is transformed into alternating current
3 - The produced electricity surplus can be fed into the grid

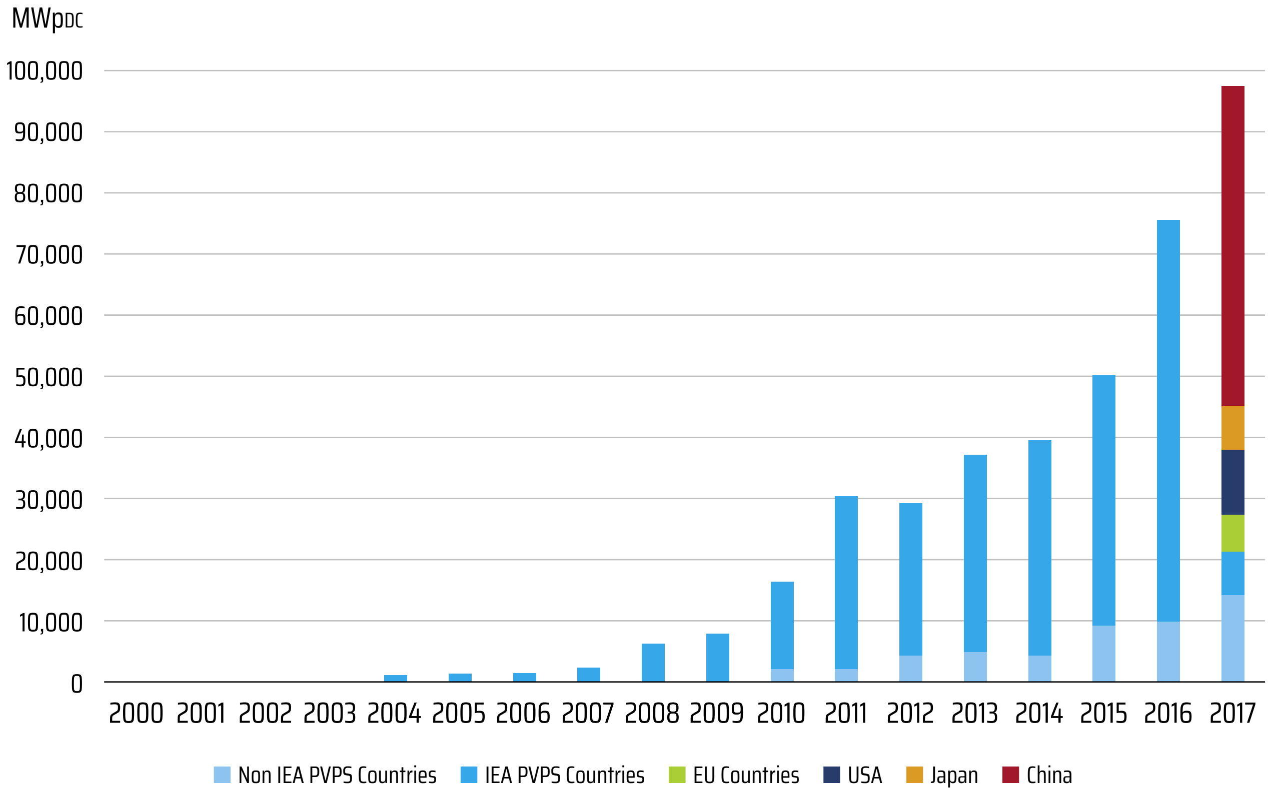
Source: (GIZ, 2016)

Overview of the solar photovoltaic market

According to research by the International Energy Agency (IEA), the global solar photovoltaic market has grown significantly, with an increase of 98 GW of installed capacity in 2017, representing an increase of more than 32% of total installed capacity in 2016. As shown in the figure below, China accounted for most of this growth, with a capacity increase of 53 GW.[9]

[9] (IEA, 2018)

Figure 3. Annual evolution of the solar photovoltaic installed capacity (MW)

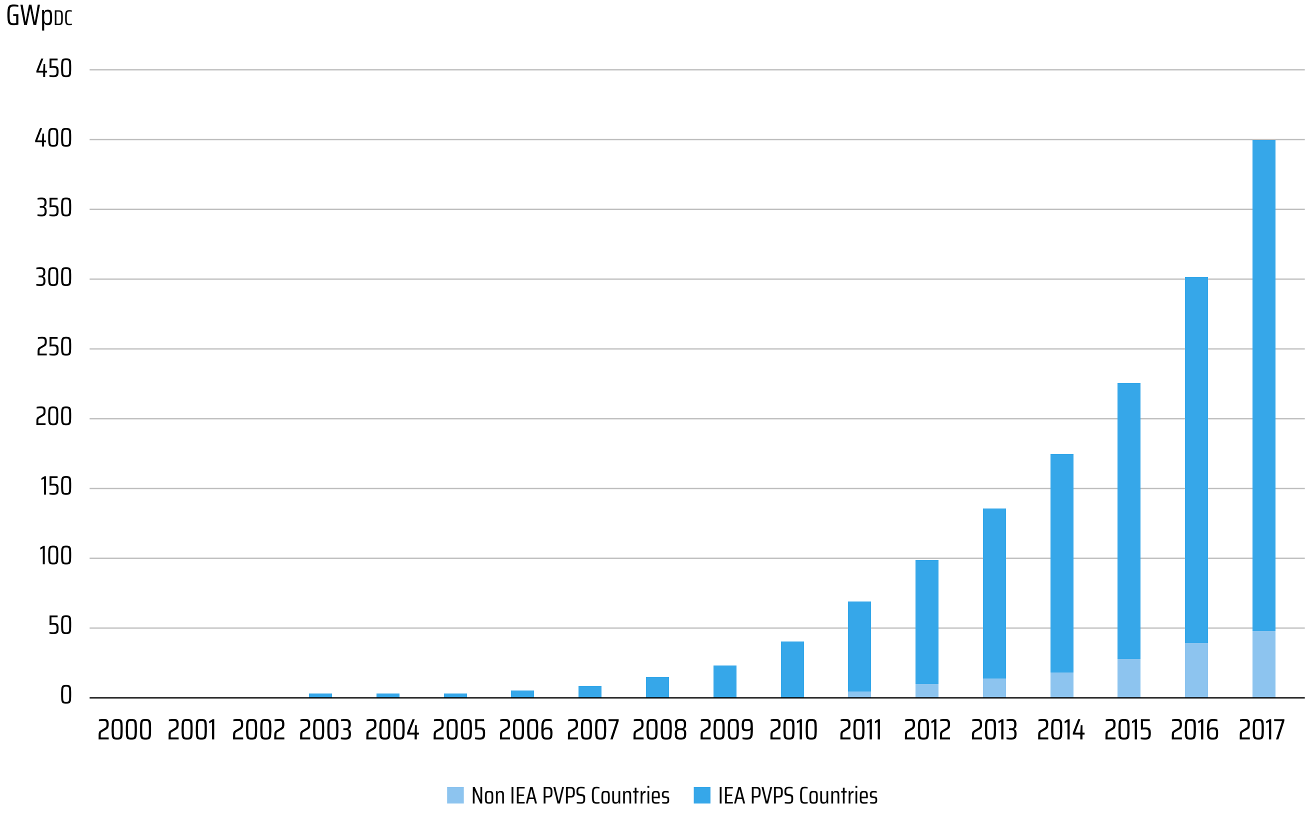


Source: (IEA, 2018)

At the end of 2017, the global cumulative installed capacity reached 402.5 GW, a figure that is seventy times higher than the cumulative installed capacity of 2006. China, the United States and Japan were leaders in cumulative installed capacity, with 131 GW, 51 GW and 49 GW respectively.[10]

[10] (IEA, 2018)

Figure 4. Annual evolution of the cumulative installed capacity (GW)

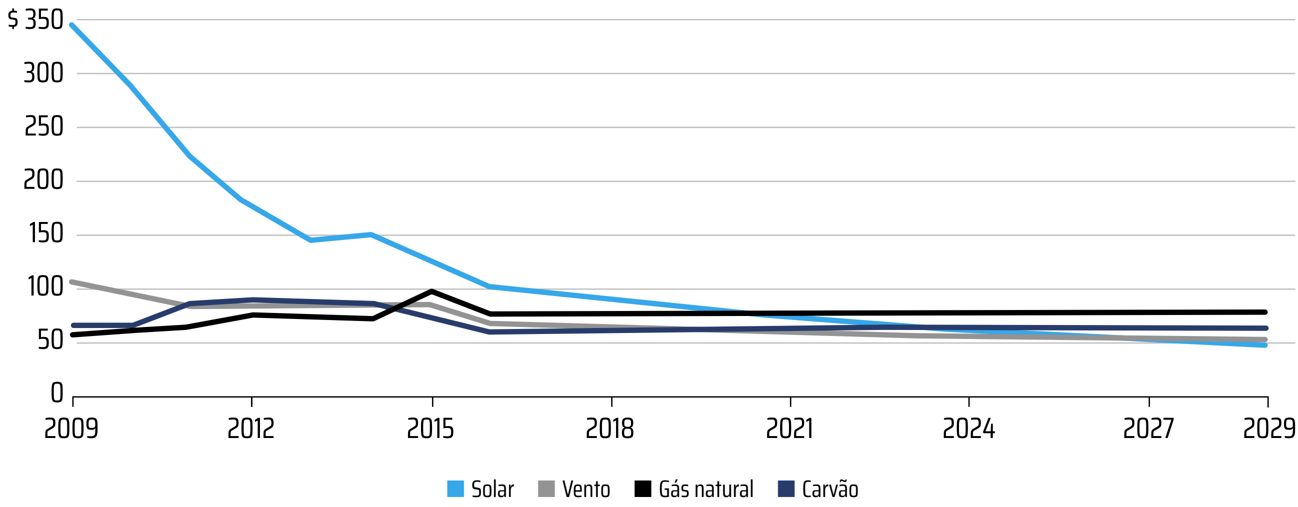


Source: (IEA, 2018)

Projections from Bloomberg New Energy Finance (BNEF) indicate that the cost of solar photovoltaic power per megawatt hour (MWh) will decline 66% between 2017 and 2040. In Germany, Australia, the United States, Spain and Italy, the cost of solar photovoltaic power already is similar to coal and it is estimated that it will be lower than coal in Brazil, India, China, Mexico and the United Kingdom by 2021.[11] Figure 5 shows the global average cost per megawatt (MWh) from different power sources and demonstrates the price decrease of solar power, especially between 2009 and 2015, and it estimates that solar power will be cheaper than coal in 2024 and cheaper than wind power in 2029.

[11] (BNEF, 2018)

Figure 5. Cost per megawatt hour of solar photovoltaic power (US$)



Source: (Landberg & Eckhouse, 2018)

Despite not featuring among the countries with the highest cumulative installed capacity, Brazil appeared in the ranking of the countries that presented the largest increase in installed capacity in 2017, as shown in the table below:

Figure 6. Top 10 countries for annual increase in installed capacity and total installed capacity in 2017

1	China	53 GW	1	China	131 GW
2	USA	10.6 GW	2	USA	51 GW
3	India	9.1 GW	3	Japan	49 GW
4	Japan	7 GW	4	Germany	42 GW
5	Turkey	2.6 GW	5	Italy	19.7 GW
6	Germany	1.8 GW	6	India	18.3 GW
7	Australia	1.25 GW	7	UK	12.7 GW
8	Korea	1.2 GW	8	France	8 GW
9	UK	0.9 GW	9	Australia	7.2 GW
10	Brazil	0.9 GW	10	Spain	5.6 GW

Source: (IEA, 2018)

According to data from ABSOLAR, Brazil's cumulative solar photovoltaic installed capacity in 2017 was 1.12 GW (177.4 MW in distributed generation and 935.3 MW in centralized generation), or the equivalent to 0.7% of the Brazilian energy matrix. In July 2018, the states with the largest solar photovoltaic power generation capacity were Minas Gerais (70.1 MW), Rio Grande do Sul (47.1 MW) and São Paulo (40.3 MW). By the end of 2018, the projection is for the national solar installed capacity to increase to 2.47 GW (410.4 MW in distributed generation and 2,065.3 MW in centralized generation).[12]

[12] (ABSOLAR, 2018)

Part II. International experience for the promotion of solar photovoltaic power generation

In order to identify which factors have stimulated the development of the photovoltaic sector internationally, as well as to analyze which incentive mechanisms for distributed power generation could be replicated in Brazil, a literature review was carried out focusing on the industry in the leading countries in terms of cumulative installed capacity (China, United States, Japan, Germany and the United Kingdom).

In general, it has been verified that the feed-in-tariff[13] (FIT), an energy supply policy focused on the development of new renewable energy projects[14], is one of the most commonly adopted incentives. The system remunerates producers of solar photovoltaic power for each kWh of electricity produced and/or exported to the grid and, in general, requires utility companies to purchase the power generated by eligible producers in their area of activity for a period of 15 to 20 years.[15]

Below is a summary of the incentive programs implemented in selected countries to stimulate the production of distributed solar photovoltaic power.

