C40 CITIES FINANCE FACILITY

The solar revolution in Brazil: How cities can take advantage

PART 2: TECHNOLOGY AND FINANCING

Contents

List of figures

List of tables

Executive summary

Brazil has the potential to become a global leader in the use of solar PV, and municipalities have a large role to play not only by incentivizing PV projects within their territories, but also by setting an example through the integration of solar PV into their own public buildings and assets.

A previous report from C40 Cities Finance Facility (CFF) presented the multiple benefits municipalities can have by "going solar". The report also provided useful information concerning Brazilian distributed generation legislation, described eligible business models, and zoomed in on the first steps a municipality should take when considering a PV project, from establishing solid governance and setting targets, to a step-by-step technical guide for preliminary sizing of a PV system.

Two crucial aspects towards the success of a municipal PV project are procurement and financing.

For the procurement, the cities must be very conscious when preparing bidding documents and very well-prepared when selecting the victor in order to ensure, as best as possible, a smooth, successful project. For this to happen, a certain level of technical knowledge about PV technology, components, and project execution is very important. Furthermore, technical specifications and terms of reference for PV projects have distinct characteristics that the city's technical and procurement departments should be aware of.

On the other hand, deciding on how a PV project will be financed can turn out to be a complex and lengthy process, and should begin during the first stages of project planning. There are many variables to consider, and it is necessary to know the options that exist in the Brazilian market for project financing. Once the options are clear and the municipality has ruled out those that do not apply – for technical, financial, or political reasons – then the city staff must analyze the advantages and disadvantages of each remaining option before finally deciding on whether to reach out to external capital or not, and which funding sources and credit lines are most appropriate to the project.

After following the recommendations in this and the preceding report, municipalities should be ready to take major steps into planning and successfully implementing their solar PV projects, and fulfill their potentials as leaders in the fight against climate change, all the while reaping multiple benefits for themselves and their populations.

Objectives of the report

In order to empower cities in the procurement of PV systems, this report provides an exhaustive overview of the technological aspects of solar PV projects. It describes the diverse components that make up a system, as well as their functions, with an attempt to increase the final quality of a city's PV system and its value-for-money.

In addition, the report also delves into the intricacies of PV project financing, presenting a panorama of financing opportunities for Brazilian municipalities that will help them take early action in their plan to "go solar".

Finally, considerations are made concerning best practices in procurement, aiding municipal project teams in understanding the typical phasing of a public PV project and recommended content for their terms of references.

This report is the second in a series of two reports. The first report focused on aspects related to the current situation of PV in Brazil, legislation, benefits for cities, business models, governance and initial planning. The first Report provided information on technical and economic feasibility assessments, and an initial step-by-step guide to designing and developing municipal PV systems.

Two crucial aspects towards the success of a municipal PV project are procurement and financing.

1. Technical aspects

The first section of this report aims to provide solid technical information about PV systems for municipalities in Brazil. This information is useful as it provides specific tools that technical teams need to successfully communicate with suppliers and make better decisions when evaluating proposals.

With this in mind, municipalities should have proper knowledge regarding technical aspects of solar PV systems in order to elaborate robust bidding documents, make better decisions when evaluating proposals, and successfully communicate with suppliers. In that sense, understanding the scope of a technical specification can be a great tool to achieve those objectives.

A technical specification is an essential document that is attached to a bidding process for the installation of a solar PV system project. This document aims to guide the Engineering, Procurement and Construction (EPC) companies with regards to the system's expected technical characteristics, as well as the minimum technical features of the equipment to be used and all services to be performed by the contracted company. The technical specification must be elaborated in as much detail as possible in order to ease the development of proposals by interested EPC companies and to reduce undesired incidents in the execution of the solar PV system. The following subsections address the main topics that should be part of the structure of a technical specification. It is important to emphasize that all topics covered in this document are considered "good practices". Therefore, they can be used as guidelines and municipalities should not be limited to the ones presented in this Report. Each project has its specific context and particularities, which must be considered for each case.

Figure 1 presents a schematic overview of the main topics that should be addressed in a technical specification.

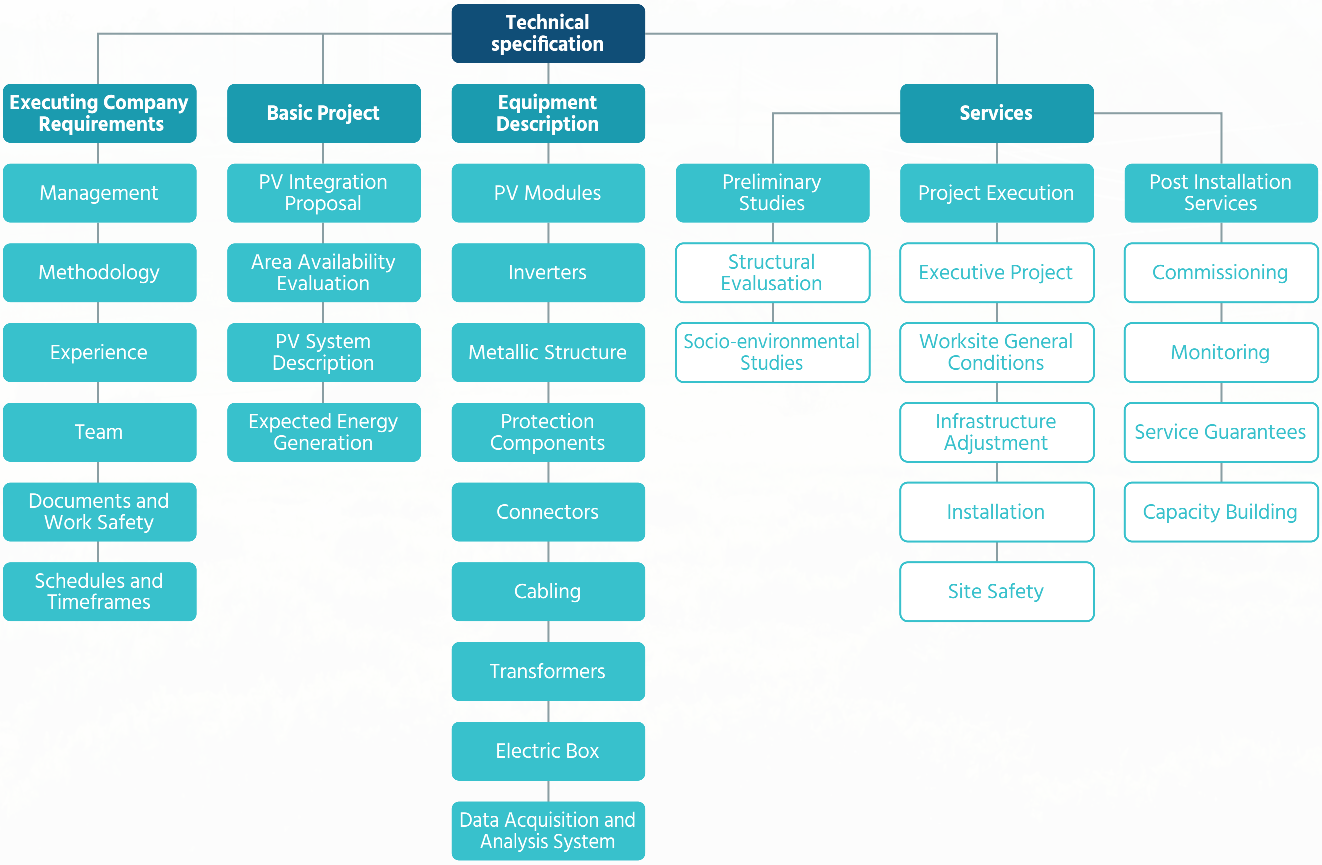


Figure 1: Flow chart of the topics that should be addressed in a technical specification document.

1.1. Executing company requirements

The "executing company requirements" must present the minimum qualifications expected from the company that will be hired to execute the project. This document must present the minimum qualifications of the company, its experience in previous projects, work methodology, team composition and other characteristics that are required in order to mitigate the risks associated with the execution of a project by an inexperienced company. The following sections describe the components that must be contemplated as part of the "executing company requirements". A summary of this topic is presented in Figure 2.

MANAGEMENT

The EPC company should include the quotation of a project manager. This project manager must have full representation capacity of the company in order to present explanations and make final decisions on solutions to be implemented. In addition, it is also important that the company considers the exclusive allocation of a supervisor to monitor the execution of the work on a daily basis, elaborating activity reports and clarifying any doubts in routine activities.

METHODOLOGY

The company must present in its proposal the technical catalogs (datasheets) of all equipment that will be used, according to the minimum characteristics required in the technical specification, as well as a detailed spreadsheet of all costs and price formation. The proposal must also present the methodology employed in the activities and the execution schedule to be applied for the fulfillment of each of the stages specified in the Work Plan.

EXPERIENCE

The proposing company should present its previous experience with similar services, through certificates of technical capacity and certificates of technical responsibility (ART, *Anotação de Responsabilidade Técnica*), as well as relevant resumés for project managers and professionals designated as the core team.

TEAM

Preferably, all employees involved in the execution of the proposed services should be part of the company's staff, a partner, or have some other type of formal attachment in accordance with Brazilian law.

It is very important to keep in mind that the person who submits the proposal will be the only one responsible for compliance with the legal obligations that regulate work relations in Brazil. In addition, all staff involved in the execution of services must have a certification of conclusion in several official safety courses, such as *NR-10*[1]*: Safety in Facilities and Services in Electricity and NR-18: Working Conditions and Environment in the Construction Industry.* The certificates should be valid through the entire duration of the service, and the staff must be qualified for that work. View Table 1 for more information regarding which safety courses are required for professionals involved in specific services.

Service	Safety course required
Load moving actions	NR-11: Transport, Storage and Material Handling
Construction, transportation, assembly, installation, adjustment, operation, cleaning, maintenance, inspection, deactivation and disassembly of machines or equipment.	NR-12: Work Safety in Machinery and Equipment
Assembly and services at heights (e.g. on roofs)	NR-35: Work at Heights valid throughout the whole service in execution

Table 1: Safety courses are required for professionals involved in specific services.

[1] The NR (*Norma Regulamentadora* are a series of occupational health and safety procedures that are mandatory for all public and private companies whose staff perform specific activities described in each of the norms. All employees performing such activities are required to hold a valid certificate of conclusion in a course pertaining to each norm relevant to his or her activities.

DOCUMENTS AND WORK SAFETY

The applicant must present all documents related to work safety, such as the Medical Control and Occupational Health Program (PCMSO, *Programa de Controle Médico e Saúde Ocupacional*), Environmental Risk Prevention Program (PPRA, *Programa de Prevenção de Riscos Ambientais*) and Work Permit (CTPS, *Carteira de Trabalho*) or other formalized relationship.

SCHEDULES AND TIME FRAME

Applicants should be requested to present the Project Analytical Structure (EAP, *Estrutura Analítica de Projeto*), the Physical Schedule, and the Financial Schedule, detailing the stages of service execution.

