Inter-American Development Bank

Energy Savings Insurance

Standard Platform for Structuring, Evaluating, and Monitoring Investment Projects in Energy Efficiency and Distributed Generation with Guaranteed Energy Performance

Rodrigo Chaparro
María Netto
Elisabeth Díaz
Adalberto Padilla
Krystian Muñoz
Raúl Riveros

Institutions for Development Sector

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ABSTRACT

Efforts to promote green investment with new financial instruments are growing; however, the speed at which markets are adopting these instruments has been limited by heterogeneity and a lack of systematic information to assess the "greenness" of investments. The Inter-American Development Bank (IDB) has developed a standard platform for structuring, evaluating, and monitoring energy efficiency and distributed generation investment projects with guaranteed energy performance. The platform seeks to fill this gap and drive technological modernization by promoting investments in more efficient technologies, where savings and energy generation are guaranteed through a combination of performance contracts, verification frameworks and insurance as a risk-mitigation mechanism. The platform includes a tool for estimating the savings or energy generation of the proposed project, checklists for the verification and review of adequate performance, and a format for monitoring results once the project is implemented. The tool for estimating the savings or energy generated by a project follows the logic of establishing a baseline and then determining the impact of the new technology through improvements in performance or generation rates, following the technical guidelines of the ISO 50000 series family of international standards. This document presents the platform's conceptual and practical aspects, includes protocols for 12 technologies applicable to both new and replacement projects, and presents examples for three specific projects. The platform's primary users are technology providers, validation entities, financial institutions, and insurers.

JEL codes: H41; O12; O13; Q12; Q13; Q18

Keywords: energy efficiency, renewable energies, financial mechanisms, climate finance, financing, ISO 50000 standards, ESI model, energy savings insurance

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ACRONYMS AND ABBREVIATIONS

EE	Energy efficiency
RE	Renewable energy
ESI	Energy Savings Insurance
EVO	Efficiency valuation organization
EVPI	Environmental Performance Index
ENPI	Energy Performance Index
FPI	Financial Performance Index
EAR	Emissions avoided rate
EGR	Energy generation rate
CAR	Cost avoidance rate
IPMVP	International Performance Measurement and Verification Protocol
ISO	International Organization for Standardization
MRV	Measurement, reporting, and verification
EPIP	Energy Performance Improvement Percentage

EXECUTIVE SUMMARY

A project that guarantees the recovery of an investment through guarantees is more attractive to investors and financial institutions. In projects where the guarantee is established on assets that entail a certain level of technological risk, both the financial entity and the insurer will need to evaluate the investment's technical reliability. Without a reliable evaluation tool and methodology, the achievement of financial closure supported by a guarantee will not be possible. On the other hand, increased efforts to promote green investment with new financial instruments such as green bonds and green insurance are limited in their implementation by the heterogeneity of investments and by the lack of systematic information on projects and on the "green" characteristics of the specific investments financed through these new instruments. The collection of this type of information is a public good that has yet to be solved by the market. The standard platform described below aims to fill this information gap.

The platform allows for the structuring, evaluation, and monitoring of energy efficiency and distributed generation investment projects with guaranteed energy performance. As a whole, it seeks to foster technological modernization by promoting investments in more efficient technologies, where energy savings or generation are guaranteed through a combination of performance contracts, validation schemes and financial guarantees as a risk mitigation mechanism. The different platform elements were developed and field-tested with suppliers, various national development banks and a number of Latin American validating entities within the framework of the "Regional Cooperation RG-X1258 Energy Savings and Risk Mitigation Insurance - ESI", financed with support from the Government of Denmark.

The platform includes a tool for estimating the savings or energy of the proposed project, checklists for validation and verification of correct performance, and a format for monitoring results once the project is implemented. The platform is complemented by an electronic system, where market players who are part of the project may track project status. The primary users of the platform are the technology providers, for whom it facilitates the structuring, estimation of savings or generation and definition of measurement protocols for their projects, as well as the validating entities, who may provide standardized evaluation of the rationale for energy savings, the proposed instrumentation, along with offering concepts on deviations in savings or guaranteed energy generation during the life of the project. Secondly, financial institutions and insurance companies may use the platform to determine when a project has completed the technical evaluation in order to grant the corresponding financing or guarantee.

The tool for estimating savings or energy generated by a project first establishes a baseline and then determines the new technology's impact through improvements in performance or generation rates, following the technical guidelines of the ISO 50000 series family of international standards applicable to energy management systems. This approach allows for the effect of changes in production that may affect the total energy consumption of a facility or process to be isolated, allowing suppliers to make a savings promise based on proper selection, installation, use and maintenance of equipment.

The tool is mainly applicable in projects where there is a predominant technology. To date, protocols have been developed for 12 technologies, which may be used in both new and substitution projects in energy efficiency (energy performance) and power generation initiatives.

The purpose of this document is to guide suppliers in the platform's conceptual and practical aspects. It is divided into three sections. The first provides a detailed explanation of the conceptual basis for the methodology used to calculate the guaranteed energy savings in energy efficiency projects and the guaranteed energy produced in generation projects. The second details the elements of the platform, tool and formats developed for the estimation, evaluation and monitoring of energy savings or generation promised by technology. The final section contains examples of the tool's use in three specific projects.

INTRODUCTION

Efforts to promote green investment with multiple financial instruments, such as green bonds and "green insurance", are growing. However, the speed at which markets are adopting these instruments has been slowed by the heterogeneity of green investments and the lack of systematic information on the characteristics or attributes that make specific investments financed through the new instruments "green". The collection of this information is a public good that the market has not solved.

A project that guarantees the recovery of the investment through a guarantee is more attractive to investors and financial institutions. In those projects where the guarantee is established on an asset that implies a certain level of technological risk, both the financial entity and the insurer will require a mechanism to evaluate the technical reliability of this investment. Without a reliable tool and protocol for such an evaluation, achievement of financial closure supported by a guarantee will not be possible. This is the case for projects where a supplier promises to guarantee savings or energy generation associated with a technological solution in an industry. The financial system and suppliers do not have a standardized scheme that allows them to evaluate the reliability of savings or generation proposals for different technologies, or to monitor project performance. As a result, evaluations become complex and have high transaction costs.

The standard platform described below seeks to fill these gaps in the case of energy efficiency (EE) and renewable energy (RE) investments with guaranteed energy performance. The platform seeks to drive technological modernization by promoting investments in more efficient technologies where savings or energy generation are guaranteed through a combination of performance contracts, validation schemes and financial guarantees as a risk-mitigation mechanism. As a whole, it enables the structuring, evaluation and monitoring of projects.

The platform includes a tool for estimating the savings or the generated energy of the proposed project, checklists for validation and verification of correct performance and a format for monitoring results once the project is implemented. The platform is complemented by an electronic system where market players may track the status of the project. It is aimed at financial entities, insurance companies, suppliers, investors, in addition to the validating entities that act as technical experts in the evaluation of projects. The different elements of the platform were developed and field-tested with suppliers, several national development banks and several validating entities in Latin America and the Caribbean (LAC).

The methodology for estimating savings is based on the concept that introducing more efficient equipment in a process leads to energy savings, which may be quantified from the difference in the energy performance index of the new equipment compared to the old unit or practice, based on energy consumption at the start of the project. This places suppliers in a better position to make a savings promise based solely on proper equipment selection, installation and maintenance. The methodology follows the technical guidelines of the ISO 50000 series family of international standards applicable to energy management systems.

1.

ESTIMATED ENERGY SAVINGS OR ENERGY GENERATED IN ENERGY EFFICIENCY AND RENEWABLE ENERGY PROJECTS

1 ESTIMATED ENERGY SAVINGS OR ENERGY GENERATED IN ENERGY EFFICIENCY AND RENEWABLE ENERGY PROJECTS

The energy savings produced by an energy efficiency project in a facility cannot be measured directly since it represents the absence of consumption or demand of a given energy source. The ideal way to establish this is to measure the energy used before and after project implementation and to observe the difference over a certain period of time (e.g., one year). For the results to be correct, the measurements carried out before and after project implementation must be made under similar operating conditions, which is not always possible, since generally in industries, the variation in energy consumption depends on factors such as production, demand, weather conditions, etc. This would imply having energy audits and continuous measurement systems.

Internationally, there are several protocols for the measurement, reporting, and verification (MRV) of energy savings; some of the best known are the International Performance Measurement and Verification Protocol (IPMVP), developed by the Efficiency Valuation Organization (EVO)[1], and the ISO 50000 standards of the International Organization for Standardization (ISO).[2] The IPMVP introduces the baseline concept as a benchmark for comparison, and offers options for projects with different levels of complexity, whether for complete facilities or individual equipment; the ISO emphasis is on energy management systems. The two protocols are guidelines where the user defines their own tools and indicators for a given project.

One of the significant contributions of the ISO standards is the creation of standard energy performance indicators that make it possible to evaluate how efficiently energy is transformed in a system or equipment, taking into account the relationship between the energy consumed and the useful service produced or "energy end-use" provided by the equipment or technology. These indicators offer an alternative procedure for estimating savings in projects with a single technology or with a predominant one, since it is only necessary to evaluate the difference in energy performance of the existing technology with respect to the most efficient one to be installed under controlled operating conditions and multiply it by the "final energy use", during a determined period of time. To corroborate the results, the performance of the new equipment may be measured once it is in operation and validate if the estimated savings correspond to reality or if there are deviations. The availability of indicators allows project developers to standardize the way in which energy savings are presented and provides financial institutions with a simple and uniform project evaluation tool.

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[1] https://evo-world.org/en/products-services-mainmenu-en/protocols/ipmvp.

[2] https://www.iso.org/iso-50001-energy-management.html.

The efficiency indicator approach allows for the isolation of production factors and requires only occasional specific performance measurements. This methodology's main limitation is that the energy consumption is based on a hypothetical energy scenario; therefore, the baseline energy quantity must be representative of the operating history of the industry in which the improvement is being implemented. A similar performance indicator scheme may be used in power generation projects. In this case, the variable of interest is not savings but generation, which in most cases is easier to measure than energy savings. The following steps are required to calculate a project's effective energy savings or generation:

- Establish the energy consumption to be used as a reference (baseline).
- Establish the proposed performance improvement or power generation with the new equipment.
- Estimate the expected savings or generation oncethe new equipment is installed.
- Define the monitoring system to be used to verify the performance or generation of the new equipment.
- Periodically verify savings or generation being achieved from energy performance measurement.

1.1. MEASUREMENT OF BASELINE ENERGY CONSUMPTION

The information corresponds to the energy consumption within the limits of the project during a given time, prior to the execution of the proposed project. To collect this data, the supplier must identify the energy sources (fuels or electricity) used to operate the technology that will be subject to improvement or replacement in the facility, and carry out measurements of specific parameters or energy audits. Some good practices before proceeding with measurements are:

- Identify the physical limits of the project to be improved in terms of energy consumption. These do not necessarily coincide with the physical limits of the facilities where the project will be located.
- Include all energetics used within the project boundaries.
- Establish and measure the service provided by the energy-consuming system or equipment or the "energy end use" (e.g., m^3 of hot water per year, tons of cooling per year, etc.).
- Establish a fixed reference energy price that will later be used to estimate possible economic compensation for underperformance. It is recommended to use the energy price in a period close to the beginning of the project
- In situations where obsolete equipment is not replaced or the data from existing equipment is unreliable, the technology commonly used in the market for such projects should be used as a reference.

In turn, at the time of making the measurements, the supplier must clearly define the operating conditions of the existing technology to be improved or replaced, taking into account that similar measurements must be used to evaluate the proposed technology; therefore, the operating limits, the parameters to be measured and the periods in which they will be measured must be clearly established under the following guidelines:

- The boundaries should allow for separation of the relevant equipment and areas in the determination of savings/generation from those that are not relevant.

- Key variables or parameters will be measured during the operation of the existing technology to establish the amount of energy it consumes when providing the service. These parameters must be maintained under "controlled conditions" (i.e., at average and/or typical operating values, with a certain degree of tolerance for variation).

- The selected period should cover a complete operating cycle of the company where the project is being implemented; in turn, the most representative period of consumption should be identified and include only periods of time for which all the determining conditions for the energy consumption of the facility are known. The time period immediately prior to project implementation should likewise be used, since a very distant period may not correctly reflect existing conditions. In the case of technologies whose parameters have little variability, a single measurement period may be sufficient, while in the case of technologies with significant variations over time, multiple periods may be required.

1.2. ESTABLISHMENT OF THE PROPOSED PERFORMANCE IMPROVEMENT OR GENERATION WITH THE NEW EQUIPMENT

1.2.1. Energy performance projects

In these projects, establishing the improvement consists of evaluating the percentage reduction in energy consumption at the project limits according to the proposed changes, which will imply having the technical specifications of the equipment to be installed.

The process is detailed as follows: from the energy consumption data of the existing equipment and the "energy end-use", the energy performance index of the existing technology is calculated (ENPI base). In turn, with the efficiency data of the equipment to be installed, the expected energy consumption is determined once the new technology is implemented, as well as its corresponding expected energy performance index (expected ENPI). Once these two indexes are obtained, the percentage of energy performance improvement (PEPIP) is established.

1.

$$ENPI_{base} = \frac{Base\ energy\ consumption}{"Energy\ end\text{-}use"}$$

2.

$$ENPI_{expected} = \frac{Expected\ energy\ consumption}{"Energy\ end\text{-}use"}$$

3.

$$PEPIP_{proposed} = \left[\frac{ENPI_{base} - ENPI_{expected}}{ENPI_{base}}\right]*100$$

In the case of measuring equipment performance over more than one period, the equipment's base ENPI will be the average[3] of the base ENPIs calculated for each period.

"Energy end-use" is the useful service produced by the equipment or technology required by the customer for the operation of its activity, either directly (e.g., tons of frozen product in cold storage) or indirectly, in order to achieve the conditions that allow the goods or services in question to be produced (e.g., hours of lighting). Table 1 presents the commonly used parameters for "energy end-use" in different technologies.

[3] Only in the case of lighting technology are the indicators obtained for each period added together instead of averaged.

Table 1. Commonly Used Parameters for "Energy End-use"

Technology		"Energy End-use"	Unit
Energy performance	Water boiler	Sanitary hot water	m^3
	Lighting	Hour-Light	h
	Electric engine	Mechanical energy delivered	hp-h
	Air conditioning	Extracted thermal energy	BTU
	Refrigeration	Extracted thermal energy	MBTU
	Solar thermal system	Sanitary hot water	m^3
	Oven/Dryer	Product mass	kg
	Air compressor	Compressed air	l
	Cogeneration	Thermal: Thermal energy transferred	kWht
	Cogeneration	Electric: Electric energy	kWhe
	Electric motorcycles	Distance traveled	km
Generation	Photovoltaic system	Electricity	kWhe
	Biogas generation	Biogas	m^3

Source: Authors' elaboration.

