Grid-Tied Solar-Powered Administration Building of DHVSU: A Cost-Benefit Analysis

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Abstract- This study investigates the effectiveness of a Grid-Tied Solar PV System in the Main Administration Building of Don Honorio Ventura State University (DHVSU) through cost-benefit analysis. The solar PV system was designed with its financial and environmental assessment considering recent market prices. The simulation and evaluation of the system are performed using PVSyst software. The several financial parameters affecting the PV system's economic feasibility were considered, such as discount rate, inflation rate, and tariff rate. The environmental aspect of the PV system, such as the reduction in carbon emissions was also taken into account. The designed PV system will yield 138 MWh of energy annually. The simulation results show a net present value of 4,239,284.00 PHP with a payback period of 8.7 years, an inflation rate of 4.9%, and a discount rate of 6%. Additionally, through the 25-year lifetime, the PV system will save 1293.981 tons of CO2 emission.

Indexed Terms- Cost-Benefit, Net Present Value, Payback Period

I. INTRODUCTION

Energy is an important element in economic development and production process in every part of the world. The fast economic development, continuous population growth, urbanization, technological improvement, and living standards have raised worries over the increasing world energy demand and depletion of fossil fuels in the future. Energy consumption in developing countries is increasing at a rate of 5% per year and 1% per year for the developed countries (M.I. Al-Najideen, S.S. Alrwashdeh, 2017). Power plants are built to meet the rising demand; however, these power plants emit carbon dioxide from fossil fuels that contribute to the carbon footprint, which harms our environment. A growing demand for the implementation of the use of renewable energy and the development of more efficient energy systems by worldwide sectors and organizations is among the key solutions to suspend the use of non-renewable energy and develop a sustainable solution.

The local government affirms the utilization of renewable energy (RE) in the Philippines. The country is mandated to accelerate the development of RE resources to effectively prevent or mitigate harmful emissions and have good alternative energy to meet and cater the current and future needs in energy for achieving economic development while protecting the health and the environment. Solar energy is clean, inexhaustible, and environmentally friendly nature of using energy.

Unprecedented growth in solar PV generation is observed, becoming solar PV the lowest-cost option for electricity generation around the world and is expected to be a good choice in investment in the coming years. A great potential is also seen in mitigating the effects of the increasing energy demands and reducing the use of fossil fuels. The rising demand for energy worldwide must be supplied continuously while implementing sustainable development goals.

One of the busiest buildings in Don Honorio Ventura State University (DHVSU) is the Administration Building. It consists of the main building where the Registrar, Cashier, Accounting Office, Management Information System Office, Planning and

Development Office, and the Office of the Physical Plants and Facilities are located, while the extension building includes the offices of the board, such as the President's and Vice President's Office. Several transactions are being made here, especially in the main building. During summer, electricity demand rises causing higher electricity bills in the country, including in the town of Bacolor, Pampanga. Since the Admin Building is one of the most used facilities in the University, the researchers decided to conduct a study of Cost-Benefit Analysis (CBA) on the implementation of a Grid-Tied Solar Photovoltaic System in the Main Administration Building to lessen the electric bill of the building to the distribution utility especially when summer if the electricity demand is high and to guarantee and understand the economic viability before the actual implementation of it.

Solar Photovoltaic System converts the sun's light to produce electrical energy that is harnessed through Photovoltaic (PV) Panels. According to J.G. Pereyras (2019), a solar power system is made up of photovoltaic (PV) panels and a power inverter that converts direct current (DC) to alternating current (AC). Typically, solar PV panels are installed on the roof. They should be oriented primarily southward. The solar panels should be slanted at precise angles to maximize the amount of sunlight that hits the panels,
A grid-tied PV system, also known as an on-grid system, is a system that is linked to the electrical grid of the local distribution utility (E.M. Santos, 2019). PV Panels, Inverters, and Bi-directional meters are key components of a grid-connected PV system. Grid-tied systems, as opposed to off-grid systems, do not require battery storage. A property with a grid-tied PV system can operate as a stand-alone or be powered by the utility's grid if the system does not meet the power demand. The system will also assist in selling excess power generated by exporting it to the utility's grid, which will be deducted from the next electricity bill. Figure 1 shows the illustration of a grid-tied PV system.

