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Design of an Assisted Photovoltaic Solar Energy System for Block 5

Diseño de un Sistema de Energía Solar Fotovoltaica Asistido para el Bloque 5

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Abstract

This study focuses on the design of a photovoltaic system to supply electricity to the building "Block 5" of the FACI - UTLVTE. This design considers obtaining energy through two sources which are photovoltaic modules and the local power grid. Therefore, the designed photovoltaic system is conceived as an assisted solar photovoltaic installation. In the present research, calculations and simulations are carried out based on an analysis of the load demand and meteorological data obtained with PVsyst software. The results obtained indicate that the designed photovoltaic system can support a percentage of the demand of the lighting circuits, general outlets and special loads of Block 5, which corresponds to a decrease in the costs associated with the consumption of electricity from the local power grid. These results demonstrate that the sizing achieved by this photovoltaic system is optimal, which is validated by means of the PVsyst software.

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Keywords: solar resource analysis, PVsyst, photovoltaic system, demand estimation.

Resumen

Este estudio se centra en el diseño de un sistema fotovoltaico que sirva para abastecer con electricidad al edificio "Bloque 5" de la FACI – UTLVTE. Este diseño considera la obtención de energía a través de dos fuentes que son unos módulos fotovoltaicos y la red eléctrica local. Por lo tanto, el sistema fotovoltaico diseñado se concibe como una instalación solar fotovoltaica de tipo asistida. En la presente investigación, se llevan a cabo cálculos y simulaciones basados en un análisis de la demanda de las cargas y datos meteorológicos obtenidos con el software PVsyst. Los resultados obtenidos indican que el sistema fotovoltaico diseñado puede soportar un porcentaje de la demanda de los circuitos de iluminación, tomacorrientes generales y cargas especiales del Bloque 5, lo que corresponde a una disminución de los costos asociados con el consumo de energía eléctrica proveniente de la red eléctrica local. Dichos resultados demuestran que el dimensionamiento alcanzado por este sistema fotovoltaico es óptimo, lo cual es validado mediante el software PVsyst.
Palabras clave: análisis del recurso solar, PVsyst, sistema fotovoltaico, estimación de la demanda.

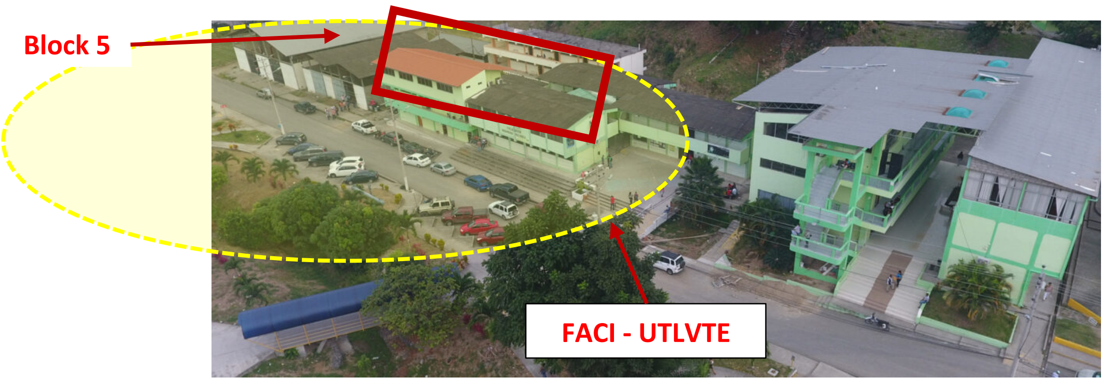
Introduction

Photovoltaic systems harness solar energy, an inexhaustible source of energy, so the implementation of this type of energy system helps to move towards a more sustainable energy matrix. Likewise, designing these systems fosters innovation and technological progress, since it contributes to the understanding of how to efficiently deliver non-conventional energy to places that require it, a concept known as "distributed generation".

At present, the power supply of FACI's "Block 5" building (Figure 1) depends exclusively on CNEL EP's distribution network. The cost generated by the consumption of energy from a public network in a building with the characteristics of Block 5 can be high. One solution to this problem, which would help reduce the costs associated with energy consumption, is the development of an assisted photovoltaic system that injects solar renewable energy into the building and can also receive energy from the available electrical grid when necessary. The implementation of such a system can be beneficial not only from an economic but also from an environmental point of view.

The objective of this article is to reveal the design of a photovoltaic power generation system for Block 5 of the FACI, where the key components of this system (i.e. inverter and photovoltaic modules) are technically defined or specified, and the feasibility of the solar installation is evaluated from the point of view of the solar resource available at the location of Block 5, while taking into account the demand of the load installed in the building. At the end, a bill of materials and a budget for the implementation of this photovoltaic system is estimated.

Figure 1. Building Block 5 - FACI - UTLVTE.

