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Feasibility Study on the Installation of Solar Photovoltaic Rooftop System for the Pangasinan State University

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Abstract **-** Pangasinan State University (PSU) particularly the Urdaneta City Campus, Sta. Maria Campus, Binmaley Campus, and Infanta Campus uses more than 590,000-kilowatt hours (kWh) of electricity annually. The PSU is searching for ways to lessen the cost and effect on the environment-related with their activities. One feasible alternative is solar energy use to produce electricity on the four (4) campuses. Solar power, however, is a complex issue for an enormous project in particular. Taking the time to assess alternatives before starting a project of this scale, it is possible to save money and effort in the future. This research is intended to verify the probability and connected benefits from solar photovoltaic (PV) rooftop system installation equals to the generation capacity on its campuses. Solar PV data were determined to compute the complete estimated quantity of electricity each solar power system would generate yearly. Cost information was used to evaluate each system's cost from the Solar Philippines and the cost of electricity per kWh from each and every solar energy system and from different distribution utility for each campus. Another, University space and energy usage data particularly from the Office of the University Engineer were used to verify the size and capacity of the required solar power systems and the accessibility of campus space. Additionally, talks and consultations with the Campus Executive Directors, Coordinator for Physical Facilities, and the Campus Accountant were used to assess both financial and non-financial advantages from the university's use of solar. A solar photovoltaic rooftop system, the cheapest choice has been proven, with a nine and a half (9.5) years payback period and a cost of 10 PHP (Philippine Peso) per kWh. With the available at the moment, 3,360 square meters of rooftop space that can be used, up to 336,000 kWh or 57% of the four (4) campuses, 2018 electricity usage could be produced with solar energy. Non-financial advantages include decreased environmental impact, possibilities for teaching and learning, a symbol of sustainability engagement, energy security, and brand advertising. The University can not produce 100% of its energy from solar power installations on campuses. Furthermore, compared to current electricity rates, solar electricity is somewhat expensive. Nevertheless, having a power purchase agreement with the Solar Philippines Inc., (SPI), and the University can install solar PV rooftop system at no cost at all and will also have an outright saving of 38% on a monthly electrical bill, and given the non-financial benefits, solar PV rooftop system installation on the said four (4) campuses should be considered by the University.

Keywords: Solar PV Rooftop System, Feasibility Study, Pangasinan State University.

Introduction

For its energy, the Philippines currently depends on coal, oil, and natural gas strongly. Fossil fuels are non-renewable, relying on resource constraints that ultimately decrease, become too pricey or dangerous to recover from the environment. The many kinds of renewables such solar energy, on the other hand, are continually replenished and never run out. Renewable energies are coming directly or indirectly from the sun. For heating and lighting homes and other buildings, electricity generation and hot water heating as well as a variety of commercial and industrial applications, sunlight

or solar energy can be used directly away. Solar power is solar energy transformed into electrical energy from the sun. Solar energy is the current cleanest and most abundant source of renewable energy. The Philippines as the industry scales up to new modern technologies and drives down manufacturing and installation costs.

A solar power system is consist of various photovoltaic (PV) panels, a direct current (DC) to alternating current (AC) power inverter and a rack system that holds the PV panels in position. Solar PV panels are normally fixed on the rooftop. Mostly they should face in the south direction. The solar panels ought to be slanting at meticulous angles to maximize the amount of sunlight that hits the panels. Solar photovoltaic panels on the rooftops of households and companies produce clean electricity by transforming energy from the sunlight. This transformation of specifically manufactured materials consisting the solar panels takes place within solar panels. It's a method that does not require moving components. Solar panels usually are attached via a device called a solar power inverter to the distribution utility power lines [1].

An on-grid or grid-tie solar power system is a system that uses inverter that converts DC electricity into AC electricity with an ability to synchronize with the distribution utility line. Its applications convert DC sources like solar panels into AC for grid tying. Figure 1 is the illustration of the said solar power set-up [2].