Germany

In 1991, the government created the "1,000 Roofs" program (1991-1995) by offering a 70% subsidy on the cost of the photovoltaic systems, which encouraged the production of 2,250 new systems. Due to the success of the initiative, in 1999, the program was expanded to the "100,000 Roofs" program (1999-2003), granting interested parties' interest-free financing of € 6,230 per kW for systems of up to 5MW and € 3,115 per kW for larger systems. With the successful installation of 100,000 photovoltaic systems connected to the grid, the program has since been discontinued.[16]

[13] The feed-in tariff system is adopted by 74 countries and 35 sub-national jurisdictions (REN21, 2016).

[14] (Couture, Cory, Kreycik, & Williams, 2010)

[15] (Muhammad-Sukki et al., 2013)

[16] (Chowdhury, Sumita, Islam, & Bedja, 2014)

In 1991, the German government also established the feed-in-tariff policy, paying for the entire generation of distributed solar photovoltaic power. The tariff rate, which was low in 1991 (€ 0.1661/kWh), was raised in 2000 (€ 0.574/kWh). In 2004, the feed-in-tariff policy was revised in order to provide greater economic incentives to final consumers. As a result of the subsidies, the German cumulative installed photovoltaic market grew quite rapidly from 126 MW in 2000 to 24.7 GW in 2011.[17]

Starting in 2012, renewable energy producers under the feed-in-tariff system were able to sell power directly to the market (not just to utility companies at a pre-determined rate)[18]. The German government also decided that the tariff would be reduced more frequently and that a maximum of 90% of the power produced would be eligible for the feed-in-tariff regime, while the remainder should be self-consumed, sold on the market, or compensated.[19]

As of 2005, the feed-in-tariff began to be reduced. According to data from April 2018, the feed-in-tariff for small photovoltaic systems was up to € 0.220/kWh.[20]

In 2000, distribution companies started to charge end-users a surcharge to compensate the gap between the remuneration paid to producers for the renewable energy (feed-in-tariff) and the revenues from sales of renewable energy. The surcharge including value-added tax for 2018 is € 0.808/kWh.[21]

[17] (Chowdhury & Sumita, 2012; Chowdhury et al., 2014)

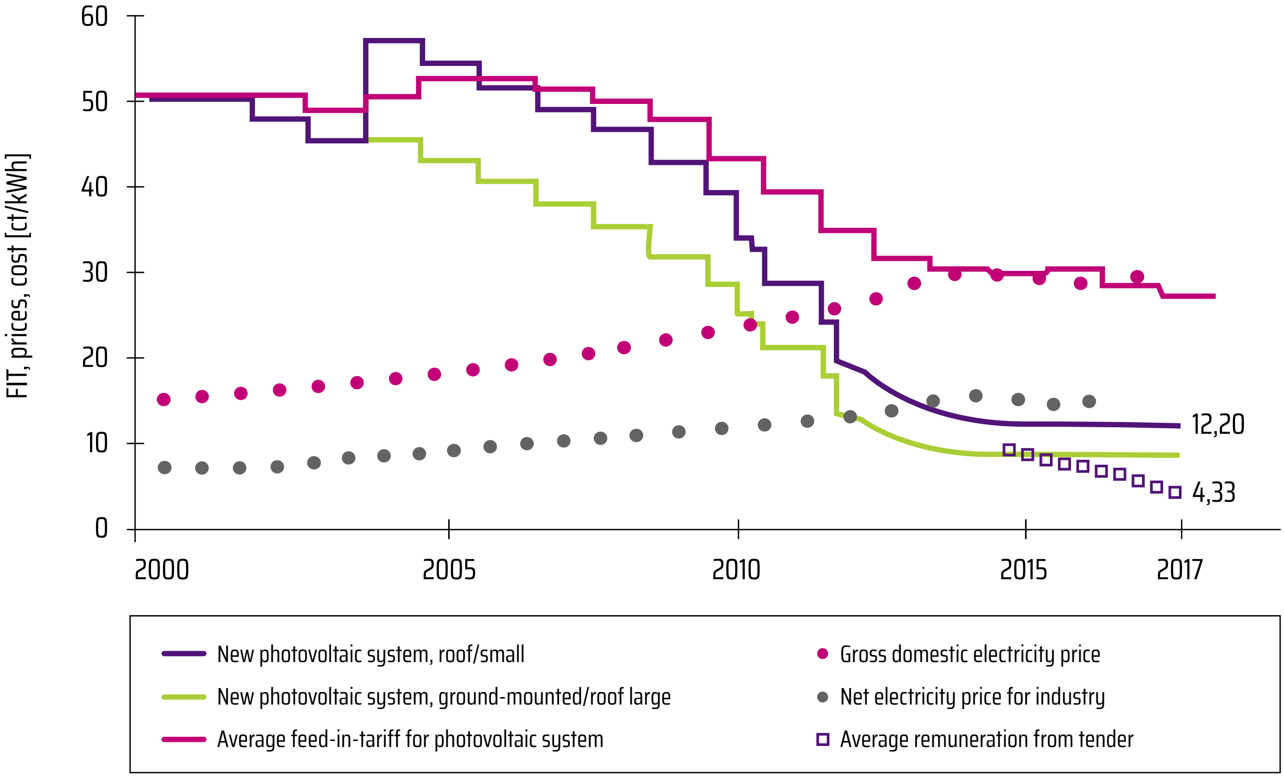
[18] (IEA, 2013)

[19] (IEA, 2013)

[20] (Fraunhofer, 2018)

[21] (DW, 2016; Fraunhofer, 2018)

Figure 7. Feed-in tariff in Germany



Source: (Fraunhofer, 2018)

Japan

✓ Since 1994, the number of photovoltaic systems has increased quite rapidly in Japan, due to various government incentives, such as:

- In 2000, the simplification of procedures for the installation of photovoltaic systems with less than 500 kW;
- In 1992, the implementation of a system for purchasing surplus power generated in the net metering model, in which the power produced is used for own consumption and the surplus is sent to the grid;
- Subsidies for the costs of installation of residential photovoltaic systems (50% between 1994 and 1996).[22]

[22] (Chowdhury et al., 2014)

- ✓ The government reduced subsidies for photovoltaic installations from 900 JPY/Watt in 1994 to 20 JPY/Watt in 2005, up to the total elimination of subsidies that year.[23] However, with the reduction of the photovoltaic market, the government reintroduced subsidies and the purchase of power surplus in 2009 (at 48 JPY/kWh).[24]

- ✓ In 2012, the Japanese government demanded electric utility companies to buy power from renewable sources for a fixed period at a fixed price. The cost of purchasing electricity is covered by consumers, who pay a surcharge per unit of energy consumed. For systems with a capacity of less than 10 kW, the eligibility period is 10 years and the tariff ranged from 42 JPY/kWh in 2012 to 31-33 JPY/kWh in 2016. For systems with a capacity of 10 kW, the eligibility period is 20 years and the tariff ranged from 40 JPY/kWh in 2012 to 24 JPY/kWh in 2016. The system contributed to an increase of the country's photovoltaic installed capacity: between July 2012 and January 2016, 25.9 GW of additional capacity was installed.[25]

China

According to China's National Development and Reform Commission and the State Grid Corporation of China, distributed solar photovoltaic power projects generate power for own consumption, at or near the user's location, with a maximum limit of less than 6 MW, while the production surplus is sent to the grid.

The Chinese government has implemented various subsidies for the development of solar photovoltaic distributed generation, including:

- ✓ In 2013, it implemented a subsidy of CNY0.42 per kWh of power generated and consumed, valid for 20 years, to be paid by China's Renewable Energy Development Fund.

- ✓ The PV power producer is also paid by the utility company for any power surplus exported to the grid, based on the price of coal-fired power, which varies between CNY0.25/kWh and CNY0.52/kWh, depending on the region of the country.

[23] (Chowdhury et al., 2014)

[24] (Chowdhury & Sumita, 2012)

[25] (IEA, 2016)

- ✓ The two largest state-owned power utility companies, the State Grid Corporation of China and the China Southern Grid, offer power producers free services to connect the photovoltaic system to the grid.

- ✓ Since April 2014, distributed generation projects are exempt from licensing requirements.

However, the incentives have not produced the expected increase in distributed solar power generation due to some restrictions, such as:

- ✓ Residential Chinese consumers pay subsidized electricity tariffs, ranging from CNY0.30/kWh to CNY0.50/kWh, which makes investment in a photovoltaic project unattractive from the economic standpoint.

- ✓ Access to financing is difficult, as Chinese financial institutions are not yet familiar with the risks of photovoltaic projects and project developers tend not to have a good credit rating.

- ✓ Investments in large-scale and long-term systems present risks due to legal uncertainty, as China's land ownership is not the same as that of construction.

- ✓ Power distribution companies may require producers to install electronic monitoring equipment, specifying the brand, model and manufacturer. Because they are expensive, the requirement discourages the connection to the grid.[26]

[26] (Zhang, 2016)

United Kingdom

- ✓ In April 2010, the British government introduced the feed-in-tariff system to encourage the adoption of small-scale renewable energy generation technologies.[27]

- ✓ One year after the implementation of the policy, 28,550 new photovoltaic systems were built, or the equivalent of 77.7 MW. In November 2011, the cumulative installed capacity increased to 102,022 systems, or the equivalent of 366 MW.[28]

- ✓ The increase in installed capacity was faster than the government anticipated. The forecast was for the cumulative capacity to reach 137 MW by April 2012, but this target was reached in July 2011 and in November of that year it reached almost three times the target.[29]

- ✓ In April 2012, the government reduced the tariff for generating photovoltaic power by up to 56% per kWh produced (depending on system capacity).[30]

- ✓ At the beginning of 2016, the feed-in-tariff was reduced by 60%. The number of new systems fell 80% in February 2016 compared to February 2015.[31]

United States

- ✓ 43 states and the District of Columbia offer the net metering system, which allows solar photovoltaic power producers to acquire electricity from utility companies when they do not produce enough for their demand. They can also export to the grid when they produce power surplus.[32]

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[27] (Ofgem, 2018)

[28] (Muhammad-Sukki et al., 2013)

[29] (Muhammad-Sukki et al., 2013)

[30] (Muhammad-Sukki et al., 2013)

[31] (Solar Trade Association & PV Financing, 2016)

[32] (Solar Energy Industries Association, 2018)

- ✓ The state of California is the most advanced in terms of incentive to renewable energy, whose legislation establishes that, by 2030, 50% of the state's electricity comes from renewable sources. California is the country's leader in photovoltaic installed capacity and has 16% of its energy matrix from solar power, a high percentage compared to the national percentage of 1.9%.[33]

- ✓ The California Solar Initiative offers reimbursement per Watt of installed solar power for homes, businesses, farms, and non-governmental organizations.[34]

- ✓ Starting in 2020, new households in the state of California are expected to install a solar power generation system, either through an individual solar panel or a solar system that serves a group of homes. The requirement should further boost the development of California's photovoltaic market.[35]

The literature review shows that government incentive systems played a key role in the development of the international photovoltaic sector, particularly in Germany, Japan and the United Kingdom. In Brazil, given the current economic and fiscal environment, there are a number of factors hindering the implementation of these incentive systems. Therefore, at this time, the efforts of the Brazilian financial sector to increase the financing of solar photovoltaic systems will be achieved by searching for market solutions that enable the development of the industry.

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[33] (Penn, 2018; Weaver, 2018)

[34] (Go Solar California, 2018)

[35] (Penn, 2018)

Part III. Current brazilian sectoral regulatory context

In 2012, ANEEL published Normative Resolution 482, which established the general conditions for access of distributed microgeneration and minigeneration system to the electric power distribution grid and created the electricity compensation system (net-metering). Two years later, in order to reduce the costs and time to connect microgeneration and minigeneration, to reconcile the Electricity Compensation System with the General Conditions of Supply, to increase the target audience and to improve information on the invoice, Normative Resolution 687/2015 was published, revising Resolution 482.[36]

Resolutions 687/2015 and 786/2017 define distributed microgeneration as a power plant generating electricity with installed capacity lower than or equal to 75 kW and using qualified cogeneration or renewable sources of electricity, connected to the distribution network. Distributed minigeneration, on the other hand, refers to a power plant with an installed capacity greater than 75 kW and lower than or equal to 5 MW.[37]

The ANEEL Resolutions characterize the power compensation system as a system in which active power injected by a consumer unit with distributed microgeneration or minigeneration is transferred to the local utility company by means of a free loan that is later compensated through the consumption of active power (net metering). This means that when the power injected into the network is greater than the consumption, the consumer receives a credit that, according to Resolution 687, remains valid for up to 60 months.

Resolutions 517/2012 and 687/2015 created additional business models of compensation of credits to expand the segment: the enterprise with multiple consumer units, shared generation and remote self-consumption.

[36] (Aneel, 2016; MME, 2017)

[37] (Aneel, 2016)

According to the ‘enterprise with multiple consumer units’ modality, consumer units located on the same property or on contiguous properties can unite to install a micro or mini central generator, share the generated power and feed the areas of collective use, with the condominium or owner of the enterprise in charge of the system. In this modality, residents of a residential condominium can come together, for example, to install a photovoltaic system on the roof of the party hall of the condominium.