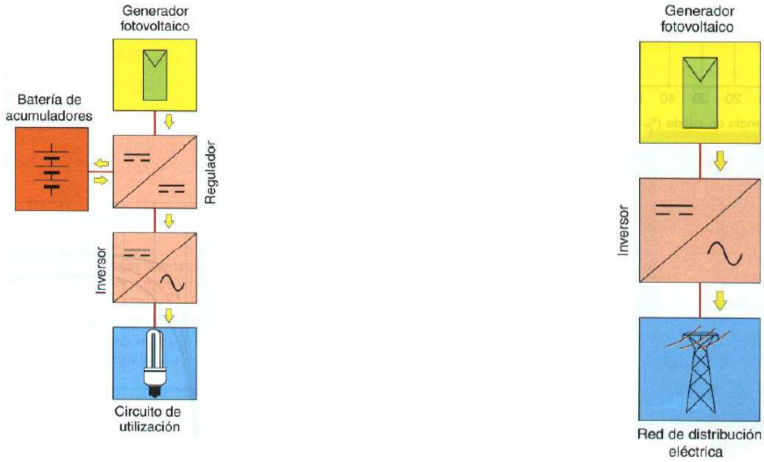


Note. Taken from (Cagua, 2023).

Methodology

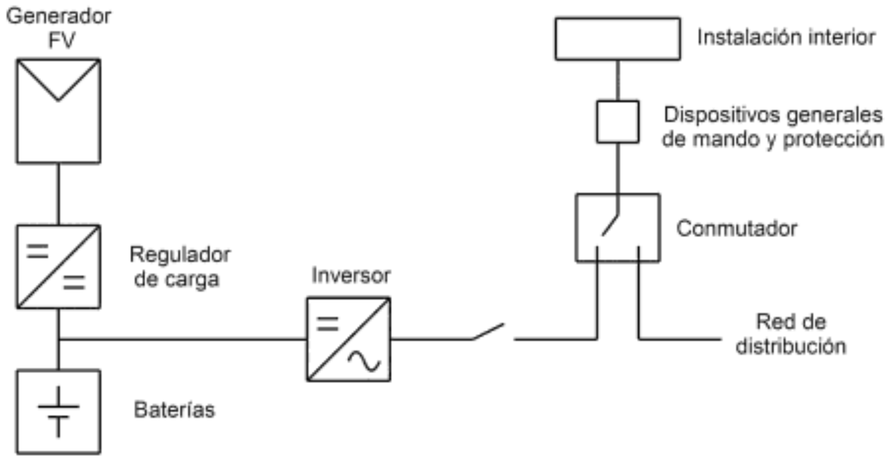
Figure 2 presents the two basic types of PV systems, which are: a) Off-grid installations, and b) Grid-connected installations. The choice of one or the other type of PV configuration depends on the application; for example, grid-connected solar installations are used when the objective is to sell electricity and/or perform self-consumption, while off-grid installations are generally used in rural electrification, pumping, signaling, and communications applications (Baselga-Carreras, 2019).. In the technical instruction ITC-BT-40 of the Spanish Low Voltage Electrotechnical Regulation, a third classification or type of photovoltaic system called Photovoltaic Assisted Solar Installation arises, which has an additional source of energy, i.e., it has photovoltaic modules that are used to feed the load (Figure 3) (Mascarós-Mateo, 2016) and the energy from the photovoltaic modules is complemented with the energy from the local power grid. This article focuses on the design of an assisted photovoltaic installation for Block 5, whose implementation will reduce the consumption of electricity from the local grid, supplying energy to the building by means of a complementary source based on photovoltaic solar energy.

Figure 2. Basic photovoltaic systems: (a) Isolated, (b) Grid-interconnected.



Note. Taken from (Castejón & Herranz, 2010)..

Figure 3. Assisted photovoltaic system



Note. Taken from (Mascarós-Mateo, 2016)..

Finally, it is necessary to mention that the main components in PV systems are usually the PV modules and the inverter. However, it is common that some of the following components are also required in a photovoltaic system, depending on the type of application (Cagua, 2023)Photovoltaic modules, inverter, rechargeable batteries (accumulator), charge controller or regulator, junction boxes (combiners), mounting structure, energy meter, automatic disconnection switches (electrical protections), wiring and monitoring system.

FACI's Block 5 building has three floors with classrooms, staff rooms and a small bar. From a survey of information, it has been established in Tables 1, 2 and 3 that the electrical load of this building, composed of lighting fixtures, general outlets and special loads (e.g. air conditioning, electric oven, etc.), demands a total estimated power of 3015 W + 14800 W + 25000 W = 42815 W. However, this total power value represents a maximum load demand value that, under normal building operating conditions, will most likely not occur. Then, in order to estimate a demand that probabilistically would be more in line with reality, the demand factors (DF) presented in Tables 4 and 5, established according to the Ecuadorian Construction Standard (NEC), are used. (Fernández & Fernández, 2022; Unamo et al., 2018)..

Table 1. *Electrical power: Luminaires*

Electrical Power - Luminaires					
		Electrical Circuit			
Zones	Environments	Device	Quantity	Watts per Device [W]	Power [W]
Second floor	Classroom 1	Fluorescent tube	12	18	216
	Classroom 2	Fluorescent tube	12	18	216
	Classroom 3	Fluorescent tube	12	18	216
	Aisle	Fluorescent tube	16	18	288
	Food Bar	Led Spotlight	1	9	9
Second floor	Classroom 1	Fluorescent tube	12	18	216
	Classroom 2	Fluorescent tube	12	18	216
	Classroom 3	Fluorescent tube	12	18	216
	Classroom 4	Fluorescent tube	12	18	216
	Aisle	Fluorescent tube	14	18	252
Third floor	Teachers' lounge #2	Fluorescent tube	12	18	216
	Teachers' lounge #3	Fluorescent tube	10	18	180
	Teachers' lounge #4	Fluorescent tube	12	18	216
	Bathrooms	Led Spotlight	2	9	18
	Aisle	Fluorescent tube	18	18	324
				Total Power (W)	3015

