Return of Investment Analysis of Solar Powered DHVSU Gymnasium

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Abstract- This study investigated the Return of Investment Analysis of Solar Powered DHVSU Gymnasium since solar energy is a vital consideration for cleaner energy source and to take advantage of the investments and jobs created by future solar power installation. The research data gathering focused on the previous monthly bills for general loads of the gymnasium, the estimated cost of the proposed solar project, monthly consumption gymnasium, and the roof area of the University Gymnasium. This study aimed to determine the Return of Investment of solar powered DHVSU Gymnasium. Also, the researchers identified the estimated cost for solar set-up, the payback periods of the estimated return of investment, and calculated the return of investment by conducting collateral interviews which are deemed valuable to obtain the objective/s of the study and by requesting relevant documents to the PELCO II. The researchers were able to compare the return of investment of 60.3 kW capacity and the 36.4 kW capacity of solar. The framework showed the steps in determination and evaluation of the inputs that includes the formulas and process that the proponents used to come up with the output. The study findings revealed that a 36.4 kW capacity solar PV system generates 4455 kWh, while the 60.3 kW -capacity solar PV system generates 6735 kWh. It is also indicated that a 36.4 kW capacity and 60.3 kW capacity solar PV system consumed 81 and 134 pieces of solar panel to satisfy the needs of a 36.4 kW and 60.3 kW solar PV system respectively. The Net profit was determined in accordance with the exported power of the 36.4 kW and 60.3 kW capacity solar PV system adding the annual monthly bill of the DHVSU gymnasium and deducting the cost of maintenance.

Indexed Terms- Renewable energy, Solar Panel, Power generation, Monthly bill, Return of Investment (ROI), Roof Area, DHVSU gymnasium, Payback periods, PELCO II, Net profit.

I. INTRODUCTION

Renewable energy is an excellent alternative for fossil fuels. It is much more reliable in producing cleaner energy than fossil fuels. Solar energy is one of the renewable energy sources, and by the used of solar panels, the heat and light produced by the sun turns into electrical energy. Furthermore, unlike fossil fuels, which cannot be replenished, renewable energy cannot be depleted. Today, many establishments are using solar panels to reduce their demand in electricity. By the used of solar PV systems such as On-grid, Off-grid and hybrid solar PV system, an establishment can save electricity.

A published website under Vision Mechatronics Pvt. ltd (2020) mentioned that a grid-tied solar panel system will allow users to save more money through higher efficiency rates, net metering, and cheaper equipment and installation cost. Solar panels create abundant electricity, much more than the end-user can consume. Net metering allows consumers to send excess electricity to the utility grid rather than keeping it in batteries. Solar generation is incentivized in part by the use of net metering. Solar systems would be far less financially viable without them. The utility grid functions as a virtual battery, requiring no maintenance or replenishment and providing substantially higher efficiency. An off-grid solar system delivers continuous power. Grid-connected systems are not protected from power outages. With the addition of an inverter, the system can convert Direct Current (DC) from the batteries into Alternating Current (AC) for use on the grid. Traditionally, battery systems had to be changed every ten years. They are complicated and costly, and they reduce the overall system efficiency. As a result, Li-Rack is a photovoltaic system that can be built in any part of the world with adequate sun exposure. This means customers will never run out of power, as the solar panels never need to be switched on or switched on at the same time.

In the Philippines, solar energy is a vital consideration in terms of the potential to take advantage of the investments and jobs created by future solar power installations, and look forward to cheaper and cleaner power that is not affected by geopolitics. Most of the electricity generated in the Philippines can be attributed to coal-fired and oil-based power plants. The bulk of the country's supply of crude and finished petroleum products comes from the Middle East. However, with more renewable energy (RE) sources in place, including solar energy, the Philippines has become less exposed to external risks. (Delmarva's News Leader).

On December 30, 2017, Agaton and Casper studied the Real Options Analysis of Renewable Energy Investment Scenarios in the Philippines at the Institute of Development Research and Development Policy, Ruhr University of Bochum, Germany. It showed that using renewable energy in the Philippines is better than using coal for electricity. Nowadays, it's usual to shift from fossil-based to renewable energy while the renewable technologies are decreasing timely. To fully invest in renewable energy, the government should set a high FIT rate and expected to meet the goal of 60%. If it causes some delays, there will be welfare losses. It's usual to shift from fossil-based to renewable energy while the renewable technologies are decreasing timely

The various studies sought to encourage the investment in renewable energy, and its factors are a call for cleaner energy and support for a low carbon future. Hence, this study contributes to the gaps and other benchmarks for installing Photovoltaic Solar Energy in the Don Honorio Ventura State University (DHVSU) Gymnasium.