In the ‘shared generation’ modality, two or more consumers located in the same concession area of the utility company can build a consortium or a cooperative to install a micro or mini generator and share the credits it generates. For example, consumers in a residential building with no space to install a photovoltaic system can join a consortium to install a photovoltaic system in another location using the pre-defined percentage of credits generated to reduce their local consumption.

In the ‘remote self-consumption’ modality, consumers can install a micro or mini generator on a property different from where they reside, but under their ownership and served by the same utility company, and use the credits generated to reduce their consumption. For example, a consumer can install a photovoltaic system in their beach house and offset the credits in their residential apartment.[38]

[38] (BlueSol, 2018)

Confaz Agreement ICMS 16/2015

To encourage the adoption of distributed generation, the National Finance Policy Council (Confaz) published the ICMS Agreement 16, dated 4/22/2015, authorizing the states to grant tax exemption in the internal operations related to electricity circulation, subject to billing under the power compensation system. Thus, in the states that have adhered to the Agreement, the State Value-Added Tax (ICMS) is imposed only on the difference between the energy consumed and the energy injected into the network in the month.[39] By May 2018, all states had already joined.

State programs to support the development of the solar photovoltaic market

In recent years, several states (Goiás, Rio de Janeiro, Mato Grosso do Sul, Tocantins, Roraima, Minas Gerais, Pernambuco and the Federal District) have developed programs to support the development of the solar photovoltaic power market. One of them is the Brasília Solar Program, which has as one of its objectives "to encourage the implementation of solar power production systems for the purposes of self-consumption by individuals and companies domiciled in the Federal District, through the adoption of economic incentives and communication actions" (Decree 37,717/2016). The survey of existing public programs can be found in Appendix II.

[39] (Aneel, 2016)

Part IV. Solar photovoltaic power financing models

There are seven major types of solar photovoltaic power financing models in Brazil.

1. Individual – Direct Consumption Model

In this model, a company specialized in photovoltaic projects develops a project to implement a solar photovoltaic system in the residence of an individual. With the project, whose value can vary between R$ 20,000.00 and R$ 75,000.00[40], depending on the installed capacity of the project, the individual requests financing from the bank. The bank analyzes the project and requests or verifies the collateral offered. Following the approval of the loan by the financial institution and payment to the specialized company, the project is implemented at the customer's residence/property and the generation of photovoltaic power begins.

Figure 8. Individual – Direct Consumption Model

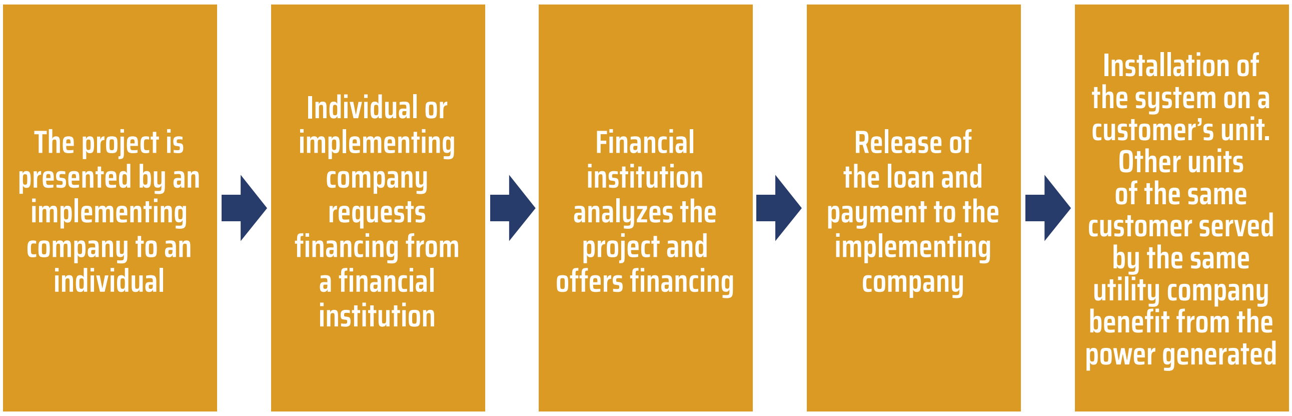
Source: FGVces

[40] The costs of solar photovoltaic systems can vary because they depend on the size and complexity of the project, noting that technological developments and market scale have been systematically reducing the costs of these projects.

2. Individual – Remote Self-Consumption Model

In this model, the same procedures as that of the Individual – Direct Consumption Model apply. The difference is that, in this case, the customer has other properties served by the same utility company as the property where the solar photovoltaic system is installed, which can also benefit from the power generated by the photovoltaic system.

Figure 9. Individual – Remote Self-consumption Model

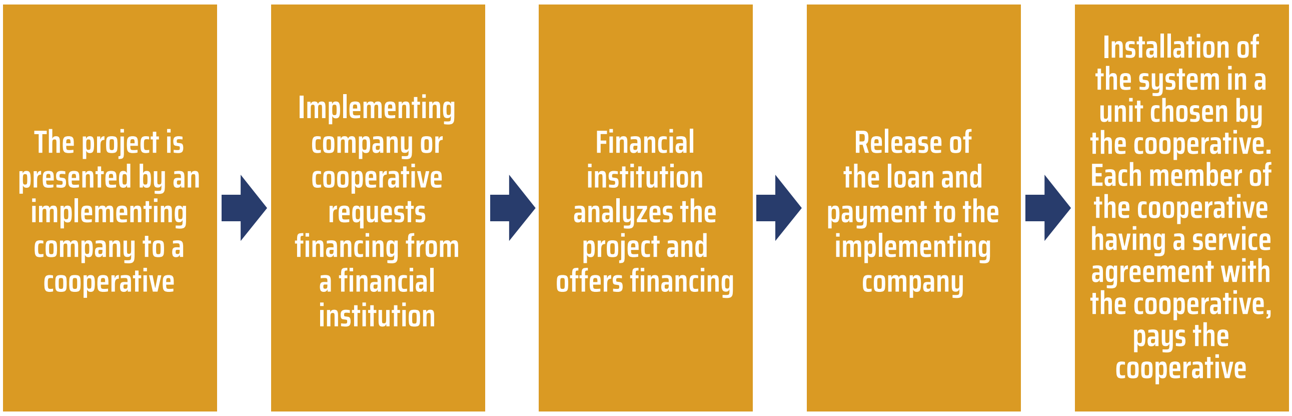


Source: FGVces

3. Individual – Shared Generation or Enterprise with Multiple Consumer Units Model

In this model, a company specialized in photovoltaic projects develops a solar photovoltaic systems project for a cooperative or a consortium. With the project, whose average value can vary between R$ 50,000.00 and R$ 200,000.00, depending on the installed capacity of the project, the cooperative or the condominium requests financing from a financial institution. The institution analyzes the project and requests or verifies the collateral offered (for example, receivables from the condominium fees). After the approval of the loan and the payment to the supplier by the cooperative or condominium, the project is implemented and the generation of photovoltaic power begins. The members of the cooperative or of the condominium pay directly to the financed party and receive a portion of the credits generated by the photovoltaic system.

Figure 10. Individual – Shared Generation or Enterprise with Multiple Consumer Units Model



Source: FGVces

4. Legal Entity – Direct Consumption Model

In this model, a company specialized in photovoltaic projects develops a project for the implementation of solar photovoltaic systems for a legal entity. With the project, whose average value can vary between R$ 200,000.00 and R$ 500,000.00, depending on the project's installed capacity, the legal entity requests financing from a financial institution. The institution analyzes the project and requests or verifies the collateral offered. After the approval of the loan and the payment to the supplier by the legal entity, the project is implemented in the company and the generation of photovoltaic power begins.

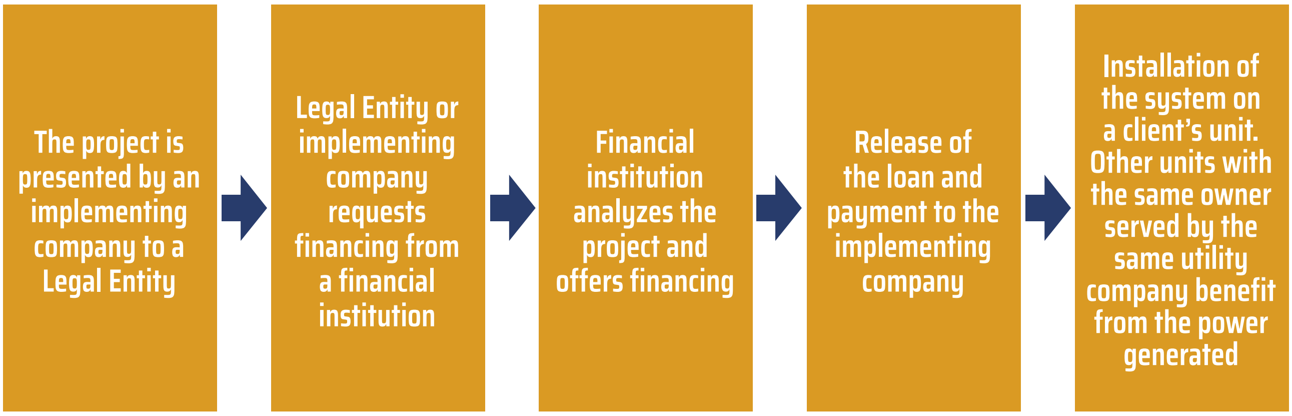
Figure 11. Legal Entity – Direct Consumption Model

Source: FGVces

5. Legal Entity – Remote Self-Consumption Model

In this model, the same procedures as that of the Legal Entity – Direct Consumption Model apply. The difference is that, in this case, the legal entity owns other properties, such as branches served by the same utility company as the property where the photovoltaic system is installed, which can also benefit from the power generated by the system.

Figure 12. Legal Entity – Remote Self-Consumption Model

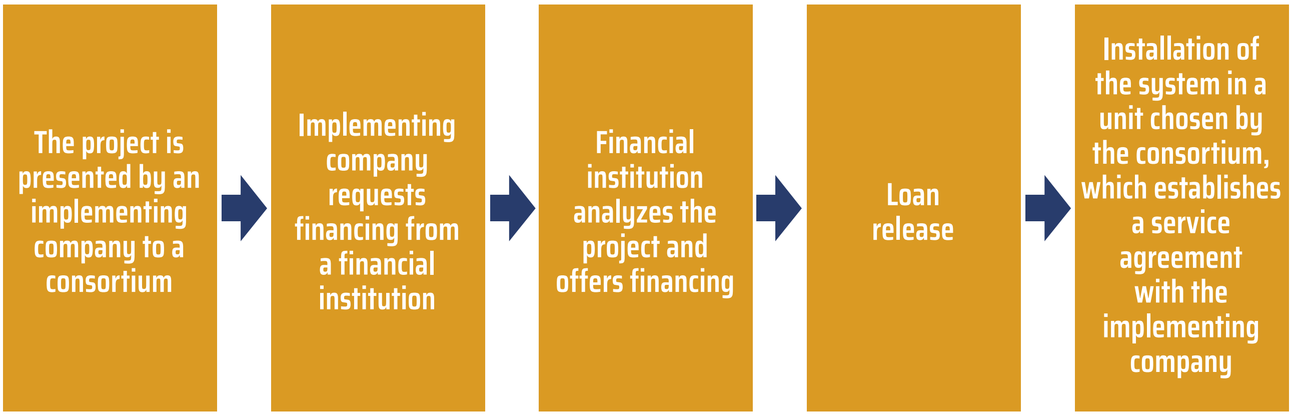


Source: FGVces

6. Legal Entity – Shared Generation or Enterprise with Multiple Consumer Units Model

In this model, a company specialized in photovoltaic projects develops a project to implement photovoltaic solar panels for a consortium or cooperative composed of different companies. With the project, whose average value can vary between R$ 1,000,000.00 and 5,000,000.00, depending on the project's installed capacity, the implementer or consortium requests financing from a financial institution. The institution analyzes the project and requests or verifies the collateral offered. After the approval of the loan, the photovoltaic system is installed. The benefited member companies pay the consortium or directly to the specialized company that pays the financing bank.