Table 2. *Electrical power: General outlets*

Electrical Power - Outlets					
		Electrical Circuit			Power [W]
Zones	Environments	Device	Quantity	Watts per Device [W]	
Second floor	Classroom 1	110 V outlet	3	200	600
	Classroom 2	110 V outlet	3	200	600
	Classroom 3	110 V outlet	3	200	600
	Food Bar	110 V outlet	2	200	400

Third floor Second floor	Classroom 1	110 V outlet	3	200	600
	Classroom 2	110 V outlet	3	200	600
	Classroom 3	110 V outlet	3	200	600
	Classroom 4	110 V outlet	3	200	600
	Teachers' lounge #2	110 V outlet	17	200	3400
	Teachers' lounge #3	110 V outlet	17	200	3400
	Teachers' lounge #4	110 V outlet	17	200	3400
				Total Power (W)	14800

Note. Taken from (Cagua, 2023).

Table 3. *Electrical power: Special loads*

Electrical Power - Special Loads					
		Electrical Circuit			
Zones	Environments	Device	Quantity	Watts per Device [W]	Power [W]
Second floor	Classroom 1	220 V power socket - Air conditioning	1	2500	2500
	Classroom 2	220 V power socket - Air conditioning	1	2500	2500
	Classroom 3	220 V power socket - Air conditioning	1	2500	2500
Second floor	Classroom 1	220 V power socket - Air conditioning	1	2500	2500
	Classroom 2	220 V power socket - Air conditioning	1	2500	2500
	Classroom 3	220 V power socket - Air conditioning	1	2500	2500
	Classroom 4	220 V power socket - Air conditioning	1	2500	2500
Third floor	Teachers' lounge #2	220 V power socket - Air conditioning	1	2500	2500
	Teachers' lounge #3	220 V power socket - Air conditioning	1	2500	2500
	Teachers' lounge #4	220 V power socket - Air conditioning	1	2500	2500
				Total Power (W)	25000

Note. Taken from (Cagua, 2023).

Table 4. *Demand factors: Luminaires and general outlets.*

Housing Type	FD Lighting	FD Outlets
Small - Medium	0,70	0,50
Medium Large - Large	0,55	0,40
Special	0,53	0,30

Note. Based on. (Fernandez & Fernandez, 2022; Unamo et al., 2018)..

Table 5. *Demand factors: Special loads.*

For one load	For two or more loads	For two or more loads	For two or more loads
1	CE<10 kW 0.8	10 kW<CE<20kW 0.75	CE>20kW 0.65

Note. Based on. (Fernandez & Fernandez, 2022; Unamo et al., 2018)..

Next, according to the type of load, Table 6 presents the power demand values of Block 5 modified with the respective demand factor (DF). (Cagua, 2023):

Table 6. *Total demand calculation for Block 5 using the respective demand factor.*

No.	Type of cargo	Power [W]	FD	Demand with FD = Power x FD [W].
1	Luminaires	3015	0,53	1598
2	Outlets	14800	0,53	7844
3	Special loads	25000	0,65	16250
			Total Demand with FD [W]	25692

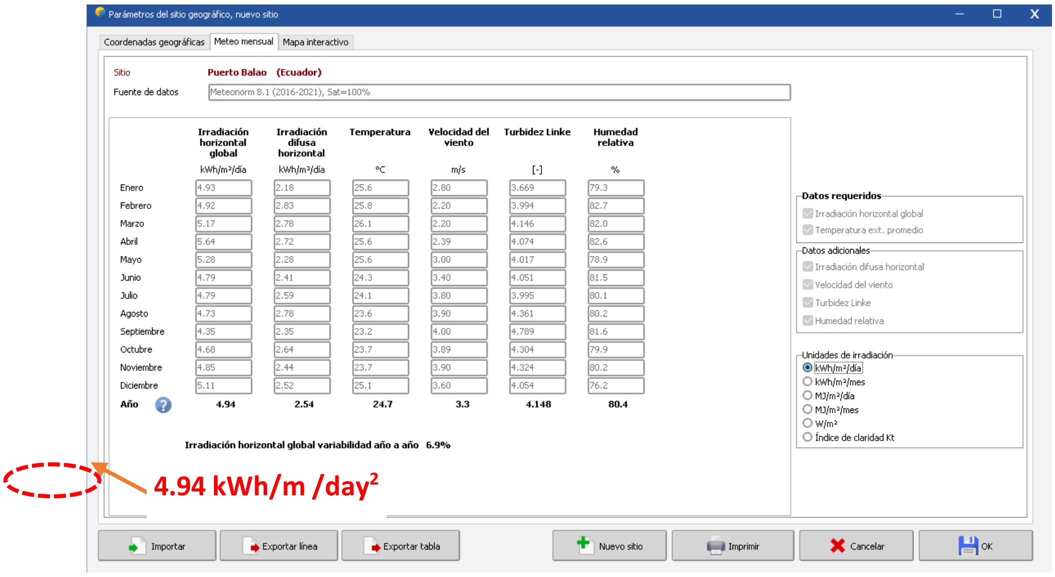
Note. Taken from (Cagua, 2023).