To estimate what the annual "final energy use" will be, the technology provider must determine the effective hours of operation of the equipment or technology in a year, taking into account the following factors, among others: i) days the equipment operates; ii) on/off controls; iii) variables that determine the increase or decrease in useful service (for example, the hours an oven operates in standby mode versus the hours it remains on with a product inside), and iv) seasonal demands of the product or service.

Since the "energy end-use" may vary each year due to changes in production, it is recommended that the technology provider and its customer agree on a fixed annual "energy end-use" figure for the entire life of the project, as this eliminates the risk of demand variation and facilitates the determination of the savings promise and the annual "guaranteed energy savings".

1.2.2. Generation projects

In generation projects, savings are not guaranteed, but rather the amount of energy that the installed system will generate annually. This means that it is not necessary to calculate a performance improvement but rather an expected rate of energy generated. In these cases, the baseline energy consumption is used by the supplier to determine the minimum specifications of the solution to be implemented, as well as to estimate the impact on emissions reduction and in financial terms.

The generated energy rate is then obtained from the renewable energy data to be generated or supplied, defined by the supplier based on the efficiency data of the equipment to be installed, the consumption of the equipment that is part of the new project (pumps, motors, etc.) and the amount of renewable resources available at the project site (e.g., radiation), collected from reliable databases.

4.

$$IEG_{Estimated} = \frac{Renewable\ energy\ supplied}{Renewable\ resource}$$

The aforementioned precepts on measurements also apply to these projects. In situations with more than one power generating system of equal technology, the "renewable energy supplied" is the sum of the energy supplied by each system in each period. However, in these cases, the "renewable resource" corresponds to the total available per period. In other words, the installed systems will generate their energy based on equal amounts of "renewable resource". In the case of estimating energy generated indexes (EGI) for several periods, the EGI of the system (or group of systems of the same technology) will be the average of the EGI of each period.

1.3. ESTIMATION OF THE EXPECTED SAVINGS OR GENERATION FROM INSTALLING THE NEW EQUIPMENT

This refers to establishing the savings or generation expected to be achieved periodically (e.g., annually) over the lifetime of the equipment. This is the amount that will be guaranteed by an insurance or a guarantee. The usual practice is to present the expected annual savings for a 10-year period or for the term of the insurance or guarantee, which in theory should correspond to the payback period. Estimated savings are calculated using data from stages 1 and 2, and may be constant or vary from year to year.

5.

$$Energy\ saving_{\ guaranteed\ annual} = \left(ENPI_{Base} - ENPI_{Expected}\right) \bullet Annual\ energy\ end\text{-}use$$

6.

$$Guaranteed\ annual_{\ energy\ generated} = IEG_{Estimated} \bullet Annual\ renewable\ resource$$

In the particular case of solar projects, the annual renewable resource data will be needed, which the supplier must obtain from the same databases used to calculate the rate of energy generated.

1.4. DEFINITION OF THE MONITORING SYSTEM TO BE INSTALLED TO VERIFY THE PERFORMANCE OR GENERATION OF NEW EQUIPMENT

The aim is to establish the parameters that will be measured once the project is in operation, in order to monitor the performance or generation of the installed equipment. The project provider must define the required instrumentation and frequency of measurements. As a good practice, the use of easy-to-measure parameters and long-lasting measurement equipment that provides good quality results is recommended, as these will be key in annual verifications.

In the case of energy performance projects, the supplier shall, at least, measure energy consumption and "energy end-use" within the project boundaries. If the energy end-use cannot be measured directly, other parameters, called "variables", must be defined and measured to determine this indirectly. Examples are voltage and current in engine projects or air flow and enthalpy in air conditioning projects.

In the case of generation projects, the measurement of "Renewable Energy Supplied" and the "Renewable Resource", and, if necessary, the energy consumed for the operation of the system (for example, in the case of biodigesters) must be ensured.

Table 2 presents references to relevant sources that may be used as a guide in the definition of project parameters and measurement instruments.

Table 2. Indicative References on Relevant Parameters by Technology or Type of Industry and Measuring Instruments

Technology	Economic activity to which it applies	Document
Electric engines	All those that use motors in their processes	Electric Engines
Electric engines	Drinking water operators	Guide to perform energy diagnostics and evaluate energy saving measures in water pumping equipment of drinking water utilities.
Electric engines	Hydraulic circuits	Energy Saving Measures in Hydraulic Circuits
Air conditioning	All those requiring air conditioning	Technical guide on procedures for the determination of the energy efficiency of water chiller plants and autonomous air handling equipment.
Air conditioning	All those requiring air conditioning	Technical guide for air conditioning installations with autonomous equipment
Include parameters to be measured for the most relevant technologies by economic sector	Agroindustry	Methodological Guide for Energy Audits in Agroindustry
	Transportation	Methodological Guide to Energy Audits for Transportation
	Mining	Methodological Guide for Energy Auditing in Mining
	Fishing	Methodological Guide to Energy Auditing for Fisheries
	Cement production	Methodological Guide to Energy Audits for Cement Plants
	Paper production	Pulp and Paper Energy Audit Methodological Guide
	Energy efficiency in buildings	Methodological Guide to Energy Audits for Buildings
	Food production	Methodological Guide to Energy Auditing for Food

Source: Authors' elaboration.

1.5. PERIODIC VERIFICATION OF SAVINGS OR POWER GENERATION

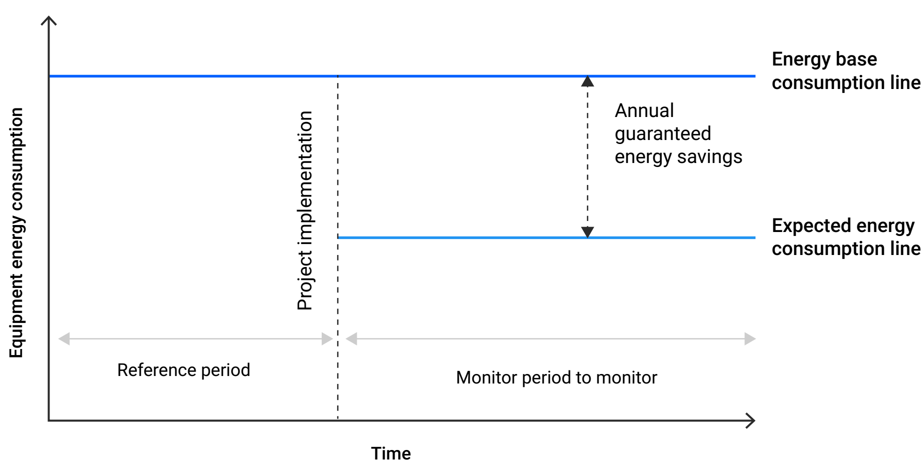
Consists of taking periodic measurements (ideally every year) of the parameters mentioned in the previous paragraph and establishing the actual savings or generation by the project, using a procedure similar to that described in the section "Estimate expected savings or generation when installing new equipment", but with actual operating data. Likewise, the CO_2 emissions avoided thanks to the project are estimated, for which it is necessary to have the emission factors of the energy sources associated with the project.

In the case of projects where savings or generation is assured through a guarantee, it is common to have a validation of the project proposal and a verification of the actual installation and performance of the project. If savings or generation are below expectations, a compensation is established, based on the variance detected and the reference energy price agreed between supplier and customer.

In summary, an alternative to evaluating savings in projects where a single technology is installed or where one technology is predominant is to compare its performance with that of the existing or commonly used technology. The savings that should be achieved by installing the most efficient equipment (estimated savings) is obtained as the product between the "final energy use "during a given period of time and the difference in energy performance of the existing technology with the more efficient technology to be installed. Actual savings are those achieved once operating performance is measured. In projects with energy savings insurance or guarantees, the technology provider guarantees the estimated savings through an energy savings insurance policy or a guarantee, which is then converted into guaranteed energy savings, or guaranteed energy production in the case of generation projects.

Solution design is always under the control and responsibility of the supplier. Therefore, to account for variations that may occur in practice (as compared with the theory) due to causes related to operation or efficiency loss, the supplier may consider the safety factors or margins it deems convenient in defining the savings or guaranteed annual generation. However, this must be done in a balanced manner, since it will have an effect on the investment's payback period and, therefore, on the time that the insurance must provide a guarantee (Figure 1).

Figure 1. Guaranteed Annual Energy Savings Scheme Considering Equal Amount of Annual "Energy End-use"



Source: Authors' elaboration.

2.

PLATFORM FOR STRUCTURING, EVALUATING, AND MONITORING OF PROJECTS

2 PLATFORM FOR STRUCTURING, EVALUATING, AND MONITORING OF PROJECTS

The platform developed by the Inter-American Development Bank (IDB) seeks to foster technological modernization by promoting investments in more efficient technologies through risk mitigation mechanisms in projects that guarantee savings or energy generation, such as performance contracts, validation and/or insurance schemes, and financial guarantees. The main elements and relationships in these projects are described below:

- There is a supplier–customer contract, where the supplier is a company dedicated to the commercialization, supply and maintenance of equipment and the customer is the company interested in acquiring this equipment and obtaining savings or generating a certain amount of energy. The customer hires the supplier to develop the necessary engineering, supply equipment and materials for construction, and perform installation and periodic maintenance. A guaranteed minimum savings or generation is agreed between the parties.

- At the beginning of the project, the supplier must submit the technical information in a pre-established format and send it to a validation entity, which must indicate whether the project has the potential to achieve the promised savings (validation). If the project is later approved, the validation entity must verify on-site that the project has been delivered according to the initially validated specifications. In addition, this entity acts as arbitrator in case of client-supplier disagreements regarding project performance during a certain period.

- Insurance is a hedging instrument purchased by the supplier for the benefit of the customer that guarantees the customer the promised savings or energy generation during the term of the contract. In the event that the project does not achieve the promised savings, the insurance will compensate the client financially. The supplier purchases the insurance for the client and pays the insurance company, and this is activated once the begin of the project operations is validated. It serves as a guarantee of compliance with the supplier-issued contract regarding project performance.

- If the client needs financial support for project execution, it requests credit from a financial institution, which primarily evaluates its financial soundness and defines the guarantees required to grant the requested credit. The commitment and insurance of the guaranteed minimum savings or generation reduce risks and the bank could benefit the project's credit risk assessment.

The details of performance contracts and insurance or financial guarantees are beyond the scope of this document, so this chapter focuses on the description of the protocol and tools developed by the IDB for the structuring, evaluation and monitoring of energy efficiency and distributed generation investment projects with guaranteed energy performance. The conceptual bases are presented in Section 1.

2.1. PROTOCOL

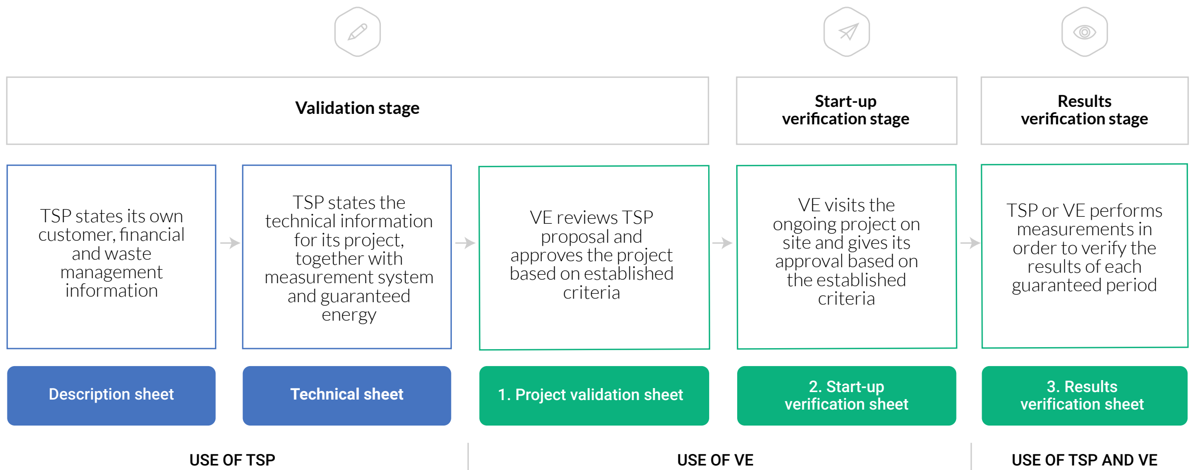
The protocol for structuring, evaluating, and monitoring energy efficiency and distributed generation investment projects with guaranteed energy performance consists of three stages (Figure 2):

- **Project validation:** the supplier submits the project in a pre-established format (see Annex 6) to a validation entity, indicating the annual savings commitment. This entity verifies whether the project has the potential to achieve the promised savings or generation. The validation is used by the bank and the insurer to assess the technical risks of the project to be financed/insured.

- **Project start-up verification:** if the project is validated, the supplier proceeds with the installation. Upon completion, the supplier or their customer will request the validation entity to verify on-site that the project has been delivered according to the specifications. Once the verification is approved, the insurance period begins.

- **Project monitoring and verification of results:** each year, the supplier measures the project performance using predefined procedures and formats. If there is a deficit in a given year, the supplier should compensate the customer. If, during a given period, the promised savings are achieved or exceeded, the supplier is in compliance. An amount of savings or energy generation in excess of the guaranteed amount may not be used to offset prior or subsequent years. The validation entity acts as arbitrator in the event of disagreement between the client and the supplier regarding savings or project generation in any given period, and its decisions are binding on the parties. Each year will be evaluated independently.

Figure 2. Protocol for the Structuring, Evaluation, and Monitoring of Energy Savings or Generated Energy Projects



Source: Authors' elaboration.
Notes: TSP= technology solution provider; VE= validation entity.

The summary of the project validation and verification criteria, as well as the format for recording data and monitoring project performance, are presented in Annex 5. These inputs may be used by both the supplier and the Validation Entity. To make it easier, we recommend that they are viewed in parallel with the tool described in the next section.

2.2. TOOL

The tool for estimating savings or energy generated by a project follows the logic of first establishing a baseline and then determining the impact of the new technology through improvements in performance or generation rates. For practical purposes, it was synthesized into two templates: a general (descriptive) one, which applies to all projects, and a specific one, for technology (technical). Thus, the tool for estimating savings or energy generated by a project (see Annex 6) consists of a fact sheet, with general information applicable to all projects, and a technical sheet, for each technology. A total of 24 formats are available for 12 technologies: 12 for replacements and 12 for new projects.

