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Photovoltaics for reaching Net-Zero Energy Standard in Educational buildings

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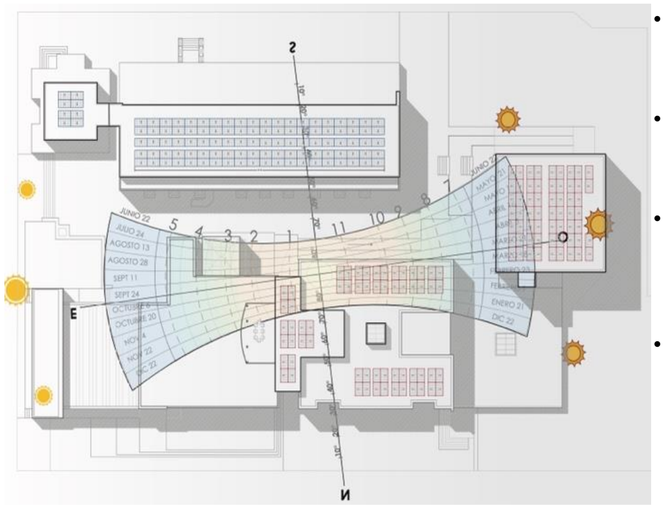
ABSTRACT

Buildings should become energy-neutral to reduce pressure on the planet's resources and the atmosphere. Then cities must be energized with in-site renewables integrated to reach low-impact sustainable cities. This research project is an initial step to figuring out the feasibility of reaching the Net Zero Energy condition in the Architecture Department buildings of the University of Cuenca, as a case sample of higher-educational facilities located next to the equator and on the highlands of the Andes mountains range. In this research we had just determined the photovoltaic (PV) potential to reach the actual energy requirement as an initial step, to do so, we had virtually constructed the building facilities and obtained the building energy requirements, considering full power requirements measured before the COVID restrictions. As the main results, we determined, that 88,6 % of the 2019 energy requirements could be solved with solar PV considering roof availability and architectural restrictions. The financial analysis also reveals that it is a profitable strategy. Next research will determine that comfort levels are adequate to foresee the total requirements to reach the NZEB standard. .

INTRODUCTION



- Several cities are located close to the equator line at a medium altitude above sea level, on plate valleys between the Andes Mountain range (between 2000 m above sea level and 3000 m above sea level).
- The analysis of PV integrated on educational buildings located in this particular climate could be significant in other South American regions, with similar conditions as Cuenca, like Bogota or Quito, capital cities.
- Any energy performance simulation output from any intermittent energy resources, no matter how accurate has been built, as a consequence of the different inputs required and that consider climate condition incidence results in certain range variability.
- To determine the variance from simulation to reality in energy potential and environmental conditions, it is possible to compare in-site measurements with simulation results. For that, to have the climate data for the simulation tools, the information must be taken on-site, to run the simulation afterwards, so then it is possible to determine the tool's accuracy.

METHODOLOGY

- Considering the operational energy consumptions that have been determined just before the COVID pandemic period, when these buildings were being used to their full capacity and irradiation availability it is possible to determine and size a PV plant to feed the energy requirements.
- The System Advisor Modeling software of the NREL software does have the capability to perform static simulations to determine the power output of specific solar products in a complete PV installation considering a complete system such as power inverters, protections, and the entire electrical wiring and considering soiling or electrical wiring loss also.
- In previous simulations, it has been observed that according to orientation and collector slope parameters, when the tilt is lower than 22 º, the power capability is only reduced maximum in 6,1 % when comparing the best orientation with the worst orientation.Then locally it is considered that the orientation of PV panels is not a restriction as loses consequence.
- Climatic files were constructed from data taken from a climatic station located in the FAUC three-block building roof while the levels of thermal comfort of 18 interior spaces of permanence for students (temperature and CO_2 detection). The climate data will be collected on-site when the PV plant is generating power. These climate data afterwards could be converted through Meteonorm software, in files .csv that works within SAM software

Spent in power *USD ($) and KW/year

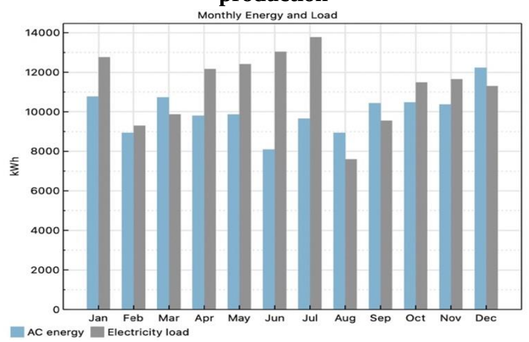
Monthly power bills ($) (2019)														
Utility Account code	Department	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
2857694	Architecture	1.039	776	768	935	1.032	1.079	1.147	630	787	952	961	934	11.041

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

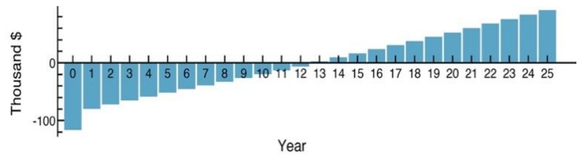
- With the PV installation proposed, it is possible to reach 119563 kWh annually from 134954.64 kWh consumption in 2019, corresponding to 88.6%. This generation does oscillate monthly according to irradiation availability as well as the monthly consumption.

2019 power demand vs SAM simulated power production

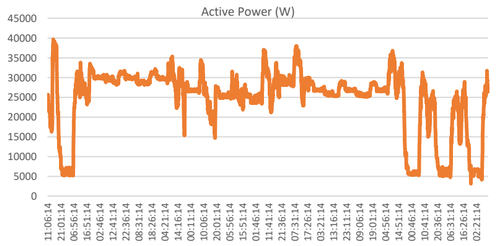


- The price by kWh purchased from the utility by the university (public university) is 0.082 dollars, 25% less than the residential cost, this price is also 47.5% cheaper than the real estimated cost of production is around $ 0,156 kWh USD. Then it is required 12,8 years to recover the total investment.

Time period for investment recovering



Monitoring and registering power and other variables with FLUKE 345 equipment



CONCLUSION

- It has been determined that, in the 1076,35 m² of an overall flat regular roof, in this available space according to architectural impact, shadowing and maintenance aspects, it was possible to integrate 228 Vertex All Black Trinasolar Products, of 385 Wp each, which implies an available PV area for solar production of 438,3 m². In consequence, this implies an available PV surface of 40,7 % occupancy rate considering to total roof area available.
- With this proposed PV system, it can potentially cover approximately 88.6 % of the 2019 power consumption. It is expected almost 13 years perior for recovering the total investment as a consequence of the power subsidies. But if we consider the power real costs, this period could be reduced to 7,9 year period approximately.
-The overall 100 % reduction could be achieved also with energy efficiency measures like by improving actual luminaries from fluorescent lighting to LED lighting and analyzing complementary other equipment that could be a high-power requirement.