Probabilistically, the value of 25692 W of total demand presented in Table 6 is more accurate than the previously mentioned 42815 W that established the value of the total power demand for building Block 5 assuming the unlikely case that the building load remains working at full load throughout the day. This power demand of 25692 W for Block 5, calculated using the respective demand factors, is the one that is subsequently used in the sizing of the PV field required for the solar installation of this building.

Solar Resource Study

In the literature. (Cevallos-Sierra & Ramos-Martin, 2018; Ulloa-Santillán, 2020) it is established that for a solar photovoltaic installation to be feasible from the point of view of the available solar resource and energy generation, it is necessary that the average annual value of the Global Horizontal Solar Irradiance (GHI - acronym in English) at the installation site is not less than 3.8 kWh/m2. With respect to the above, it has been identified through the PVsyst software, that for the location of Block 5, whose coordinates are latitude 0.9721 and longitude -79.6662, the GHI value is on average 4.94 kWh/m2/day (Figure 4), which indicates that, from the point of view of available solar resource and photovoltaic energy production, the implementation of a photovoltaic system is viable in this location.

Figure 4. Annual average of Global Horizontal Irradiance in Block 5 of the FACI.



	Irradiación horizontal global kWh/m²/día	Irradiación difusa horizontal kWh/m²/día	Temperatura °C	Velocidad del viento m/s	Turbidez Linke [-]	Humedad relativa %
Enero	4.93	2.18	25.6	2.80	3.669	79.3
Febrero	4.92	2.83	25.8	2.20	3.994	82.7
Marzo	5.17	2.78	26.1	2.20	4.146	82.0
Abril	5.64	2.72	25.6	2.39	4.074	82.6
Mayo	5.28	2.28	25.6	3.00	4.017	78.9
Junio	4.79	2.41	24.3	3.40	4.051	81.5
Julio	4.79	2.59	24.1	3.80	3.995	80.1
Agosto	4.73	2.78	23.6	3.90	4.361	80.2
Septiembre	4.35	2.35	23.2	4.00	4.789	81.6
Octubre	4.68	2.64	23.7	3.89	4.304	79.9
Noviembre	4.85	2.44	23.7	3.90	4.324	80.2
Diciembre	5.11	2.52	25.1	3.60	4.054	76.2
Año	**4.94**	**2.54**	**24.7**	**3.3**	**4.148**	**80.4**

Note. Taken from (Cagua, 2023).

In the following section of this article, the work of selecting the main components of the assisted photovoltaic system for Block 5 is carried out. This selection or identification of components, which could also be called sizing or design of the photovoltaic system, is carried out through the use of the PVsyst software. Basically, this sizing consists of entering in the software the parameters or characteristics related to the installation and operation of the photovoltaic system. Among the main parameters to be entered are: the optimal inclination of the photovoltaic modules, their orientation and output voltage, the power consumption of the load, and the system losses.

The orientation and inclination of the photovoltaic modules (Figure 5) should be such that they receive as much energy as possible when they receive the sun's rays. The greatest amount of energy received by the modules is when the sun's rays strike perpendicularly on the solar cells of the panel (Institute of Educational Technologies, 2023). (Institute of Educational Technologies, 2023).. To achieve this, the orientation (**α** = Azimuth) of the photovoltaic modules must be in the direction of the equator (parallel 0°). As the Block 5 building is located in Esmeraldas - Ecuador (northern hemisphere), the orientation of the photovoltaic modules must be towards the south, in other words, towards the equator, with an azimuth angle of 0° (**α** = 0°). On the other hand, the optimal tilt (**βopt**) of the modules can be determined through equation 1, as follows, where **φ** is the latitude of the installation site (Rodriguez-Mas et al., 2022):

$$\beta_{opt} = 3.7 + 0.69 \cdot |\varphi| \quad \text{Eq. 1}$$

Therefore:

$$\beta_{opt} = 3.7 + 0.69 \cdot |0.9721| = 4.37°$$

Regarding the output voltage of the photovoltaic modules, it is recommended that. (Mascarós-Mateo, 2016; Ulloa-Santillán, 2020) that it be selected based on the information provided in Table 7.

Table 7. *Recommended output voltage levels for photovoltaic modules.*

Rated Working Voltage (V)	Cargo Demand
12 V	Less than 1500 W
12 V or 48 V	Between 1500 W and 5000 W
48 V or 120 V	Greater than 5000 W

Note. Taken from (Cagua, 2023)

Losses in a photovoltaic installation can be of various types as shown in the example Loss Diagram in Figure 6, where an interconnected solar installation reinjects 1834 MWh to the electrical grid. Note that for this PV system the nominal power generated by the PV modules at standard test conditions (STC) is 2390 MWh. However, note that this input PV power, generated by the PV modules and transferred to the load, presents losses of various kinds that cause that, at the output of the PV system, a lower value of energy is obtained which is equal to 1834 MWh.

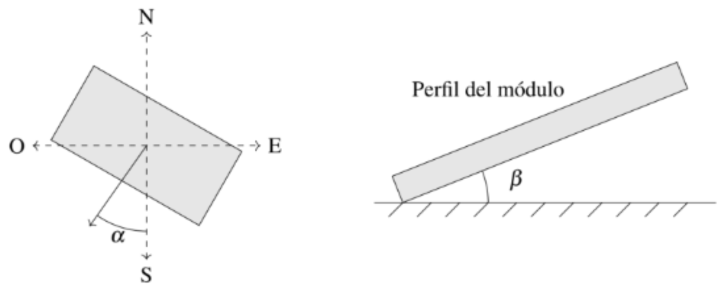
The sizing of the assisted photovoltaic system is done with the PVsyst software. In this software the meteorological data of the installation point are selected and the basic parameters of the PV system are also entered, which as mentioned in the previous section, are basically the following: a) inclination of the modules and their output voltage, b) demand of the fed load, c) losses of the PV system.