The high electricity bill has become a problem for any establishment. More loads of consumer use can lead to more electricity consumption. Since the university gymnasium holds numerous events, it also consumes a lot of electricity. Therefore, the university's management proposes using an on-grid solar system; all of the excess electricity generated by the solar panels can be fed back to the grid. Installing solar panels can help to minimize the electricity demand. This form of renewable energy is not just beneficial for energy conservation. Still, it can also help the university with the right financial savings as it preserves energy and lessens the cost of annual utilities. For this reason, the researchers aim to find a solution to reduce the electricity bill of the gymnasium through net metering by the use of solar energy, which is a widely used renewable energy source today. As a result, this study will determine the return of investment analysis of the solar-powered DHVSU gymnasium.

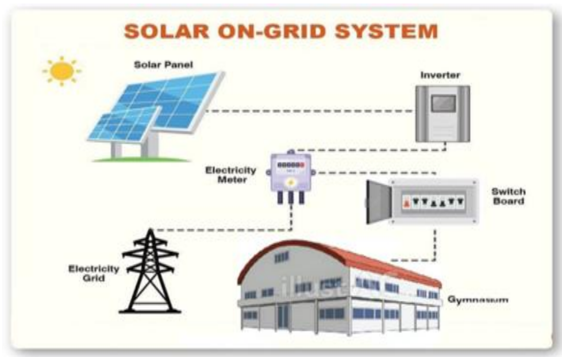


Figure 1. Grid-tied solar system setup

The Philippines is in a good location on the equator because of its excellent access to sunlight. The Philippines is geographically positioned in an area with plentiful sunlight throughout the year. However, it was only lately that the country invested in large-scale solar farms in Cavite, Pampanga, Ilocos Norte, and Cagayan De Oro. (Solenergy System Inc. 2022). Therefore, solar energy being put in a suitable place and implementing renewable solar power will primarily help the nation solve the crisis of energy sufficiency. Hence, the study aims to determine the investment return of installing a Photovoltaic System in the DHVSU gymnasium. Return on Investment depends on factors such as the amount of energy used on average, the location where to put the solar power to have good access to sunlight, and the enormity of the university to hold such capacity. Specifically, the researchers sought to answer the following question:

1. What is the monthly capacity of the solar power panels in terms of energy efficiency?
   a. kW capacity of each panel
   b. Roof area
2. What are the factors that are needed for the computation of Return of Investment?
   a. Initial Investment
   b. Cost Savings that Solar Powered Gymnasium generates
   c. Maintenance
3. What are the factors in determining the time frame for earning back the investment?
   a. Net profit
   b. Payback Period

The study aimed to conduct the return of investment analysis of the solar-powered DHVSU gymnasium. The study's specific objectives are: (1) to know the initial cost for solar setup. (2) to determine the payback periods that will help them know the estimated investment return. (3) to calculate the return of investment. Finally, (4) to compare the return of investment of 36.4 kW and 60.3 kW of solar PV system.

The locality of this study is the specific gymnasium of Don Honorio Ventura State University, a place that holds multiple events of the university. The researchers mainly focused for the computation and analysing the return of investment of solar powered DHVSU Gymnasium. Lastly, this study is limited to the ROI computation related to the energy consumption of gymnasium only through the use of renewable solar power. Therefore, this study did not cover the usage of the whole university in terms of electricity consumption.

The study assumed that factual studies and cooperation from the DHVSU are vital in collecting data. The collected data from scholarly research were the baseline data to analyze the return of a solar-powered energy resource investment. Objectively, the analysis included calculation and formula to determine the impact of the study, which is for the benefit of the university and future installation of PV panels. Cost savings generated by using solar power would be the basis of income, ROI and payback period. Moreover, the study undergone in-depth data collection backup with the available resources of the researchers and the university. Finally, the interpretation of the data was validated by a specialized person who knows the research topic.

INPUT	PROCESS	OUTPUT
Solar powered gymnasium: Materials Solar Panels Inverter Main Switch box Utility meter Return of Investment Analysis: -Cost Savings on Utilities -Net Investment -Maintenance Knowledge Requirements: Renewable Energy Philippine Topography Weather Solar Energy Solar System types ROI understanding	Evaluation: Calculate the generation capacity of the solar panel (monthly). Calculate the payback period Summarizing the overall cost of the investment Calculate the cost savings ROI analysis	Return of Investment Analysis of a Solar Powered Don Honorio Ventura State University (DHVSU) Gymnasium. -Cost estimated for solar set up -Payback period -Cost savings

Figure 2. Conceptual Framework

Figure 2 above determined the underlying conceptual framework that the researchers intended to use. The first step was the determination of the inputs. Accordingly, the proponents used the solar-powered gymnasium and the factors that determine the computation of return of investment as the input of this study. Mixed with the appropriate knowledge, the monthly production of energy used in solar power was gathered along with the costs incurred from purchasing the materials needed for a solar-powered gymnasium.