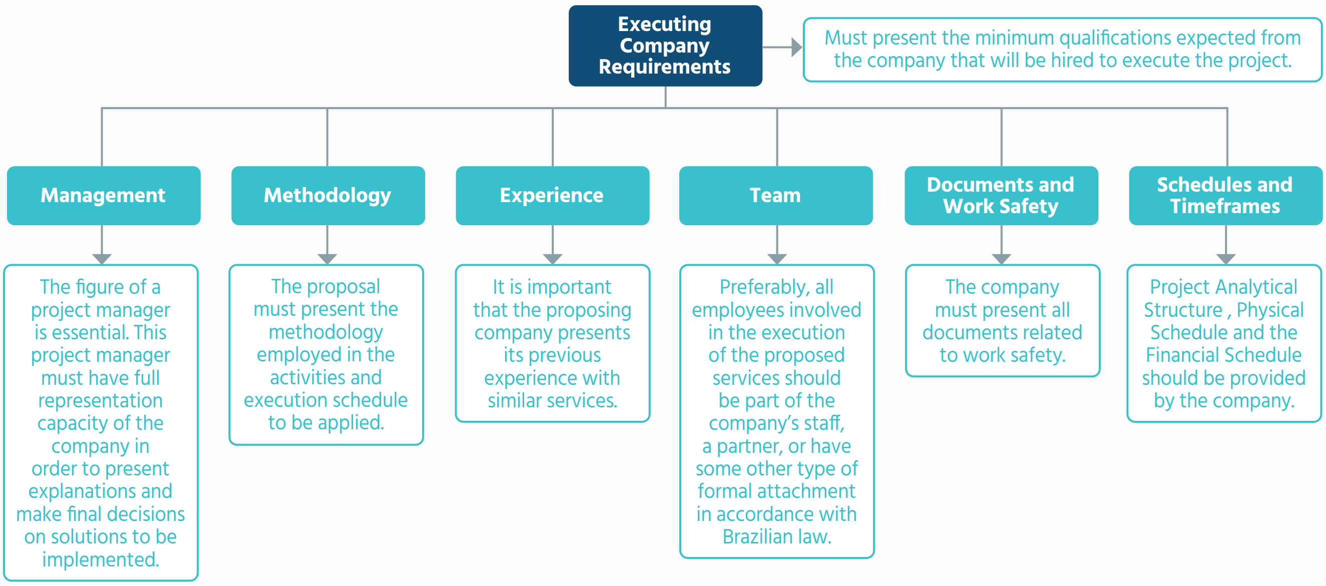


Figure 2: Executing Company Requirements components summary

1.2. Basic project

With regards to the project itself, a good practice is for the technical specification to also include the PV system's basic design, developed beforehand by the municipality or by an external company or consultant. In this context, the basic project aims to guide the EPC company in terms of the expected technical characteristics of the project. It is not a mandatory document, but if elaborated with the minimum specifications, it can avoid inconveniences in the system implementation phase. Therefore, for the procurement process, it is recommended to specify in the Term of Reference (ToR) that the proposal must consider the elaboration of a basic project management.

It is often questioned by public managers whether in the bidding phase it would be appropriate to already present an executive project detailing the requested solutions. Currently there are dozens of manufacturers of modules, inverters and metallic structures in the market that present simulated technical characteristics with excellent quality and performance standards respecting all national and international certifications, but with slightly different technical characteristics. With this scenario, a detailed executive project may end up directing the project towards a small group of suppliers and unjustly limiting the participation of the companies in the bidding process. In the particular case of a solar PV system procurement process, it is understood that a basic project with the proper detailing and a strict technical specification in the equipment requirements section can replace the need for an executive project.

The basic project must contain the PV integration proposal, area availability evaluation, the PV system description, and the expected energy generation. A summary of the basic project main components is presented at Figure 7.

PV INTEGRATION PROPOSAL

The PV integration proposal includes the basic orientation layout, containing the PV modules' orientation and inclination specifications, quantity of PV modules and total power installed. A 3D model layout (Figure 3) should be presented for a better overview of the PV system proposed.

AREA AVAILABILITY EVALUATION

The area availability evaluation should analyze all the areas that can be used for allocating the PV modules. In this step, it is important to analyze the shading impact due to surrounding objects, such as trees or taller buildings, as well as between rows of the system itself, in order to position the modules with less negative impact. The spacing required (between rows or on the sides) for proper and safe maintenance of the system should also be taken into account. At this stage, the roof or soil conditions must also be evaluated regarding the PV system extra load and how this would impact on the building's structure or soil stability. In addition, visual impacts of the PV system should be considered, especially when installed in buildings listed as historic landmarks, paying attention to the visualization of the system at the pedestrian level (Figure 4), as well as the visual architectural impact of the existing building (Figure 5). It is recommended that the municipalities, during the bidding period, establish a deadline for the bidders to make technical visits to better understand the reality of the project so that both expectations, of the supplier and the municipality, are aligned.

The basic project sets out the expected technical characteristics of the project.

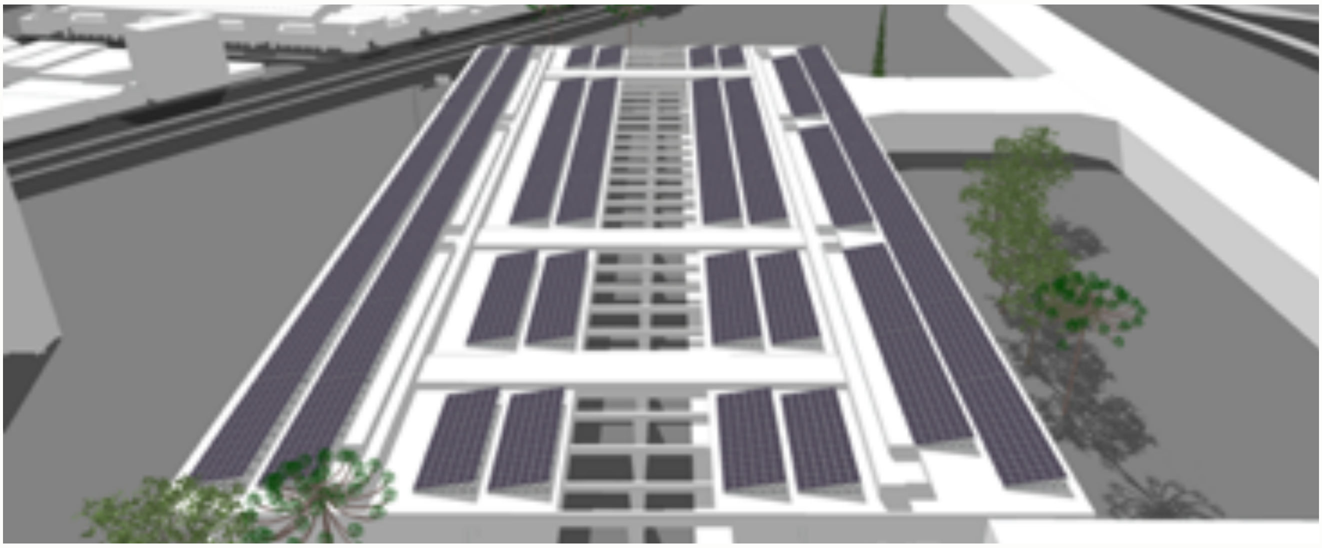


Figure 3: Demonstrative 3D layout of PV modules' proposed position for a roof-mounted PV project proposal.

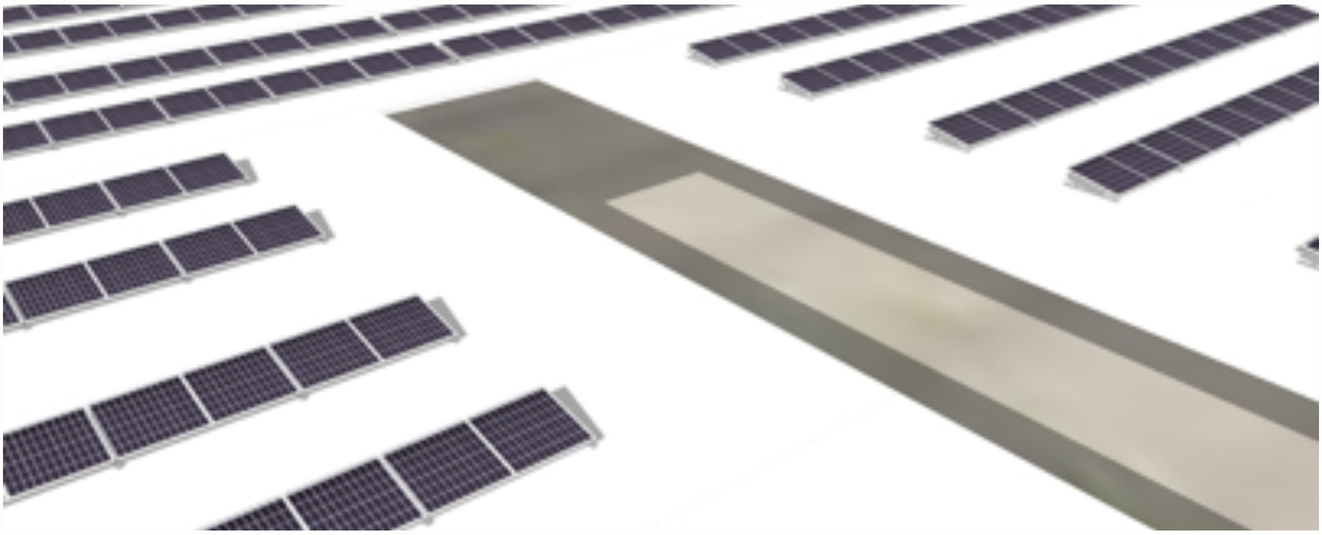


Figure 4: Layout demonstrating the distance from the edges for safe maintenance and sufficient distance between rows to minimize as much shading as possible.

Figure 5: Building front view at ground level, demonstrating that PV modules are slightly less visible, a requirement in this case because the building is listed as part of the city's historical heritage.

1.2. Basic project (cont)

PV SYSTEM DESCRIPTION

A brief description of the PV system and the electrical characteristics of the PV modules and inverters that were considered for the elaboration of the guiding project should be presented. The necessary components are described below:

PV array description

The PV array is the combination of associated PV modules in series (strings) and in parallel. A brief description of all arrangements that will make up the system must be made, as well as the number of inverters used for the entire system

Multi-wire and single-wire diagrams

The system's electrical diagrams (multi-wire and single-wire diagrams) must be presented, representing all the components that make up the system, such as PV strings, inverters, protection switchboards, etc., as well as the simplified scheme for connecting the system to the electricity grid.

Layout and connection of strings

The PV modules' electrical connection in series – known as strings – as well as the distribution of the strings themselves in the system must meet technical requirements in order to optimize the connections. Thus, the basic design should contain a color diagram showing the electrical distribution of PV modules and strings in the system.

Proposed guiding metal structure

The basic project design must present a guiding metallic structure layout to support and fix the PV modules, as well as basic specifications about the materials to be used (e.g. Figure 6).

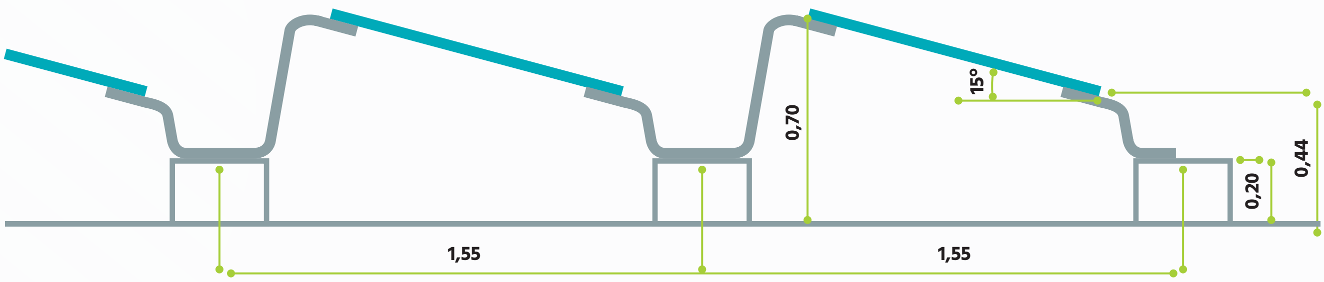


Figure 6: Proposed guiding structure for fixing PV modules

EXPECTED ENERGY GENERATION

The basic project should present the expected energy generation of the PV system. This expected generation should be simulated using an appropriate simulation software tool (PVsyst, PVSOL, SAM, among others), and should consider a simplified loss analysis in the system.