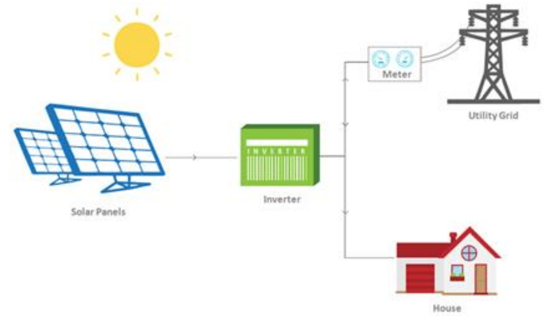

Figure 1: Grid-Tied PV System Setup

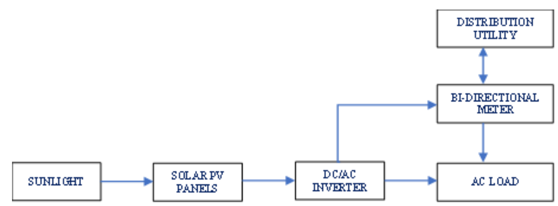

Figure 2: Block Diagram of a Grid-Tied PV System

As shown in Figure 2, the process of a Grid-Tied Solar PV system starts with the sun's light that is harvested through the solar PV panels. The energy harvested by the panels is in the form of DC; however, household appliances operate in AC supply. To utilize the energy harvested by the solar panels, it is converted from DC to AC with the use of the inverter. The generated energy will be fed mainly to the load. If the power produced by the system exceeds the amount of power needed by the load, it is then fed to the grid or to the distribution utility, which will be measured by the bi-directional meter. The energy fed to the grid will be applied and credited to the next electricity bill. However, power will be drawn from the distribution utility during nighttime or if there is no sunlight during the daytime.

The Philippines enjoys a decent amount of sunshine. The country can harness the sun's power as its radiation across the country has a power generation potential of 4.5 to 5.5 kWh per square meter per day (Department of Energy, 2014). The introduction of Grid-Tied Solar PV paves the Net-Metering scheme. The Department of Energy (2014) states that Net-metering enables Distribution Utilities (DU) customers to establish an on-site Renewable Energy (RE) facility with a maximum capacity of 100 kW that can produce power for their own consumption. Any electricity produced that the user does not use is immediately sent to the DU's distribution network. The DU then deducts the credits gained from the customer's energy bill and grants a peso credit for the extra electricity received in an amount equal to the DU's blended generation cost, excluding additional generation adjustments.

A study made by Green Global Growth Institute (2021) stated that a 100kW net-metered rooftop solar PV installed on the main building of the Provincial Capitol Complex of Oriental Mindoro, Philippines could generate an average of 110 MWh per year within the 25 years of forecasted operational period with a degradation value of 0.5% per year in electricity generation. Using the Department of Energy's Return on Investment Calculator, the estimated cost for the project, including the per-kilowatt installation and maintenance cost, is calculated as well as the total savings on an annual basis.

As stated by J.D. Garcia (2018), designing a 3MWp Grid-Tied Solar PV will augment the power supply demand of Tabas Island in the province of Romblon. With the use of PV system photovoltaic simulation software such as PVSyst, it will be able to determine the solar potential of the proposed PV plant based on its geographical location considering the parameters involved in the area. Furthermore, the PV system would prevent CO2 from entering the atmosphere and save gallons of diesel each year.