Figure 13. Legal Entity – Shared Generation or Enterprise with Multiple Consumer Units Model



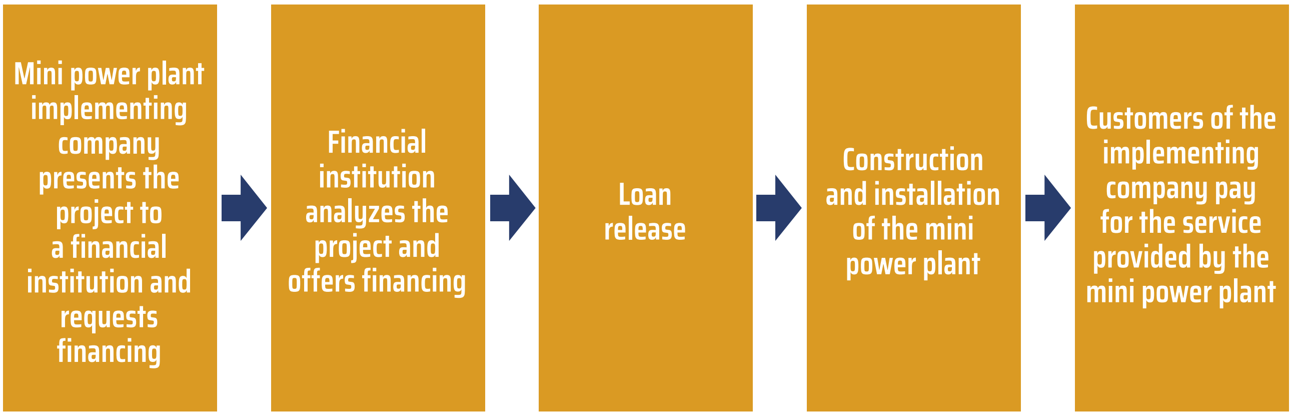
Source: FGVces

7. Legal Entity – Mini Power Plant Model

In this model, a company specialized in photovoltaic projects develops a mini power plant project (with power equal to or close to 5 MW) and, with the project, whose average value is over R$ 5 million, requests financing from a financial institution. The financial institution analyzes the project and requests or evaluates the collateral offered. After the loan is approved, the mini power plant is constructed and installed. Mini power plant's client companies, which have contracts with the specialized company, benefit from the system's power generation and pay directly to the company, which is responsible for paying the financing bank.

It is worth mentioning that, although the Legal Entity – Shared Generation Model and the Legal Entity – Mini Power Plant Model have similar characteristics, these were differentiated in the study, since there is a significant difference in the value to be financed in each one of the models, which may cause financial institutions to analyze the credit risk of each one differently.

Figure 14. Legal Entity – Mini Power Plant Model



Source: FGVces

Economic and financial evaluation of the solar photovoltaic power financing models

In order to contribute to a better understanding/standardization of the financing models and to the risk analysis of photovoltaic projects by financial institutions, the financial return of three[41] out of the seven models presented were analyzed: Individual - Direct Consumption, Legal Entity - Direct Consumption and Legal Entity - Mini Power Plant.

The financial feasibility was examined in the states of São Paulo, Minas Gerais, Goiás and Paraíba, which were selected based on the following criteria: degree of solar irradiation, number of ongoing projects, number of companies in the industry, existence of state incentive programs for solar photovoltaic power, and demand potential.

The assumptions used in the model were:

(1) The total cost of the photovoltaic system was calculated based on the following assumptions:

a. **Total cost of installation:** calculated by the sum of the project's cost of installation, cost of equipment and components, cost of transportation, cost of services, and cost of connection (in the case of the mini power plant). For example, it was assumed in the model that distance to ports and lack of skilled labor increase the cost of installation.

[41] These three models were selected, due to the availability of data, by IDB, concerning projects of these models.

b. **Total system capacity:** calculated by multiplying the module's capacity by the number of modules.

c. **Annual maintenance cost:** considered the number of years of operation of the system, the cost of replacing the inverter, and the year in which the replacement is required (year 13[42]). For the Individual and Legal Entity Direct Consumption models, an annual percentage of 0.75% of the total investment cost was adopted. For the Legal Entity - Mini Power Plant model, a figure of R$ 35/Watt was used.[43]

d. **System's lifespan:** considered a 25-year period, which is the system's expected lifespan.

e. **System performance index:** ranged from 99% in year 1 to 85% in year 25. The index affects the capability to use the full power of the system.

f. **States' degree of solar irradiation:** irradiation index of each region of the country. The degree of irradiation affects the capability to use the full power of the system.

(2) **The tariff of the utility companies was calculated by adding the following taxes: ICMS, PIS/PASEP and Cofins.**

(3) **The cost of availability was based on a three-phase connection, i.e. the equivalent of 100 kWh/month, a value charged by all utility companies to low voltage electricity consumers.**

(4) **The financing conditions adopted in the model were: rate of 18.72% per year, down payment of 20% and repayment period of five years (no grace period), defined based on the conditions offered by some dedicated banking products when the financial modeling was carried out in November 2017.**[44]

For each financing model and in each of the states, the payback period, which is the period of time in which the proponent of the photovoltaic project recovers the investment made with the installation of the project, was calculated.[45]

[42] In general, the inverter must be replaced by a new one in the 13th year of the system.

[43] In addition to maintenance costs, the costs of the Mini power plant also included land leasing, plant management, communication lines, telesecurity, operation and maintenance, civil liability insurance, cleaning of the modules, and water for cleaning.

[44] However, depending on the size and scale of the customer, financing conditions can vary significantly.

[45] The recovery of the investment is calculated from the comparison with the avoided cost with electric power (total annual consumption multiplied by the tariff of the utility company). The investment is calculated by multiplying the total capacity of the installed modules by the implementation cost per Watt. From this value, the availability rate that users pay the utility company, the maintenance cost of the equipment and possible electric power costs (which were made necessary because the maximum productivity index due to the degree of solar irradiation and the performance index of the equipment compromised the use of the maximum power of the equipment) are added.

For calculating the investment with the project installation, the following values of installation costs (1a) and installed capacity (1b) were used:

Table 1. Installation cost (net present value) without bank financing

Model	Installed capacity (kWp)	Assumed installation cost	São Paulo (R$)	Goiás (R$)	Minas Gerais (R$)	Paraíba (R$)
Individual – Direct Consumption	4.6	SP: R$ 5.05/Watt GO: R$ 5.31/Watt MG: R$ 5.2/Watt PB: R$ 5.31/Watt	23,347	24,534	24,033	24,534
Legal Entity – Direct Consumption	82.5	SP: R$ 4.91/Watt GO: R$ 5.15/Watt MG: R$ 5.05/Watt PB: R$ 5.15/Watt	404,813	425,000	416,500	425,000
Legal Entity – Mini Power Plant	5,000	SP: R$ 4.21/Watt GO: R$ 4.3/Watt MG: R$ 4.28/Watt PB: R$ 4.3/Watt	21,048,500	21,500,000	21,403,250	21,500,000

Source: IDB project data

For the calculation of avoided costs with electricity, the tariffs of the following utility companies (2) were used:

Table 2. Electricity tariffs

State	Utility company	Initial rate (R$/kWh)	ICMS	PIS/PASEP	Cofins	Final rate (R$/kWh)
São Paulo	Eletropaulo	0.42	25%	0.70%	3.22%	0.59
Goiás	Celg-D	0.42	29%	0.91%	4.19%	0.64
Minas Gerais	Cemig-D	0.494	30%	1.12%	5.17%	0.78
Paraíba	EBO	0.427	27%	0.91%	4.19%	0.63

Source: (Aneel, 2017b)

The table below shows the project payback for each of the three financing models, and in each of the surveyed states. The state of Minas Gerais presented the shortest payback period due to the high electricity tariff, which is the highest of the four states, and the high degree of solar irradiation (which positively impacts the productivity of the photovoltaic system).

Table 3. Project's payback period without bank financing (in years)

Model	Minas Gerais	Goiás	São Paulo	Paraíba
Individual – Direct Consumption	4	5	5	5
Legal Entity – Direct Consumption	4	5	5	5
Legal Entity – Mini Power Plant	4	5	6	6

Source: FGVces

On the other hand, the state of Paraíba presented a longer payback period, due to the lower geographical proximity to the equipment installation site/point of import (which negatively impacts the installation costs) and the shortage of skilled labor (which increases the installation risk), although the state presents a high degree of solar irradiation. São Paulo also has long payback period, due to low electricity tariffs and a lower degree of solar irradiation (which reduces the installation's productivity).

When the proponent of the photovoltaic project has access to bank financing (under the conditions described in Assumption 4), there is an increase in the payback period of one to two years, as shown in the table below:

Table 4. Project's payback period with bank financing (in years)

Model	Minas Gerais	Goiás	São Paulo	Paraíba
Individual – Direct Consumption	5	6	7	7
Legal Entity – Direct Consumption	5	6	7	6
Legal Entity – Mini Power Plant	6	7	8	8

Source: FGVces

Access to financing also promotes an increase in the cost of installation (brought to present value):

Table 5. Installation cost (net present value) with bank financing

Model	Installed capacity (kWp)	Assumed installation cost	São Paulo (R$)	Goiás (R$)	Minas Gerais (R$)	Paraíba (R$)
Individual – Direct Consumption	4.6	SP: R$ 5.05/Watt GO: R$ 5.31/Watt MG: R$ 5.2/Watt PB: R$ 5.31/Watt	36,851	38,724	37,933	38,724
Legal Entity – Direct Consumption	82.5	SP: R$ 4.91/Watt GO: R$ 5.15/Watt MG: R$ 5.05/Watt PB: R$ 5.15/Watt	638,948	670,812	657,395	670,812
Legal Entity – Mini Power Plant	5,000	SP: R$ 4.21/Watt GO: R$ 4.3/Watt MG: R$ 4.28/Watt PB: R$ 4.3/Watt	33,222,542	33,935,181	33,782,473	33,935,181

Source: IDB project data

Sensitivity analysis

In order to identify the critical factors affecting the payback period of photovoltaic projects, a sensitivity analysis was performed (results in Appendix IV) by varying the following variables:

- ✓ Electricity tariff of the utility company (20% below and 20% above the base case)
- ✓ Total cost of installation (20% below and 20% above the base case)
- ✓ System's performance index (10% and 30% below the base case)
- ✓ Repayment period (10 years above base case)
- ✓ Annual interest rate (7% below the base case)

The percentages of variation were defined by the members of FEBRABAN Solar Energy Working Group, who considered these variations as critical cases.

The results of the analysis demonstrated that:

- ✓ A 20% reduction in the utility company's tariff would promote an increase in the payback period of one to two years.
- ✓ A 20% increase in installation cost would generate an increase in the payback period of one to two years.
- ✓ A 30% reduction in the system's performance index would increase the payback period by one year.
- ✓ Regarding the financing conditions, an increase in the repayment period of 10 years (totaling 15 years) would have a greater impact on the project payback period (reduction of three to seven years), than a reduction of 7% in the financing's annual interest rate (reduction of one year).

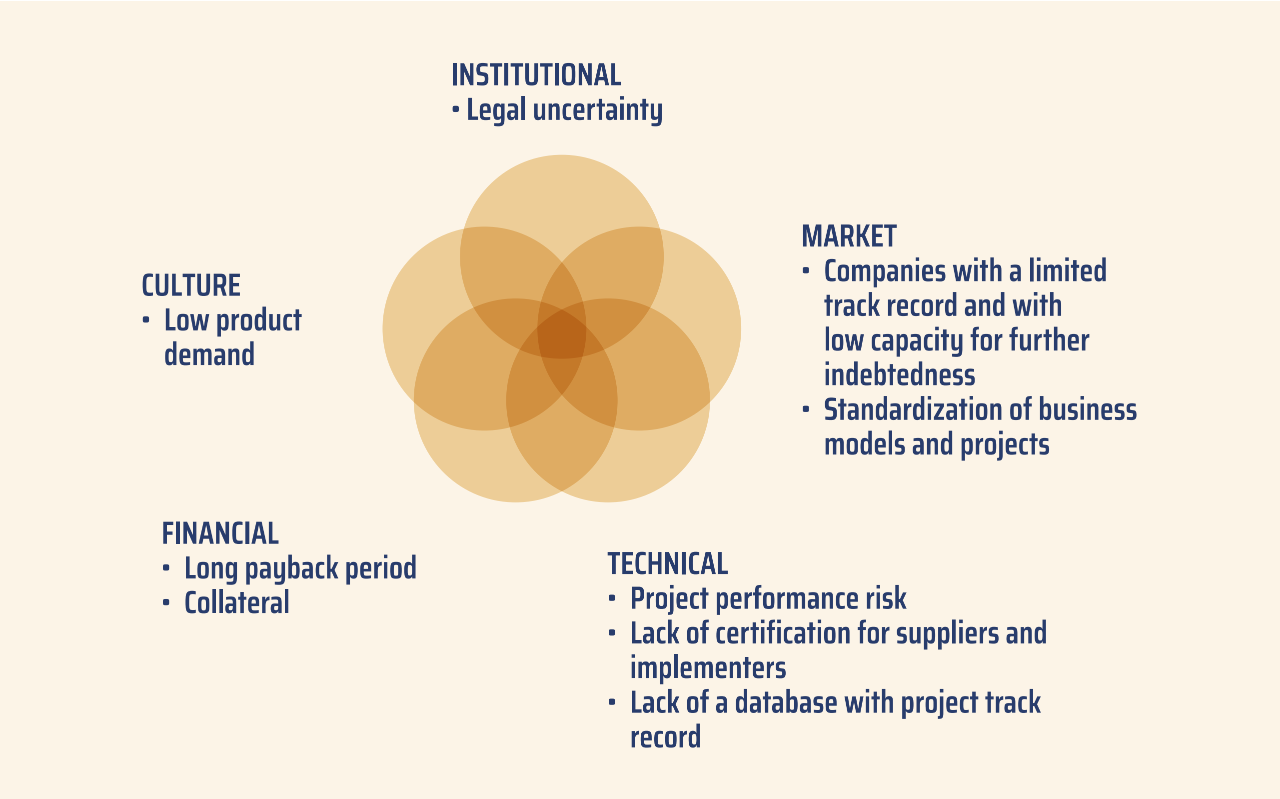
Based on the results of the sensitivity analysis, the following considerations were made:

- ✓ Since the performance index of the equipment has an impact on the project payback period, proper installation of the equipment and the employment of implementing companies with a strong track record would contribute to achieving the expected financial results.
- ✓ It is expected that technological development will promote a greater reduction in installation costs, with consequent reduction of the payback period.
- ✓ Projects with a repayment period of over five years do not fit the business models of financial institutions, because they are not projects that fit the infrastructure profile.

