280-24-zalamea

Incidence of non-working days on limiting photovoltaic potential on a building with day-hours high power consumption, without storage and grid injection

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ABSTRACT

This study investigates the practicality of a 7 kWp photovoltaic (PV) system designed to partially supply power to the Faculty of Architecture and Urbanism buildings at the University of Cuenca, Ecuador, without storage or bidirectional meter. Leveraging theoretical capacity alignment with irradiation, the system aims to avoid surpluses, as it is not connected to the grid through net metering, net billing, or a storage system. Despite the equatorial location's low seasonal fluctuations and reduced irradiation and energy demand variations, significant consumption fluctuations between working and non-working days pose a primary challenge. Implementing a system with the potential to cover around 7,5% of the total annual demand, surpluses occur at midday on non-working days, reaching 2,7 kW, yet annually constituting only 0,17% of overall consumption or 2,2% of total energy production. This underscores the limitations of non-working day fluctuations despite the system's potential for on-site energy generation during working hours.

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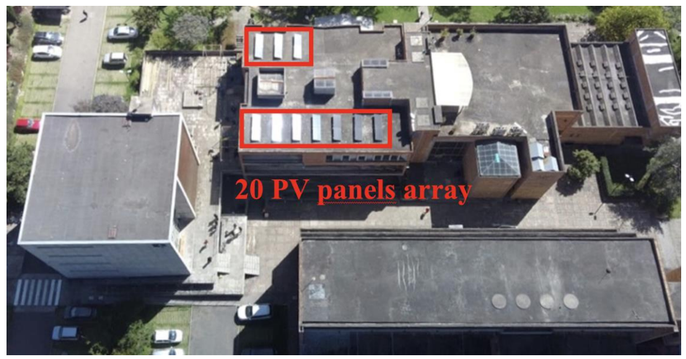
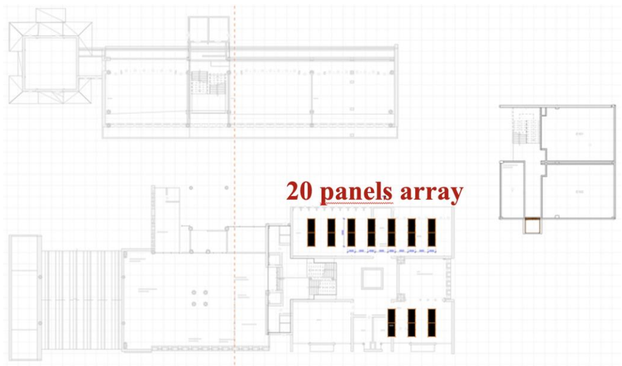
INTRODUCTION





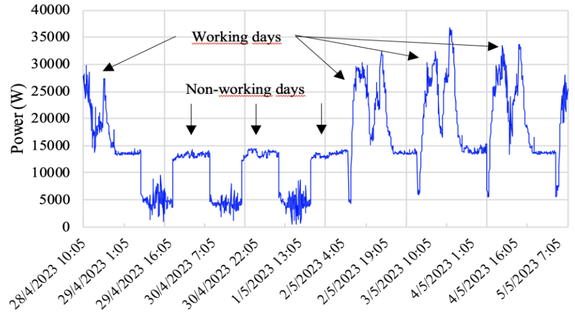
- This analysis corresponds to carrying out local studies that allow proper conditions to introduce urban micro-generation, under the concept of reaching high energy self-supply, without introducing storage and grid power exchange.
- Mismatching between power PV production and power consumption is an important barrier to be solved for using the urban power grid as a virtual battery. But in some circumstances where there are limited resources or no possibility to exchange power with the urban grid.
- Injecting exceedings is economical but is the actual tendency to keep the “long-time sustainability” of the micro producer integration.

METHODOLOGY

- We had the annual power requirements of the higher educational building complex of the Faculty of Architecture of the University of Cuenca. We also consider the space area availability feasible to integrate PV technology.
- The system will be dimensioned to avoid power surpluses, proposing and installing a system dimensioned to achieve the maximum base consumption, as a consequence of economic restrictions.
- As an equatorial latitude, the power consumption fluctuation as a consequence of seasonal fluctuation is considered low, then as been a hours day mainly use of the buildings, it is expected to reach a good matching.
- The initial part corresponds to detecting lowest consumption registered, then a measurement of a 10 minute consumption fluctuation is performed with a FLUKE 435 Series II (Power Quality and Energy Analyzer)
- In concordance with the minimum power requirements detected at midday, it is dimensioned that the PV system can reach this base consumption coinciding with midday. After installing the PV system and when it is under production and connected to the building's internal grid, the fluctuation between production and consumption is measured in a week.

Monthly energy consumption (Kwh) and 10 min. Power fluctuation, through a week.