A PV system's capital cost comprises the Balance of System (BOS) cost, the PV module cost, and the inverter cost. For the PV system, the BOS cost breakdown is divided into three categories. First, the hardware cost is dictated by cabling, racking and mounting, safety and security, and grid connection fees. The second division is the installation cost, which is determined by electrical installation, mechanical installation, and inspection. Lastly, the soft cost division is the final section, which covers incentive application, system design, permitting, client acquisition, margin, and financing charges. (IRENA, 2016)

A study conducted in Bangladesh states that the worldwide power generating scenario primarily relies on fossil fuel, which is not climate-friendly and emits greenhouse gases that contribute to global warming. In the study, simulation software was used to simulate the on-grid PV system in National Mosque in Bangladesh to analyze the cost-benefit of the system. The study showed that the system is economically and environmentally beneficial (S.Rasel, Md. J. Hasan, 2021).

The Grid-Tied solar power system could be a more efficient and reliable energy source besides being environmentally friendly; it is also a renewable energy source. This study tries to solve the following concerns:

- The benefit of the Grid-Tied PV System compared to its total cost
- The Net Present Value of the installed Grid-Tied PV System
- How environmentally friendly is the PV System?

The study aims to implement the Grid-Tied Solar PV System in the Administration Building of Don Honorio Ventura State University (DHVSU) to meet the energy demand in the building, especially during peak season, and reduce the CO2 emission in the environment. The main objectives of this study are:

- To analyze the benefit of Grid-Tied PV System compared to the total cost
- To determine the Net Present Value (NPV) of the installed Grid-Tied PV system
- To analyze the environmental effect of the PV system

This study focuses on the Main Administration Building of DHVSU to accommodate the 100kW Net Metering Scheme. It also focuses on the cost and benefit of the grid-tied system on the Main Admin Building. The potential net profit from the Grid-Tied PV System, reduction in carbon emissions, and energy generated are the benefits that were considered. Design of the fabrication of cable trays, railings, mounting structures, and electrical wiring are excluded in this study, as well as any civil works related to the modification of the roof of the structure to meet the mounting and weight requirements of the solar PV system.

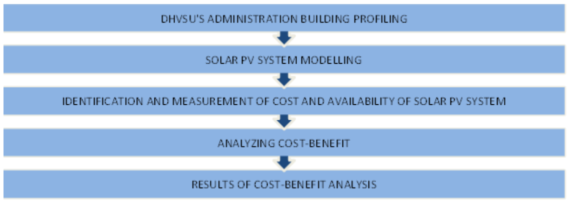

Figure 3: Conceptual Framework

In figure 3, the researchers will conduct profiling of relevant data on the Admin Building of the DHVSU. First, identifying the daily energy consumption and the total electrical load of the building to determine the required solar PV capacity needed to supply the electricity demand as well as the roof area of the building. Second, a modeling of the solar PV will be applied considering the total roof area, the load of the building, and the structural analysis of the roofing. Third, identification of the cost and availability of the appropriate PV panels, inverter, and net-meter that will administer the building. Fourth is analyzing the cost-benefit of the study and calculating the estimated savings that the university could achieve—lastly, the results of the study.

This study will include the comparison of the cost of electricity by using Grid-tied solar PV and by relying only on the distribution utility's electricity generation. Additionally, the estimated monthly and annual monetary savings of the University's Admin Building and the reduction of CO2 emissions will also be included in this study

II. METHODS

Figure 4 is the research design that shows the steps in determining the cost-benefit analysis of a grid-tied solar-powered Admin Building in DHVSU. It involves data gathering, analysis of data gathered, development of Grid-Tied Solar PV System, and simulation and evaluation of the system.

Figure 4: Design of Research

2.1 Energy Demand of the Admin Building

Data gathering is the first step which includes the identification of electrical load to attain the electrical consumption of the building. The set of relevant data needed for this study was provided by the University's Office of the Physical Plants and Facilities.

Equation 1 is used to identify the total wattage of each load; Equation 2 is used to calculate the watt-hour per day for each load used.

Total Wattage = Quantity of Load x Wattage of Load (Equation 1)

Watt-hour/day = Total Wattage x Operation Hour/Day (Equation 2)

2.2 Rooftop Overview of the Admin Building

The roof of the Administration Building, as shown in figure 5, is where the solar modules are to be installed. This will determine and verify if it can accommodate the number of installed computed solar modules and assess the maximum usable area on the roof.