The Excel formats have pre-established routines for the automatic calculation of indicators, savings or generation by technology and data verification. In other words, it is not just a data entry form but a software that guides the supplier in developing its savings promise proposal. However, the supplier will be responsible for design data and monitoring parameters and must establish the parameters to be measured and monitored to estimate savings or generation, and verify the performance of the project itself.

The tool has been tested by technology providers, validators and investors in real projects, both in generation and energy efficiency. The forms have been designed in such a way that the information is recorded in a logical order, presenting explanatory tables for each section of information to be completed.

As indicated, in each technology there are two options for new and replacement projects. The new ones are those where there was no similar technology in the installation; the replacement ones are those where an obsolete equipment is substituted. Table 3 details the technologies and the abbreviated title on the Excel sheets. The following section details the descriptive and technical sheets.

Table 3. Technologies and Abbreviated Name in Excel Spreadsheets

Classification	Technology	Term sheet abbreviation for "Technology substitution".	Term sheet abbreviation for "New technology".
Energy performance	Boilers	BOI-S	BOI-N
	Lighting	LI-S	LI-N
	Engines	EN-S	EN-N
	Air conditioning	HVAC-S	HVAC-N
	Refrigeration	Refrg-S	Refrg-N
	Ovens-Dryers	Oven-S	Oven-N
	Air Compressors	AirComp-S	AirComp-N
	Motorcycle cab fleets	TaxiE-S	TaxiE-N
	Solar thermal system	STS-S	STS-N
	Combustion generation	CHP-S	CHP-N
Energy generation	Photovoltaic solar generation	PV-S	PV-N
	Biogas generation	BGas-S	BGas-N

Source: Authors' elaboration.

2.2.1. Fact sheet

In this sheet the supplier presents general details of the customer, supplier, project and waste management. The fact sheet includes the document requirements that the supplier must submit to an independent entity for project validation and verification when they decide to proceed with these steps. It consists of four sections:

1) General project information:

- Identification and contact details of the customer's legal representative, as well as an additional contact of the customer who has knowledge of the project proposed by the supplier.

- Identification and contact details of the supplier's legal representative.

- Type of project and technology proposed by the supplier. The GPS coordinates of the project location should also be entered. This is particularly important for clients with large installations or projects where location is important for the calculation of "guaranteed energy savings" or "guaranteed energy generated". In atomized projects such as the installation of luminaires, the customer's main coordinates may be recorded.

- Brief description of how the customer is currently operating and how they will operate once the project is implemented.

2) Project financial information

This section should summarize the total project costs separated, into Capital Expenditures (CAPEX) and Operating Expenditures (OPEX). Capital costs include costs for the purchase of fixed assets, such as the technology, and costs related to design and installation, such as feasibility costs, engineering, transportation, etc. Operating costs account for the annual costs associated with the operation of the technology including aspects such as operation, maintenance and parameter monitoring.

A summary of the energy savings or energy generated by the project, its financial equivalent and CO_2 emissions avoided is presented at the end of this section. This information is calculated from the datasheets and is shown after the information requested is provided in the respective datasheet of the proposed technology.

3) Waste management

Refers to the main equipment to be replaced (if applicable) and the treatment to be applied. It also includes identification of the types of waste to be generated by the facility, which wastes are to be treated, and the specific treatment they will receive, taking into account compliance with all applicable waste management legislation.

4) Technical support documents

Details the list of documents that the supplier must attach so that the Validation Entity may evaluate the project. The documents include plans, diagrams, catalogs and others that support the figures and the system presented in the validation form. The detailed list is presented in section 4 of the Fact Sheet.

The Validation Entity may request additional information, such as certifications of the proposed equipment or proper waste management during project verification, or other relevant documents it deems appropriate.

2.2.2. Data sheet

In this sheet, the supplier presents the technical information of the project according to its technology and the measurements that will allow them to determine and verify the "guaranteed energy savings" or the "guaranteed generated energy". The datasheet is available for substitution projects and for new projects. The supplier must select only one option.

Substitution: in energy performance projects, this refers to projects aimed at replacing existing equipment at the customer's facilities, which has a lower energy performance than the equipment proposed by the supplier. In generation projects, this refers to projects that will totally or partially cover the customer's current energy demand, obtained by another generation system or through an energy distribution system.

New: in performance projects, this corresponds to a project that incorporates equipment that offers an "energy end-use" that the customer does not currently require; therefore, the supplier must propose its "baseline energy consumption" taking into account the "reference equipment" that the customer would have installed in the absence of the supplier's proposal, corresponding to an equipment with a standard energy performance within the industry. In generation projects, this corresponds to a project in which the customer does not currently require the energy that will be generated by the project; therefore, the supplier must propose an industry-standard generation (or distribution) system that the customer would have installed or acquired to supply this future demand if they had not opted for the project proposed by the supplier.

Table 4 shows the structure and order in which the information in the data sheet should be completed for both energy performance and energy generation projects. The specific sheet details for each project type are presented in the following sections.

Table 4. Logical Order Scheme to Complete the Project Datasheet

	Energy Efficiency	Energy Generation
1. Project technical information	Information on the equipment proposed for the project	
	List of existing (or reference) equipment on site	Customer's current (or baseline) power supply
	Information on the energy sources associated with the project	
2. Monitoring system	Statement of rationale for the project measurement	
	Statement of the project parameters	
3. Establishment of indicators	Definition of measurement periods	
	Parameter measurement	
	Base indicators	
	Estimation of energy consumption	Expected energy supply of the system
	Estimated indicators	Generated energy indicator
	Proposed energy performance improvement percentage	
4. Guaranteed energy	Guaranteed energy savings	Guaranteed generated energy
5. Environmental benefits	Environmental benefits	

Source: Authors' elaboration.

The cells of the tool for estimating energy savings or energy generated include a symbology whose meaning is detailed in Table 5.

Table 5. Project Formulation Sheets cells Format

Cell format	Description
	Gray cells: cells where information is recorded manually.
	Blue cells: cells that are automatically calculated according to the information recorded in the gray cells.
	Strikethrough cells: cells that are released when an option is selected in a drop-down list of a previous gray cell that implies the need to provide additional information.

Source: Authors' elaboration.

2.2.3 Energy efficiency projects

Technical information about the project

In this section the supplier will describe the project technically and conceptually, as follows:

- The characteristics of the equipment to be installed and, in the case of some technologies, the ancillary equipment or other energy efficiency measures to be implemented, along with the main technology proposed.
- The characteristics of the technology to be installed. Two cases are used to describe the technology to be replaced: i) for replacement projects, and ii) for new projects.
- Information on the energy sources associated with the project. The energy sources are recorded in two subsections. The first corresponds to "energy sources currently used". The second, "energy sources used in the proposed condition", refers to the energy sources to be used with the new equipment. In the case of "new projects", the first section corresponds to the "reference energy sources" that would utilize the "reference technology" chosen by the supplier. Information for up to three (3) energy sources per section may be detailed (if the current and proposed energy sources are the same, they must be recorded in both sections).

All the fields requested in this section must be completed, since they are input for further calculations. The price data and the calorific value of the energy must be indicated in the same units in which the energy is measured. In turn, the corresponding emission factor for each energy source must be indicated. For reference, Annex 2 includes values that may be used as defaults.

Monitoring system

In this section, the supplier should conceptually explain why the proposed monitoring system is adequate for determining the project's energy performance or energy generation, and justify why its measurement system is in the located correctly to record the necessary data. The supplier should also define and describe all relevant parameters to be measured to determine the energy performance of both the existing and proposed equipment.

The Excel format allows for up to 10 parameters (P1 to P10) to be recorded, which have been divided into five categories:

1. **"Energy end-use":** parameter used to directly characterize the useful service produced by the energy consuming equipment.

2. **Variable:** parameter used to indirectly characterize the "energy end-use" or "renewable energy supplied" in a project.

3. **Controlled condition:** any parameter that influences the system's energy performance and which needs to be kept at a constant value or with limited fluctuations in order to obtain representative measurements.

4. **Current consumption:** parameter used to characterize the consumption of each of the energy sources used by the existing system or equipment.

5. **Proposed consumption:** parameter used to characterize the expected consumption of each of the different energy sources to be used by the technological solution to be installed.

The "Reference consumption" parameter appears only in new projects and is used to characterize the consumption of each of the energy sources used by the selected reference system or equipment.

The supplier is free to determine the number and type of parameters it deems necessary, taking into account that the following must be defined for each parameter:

- Descriptive name; in some cases, the tool offers predefined names, if applicable.

- Unit in which the measurement of this parameter will be made.

- Frequency of the measurement with which measurement records of that parameter will be kept, which may correspond to:

› ***Estimated from variable:*** applies only to the "energy end-use" parameter when it is obtained by measuring variables.

› ***Instantaneous:*** measurements that are taken on the spot, without a predetermined frequency.

- ***Less than hourly:*** measurements that are taken less frequently than every hour.
- ***Schedule:*** measurements taken every hour, which may be one or more hours.
- ***Daily:*** measurements taken every day, once a day.
- ***Weekly:*** measurements taken every week, once a week.
- ***Monthly:*** measurements taken once a month.
- ***More than monthly*:** measurements that are taken more than once a month.
- ***Database:*** parameter measurements that are taken from freely accessible public databases, which record measurements with a frequency necessary and sufficient for the project.

If a parameter is declared as "controlled condition", the following data should be recorded:

- **Desired value of the controlled condition:** corresponds to the number or value, in the declared units, at which the parameter is to be kept stable.
- **Percentage of tolerance and variability of the controlled condition:** refers to the percentage of tolerance by which the value of the controlled condition is allowed to vary in order to be considered an acceptable controlled value.

After declaring all the parameters to be measured and their measurement conditions, it is necessary to present the details of the measurement system for each parameter, which include:

- **Meter Type or [Database Name]:** type of meter to be used or database name, as appropriate.
- **Brand or [Database Source]:** brand of the meter or database source used.
- **Model or [Other Database Details]:** meter model or other database details.
- **Id or Serial No:** meter serial number.
- **Error percentage of measuring equipment:** percentage of error of measurements taken from the meter's data sheet.

Construction of indicators

This section details the steps to determine the baseline and expected performance indicators and the Proposed Energy Performance Improvement Percentage (PEPIP). Some data is recorded by the supplier while others are generated automatically. The sequence is as follows:

Definition of measurement periods: here the supplier defines how many times the existing equipment will be measured and the duration of each measurement. Each measurement is known as a "measurement period". Its duration should be long enough to record natural fluctuations of parameters affecting energy consumption, taking into account that certain parameters are kept at controlled values in order to produce reproducible measurements.

As many periods should be measured as the supplier deems appropriate for the technology being measured. Generally speaking, the more complex the technology and the more parameters to be recorded, the more measurement periods are desirable. To define the "measurement periods" for reference equipment, the same procedure used for existing equipment is followed, since the measurement periods are subsequently used in the verification of savings.

For lighting projects, an exception is made to this procedure: each measurement period corresponds to a single circuit or group of luminaires being measured, meaning that only the measurement of the same circuit or group of luminaires should be recorded as a single measurement period.

Parameter measurement: using the information provided in the monitoring system section, the Excel spreadsheet automatically fills in the column headings of the parameter measurement figure; here, the supplier must record the per period measurement results for each parameter. The duration of the measurement will be equal to the time defined for each period. When declaring "controlled conditions", the supplier must ensure that the measurement range for each condition remains within the ranges established by the supplier; otherwise, the measurement will be considered invalid.

Baseline performance indicator: from the existing equipment energy consumption and "energy end-use" data entered, the tool automatically calculates the performance index of the existing technology (ENPI base). For the different technologies, the value presented corresponds to the average of the indicators calculated for each measurement period. The exception is lighting technology, where the figure corresponds to the sum of the indicators calculated for each period.

Estimation of energy consumption: Within the figure, the supplier must record the expected consumption of each of the energies used by the technological solution that will be installed, with which it will deliver the same amount of "energy end-use" during each of the planned measurement periods.

Estimated performance indicator: the tool calculates the performance index of the proposed new technology (expected ENPI) automatically. This corresponds to the average of the indicators calculated for each measurement period, except for lighting technology, which corresponds to the sum of the indicators calculated for each period.

Proposed Energy Performance Improvement Percentage (PEPIP): using the baseline ENPI and the expected ENPI, the tool automatically generates the project's PEPIP.

Guaranteed energy savings

This section sets out the energy savings promise made by the technology provider to the customer. This promise is defined in both energy and monetary terms. The supplier must simply indicate the amount of "energy end-use" that has been agreed to with the client for each year of project operation, and with that, the tool automatically generates the annual savings values using the baseline data of energy prices and performance indices previously recorded in sections 1 and 3 of the form, respectively. The "energy end-use" data may be recorded for up to 10 years, and may vary from year to year. It is vital that the supplier agree upon this figure with the customer,based on historical data and knowledge of how the customer uses the service provided by the technology, since this figure is the basis for possible compensation in case of underperformance of the technology.

Energy savings are calculated according to the procedure described in Section 1.3. Savings in monetary units are calculated as shown in Table 6. The monetary savings in monetary terms are generated by the tool based on the energy prices recorded in section 1 of the Excel spreadsheet. The savings commitment with the customer is established in the performance contract in energy units. Based on the information recorded on energy prices, the tool automatically generates the unit price of energy to be used by supplier and client in defining the energy base price to be used in the performance contract. This is used to calculate possible economic compensation for underperformance of the project.

Table 6. Formulas for the determination of avoided financial expenses, by project type

Type of project	Indicator name	Indicator formula by project type	Annual "Financial costs avoided" formula by project type
Energy efficiency	Financial Performance Index (FPI)	$FPI_{Base} = \frac{\text{Monetary base cost of energy resource}}{\text{Energy end-usea}}$ $FPI_{Expected} = \frac{\text{Expected monetary cost of energy resource}}{\text{Energy end-use}}$	$(FPI_{Base} - FPI_{Expected}) \cdot \text{Annual energy end-use}$
Energy generation	Cost Avoidance Index (EAI)	$CAI = \frac{\text{Costs avoided in energy resources currently used}}{\text{Renewable resource}}$	$EAI \cdot \text{Annual renewable resource}$

Source: Authors' elaboration.

Environmental benefits

The reduction in greenhouse gas emissions that is estimated will be credited to the project. These results are informative and of interest mainly to the client and the financial institution. They do not imply any type of commitment by the supplier.

The tool automatically calculates the annual tons of CO_2 avoided from the annual emission factors and "energy end-use" data previously recorded in sections 1 and 4, respectively, of the Excel spreadsheet, using the formulas indicated in Table 7. As the energy performance indicators, these indicators are determined for each measurement period and then averaged to obtain the final indicator for the equipment or technology.