It is also important to emphasize that the EPC company can decide whether to execute the basic project presented or to propose a new project.

Therefore, it is also recommended to require in the technical specification that in the case where the EPC company decides to elaborate a new project, the contractor must previously accept it.

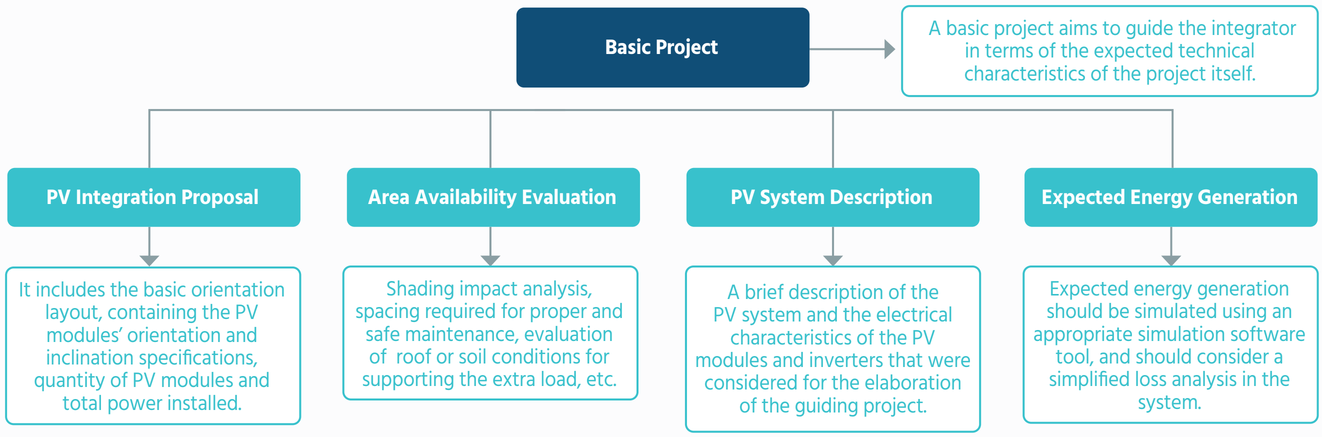


Figure 7: Basic Project components summary

1.3. Equipment description

The technical specification must present the minimum characteristics of the equipment to be used in the PV system project, in order to reduce the incidence of problems in the execution and post-execution stages. The main types equipment that should present minimum characteristics and detailed requirements are listed below and a summary of this topic is presented at Figure 8.

METALLIC STRUCTURE

The metallic structure is the component responsible for supporting the PV modules. The structure model and fixing method will depend directly on the installation surface. The need to use the appropriate material, such as fire-galvanized steel and aluminum, containing all the screws in stainless steel with a guarantee against corrosion must be specified.

PV MODULE

The PV modules are the main components of the system. They are responsible for generating the system's electrical energy (the modules transform solar energy into electrical energy).

For this reason, it is indispensable to include specifications on which PV module technology should be used since there are several available options on the market. The modules most commonly used in PV installations in Brazil are multicrystalline or monocrystalline silicon due to greater market availability, better efficiency and better cost x benefit. In addition, The minimum technical characteristics allowed for the PV module to be used in the system, such as nominal power, efficiency, tolerance, etc, must be specified.

The proposed PV modules must present the Labeling Certificate, in accordance with the criteria established in the Conformity Assessment Requirements attached to National Institute of Metrology, Quality and Technology (INMETRO - Instituto Nacional de Metrologia, Qualidade e Tecnologia) No. 4/2011, INMETRO No. 357/2014, and INMETRO No. 17/2016 and Certificate of Registration, from INMETRO, of the labelled PV module model.

In addition to the Certificate of Labeling, PV modules must have certificates of compliance with the requirements of standards issued by internationally recognized institutions and INMETRO, These certificates do not limit competitors in order to benefit some companies in special, since several companies have them. Below are some certificates that can be requested:

- IEC 61215 - Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 2: Test procedures;
- IEC 61701 - Photovoltaic (PV) modules - Salt mist corrosion testing; IEC 61730 - Photovoltaic (PV) module safety qualification - Part 1: Requirements for construction;
- IEC 62716 - Photovoltaic (PV) modules - Ammonia corrosion testing.

INVERTER

The PV inverter is the component responsible for the conversion of DC energy (direct current) from the PV module generation into AC energy (alternating current), used by most building appliances.

The minimum technical characteristics allowed for the inverters must be identified, such as nominal power, efficiency, protection index, etc. In addition, it is important that the specification of the inverter clearly states the operating frequency of the equipment (60 Hz for the conventional power grid in Brazil) and the nominal output voltage compatible with the local power grid voltage. If the voltage is not compatible, the use of an isolating transformer will be mandatory.

The photovoltaic inverter must have certifications according to the standards: IEC 61727, EN 61000, EN 50178, IEC 62109-1, IEC 62109-2, NBR[2] 16149, NBR 16150 and NBR IEC 62116:2012.

In some cases, a Data Acquisition and Analysis System (SAAD, *Sistema de Aquisição e Análise de Dados*) is provided for monitoring the PV system. If this occurs, the communication interface of the inverter must be compatible with the SAAD.

PROTECTION COMPONENTS

The protection components of the PV system serve to protect both the components against surges, overcurrent, etc. and the users, through sectioning, to allow possible maintenance and disconnections of the system. All protection components required provided must be in accordance with NBR 16690:2019 recommendations.

[2] Brazilian Technical Standard (NBR – Norma Técnica Brasileira)

CONNECTORS

The DC connectors make the electrical connection between the strings and the main cable that parallels the PV circuit. For the DC part of the system, it is recommended that specific connectors for PV systems (MC4 type connectors) are used in all connections. For cable terminations that do not use MC4 connectors, it is recommended to use pre-insulated terminals which must comply with NBR 5474. Splices should be avoided.

CABLING

The conductors must be sized in accordance with NBR 5410 in order to withstand the specific system current and allowable voltage falls, as desired in the project.

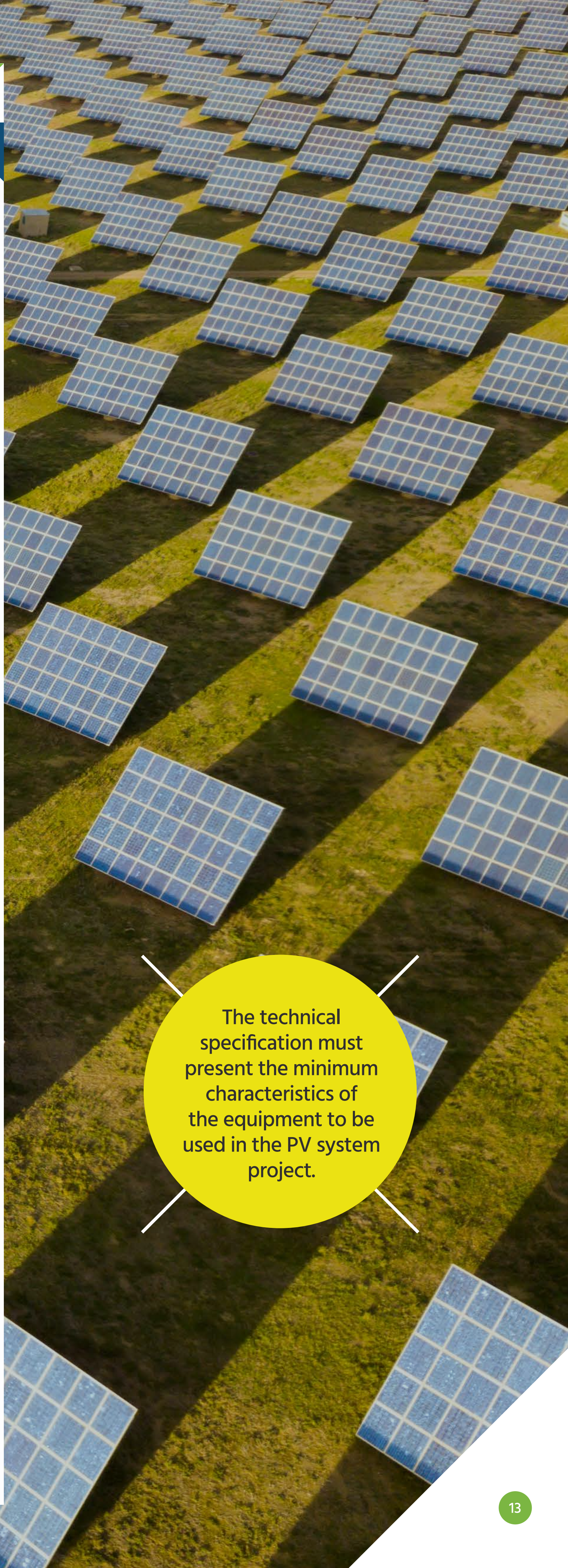
It is important to emphasize that the conductors must be installed in appropriate locations and it must be ensured that the chosen location does not accumulate water, which could damage not only the cables, but also the connectors. The cables must always be protected from direct ultraviolet (UV) radiation. In addition, it must be ensured that the cables do not become loose or overstretched, and that they are not subject to bottlenecks. Cables for application in PV systems must also meet the requirements of NBR 16612.

TRANSFORMERS (IF NEEDED)

The use of a transformer is required in cases where the PV inverter does not have an output voltage compatible with the local electricity grid. The equipment must be specified according to the size of the PV system.

ELECTRIC BOX

The electric boxes hold the protection components and connecting the circuit in parallel. In a PV system, electric boxes can group the components into direct current (called junction box or string box) - to parallel strings, to hold fuse boxes, DPS and disconnecting switches - and also group the components into alternating current, which are the conventional distribution boards - to parallel inverter circuits, to hold DPS, circuit breakers, etc. and promote the coupling between components ensuring the general protection of the electrical components.



The technical specification must present the minimum characteristics of the equipment to be used in the PV system project.

1.3. Equipment description (cont)

DATA ACQUISITION AND ANALYSIS SYSTEM (SAAD, SISTEMA DE AQUISIÇÃO E ANÁLISE DE DADOS)

The Data Acquisition and Analysis System (SAAD) is usually composed of a solarimetric station, data loggers, sensors, energy meter analyzers, workstation for data visualization and other accessory components. The amount of SAAD equipment and complexity is variable and depends on the interest of monitoring the system variables. It should be emphasized that it is very important to guarantee a robust SAAD because the data provided will be necessary for future performance evaluation of the system and to ensure the guarantee of the installation. In case the PV system presents lower performance than expected, the data acquired by SAAD will be used in order to investigate the possible causes of this low performance.