Figure 5: DHVSU's Administration Building Rooftop (Google Earth, 2021)

2.3 Solar Irradiance

The Global Horizontal Irradiance (GHI) is defined as the total amount of shortwave terrestrial irradiance received by a surface horizontal to the ground (S. Qazi, 2016). The GHI of the site was determined by using PVSyst Software. Figure 6 shows that the average daily global horizontal irradiance is 4.91 kWh/m2/day.

	Global horizontal irradiation	Horizontal diffuse irradiation	Temperature	Wind Velocity	Linke turbidity	Relative humidity
	kWh/m²/day	kWh/m²/day	°C	m/s	[-]	%
January	4.65	1.86	24.9	2.40	3.756	68.9
February	5.21	2.12	26.5	2.30	3.715	66.6
March	5.91	2.42	28.5	2.30	4.026	64.3
April	6.20	2.50	30.5	2.10	4.318	66.1
May	5.51	2.83	29.4	1.90	4.161	71.9
June	5.04	2.75	27.3	1.80	4.139	79.3
July	4.64	2.62	26.4	1.80	4.130	82.6
August	4.08	2.67	26.0	1.80	4.203	84.9
September	4.41	2.41	26.0	1.70	4.095	81.9
October	4.58	2.30	25.8	1.90	4.294	77.9
November	4.45	1.89	25.1	2.00	3.879	73.8
December	4.31	1.97	24.3	2.30	3.918	70.4
Year	4.91	2.36	26.7	2.0	4.053	74.1

Figure 6: Location Climate Data (PVSyst, 2021)

2.4 Solar PV System Size

There are two types of solar PV panels: Monocrystalline silicon and Polycrystalline silicon. According to the Department of Energy (2021), monocrystalline solar panels have the highest efficiency rating from 17% to 22% that can take lesser space for the required capacity but is costly than the other solar panels, while the polycrystalline solar panels have only 15% to 17% efficiency but much cheaper than the others. In this study, Monocrystalline silicon is preferred due to its improved effectiveness and efficiency. The PV modules are then tilted at least 10 degrees facing south to lessen shadowing. Low-cost but highly efficient PV Panels must be identified. In Equation 3, the energy required by the solar PV is calculated using the formula (Department of Energy, 2021).

Solar PV System Size = (Daily kWh / Peak Sun Hours) x Panel Efficiency Factor (Equation 3)

2.5 Number of PV Modules Required

The total number of PV modules is identified using Equation 4 (A.B. Owolabi et al., 2019).

No. of Solar PV Modules = Solar PV System Size / PV Output Power Rating (Equation 4)

2.6 Inverter Sizing

The size of the inverter to be utilized for the system is also computed using Equation 5 (M.C. Layson, et al., 2019).

Inverter Size = (Total System Size) + (1+20%) / Efficiency of the Inverter (Equation 5)

With the required inverter size in Equation 5, the researchers can now calculate for the needed number of inverters in the system as shown in Equation 6 (R. Khatri, 2016).

No. of Inverters = Inverter Size / Rated Power of Inverter (Equation 6)

In step 3, the total cost of the system including installation, cost of materials such as PV panels and inverter, and the cost of operations and maintenance are needed to be obtained. Different solar companies within Luzon, especially in Pampanga, offer solar energy systems which are differentiated by their system performance and efficiency.

Step 4 is the simulation and evaluation of the system. This study uses PVSyst software to simulate the system in DHVSU's main admin building. The PVSyst software is most widely used for developing and estimating the performance characteristics of a solar PV power plant. With its numerous settings and built-in features, this software produces results that are nearly identical to theoretical findings. This software's best feature is its ability to import data from numerous meteo data sources as well as personnel data. This software allows to evaluate the PV system's main performance in the following scenarios: stand-alone, grid-connected, and pumping system (F.U.H. Faiz, 2021). It can also simulate the economic evaluation of a solar PV system like system cost evaluation, pricing strategy, financial analysis, and profitability analysis (PVSyst, 2022).