The next step was the evaluation of the inputs. Through the process that the proponents used, it came up with the output of a complete analysis of the return of investment for the DHVSU gymnasium that is solar-powered. To analyze, the following formulas were used:

$$E = Wp \times T \times 75\%$$

Where in:
E =Power generated by a solar panel in daytime (kWh)
Wp = Wattage of the solar panel
T = Average sunlight duration in Hours

$$ROI = (\text{Net Profit} / \text{Investment cost}) \times 100\%$$

Where ROI helps to measure the performance of an investment which likewise provides an analysis of what percentage of the investment has already been earned in a period of time

$$\text{Payback Period} = \text{Project cost} / \text{Annual cash-in flow}$$

Where payback period can help the researchers determine the estimated and probable period of return on investment, assuming that the earnings are made equally every year.

II. METHODS

Figure 3 is the research design that showed the various steps in determining the Return of investment analysis of a solar-powered DHVSU gymnasium. It involved profiling, gathering of data, overall evaluation and implementation.

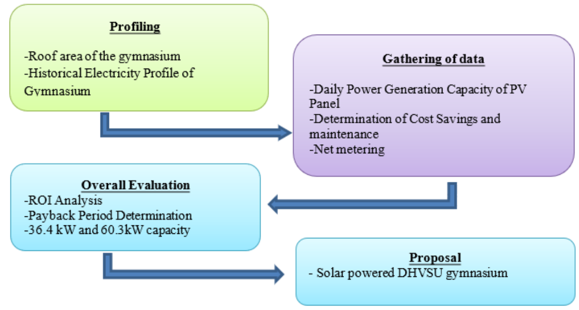


Figure 3. Research design

Birken and Curry (2021) that the best way to calculate the return of investment is through the following formula; ROI = (Net Profit / Cost of Investment) x 100 Chard (2021) introduced the following formula to calculate the solar panel output (wattage); E =Wp x T x 75%

According to Julia Kagan (2022), tracking your finances could save you from financial ruin. To calculate the payback period; Payback Period = Cost of Investment ÷ Average Annual Cash in Flow

Through Profiling, the first step in determining the return of investment analysis of a solar-powered DHVSU gymnasium, the researchers coordinated thru the Office of Physical Plant and Facilities (OPPF) to get the data needed, such as the gymnasium's consumption in kWh. In determining the consumption of the university gymnasium, the needed capacity for solar PV system can be determined. According to Oliver Jay (2020), designing an On-grid system only has 3 steps. First is the Load analysis, where the daily consumption was determined by dividing the highest monthly consumption by 30 days.

$$\textit{Daily consumption} = \textit{Highest kWh of the month} / \textit{30 days}$$

Equation 1,

Second, Sizing of solar PV panels and determining the exact number of solar panel with regards to the daily consumption of the university gymnasium, the following formulas will be used:

$$\textit{PV power} = (\textit{Daily consumption} / \textit{Sun peak Hours}) \times 1.3$$

Equation 2,

$$\textit{No. Of PV panels} = \textit{PV power} / \textit{PV panel wattage}$$

Equation 3,

And lastly, sizing the Inverter. Where the Inverter max power must be higher than the capacity of the solar PV system.

Obtaining the roof area of the university's gymnasium ensured that the solar capacity system can be fit on the roof of the DHVSU gymnasium. Furthermore, by calculating the power generated by a Solar panel, the researchers were able to calculate the power output of the solar panel installed on the roof area of the DHVSU gymnasium. As for the historical electricity profile of the gymnasium, the researchers requested the data from the OPPF; in this way, the researchers can compare the monthly consumption of the DHVSU gymnasium before and after the installation of the solar panel and for the canvasing of the cost of materials, installation and maintenance. The researchers collected the data by interviewing a contractor. This was one of the factors needed to determine the Cost of Investment; by assessing the investment cost, the researcher can calculate the return of investment of a solar-powered DHVSU gymnasium.

Step 2 is the Gathering of data. The researchers calculated the daily power generation capacity of a solar panel to determine if it is possible to provide the gymnasium with sufficient energy. To compare the monthly consumption before and after the installation of solar panels, the researchers computed the possible generation of solar panels. In determining the daily power generation capacity of a solar panel, the following formula was needed:

Equation 4, $$E = Wp \times T \times 75\%$$

Where in:

E = Power generated by a solar panel in daytime (kWh)

Wp = Wattage of the solar panel

T = Average sunlight duration in Hours

Determining the cost of materials used and cost of installation, the researchers used this data to determine the cost of investment which is also one of the factors needed to determine the return of investment analysis of solar-powered gymnasium. And upon determination of cost savings (which is the electricity saved by the solar-powered gymnasium in terms of the monthly electricity bill), the monthly consumption of the university gymnasium was compared to the monthly computed electricity produce by the solar panels. Lastly, the determination of maintenance needed in maintaining the solar PV system. The researchers collected the data by interviewing a contractor. In determining the net profit, the following formula was be used:

$$\textit{Net Profit} = \textit{Cost savings} - \textit{Maintenance}$$

Equation 5,

To determine the net metering system, the data was collected by interviewing the electricity supplier at the University. The data collected was compared the ROI of a 36.4 kW capacity and 60.3 kW-capacity solar system.