Table 2 presents a compilation of the standards, already mentioned above, which define the minimum requirements of the equipment presented:

Equipment	Standards
PV Module	• IEC 61215 - Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 2: Test procedures • IEC 61701 - Photovoltaic (PV) modules - Salt mist corrosion testing • IEC 61730 - Photovoltaic (PV) module safety qualification - Part 1: Requirements for construction • IEC 62716 - Photovoltaic (PV) modules - Ammonia corrosion testing
Inverter	• IEC 61727 - Photovoltaic (PV) systems - Characteristics of the utility interface • EN 61000 - Electromagnetic compatibility (EMC) • EN 50178 - Electronic Equipment for Use in Power Installations • IEC 62109-1 - Safety of power converters for use in photovoltaic power systems - Part 1: General requirements • IEC 62109-2 - Safety of power converters for use in photovoltaic power systems - Part 2: Particular requirements for inverters • NBR 16149 - Photovoltaic Systems (PV) - Characteristics of the connection interface with the distribution grid • NBR 16150 - Photovoltaic Systems (PV) - Characteristics of the connection interface with the electrical distribution network - Conformity test procedure • NBR IEC 62116:2012 - Anti-stacking test procedure for grid-connected PV inverters
Protection Components	• NBR 16690:2019 - Electrical installations of photovoltaic arrangements - Project requirements
Connectors	• NBR 5474:1986 - Electrical connector • NBR 16690:2019 - PV Electrical Installations - Project Requirements
Cabling	• NBR 5410 - Low voltage electrical installations • NBR 16690:2019 - Electrical installations of photovoltaic arrangements - Design requirements • EC 60332-1 - Test methods for electric cables under fire conditions - Part 1: Single conductor test or single insulated cable in vertical position • NBR16612: 2020 Power cables for photovoltaic systems, non-halogenated, insulated, with cover, for voltage up to 1.8 kV DC between conductors - Performance requirements
Electric Boxes	• IEC 60439 - Low voltage switching and control assemblies • IEC 61439-1:2011 - Low-voltage switchgear and control gear assemblies

Table 2: Standards that establish the minimum PV system equipment requirements

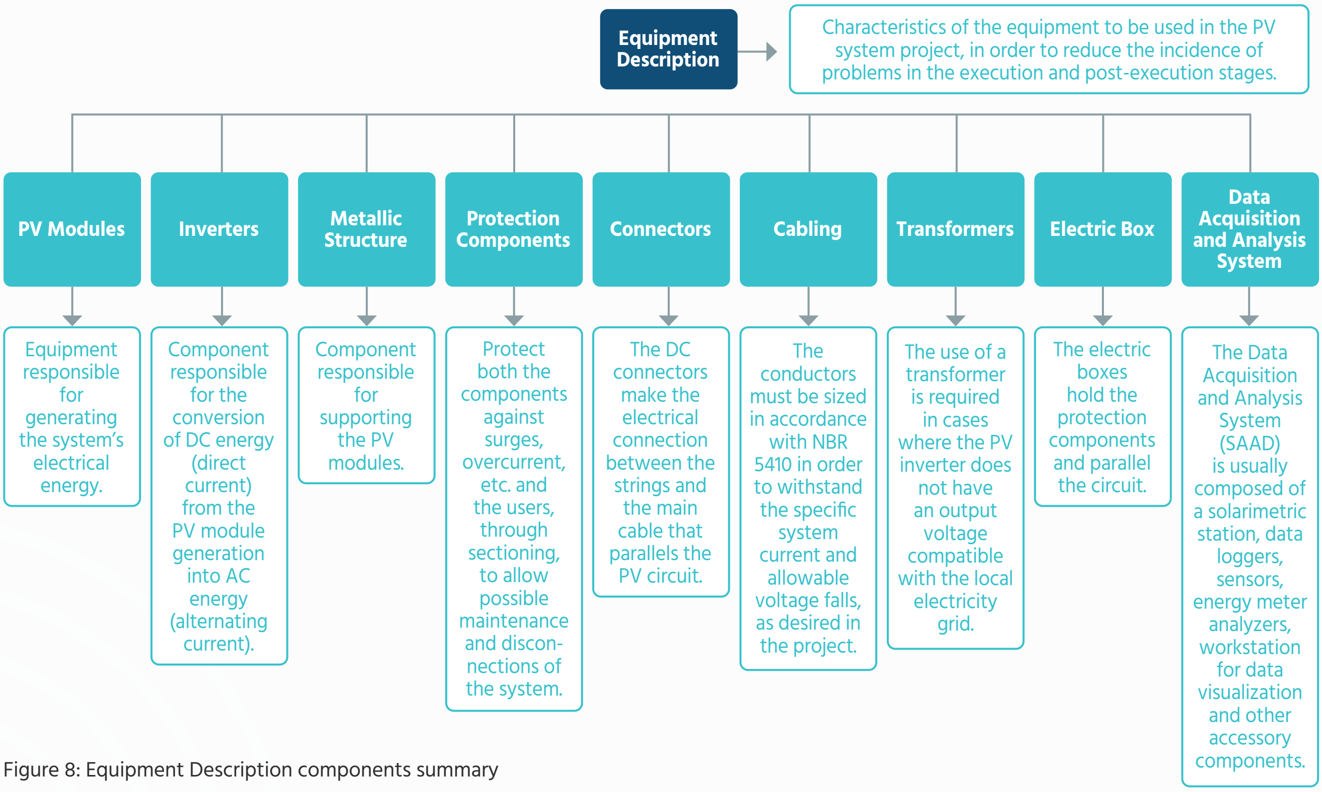


Figure 8: Equipment Description components summary

1.4. Services

All services that are the EPC company's responsibility must be provided and listed in detail in the technical specification. The main activities that must be mentioned and carefully specified in the document should consider preliminary studies, the project execution and post installation services. These topics are explained as follows.

PRELIMINARY STUDIES

Preliminary studies could account for a structural evaluation and socio-environmental studies as explained as follows. Figure 9 summarizes this topic.

Structural Evaluation

Prior to the installation of the PV system on buildings, it is necessary to carry out preliminary studies and structural calculations in order to assess the maximum load supported by the roof. In cases in which the PV system will be installed on the ground, the soil conditions must also be evaluated by a specialist.

Socio-environmental Studies

Depending on the context in which the project is inserted, socio-environmental studies must be carried. These preliminary studies aim to identify the vulnerabilities of the project, as well as to mitigate possible environmental and social risks and impacts that may delay or make the implementation of the PV system unfeasible. It is recommended that these studies be carried out in projects inserted in the context of buildings listed by the Institute of National Historical and Artistic Heritage (IPHAN, *Instituto do Patrimônio Histórico e Artístico Nacional*), close to areas of environmental preservation, areas of economic vulnerability, among others.

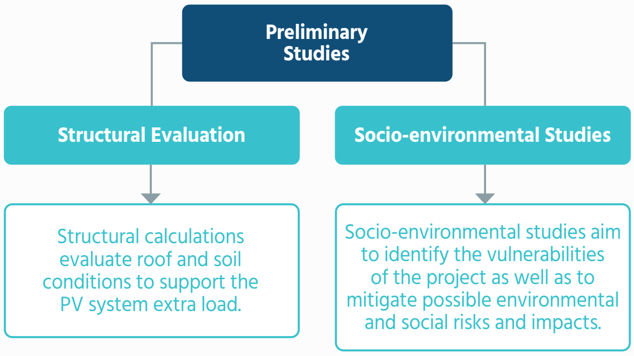


Figure 9: Preliminary Studies components summary

PROJECT EXECUTION

Project execution includes the executive project, worksite general conditions, infrastructure adjustment, installation and site safety as explained bellow and as summarized at Figure 10.

Executive Project

The executive project represents the final project proposal to be implemented by the winning bidder. It contains all relevant information for the PV system to be installed. Minimally, the executive project to be elaborated by the EPC company must contain:

- Static and wind load calculation memorial of the support structure, with the modules installed, and loads on the roof or soil where it will be mounted;
- Structural report ensuring that the roof has the capacity to support the additional load caused by the integration of the PV system.
- Distribution layout of the PV modules on the surface to be installed;
- Uni-wire and multi-wire electrical diagrams detailing the modules, strings, inverters, electric boxes, transformers and grid connection point (when relevant);
- Instruction manual for preventive maintenance;
- Other information according to the project needs, such as adaptation works.

Worksite general conditions

For the execution of the services, there is usually the need to deploy worksite infrastructure. The installation must be made in accordance with the conditions stipulated in the Regulatory Standard NR-18 and in the Basic Safety and Labor Medicine Guidelines.

Prefabricated containers or any equivalent construction system are used on temporary construction sites, having all the pre-installed utilities, to facilitate and speed up both the mobilization and the demobilization of the construction site.

Infrastructure adjustment

The proposed building will not always be completely adequate to host a PV system. In those cases, works will be necessary to adapt the infrastructure, ranging from structural reinforcement to ensure that the building supports the weight of the materials, to reallocation of some pre-existing components, such as lightning rods.

It is important to emphasize that these works must occur in a way that minimally interferes with the aesthetics and, most importantly, ensures the original characteristics of the building.

Installation

The EPC company must perform the installation service according to the amount of days indicated in the technical specification. It will be responsible only for the conclusion of the service and may be penalized if it does not meet the deadline. The EPC company should be responsible for delivering the PV system ready to go into operation fulfilling all the requirements made by the local utility company.

Site Safety

Since the services are expected to last for a certain time, given the size and complexity of the system, it is necessary to guarantee the security of the equipment and materials used, which is usually the responsibility of the EPC company.

In addition, it is also important to carry out an access control of the workforce, vehicles and loads related to the execution of the service and the restriction of access by unauthorized persons on site. However, this is not always possible, since in some cases it is a place of continuous flow of people. In such cases, safety of the equipment must be ensured (to prevent damage, theft and misappropriation) as well as of the people who will be in transit, providing warning signs regarding the risks on the premises of the worksite.

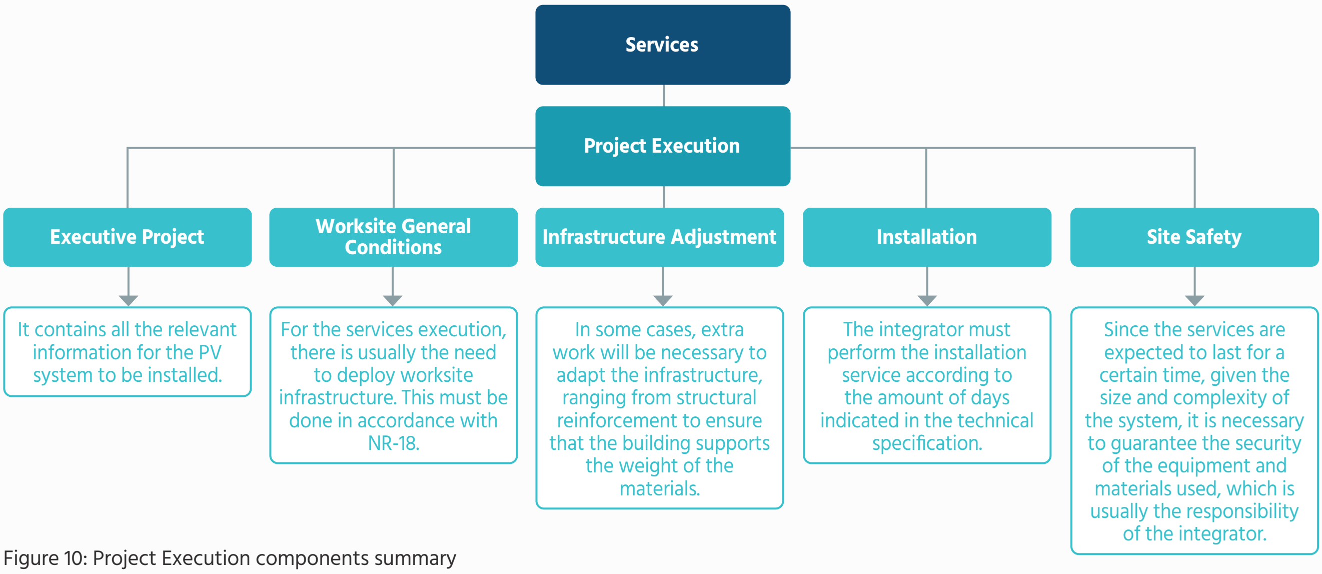


Figure 10: Project Execution components summary

POST-INSTALLATION SERVICES

Post-installation services account with commissioning, monitoring, services guarantees and capacity-building as explained as follows and as summarized at Figure 11.

Commissioning

The commissioning comprises the set of inspections, technical services and field tests that must be performed on the PV generator system, according to the details presented in the technical specification following the NBR 16274:2014 standard, which presents the minimum documentation requirements and commissioning tests. A good method to evaluate the commissioning is the creation of control sheets that must be completed as the tests are being performed. The results will be evaluated in order to confirm if the system is ready to go into operation.

Monitoring

Once the service of installation and commissioning of the PV system is completed, the system must be monitored through periodic inspections and analysis of data acquired by SAAD. The follow-up service can be done by the integrating company itself or by a third party, as preferred.