Challenges related to the financing of each model

In discussions with companies in the industry and financial institutions, several challenges have been identified that inhibit a greater supply of credit products by financial institutions to finance photovoltaic projects. In general, the financial challenges originate from institutional, technical, market, cultural, and financial aspects, which are summarized in the figure below.

Figure 15. Barriers to the advancement of financing to the solar photovoltaic sector



Source: FGVces

Regarding **institutional issues**, the delay in the implementation of state and local programs to encourage solar power generation, as well as uncertainties regarding possible changes in legislation, create an environment of legal uncertainty and jeopardize the interest of financial institutions in financing solar photovoltaic systems. For example, the implementation of the binomial tariff, under discussion by Aneel, could increase the payback period of the projects.[46] ABSOLAR has played an important role in articulating with Aneel to ensure that new resolutions are not detrimental to the development of the sector, guaranteeing an institutional environment with legal certainty for the industry.

[46] The possibility of adopting the binomial tariff is being discussed in the revision process of Resolution 482/2012.

On **the technical side**, the lack of a database with the track record of photovoltaic project implementers, as well as the lack of a certification standard for equipment suppliers and photovoltaic project implementers, compromises the ability of financial institutions to assess the project's risk of performance and, consequently, to assess the customer's risk of default. To address this issue, FEBRABAN, IDB and ABNT have joined efforts to develop a methodology for the certification of implementers and for the analysis of photovoltaic projects, as shown in the last sections of this report.

Similarly, in relation to **market issues**, since photovoltaic project implementers have a limited track record and a low capacity to increase their indebtedness, the banks' perception is that the implementers' risk of default is high. Alternatively, financing can be provided directly to the final beneficiary of the project, i.e. the individual or legal entity that hires the implementers. In addition, the fact that only the credit risk of the borrowing customers (whether or not they are the implementers) is analyzed by the financial institutions for granting financing, not including the project risk, also compromises the risk perception of the project. To address this issue, an integrated risk analysis model was developed (which considers both project risk and customer risk), as will be presented in the next section of the report. Considering the final customer of the solar photovoltaic solution as a borrower, in turn, can contribute to the expansion of the market and to the possibilities of financing and may dilute the risk of a financing portfolio of solar photovoltaic power projects.

In terms of **cultural issues**, there is still a low demand of the Brazilian population for the installation of photovoltaic projects, reflected in the low demand for this type of financing. On the other hand, demand is expected to increase in the short term due to the market potential and, among other factors, to the high degree of solar incidence in the country, electricity tariffs, increased knowledge of the advantages of solar photovoltaic power, the wide possibility of its use in rural areas where the cost of power transmission is high, and the need to comply with Brazilian NDCs.

Lastly, with regards to the **financial aspects**, the long payback period of photovoltaic projects, as demonstrated in the analysis of financial feasibility, reduces the interest of financial institutions in financing them, since repayment periods of over five years do not fit into their current business models. In addition, it is necessary to extend the types of collateral beyond the equipment, since their seizure in case of default of the customer is hampered by property rights, and there is no secondary market for it. On the other hand, the great potential of the Brazilian photovoltaic sector is attractive to the financial institutions.

Regarding the specific challenges of each financing model, respondents (financial institutions and companies in the photovoltaic sector) mentioned:

Table 6. Challenges related to the financing of each model

Challenges	Individual – Direct Consumption	Individual – Remote Self-Consumption	Individual – Shared Generation	Legal Entity – Direct Consumption	Legal Entity – Remote Self-Consumption	Legal Entity – Shared Generation	Legal Entity – Mini Power Plant
The system's risk of performance may generate a risk of customer default	x	x	x	x	x	x	x
Seizure of the collateral (equipment) is difficult	x	x	x	x	x		
Additional risk arising from the cooperative members in case they default			x			x	
Credit analysis based only on the customer risk, not considering the project risk	x	x	x	x	x	x	x

Financial institution does not have a specific product for the category			x	x
Capacity of indebtedness of the implementer does not accommodate the size of the operation			x	x
Collateral cannot be only the receivable and/ or equipment. Need for additional collateral			x	x

Source: FGVces

- **System's performance risk:** For all models, the risk that the equipment is not installed correctly has been mentioned, which may cause the equipment to fail to reach its maximum capacity, causing customer default. In order to reduce this type of risk, the respondents commented that a certification for photovoltaic project implementers should be created, attesting to their ability to perform the services. As mentioned above, ABNT is working on the development of a certification aimed at equipment producers and implementers of photovoltaic projects.

- **Difficulty to seize the collateral (equipment):** The respondents mentioned the difficulty to seize the collateral in case of default when the collateral is the equipment. As already mentioned, there is a legal barrier to accessing customer property and removing equipment. In addition, there is still no secondary market for the purchase and sale of photovoltaic equipment, compromising the value of the collateral for the financial institution. The solution would be to develop other collateral mechanisms, as will later be presented in this study.

- **Credit analysis based on customer risk only:** For all models, the respondents commented on the fact that credit analysis is based solely on the customer risk, not considering the project risk, compromising the ability of proponents of photovoltaic projects to access financing. This is because photovoltaic project implementers do not have a strong track record, (the industry is recent) and tend to be heavily indebted, compromising their credit rating. As previously mentioned, the financing proponent can, and sometimes, should be the parties that benefit from the installation of the project, be it individual or a legal entity, customers of financial institutions. Considering new financing proponents of solar photovoltaic projects means broadening the market and diluting the risk of a financing portfolio of solar photovoltaic solar power projects. In addition, including the risk of the photovoltaic project in the credit analysis could reduce the operation's risk perception as a whole and facilitate access to financing, as will be demonstrated later.

- **Financial institutions do not have specific products:** According to the survey of financial products carried out by this study, financial institutions do not yet have specific products to finance the Legal Entity – Shared Generation and the Legal Entity – Mini Power Plant models. However, the refinement of the risk analysis (consideration of project risk and customer risk) can facilitate access to financing by these modalities.

- **Need for additional collateral:** It is necessary to offer additional collateral (in addition to the equipment and credit rights received from its customers) to the financial institution, such as a property, or performance bonds, insurance, among other collateral, to facilitate credit access.

Part V. Evaluation of a proposed risk analysis model for the financing of photovoltaic projects

Considering that one of the barriers pointed out in the previous section for the financing of photovoltaic projects is the fact that the project risk analysis is based only on the customer's credit risk[47], an integrated risk analysis model was proposed in this study. The financial institutions can adopt this in order to evaluate project financing, especially for small and medium-sized Legal Entities. By integrating the **credit risk of the customer** to be financed to the **project risk** in the analysis, the bank can examine the operation risk as a whole.

According to this proposal, the **project risk** rating is composed of a score derived from the project payback period and a score derived from the technical and financial collateral offered to the financial institution.

✓ The project risk score is inversely proportional to the payback period. Therefore, the longer the project payback period, the greater the project risk and, therefore, the lower the project rating.

✓ The technical and financial collateral have a higher or lower score, depending on their value to the financial institution. For example, because the equipment is difficult to seize, this type of collateral would add a lower score to the project rating. A property as collateral would have a higher score because of its greater liquidity.

The following is a brief description of each of the technical and financial collateral used in the model to evaluate the project risk, noting that some of these technical collaterals are still under development in Brazil.

[47] either the implementer or the buyer of the project – individual or legal entity

Table 7. Types of technical and financial collateral that compose the project risk analysis

Technical collateral	Description
Performance Insurance	The financial institution's customer can purchase an insurance that ensures that, if the equipment does not operate properly due to issues related to the operation, maintenance and/or implementation and the projected amount of photovoltaic power is not generated, the customer will be financially compensated for the additional expenses with electric power.
Climate performance insurance	The financial institution's customer can purchase an insurance that ensures that if the projected amount of photovoltaic power is not generated due to climate change, the customer will be financially compensated for the additional expenses with electric power.
Operation & Maintenance (O&M) Insurance	The financial institution's customer can purchase an insurance that ensures that if the projected amount of photovoltaic power is not generated due to issues related to equipment operation and maintenance, the customer will be financially compensated for the additional expenses with electric power.
Implementation insurance: engineering	The financial institution's customer can purchase an insurance that ensures that if the equipment is not installed correctly and the projected amount of photovoltaic power is not generated, the customer will be financially compensated for the additional expenses with electric power.
Software for monitoring system performance	Installation of a software by the customer that monitors system performance.
Collateral – Equipment	The customer can offer the photovoltaic system as collateral to the financial institution.
On-site audit of the implementer	The financial institution or the implementing company may choose to hire auditing services to verify the technical capacity of the implementer and the quality of the project installation.
List with pre-qualification criteria for suppliers and implementers	FEBRABAN and ABNT have developed a list with criteria that attest to the technical capacity of equipment suppliers and photovoltaic project implementers. The customer can provide evidence to the financial institution that the implementer meets these criteria.
Financial collateral	**Description**
Physical collateral – real estate	The customer can offer one of its properties as collateral to the financial institution.
Collateral – receivables	In the Individual and Legal Entity – Shared Generation models, the consortium may offer to the financial institution the receivables from agreements with consortium customers as collateral.
Cash collateral or shares of the company, in case of Legal Entity	In the Individual and Legal Entity – Shared Generation models, the consortium may offer to the financial institution the financial amount that customers have already paid as down payment to the consortium as collateral. Legal Entity customers can also offer company shares as collateral.

Below is an illustrative example of a photovoltaic project risk analysis model. It is worth noting that the project risk score, composed of payback period and technical and financial collateral, is at the discretion of the financial institution that is evaluating the credit grant.

Figure 16. Example of a photovoltaic project risk analysis model

Project risk = Payback Period + (Technical Collateral + Financial Collateral)

Project's potential risk	Score[3]
AAA	10
AA	9
A	8
BBB	7
BB	6
B	5

=

Payback period (years)	Score[3]
1-2	10
3	9
4	8
5	7
6	6
7	5
8	4
9	3
10	2

+

Technical Collateral [3]	Potential to improve risk perception
Performance insurance[1]	2
Climate performance insurance	2
O&M insurance	1
Implementation insurance: engineering	1
Software to measure system performance	0,5
Collateral: equipment seizure	0,2
On-site audit of the implementer	0,3
List of pre-qualification criteria for suppliers and implementers[2]	0,2

Financial Collateral[3]	Potential to improve risk perception
Physical collateral: property	2
Collateral: receivables	1
Cash collateral or company shares if it is a Legal Entity	1

(1) BID is articulating with Insurers

(2) FEBRABAN and ABNT, with the support of the members of the Working Group, composed a list of requirements for suppliers and implementers that will become an ABNT certification in the future

(3) Score for each risk level, payback period and collateral is defined by the bank.

Source: FGVces

Using this illustrative model of risk analysis, the project of a customer with a 6-year payback period offering a property as financial collateral and a performance insurance as technical collateral will have an AAA project risk rating (6 + 2 + 2 = 10).

Figure 17. Calculation of the operation's risk assessment in the illustrative model

Project risk: defined by a combination of the payback period, and technical and financial collateral
Customer risk: defined by traditional analysis

Payback period (years)	Initial score (BB)
6	6

\+

Technical Collateral	Rating improvement
Performance insurance	2

\+

Financial Collateral	Rating improvement
Property	2

=

Project's potential risk	Final score
AAA	10

Customer risk	Score
AAA	10
AA	9
A	8
BBB	7
BB	6
B	5

Weight[1]: 80%

\+

Project risk	Score
AAA	10
AA	9
A	8
BBB	7
BB	6
B	5

Weight[1]: 20%

=

Risk perception of the operation	7,6

Rating based on combined customer risk and project risk which, in this case, reduced the operation's risk perception.

Source: FGVces

It is also at the discretion of the financial institution that evaluates the financing what weight will be attributed to the project risk analysis, and what weight will be assigned to the customer's risk analysis. In this illustrative model, it was considered that the financial institution attributed 20% to project risk and 80% to customer risk (the institution could, for example, have assigned 30% and 70%, respectively). Thus, a customer with a BBB risk rating that presented a project with AAA rating, had a BBB credit rating (10*20% + 7*80% = 7.6). Therefore, a customer with a regular rating who presents a project with a good rating will have a higher rating, providing better credit conditions.

It is important to emphasize that, once again, the model allows the bank to define the weights and scoring of each component of the analysis at its own discretion, considering its risk appetite, the value of the collateral and other criteria from its risk analysis process. The novelty of the model is to incorporate the project risk to the analysis, taking the technical quality of the project, the competence of the implementer, and the fulfillment of requirements standardized by the market into consideration, in addition to the credit risk profile of the borrowing customer.