Step 3 is overall evaluation. The researchers evaluated the data gathered to determine the return of investment analysis and payback period of the solar-powered DHVSU gymnasium. In determining the return of investment and payback period, the following formula was needed:

Equation 6,

$$\textbf{ROI} = (\textbf{Net Profit} / \textbf{Investment cost}) \times 100\%$$

This was the basis of the project's output and will have a potential for returning the investment. In this study, net profit would be the cost savings attributed to the electricity saved through the use of a solar-powered gymnasium in terms of a monthly bill adding the payback of the utility for the excess electricity generated by the solar panels and deducting the maintenance cost.

Equation 7,

$$\textbf{Payback Period} = \textbf{Project cost} / \textbf{Annual cash-in flow}$$

Payback period will depend on the cost of the project or Investment and it will vary to the annual cash-in flow or the net profit (saved electricity or monthly bill that goes through the meter minus the maintenance). The following formula above was in comparing the ROI of the 36.4 kW capacity and 60.3 kW capacity solar system.

Step 4 is the proposal of the solar-powered DHVSU gymnasium. After all the data was examined and analyzed, the university can use this study to implement solar powered gymnasium. The data obtained including the cost of investment (cost of the project), the Payback period of the return of investment, and cost savings can be used by the university and future researchers for reference.

III. RESULT AND DISCUSSIONS

The study aimed to analyze the return of investment of Solar Powered DHVSU Gymnasium. The study's findings comprise the university gymnasium power consumption, historical electricity profile, power generated, and the cost of installation for the solar panel that was used as an assertion in obtaining the objectives of the study. The data gathered were organized and processed with the use of an interview and request letter, which revealed the following significant results:

Month	kWh used
JAN. 2019	1340
FEB. 2019	2020
MAR. 2019	1736
APR. 2019	1514
MAY 2019	1404
JUN. 2019	1466
JUL. 2019	2030
AUG. 2019	2452
SEPT. 2019	2626
OCT. 2019	3272
NOV.2019	4204

Table 1: Power consumption of University Gymnasium per month

Using equation 1, Daily consumption = 4204 kWh / 30 days

the daily consumption of the university gymnasium was 140.13 kWh. And as for the number of capacity of the solar PV system, equation 2 was used.

PV capacity = (140.13/5hrs) x 1.3

The exact capacity needed for the solar powered DHVSU gymnasium was 36.4 kW solar PV system. Based on the calculated capacity of solar PV system the 60.3 kW PV system was over capacity.

Using equation 3,

No. Of PV panels = 36.4 kW/ 450 W

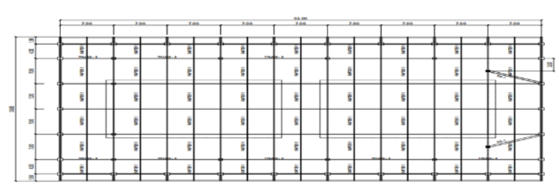
No. Of PV panels = 60.3 kW/ 450 W

Number of capacity	Wattage of solar panel	Number of solar panel used
36,400 Watts	450 Watts	81 Pieces
60,300 Watts	450 Watts	134 Pieces

Number of solar panels for a 36.4 kW and 60.3 kW PV system was obtained. (see table 2)

Table 2: *Number of solar panel of an 36.4kW capacity and 60.3kW Capacity Solar PV system*

Table 2 shows the pieces of solar panel used in an 36.4kWcapacity and 60.3kW capacity solar PV system. The orange color indicates the System capacity. The blue color shows the wattage of the solar panel used. And lastly, the green color indicates the number of solar panel used in the solar PV system.



OPPF. By multiplying the length and its width, the area was computed. (Roof Area= 39.95 x 63.00, equal to 2516.85 square meters.) The consumed area occupied by the solar panels was obtained by multiplying the length, width and number of panels used (see Figure 5 to see the size of 450watts panel) 1.1 X 2.3 =2.53 square meters, 2.53 x 81 = 205.74 square meters, 2.53 x 134 = 339.02 square meters.

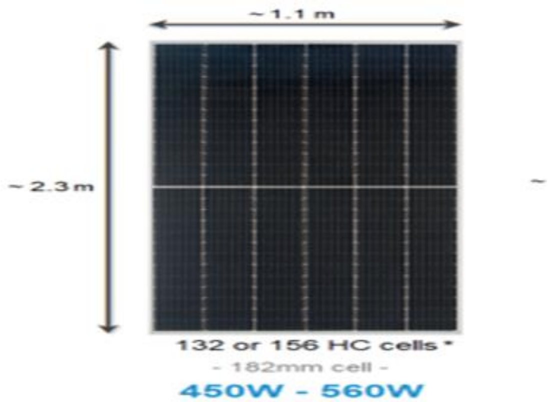


Figure 5: Standard size of solar panels. N-type IBC (20-23%) efficiency.