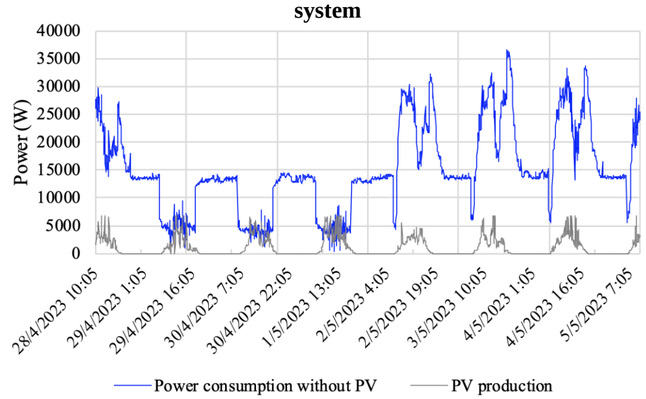
Montly Power Consumption (kWh) (2019)													
Utility Account code	Department	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
2857694	Architecture	12.763	9.302	9.875	12.172	12.415	13.043	13.777	7.603	9.554	11.489	11.654	11.308	134955



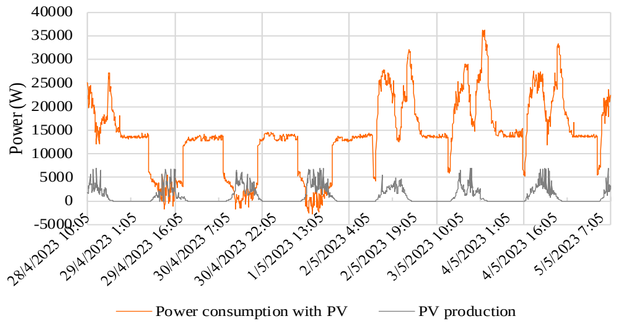
RESULTS

- 20 385 KWp PV solar panels are connected to supply power consumption connected to two inverters: 14 panels to a 5 kVA inverter and six to a 2 kVA inverter, since even on non-working days it is observed the lower consumption is a base consumption close to 5 KW. With 7 Kva maximum output, it is expected low power exceedings, and it will be determined.
- After installing the PV system and measuring the power consumption, power surpluses were observed on non-working days as expected during periods of higher irradiation with no consumption.
- When overlapping the power consumption with PV power output curves revealed that the energy capacity of the PV system falls short of generating surpluses on regular working days, even at peak moments (6,9 kW). While the 7 kWp PV system effectively utilizes total power production on-site during working days, surpluses occur on non-working days only.
- When integrating the total power in energy production in kWh, and from this, the total energy injected in the grid as a surplus, when considering the holidays, in two days it was injected 1 kWh or less, and one day with higher irradiation it is observed a little more than 4 kWh, as a consequence of the higher irradiation. Then only considering the non-working days, in % of the total PV production, between 13% and 3% is injected without energizing the building demand. In that specific week with 3 non-working days, it reached 2.92 kWh, but if we estimate proportional the total yearly holiday days, the surpluses expected would be 2,2 % of the total production.

Monitoring and registering power demands jointly with PV power production detected in the Growatt monitoring system



Hourly balance in a week of power consumed by the building with the implementation of the PV system



Daily Produced Energy vs Surplus Energy (*Non-working Day).

Date	Daily Produced Energy (kWh) (P)	Surplus Daily Energy to the Grid (kWh) (I)	Surplus Energy vs Produced Energy (I/P) (%)
28/4/2023	17.96	-	0.00
29/04/2023*	21.17	0.72	3.41
30/04/2023*	25.07	0.99	3.94
01/05/2023*	30.85	4.03	13.08
02/05/2023	23.06	-	0.00
03/04/2023	23.23	-	0.00
04/05/2023	26.67	-	0.00
Daily Produced Energy Average	24.00	1,91	2.92

CONCLUSION

- Since Ecuador had 12 public holidays, 52 Saturdays and 52 Sundays. This, therefore, means that if we considered an average of the exceeding detected in the three non-working days, about 223,50 kWh of annual surplus PV would be expected. Comparing this to the total energy requirements in practical terms, this non-billed surplus energy injected corresponds to only 0,17 % of the total annual energy consumed by the faculty. Then even if the PV system exceeds the lower energy demands, pretty low exceedings were obtained.

-About 223,50 kWh of annual surplus PV production would be expected to be injected into the grid and not accounted for by a non-bidirectional meter. In economic terms, this represents an annual loss of only USD 22,14 for the faculty building spending on electricity with the actual subsidized electricity prices (0,099 USD/kWh). It is a negligible quantity compared to the overall savings expenditure of 935 USD expected to be reduced in the power bills.