The PV System in DHVSU's Main Admin Building will be designed and simulated using the software to find and calculate all the data needed for this study. This will determine the net present value of the system, the cost-benefit of the system, total energy generated by the system, the total cost of energy savings, and the number of carbon emissions reduced.

III. RESULTS AND DISCUSSIONS

Data are obtained from the Office of the Physical Plants and Facilities. With the gathered data, roof dimensions are acquired to figure out the available usable area of the roof. The roof left-wing has a 174.06 m^2 area, the right-wing has an area of 171.66 $m^{2,}$ and the rear wing has 412 m^2 which in total is 757.8 m^2 usable area.

The total electrical load in the Main Admin Building is identified. Table 1-3 provides the complete details of equipment and appliances with their corresponding wattages and hours of operation.

Table 1
Energy required in the Main Admin Building's Offices (1st and 2nd Floor)

Name of Appliance / Equipment	*Quantity (1st Floor)*	*Quantity (2nd Floor)*	*Rating (W)*	*Total Wattage*	*Operation Hours*	*Energy Required (kWh)*
Pin light	12	8	9	18	9	1.6
Fluorescent	18	29	40	18	9	16.
Circular	3	-	40	12	9	1.0
Compact	7	4	22	24	2	0.4
ACU 1HP	2	-	84	16	9	15.
ACU 1.5HP	-	2	11	23	9	20.
ACU 2HP	4	4	16	13	9	120
Desktop	40	24	22	14	9	129
Refrigerator	3	-	90	27	24	6.4
Water	3	3	58	35	9	31.
Electric Fan	3	7	50	50	9	4.5
Printer	33	9	35	14	4	5.8
Photocopy	2	-	80	16	2	3.2
					Tot	357

Table 2
Energy required in the Main Admin Building's Hallway (1st and 2nd Floor)

Name of Appliance / Equipment	*Quantity (1st Floor)*	*Quantity (2nd Floor)*	*Rating (W)*	*Total Wattage*	*Operation Hours*	*Energy Required (kWh)*
Pin light	9	8	9	153	2	0.30
Wall	22	8	9	180	2	0.54
Fluoresc	10	13	40	920	2	1.84
					Tota	2.68

Table 3
Energy required in the Main Admin Building's Roof Shaft

Name of Appliance / Equipment	*Quantity (1st Floor)*	*Rating (W)*	*Total Wattage*	*Operation Hours*	*Energy Required (kWh)*
Pin light	26	9	234	2	0.46
Chandelier	3	70	210	2	0.42
				Total	0.88
				Subto	361.

The total energy needed to be supplied by the solar PV system is 361.168 kWh/day.

Locally available PV panels were identified. Peak power of 540W to 550W was considered to lessen the total number of panels needed by the PV system. Table 4 shows the comparison of the selected PV panels by the researchers.

Table 4
Comparison of PV Modules

Brand	*Model*	*Watt*	*Effici*	*Pri*	*Supplier*
Canadia	HiKu	550	21.5	999	Solarho
Jinko	Tiger	545	21.13	970	Handro
JA Solar	Deep	540	20.9	975	Solarho
Longi	HiM	545	21.3	940	Superm

Longi Hi-MO 5m LR5-72HPH-545M with a peak power output of 545 watts was considered in this study with a cell efficiency of 21.3%. In comparison to other brands, it has the second high-efficiency rating having the lowest price. Table 5 provides the specifications of the selected module.

Table 5
PV Module Specification (Longi Hi-MO 5m LR5-72HPH-545M)

PV Module	*LR5-*
Peak Power Output Watts (W_P)	545
Voltage at Maximum Power (V_{MP}/V)	41.80
Current at Maximum Power (I_{MP}/I)	13.04
Open Circuit Voltage-V_{OC} (V)	49.65
Short Circuit Current-I_{SC} (I)	13.92
Module Efficiency (%)	21.3
Dimensions (mm)	2256 x
Weight (kg)	27.2

Using Equation 3, the researchers identified the total PV system size that can accommodate the daily kWh consumption in the Main Admin Building.