The follow-up has the objective of maintaining the availability and correct functioning of the equipment in order to obtain the foreseen energy generation according to the executive project. Throughout this period, the executing company is responsible for the corrective maintenance of any equipment failure.

Service Guarantees

Like any product purchase, the guarantee of the service performed must be required, in which the hired company must comply with the clauses agreed between the parties. Failure to comply with the agreement may lead to a fine, as long as previously established in the technical specification.

The guarantee can be subdivided into installation guarantee and performance fee guarantee.

Installation guarantee:

The EPC company commits to guaranteeing the services performed against any labor and/or structure defect, for a previously established period (usually in years) counted since the final delivery of the product, according to article 618 and subsequent articles of Law 10.406 of 2002 (Civil Code). Furthermore, the EPC company should be assigned as the responsible for the warranty of materials and equipment supplied and installed against any manufacturing defect, as well as equipment performance warranty, for the respective periods defined in the technical specification.

Performance fee guarantee:

The Performance Ratio (PR) is defined as the ratio between the actual energy production of a PV system and the estimated generation if there were no losses in the system. The PR is an indicator of the actual system output compared to an ideal system. This coefficient aims to quantify the overall effect of losses in energy production due to losses of the DC/AC inverter, shading, dirt, temperature coefficients, mismatching, among others.

The EPC company must inform in the executive project the PV system's PR estimate, in relation to the irradiation on the modules' plane from representative simulations.

To verify the real performance of the PV system, a comparative evaluation methodology is usually defined, to be presented in a document attached to the technical specification. In case the real PR values obtained by the methodology are lower than agreed, the EPC company must justify and/or correct possible defects in order to always reach the expected value.

The capacity-building of the client's technical team in solar PV energy is an important service and it can be considered in the technical specification.

Capacity-building

The capacity-building of the client's technical team in solar PV energy is an important service and it can be considered in the technical specification. The training should enable the PV system operation and maintenance team to follow the execution of operation tests, maintenance, as well as train them in the effective execution of these procedures. It is suggested that the training contemplate at least:

- Fundamentals of PV Solar Energy
- PV Systems Operation and Maintenance Training
- Data Acquisition and Analysis System (SAAD) maintenance training
- Training in data analysis and monitoring using the Data Acquisition and Analysis System (SAAD)

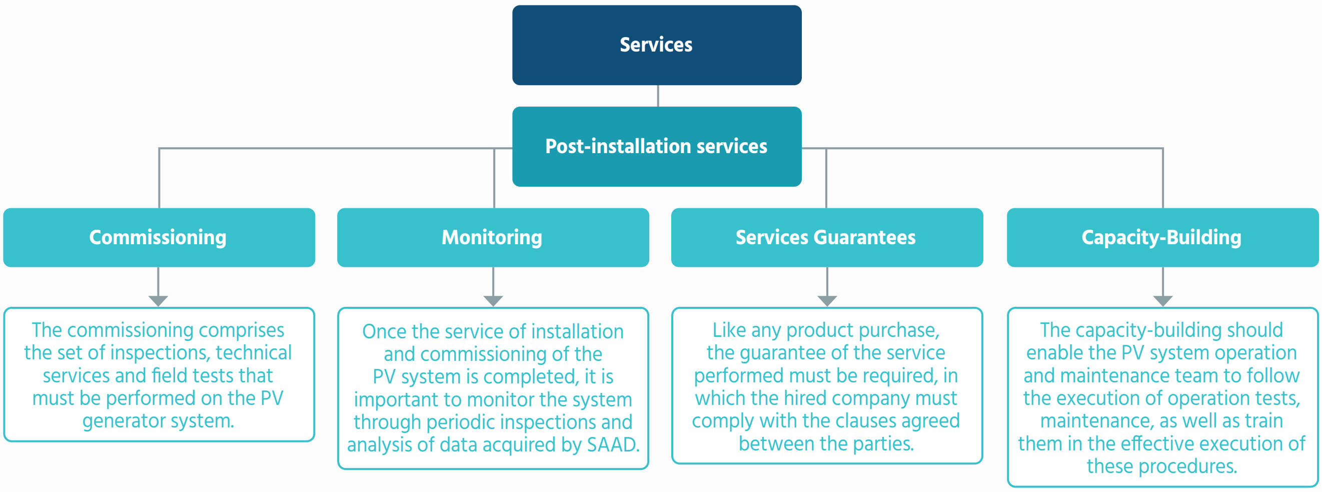
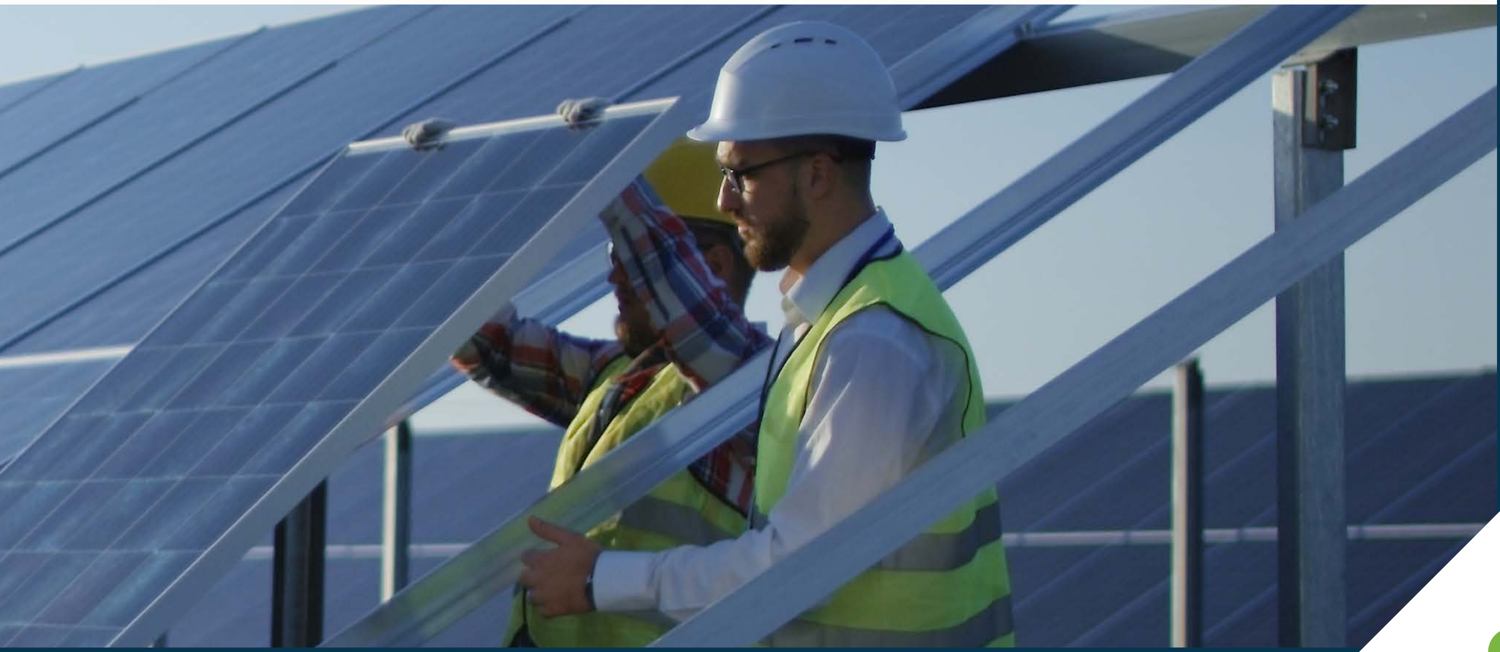


Figure 11: Post-installation services components summary



1.5. Best practices in elaboration of Terms of References

The document entitled terms of reference (ToR) is an integral part of the procurement process. It defines the project specifications and contains the necessary elements for successful procurement and implementation. The best practices outlined below refer to the establishment of technical criteria that aim to ensure high quality when procuring equipment and services.

The ToR should include requirements to verify the technical qualification of the proponents, including proven past experience in executing projects similar to the one in question. Examples of these requirements may be found below, with brackets representing numbers to be defined case by case:

- Past experience implementing at least [x] PV projects of [y] kWp or more;
- Past experience in structural evaluation (when applicable);
- Past experience in the commissioning of at least [x] PV projects of [y] kWp or more;
- Past experience performing measurement and verification (M&V);
- Inclusion of a professional that has been working on the implementation of solar PV projects for at least [z] years;
- Inclusion of an Electrical, Mechanical, Environmental and/or other Engineer on the project team.

Minimum quality or performance requirements may be established in the ToR, defining the way each requirement indicator may impact payment in case it is not met.

A ToR should contain, at a minimum:

- Object ("what")
- Justification ("why")
- Technical qualification requirements ("who")
- Timetable / Schedule with Milestone Dates ("when")
- Location of execution of services ("where")
- Detailed description of services and equipment ("how")

The document entitled terms of reference (ToR) is an integral part of the procurement process.

2. Procurement, financing and implementation

The second section of this report explores different financing options for municipal PV projects of various sizes.

A) PROJECT PREPARATION

Brazilian cities experience routine budget pressures that serve as obstacles for investments in solar PV projects. Observing this restriction, the public and private financial system has been creating alternatives to meet this growing demand, making several credit lines available to enable municipal public administration projects.

Besides financing, the municipalities can count on other strategies to make their projects feasible, such as the use of own capital and attracting private sector investment such as through a public-private partnership (PPP) or a PV system rental model.

Different financial options for municipalities available in the Brazilian market are presented and compared in the following pages.

Brazilian cities experience routine budget pressures that serve as obstacles for investments in solar PV projects.

Editorial credit: Michel luiz de freitas / Shutterstock.com

2.1. Project financing

Loans are quite common in public administration projects. However, this model is not yet widely explored in public distributed generation projects. In recent years, there has been an exponential growth in the renewable energy sector in Brazil, both in consumption and generation, and this growth is accompanied by increased availability of financial products by national and international agents.

For both national and international financing, the business model is virtually the same, since only the source of resources is different. For both, the most common model for municipal PV projects can be found in Figure 12.

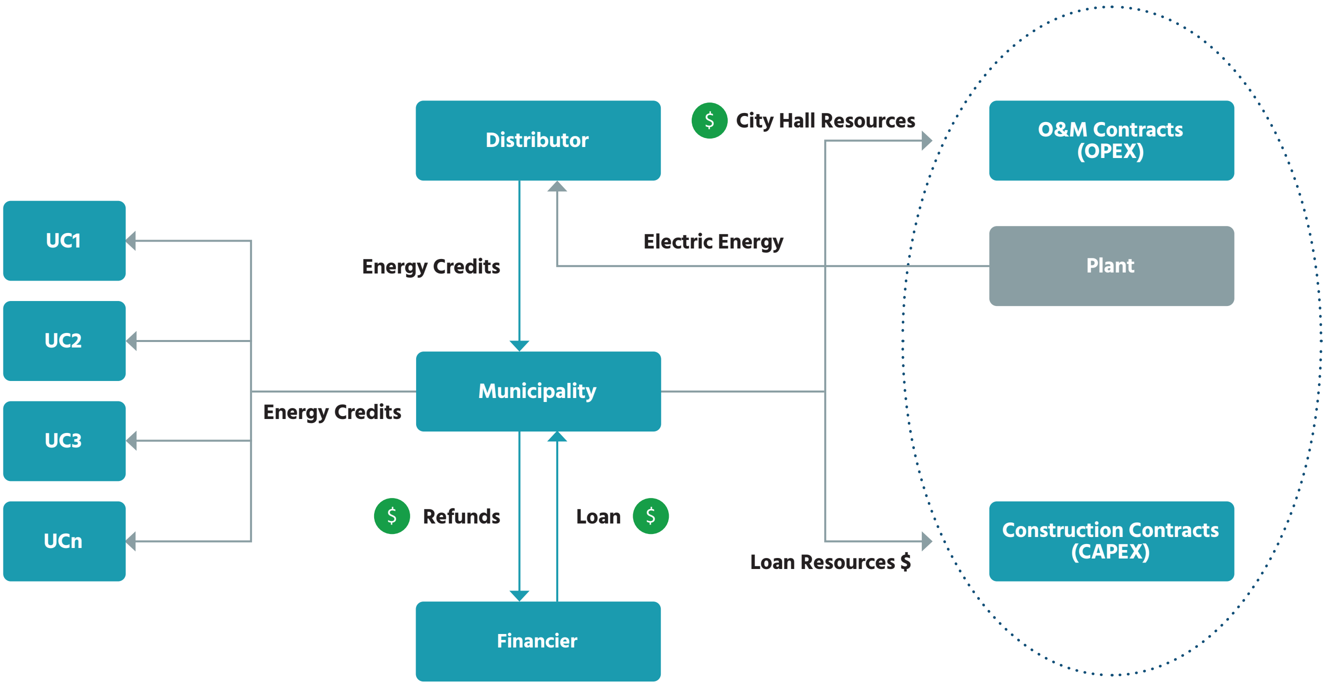


Figure 12: Typical business model for municipal PV project financing. UC = Consumer Unit.

a. National financing

In the Brazilian domestic market, major financial agents that play a large role in the economic feasibility of public projects include the National Bank for Economic and Social Development (BNDES – Banco Nacional de Desenvolvimento Econômico e Social), state development agencies, state and regional development banks, and the Caixa Econômica Federal (CEF).