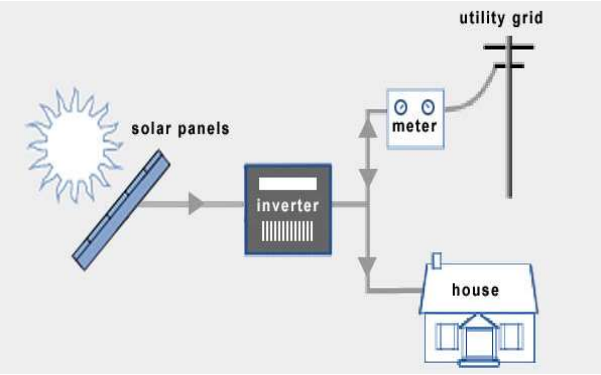

Figure 1. On-Grid Solar Power System Set-up

The consumption of fossil fuels and coal burned by major corporations and industry sectors produces a lot of atmospheric greenhouse gasses and rooting climate change and other significant environmental issues. Energy resource outlay has been on the rise in recent years. Now is the time to begin looking at future techniques to make the Pangasinan State University a more sustainable place. Implementing the University's plan for solar power installation could be significantly useful. The sun is the ultimate source of energy in nature and can be harnessed using the right technology. This alternative source of energy could result in significant annual savings on electricity costs. Due to the amount of space available on the rooftop for solar PV panels, campuses have the potential for very high output gains. Solar power has become one of the high rising sources of renewable energy. It gives an admirable answer to the problem of declining limited energy assets. Solar also offers "safety" power as it came from the most ample resources, the sun. Base on that, as long as the sun exists, solar energy will be a viable chance for energy. Figure 2 is the illustration of annual sun hours in the Philippines, and Pangasinan has an average 5.0-5.5 annual sun hour [3].

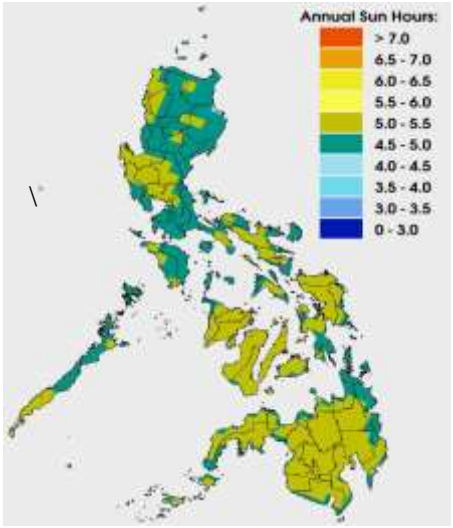

Figure 2. Annual sun hours in the Philippines

Solar Philippines is Southeast Asia's largest solar company and only integrated Developer, Investor, and Manufacturer, with 300 Mega Watt (MW) in projects under building and in operation; solar power purchase agreement (PPA) with the cheapest price in East Asia, including the world's biggest off-grid solar projects on non-electrified areas; and a factory of 800 MW solar panels, one of the region's biggest and most developed. The Solar Philippines is also committed to sustainable development and renewable energy. With the impending threat of price hikes and power shortages, Solar Philippines will help reduce both electricity costs and carbon footprint [4].

One of the most opportunities for rising the use of solar energy in the Philippines comes from growing the solar electricity generation capacity at different large scale institutions and industry throughout the country. Colleges and Universities often have many buildings with large roofs that would be fit for solar power system installations. Some industry, manufacturing companies and corporations, both local and abroad, have by now begin to produce solar electricity. A college or university has many non-financial advantages allied with solar installation, first benefit is a boost in institutional ranking for colleges and universities pursuing the sustainability agenda and low environmental impact. Adding up, using solar electricity produced on campuses serves as a symbol of the university's dedication to the environment. This move motivates students, faculty, staff, and other stakeholders to support and do pro-environmental actions into their day to day activities. Lastly, a solar power installation on campuses provides important teaching and learning opportunities. A university with solar power technologies can allow students, particularly Engineering and Technology students, a hands-on education with solar power energy. Additionally, courses and curricula can be aligned to take improvement of the opportunity to have immediate access to a solar power system. A solar power installation will provide an immense starting point for this call for awareness-raising of environmental issues and implementing sustainable practices. Based on these promising benefits, Pangasinan State University may look at the opportunity of using solar energy to present for a noteworthy portion of its electricity consumption.

Objectives of the Study

The objective of this study is to explore and provide information on the feasibility and related benefits of Pangasinan State University installing solar power electricity generation capacity particularly the Urdaneta City Campus, Sta. Maria Campus, Binmaley Campus, and Infanta Campus. Furthermore, this study is intended to inform the Campus Executive Director and the Coordinator for Physical Facilities about potential locations for such an installation and providing 38% of the Campus' electricity needs. Additionally, this study will survey the benefits to Pangasinan State University linked with availing such a project including the environmental, financial, teaching and learning, and publicity benefits.