Month	kWh used	Price (PHP)
JAN. 2019	1340	14,446.72
FEB. 2019	2020	17,895.46
MAR. 2019	1736	15,712.90
APR. 2019	1514	16,688.12
MAY 2019	1404	18,752.10
JUN. 2019	1466	15,126.09
JUL. 2019	2030	20,081.40
AUG. 2019	2452	23,079.45
SEPT. 2019	2626	56,959.29
OCT. 2019	3272	26,689.50
NOV.2019	4204	28,338.86
	TOTAL:	PHP 253,769.89

Table 3: Historical Electricity Profile (year 2019)

Table 3 shows the Historical Electricity profile of the gymnasium from January to November (2019). The Green color indicates the monthly energy consumption, and the blue color indicates the monthly bill in pesos of the DHVSU gymnasium. The consumption of the university gymnasium in the year 2020 up to present was not accurate due to pandemic not like for the year 2019 where activities are held in the gymnasium. Therefore, the historical electricity profile for the year 2019 was the best basis for getting the following; Cost savings, capacity of solar PV system, ROI and payback period.

Power generation of a 36.4kW capacity of solar PV system

The results of the computing power generated by a solar panel can be obtained using the formula stated in the methodology (equation 1). Using Equation 1, the power generated by a solar panel was equal to 1.688 kWh per day. Therefore, the daily power generated by the solar PV system within a day was 148.5 kWh. Power generated by the solar PV system within a month was obtained by multiplying 148.5 kWh by 30 days. Hence, the maximum power generated in a month by the solar PV system was 4455 kWh (see Table 4). To compare the monthly consumption of the gymnasium before and after the installation of solar panels (see Figure 6).

Power generation of a 60.3kW capacity of solar PV system

The results of the computing power generated by a solar panel can be obtained using the formula stated in the methodology (equation 1). Using Equation 1, the power generated by a solar panel was equal to 1.688 kWh per day. Therefore, the daily power generated by the solar PV system within a day was 224.5 kWh. Power generated by the solar PV system within a month was obtained by multiplying 224.5 kWh by 30 days. Hence, the maximum power generated in a month by the solar PV system was 6735 kWh (see Table 4). To compare the monthly consumption of the gymnasium before and after the installation of solar panels (see Figure 6).

Wattage of Solar panel (watts)	average sun duration (hr)	Power generated of solar panel per day (kWh)	Power generated of solar PV system per day(kWh)	Power generated of solar PV system per day(kWh)
450 W	5 hrs	1.688	148.5	4455
450 W	5 hrs	1.688	224.5	6735

Table 4 shows the computed power generation of the solar panels. The first column indicates the Wattage of the solar panel. The second column indicates the average sunlight duration. According to the world weather and climate information (2022), the average sunlight duration within Luzon (manila) in April was 261 hours and 132 hours for September. On that account, the average sunlight duration per day is 5 hours. The third column indicates the power generated by a solar panel within a day. The fourth column shows the power generated by the solar PV system within a day. And lastly, the fifth column indicates the power generated by a solar PV system within a month.

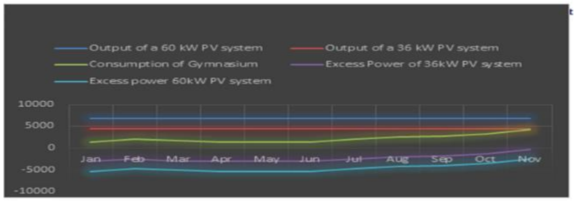


Figure 6: Comparison of power consumption of gymnasium.

Figure 6 shows the comparison of power consumption of the gymnasium before and after installing solar panels (36.4 kW and 60.3 kW) as of year 2019. The Blue line indicates the power generated by the 60.3kW Solar PV system. The red line indicates the power generated by the 36.4kW solar PV system. The green line shows the consumption of the gymnasium before the solar panels were installed. The violet line indicates the excess power of a 36.4kW can generates. And lastly, the cyan line indicates the excess power of a 60.3kW can generates.