BNDES - NATIONAL BANK FOR ECONOMIC AND SOCIAL DEVELOPMENT

The BNDES has been one of the main national figures in financing projects regarding high investment value for many years. With low interest rates and long amortization and grace periods, the bank offers attractive loan conditions in the Brazilian market. Another positive factor is the wide variety of products available offered by BNDES, such as *Fundo Clima – Energias Renováveis*[3] and Finem – *Geração de energia*[4]. Some important features of these credit lines are highlighted below.

BNDES FINEM - MEIO AMBIENTE - GERAÇÃO DE ENERGIA

Interest rate (per year):	TLP + 1.05% + financial agent rate (Indirect)[5] TLP + 0.9% + risk rate (Direct)[6]
Charges:	Credit reserve of 0.1% per month levied on the balance contracted and not released, charged monthly Commission for Financial Collaboration of 0.5% (in the case of operations where the Study Commission was applicable, the rate is 0.3%)
Financing:	Up to 80% of the total value of the project, limited to 100% of the fundable items.
Term:	Up to 24 years, including grace period of up to 6 months after the project begins commercial operation.

FUNDO CLIMA - SUBPROGRAMA ENERGIAS RENOVÁVEIS

Interest rate (per year):	1.0% + 0.9% or 1.4% + up to 3% (Indirect) 1.0% + 0.9% + risk rate (Direct)
Charges:	Credit reserve of 0.1% per month levied on the balance contracted and not released, charged monthly
Financing:	Up to 80% of the value of the fundable items
Term:	Up to 16 years, including grace period of a maximum of eight years
Fundable items:	Projects for electricity generation from solar energy, including distributed generation, as well as other items

[3] https://www.bndes.gov.br/wps/portal/site/home/financiamento/produto/fundo-clima

[4] https://www.bndes.gov.br/wps/portal/site/home/financiamento/produto/bndes-finem-energia

[5] In indirect operations, the financing analysis is made by the accredited financial institution, which assumes the risk of non-payment of the operation. Therefore, the institution can accept or refuse the credit application. It is also she who negotiates the financing conditions with the client, such as payment terms and required guarantees, respecting some rules and limits defined by BNDES

[6] It reflects the remuneration to cover the credit risk incurred in direct financing carried out by BNDES, defined in accordance with the BNDES Credit Policy.

STATE DEVELOPMENT AGENCIES, STATE AND REGIONAL DEVELOPMENT BANKS AND CAIXA ECONÔMICA FEDERAL

There are several other financial agents besides BNDES in Brazil. For the public administration, the most important are the Development Agencies, Development Banks, and Caixa Econômica Federal, due to their favorable conditions.

Development agencies are financial institutions that usually have a statewide scope. These companies are linked to the government of each state and have mainly the function of stimulating development through loans. Currently, there are 16 development agencies belonging to different states.

State Development Agencies	Abbreviation
AF do Estado Santa Catarina	Badesc
AF do Rio Grande do Sul	Badesul
AF do Estado de Roraima	Desenvolve RR
AF do Amapá	Afap
AF do Estado do Amazonas	Afeam
AF do Paraná	Fomento Paraná
AF do Rio Grande do Norte	AGN
AF do Estado de Goiás	Goiás Fomento
AF do Estado da Bahia	Desenbahia
AF do Estado de Tocantins	Tocantins Fomento
AF do Estado do Rio de Janeiro	Agerio
AF do Estado de Mato Grosso	Desenvolve MT
AF Paulista	Desenvolve SP
AF do Estado de Alagoas	Desenvolve
AF do Estado do Piauí	Piauí Fomento
AF do Estado de Pernambuco	Agefepe

Table 3: State Development Agencies[7]

Besides the agencies mentioned, there are also regional and state development banks. In practice, they function in similar ways to the development agencies and replace them in some cases. The regional banks also operate as development institutions but are controlled by more than one state so that their operations are restricted regionally.

Development Banks	Abbreviation	Coverage
Banco de Desenvolvimento do Espírito Santo S.A.	BANDES	State
Banco de Desenvolvimento de Minas Gerais S.A.	BDMG	State
Banco Regional de Desenvolvimento do Extremo Sul	BRDE	Regional
BADESUL Desenvolvimento S.A.	BADESUL	Regional
Banco da Amazônia S.A.	BASA	Regional
Banco do Nordeste	BDE	Regional

Table 4: Development Banks[8]

In recent years, there has been an exponential growth in the renewable energy sector in Brazil, both in consumption and generation, and this growth is accompanied by increased availability of financial products by national and international agents.

[7] https://www.scielo.br/scielo.php?script=sci_arttext&pid=S0104-06182019000100012
[8] https://www.scielo.br/scielo.php?script=sci_arttext&pid=S0104-06182019000100012

The other financial institution is Caixa Econômica Federal, which has closed capital and is totally controlled by the federal government.

Category	Main Advantages	Main Disadvantages
BNDES	• Extended financing period (including grace period); • Low rates in the domestic market; • Low rates in the domestic market; • Major financing player of renewable energy in Brazil; • Specific credit line for renewable energies.	• Restriction of equipment and materials that can be financed; • Does not carry out the total financing of the project (up to 80%); • Credit lines only for larger projects, at least R$ 3 million for the Climate Fund and R$ 10 million for Finem.
Development Agencies and Banks and Caixa Econômica Federal	• Specific financing programs for municipalities; • Extended financing period (including grace period) longer than commercial banks; • Extended financing period (including grace period) longer than commercial banks; • Can finance smaller projects; • There are credit lines that finance 100% of the project; • Reduced external procedures.	• Higher financing rates than BNDES; • Lower payment and grace period than BNDES offers.

Table 5: Main advantages and disadvantages for State Development Agencies, State and Regional Development Banks and Caixa Econômica Federal

b. International Financing

International institutions are also responsible for providing part of the loans in Brazil. Mostly, there are investment funds and development banks, which in most cases have specific operations for certain purposes. The main focuses are on adaptation projects, general mitigation, REDD (Reducing Emissions from Deforestation and Forest Degradation) mitigation, or in many cases a combination of these focus areas.

The international financing mechanisms have, differently from the national ones, more varied financial products, from the most common ones such as loans, to grants and equities. Frequently, international institutions offer lower interest rates and longer repayment terms than national ones. However, access to international resources is more complex and time-consuming.

The list of funding institutions can be quite extensive, and it is not convenient to list all of them. However, the Ministry of the Environment (MMA – Ministério de Meio Ambiente) has produced a table with several of the main institutions with some extra information regarding financing conditions[9].

In addition, to be used as a reference of information, there is the System of Public Debt Analysis, Credit Operations and Guarantees of the Union, States, and Municipalities[10] (SADIPEM - Sistema de Análise da Dívida Pública, Operações de Crédito e Garantias da União, Estados e Municípios) database, which contains information on the credit operations that municipalities, states, and public companies have carried out with international financing agents.

The table below lists the main advantages and disadvantages for municipalities to obtain financing through international financial institutions.

Main Advantages	Main Disadvantages
• Low financing rates; • Extended financing period (including grace period); • There are options that use local currency.	• Requirement of demanding environmental and social considerations; • Rates are linked to the international index (in some credit lines); • Potential exposure to exchange rate variation (in some credit lines); • Demanding procedures to access the resources.

Table 6: Main advantages and disadvantages of international loan

[9] https://www.mma.gov.br/apoio-a-projetos/fontes-de-financiamento

[10] https://sadipem.tesouro.gov.br

2.2 Public-Private Partnership (PPP)

The Public-Private Partnerships (PPP) model is characterized by the presence of a concessionaire, to which the public administration grants responsibilities through a concession. PPPs have been gaining space in private investments in municipalities. Law 11.079/2004[11] regulates PPPs in two concession modalities: sponsored or administrative. The law also determines specific conditions for a PPP to be established, such as:

Duration: the service must last between 5 and 35 years (including any extensions)

Values: the value of the contract cannot be less than 10 million BRL (value updated by Law 13.529/2017). There is no maximum.

Services: contracts whose only objectives are the supply of labor, supply and installation of equipment or execution of public works are not eligible.

In this business model, the private initiative can provide the necessary investment, carry out the installation, maintenance and operation of the system, monitor the performance of the PV plant and also act in the management of the compensation of energy credits for public buildings in the municipality. The figure below illustrates a typical business model that can be applied in establishing a PPP for PV generation.

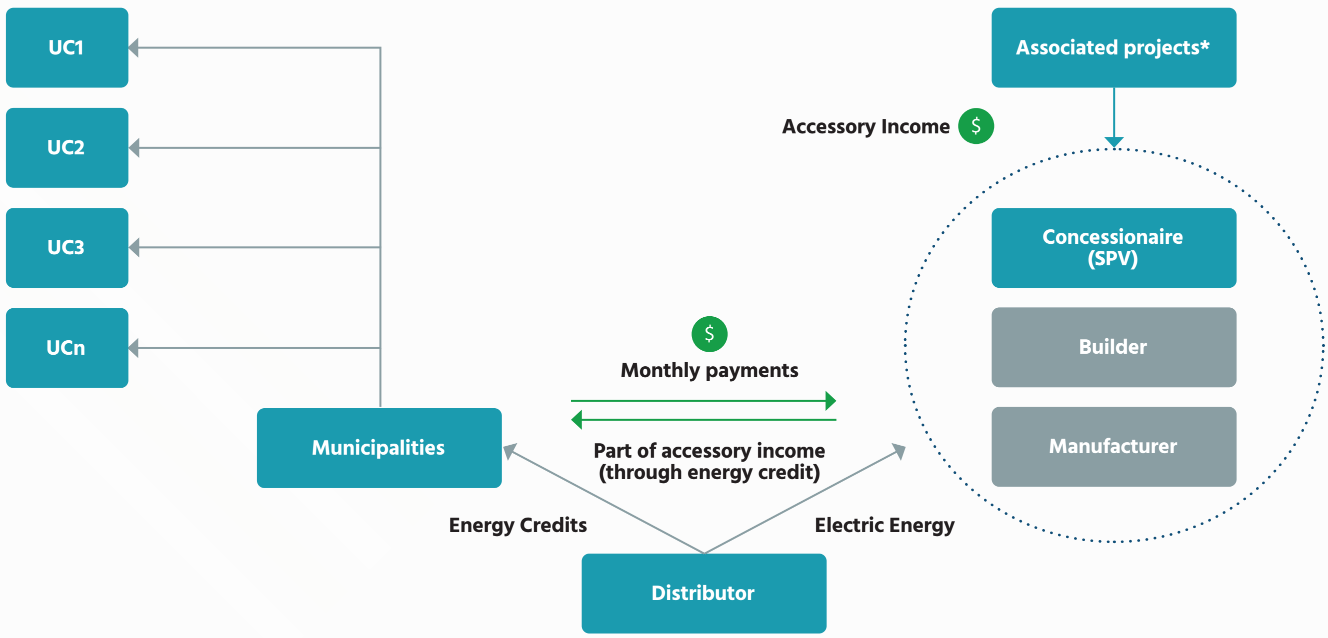


Figure 13: Typical business model for administrative concession for a PPP. UC = Consumer Unit. SPV = Special Purpose Vehicle.