Solar PV System Size = *(Daily kWh / Peak Sun Hours) x Panel Efficiency Factor*
= (361 kWh / 4.91) x 1.213
= 89.23 kWp

The total PV modules required in this study depends on the peak output rating of the selected PV module. Using Equation 4, it was found that:

No. of Solar PV Modules = *(Solar PV System Size / PV Output Power Rating)*

= (89230 / 545)
= 164 PV Modules

Figure 7 shows the layout plan of the solar panels on the roof of the admin building.

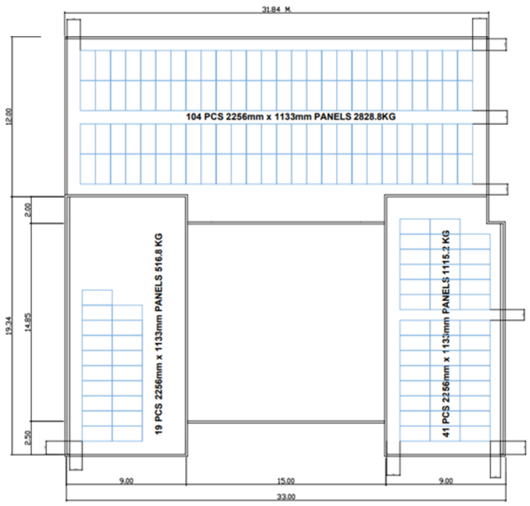

Figure 7: Solar Panel Layout

Each solar module has an area of 2.56 m2 with a total of 164 modules. Computing the total area of all required solar modules gave us an area of 419.84 m2. With a usable roof area of 757.8 m2, the roof can accommodate the total number of solar modules required in this study.

Structural of the roof was analyzed and signed by Engr. Genesis I. Castro, RCE (See Appendix A). Total force and compression of the roof, which is the maximum force it can handle, are computed with 118.75 kN and 190 kN respectively. Considering the largest mass of the roof at the rear roof of the building which handles 24 pieces of solar panels, wind load and loads of panels are computed. The total load, which is the sum of the load of panels and wind, resulted in only 65.98 kN. This means that the roof can accommodate and support the load weight of the solar panels that will be installed. Table 6 shows the results of the structural analysis.

Table 6
Structural Analysis of Roof

Units	*Load*	*Maximum*
P (Total Load)	65.98	118.75
LG (Member LG)	65.98	118.75
LKv (Vertical force at	32.99	190
MLv (Vertical force at	32.99	118.75

Deye Grid-Tied Inverter SUN-50K-G-LV was selected in this study with a rated output power of 50kW and an efficiency of 98.7%. Using Equation 5, the required inverter size of the system is determined.

Inverter Size = *(Total System Size + (1+20%)) / Efficiency of the Inverter*
= (89.23 + (1.20)) / .987
= 91.62 kW

Total number of inverters are calculated using the Equation 6.

No. of Inverters = Inverter Size / Rated Power of Inverter
= 91.62 kW / 50 kW
= 1.83 ≈ 2 *Units Inverter*

Two (2) units of inverter were used for the future expansion of the system.

Surge Electrical Supply & Contracting Corporation (SESCO) gave us a proposal amounting to PHP 4,592,514.00 VAT-included. This brings the system cost to PHP 51601.28 per kWp. The proposal consists of the selected solar panel and inverters by the researchers as well as the materials needed for the installation, such as the protective devices, cables, and mountings. Fee for the Net-Metering is also included in which the company itself will assist and apply the PV system to the Distribution Utility where the DHVSU's Main Admin Building is connected, which is Pampanga II Electric Cooperative, Inc. (PELCO II). The system's cost-benefit and environmental impact are analyzed using PVSyst Software. To start the simulation, the location of the facility where the system will be installed is determined. The software will provide the complete weather condition of the selected location such as the air temperature, daily solar radiation (horizontal), humidity, and wind velocity.