In the present study, we have determined that the optimal tilt of the PV modules is **βopt** = 4.37° and the orientation **α** = 0° is southward (Figure 7). The total load demand has also been estimated to be a value of 25692 W using demand factors. Finally, as for the losses these have been defined with the default values set in PVsyst. With this information, the software allows the selection of the fundamental components of the system, which are the photovoltaic modules and inverters.

Figure 8 shows the window for selecting the key components (inverter and PV modules). In this window, the PV modules are selected with the criterion of having a high peak power level, since this reduces the number of modules needed to meet the building's demand. In addition, to comply with Table 7, the PV modules should have an output voltage between 48 to 120 V DC.

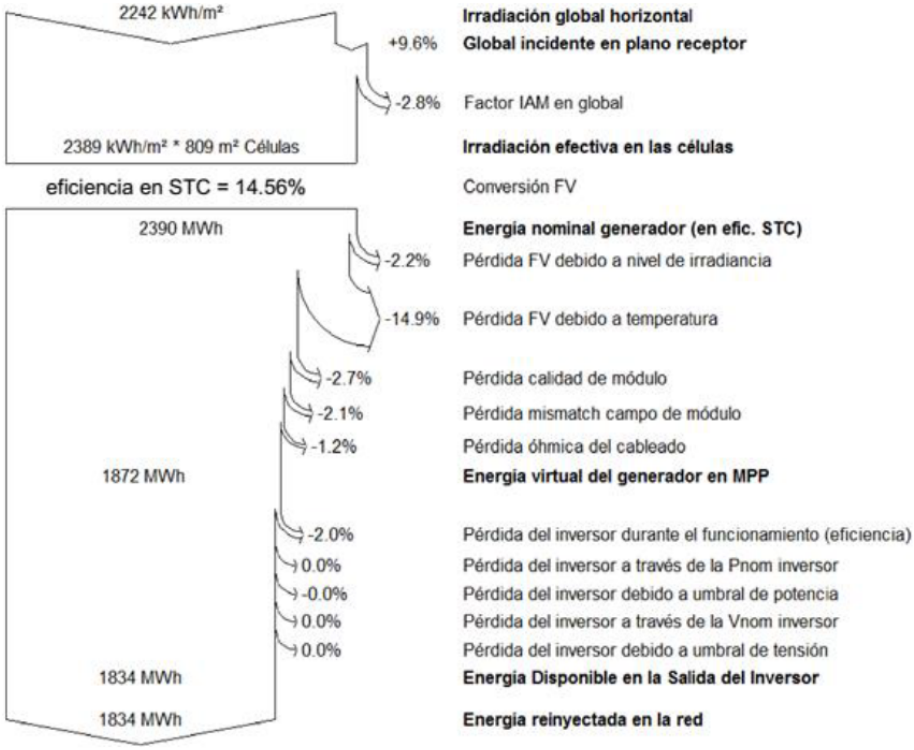
The selected inverter would be expected to be able to transfer all levels of input DC power to the AC load, regardless of irradiance and temperature conditions. However, in a real scenario, the PV system will operate at the highest DC power levels only on very occasional occasions throughout the year; for this reason, in order to reduce the cost of the inverter, it is generally recommended to undersize its respective output power. In other words, it is recommended to oversize the PV generator field with respect to the inverter output power. This concept is known as the Inverter Load Ratio (ILR) which is equal to the division between the input DC power (STC) of the PV system divided by the nominal AC output power of the inverter. According to (Masters & Hsu, 2023), in the United States normally an accepted value of ILR should be between 1 and 1.25. In the present study, an ILR of 1.2 is selected, i.e., the selected inverter is expected to be able to handle without overloading up to 80% of the maximum DC power level of the generator field. It is worth mentioning that an inverter normally has a mechanism that avoids overshooting the output power capacity by automatically limiting it to the nominal value whenever there is excess input power. The excess output power is not transferred by the inverter to the load and instead this device cuts the output power so that it does not exceed the nominal power. This behavior in the inverter is referred to as "clipping." (Good & Johnson, 2016; Masters & Hsu, 2023; Sandia National Laboratories, 2024)..

Figure 5. Orientation (angle **α**) and tilt (angle **β**) of a Photovoltaic Module.