Usually, the concessionaire is a Special Purpose Vehicle (or corporation) – SPV or SPC – formed by the company or by a consortium of companies winning the public bidding, which may include, among others, an operator, a financier and an equipment manufacturer. The return on investment occurs through monthly payments by the municipality, linked to power generation performance. Furthermore, the company or consortium of companies that have been awarded with the concession to build and operate the plant is chosen by offering the lowest monthly payment by the city.

[11] http://www.planalto.gov.br/ccivil_03/_ato2004-2006/2004/lei/l11079.htm

* Associated projects are ways that the concessionaire can generate extra income besides the monthly payments of the municipality. In most of the contracts analyzed there is this possibility. For example, the concessionaire my install PV panels to exploit them through leasing to third-party private companies.

One possible modeling for PPP is Build, Operate and Transfer (BOT). In the BOT, one party, whether a public or private entity ("Grantor"), grants the other party ("Entrepreneur") the right to design, build and operate a business at a location owned by the Grantor for a certain period of time, the operational core of which is a concession contract or a private instrument entered into between the parties, as the case may be. However, unlike the PPP, the modeling of the BOT must provide for a period at the end of the project in which the concessionaire transfers the management of the unit back to the Grantor. In a PPP, this issue must be agreed between the parties and may be associated with the payment of a fee.

In addition, each municipality may have its own legislation related to the creation of a PPP, establishing minimum and maximum contract values and minimum service provision time, for example. The clear understanding of this legislation is very important to make the realization of the projects possible.

The table below presents data related to four different recent public bids in Brazil for the establishment of PPPs involving the construction of PV generation plants.

Grantor	CODANORTE	Piauí	Uberaba	Goianésia
Public Entity	Consortium of municipalities	State	Municipality	Municipality
Publication date of the notice	2018	2019	2019	2020
Modeling	Administrative Concession	Administrative Concession	Administrative Concession	Administrative Concession
Criteria for rating	Lower monthly payment	Lower monthly payment	Lower monthly payment	Lower monthly payment
Plant Destination after contract	Grantor	State Government	Grantor	Grantor
Concession Time (years)	1 + 25	1 + 24	1 + 25	1 + 24
Energy destination	Building and public lighting installations of city halls	Piauí state government building facilities	Part is for city hall and the rest can be exploited by the concessionaire by leasing	Part is for city hall and the rest can be exploited by the concessionaire by leasing
Designed power	5 MWp	5 MWp	Three plants of 5 MWp each	3 MWp
Minimum mandatory generation	8.7 GWh/year	7.8 GWh/year	19.5 GWh/year	2.0 GWh/year
CAPEX (BRL)	R$20.5 million	R$21.8 million	R$61.6 million	R$10.6 million
Basis for calculating the monthly remuneration	After 20% electricity expense savings	After 18% electric power expense savings	After reaching Internal Rate of Return (IRR) equal to Hurdle Rate of 9.47%	After reaching Internal Rate of Return (IRR) equal to Hurdle Rate of 7.14%
Current step (Update date 10/11/20)	Bidding process	Contract signature	Contract signature	Bidding process
Link to bidding documents	PPP-CODANORTE	PPP-Piauí	PPP-Uberaba	PPP-Goianésia

Table 7: Studied cases of PPP.

PPP OF DISTRIBUTED GENERATION WITH DISTRIBUTION CONCESSIONAIRES

Another viable PPP model is the establishment of a partnership between municipalities and electricity distributors. Many of the distributors already have investments in solar energy, such as CPFL Renováveis[12], ENEL X[13] and CEMIG SIM[14]. The establishment of partnerships with municipalities can be positive for both, due to the previous knowledge of the utility companies in PV solar energy and the potential for financial savings for municipalities.

Like other possible business models, the establishment of a PPP brings with it a series of advantages and disadvantages that should be evaluated in order to verify which model is more adherent to projects under development. The Table 8 presents the main advantages and disadvantages identified.

Main Advantages	Main Disadvantages
• Increases cooperation between private sector and municipality; • Energy cost reduction for the municipality without depending on financial disbursement; • Quick and efficient delivery of projects; • The municipality shares the risks with the private institution; • Monthly payment by the municipality can be linked to the performance of the power plant; • At the end of the concession term the power plant is transferred to the public entity; • The municipality uses the knowledge of the private sector in the construction and operation of the power plant.	• It is a fairly new business model, there are still no PV plants working with this model in Brazil; • Establishment of a long-term contract; • Does not eliminate the costs of the municipality with energy, just reduces the tariff paid; • Risk of changes in legislation, reducing the discount provided in the energy tariff over the years. • The private sector partner may go bankrupt or need to renegotiate the agreement.

Table 8: Main advantages and disadvantages for PPP for municipalities

[12] http://www.cpflrenovaveis.com.br [13] https://www.enelx.com/br/pt [14] http://cemigsim.com.br/index.html

2.3 Asset Rentals

The asset lease or rental model is a kind of atypical contract (regulated by Law 13.190/2015 and by article 47-A of Law 12.462/2011, the "RDC Law", explained below) which is quite innovative in the Brazilian legal field, even more so in the renewable energy sector in Brazil. So far, there is no specific law that regulates this contractual instrument for public administration, it is only necessary that it does not contradict the general guidelines of Law 8.666/93 and its subsequent amendments that establish the principles that govern public bidding.

One of the changes in Law 12.462/2011, which established the Differentiated Regime of Contracting (RDC – Regime Diferenciado de Contratação), was with article 47-A, added by virtue of Law 13.190/2015 and which determines some provisions for the regime of leasing:

- **1.** The contracting referred to in the main section is subject to the same dispensation and unenforceability of bidding discipline applicable to common leases.
- **2.** The hiring referred to in the main section may provide for the reversion of the assets to the public administration at the end of the lease, provided that it is established in the contract.
- **3.** The value of the lease referred to in the caption sentence may not exceed, per month, one percent (1%) of the value of the leased goods.

In practice, what occurs is a bidding process in which the classification criteria is the lowest monthly rental value (VML – Valor mensal de Locação) offered for the rental. The winning consortium or company must have measured the costs with works, financing charges, taxes, administrative expenses and the profit margin. Then, an SPV must be constituted for the implementation of the contract.

The consortium must then install the plant according to what was defined by the grantor. Once the work is completed, the ownership and benefits of the work are transferred to the city hall, which must make payments for the lease in a periodic manner and established in contract. This is a factor that occurs differently from the concession where the operation and maintenance are still the responsibility of the concessionaire, whereas with leasing these duties are transferred to the city hall.

Generally, the contracts have a duration between 10 and 30 years, during which the administration will make the payments related to the rent with fixed value corrected for inflation. At the end of the period the PV plant can be transferred with or without additional costs to the municipality, or the contract can be extended. Figure 14 illustrates a generic business model for this modality.

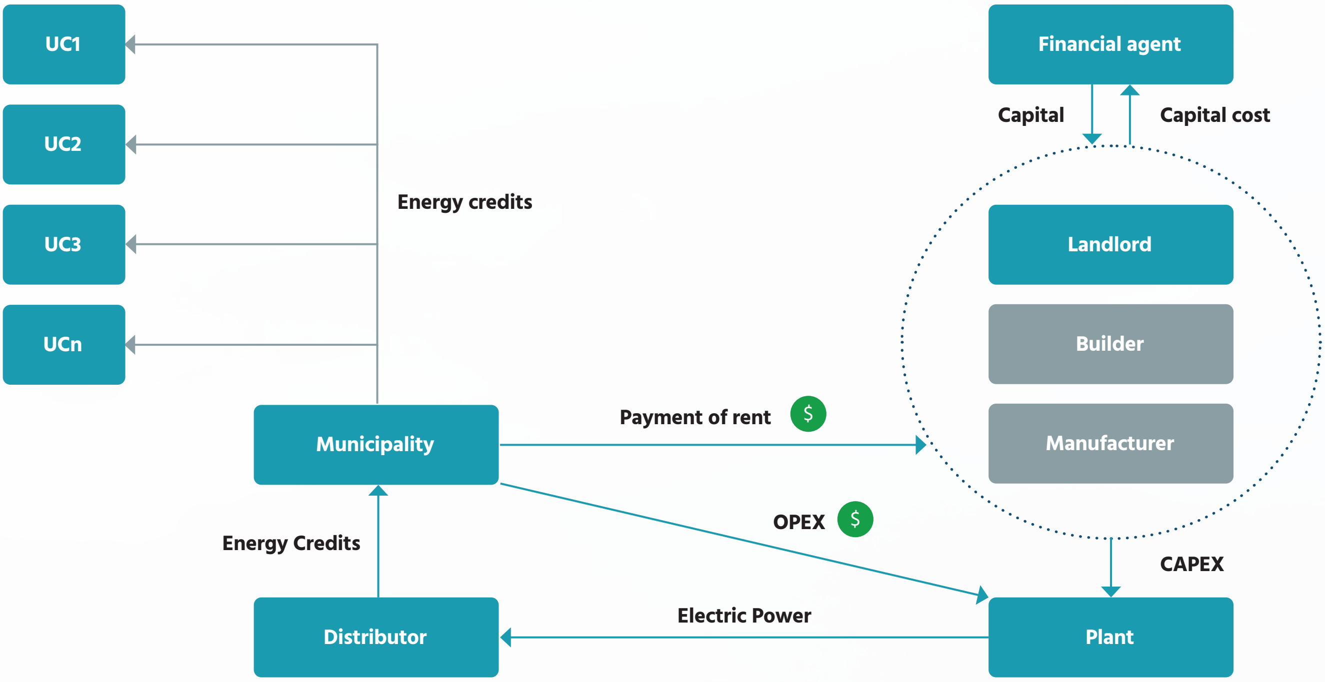


Figure 14: Business Model for Asset Rentals. UC = Consumer Unit.

The table below describes the main advantages and disadvantages of the lease or rental model for municipal governments.

Main Advantages	Main Disadvantages
• Energy cost reduction for the municipality without depending on financial disbursement; • Quick and highly efficient delivery of projects; • The municipality shares the construction risks with the private institution; • Monthly payment by the municipality is fixed, thus it can be adequately budgeted in the future; • At the end of the concession term, the power plant can be transferred to the public power; • The PV plant is built by a private company with consolidated knowledge and experience in the technology; • The power plant can be built on several public buildings, increasing energy cost reduction for the city.	• It is a new business model, there are still no PV plants working from this model; • Establishment of a long term contract; • It does not eliminate the costs of the municipality with energy, just reduces the tariff paid.

Table 9: Main advantages and disadvantages for Asset rentals

2.4 Own Investment

The financing of projects from investment with own treasury resources is quite common among municipalities. The main advantage of this mechanism is the low costs associated with the life of the project, because there is no need to pay for the capital invested. Thus, based on economic analyses, payback and Net Present Value (NPV) tend to be more advantageous compared to projects financed by financial agents. If the public administration has the resources available to make the initial investment and is in accordance with Complementary Law No. 101/2020, known as the Fiscal Responsibility Law, which determines the limits of indebtedness of municipalities, the alternative of own investment may be interesting.