Main parameters are determined after the selection of site location. Orientation of the PV panels is set at 15 degrees to maximize solar energy harvest. On the System tab, the selection of PV modules and inverters is carried out. PVSyst contains an extensive database of photovoltaic components such as the PV panel and inverter provided by the manufacturers to simulate accurate system data. With this, selected components by the researchers are available in the database. Figure 8 shows the selected system components for the system. Under the self-consumption tab, the daily 361 kWh usage is defined by the software to simulate the dependency of the building's energy consumption on the system and the grid. This will also calculate the estimated unused and exported energy to the grid harvested by the PV system.

The simulation resulted in the system's total expected energy production annually at 138 MWh/year. The PV panel's collection loss is also computed at 0.8 kWh/kWp/day and the system's loss at 0.07 kWh/kWp/day. The total produced usable energy of the system is computed at 4.21 kWh/kWp/day. These losses are presented in the normalized production diagram in Figure 9.

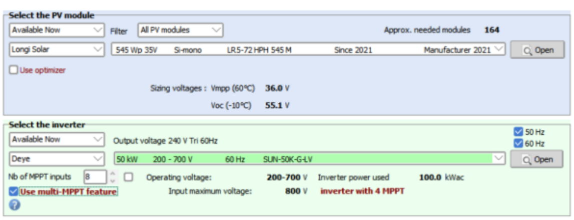

Figure 8: Selection of PV system components

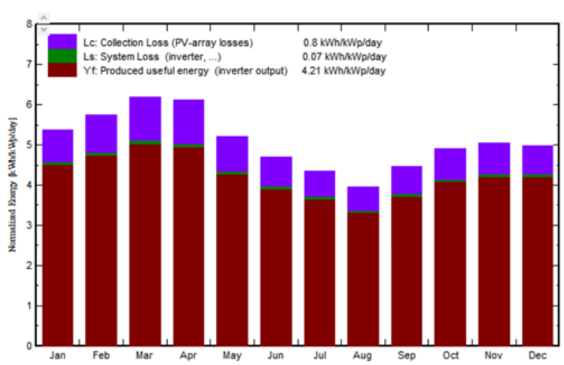

Figure 9: Normalized Production Diagram

The economic evaluation of the system requires the project's total cost, including the annual maintenance and financial parameters inputs such as inflation rate, discount rate, and tariff charges. In this study, the researchers consider fixed feed-in tariffs and consumption FIT. Data obtained from PELCO II website (PELCO II, 2022) (Table 7) shows the monthly electricity rates or consumption FIT from June 2021 up to April 2022, which rates are based on the commercial LV averaging PHP 8.1589 monthly which will be used in this study. The price of the feed-in tariff is computed depending on the distribution utility's generation charge which is based on the blended generation cost of the month (Department of Energy, 2021). In this parameter input, the researchers assumed 3.00 PHP per kWh of exported energy to the distribution utility.

Table 7
Monthly electricity rate (PELCO II)

Month/Year	*Rate (PHP)*
June 2021	9.8206
July 2021	8.6497
August 2021	8.2882
September 2021	7.183
October 2021	6.8732
November 2021	7.8762
December 2021	7.6303
January 2022	7.9453
February 2022	8.0851
March 2022	7.847
April 2022	8.6963
May 2022	9.0117
Average	8.1589

The parameter values for the inflation rate, discount rate, and product variation rate are chosen to demonstrate the approach used in this research. The inflation rate in this study is set to 4.9%, which is the inflation rate in the Philippines for April 2022 (Philippine Statistics Authority, 2022), and a discount rate of 6% per year. Product variation rate is the annual degradation of the PV panels, which is automatically set by the software as a default value of 0.5%.

Levelized Cost of Energy (LCOE) is the price at which the generated electricity should be sold for the system to break even at the end of its life. The LCOE is a valuable asset for determining the unit cost of energy produced by the system. If the LCOE of the system is less than the average electricity retail price, the investment of the system is considered profitable; otherwise, not (H. Gholami, H.N. Rostvik, 2021).