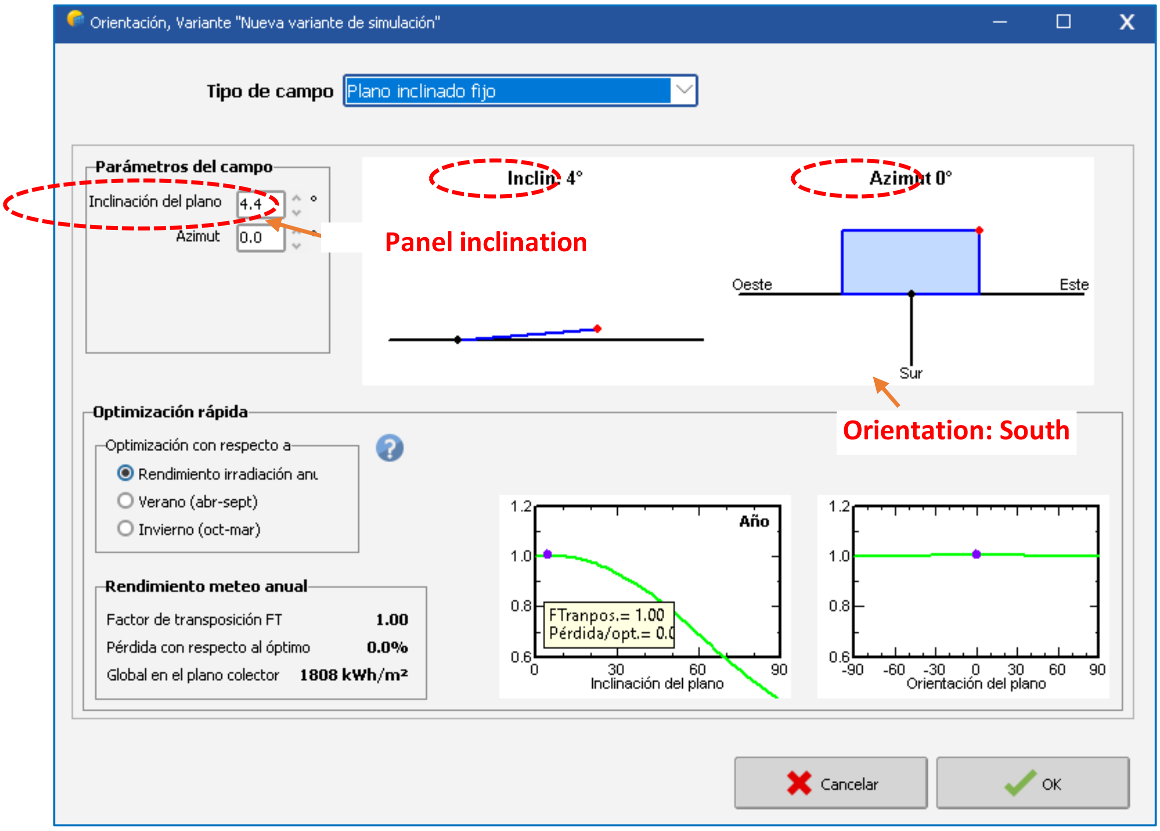
Note. Taken from (Rodríguez-Mas et al., 2022)..

Figure 6. Example of losses of a solar PV system interconnected to the grid.



Note. Taken from (Diaz-Santos et al., 2017)..

Figure 7. Entry of PV module tilt and orientation parameters in PVsyst.



Note. Taken from (Cagua, 2023).

Figure 8. Selection of the technical specifications of the main components of the block 5 assisted photovoltaic system.

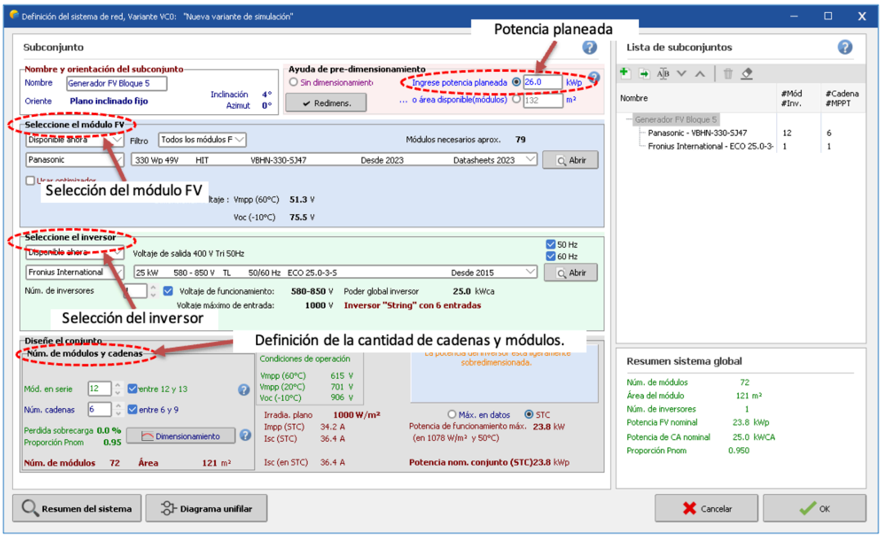


Table 8 presents a summary of the sizing of the assisted photovoltaic system for Block 5. This table shows the fundamental components of the system and also mentions other aspects related to the design of the photovoltaic field; for example, the number of modules required, the configuration of the photovoltaic array, the power generated, etc., are determined.

Note in Table 8, that an area of 121 m2 is required for the installation of the 72 solar panels needed by the assisted photovoltaic system. It has been determined that the terrace of Block 5 has an available area of approximately 600 m2; therefore, there is sufficient area to implement the photovoltaic field (photovoltaic modules) on the terrace of this building.

Table 8. *Technical specifications of the assisted photovoltaic system.*

Description	Manufacturer	Model	Features
PV modules	Panasonic	VBHN-330-SJ47	Rated power (STC): 330 Wp V_{MPP} @ 60 °C: 51.3V
Inverter	Fronius International	ECO 25.0-3-S	Rated power: 25kW Input voltage: 580 - 850V
Photovoltaic field design	N/A	N/A	Modules in series: 12 Strings: 6 Number of modules: 72 Area covered by modules: 121 m^2 Rated power of photovoltaic field (STC): 23.8 kWp

Note. Based on (Cagua, 2023).