However, the high initial value often required to install a PV plant is a critical factor, because it is necessary to make the investment of the entire project at the beginning, before the plant operates, posing several financial and accounting risks to the municipality.

Main Advantages	Main Disadvantages
• No payment of interest; • More financial return with the project; • Limit the need for long term contracts.	• Municipality assumes the project and technology risks; • Large initial financial disbursement.

Table 10: Main advantages and disadvantages for own investment

2.5 Energy Efficiency Program (PEE- Programa de Eficiência Energética)

The PEE is an official program run by the National Electricity Regulating Agency (ANEEL - Agência Nacional de Energia Elétrica) and was designed to promote the efficient use of energy by financing projects related to improving energy efficiency. Since its inception through 2019, it was responsible for financing 4,850 projects concluded to date, saving about 63 TWh, thus establishing itself as a program with large social and environmental benefits for Brazil.

The rules of the program are governed mainly by Law No. 9.991/2000 and the ANEEL Energy Efficiency Program Procedures Manual (PROPEE - Procedimentos do Programa de Eficiência Energética), Normative Resolution 830/2018. This regulation establishes that all energy utility companies must invest 0.5% of their yearly net operating revenue (NOR) towards PEE projects, and establishes the program's guidelines.

Annually, the distributors publish a public notice through which third parties may submit the projects to be evaluated. These projects may include distributed generation from renewable sources, as long as they are accompanied by energy efficiency measures, such as the exchange of equipment. The main parameter analyzed to determine the classification is the cost-benefit ratio (RCB – Relação Custo-Benefício), however the total score is composed of several elements that can be consulted in the Practical Guide[15] prepared by ANEEL.

To apply for the PEE, there are two categories of projects that can enter the public call of the distributors. The first is for non-profit consumer units, such as the public sector and educational buildings, which are funded by non-refundable funds and therefore do not have to return the amount received; and the other is for profit units, in other words, most of the private sector. In the latter, the utility company actually makes a zero-interest loan to the consumer, which must be paid back within 10 years with only monetary correction, so there is no capital cost associated with this loan. It is mandatory to perform Measurement & Verification (M&V) according to ANEEL's M&V Guide, the result of which will determine the installments of payments back to the utility company.

Therefore, the PEE is an alternative for financing energy efficiency improvement projects, which in this case includes distributed PV generation. As it is non-refundable for the public administration, the use of the program to enable distributed generation projects is perhaps the most attractive among the options available to municipalities. However, there are some limitations to access this funding. The project must be associated with an improvement of energy efficiency, the value of the project is limited according to the each utility company's revenues, and the submittal of proposals can be a bureaucratic process that may require the aid of consultants and often results in projects that are not selected for documental or administrative reasons.

Main Advantages	Main Disadvantages
• Grant funding for the public administration, with no need to return the money.	• Limitation of the available budget; • Distributed generation alone is not eligible without the inclusion of energy efficiency actions; • The public selection process has very detailed criteria sometimes difficult for municipalities to meet. • Professionals with knowledge in distributed generation, energy efficiency and M&V, whether public servants are hired consultants, are needed to adjust the project to the conditions of the public call for proposals.

Table 11: Main advantages and disadvantages of PEE for the municipality

[15] https://www.aneel.gov.br/documents/656831/15104008/Guia+CPP+-+Proponentes.pdf/ba29a041-83f0-41be-956f-50885b709e33?version=1.0

2.6 Valuation of plant size by recommended financial model

As demonstrated above, each way of making the project financially viable, whether through financing, equity, private capital or public resources, has advantages and disadvantages that must be observed. Based on these, Table 12 presents a preliminary evaluation indicating the likely most appropriate financial alternative according to the size of the PV plant. This is, of course, a simplification; an in-depth evaluation of each project is nevertheless necessary before the decision can be made.

Plant Size	Estimated Value Range[16]	Recommended alternative
Microgeneration (up to 75 kWp)	below R$ 300k	• Energy Efficiency Program • Own Investment
Small minigeneration (75 kWp to 200 kWp)	R$ 300k to R$ 700k	• Development Agencies • Development Banks • Public Banks
Medium-sized minigeneration (200 kWp to 2 MWp)	R$ 700k to R$ 6.5 million	• BNDES (from R$ 3 Million) • Rental Model
Large minigeneration (2 MWp to 5 MWp)	R$ 6.5 million to R$ 16 million	• National Financing • Rental Model
Several large minigeneration plants (total power above 5 MWp)	Greater than R$ 16 million	• BNDES • PPP • International Financing

Table 12: Recommended financial model by plant size

[16] The price range presented was estimated from GREENER reports (https://www.greener.com.br/), where the following values were considered:
- 3.52 R$/Wp for systems between 31 and 100 kWp,
- 3.22 R$/Wp for installations between 100 kWp and 5 MWp.

2.7 Success Cases

CITY OF CÁCERES - MATO GROSSO

Origin of the Investment:	Financed by Caixa Econômica Federal
Investment:	R$ 10.7 Million
Objective:	Installation of PV plants to reduce the municipality's energy costs.
More information:	https://caceresnoticias.com.br/politica/prefeitura-de-caceres-consegue-financiamento-de-mais-de-10-milhoes-para-energia-solar-em-escolas/652260

CITY OF SANTA ROSA - RIO GRANDE DO SUL

Origin of the Investment:	Financed by Caixa Econômica Federal and FINISA
Investment:	R$ 1.3 Million
Objective:	Installation of PV plants to reduce the energy costs of 25 municipal schools, seeking a reduction of R$ 500k per year.
More information:	https://www.santarosa.rs.gov.br/noticias_ver.php?id=7150

CITY OF RIO GRANDE - RIO GRANDE DO SUL

Origin of the Investment:	Compensation measures applied to companies that caused environmental damage in Rio Grande
Investment:	R$ 90k
Objective:	Installation of PV plants to supply all the electricity consumed by two municipal schools and generate energy credits for other buildings.
More information:	http://www.riogrande.rs.gov.br/consulta/index.php/noticias/detalhes+2c8ae4,,prefeitura-inaugura-sistema-de-captacao-de-energia-solar-em-duas-escolas-da-rede.html#.X4m2LtBKjlU

SEVERAL MUNICIPALITIES OF PARANÁ[17]

Origin of the Investment:	A portion of the resources is from the PEE of COPEL (Companhia Paranaense de Energia), a non-repayable grant. The rest is complemented by City Hall with own resources or obtained by the Municipal Financing System (SFM – Sistema de Financiamento Municipal), released by the State Department for Urban Development and Public Works, with the operation of the autonomous social service of ParanaCidade.
Investment:	R$ 46.5 Million
Objective:	Installation of PV systems in 224 schools in seven municipalities of the state of Paraná, using the PEE's resources and loans from Paraná State.
More information:	https://radioalianca.com.br/regiao/prefeitura-de-ita-licita-sistema-que-gera-energia-solar-para-atender-demanda-de-predios-publicos

CITY OF ITÁ - SANTA CATARINA

Origin of the Investment:	PEE - CELESC (Electricity Company of Santa Catarina), non-repayable.
Investment:	R$ 950k
Objective:	Energy efficiency of 24 public buildings in the municipality, with the replacement of approximately 1,500 low efficiency light bulbs with LED lamps, in addition to the installation of two 75.24 kWp PV systems. At the end of the project, the municipality will save approximately R$ 145,000 per year on electricity bills.
More information:	https://radioalianca.com.br/regiao/prefeitura-de-ita-licita-sistema-que-gera-energia-solar-para-atender-demanda-de-predios-publicos

[17] Balsa Nova, Cascavel, Fazenda Rio Grande, Foz do Iguaçu, Maringá, Paranavaí and São José dos Pinhais

2.8 Best practices regarding bids and hiring

This section summarizes important aspects that should be considered when preparing the Terms of Reference and other bidding documents as well as preparing financing documents *(The information below can be organized into a Box format, as an overview of which services should be contracted/ procured and when, such as basic project, executive project, roof structural analysis, implementation, etc.)*

While technical teams are sizing the PV system and defining sites and feed-in modalities, described in a previous report, other activities must be developed in parallel to ensure everything will be ready.

Social / Environmental Impact Assessments may be required and differ depending on project size and source of financing.

The **procurement model** must be selected, as this strongly impacts the timeline and documents to be developed. Options include **EPC** (Engineering, Procurement, Construction) using **public bidding** *(licitação pública)* or ***pregão eletrônico*** (price-only); **energy performance contracts** using **RDC** *(Regime Diferenciado de Contratação);* **PPP's** (public-private partnerships); **leasing; BOT** (build-operate-transfer); among others.

A ***projeto básico*** (basic project design) signed by an engineer is an important component of the tendering process.

Financing documents must be prepared and submitted if loans are to be applied for. Documents differ for each bank or institution.

Procurement documents must be elaborated, such as the *edital* and the Terms of Reference (ToR), containing full technical specifications outlining all technical information related to the project, including applicable standards. The ToR should contain enough data and requirements in order to ensure high project quality, but must take care to be fair and compatible with standard market practices in order to attract companies and ensure competition.

The project scope to be contracted may include: ***projeto executivo*** (executive project design), **roof structure verification** by a civil or structural engineer, **project implementation, connection to the electricity grid, registration with the utility company, O&M** (operations & maintenance), and **M&V** (measurement & verification).

Project management and **commissioning** are the municipality's roles during implementation, but may be executed by a third party.

M&V should be enforced to adequately determine energy savings and may be required depending on contract model and financing source.

3. Conclusion

Municipal solar PV projects bring many benefits to cities. However, these are not simple projects and should be well planned, managed, designed, and implemented in order to maximize positive impacts in the smoothest way possible.

Training of internal staff from different municipal departments is important so that all internal stakeholders of these multidisciplinary projects are aligned in terms of thinking and general knowledge.

The technical and procurement departments should have enough technical information about PV projects so that they can successfully prepare technical specifications and bidding documents that will result in the engagement of a well-qualified, experience company to carry out the project.

Finally, even with the growing availability of credit lines and different business models for solar energy, municipalities need to be analyzed when choosing the financial option to make their distributed generation projects viable. A critical analysis of the adherence of the chosen model to the project to be developed is necessary and allows municipalities to direct their resources, make partnerships with private institutions or even contract a debt, when this is the best way according to the project and its priorities. Many financing options are available, and defining the best one as early as possible in the process is key to the success of PV projects.

Municipalities can truly play a leading role in the fight against climate change. Energy efficiency and distributed generation are important and complementary ways that they can do that, starting today.

Acknowledgements

This report was written by:
Alexandre Schinazi (Mitsidi Projetos),
Bruno Chaves (Mitsidi Projetos),
Rosane Fukuoka (Mitsidi Projetos),
Thiago Osawa (Mitsidi Projetos),
Kathlen Schneider (IDEAL),
Lucas Nascimento (IESS),
Anelise Medeiros Pires (IESS),
Pedro Henrique Veríssimo (Fotovoltaica-UFSC),
and Ricardo Rüther (Fotovoltaica-UFSC & IDEAL).

Suggested citation:
C40 Cities Finance Facility (2019).
'The solar PV revolution in Brazil: How cities can take advantage - Part 2: Technology and financing'

Design by:
www.blushcreate.com

C40 Cities Climate Leadership Group
3 Queen Victoria Street, City
London EC4N 4TQ
United Kingdom

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
Potsdamer Platz 10
10785 Berlin
Germany

E contact@c40cff.org
W c40cff.org

Funding partners:

Federal Ministry for Economic Cooperation and Development

CIFF CHILDREN'S INVESTMENT FUND FOUNDATION

UK Government

USAID FROM THE AMERICAN PEOPLE

Implementing agencies:

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

C40 CITIES

Institutional Supporter:

ABSOLAR Associação Brasileira de Energia Solar Fotovoltaica