Table 7. Formulas for the determination of avoided greenhouse gases, by project type

Type of project	Indicator name	Indicator formula by project type	Formula for "Greenhouse gases avoided" per year by project type
Energy efficiency	Environmental Performance Index (ENPI)	$ENPI_{Base} = \frac{\textit{Base emissions generated}}{\textit{Energy end-use}}$	$(ENPI_{Base} - ENPI_{Expected}) \cdot \textit{Annual energy end-use}$
		$ENPI_{Expected} = \frac{\textit{Expected emissions generated}}{\textit{Energy end-use}}$	
Energy eneration	Avoided Emissions Index" (AEI)	$AEI = \frac{\textit{EGI emissions avoided by energy resources currently used}}{\textit{Renewable resource}}$	$AEI \cdot \textit{Annual renewable resource}$

Source: Authors' elaboration.

The formulas for the indicators presented in Figures 5 and 6 are simplified versions. When a project involves the use of more than one energy source, each formula must be expanded to cover all the energy sources associated with the project. The expanded versions, which are those used by the tool, are presented in Annex 4.

2.2.4 Power generation projects

The fact sheet for power generation projects follows the same structure and concepts as for energy performance projects (see Figure 3). The same guidelines mentioned in the previous sections therefore apply to generation projects, except for some specificities described below.

Technical project information

In the section on the customer's current energy supply, the supplier must indicate the type of technology or distribution system which is supplying the customer, the energy used in the facility, and what percentage of the demand is covered by each of them. It refers to the sources to be replaced by the system that will be installed or to the reference supply, in the case of new projects. In these cases, the supplier must indicate which generation or distribution system the customer would use to meet the energy demand in the absence of the proposed project.

The energy associated with the project corresponds to the energy used by the customer to supply generation systems, if the customer generates their own energy, or to the energy received from distribution systems.

Monitoring system

As in the case of energy performance projects, in this section, the supplier shall define and describe all relevant parameters to be measured in order to determine the proposed project's performance indicator in terms of energy generated.

The "proposed consumption" parameter for generation projects refers to the energy consumed by the generation system for its operation. This consideration is valid only for biogas generation, in which agitators, pumps and a temperature stabilizer are used in the reactor. This "proposed consumption" will be automatically deducted from the energy generation to account for the net energy generation.

The Excel format allows up to 10 parameters (P1 to P10) to be recorded, which include the five categories mentioned in section 3.2.3B ("energy end-use", variable, controlled condition, current consumption and proposed consumption) and two specific categories for power generation projects: i) renewable energy supplied, which refers to the amount of energy supplied by a power generation system that uses a renewable resource, and ii) renewable resource, which refers to the amount of a natural resource available to the customer to produce energy.

Construction of indicators

This section describes the steps to determine the generated energy indicator (GEI). Some data is recorded by the supplier while others are automatically generated. The sequence is as follows:

- Definition of measurement periods: here the supplier defines the number and duration of parameter measurements. Each measurement is known as a "measurement period". The duration should be long enough to record natural parameter fluctuations that may affect energy consumption.

- Expected energy supply of the generation system: the supplier records the results of the parameters measured for each period.

- Expected GEI: the tool automatically calculates the expected generated energy index (expected GEI). Corresponds to the average of the indicators calculated for each measurement period. In the event that more than one generation system is installed with different yields, the "renewable energy supplied" by each system will be measured separately, considering a single amount of the "renewable resource" available per period. In that situation, the expected GEI will be equal to the sum of the renewable energies supplied by each generation system divided by the amount of "renewable resource".

Guaranteed generated energy

This section establishes the promise that the supplier makes to the customer about the energy that the system will generate. This promise is defined in both energy and monetary units. The supplier must simply indicate the amount of "renewable resource" determined as available for each year of project operation, and the tool automatically generates the annual values, since at this point it has the data on energy prices and performance indexes recorded in sections 1 and 3, respectively, of the Excel spreadsheet. The "annual energy generated" is calculated using the procedure indicated in section 1.3 of this document. Savings in monetary units are calculated as illustrated in Figure 5.

The "renewable resource" data may be recorded for up to 10 years and may vary from year to year. It is recommended that the supplier establishes the generation promise, based on a conservative design, since this figure is the basis for possible compensation.

The generation commitment with the customer is established in the performance contract in energy units. The value in monetary terms is generated by the tool based on the energy prices recorded in section 1 of the Excel spreadsheet. The tool also automatically generates the unit price of energy to be used by supplier and customer to define the energy base price to be used in the performance contract to calculate possible economic compensation for underperformance of the project.

Environmental benefits

Correspond to the reduction in greenhouse gas emissions estimated as attributable to the project. These results are informative and of interest mainly to the client and the financial institution. They do not imply any type of commitment on the part of the supplier.

The tool automatically calculates the annual tons of CO_2 avoided from the annual emission factors and renewable resource data previously recorded in sections 1 and 4 of the form, respectively, using the formulas shown in Figure 6. As with the performance indicators, these indicators are determined for each measurement period and then averaged to obtain the final indicator for the equipment or technology.

3.

EXAMPLES

3 EXAMPLES

This section presents three examples of projects that have used the formats, have been validated and have secured the savings with energy savings insurance (ESI) or the technology guarantee. For simplicity's sake, not all form details are repeated in each case. Rather, only the most important aspects - those which may create doubts for users when filling out the form and using the tool - are highlighted. Cases include a project to replace a boiler with a solar thermal system, a project to replace air conditioners, and a project to install a solar photovoltaic panel system at a company that previously used the grid energy. The formats for each of these technologies are shown in Annex 6.

3.1. REPLACEMENT OF A SHELL BOILER WITH A SOLAR THERMAL SYSTEM FOR WATER HEATING

This was a project in which the water heating system in a hotel was replaced. The hotel used a 24-year-old vertical pyro-tubular boiler that ran on liquefied petroleum gas (LPG), generating 5,917 liters per day (2,160 m^3 per year) of hot water for laundry, kitchen and showers. The boiler consumed an average of 2,410 kg of LPG per month. The investor's objectives were to install a more efficient technology that would reduce LPG consumption to generate savings in the hotel operating expenses and reduce CO_2 emissions. The customer requested the bidders to guarantee the promised energy savings through an energy performance policy.

The system proposed by the supplier included 22 flat plate solar collectors installed on an area of 61.7 m^2, a 5HP backup heat pump, controls, motor pump and connections. The supplier promised a 70% reduction in gas consumption, which would repay the investment in 18 months.[4] The project is currently in operation and the experience with the use of the energy saving insurance may be seen in this video.

[4] Information provided by the administrative staff of the Neiva Plaza Hotel.

Fact sheet

On this sheet, the supplier enters its contact information and that of the investing company, describes in general terms how it will manage the waste, and lists the documents attached to the proposal. Although the new water heating system is a combination of solar thermal and heat pump equipment, in technology type, "solar thermal system" was selected, since it will be the main equipment. The heat pump will function as a backup to supply hot water when there are deficiencies in the daily radiation or when the demand is higher than expected (image 1).

Table 8. Section: Project Description

Record the information that will help to clearly establish the current conditions of the customer's installation prior to project implementation, as well as the result expected from using the proposed equipment. Reference should be made to the technologies, equipment, services provided, energy uses and any particular characteristics of the installation that may influence the energy consumption of the firm in which this project is developed.		
Project name		Hotel solar thermal system
Type of project	Step 1	Energy performance
Type of technology	Step 2	Solar thermal system
Replacement/New	Step 3	Replacement of the technology

- **Financial information**

  The supplier included the cost of equipment and costs other than diagnostics and engineering in Capital Expenditures (CAPEX). Operating Expenditures (OPEX) include operating, maintenance and monitoring costs. Energy, financial and CO_2 emissions savings are calculated automatically by the tool.

- **Waste management**

  The supplier identified three types of waste from the project: (i) the boiler to be replaced; (ii) thermal insulation; and (iii) other waste. The boiler was scrapped, while the thermal insulation and other waste were delivered to a company specialized in the final disposal of this type of material. The results were recorded as shown in Image 2.

Image 2. Section: Waste Management

Describe how the replaced equipment will be disposed of, alongside its associated waste, if any, complying with all legislation applicable to the treatment of such waste. Waste can be categorized as:

- Hazardous: presents a risk to public health and/or adverse effects for the environment.

- Non-hazardous: does not present a risk to public health and/or adverse effects for the environment.

- Inert: type of waste that is non-hazardous, does not undergo significant physical, chemical or biological changes, is not soluble or combustible and does not react physically, chemically, or in any other way.

	Waste identification	Quantity	Unit	Waste classification	Waste management
1	Vertical pyrotubular boiler	1	Unit	Non-hazardous	Scrapping
2	Boiler thermal insulation	1	Unit	Non-hazardous	Disposal by specialist firm
3	Other	1	Kilogram	Non-hazardous	Disposal by specialist firm

Technical support documents

The supporting documents provided by the technology provider for the validation of the project were as follows:

- Technical-economic proposal.
- Project description and calculation memories of the projected energy savings.
- Description of the equipment to be installed.
- Project schedule.
- Occupational health and safety policy of the investing hotel.
- Instruction and operation manual for the installed equipment.

Technical sheet

Technical project information

The format allows information to be provided regarding the main equipment and up to five auxiliary technologies that are part of the system. As shown in Figure 3, information about the heat pump was also entered.

Image 3. Section: Information on Proposed Equipment

Record the details of the new equipment to be installed as appropriate.			
How many different solar thermal systems will be installed in your project ?:	1		
	Information about the proposed equipment No.1		
Characteristics of solar collectors			
Type of service	ACS	Which?	
Type of system	Flat plate	Which?	
System subtype (if applicable)	Heat pumps	Which?	
Manufacturer	Chromagen		
Model	QA-F		
Heat transfer liquid	Water	Which?	
Collection area per solar collector (m2/unit)	2.8		
Solar collector efficiency (%)	56%		
Nominal heat capacity per collector	272	Unit	lists/day
Number of solar collectors	22		
Description of other changes in the facility associated with technology	No additional changes to the system are required		
How many pieces of auxiliary equipment of different technology and/or characteristics are part of your system?	1		
Auxiliary equipment 1			
Name	Heat pump		
Manufacturer	Más centígrados		
Model	5 HP - three phase		
Serie			
Nominal capacity (if applicable)	75,000	Unit	BTU/h
Efficiency (if applicable)		Unit	
Energy or fuel type (if applicable)	Electricity	Which?	
Control type (if applicable)	Differential thermostat		
Annual hours of operation (if applicable)	2,160		
Quantity	1		
Provide details on the function of this equipment within the solar thermal system	Support system to supply hot water when there are deficiencies in daily radiation or when demand is higher than expected		
Provide details on other relevant characteristics of this equipment	NA		

As part of the description, information must be entered on the energy sources used, both in the equipment to be replaced and in the equipment to be installed: i.e., type of energy, price, calorific value and CO_2 emissions factor, with the respective sources of information. Image 4 includes LPG, which is the fuel that the boiler to be replaced runs on. Although the proposed system (solar thermal) does not require an energy source, electricity is included because the heat pump will use electrical energy for its operation.

Image 4. Section: Information on the Energy Sources Associated with the Project

Record the fuel associated with the project for both current and proposed technology						
	Fuels currently used			**Fuels used in the proposed condition**		
Fuels involved in the project	**Fuel 1**	**Fuel 2**	**Fuel 3**	**Fuel 1**	**Fuel 2**	**Fuel3**
Fuel type	Liquid gas			Electricity		
Unit	kg			kWh		
Price ($/unit)	3,007			405		
Price information source	Monthly turnover of the company			Monthly turnover of the company		
Lower heating value (LHV) (kWh/unit)	12,614			1		
LHV information source	UPME			UPME		
Emission factor (tCO_2eq/kWh)	2.42E-04			1.99E-04		
Emission factor information source	UPME			UPME		

- Monitoring system

The parameters considered important by the supplier to be measured in order to determine the energy performance of both the existing and proposed equipment were (Image 5):

- The "energy end-use" provided by the technology, which was defined in m^3 of hot water. This parameter could be measured directly with equipment already in the facility.
- Current energy consumption, defined as monthly LPG consumption (2,410 kg of LPG/month), which was measured directly with equipment already in the facility.

- A controlled condition was the hotel occupancy rate, since this has a direct impact on the amount of hot water demanded: the higher the occupancy rate, the higher the demand.
- One variable was the water outlet temperature, which was measured directly to ensure that the system delivers water at the temperature required for use.

Image 5. Section: Relevant Parameter Data

Parameter data							Measurement System Data associated with the measured parameter (when applicable)				
Id	Type	Nombre	Unidad	Measure-ment frequency	Desired value of the controlled condition	% tolerance and variability of the controlled condition	Meter type Database name]	Brand or [Database Source]	Model or [Other database details]	ID or Serial No.	Equipment precision
P1	End use of energy	Hot water	mt^3	Monthly			Customer meter	Gricol	PI R63 Gr	Lm 354	100%
P2	End use of energy	Liquid gas	kg	Monthly			Customer meter	EKM	P213883	Uv876oX	100%
P3	Variable	Water outlet temperature	°C	Monthly			Thermometer	Good Quality	T300MAX	ss304	98%
P4	Proposed consumption	Electricity	kWh	Monthly			Network meter	Proelco	Electronic single phase	TIOM86Y9x	97%
P5	Controlled condition	Hotel occupancy	Unit	Monthly	60%	5%	Hotel records	NA	NA	NA	NA

Construction of indicators

For the measurement periods of the existing equipment, the supplier determined that it was best to make measurements of the selected parameters during three months, since these included months of high and low occupancy seasons (image 6).

Image 6. Section: construction of indicators

3.1. Definition of measurement periods								
Defines all the completed measurement periods for gathering information associated with current technology, information that will be used to calculate the energy performance of the initial stage of the project.								
	Measurement from				**Measurement up to**			
Period ID	**Hour**	**dd**	**mm**	**yyyy**	**Hour**	**dd**	**mm**	**yyyy**
1	12:00:00 a.m.	1	1	2018	11:59 p.m.	31	1	2018
2	12:00:00 a.m.	1	2	2018	11:59 p.m.	28	2	2018
3	12:00:00 a.m.	1	3	2018	11:59 p.m.	31	3	2018

3.2. Measurement of Parameters										
Once the energy performance measurements of the current technology have been performed, record the results obtained for the parameters previously stated (section 2.2.) in each measurement period.										
Id	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**
Type	Energy end use	Current consumption	Variable		Controlled Condition					
Name	Hot water	Liquid gas	Water outlet temperature		Hotel occupation					
Unit	mt^3	kg	°C		Unit					
Measurement period ID	Value measured	Value measured	Value measured	Value measured	Value measured	Value measured	Value measured	Value measured	Value measured	Value measured
1	166.9	2,235	39		63					
2	177	2,371	40		58					
3	196.1	2,626	40		60					

Next, in section 3.4 of the sheet, the supplier should record the amount of energy that will be used by the technology to be installed to produce the same amount of hot water produced ("final energy use"). The parameters are automatically activated in the format after entering them in section 2.2 of the sheet (image 7).