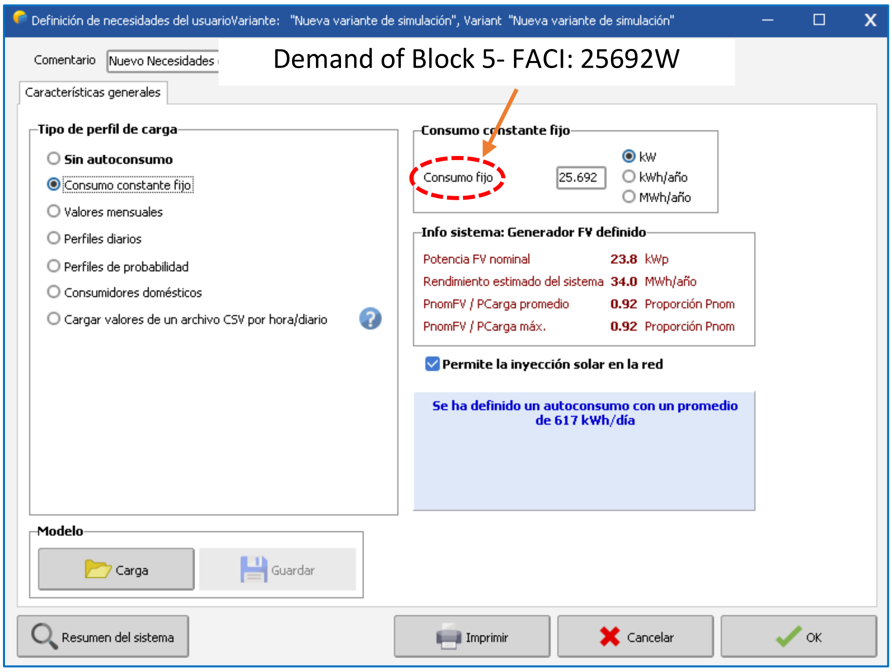
Results

Once the key components of the system have been dimensioned in PVsyst (Figure 8) and the self-consumption needs for the building load have been established (Figure 9), the PV system performance simulation is run in PVsyst. The result of the simulation is the "PVsyst - Simulation Report" (Figures 10 and 11) which indicates various details related to the performance of the assisted PV system.

Among the information presented on page 5 of the PVsyst simulation report (Figure 11), it is possible to identify that the annual consumption of the load is 225044 kWh. Additionally, it can be observed that the PVsyst system contributes 36973 kWh to the load, while the grid provides the remaining energy, i.e. 188071 kWh. This means that, once the assisted PV system is implemented, about 20 % of the total energy to power the load will come from the solar panels throughout the year. Logically, this would represent a 20% reduction in energy consumption from the grid. This fact means that an economic saving of the same percentage (20%) would be expected in the monthly energy consumption bills of this building once the assisted photovoltaic system is implemented.

Finally, Table 9 shows an approximate budget for the materials, main equipment and services required to build the assisted photovoltaic system that we have studied in this article.

Figure 9. Entry of self-consumption parameters in PVsyst.

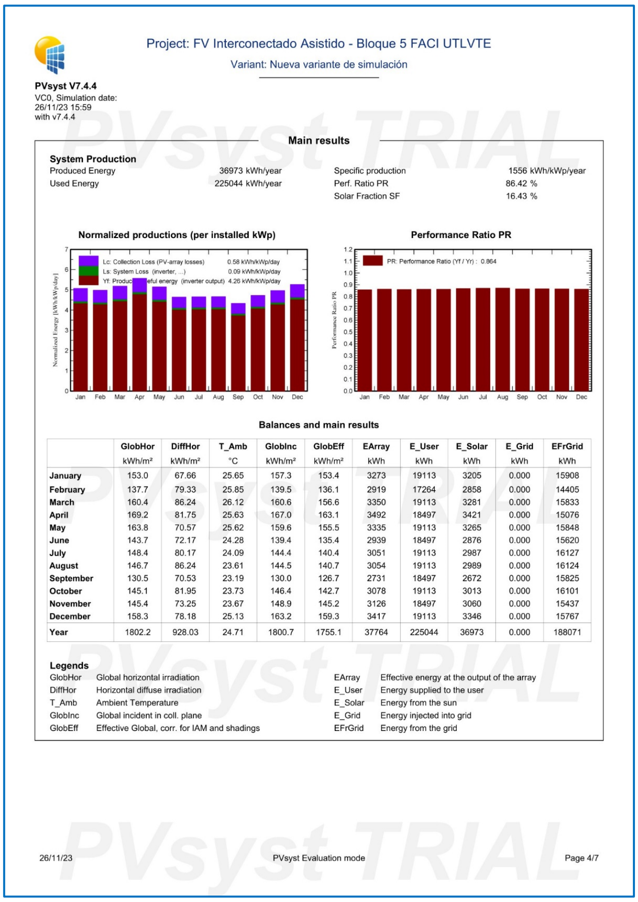


Note. Taken from (Cagua, 2023).

Figure 10. PVsyst simulation report (page 1).

Note. Taken from (Cagua, 2023).

Figure 11. Production of the assisted photovoltaic system.