Figure 18. Calculation of the project financing risk assessment in the illustrative model

Percentage of project risk in the final risk analysis
20% Project with AAA risk

Percentage of customer risk in the final risk analysis
80% Customer with BBB risk

Risk perception	Final score
AAA	10
AA	9
A	8
BBB	7
BB	6
B	5

Final risk perception	7,6

Final Risk (rating) based on combined customer risk and project risk

Source: FGVces

Evaluation of the integrated risk analysis model for photovoltaic projects

FEBRABAN and IDB have implemented an initiative to encourage financial institutions to review the proposed risk analysis model.

Eight financial institutions analysed the risk model. In general, the banks consulted consider the model feasible for credit risk analysis, especially for projects with a ticket starting at R$ 1 million, since projects with lower tickets would have a higher transaction cost. They also state that the adoption of the model could increase the number of operations and that its application changes the paradigm of credit risk analysis of operations (from borrower to operation), reduces the need for real collateral (by diversifying the collateral options) and assists entrepreneurs to the extent that project attributes are incorporated into the risk analysis of the operation. To make the effective adoption of the model possible, the financial institutions consulted consider that there is a need to calibrate it according to the risk and credit policies of each one. Among the necessary calibrations, there is a need to measure the weights assigned to corporate risk assessment and to project risk assessment, an activity to be carried out jointly by the departments of the bank that serve the customer, such as the relationship management officer, the credit department and the project finance team. Institutions also believe that the weight attributed to the technical collateral related to supplier assessment should be high because their capacity influences the performance of the system. In addition, they note that the model must be institutionalized, by including it in the financial institutions' policies. Of the eight financial institutions that evaluated the model, three of them showed interest in testing the tool.

Finally, the financial institutions consider that there are opportunities to develop new products due to the wide variety of profiles of solar photovoltaic projects. Additionally, they believe that they should invest in a credit risk analysis framework for these projects and that the technological complexity requires the training of the agents of the financial institutions responsible for their analysis.

Part VI. Reflections and recommendations

FEBRABAN believes that the financial sector could play a more active role in finding solutions for the risk analysis of photovoltaic projects and for the limited track record of the sector. Therefore, this section offers a set of recommendations to financial institutions and to FEBRABAN.

For financial institutions, it is recommended:

To analyze the risks of the solar photovoltaic power project together with the customer's credit risk:

As discussed in the previous section, financial institutions that evaluated the risk analysis model proposed by this study stated that the tool is feasible for operations' credit risk analysis and contributes to change the paradigm of operations' risk and credit analysis. Thus, it is recommended that financial institutions interested in financing distributed solar photovoltaic solar generation power projects in the Legal Entity Medium-Sized and Mini Power Plant modalities adopt the proposed risk model.

To consider the certifications of the implementers of photovoltaic systems:

As the photovoltaic sector is recent and project implementing companies have a short track record, it is important to consider the certifications of these companies, so that financial institutions can have more assurance when financing the projects. The National Service of Industrial Learning (SENAI) certifies professional installers, but there is still a need to create certifications for implementing companies and systems.

In 2018, FEBRABAN and ABNT jointly developed a list of requirements that will serve as a basis for ABNT certification. The criteria are as follows:

Table 8. Criteria for certification of suppliers and implementers of photovoltaic projects

Legal constitution of the company
Copy of the constituent act as a legal entity
Federal taxpayer registration and latest income tax return (previous fiscal year)
Proof of address for tax purposes
Registration Certificate of the professional technician in the Regional Council of Engineering and Agronomy (CREA)
Technical Term of Responsibility (ART) of the technical professional.
Company's financial strength
Capitalization: Proof of own resources to meet project needs with a ratio of capital to project superior to two
Liquidity: Proof of cash flow's capacity to deal with a net collateral immediately
Solvency: Proof of profit in at least one fiscal year, with the latest financial year being profitable
Financing track record for specific solar photovoltaic projects, with start and end dates, information about the agreement and value
Technical experience and infrastructure
Company's curriculum showing its previous experience, including national and global operations
List of at least the latest 5* specific solar photovoltaic projects, with start and end dates, information about the agreement and value
List of ongoing projects and value of the agreements
List of projects' actual performance in relation to the estimated performance
Proof of availability of performance insurance for the project
Proof of personalized service after project installation
Form for recording claims, complaints or failures by users
Product certificates in compliance with Brazilian official standards, Brazilian technical standards, international standards or opinions on the materials and equipment used in the systems (when applicable)

* It can be the previous experience of the technical professional

Source: FEBRABAN and ABNT (2018)

While certifications for implementing companies are under development, financial institutions can verify whether companies have certified professionals, as well as use the above criteria to better select implementing companies, including hiring auditing services (i.e. ABNT, which is developing its own certification and audit process) to assess the technical qualification of the implementers according to these criteria.

To train bank staff to foster financing for new business models:

It is recommended that banks train their teams, in order to encourage the financing of new business models.

Finally, it is recommended that FEBRABAN continue to follow up and articulate the issue with the government, the productive sector and specialists, giving continuity to the recommendations proposed here. Therefore, it is suggested that FEBRABAN:

a) **Follows the development of ABNT's process to create certification for implementers and photovoltaic projects:** It is suggested that FEBRABAN monitor the process, since the certification will bring greater assurance to the project.
b) **Articulate with government:** It is suggested that FEBRABAN present the results of the study and engage with government agencies related to the subject, following possible changes in legislation in the sector and demonstrating the need for greater legal certainty for the industry's development.
c) **Participate in the public consultation for revision of ANEEL Normative Resolution 482/2012:** It is recommended that FEBRABAN propose increased flexibility in the constitution of collateral in the form of credit rights. Thus, in the event of default, the financial institution could benefit from the electricity produced by the customer's photovoltaic system.

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IEA. (2016). Energy Policies of IEA Countries - Japan 2016 Review. Retrieved from https://www.iea.org/publications/freepublications/publication/EnergyPoliciesofIEACountriesJapan2016.pdf

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Appendix I. Financial products for solar photovoltaic distributed generation equipment

Financial institution	Products	Product description
Bradesco	Environmental Leasing	Description: Bradesco Leasing purchases the equipment that the customer chooses (photovoltaic modules are eligible) and makes it available for use by means of a lease agreement. At the end of the agreement's term the customer can choose to keep the equipment, return it, or renew the agreement. Amount financed: NA Repayment period: 36 to 60 months Minimum down payment: 30% Interest rate: NA Audience: available to account holders with a minimum age of 18 years old and to Bradesco Empresas e Negócios (Bradesco Companies and Businesses) account holders Collateral: • Individual: "aval" guarantee and others • Legal Entity: promissory note, "aval" guarantee and others[1]
Santander	CDC Equipment Energy Efficiency	Description: the bank finances the purchase of equipment and services that use renewable energy, such as solar photovoltaic power generation equipment. Amount financed: R$ 2,500.00 to R$ 500,000.00, after analysis and approval of the loan. Repayment period: up to 5 years Minimum down payment: NA Interest rate: varies according to the values, repayment period and other conditions chosen by the customer at the time of purchase Audience: • Account holders and non account holders, either individuals or legal entities, may pay in installments for the installation of solar panels to generate power, among other solutions. • It is not necessary to be a Santander account holder. Collateral: the financed goods[2]

[1] Available at: https://banco.bradesco/html/classic/produtos-servicos/emprestimo-e-financiamento/leasing/leasing-ambiental.shtm. Accessed on 04/20/2018. Available at: https://banco.bradesco/html/pessoajuridica/solucoes-integradas/emprestimo-e-financiamento/leasing-ambiental.shtm. Accessed on 04/20/2018.

[2] Available at: https://sustentabilidade.santander.com.br/pt/Produtos-e-Servicos/Paginas/Santander-Financiamentos.aspx. Accessed on 04/20/2018.

Financial institution	Products	Product description
Caixa	Construcard	Description: credit line to buy building materials at Caixa-accredited stores. When the financing is approved, the customer receives a card and has up to six months to buy everything they need. The customer can buy solar heaters and photovoltaic power equipment. Amount financed: NA Repayment period: flexible terms of up to 240 months for customers that present a property as collateral. Minimum down payment: NA Interest rate: NA Audience: • Over 18 years old or emancipated • Account holder at Caixa • Be approved in the registration and credit risk assessments Collateral: “aval” guarantee, movable property, deposit/financial asset or immovable property.[3]
SICREDI	Solar Power Financing	Description: the bank finances various equipment needed to install solar power technology for electrical power generation, such as assembly systems, inverters and solar panels. Amount financed: NA Repayment period: up to 120 months Minimum down payment: NA Interest rate: NA Audience: individuals and companies associated with Sicredi willing to acquire equipment and technology for solar power generation in their residences. Collateral: NA[4]
Banco Votorantim (Votorantim Bank)	BV Solar Power Financing	Description: credit line for those interested in installing solar photovoltaic panels in their residence to generate their own electric power and reduce the electricity bill. Amount financed: from R$ 5,000 Repayment period: 12 to 60 months (up to 30 days to pay the 1st installment) Minimum down payment: 100% equipment financing Interest rate: pre-fixed rate from 1.48% per month Audience: the financing can be granted to anyone over the age of 18 years old who has approved credit and seeks financing to a solar system project for their own residence. Monthly income that can be committed with the payment of installments: Up to 30% of gross income. Composition of income with the spouse is allowed.[5]

3 Available at: http://www.caixa.gov.br/voce/cartoes/casa/construcard/Paginas/default.aspx?pk_campaign=credito-pf-2016-08&pk_kwd=cross-construcard-landing-credito. Accessed on 04/20/2018.

4 Available at: https://www.sicredi.com.br/html/para-voce/credito/credito-energia-solar/. Accessed on 04/20/2018.
Available at: https://www.sicredi.com.br/html/para-sua-empresa/credito/credito-energia-solar/. Accessed on 04/20/2018.

5 Available at: https://www.bv.com.br/site/saiba-mais/condicoes-gerais-financiamento-para-energia-solar/. Accessed on 04/20/2018.
Available at: https://www.bv.com.br/site/financiamento/financiamento-solar/. Accessed on 04/20/2018.

Financial institution	Products	Product description
Banco do Nordeste do Brasil (Brazilian Northeast Bank)	CDC Renewable Energies	Description: acquisition of distributed microgeneration and minigeneration systems based on renewable sources, including the required structure for the generation of power and installation of solar panels, encouraging the preservation of the environment. Amount financed: NA Repayment period: up to 72 months, with a grace period of up to 6 months. Minimum down payment: financing of up to 100% of the value of the goods, plus cost of transportation and installation services. Interest rate: NA Audience: • To be an account holder at BNB. • To have available credit limit. Collateral: the power generation system[6]
Banco do Nordeste do Brasil (Brazilian Northeast Bank)	FNE Sun	Description: credit line specially designed for the financing of distributed microgeneration and minigeneration systems based on renewable sources, for self-consumption. The Program finances all components of the electric power microgeneration and minigeneration systems based on photovoltaic, wind, biomass, or small hydroelectric power plants (SHP) technology, as well as their installation. Amount financed: up to 100% of the investment, depending on the customer's size, location and collateral. Repayment period: up to 12 years, with a grace period of 6 months to 1 year. Minimum down payment: up to 100% financing of the investment, depending on the customer's size, location and collateral. Interest rate: varies according to size Audience: all sizes of industrial, agroindustrial, commercial and service companies, rural producers and rural companies, cooperatives and legally constituted associations. Collateral: the collateral will be, cumulatively or alternatively: a) mortgage; b) fiduciary alienation; c) bond or "aval" guarantee. Source of Funds: Constitutional Fund for the Financing of the Northeast – FNE.[7]

[6] Available at: https://www.bnb.gov.br/credito/cdc-energias-renovaveis. Accessed on 04/20/2018.

[7] Available at: https://www.bnb.gov.br/programas_fne/programa-de-financiamento-a-micro-e-a-minigeracao-distribuida-de-energia-eletrica-fne-sol. Accessed on 04/20/2018.