COST OF MATERIALS FOR 36.4 KW SOLAR SYSTEM			
ITEM DESCRIPTION	**Quantity**	**Price (Per Piece)**	**Total Price**
450 W CANADIAN SOLAR PANEL MONOCRYSTALLINE Dimensions: 2108 X 1048 X 35 mm, VPM=41.1 V, IMP=10.96 A, VOC=49.1 V, ISC=11.6 A	81 pcs	₱7,800	₱631,800
SOLIS SOLAR INVERTER 40KW ON GRID MPPT Input range=200-1000V, Maxinput voltage=1100V, MaxOutput Current=69.9, Peak efficiency: grid (Amps)=98.7%,	1 pc	₱200,000	₱200,000
SOLIS EXPORT POWER MANAGER 3P, 2G	1 pc	₱20,500	₱20,500
DC ISOLATION SET 63A	4 pcs	₱2700	₱10,800
10MM^2 PV CABLE SINGLE CORE	650 m	₱150	₱97,500
DC CIRCUIT BREAKER (Miniature Type), 2POLE, 63A	4 pcs	₱700	₱2,800
DC SURGE PROTECTION DEVICE DC 1000V, 40KA, 2 POLE	4 pc	₱1000	₱4,000
AC CIRCUIT BREAKER (Miniature Type), 3POLE	1 pc	₱1,700	₱1,700
AC SURGE PROTECTION DEVICE 400V, 40KA, 3POLE	1 pc	₱2,500	₱2,500
THHN/THWN WIRE #6 AGW OR 14mm2	100 m	₱150	₱15,000
THHN/THWN WIRE #12 AGW OR 3.5mm2	100 m	₱43	₱4,300
EMT PIPE 2" 50mm x 10'	70 pcs	₱1,705	₱119,350
EMT PIPE 3/4" 20mm x 10'	5 pcs	₱540	₱2,700
EMT ELBOW 2"	5 pcs	₱800	₱4,000

EMT COUPLING 2"	50 pcs	₱252	₱12,600
EMT ELBOW 3/4"	2 pcs	₱110	₱220
EMT COUPLING 3/4"	5 pcs	₱45	₱225
UNI-STRUT CHANNEL 1 5/8" x 1 5/8" x 3m	30 pcs	₱706	₱21,180
UNI-STRUT CLAMP WITH BOLT AND NUT 2" Diameter	160 set	₱51	₱8,160
UNI-STRUT CLAMP WITH BOLT AND NUT 3/4" Diameter	20 set	₱18	₱360
LIQUID-TIGHT CONDUIT 3/4" Diameter	100 m	₱68	₱6,800
L-FOOT WITH RUBBER PV SOLAR PANEL FRAME MOUNTING STRUCTURE	396 pcs	₱90	₱35,640
ALUMINUM SOLAR MOUNTING PRO RAILINGS 2.1m	132 pcs	₱600	₱79,200
MID CLAMP SOLAR MOUNTING	250 pcs	₱40	₱10,000
END CLAMP SOLAR MOUNTING	60 pcs	₱40	₱2,400
TEX SCREW 65mm (2½")	1 box	₱238	₱238
DYNA BOLT 3/8" x 75mm	280 pcs	₱18	₱5,040
MC4 CONNECTOR FOR SOLAR CABLE PER SET	100 set	₱55	₱5,500
SURFACE MOUNT MCB DISTRIBUTION BOX 12 - WAYS EQUIVALENT, 2POLE	2 pcs	₱2,000	₱4000
TOTAL COST OF MATERIALS:			₱1,308,513.0
COST OF INSTALLATION			₱408,933.9
TOTAL COST:			₱1,717,446.9
MAINTENANCE			₱2,500

COST OF MATERIALS FOR 60 KW SOLAR SYSTEM

ITEM DESCRIPTION	Quantity	Price (Per Piece)	Total Price
450W CANADIAN SOLAR PANEL MONOCRYSTALLINE Dimensions: 2108 X 1048 X 35 mm, VPM=41.1 V, IMP=10.96 A, VOC=49.1 V, ISC=11.6 A	134 pcs	₱7,800	₱1,045,200
SOLIS SOLAR INVERTER 70KW ON GRID MPPT Input range=200-1000V, Max input voltage=1100V, Max Output Current=69.9, Peak efficiency: grid (Amps)=98.7%,	1 pc	₱250,000	₱250,000
SOLIS EXPORT POWER MANAGER 3P, 2G	1 pc	₱20,500	₱20,500
DC ISOLATION SET 63A	4 pc s	₱2700	₱10,800
10MM² PV CABLE SINGLE CORE	800 m	₱150	₱120,000
DC CIRCUIT BREAKER (Miniature Type), 2POLE, 63A	4 pcs	₱700	₱2,800
DC SURGE PROTECTION DEVICE DC 1000V, 40KA, 2 POLE	4 pc	₱1000	₱4,000
AC CIRCUIT BREAKER (Miniature Type), 3POLE	1 pc	₱1,700	₱1,700
AC SURGE PROTECTION DEVICE 400V, 40KA, 3POLE	1 pc	₱2,500	₱2,500
THHN/THWN WIRE #6 AGW OR 14mm2	200 m	₱150	₱30,000
THHN/THWN WIRE #12 AGW OR 3.5mm2	200 m	₱43	₱8,600
EMT PIPE 2" 50mm x 10'	100 pcs	₱1,705	₱170,500
EMT PIPE 3/4" 20mm x 10'	10 pcs	₱540	₱5,400
EMT ELBOW 2"	10 pcs	₱800	₱8,000