Project: FV Interconectado Asistido - Bloque 5 FACI UTLVTE

Variant: Nueva variante de simulación

PVsyst V7.4.4
VC0, Simulation date:
26/11/23 15:59
with v7.4.4

Main results

System Production

Produced Energy	36973 kWh/year	Specific production	1556 kWh/kWp/year
Used Energy	225044 kWh/year	Perf. Ratio PR	86.42 %
		Solar Fraction SF	16.43 %

Normalized productions (per installed kWp)

Lc: Collection Loss (PV-array losses) 0.58 kWh/kWp/day
Ls: System Loss (inverter, ...) 0.09 kWh/kWp/day
Yf: Produced useful energy (inverter output) 4.26 kWh/kWp/day

Performance Ratio PR

PR: Performance Ratio (Yf / Yr) : 0.864

Balances and main results

	GlobHor	DiffHor	T_Amb	GlobInc	GlobEff	EArray	E_User	E_Solar	E_Grid	EFrGrid
	kWh/m²	kWh/m²	°C	kWh/m²	kWh/m²	kWh	kWh	kWh	kWh	kWh
January	153.0	67.66	25.65	157.3	153.4	3273	19113	3205	0.000	15908
February	137.7	79.33	25.85	139.5	136.1	2919	17264	2858	0.000	14405
March	160.4	86.24	26.12	160.6	156.6	3350	19113	3281	0.000	15833
April	169.2	81.75	25.63	167.0	163.1	3492	18497	3421	0.000	15076
May	163.8	70.57	25.62	159.6	155.5	3335	19113	3265	0.000	15848
June	143.7	72.17	24.28	139.4	135.4	2939	18497	2876	0.000	15620
July	148.4	80.17	24.09	144.4	140.4	3051	19113	2987	0.000	16127
August	146.7	86.24	23.61	144.5	140.7	3054	19113	2989	0.000	16124
September	130.5	70.53	23.19	130.0	126.7	2731	18497	2672	0.000	15825
October	145.1	81.95	23.73	146.4	142.7	3078	19113	3013	0.000	16101
November	145.4	73.25	23.67	148.9	145.2	3126	18497	3060	0.000	15437
December	158.3	78.18	25.13	163.2	159.3	3417	19113	3346	0.000	15767
Year	1802.2	928.03	24.71	1800.7	1755.1	37764	225044	36973	0.000	188071

Legends

GlobHor	Global horizontal irradiation	EArray	Effective energy at the output of the array
DiffHor	Horizontal diffuse irradiation	E_User	Energy supplied to the user
T_Amb	Ambient Temperature	E_Solar	Energy from the sun
GlobInc	Global incident in coll. plane	E_Grid	Energy injected into grid
GlobEff	Effective Global, corr. for IAM and shadings	EFrGrid	Energy from the grid

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Note. Taken from (Cagua, 2023).

Table 9. *Approximate budget of the assisted photovoltaic system for Block 5 - FACI.*

Assisted Photovoltaic System Budget					
No.	Description	Quantity	Unit	Unit Cost	Total Value
1	330 Wp photovoltaic module. Manufacturer: Panasonic. Model: VBHN-330-SJ47	72	EA	$320,00	$23.040,00
2	Inverter 25 kW. Manufacturer: Fronius International. Model: ECO 25.0-3-S	1	EA	$3.500,00	$3.500,00
3	Structure	1	GB	$1.800,00	$1.800,00
4	Grounding rod.	1	EA	$16,00	$16,00
5	General switch.	1	EA	$35,00	$35,00
6	Differential switch of 30 mA sensitivity.	1	EA	$12,00	$12,00
7	gPV fuses.	8	EA	$8,00	$64,00
8	Photovoltaic Cable. 300 meters.	1	EA	$1.062,00	$1.062,00
9	MC4 connectors.	150	EA	$7,14	$1.071,00
10	SPD (varistors).	5	EA	$35,12	$175,60
11	Labor.	1	GB	$2.000,00	$2.000,00
				Total Power (W)	$32.775,60

Note. Taken from (Cagua, 2023)

Conclusions

The use of specialized tools such as PVsyst has made it possible to predict the performance of an assisted photovoltaic system designed for the FACI Block 5 building. Through the use of this software it has been possible to select the essential components of this type of photovoltaic system, such as the photovoltaic modules and the inverter. The results obtained in the PVsyst simulation report support the design decisions and ensure the efficiency of the proposed system.

On the other hand, meteorological and geolocation information has been used in this study, and at the same time information has been gathered through visual inspections of the installation site, in order to evaluate whether the conditions are favorable to support the implementation of the project in a technical manner.

In addition, the detailed study of the installed load in the "Block 5" building has revealed crucial information to determine the energy demand. This step has been essential to properly size the PV-assisted system, ensuring that it can meet the needs efficiently. Effective planning has been made possible by understanding consumption patterns and projecting solar power generation. A detailed budget has also been prepared considering the costs associated with equipment acquisition and installation.

To conclude, the results of this work have supported the feasibility of implementing an assisted photovoltaic system in Block 5. The detailed identification of the technical specifications of the main components, the accurate identification of the load and the presentation of a detailed budget form a comprehensive framework for the successful implementation of the project.

This work lays the groundwork for the transition to a more sustainable energy source in Block 5, and also suggests that the adoption of solar energy will not only be beneficial from an environmental standpoint, but may also have a positive impact on long-term cost reduction.

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