In this project, the electricity consumption of the heat pump was included as an energy cost of the new system. However, it should be noted that, besides solar radiation, the solar thermal system does not require any additional energy for its operation.

Image 7. Section: estimation of energy consumption

3.4. Estimation of fuel consumption										
Record information associated with the energy consumption that the new system would use to produce the same amount of "energy end use" for each of the measurement periods considered.										
Id	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**
Type	Energy end use		Variable	Proposed consumption	Controlled condition					
Name	Hot water		Water outlet temperature	Electricity	Hotel occupancy					
Unit	mt^3	kg	°C	kWh	Unit					
Measurement period ID	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value
1	166.9		39.0	6.0	63.0					
2	177		40.0	5.1	58.0					
3	196.1		40.0	4.5	60.0					

With the above information —energy data associated with the project and measurement data— the format calculated the baseline and expected performance indicators and the percentage improvement automatically:

- ENPIbase: KWh/mt^3= 187,48
- ENPIexpected: KWh/mt^3= 5,02
- PEPIP: 97%

Guaranteed energy savings

The supplier and the customer agreed that "energy end-use" would be the same volume that the original boiler produced, i.e., 2,160 m^3 of hot water per year, constant for five years. With this, the format automatically calculates the savings in energy units and its monetary equivalent, based on the energy price recorded in the energy data. Likewise, it shows the annual tons of CO_2 avoided and the unit price of energy to be used by supplier and customer in defining the base price of energy to be used in the performance contract to calculate possible economic compensation. This value is 405 COP per kWh (image 8).

Image 8. Section: calculation of guaranteed energy savings

	Annual hot water	Guaranteed energy savings	
Year	**m^3/year**	**kWheq/year**	**$/year**
1	2.160	364,804	86,953,730
2	2.160	364,804	86,953,730
3	2.160	364,804	86,953,730
4	2.160	364,804	86,953,730
5	2.160	364,804	86,953,730
	Total	**1,824,022**	**434,768,648**

3.2 AIR CONDITIONING REPLACEMENT PROJECT

The headquarters of an accounting firm consisting of eight offices and two common spaces has 10 split-type air conditioning systems with 2 metric tons of refrigeration (TR, 24,000 BTU/h) each. The company noted high energy costs and user dissatisfaction due to non-uniform and accelerated air conditioning of the spaces, which caused a frequent change of the preset temperatures for each piece of equipment and recurrent switching on and off. Users stated that this causes colds and respiratory problems, which affects productivity.

As a solution, one supplier offered to install a more efficient 5 TR rooftop package central unit combined with thermally-insulated ducts and variable air volume boxes in each service zone. This will allow for lower energy consumption and greater thermal comfort thanks to a common set point temperature, indoor and outdoor temperature and humidity sensors to regulate the box dampers through an energy management system, and duct pressure sensors to regulate the frequency of fan operation.

Fact sheet

In this type of project, the user must select "energy performance" as the project type, "air conditioning" as the technology, and indicate that it is a replacement project (image 9).

Image 9. Section: project description

Register the information in order to clearly establish the current conditions of the customer's facilities prior to the implementation of the project as well as the expected result with the proposed equipment. Reference should be made to the technologies, equipment, services provided, energy uses and particularities of the facility that influence the energy consumption of the company for which this project will be developed.		
Project name		Hotel solar heating system
Project type	Step 1	Energy performance
Technology type	Step 2	Solar heating system
Replacement/New	Step 3	Technology substitution

Financial information

The CAPEX cost item included the equipment (package unit, ducts, variable volume boxes, insulation material, fans, sensors) and the management system, the costs of removing existing equipment and installing new equipment, and the costs of diagnostics and engineering.

Waste management

In this type of project, it is essential that the equipment is disposed properly, especially the polluting gases, such as the family of hydrofluorocarbons (HFCs), chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), which are banned or being phased out in several countries. Once the refrigerants have been safely disposed, another company will take care of recycling the useful components of the equipment removed. For each project, the supplier must consider the country's current legislation (image 10).

Image 10. Section: waste management

Indicate the treatment to be given to the equipment removed together with its associated waste, if any, complying with all legislation applicable to the treatment of such waste. They can be categorized as:

- **Dangerous:** presents a risk to public health and/or adverse effects on the environment.
- **Not dangerous:** does not present a risk to public health and/or adverse effects on the environment.
- **Inert:** a non-hazardous type of waste that does not undergo significant physical, chemical or biological variations, is not soluble, is not combustible, does not react physically or chemically, or in any other way.

	Waste identification	Quantity	Unit	Waste category	Waste management
1	Vertical pyrotubular boiler	1	Unit	Not dangerous	Scrapping
2	Boiler thermal insulation	1	Unit	Not dangerous	Provided by specialized company
3	Other	1	Kg	Not dangerous	Provided by specialized company

Technical support documents

The supporting documents provided by the supplier for the validation of the project were as follows:

- Technical-economic proposal.
- Project description and calculation memories of the projected energy savings.
- Catalogs and manual of the equipment to be installed and power management system.
- Authorization records from the country's competent authority for marketing of the equipment.
- Maintenance plan for all the years of the project's warranty.
- Diagram of the location of the equipment to be installed for the measurement of the energy performance of the existing and proposed equipment.

Technical sheet

Technical project information

The format records the most relevant data of the new system: i) type of equipment; ii) type of control; iii) air handling; iv) efficiency and cooling source; v) operating conditions; and vi) complementary equipment or measures (image 11). The existing equipment information (not shown in image 11) should also be included.

Image 11. Section: technical project information

Record the details of the new equipment to be installed as appropriate.			
How many different air conditioning technologies does your project consider?	1		
	Information about the proposed equipment No.1		
Name	Centralization of air conditioning		
Manufacturer	Trane		
Model	Impack		
Equipment type	Package unit	Which?	
General characteristics			
Control type	Power management software (EMS)	Which?	
Air handling type	Variable air volume		
Coverage	Multizone		
Minimum percentage of outside air (%)	30%		
Quantity	1		
Characteristics of the cold system			
Cooling efficiency	4	Unit	COP
Cooling capacity	5	Unit	ton
Cold source	DX compressor	Which?	
Terminal unit type	Variable air volume boxes	Which?	
Setpoint temperature - business hours (setpoint) (° C)			20
Total hours of cooling operation per year - business hours			1460
Setpoint temperature - non-business hours (setpoint) (° C)			24
Total hours of cooling operation per year - non-business hours			730
Other information			
Complementary equipment or solution in addition to main equipment 1	Duct isolation and/or pipes	Which?	
Complementary equipment or solution in addition to main equipment 2	Other	Which?	Fans with variable frequency drive
Complementary equipment or solution in addition to main equipment 3	Other	Which?	Temperature and pressure sensors
Describe additional benefits that the new technology incorporates that were not being covered by the previous technology			
Description of other installation changes associated with the new equipment			

Subsequently, information on the energy sources used for the project is provided (price, emission factor and lower calorific value). In this case, electricity is involved in both the new equipment and in the equipment to be removed, and it must be indicated in both situations (current and proposed). The price of the energy was defined with the customer's invoicing. For the emission factor, the country's energy matrix was used. The calorific value for electricity should be left as 1 (image 12).

Image 12. Section: energy associated with the project

Record the fuel associated with the project for both current and proposed technology						
	Fuels currently used			**Fuels used in the proposed condition**		
Fuels involved in the project	**Fuel 1**	**Fuel 2**	**Fuel 3**	**Fuel 1**	**Fuel 2**	**Fuel 3**
Fuel type	Electricity			Electricity		
Unit	kWh			kWh		
Price ($/unit)	130			130		
Price information source	Supplier			Supplier		
Lower heating value (LHV) (kWh/unit)	1			1		
LHV information source	Literature			Literature		
Emission factor (tCO_2eq/kWh)	4.19E-04			4.19E-04		
Emission factor information source	BD Open Energy			BD Open Energy		

Monitoring system

The parameters that the supplier considered relevant to measure in order to determine the energy performance of both the existing and proposed equipment were (image 13):

- The "end-use of the energy" provided by the technology, which was defined as the "extraction of thermal energy" since the purpose of the air conditioning equipment for cooling is precisely to extract thermal energy from the interior and release it to the exterior. It is not possible to measure this value directly, but it is determined indirectly by three variables: conditioned air flow, air delivery and return air enthalpy. These parameters change constantly and are usually measured on an hourly or less than hourly basis.

- The actual energy consumption (electricity in this case), which was measured directly.

- A controlled condition that was the relative humidity of the air, which must be maintained within an acceptable range during the measurements.

Image 13. Section: relevant parameter data

Parameter data							Measurement System Data associated with the measured parameter (when applicable)				
Id	**Type**	**Name**	**Unit**	**Measurement frequency**	**Desired value of the controlled condition**	**% of tolerance and variability of the controlled condition**	**Type or Database name]**	**Brand or [Database source].**	**Model u [Other database details]**	**ID of serial No.**	**Equipment precision rating**
P1	Energy End Use	Thermal energy extracted	BTU	Estimated from variable							
P2	Variable	Air conditioning flow	lb/h	Under schedule			Thermal anemometer	Testo	405i	123	98%
P3	Variable	Output air enthalpy	BTU/lb	Under schedule			Thermohy-drometer	Testo	605i	123	99%
P4	Variable	Return air enthalpy	BTU/lb	Under schedule			Thermohy-drometer	Testo	605i	124	99%
P5	Controlled Condition	Relative air humidity	-	Data base	0.40	0.05	Weather Station	wunderground .com	Station ID: ISANTIAG245		
P6	Current consumption	Electricity	kWh	Schedule			Network analyzer	Fluke	NA	1234	98%
P7	Proposed consumption	Electricity	kWh	Schedule			Network analyzer	Fluke	NA	1235	98%
P8											
P9											
P10											

Define and indicate how the "Energy End Use" is obtained from its "variable(s)" defined in section 2.2 (when applicable).

i) Measurements are taken in the output and return ducts of the wet and dry bulb temperature, then the air enthalpy is determined using a psychometric chart.

ii) Additionally, the anemometer is used to determine the amount of air output per hour considering the air volume output per minute and the density of the air at the temperature and relative humidity on the date of measurement.

iii) Finally, the enthalpy difference between output and return multiplied by the hourly air output amount and the hours of measurement will give the thermal load extracted by the system.

Construction of indicators

Considering that the company operates from Monday to Saturday, for the existing equipment measuring periods, the supplier defined six continuous daily measurements as sufficient and representative. The proposal and results for each measurement period are shown in image 14.

Image 14. Section: definition of measurement periods

3.1. Definition of measurement periods								
Define all the completed measurement periods for gathering information associated with current technology, information that will be used to calculate the energy performance of the initial stage of the project.								
	Measurement from				**Measurement up to**			
Period ID	**Time**	**dd**	**mm**	**yyyy**	**Time**	**dd**	**mm**	**yyyy**
1	9:00:00	3	1	2020	9:00:00	4	1	2020
2	9:00:00	4	1	2020	9:00:00	5	1	2020
3	9:00:00	5	1	2020	9:00:00	6	1	2020
4	9:00:00	6	1	2020	9:00:00	7	1	2020
5	9:00:00	7	1	2020	9:00:00	8	1	2020
6	9:00:00	8	1	2020	9:00:00	9	1	2020
7								
8								

3.1. Definition of measurement periods										
Once the energy performance measurements of the current technology have been made, record the results obtained for the previously stated parameters (paragraph 2.2.) in each measurement period.										
Id	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**
Type	Energy end use	Variable	Variable	Variable	Controlled condition	Current consumption				
Name	Thermal energy extracted	Air conditioning flow	Output air enthalpy	Return air enthalpy	Relative air humidity	Electricity				
Unit	BTU	lb/h	BTU/lb	BTU/lb	-	kWh				
Measurement period ID	Measured value	Measured value	Measured value	Measured value	Measured value	Measured value	Measured value	Measured value	Measured value	Measured value
1	36.3	100	20	26	0.36	21.8				
2	30.2	100	20	25	0.35	18.1				
3	12.1	100	20	22	0.37	7.3				
4	6	100	20	21	0,40	3.6				
5	18.1	100	20	23	0,36	10.9				
6	24.2	100	20	24	0.35	14.5				
7										
8										

Then, based on theoretical estimations and on their experience, the supplier must propose what the energy consumption of the proposed technology's energy consumption would be when extracting the same thermal load per period as in the baseline case. In this case, the supplier, taking into account the coefficient of operation or efficiency (COP) of the proposed equipment and the best overall performance of the entire system, determines the expected electricity consumption for each of the measurement periods (image 15).

Image 15. Section: estimation of energy consumption

Id	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Type	Energy end use	Variable	Variable	Variable	Controlled condition		Proposed consumption			
Name	Thermal energy extracted	Air conditioning flow	Output air enthalpy	Return air	Relative air humidity		Electricity			
Unit	BTU	lb/h	BTU/lb	BTU/lb	-		kWh			
Measurement period ID	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value
1	36.3	100.0	20.0	26.0	0.4		5.4			
2	30.2	100.0	20.0	25.0	0.4		4.5			
3	12.1	100.0	20.0	22.0	0.4		1.8			
4	6.0	100.0	20.0	21.0	0.4		0.9			
5	18.1	100.0	20.0	23.0	0.4		2.7			
6	24.2	100.0	20.0	24.0	0.4		3.6			
7										
8										

With this information, the form automatically calculates the estimated energy performance indicator (ENPI) in the same way as for the baseline case, giving a value of 0.15 kWh/BTU. With the baseline and estimated energy performance indicators, the form automatically generates the percentage of energy performance improvement (PEPIP), which gives a value of 75% (image 16).