Financial institution	Products	Product description
BNDES (the Brazilian Development Bank)	PRONAF – ECO Climate Fund Program (Efficient Machines and Equipment subprogram)	**PRONAF – ECO:** **Description:** To install, use and/or recover: Renewable energy technologies such as the use of solar power, biomass, wind power, biofuel mini power plants and the replacement of fossil fuel by renewable technology in agricultural equipment and machinery; **Amount financed:** differentiated according to the purpose of the credit, and can reach up to R$ 165,000.00 per crop year. **Repayment period:** up to 10 years, including a grace period of up to 3 years, depending on the purpose of the credit. **Minimum down payment:** NA **Interest rate:** effective interest rate of 2.5% p.a. **Public:** family farmers in PRONAF. **Collateral:** NA[8] **Climate Fund Program:** **Description:** financing for the installation of solar heating systems and cogeneration systems (photovoltaic panels, wind turbines, biogas generators and necessary equipment). **Amount financed:** the limits of the Climate Fund reach 80% of the financeable items, up to R$ 30 million every 12 months per beneficiary. For acquisition of machinery and equipment associated with investment projects, the minimum value of the project financing should be R$ 10 million. **Repayment period:** the program allows a grace period of 3 to 24 months, with a maximum term of 144 months. **Minimum down payment:** the limits of the Climate Fund reach 80% of the eligible items. **Interest rate:** in indirect operations, the interest rate is composed of the financial cost, the BNDES rate and the financial agent fee. In direct operations, the interest rate is composed of the financial cost, the BNDES remuneration and the credit risk rate. For annual income up to R$ 90 million, the cost is 0.1% per year, and BNDES remuneration is 0.9% per year. For annual income over R$ 90 million, the cost is 0.1% per year, and BNDES remuneration is 1.4% per year. The remuneration of financial agents is limited to 3% per year. Once the maximum remuneration defined by the public banks is applied, the final rates are as follows: for annual income up to R$ 90 million, the final cost is 4.03% per year; for annual income above R$ 90 million, the final cost is 4.55% per year. **Audience:** for both individuals and legal entities (companies, city councils, state governments and rural producers). **Collateral:** • For direct support: defined in the analysis of the operation. • For indirect support: negotiated between the accredited financial institution and the customer.[9]

[8] Available at: http://www.bancoamazonia.com.br/index.php/financiamentos1/eco. Accessed on 04/20/2018.

[9] Available at: https://www.bndes.gov.br/wps/portal/site/home/imprensa/noticias/conteudo/bndes-muda-regra-e-pessoas-fisicas-podem-investir-em- energia-solar. Accessed on 06/11/2018.
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Financial institution	Products	Product description
CredCREA	Sustainable Credit	Description: financing to invest in sustainable equipment, such as: • Solar power panels; • LED lamps, for power saving; • Wind power generators, microgenerators and minigenerators; • Solar heating panel kits, among others.[10] Amount financed: NA Repayment period: NA Minimum down payment: NA Interest rate: NA Audience: NA Collateral: NA
Desenvolve SP – Agência de Desenvolvimento Paulista (São Paulo State Development Agency)	Green Economy Line	Description: financing of equipment purchase and installation for the production of renewable energy – solar panels, wind turbines, biomass-fired boilers, equipment for small hydropower plants, landfill biogas, and others. Amount financed: NA Repayment period: up to 120 months, including grace period (up to 24 months) Minimum down payment: up to 80% of the value of the financeable items Interest rate: from 0.53% per month, adjusted by the IPCA rate Audience: NA Collateral: Desenvolve SP operates four Collateral Funds[11]
Banco Regional de Desenvolvimento do Extremo Sul – BRDE (Regional Development Bank of the South)	BRDE Energy Program	Description: the program supports investments in clean and renewable energy generation, to increase the use of alternative power sources such as wind, solar, biomass, and distributed microgeneration.[12] Amount financed: NA Repayment period: NA Minimum down payment: NA Interest rate: NA Audience: NA Collateral: NA

[10] Available at: https://www.credcrea.coop.br/para-voce/credito#!#emprestimos-e-financiamentos Accessed on 04/20/2018.
[11] Available at: http://www.desenvolvesp.com.br/empresas/opcoes-de-credito/projetos-sustentaveis/linha-economia-verde/ Accessed on 04/20/2018.
Available at: http://www.desenvolvesp.com.br/empresas/guia-do-financiamento/garantias/. Accessed on 04/20/2018.
[12] Available at: http://www.brde.com.br/infraestrutura/energia-eletrica/ Accessed on 04/20/2018.

Financial institution	Products	Product description
Agência de Fomento do Estado de Santa Catarina – BADESC (Santa Catarina State Development Agency)	BADESC Energy	Description: the agency aims to support projects to replace commercial electrical power by private photovoltaic power generation units in the industrial, commercial and service sectors, aimed at different company sizes and private sector institutions. Amount financed: admits the financial granting of a minimum amount of R$ 250,000.00 up to R$ 2,000,000.00 and serves up to 100% of the items, going beyond the equipment and covering: migration fees, ART of CREA and installation services. It also allows to purchase imported components. Repayment period: the grace period and the total financing term will be defined according to the company's ability to pay, observing the following maximum limits: • Grace period: up to 12 months with payment of monthly interest only; • Total repayment period (grace period and amortization): up to 96 months. The payments will be monthly, including during the grace period, when the interest for the period will be due. Minimum down payment: Badesc's participation in the projects is up to 100%, thus the total investment in the implementation of a private photovoltaic power generation plant can be financed. Interest rate: the final interest rate of the operation may be changed by reducing factors according to credit analysis Audience: different company sizes and private sector institutions Collateral: NA[13]
Agência de Fomento do Estado de Pernambuco – AGEFEPE (Pernambuco State Development Agency)	PE Solar	Description: finances the replacement of power sources by alternative ones with environmental gains (e.g. photovoltaic panels). Amount financed: up to R$ 300,000.00 Repayment period: up to 96 months (including grace period – 6 months) Minimum down payment: NA Interest rate: 11.18% per year (with a 15% bonus for installments' timely payments) Audience: cooperatives or associations with a R$ 16,000,000.00 revenue per year. • Industrial, Agroindustrial and Commercial Companies • Service Companies • Rural Producers, associated to their Cooperatives or Associations • Cooperatives of rural producers and associations[1] [1] Credit granted directly to the member of the cooperative or to the cooperative Collateral: • "Aval" guarantee from owner or partners. • Third Party "aval" guarantee (trusted person with sufficient income to honor the debt). • The financed good. Note: other collateral may be requested at the discretion of the analysis. • Other real collateral accepted by financial institutions.[14]

[13] Available at: http://www.badesc.gov.br/portal/linha_energia.jsp Accessed on 04/20/2018.
[14] Available at: http://www2.agefepe.pe.gov.br/web/agefepe/pe-solar Accessed on 04/20/2018.

Financial institution	Products	Product description
Banco de Desenvolvimento de Minas Gerais (Minas Gerais State Development Bank)	BDMG Solar Photovoltaic	Description: in December 2017, the Development Bank of Minas Gerais – BDMG, presented its new plan to encourage the adoption of solar photovoltaic power by the productive sector. The program, called BDMG SOLAR PHOTOVOLTAIC, aims to foster the development of photovoltaic power in micro and small companies through a specific credit line and with special conditions for project installation and for the growth of the sector in Minas Gerais.[15] Amount financed: NA Repayment period: NA Minimum down payment: NA Interest rate: NA Audience: NA Collateral: NA
Agência de Fomento de Goiás (Goiás State Development Agency)	Solar Power Productive Credit	Description: purchase of machinery, equipment, installation, associated working capital, and other investments related to solar power generation. Amount financed: up to R$ 50,000 Repayment period: up to 60 months (grace period of up to 6 months) Minimum down payment: NA Interest rate: 0.5% per month Audience: micro-enterprises, small businesses and individual entrepreneurs, for the purchase of solar power generation equipment Collateral: “Aval” guarantee by partners and spouses and/or by a third party; REAL 1. Certificate of registration of the property (Notary’s Office), which must be in full content, include limits and confrontations, mention the inexistence of any charges on it (date of issue less than 30 days); 2. Value of the property – IPTU/ITU/ITR (latest fiscal year), including the market value and/or an evaluation report issued by the City Hall/Evaluation by “Goiás Fomento”/Real Estate Securities Chamber (55 62 3223-8010). Evaluation of three different Real Estate Agents will also be accepted. 3. Negative certificate of municipal debts in the CPF (Individual Taxpayer’s Registry) of the owner of the property.[16]

[15] Available at: http://www.solarvoltenergia.com.br/bdmg-lanca-programa-de-financiamento-para-energia-fotovoltaica/ Accessed on 04/20/2018.
[16] Available at: http://www.fomento.goias.gov.br/linhas-de-credito-detalhes/?idLinha=102 Accessed on 04/20/2018.
Available at: http://www.fomento.goias.gov.br/linhas-de-credito-lista/ Accessed on 04/20/2018.

Financial institution	Products	Product description
Banco do Brasil (Bank of Brazil)	BB Financing Automatic loan Payroll loan Sustainable Goods Consortium BB Credit Company FCO Business Proger Urban Business BNDES Finem	We finance the installation of equipment for energy efficiency (lighting, motors, air conditioning, solar panels, wind power, among others) and water efficiency (water collection, reuse and treatment, water meter, regulators, among others), generating cost reduction and savings. For Individuals: BB Financing: financing of equipment or services directly in the store. You can buy solar modules, LED bulbs, home appliances, water meters, regulators, water reuse systems, building materials, among other items. Automatic loan: acquisition of goods that aim towards the efficient use and reduction of energy and water consumption such as lighting retrofits, more efficient equipment, solar power and rainwater collection and reuse. Payroll loan: a loan to use as you wish, with the best rates and terms, for those who work in a company or agency that is affiliated for consignment of payroll-deductions with Banco do Brasil. Sustainable Goods Consortium: you can buy sustainable goods and services in special and interest-free conditions, such as electric bicycles, water collection and reuse systems, solar lighting, solar thermal systems, and others. For Micro and Small Businesses: BB Credit Company: it finances the acquisition of machinery and equipment that contribute to the rational use of energy and water, building material and vehicles for your company with pre-approved credit. FCO Business: the FCO finances goods and services necessary for the implementation, expansion and modernization of projects focused on energy and water efficiency, except for the non-financeable items as defined in the Fund's regulations. Proger Urban Business: it allows the financing of machinery and equipment that contribute to the rational use of energy and water, solar modules, bank of batteries, meters, water reuse and treatment systems, expenses with project development, provision of management advice and labor for installation, as well as renovation and adaptation in buildings. For Large Enterprises: BNDES Finem: ideal for companies seeking long-term financing for implementation, expansion, recovery or modernization. You can finance machinery and equipment, projects to reduce energy consumption focused on air conditioning, lighting, distributed generation, construction works, assembly and facilities, associated working capital.[17]

[17] Available at: http://www.bb.com.br/pbb/sustentabilidade/negocios-sustentaveis#/ Accessed on 04/20/2018.

Appendix II. State policies to encourage solar photovoltaic power generation

State	Policy/legislation
Goiás	State Policy to Encourage the Use of Solar Power (Law 16,488/2009)[18]: Law 16,488/2009 establishes the State Policy to Encourage the Use of Solar Power, which aims to "stimulate, with a view to reducing the consumption of different power sources, investments and the implementation of environmentally-friendly solar power systems, encompassing technological development, in private and public, residential, community, commercial and industrial enterprises; and to create alternative sources of employment and income." Goiás Solar Program[19]: The Goiás Solar Program "seeks to solve the emerging issue of distributed microgeneration and minigeneration from renewable sources of energy, especially solar photovoltaic power, in the state of Goiás, making it possible to attract and foster enterprises, as well as stimulating initiatives for the efficient use of solar power in compliance with the model of complementarity to the other sources that compose the energy matrix of the state of Goiás." The Program has five major lines of action: Taxation: exempted from ICMS (State Value-Added Tax) the energy of REN 482/2012 and extended ICMS exemption to the supplies and equipment needed to install distributed microgeneration and minigeneration systems; Financing: increased the Productive Credit for solar photovoltaic power through "Goiás Fomento". Debureaucratization and infrastructure: it seeks, among other goals, to work with the state's utility companies, to reduce bureaucratic and regulatory bottlenecks for the connection of microgeneration and minigeneration systems to the power distribution network. Strengthening of the production chain: it seeks, among other goals, to stimulate the creation of innovative companies, from the solar photovoltaic renewable source; Education and communication: it seeks, among other goals, to promote the training and education of professionals to act in all stages of the solar photovoltaic power production chain.
Bahia	The state of Bahia has a bill to create a State Policy to Encourage Shared Generation and the Use of Solar Power in the State of Bahia (Law 20,798/2014).[20]

[18] Available at: http://www.gabinetecivil.go.gov.br/pagina_leis.php?id=7852 Accessed on 04/24/2018.
[19] Available at: http://www.secima.go.gov.br/post/ver/219145/programa-goias-solar Accessed on 04/24/2018.
[20] Available at: http://www.al.ba.gov.br/docs/Proposicoes2014/PL__20_798_2014_1.rtf Accessed on 04/24/2018.

State	Policy/legislation
Rio de Janeiro	State Policy to Encourage the Use of Solar Power (Law 7122/2015)[21]: Law 7122/2015A establishes the State Policy to Encourage the Use of Solar Power with the following objectives: I – to increase the share of solar power in the state power matrix; II – to contribute to the improvement of the living conditions of low-income families; III – to stimulate the use of photovoltaic power in urban and rural areas; IV – to stimulate the use of thermosolar power mainly in residential units; V – to reduce the demand for electric power at times of peak consumption; VI – to contribute to the electrification of locations distant from the power distribution networks; VII – to stimulate the establishment, in the state of Rio de Janeiro, of plants that produce equipment and materials for solar energy systems; VIII – to stimulate the development and training of commercial sectors and services related to solar energy systems.
Mato Grosso do Sul	State Policy to Encourage the Generation and Use of Solar Power (Law 4,967/2016): Law 4,967/2016 authorizes the Executive Power to create the State Policy to Encourage the Generation and Use of Solar Energy in the State of Mato Grosso do Sul, with the objective of "stimulating, with a view to reducing consumption of the different power sources, investments and the implementation of environmentally-friendly solar energy systems, encompassing technological development, in private and public, residential, community, commercial and industrial enterprises; and to create alternative sources of employment and income." [22] Law 4,966/2016: Law 4,966/2016, which amends state Law 3,709/2009, relieves enterprises designed for the production of electric power from renewable sources (such as solar photovoltaic) from the payment of environmental compensation, when these are licensed "based on environmental studies other than the EIA-RIMA and provided that they represent the use of anthropized territorial spaces, as defined in the regulation." [23]

[21] Available at:http://alerjln1.alerj.rj.gov.br/CONTLEI.NSF/c8aa0900025feef6032564ec0060dfff/b0db12f948a8ab6483257f170054227d?OpenDocument Accessed on 04/24/2018.