EMT COUPLING 2"	100 pcs	₱252	₱25,200
EMT ELBOW 3/4"	4 pcs	₱110	₱440
EMT COUPLING 3/4"	10 pcs	₱45	₱450
UNI-STRUT CHANNEL 1 5/8" x 1 5/8" x 3m	60 pcs	₱706	₱42,360
UNI-STRUT CLAMP WITH BOLT AND NUT 2" Diameter	250 set	₱51	₱12,750
UNI-STRUT CLAMP WITH BOLT AND NUT 3/4" Diameter	40 set	₱18	₱720
LIQUID-TIGHT CONDUIT 3/4" Diameter	200 m	₱68	₱13,600
L-FOOT WITH RUBBER PV SOLAR PANEL FRAME MOUNTING STRUCTURE	792 pcs	₱90	₱71,280
ALUMINUM SOLAR MOUNTING PRO RAILINGS 2.1m	264 pcs	₱600	₱158,400
MID CLAMP SOLAR MOUNTING	500 pcs	₱40	₱20,000
END CLAMP SOLAR MOUNTING	120 pcs	₱40	₱4,800
TEX SCREW 65mm (2½")	2 box	₱238	₱476
DYNA BOLT 3/8" x 75mm	560 pcs	₱18	₱10,080
MC4 CONNECTOR FOR SOLAR CABLE PER SET	200 set	₱55	₱11,000
SURFACE MOUNT MCB DISTRIBUTION BOX 12 - WAYS EQUIVALENT, 2POLE	2 pcs	₱2,000	₱4000
TOTAL COST OF MATERIALS:			₱2,047,756.00
COST OF INSTALLATION			₱614,326.8
TOTAL COST:			₱2,662,082.8
MAINTENANCE			₱5,000

Table 5: cost of installation for a 36.4 kW and 60.3 kW solar PV system

Table 5 shows the Cost of materials needed for a 36.4 kW solar PV system and 60.3 kW solar PV system. Adding the cost of materials and cost of installation, the Investment cost was obtained. (see table 8)

Date	Energy Consumption	Power generated 36.4kW Capacity kWh	Power generated 60.3kW Capacity kWh	kWh export of 36.4kW capacity	kWh export of 60.3kW capacity
January	1340	4455	6735	3115	5395
February	2020	4455	6735	2435	4715
March	1736	4455	6735	2719	4999
April	1514	4455	6735	2941	5221
May	1404	4455	6735	3051	5331
June	1466	4455	6735	2989	5269
July	2030	4455	6735	2425	4705
August	2452	4455	6735	2003	4283
September	2626	4455	6735	1829	4109
October	3272	4455	6735	1183	3463
November	4204	4455	6735	251	2531

Table 6: Power Export by a 36.4kW capacity and 60.3kWcapacity solar PV system as of January to November year 2019.

Table 6 shows the power export that the solar PV system can generate. The blue color indicates the energy consumption of the gymnasium. The yellow color shows the power generated by the 36.4kW and 60.3kW capacity solar PV system. And lastly, the green color indicates the power exported by the 36.4kW and 60.3kW capacity solar PV system.

2019	kWh export (36.4 kW)	kWh export (60.3 kW)	Generation Charges Php/kWh	Supply System Charges - Php/kWh	Metering System Charges - Php/kWh	Retail Metering Customer Charges - Php/Customer	Value Added Taxes (VAT) - %	Cost Savings Of 36.4 kW capacity(Pesos)	Cost Savings Of 60.3 kW capacity(Pesos)
January	3115	5395	3.99	0.5376	0.3205	5	12%	9429.64	16335.69
February	2435	4715	4.7614	0.5376	0.3205	5	12%	9248.28	17913.11
March	2719	4999	4.6562	0.5376	0.3205	5	12%	10041.35	18466.16
April	2941	5221	5.2221	0.5376	0.3205	5	12%	12526.08	22241.23
May	3051	5331	5.935	0.5376	0.3205	5	12%	15169.85	26510.41
June	2989	5269	5.66	0.5376	0.3205	5	12%	14039.5	24753.05
July	2425	4705	5.9192	0.5376	0.3205	5	12%	12017.86	23322.39
August	2003	4283	4.9098	0.5376	0.3205	5	12%	7903.7	16906.8
September	1829	4109	4.0991	0.5376	0.3205	5	12%	5733.85	12888.56
October	1183	3463	3.3886	0.5376	0.3205	5	12%	2866.17	8400.93
November	251	2531	4.4827	0.5376	0.3205	5	12%	878.33	8907.64
							Total:	99854.61	196645.97

Table 7: Annual Cost savings (January - November, 2019)