Image 16. Section: performance indicator and performance improvement index

3.5. Estimated indicators	
The following table shows the self-calculated "Energy performance indicator" with the information previously recorded that considers all the proposed energy sources and indicates how much energy is consumed per 1 unit of "Energy End Use"	
	Estimated ENPI
	kWh/Thermal energy extracted
Average value	0.15
3.6. Proposed energy performance improvement indicator (proposed EPI)	
Based on the above information, the worksheet will determine the proposed energy performance improvement index, which corresponds to the estimated savings percentage of the energy project in relative terms.	
Proposed EPI	75.0%

Guaranteed energy savings

Since the "final energy use" was defined as the thermal energy extracted, the supplier should indicate the amount of thermal energy extracted that has been agreed with the client for each year of project operation. In this case, 8,000 BTUs per year for one year were proposed. The tool will automatically generate annual savings values using baseline data from previously recorded energy prices and performance indicators. On the other hand, it generates the annual tons of CO_2 avoided and the unit price of energy to be used by supplier and customer to define the base price of energy to be used in the performance contract to calculate potential economic compensations. In the case of this project, it would be $130 pesos/kWh (image 17).

Image 17. Section: guaranteed energy savings

Year	Annual	Guaranteed energy savings	
	BTU / year	kWheq/year	$/year
1	8,000	3,600	468,000
2			
3			
4			
5			
	Total	3,600	468,000

Unit price of energy to include in the contract:	130

3.3 INSTALLATION OF A PHOTOVOLTAIC SOLAR GENERATION SYSTEM

The project consisted of the installation of a system of 640 solar panels of 340W of power each, in an food packaging industry in the Yucatan Peninsula. The investor sees solar generation as an opportunity to reduce energy costs. The supplier's proposal was to take advantage of the roof structure of the packaging factory, highlighting that the system guarantees an annual generation of 305,000 kWh, which allows replacing 20% of the electricity consumed by the company from the national power grid.

The project was financed through the Energy Efficiency Program of FIRA, an agricultural and agribusiness development bank in Mexico. FIRA offers a "technology guarantee", which is a coverage instrument equivalent to energy savings insurance, which, through a revolving fund, seeks to create project statistics in different technologies. The technology warranty provides coverage for the life of the financing, which in this case was three years. If the system demonstrates that the promised generation is achieved during the first year, the goal is considered met and the guarantee is canceled; otherwise, it is executed on the basis of the first year's performance.

Fact sheet

On this sheet, the supplier enters its contact information and that of the company that will carry out the investment, describes in general terms the investment and expenditure budget and waste management, and lists the documents attached to its proposal. In this case, it is specified that it is a power generation project and refers to the installation of new equipment. In this technology, since no equipment is replaced at the investor's facilities, it is not necessary to complete the waste record in the form.

Technical sheet

- Technical project information

  The scope of the project includes the design, supply and installation of the solar panels and inverters and the design of the structure that supports them. Equipment data are recorded in section 1.1 of the format (image 18).

Image 18. Section: information on proposed equipment

Record the details of the new equipment to be installed as appropriate.			
General characteristics of the system			
Type of system	Connected to the network		
Does it deliver surplus energy?	No		
System effective area (m^2)	1165.8816		
Installation mounting location	Ceiling	Which?	
System operating capacity (kW)	160		
Global efficiency of the photovoltaic system (%)	80.76		
Characteristics of PV panels			
Panel type	Monocrystalline silicon (mono-yes)	Which?	
Manufacturer	BYD Solar		
Model	360M HK-30		
Panel area (m^2)	1.82169		
Panel unit capacity (W)	360		
Panel voltage (V)	39.14		
Efficiency (%)	19.76%		
Azimuth (0 is north)	180 degrees		
Inclination (°)	20 degrees		
Solar tracking mode	No		
Electrical protection system	Yes		
System panel quantity	640		
Investor Features			
Inverter type	Inverter		
Manufacturer	HUAWEI		
Model	SUN2000-40KTL-US		
Efficiency (%)	98.9%		
Inverter rated capacity (kW)	40		
Number of inverters	4		
Does the system include storage?	No		
Description of other changes in the facility associated with technology			

In a solar photovoltaic generation installation, the reference energy will normally be that supplied by the electrical grid or other sources of electrical self-generation. In this case, the power grid was used as a reference. The cost of energy was estimated based on the latest invoice from the electricity supplier. It is important to consider the electricity billing policies in each country and make sure to integrate or exclude elements that affect the price, such as required power and load factor (image19).

Image 19. Section: information on the energetics associated with the project

Record the energy associated with the project for the reference generation technology (if applicable).

If your photovoltaic installation considers electricity from the national electricity system as reference energy, the price you write for this energy may be (i) the reference price normally paid to the distributor per kWhe or (ii) if the photovoltaic system delivers surpluses, this price must take this condition into account.

	Reference fuels used		
Fuels involved in the project	**Fuel 1**	**Fuel 2**	**Fuel 3**
Fuel type	Electricity		
Unit	kWh		
Price ($/unit)	2.47		
Price information source	CFE		
Lower heating power (LHP) (kWh/unit)	1.00		
LHP information source	NA		
Emission factor (tCO_2eq/kWh)	0.00045800		
Emission factor information source	CRE		

Monitoring system

Photovoltaic technology is one of the easiest to measure, since the devices involved are self-measuring and historical irradiance records, one of the essential design factors, are available. The parameters whose measurement the supplier considered relevant in order to determine the performance indicator of the proposed project in terms of energy generated are available on image 20:

- Renewable energy supplied, which refers to the amount of energy supplied by the power generation system. In this case it was possible to measure it directly through the inverters, which in turn transmit the data to monitoring applications supplied by the technology provider.

- Renewable resource, which refers to the amount of natural resource that is available to the customer to produce energy. The application employed by the technology provider uses information on renewable resources provided by NASA.

Image 20. Section: relevant parameter data

Parameter data							Measurement System Data associated with the measured parameter (when applicable)				
ID	Type	Name	Unit	Measure-ment frequency	Desired value of the controlled condition	% tolerance and variability of the controlled condition	Meter type or [Database name]	Brand or [Base source details]	Model or [Other database details]	ID or Serial No.	% of measurement equipment error
P1	Renewable resource	Solar irradiation	kWh/m^2	Monthly			Internet	NASA	NA	NA	NA
P2	Renewable energy supplied	Electricity	kWh	Monthly			MODBUS-TCP for connections	Huawei NetEco	NA	NA	NA
P3											
P4											
P5											
P6											
P7											
P8											
P9											
P10											

Define and indicate how the “Supplied renewable energy” is obtained from its “variable(s)” defined in section 2.2 (when applicable).
Based on the solar radiation of the place, design conditions such as slope, orientation and shade are considered.

Construction of energy indicators

In this project, the supplier decided to use the common practice of taking a year's irradiance records separated into monthly periods, thanks to the availability of information in historical solar radiation databases. Image 21 shows the measurement periods for the solar photovoltaic generation project:

Image 21. Section: construction of indicators

3.1. Definition of the measurement periods for the proposed case								
Define all the time periods that you will use to calculate the "Estimated Energy Index" (EEI) for the new renewable energy technology.								
	From				**Until**			
Period ID	**Time**	**dd**	**mm**	**yyyy**	**Time**	**dd**	**mm**	**yyyy**
1	0:00:00	1	4	2018	23:59:00	30	4	2018
2	0:00:00	1	5	2018	23:59:00	31	5	2018
3	0:00:00	1	6	2018	23:59:00	30	6	2018
4	0:00:00	1	7	2018	23:59:00	31	7	2018
5	0:00:00	1	8	2018	23:59:00	31	8	2018
6	0:00:00	1	9	2018	23:59:00	30	9	2018
7	0:00:00	1	10	2018	23:59:00	31	10	2018
8	0:00:00	1	11	2018	23:59:00	30	11	2018
9	0:00:00	1	12	2018	23:59:00	31	12	2018
10	0:00:00	1	1	2019	23:59:00	31	1	2019
11	0:00:00	1	2	2019	23:59:00	28	2	2019
12	0:00:00	1	3	2019	23:59:00	31	3	2019

Then, using theoretical estimates and experience, the supplier defined how much "delivered renewable energy" the proposed system would generate, considering design conditions such as geographic location, tilt, orientation, shading, and technical characteristics of panels and inverters.

In this case, the supplier selected panels with 20 degrees of inclination at 180 degrees with respect to geographic north for which, considering shading and tilt losses, an engineering-determined efficiency of 80% was obtained. Then, the supplier defined a lower efficiency (75%) to absorb any deviation not calculated in the design (image 22).

Image 22. Section: expected energy supply of the system

3.2. Expected energy supply of the photovoltaic system										
Record “renewable energy supplied” based on the estimated availability of the “renewable resource” for each period (proposed in section 3.1).										
Id	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**
Type	Renewable resource	Renewable energy supplied								
Name	Solar irradiation	Electricity								
Unit	Kwh/m²	kWh								
Measurement period ID	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value
1	196.50	31,895.2								
2	191.27	30,044.8								
3	188.10	30,531.7								
4	182.90	28,730.0								
5	163.68	25,710.9								
6	138.90	22,545.8								
7	129.58	20,345.5								
8	109.50	17,773.6								
9	163.06	25,613.5								
10	128.65	20,208.4								
11	132.72	23,081.4								
12	178.56	28,048.3								

With this data, the tool performs automatic calculations and presents in section 3.3 of the sheet the expected energy generated index (EGI), which in this case corresponds to the average of the indicators calculated for each measurement period. The result was a EGI of 160 kWh/kWh/m^2.

Guaranteed generated energy

The supplier must indicate to its client the amount of annual "renewable resource" that it has calculated based on statistical information on irradiation in the area where the project is located. The tool automatically generates annual values as it has data on energy prices and performance indexes.

The "renewable resource" figure was recorded for five years in this case. The sheet shows a slight decrease in generation capacity in the years following the installation. This is due to the fact that in order to consider the degradation of the panels, the supplier opted to apply a 0.3% annual decrease in annual radiation.

The generation commitment with the customer is established in the performance contract in energy units. The value in monetary terms is generated by the tool based on the energy prices recorded above. The tool also automatically generates the annual tons of CO_2 avoided and the unit price of energy to be used by supplier and customer to define the base price of energy to be used in the performance contract in order to calculate possible financial compensation for underperformance. In this case the value is MXN 2.47 per kWh (image 23).

Image 23. Section: guaranteed generated energy

4. Guaranteed generated energy			
Indicate the estimated annual availability of the “renewable resource”, agreed with the client. With this value the “Annual guaranteed energy generated” in energy units and its monetary equivalent will be calculated. The contractor may guarantee the generation of energy for more than 5 years, if he so considers it, but must bear in mind that the insurance coverage for the ESI program operates for the first 5 years of the project.			
Select the number of additional years for which power generation is guaranteed.	5		
	Annual hot water	**Guaranteed energy savings**	
Año	**Kwh/m²-year**	**kWh/year**	**$/year**
1	1,902.23	304,792	752,835
2	1,896.53	303,877	750,577
3	1,890.84	302,966	748,325
4	1,885.17	302,057	746,080
5	1,879.51	301,151	743,842
	Total	**1,514,842**	**3,741,659**

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ANNEX 1. GLOSSARY

Avoided Cost Index (ACI)	Quantitative value representing the ratio between the costs avoided thanks to the renewable energy generated by the system and the "renewable resource" used for this purpose.
Avoided Emissions Index (AEI)	Quantitative value representing the ratio between the GHG emissions avoided thanks to the renewable energy generated by the system and the "renewable resource" used for this purpose.
Base Energy Performance Index (EPI_{base})	Quantitative value or measure of the energy performance of existing (or reference, as the case may be) equipment, established as the ratio of the input energy consumption to the "energy end-use" produced.
Base Environmental Performance Index ($ENPI_{base}$)	Quantitative value resulting from the ratio between the amount of GHG emissions produced by the existing equipment (or reference equipment, as the case may be) and the "energy end-use" produced.
Base Financial Performance Index (FPI_{base})	Quantitative value resulting from the ratio between energy costs generated by the use of existing equipment (or reference equipment, as the case may be) and the "final energy use" produced.
Controlled condition	Any parameter that influences the energy performance of the system and that must be kept at a constant value or with a limited fluctuation in order to obtain representative measurements.
Current consumption	Parameter used to characterize the consumption of each of the energy sources used by the existing system or equipment.
Customer	Natural or legal person engaged in any industrial, commercial or service activity constituted as a legal person, which will make the investment in an energy efficiency or energy generation project.
Energy	Any substance, material or form of energy that may be used as a source of energy for the operation of any equipment necessary for a customer's business activity directly or indirectly.
Energy end-use	It is the useful service produced by the equipment or technology required by the customer for the activity operations, either directly (e.g., tons of frozen product in cold storage) or indirectly, in order to obtain the conditions that allow it to produce its goods or services (e.g., hours of lighting).

Energy generation rate	Quantitative value representing the ratio between the renewable energy generated by the system and the "renewable resource" used for this purpose.
Energy Performance Index (EPI)	A quantitative value or measure of the energy performance of a system or equipment, established as the ratio of input energy consumption to the "energy end-use" produced.
Energy savings	Reduction in energy consumption during the production of a good or the provision of a service within a given period.
Expected Energy Performance Index (Expected EPI)	Quantitative value or measure of the energy performance expected to be achieved by the equipment or system to be installed, established as the ratio between the input energy consumption and the "energy end-use" produced.
Expected Environmental Performance Index ($ENPI_{expected}$)	Quantitative value resulting from the ratio between the amount of GHG emissions expected to be achieved by the equipment or system to be installed and the "energy end-use" produced.
Expected Financial Performance Index ($FPI_{expected}$)	Quantitative value resulting from the ratio between the expected theoretical energy costs generated by the use of the equipment or system to be installed and the "final energy use" produced.
Financial cost avoided	The monetary savings generated by the energy savings achieved in an energy performance project. In a power generation project, it refers to the monetary savings achieved thanks to the renewable energy generated.
Greenhouse Gases (GHG) avoided	For an energy performance project, this corresponds to the GHG avoided due to the energy savings achieved. In the case of a power generation project, this corresponds to the GHG avoided thanks to the renewable energy generated.
Guaranteed energy savings	Corresponds to the minimum energy savings guaranteed by the supplier to the customer, based on an agreed "energy end-use" for the project.