Based on the simulation results, table 8 shows the financial summary of the system with a payback period of 8.7 years. With 25 years of the system's lifetime, this is reasonable despite the costly investment, and can benefit from the rest of the operational years financially. With the increasing price of electricity sold by the grid due to high demand and the country's dependence on imported fossil fuels (Agaton et al. 2020), the payback period of 8.7 years is possible to decrease.

Table 8
Summary of Financials from PVSyst

Financial Summary	
System Lifetime	25 Years
Initial Investment	4,561,014.00
Total Yearly Expenses	18829.73
Net Present Value	4,239,284.00
Payback Period	8.7 Years
Return of Investment	92.9 %
Levelized Cost of Electricity	2.429

The result shows that the NPV of the system is 4,239,284.00 PHP, indicating a positive NPV which means that the system is favorable for the main admin building of DHVSU and financially feasible. With an initial yearly cost of 6000.00 PHP for repairs and 4000.00 PHP for the cleaning of panels, the estimated total yearly expense is computed by the software with respect to the annual average value within the system's lifespan, including the inflation rate which resulted in 18829.73 PHP. The ROI with a total return of 92.9% from the total amount of investment also indicates a positive result.

The Levelized Cost of Electricity simulated by the software shows an amount of 2.429 PHP per kWh. Compared to the distribution utility's average electricity price, which amounts to 8.1589 PHP per kWh, the LCOE is lesser. The result indicates that the PV system is profitable and has a positive result.

Emission analysis specifies the reduced CO2 emission from utilizing the solar PV system instead of the non-renewable energy. The outcome is given in the form of reduced carbon dioxide emission, which is expressed in tonnes that are not emitted by the system. As a result, as shown in Figure 10, this study determined that the 25-year lifetime of the PV system will save 1293.981 tons of CO2 emission as the PV system will replace the energy dependence of the building from the distribution utility.

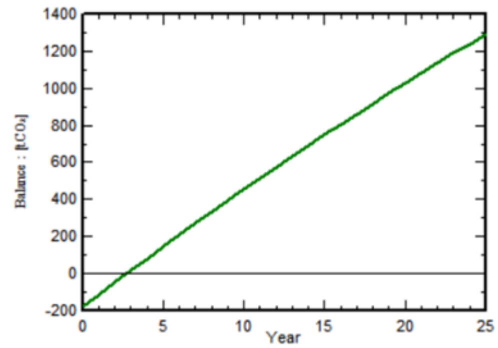

Figure 10: Reduced CO2 Emissions

CONCLUSION AND RECOMMENDATION

This study has shown that the PV system helped the DHVSU's Main Admin building lessen its dependency on the distribution utility. This will reduce the energy consumption of the building from the grid and the electricity charges on the utility. The PV system is designed with all components identified from solar panels and inverters. Simulation using PVSyst software indicates that the financial summary of the system will benefit the building, not only financially but also environmentally. The benefits outweigh the cost of the system; thus, it is potentially a good investment. A positive net present value of 4,239,284.00 PHP and a levelized cost of energy of 2.429 PHP/kWh were computed based on the simulation. 1293.981 tons of CO2 emissions will be saved using the PV system, reducing the carbon emissions in the atmosphere. With a payback period of 8.7 years, the summary of the figures can be considered acceptable, but the results can be improved if the cost of the system and the parameter values such as the discount rate is driven down in the future as well as if the FIT rate increases.

The Administration Building is considered one of the most used buildings at Don Honorio Ventura State University (DHVSU). That is why the researchers recommend including battery banks in future studies to continue the services in the building despite power outages, as the battery banks will provide the needed energy for the building. The researchers recommend having a copy of the net-metering guideline from

PELCO II to verify if the 100-kW net-metering scheme of the Department of Energy is utilized. The researchers also recommend a company that shall conduct an ocular site inspection of the building to provide an exact amount of quotation for the cost of the PV system. The researchers also recommend a study in the admin's extension building so that the entire building will be powered by a solar PV system.

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