The results of annual cost savings were obtained by summing up the export of the solar PV system per month in terms of Pesos and the monthly bill within that year (Php 99,854.61 plus Php 253,769.89)Therefore, the annual cost savings by the solar-powered gymnasium as of the year 2019 by for a 36.4kW capacity solar PV system was PHP 353,624.5 and the annual cost savings for a 60.3 kW capacity solar PV system was annual electricity bill plus the annual exported energy(Php 253,769.89 Plus Php 196,645.97). Therefore, the annual cost savings by the solar-powered gymnasium as of the year 2019 for a 60 kW capacity solar PV system was Php 450,415.86

The excess energy generated from a solar was subtracted from the total amount of import energy consumed by the consumer. The excess energy produced by the solar was credited and applied to the future billing of the Distribution Utility (DU) with a certain charges which means, not all the excess energy produces by the solar are being deducted for the future billing. The pricing of the exported energy to DU shall be the DU monthly generation charge, which is based on its blended generation cost excluding another generation adjustment (section 6, terms and conditions).

Capacity of Solar PV system	Cost of Installation (Investment Cost)
36.4kW Capacity	₱1,717,446.9
60.3kW Capacity	₱2,662,082.8

Table 8: Investment Cost of a 36.4kW Capacity and 60.3 kW Capacity Solar PV system.

Table 8 shows the cost of installation for a 36.4 kW capacity and 60.3 kW -capacity solar PV system. The data obtained was computed in accordance with the information about the cost of Materials and cost of installation that are stated in table 5.

System Capacity	(Net Profit)	Cost of Installation (Investment Cost)
36.4 kW Capacity	PHP 351,124.5	₱ 1,717,446.9
60.3 kW Capacity	PHP 445,415.86	₱2,662,082.8

Table 9: Net Profit and Investment Cost

Table 9 shows the Net profit and cost of investment of a 36.4 kW capacity and 60.3 kW capacity solar PV system. By the use of equation 5, Net profit of the 36.4 kW and 60.3 kW PV system was obtained.

Units	Return of Investment (36.4 kW capacity)	Return of Investment (60.3 kW capacity)
Percentage	20.45	16.73
Year(s)	4.9	6

Table 10: Return of Investment and Payback Period as for the year 2019

The data above was obtained through the use of equations 2 and equation 3 stated in the methodology. The yellow color indicates the ROI and Payback period of a 36.4 kW capacity solar PV system. The red color indicates the ROI and Payback Period of a 60.3 kW -capacity solar PV system.

CONCLUSION

This study sought to determine the return of investment analysis of a solar power DHVSU gymnasium. The data were collected from interviews and request letters. By evaluating the data, the following conclusions were drawn: [1] The findings showed that a 36.4 kW capacity solar PV system generates 4455 kWh, while the 60.3 kW -capacity solar PV system generates 6735 kWh. It is also indicated that a 36.4 kW capacity and 60.3 kW capacity solar PV system consumed 81 and 134 pieces of solar panel to satisfy the needs of a 36.4 kW and 60.3 kW solar PV system respectively. The net profit was determined in accordance with the exported power of the 36.4 kW and 60.3 kW capacity solar PV system plus the annually electrical bill deducting the maintenance cost. [2] As for the export power of a 36.4 kW and 60.3 kW capacity solar PV systems, it showed that a 60.3 kW capacity solar PV system was much higher in exporting energy produces by the solar PV system. However, the cost of installation was also greater than the 36.4 kW capacity solar PV systems. And also with the accordance to the terms and agreement in net-metering of PELCO 2, the excess energy produced by the solar was deducted to the future billing of the distribution utility. However, there are only certain charges that will be deducted. [3] The findings showed that the return of investment of a solar-powered DHVSU gymnasium varies from the Cost of installation and net profit which was attributed to the electricity saved through the use of a solar-powered gymnasium in terms of the monthly bill adding the sum of monthly bill within that year and deducting the cost of maintenance. The ROI of a 36.4 kW capacity solar PV system was greater than the 60.3 kW Capacity solar PV system which has a value of 20.45% and 16.73% respectively. It shows that the ROI of a 36.4 kW Capacity solar PV system was greater than the 60.3 kW Capacity solar PV system. The payback period of a 36.4 kW and 60.3 kW capacity solar PV system was 4.9 years and 6 years respectively, which shows that a 36.4 kW capacity system has the advantage of quickly returning the investment for a solar-powered gymnasium.

RECOMMENDATION

With a goal of flourishing this study and offering substantial output to the university, the researchers are recommending the following; [1] The researchers suggest that a 36.4 kW capacity system was more advantageous than the 60.3 kW capacity solar PV system. Therefore, the usage of a 36.4 kW capacity solar PV system was better in returning the Investment and has a quick payback period. [2] Future researchers may consider conducting studies incline with the return of investment analysis of solar powered DHVSU gymnasium. [3] Other researchers may also consider conducting a study regarding the cost of investment, cost savings and payback period of a solar powered DHVSU gymnasium.

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