Guaranteed generated energy	Corresponds to the minimum energy that the supplier guarantees the customer that it will generate with the project, based on a fixed annual availability of the "renewable resource" agreed with the customer.
Hazardous waste	A waste or mixture of wastes that presents a risk to public health and/or adverse effects to the environment, either directly or due to its current or anticipated management.
Inert waste	Non-hazardous waste that does not undergo significant physical, chemical or biological variations, is not soluble, combustible, does not react physically, chemically or in any other way. It is not biodegradable and does not adversely affect other materials with which it comes into contact.
Installation	Establishment where the client carries out its industrial or commercial activity and where the project will be carried out.
Measurement period	Period of time during which a measurement (or estimate, as the case may be) of some relevant parameter will be made to determine either the energy performance of an existing (or reference, as the case may be) equipment or the renewable energy supplied by a generation system.
New technology	Refers to situations where there is no change of existing equipment. In energy efficiency projects, the equipment used as a reference for estimating savings will be that owned by the client, based on information from industry studies, the supplier or the literature. In the case of a generation project, the reference may be a self-generation system, the grid or a combination of the two.
Non-hazardous waste	Waste that does not present a risk to public health or adverse effects on the environment.
Parameter	It represents a measurable or quantifiable characteristic of an equipment or system and/or its environment that is relevant to assess its operating condition.
Proposed consumption	Parameter used to characterize the expected consumption of each of the different energy sources to be used by the technological solution to be installed.

Reference consumption	Parameter used to characterize, in new projects, the consumption of each of the energy sources used by the selected reference system or equipment.
Reference equipment	Equipment defined by the supplier as a standard technology used in the customer's industry or sector, when the customer is not currently requiring the product or service offered by the equipment proposed by the supplier.
Renewable energy supplied	Energy supplied by a generation system over a period of time, through the use of renewable resources.
Renewable resource	A natural resource used to produce energy (e.g., radiation, biomass, wind) that may be renewed by nature's own mechanisms at a faster rate than it is consumed.
Supplier	Natural or legal person dedicated to the commercialization, supply and maintenance of equipment, offering the development of energy efficiency projects and/or the use of renewable energies.
Technology replacement	Refers to situations where there is no change of existing equipment. In energy efficiency projects, new equipment must have better energy performance than the equipment to be replaced. In the case of a generation project, the new equipment is a generation system that operates with renewable resources and will totally or partially replace a fuel-consuming system or an obsolete renewable system.
Validation	Independent evaluation process by the validation entity of an energy efficiency or energy generation project, which seeks to assess the reasonableness of the guaranteed savings or energy generated, proposed by the supplier according to the information presented.
Validation entity	A legal entity with skills and experience in evaluating energy efficiency and power generation projects whose role is to review the consistency of the information submitted for the project and: (i) assess whether the project has the potential to achieve the promised savings (project validation); (ii) verify on-site whether the project has been delivered according to specifications (project verification); and (iii) act as arbitrator in case of any disagreement between client and supplier regarding project performance over a certain period (performance verification).
Variable	Parameter used to indirectly characterize the "energy end-use" or renewable energy supplied in a project.

ANNEX 2. MEASUREMENT PARAMETERS BY TECHNOLOGY

The charts below show some examples of measurement variables and controlled conditions for energy efficiency and power generation project technologies.

Chart A2.1. Example of relevant parameters for energy performance projects

Technology	"Energy end-use"		Variable		Controlled condition	
	Name	Unit	Name	Unit	Name	Unit
Water boiler	Sanitary hot water	m^3			Cold water inlet temperature	°C
					Hot water delivery temperature	°C
					Load factor	%
Lighting	Hour-Light	h				
Electric engine	Mechanical energy delivered	hp-h	Voltage	V	Load factor	%
			Current	A		
			Power factor	-		
Air conditioning	Extracted thermal energy	BTU	Air conditioning flow	Lb/h	Relative humidity	%
			Outbound air enthalpy	BTU/lb		
			Inbound air enthalpy	BTU/lb		
Refrigeration	Extracted thermal energy	MBTU	Capacity	kW	Ambient temperature	°C
					Indoor cold room temperature	°C
Solar thermal system	Sanitary hot water	m^3	Measuring time	h	Cold water inlet temperature	°C
					Hot water delivery temperature	°C
Oven or dryer	Product mass	kg			Ambient temperature	°C
					Substrate humidity	g/kg

Chart A2.1. Example of relevant parameters for energy performance projects (continuation)

Technology	"Energy end-use"		Variable		Controlled condition	
	Name	Unit	Name	Unit	Name	Unit
Cogeneration	Thermal energy transferred	kWht			Load factor	%
	Electric power (corresponds to the parameter "electric generation")	kWhe				
Electric motorcycle cabs	Distance traveled	km			Weight transported	kg
Air compressor	Compressed air	l			Ambient temperature	°C

Source: Authors' elaboration.

Chart A2.2. Example of relevant parameters for power generation projects

Technology	Renewable energy supplied		Renewable resource		Controlled condition	
	Name	Unit	Name	Unit	Name	Unit
Photovoltaic system	Electricity	kWhe	Solar radiation	kWh/m^2		
Biogas generation	Biogas	m^3	Substrate	m^3	Digestion temperature	°C
					pH	

Source: Authors' elaboration.

ANNEX 3. EMISSION FACTORS AND OTHER ENERGY DATA

Chart A3.1. Emission factors for combustion in stationary sources

Fuel	Emission factor	Emission factor	Emission factor
Stationary combustion	**kg CO_2/TJ**	**kg CH_4/TJ**	**kg N_2O/TJ**
Crude oil	73,300	3	0.6
Orimulsion	77,000	3	0.6
Liquefied natural gas	64,200	3	0.6
Gasoline for engines	69,300	3	0.6
Aviation gasoline	70,000	3	0.6
Gasoline for jet engines	70,000	3	0.6
Jet engine kerosene	71,500	3	0.6
Other kerosene	71,900	3	0.6
Oil shale	73,300	3	0.6
Gas/Diesel oil	74,100	3	0.6
Residual fuel oil	77,400	3	0.6
Liquefied petroleum gases	63,100	1	0.1
Ethane	61,600	1	0.1
Naphtha	73,300	3	0.6
Bitumen	80,700	3	0.6
Lubricants	73,300	3	0.6
Petroleum coke	97,500	3	0.6
Refinery process feed	73,300	3	0.6
Refinery gas	57,600	1	0.1
Kerosene waxes	73,300	3	0.6
White spirit and SBP	73,300	3	0.6
Other petroleum products	73,300	3	0.6
Anthracite	98,300	1	1.5
Coking coal	94,600	1	1.5
Other bituminous coal	94,600	1	1.5
Sub-bituminous coal	96,100	1	1.5
Lignite	101,000	1	1.5
Oil shale and tar	107,000	1	1.5
Coal and lignite briquettes	97,500	1	1.5
Fuel evident	97,500	1	1.5
Coke oven coke and lignite coke	107,000	1	1.5

Chart A3.1. Emission factors for combustion in stationary sources

Fuel	Emission factor	Emission factor	Emission factor
Stationary combustion	kg CO_2/TJ	kg CH_4/TJ	kg N_2O/TJ
Gas coke	107,000	1	0.1
Coal tar	80,700	1	1.5
Gas from gas works	44,400	1	0.1
Coke oven gas	44,400	1	0.1
Blast furnace gas	260,000	1	0.1
Oxygen furnace gas for steels	182,000	1	0.1
Natural gas	56,100	1	0.1
Municipal waste (without biomass)	91,700	30	4
Industrial waste	143,000	30	4
Waste oils	73,300	30	4
Peat	106,000	1	1.5
Wood/wood waste	112,000	30	4
Sulfite bleach (black liquor)	95,300	3	2
Other primary solid biomass	100,000	30	4
Charcoal	112,000	200	4
Biogasoline	70,800	3	0.6
Biodiesel	70,800	3	0.6
Other liquid fuels	79,600	3	0.6
Landfill gas	54,600	1	0.1
Sewage sludge digestion gas	54,600	1	0.1
Other biogas	54,600	1	0.1
Municipal waste (biomass)	100,000	30	4

Source: Matsika et al. (2006) [14].

Chart A3.2. Network emission factors, calorific value and energy prices by country

Country	Emission factors		Combustible calorific value	Fuel prices	Electricity price
	Fuels	**Electrical system**			
Colombia	Emissions calculator (UPME, 2016)	Calculation of the CO_2 emission factor of the INS (UPME, 2020)	Emissions calculator (UPME, 2016)	Fuel prices (Minenergía, 2020)	Average price and energy traded (XM, 2020)
Chile	National Greenhouse Gas Emissions Inventory (INVENTARIO NACIONAL DE EMISIONES DE GASES EFECTO INVERNADERO, 2018)	Average annual emission factor (Comisión Nacional de Energía - CNE, 2020)	National Greenhouse Gas Emissions Inventory (INVENTARIO NACIONAL DE EMISIONES DE GASES EFECTO INVERNADERO, 2018)	Hydrocarbon statistics (Comisión Nacional de Energía, 2020)	Electricity pricing (Comisión Nacional de Energía, 2020)
Brazil	Dispatch Analysis Method (Ministério da Ciência, Tecnologia e Inovações, 2020)	Dispatch Analysis Method (Ministério da Ciência, Tecnologia e Inovações, 2020)	Conversion factors, densities and net calorific values (FATORES DE CONVERSÃO, DENSIDADES E PODERES CALORÍFICOS INFERIORES, 2018)	Preços ANP (ANP, 2020)	Ranking das Tarifas - ANEEL (ANEEL, 2020)
Mexico	Technical peculiarities and formulas for the application of methodologies for the calculation of greenhouse gas or compound emissions (Secretaría de Gobernación, 2015)	Emission Factor of the National Electric System 2019 - CRE (Comisión Reguladora de Energía, 2020)	List of fuels, net calorific values and equivalence in terms of barrels of crude oil equivalent - CONUEE (Combustibles, 2020)	Prices of petroleum products, LPG and natural gas reference price indexes (Gobierno de Méjico, 2020)	Short-term market energy prices (Gobierno de Méjico, 2020)
Peru	Environmental performance study (Ministerio del Ambiente, 2020)	Environmental performance study (Ministerio del Ambiente, 2020)	Ministry of Energy and Mines (Ministerio de Energía y Minas, 2020)	Facilito - Fuel prices (Osinergmin, 2020)	Facilito - Tariff sheets applicable to the end customer (Osinergmin, 2020)

Source: Authors' elaboration.

ANNEX 4. INDICATORS

The following gives a more detailed description of the indicators in question and the variations they undergo in certain specific technologies.

Energy performance

- Energy performance index (extended formula)

When considering three energetics, the energy performance indicator is defined as:

7.

$$ENPI\left[\frac{kWheq}{Unit\ end\text{-}use}\right]=\frac{Energy\ consumption}{Energy\ end\text{-}use}=\frac{\left(\begin{array}{l}Energy_{consumption1}\left[Unit\ of\ energy\ 1\right]\bullet PCI_{Energy1}\left[\frac{kWh_{eq}}{Unit\ of\ energy\ 1}\right]+\\Energy_{consumption2}\left[Unit\ of\ energy\ 2\right]\bullet PCI_{Energy2}\left[\frac{kWh_{eq}}{Unit\ of\ energy\ 2}\right]+\\Energy_{consumption3}\left[Unit\ of\ energy\ 3\right]\bullet PCI_{Energy3}\left[\frac{kWh_{eq}}{Unit\ of\ energy\ 3}\right]\end{array}\right)}{Unit\ of\ energy\ end\text{-}use}$$

- Environmental performance index (extended formula)

8.

$$ENPI\left[\frac{tCO_2}{Unit\ end\text{-}use}\right]=\frac{\left(\begin{array}{l}FE_{Energy1}\left[\frac{tCO_2}{kWh_{eq}}\right]\bullet Energy_{consumption1}\left[Unit\ of\ energy\ 1\right]\bullet PCI_{Energy1}\left[\frac{kWh_{eq}}{Unit\ of\ energy\ 1}\right]+\\FE_{Energy2}\left[\frac{tCO_2}{kWh_{eq}}\right]\bullet Energy_{consumption2}\left[Unit\ of\ energy\ 2\right]\bullet PCI_{Energy2}\left[\frac{kWh_{eq}}{Unit\ of\ energy\ 2}\right]+\\FE_{Energy3}\left[\frac{tCO_2}{kWh_{eq}}\right]\bullet Energy_{consumption3}\left[Unit\ of\ energy\ 3\right]\bullet PCI_{Energy3}\left[\frac{kWh_{eq}}{Unit\ of\ energy\ 3}\right]\end{array}\right)}{Unit\ end\text{-}use}$$

- Financial performance index (extended formula)

9.

$$FPI\left[\frac{\$}{\text{Unit end-use}}\right]=\frac{\dfrac{Energy_{Price1}\left[\dfrac{\$}{\text{Unit of energy 1}}\right]}{PCI_{Energy1}\left[\dfrac{kWh_{eq}}{\text{Unit of energy 1}}\right]}\bullet Energy_{consumption1}\left[kWh_{eq}\right]+\dfrac{Energy_{Price2}\left[\dfrac{\$}{\text{Unit of energy 2}}\right]}{PCI_{Energy2}\left[\dfrac{kWh_{eq}}{\text{Unit of energy 2}}\right]}\bullet Energy_{consumption2}\left[kWh_{eq}\right]+\dfrac{Energy_{Price3}\left[\dfrac{\$}{\text{Unit of energy 3}}\right]}{PCI_{Energy3}\left[\dfrac{kWh_{eq}}{\text{Unit of energy 3}}\right]}\bullet Energy_{consumption3}\left[kWh_{eq}\right]}{\text{Unit of energy end-use}}$$

Cogeneration (Combustion generation)

- Base energy performance index (extended formula)

For cogeneration, the "final energy use" is considered as the thermal energy transferred to service, which is the point of comparison between the current system and the cogeneration system that will be installed; therefore, the base indicator considers the equipment that is currently producing thermal energy. A maximum of three different energy sources may be considered for this purpose, as shown in the following equation:

10.

$$ENPI\left[\frac{kWheq}{\text{Unit end-use}}\right]=\frac{\text{Energy consumption current equipment}}{\text{Thermal energy supplied }(kWh_t)}=\left(\begin{array}{l}Energy_{consumption1}\left[\text{Unit of energy 1}\right]\bullet PCI_{Energy1}\left[\dfrac{kWh_{eq}}{\text{Unit of energy 1}}\right]+\\ Energy_{consumption2}\left[\text{Unit of energy 2}\right]\bullet PCI_{Energy2}\left[\dfrac{kWh_{eq}}{\text{Unit of energy 2}}\right]+\\ Energy_{consumption3}\left[\text{Unit of energy 3}\right]\bullet PCI_{Energy3}\left[\dfrac{kWh_{eq}}{\text{Unit of energy 3}}\right]\end{array}\right)/kWh_t$$

- Expected energy performance index (extended formula)

The expected energy performance index for the cogeneration system covers the declared thermal energy yielded for the current base case, adding to that the generation of electrical energy, which produces improvements in energy performance when compared to mere thermal energy production. The following equation shows the energy performance calculation when considering three types of energy; however, it is most common for the system to use only one type of energy:

11.

$$ENPI\left[\frac{kWheq}{Unit\ end\text{-}use}\right]=\frac{Energy\ consumption\ Cogeneration}{Thermal\ energy\ supplied\ (kWh_t)+\ Electrical\ energy\ generated\ (kWh_e)}=\begin{pmatrix} Energy_{consumption1}\left[Unit\ of\ energy\ 1\right]\bullet PCI_{Energy1}\left[\frac{kWh_{eq}}{Unit\ of\ energy\ 1}\right]+ \\ Energy_{consumption2}\left[Unit\ of\ energy\ 2\right]\bullet PCI_{Energy2}\left[\frac{kWh_{eq}}{Unit\ of\ energy\ 2}\right]+ \\ Energy_{consumption3}\left[Unit\ of\ energy\ 3\right]\bullet PCI_{Energy3}\left[\frac{kWh_{eq}}{Unit\ of\ energy\ 3}\right] \end{pmatrix}/kWh_t+\ kWh_e$$

Note: The thermal energy given up is the energy given up to a quantity of some "thermal product" such as hot water, steam, etc. It is also what determines the point of comparison for the performance of the current system and the cogeneration system.