[22] Available at: http://www.spdo.ms.gov.br/diariodoe/Index/Download/DO9318_30_12_2016 Accessed on 04/24/2018.
Available at: http://www.ms.gov.br/2912-2/ Accessed on 04/24/2018.

[23] Available at: http://www.spdo.ms.gov.br/diariodoe/Index/Download/DO9318_30_12_2016 Accessed on 04/24/2018.
Available at: http://www.ms.gov.br/2912-2/ Accessed on 04/24/2018..

State	Policy/legislation
Tocantins	State Policy to Encourage the Generation and Use of Solar Power (Law 3,179/2017): Law 3,179/2017 establishes the State Policy to Encourage the Generation and Use of Solar Energy (Pro-Solar), in order to take advantage of the State's solar potential to reduce energy consumption.[24] Tocantins also offers incentives for the generation and use of solar energy, instituted through two decrees (2,912 and 5,338), which exempt from ICMS the purchase of photovoltaic and photothermal power equipment by companies established in the state until 2021 and as compensation for the solar power generated.[25]
Roraima	State Policy to Encourage the Generation and Use of Solar, Wind and Biomass Power (Law 1,109/2016): Law 1,109/2016 establishes the State Policy to Encourage the Generation and Use of Solar, Wind and Biomass Power, which aims to "stimulate, with a view to reducing consumption of different power sources, investments and the implementation of environmentally-friendly solar energy systems, encompassing technological development and the production of photovoltaic solar, photothermal, wind and biomass power for self-consumption in private and public, residential, community, commercial and industrial enterprises; and to create alternative sources of employment and income."[26]

[24] Available at: http://www.al.to.leg.br/arquivo/40672 Accessed on 04/24/2018.
Available at: http://to.gov.br/noticia/2017/1/24/tocantins-institui-a-pro-solar-que--incentiva--geracao-e-use-de-energia-solar/ Accessed on 04/24/2018.

[25] Available at: http://to.gov.br/noticia/2017/1/24/tocantins-institui-a-pro-solar-que--incentiva--geracao-e-uso-de-energia-solar/ Accessed on 04/24/2018.

[26] Available at: http://www.tjrr.jus.br/legislacao/phocadownload/leisOrdinarias/2016/lei%20estadual%201109%20-%202016%20-%20institui%20a%20poltica%20de%20 aproveitamento %20de%20energia%20solar.pdf Accessed on 04/24/2018.

State	Policy/legislation
Minas Gerais	State Policy to Encourage the Use of Solar Power (Law 20,849/2013): Law 20,849/2013 establishes the State Policy to Encourage the Use of Solar Power, with the following objectives: I – to increase the share of solar power in the state power matrix; II – to contribute to the electrification of locations distant from the power distribution networks; III – to stimulate the use of photovoltaic power in urban and rural areas; IV – to stimulate the use of thermosolar power in residential, industrial, agricultural, commercial and service units; V – to reduce the demand for electric power at peak consumption hours; VI – to contribute to the improvement of the living conditions of low-income families; VII – to contribute to the reduction of greenhouse gas emissions; VIII – to contribute to the reduction of areas to be flooded for the generation of hydroelectric power; IX – to stimulate the establishment, in the state of Minas Gerais, of plants that produce equipment and materials used in solar power systems; X – to stimulate the development and training of commercial and service sectors related to solar power systems.[27] Renewable Energy Program from the State of Minas Gerais – Energies from Minas (Decree 46,296/2013): Decree 46,296/2013 provides for the Renewable Energy Program from the State of Minas Gerais – Energies from Minas – and for measures to encourage the production and use of renewable sources. The Decree grants tax incentives and differential tax treatment to enterprises located in Minas Gerais, as defined in the tax legislation, in the following cases: I – production of pieces, parts, components and tools used in the generation of renewable power; II – materials to be used as supplies in the civil construction works necessary for renewable power generation projects; III – infrastructure of connection and transmission required for projects generating renewable power for their interconnection in the National Interconnected System; and IV – supply of electric power produced by power plants generating power from solar, wind, biogas, reforestation biomass, urban waste biomass, and animal waste biomass sources or hydroelectricity from HGPs (Hydroelectric Generating Plants) for a period of fifteen years from the date of the start of operation.[28] Law 20,824/2013: Law 20,824, as of July 31, 2013, provides for the exemption from ICMS to various equipment designed for the generation of solar, wind, biomass, and biogas power and hydropower generated in the HGP and Small Hydropower Plants (SHP), as well as total exemption from ICMS to the supply of power generated for a ten-year period starting from the date of the start of the operation of the generating plant, with annual, gradual and proportional recomposition over the following five years, so that the original taxation is reestablished in the sixteenth year. There is also a tax benefit forecast for power microgenerators and minigenerators.[29]

[27] Available at: https://www.almg.gov.br/consulte/legislacao/completa/completa.html?tipo=LEI&num=20849&comp=&ano=2013 Accessed on 04/24/2018.

[28] Available at: https://www.legisweb.com.br/legislacao/?id=257589 Accessed on 04/24/2018.

[29] Available at: http://www.casacivil.mg.gov.br/index.php/component/gmg/story/3751-estado-lanca-programa-de-estimulo-a-producao-de-energia-limpa Accessed on 04/25/2018..

State	Policy/legislation
Pernambuco	PE Solar Program (Decree 41,786/2015): Decree 41,786/2015 establishes the Pernambuco Program of Solar Power Microgeneration and Minigeneration – PE Solar, with the following objectives: I – to encourage self-production of electric power by companies in the state of Pernambuco by means of solar photovoltaic power microgeneration and minigeneration systems; II – to develop the market of suppliers of equipment and services for the solar photovoltaic power industry; III – to foster training and education of human resources to act in all stages of the solar photovoltaic power production chain; IV – to stimulate the creation of local companies that provide services of installation and maintenance of solar photovoltaic systems; V – to increase the technical and environmental sustainability of the electricity supply in the State.[30]
Paraná	IAP Ordinance 19 of 2017: It establishes procedures for the environmental licensing of solar power generation projects.[31]
Rio Grande do Sul	RS Renewable Energies Program: The RS Renewable Energies program seeks to encourage existing renewable sources, aiming to diversify the electric matrix and at energy autonomy. The program does not include distributed microgeneration and minigeneration.[32]
Ceará	Energy Efficiency and Distributed Generation Incentive Fund (FIEE): Sanctioned on January 13, 2017, the law creates the Energy Efficiency and Distributed Generation Incentive Fund (FIEE). The objective is to encourage the development and financing of energy efficiency projects and microgeneration and minigeneration of electric power to foster renewable energy sources, as well as to support the modernization of the electrical systems of the bodies and entities of the public administration. The government is authorized to create special additional credit in the amount of R$ 10 million to be allocated to the Energy Efficiency Incentive Fund.[33]

[30] Available at: http://www.energia.pe.gov.br/?page_id=77 Accessed on 04/24/2018.
[31] Available at: https://www.legisweb.com.br/legislacao/?id=337165 Accessed on 04/25/2018.
[32] Available at: http://minasenergia.rs.gov.br/sobre-o-programa Accessed on 04/24/2018.
[33] Available at: http://www.ceara.gov.br/2017/01/13/sancao-energia/ Accessed on 04/24/2018.

State	Policy/legislation
Federal District	Brasília Solar Program (Decree 37,717/2016): Decree 37,717, as of 10/19/2016 creates a program to stimulate the use of Solar Photovoltaic Power in the Federal District – Brasilia Solar Program, in order to: I – promote the implementation of solar power production systems for the purpose of self-consumption by individuals and legal entities domiciled in the Federal District, through the adoption of economic incentives and communication actions; II – promote the use of public buildings, such as schools, universities and hospitals, for the installation of solar power production systems, in order to generate power for self-consumption in the Federal District and encourage the adoption of this technology by private actors; III – encourage the establishment of plants that manufacture photovoltaic panels, other equipment and their respective components necessary for the installation, operation and maintenance of solar power production systems within the Federal District; IV – create an environment conductive to the creation and establishment of companies providing services of installation and maintenance of solar power production systems, as well as fostering training and education of human resources to act in all stages of the solar power production chain; V – promote the attraction of national and international investments, as well as favor cooperation for the transfer of competitive technologies for solar power.[34]
São Paulo	Resolution SMA (Secretariat for the Environment) 74/2017: Resolution SMA 74/2017 provides for the environmental licensing of solar photovoltaic power generation projects.[35]

[34] Available at: http://www.sema.df.gov.br/programa-brasilia-solar-decreto/ Accessed on 04/25/2018.

[35] Available at: http://arquivos.ambiente.sp.gov.br/legislacao/2017/08/resolucao-sma-074-2017-processo-3222-2017-estabelece-procedientos-para-o-licenciamento-ambiental-de-usinas-fotovoltaicas-agosto.pdf Accessed on 04/25/2018.

APPENDIX III. Data used to analyze the financial feasibility of photovoltaic models

Investment with the photovoltaic system (CAPEX): a basic photovoltaic system comprises the following items:

Table 9. Components of a photovoltaic system

System component	Cost per state
Project	Constant for all states
Photovoltaic Modules	5% additional for Goiás, Minas Gerais and Paraíba
Inverters	Constant for all states
Metal structure	Constant for all states
Installation services	5% additional for Goiás and Paraíba
Connection	Constant for all states

Source: IDB project data

The average costs used in the modeling were defined according to information about previous projects.

Appendix IV. Sensitivity Analysis

Individual – Direct Consumption Model – São Paulo

Parameters	Variation	Parameter value	Payback period without financing (years)	Payback period with financing (years)	Total cost without financing (R$)	Total cost with financing (R$)
Tariff (R$/kWh)	+ 20%	0.71	4	6	23,347	36,851
	base case	0.59	5	7	23,347	36,851
	-20%	0.47	6	8	23,347	36,851
Cost of the system (R$)	+ 20%	28,016	6	8	28,016	44,220
	base case	23,347	5	7	23,347	36,851
	-20%	18,677	4	6	18,677	29,479
Performance of the system	base case		5	7	23,347	36,851
	-10%		5	7	23,347	36,851
	-30%		5	8	23,347	36,851
Repayment period (years)		15	5	4	23,347	62,182
	base case	5	5	7	23,347	36,851
Annual interest rate (%)	base case	19	5	7	23,347	36,851
		12	5	6	23,347	31,249

Legal Entity – Direct Consumption Model – São Paulo

Parameters	Variation	Parameter value	Payback period without financing (years)	Payback period with financing (years)	Total cost without financing (R$)	Total cost with financing (R$)
Tariff (R$/kWh)	+ 20%	0.71	5	6	404,813	638,94
	base case	0.59	5	7	404,813	638,94
	-20%	0.47	6	8	404,813	638,94
Cost of the system (R$)	+ 20%	485,774	6	8	485,774	766,737
	base case	404,813	5	7	404,813	638,94
	-20%	323,850	4	6	323,850	511,158
Performance of the system	base case		5	7	404,813	638,94
	-10%		5	7	404,813	638,94
	-30%		5	8	404,813	638,94
Repayment period (years)		15	5	4	404,813	1,078,153
	base case	5	5	7	404,813	638,94
Annual interest rate (%)	base case	19	5	7	404,813	638,94
		12	5	6	404,813	541,813

Legal Entity – Shared Generation Model – São Paulo

Parameters	Variation	Parameter value	Payback period without financing (years)	Payback period with financing (years)	Total cost without financing (R$)	Total cost with financing (R$)
Tariff (R$/kWh)	+ 20%	0.71	5	7	21,048,500	33,222,542
	base case	0.59	6	8	21,048,500	33,222,542
	-20%	0.47	8	10	21,048,500	33,222,542
Cost of the system (R$)	+ 20%	25,258,200	8	10	25,258,200	39,867,051
	base case	21,048,500	6	8	21,048,500	33,222,542
	-20%	16,838,80	5	7	16,838,800	26,578,034
Performance of the system	base case		6	8	21,048,500	33,222,542
	-10%		6	8	21,048,500	33,222,542
	-30%		6	9	21,048,500	33,222,542
Repayment period (years)		15	6	1	21,048,500	39,845,988
	base case	5	6	8	21,048,500	33,222,542
Annual interest rate (%)	base case	19	6	8	21,048,500	33,222,542
		12	6	7	21,048,500	28,171,949

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