- Base environmental performance index (extended formula)

The base environmental performance index for cogeneration accounts for the consumption of energy by the current technology which, when multiplied by its respective emission factors, accounts for the generation of greenhouse gas (GHG) emissions to produce the thermal energy that is transferred to service. In addition, the emission factor of the national electric system (or generator set, as appropriate) is added, as shown in the following equation:

12.

$$ENPI\left[\frac{tCO_2}{Unit\ end\text{-}use}\right]=\frac{\begin{pmatrix} FE_{Energy1}\left[\frac{tCO_2}{kWh_{eq}}\right]\bullet Energy_{consumption1}\left[Unit\ of\ energy\ 1\right]\bullet PCI_{Energy1}\left[\frac{kWh_{eq}}{Unit\ of\ energy\ 1}\right]+ \\ FE_{Energy2}\left[\frac{tCO_2}{kWh_{eq}}\right]\bullet Energy_{consumption2}\left[Unit\ of\ energy\ 2\right]\bullet PCI_{Energy2}\left[\frac{kWh_{eq}}{Unit\ of\ energy\ 2}\right]+ \\ FE_{Energy3}\left[\frac{tCO_2}{kWh_{eq}}\right]\bullet Energy_{consumption3}\left[Unit\ of\ energy\ 3\right]\bullet PCI_{Energy3}\left[\frac{kWh_{eq}}{Unit\ of\ energy\ 3}\right] \end{pmatrix}}{kWh_t}+\frac{tCO_{2\ National\ Electric\ System\ or\ Electric\ generator}}{kWh_e}$$

- Estimated environmental performance index (extended formula)

The estimated environmental performance index for cogeneration considers the direct emissions of the cogeneration system when using up to three different energy sources (if applicable) with respect to the total thermal energy transferred, together with the electrical energy generated.

13.

$$ENPI\left[\frac{tCO_2}{Unit\ end\text{-}use}\right]=\frac{\left(\begin{array}{l} FE_{Energy1}\left[\frac{tCO_2}{kWh_{eq}}\right]\bullet Energy_{consumption1}\left[Unit\ of\ energy\ 1\right]\bullet PCI_{Energy1}\left[\frac{kWh_{eq}}{Unit\ of\ energy\ 1}\right]+\\ FE_{Energy2}\left[\frac{tCO_2}{kWh_{eq}}\right]\bullet Energy_{consumption2}\left[Unit\ of\ energy\ 2\right]\bullet PCI_{Energy2}\left[\frac{kWh_{eq}}{Unit\ of\ energy\ 2}\right]+\\ FE_{Energy3}\left[\frac{tCO_2}{kWh_{eq}}\right]\bullet Energy_{consumption3}\left[Unit\ of\ energy\ 3\right]\bullet PCI_{Energy3}\left[\frac{kWh_{eq}}{Unit\ of\ energy\ 3}\right] \end{array}\right)}{kWh_t+kWhe}$$

- Baseline financial performance indicator (extended formula)

The baseline financial performance index for cogeneration accounts for the consumption of energy by the current technology which, when multiplied by the respective prices, accounts for the financial expense needed to produce the thermal energy transferred to service. In addition, the cost per kWhe of the national electricity system (or generator set, as appropriate) is added, as shown in the following equation:

14.

$$FPI\left[\frac{\$}{Unit\ end\text{-}use}\right]=\frac{\begin{array}{l} \frac{Energy_{Price1}\left[\frac{\$}{Unit\ of\ energy\ 1}\right]}{PCI_{Energy1}\left[\frac{kWh}{Unit\ of\ energy\ 1}\right]}\bullet Energy_{consumption1}\left[kWh_{eq}\right]+\\ \frac{Energy_{Price2}\left[\frac{\$}{Unit\ of\ energy\ 2}\right]}{PCI_{Energy2}\left[\frac{kWh}{Unit\ of\ energy\ 2}\right]}\bullet Energy_{consumption2}\left[kWh_{eq}\right]+\\ \frac{Energy_{Price3}\left[\frac{\$}{Unit\ of\ energy\ 3}\right]}{PCI_{Energy3}\left[\frac{kWh}{Unit\ of\ energy\ 3}\right]}\bullet Energy_{consumption3}\left[kWh_{eq}\right] \end{array}}{kWh_t}+\frac{\$_{National\ Electric\ System\ or\ Electric\ generator}}{kWh_e}$$

- Estimated financial performance indicator (extended formula)

The estimated financial performance index for cogeneration considers the costs of the cogeneration system when using up to three different energy sources (if applicable) with respect to the total thermal energy transferred together with the electrical energy generated, as shown in the following equation:

15.

$$FPI\left[\frac{\$}{Unit\ end\text{-}use}\right]=\frac{\dfrac{Energy_{Price1}\left[\dfrac{\$}{Unit\ of\ energy\ 1}\right]}{Energy_{Price1}\left[\dfrac{kWh_{eq}}{Unit\ of\ energy\ 1}\right]}\bullet Energy_{consumption1}\left[kWh_{eq}\right]+\dfrac{Energy_{Price2}\left[\dfrac{\$}{Unit\ of\ energy\ 2}\right]}{Energy_{Price2}\left[\dfrac{kWh}{Unit\ of\ energy\ 2}\right]}\bullet Energy_{consumption2}\left[kWh_{eq}\right]+\dfrac{Energy_{Price3}\left[\dfrac{\$}{Unit\ of\ energy\ 3}\right]}{Energy_{Price3}\left[\dfrac{kWh_{eq}}{Unit\ of\ energy\ 3}\right]}\bullet Energy_{consumption3}\left[kWh_{eq}\right]}{kWh_{t}+kWh_{e}}$$

Power generation

- Energy Generated Index (EGI)

In the case of the base generated energy index, it is the same as the one detailed in section 1.2.2 of this document, as shown in the following equation:

16.

$$EGI\left[\frac{kWh_{\ generated}}{Unit\ of\ renewable\ resource}\right]=\frac{Renewable\ energy\ supplied}{Renewable\ resource}$$

In case the renewable energy generation system requires energy consumption to operate, as could be the case of a biogas reactor this consumption should be discounted from the energy generated, as shown in the following equation:

17.

$$EGI\left[\frac{kWh_{generated}}{Unit\ of\ renewable\ resource}\right] = \frac{Renewable\ energy\ supplied\ -\ Energy\ consumed\ by\ the\ renewable\ system}{Renewable\ resource}$$

- Avoided Emissions Index (AEI)

In the case of the AEI, this is calculated based on the amount of energy generated by the renewable energy system and the amount of emissions that this energy would have if it were generated by the current generation systems and/or consumed by the distribution system by the customer.

Understanding that this energy demanded by the customer may also be generated by different equipment, it is necessary to consider the percentage distribution of how the generation is distributed in the different current generation equipment and/or the distribution system, which is stated in the technical sheet. The calculation is performed as shown in the following equation:

18.

$$AEI\left[\frac{tCO_2}{Unit\ of\ renewable\ resource}\right] = EGI\left[\frac{kWh_{generated}}{Unit\ of\ renewable\ resource}\right] \bullet \left(\frac{\%Generation\ current\ equipment1}{\%\ Efficiency\ equipment1} \bullet FE_{fuel\ equipment1}\left[\frac{tCO_2}{kWh_{eq}}\right] + \frac{\%Generation\ current\ equipment\ n}{\%\ Efficiency\ equipment\ n} \bullet FE_{fuel\ equipment\ n}\left[\frac{tCO_2}{kWh_{eq}}\right] + \%Use\ of\ distribution\ system \bullet FE_{distribution\ system}\left[\frac{tCO_2}{kWh}\right]\right)$$

In case the renewable energy generation system requires energy consumption to operate, as could be the case for a biogas reactor, the GEI used in the equation just shown would have discounted this energy that the renewable energy system uses in order to operate.

- Avoided Cost Index (ACI)

In the case of the ACI, this is calculated based on the amount of energy generated by the renewable energy system and the cost that this energy would have if it were generated by the current generation systems and/or consumed from the distribution system by the customer.

Understanding that this energy demanded by the customer may also be generated by different equipment, it is necessary to consider the percentage distribution of how this generation is distributed in the different current generation equipment and/or the distribution system, which is stated in the technical sheet. The calculation is performed as shown in the following equation:

19.

$$EGI\left[\frac{\$}{Unit\ of\ renewable\ resource}\right] = EGI\left[\frac{kWh_{generated}}{Unit\ of\ renewable\ resource}\right] \bullet \left(\frac{\%Generation\ current\ equipment\ 1}{\%\ Efficiency\ equipment1} \bullet \frac{Combined_{price\ equipment1}\left[\frac{\$}{Unit\ of\ fuel}\right]}{Combined_{PCI\ equipment1}\left[\frac{kWh_{eq}}{Unit\ of\ fuel}\right]} + \frac{\%Generation\ current\ equipment\ n}{\%\ Efficiency\ equipment\ n} \bullet \frac{Combined_{price\ equipment\ n}\left[\frac{\$}{Unit\ of\ fuel}\right]}{Combined_{PCI\ equipment\ n}\left[\frac{kWh_{eq}}{Unit\ of\ fuel}\right]} + \%Use\ of\ distribution\ system \bullet Price_{Distribution\ system}\left[\frac{\$}{kWh}\right]\right)$$

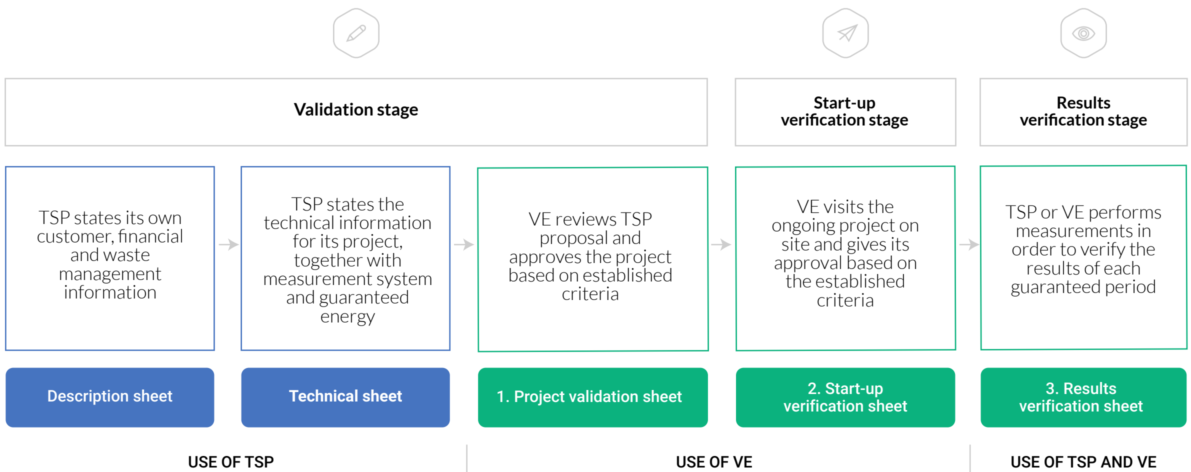
In case the renewable energy generation system requires energy consumption to operate —as could be the case for a biogas reactor—, the EGI used in the equation just shown would have discounted this energy that the renewable energy system uses in order to operate.

ANNEX 5. PROJECT VALIDATION, VERIFICATION AND PERFORMANCE MONITORING FORMS

ANNEX 6. TOOL FOR ESTIMATING ENERGY SAVINGS OR GENERATION, BY TECHNOLOGY TYPE

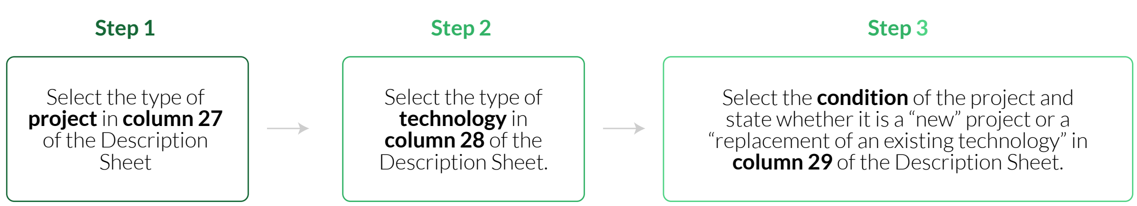
CONTEXTO

The Energy Savings Insurance Program, developed by the Inter-American Development Bank (IDB), with the support of Denmark's Ministry of Energy and Green Finance LAC, is a new risk mitigation mechanism, whose aim is to promote investments in energy efficiency throughout the private sector in different countries (Brazil, El Salvador, Chile, Mexico, Peru and Colombia, among others), using energy savings insurance during the system operation process.



Technical project validation:

Corresponds to technical validation of the project to be executed and carried out using only the Description Sheet and the Technical Sheet corresponding to the technology to be implemented. Follow these indications to activate the specific Technical Sheet of the technology and type of project. To amend the condition of the technology in Step 3, return to Step 2 before continuing.



Results verification stage:

Corresponds to the validation of the results of energy resources savings achieved by the installed project, using only the Results Verification Sheet.

Key to cell colors used in the description form:

	Gray cells: cells where information is recorded manually.
	Blue cells: cells that are automatically calculated according to the information recorded in the gray cells.
	Strikethrough cells: cells that are released when an option is selected in a drop-down list of a previous gray cell that implies the need to provide additional information.

Recommendations and indications:

- Enable macros in order to begin working with this form.
- This form has been tested in Office 2016 and Office 365.
- This form has been tested in Windows 10 and macOS 10.0.4.