Methodology

The methodology of this research is qualitatively based on the interview method. The focus group of this interview will be:

University Officials of Pangasinan State University and Campus Officials of four (4) selected Campuses namely, PSU - Urdaneta City Campus, Sta. Maria Campus, Binmaley Campus, and Infanta Campus, Solar Philippines Inc. Technical Representatives and the Regional Manager, and the, Distribution Utility (DU) for the selected campuses namely, Pangasinan Electric Cooperative III (PANELCO III) for PSU – Urdaneta City Campus and Sta. Maria Campus, Central Pangasinan Electric Cooperative (CENPELCO) for PSU – Binmaley Campus, and the Pangasinan Electric Cooperative I (PANELCO I) for PSU – Infanta Campus.

The method of interviewing relevant for collection of information and data with the University officials namely, the Vice President for Finance and Budget Management, University Engineer, and the University Legal Officer, and

confirmation by the data and information gathered from the Campus Executive Director, Physical Facilities Coordinator and the Campus Accountant of the Pangasinan State University, particularly PSU - Urdaneta City Campus, Sta. Maria Campus, Binmaley Campus, and Infanta Campus.

The Technical Representatives and the Regional Manager of Solar Philippines Inc. are therefore the real individuals who have been chosen for the interview sessions to know and comprehend the entire energy costing and flows. To obtain details on costing and design specifications, Solar Philippines Inc. made the prerequisite for field trips and benchmarking activity from some prior customers/clients to it.

Another, Interview with the General Managers and the Technical Engineers of the different distribution utility in the province of Pangasinan namely the Pangasinan Electric Cooperative III (PANELCO III) for PSU – Urdaneta City Campus and Sta. Maria Campus, Central Pangasinan Electric Cooperative (CENPELCO) for PSU – Binmaley Campus, and the Pangasinan Electric Cooperative I (PANELCO I) for PSU – Infanta Campus were interviewed in order gain information regarding the utilization of renewable energy permits, net metering procedures, kilowatt-hour (kWh) rates for the last ten (10) years, and other solar power installation procedures and guides.

The interview technique has been chosen because it gives an atmosphere for the research subject to obtain clarity and confirmation on information or data details [5]. For each specific focus group, the questions were created and answered.

Results and Discussion

The Pangasinan State University is the only state university in the province of Pangasinan which caters more than 1,000 employees and more than 25,000 students. There are nine (9) campuses of the said university strategically located in the different cities and municipalities of Pangasinan. As of calendar 2018, Pangasinan State University particularly on its selected campuses namely PSU - Urdaneta City Campus, Sta. Maria Campus, Binmaley Campus, and Infanta Campus purchased approximately 590,000 kilowatt-hours of electrical energy that is equivalent to five million nine hundred thousand (P5,900,000.00) pesos in cost. Table 1 is the summary of electricity consumption of the four (4) campuses.

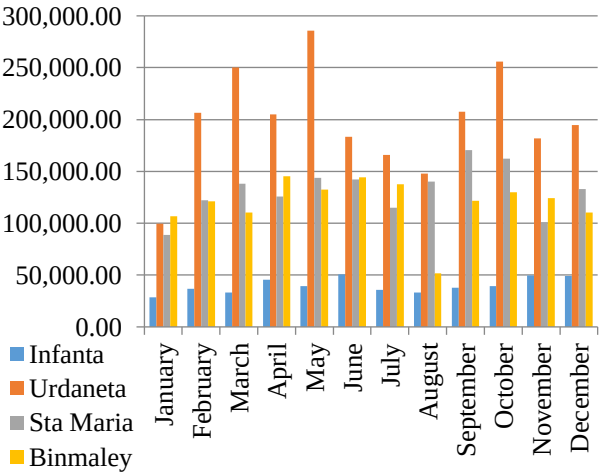

Table 1. Electricity consumption of the four Campuses

Because of its free tuition fee system and its ongoing construction cand growth of infrastructure projects, the present statistics on energy use and cost of electrical use at Pangasinan State University gradually increased with the rise in the population of learners on each campus. The University Administration has tried other ways to decrease the cost of energy use, such as altering all lighting to low consumption tubes and light-emitting diode (LED) bulbs, but has shown a slim improvement; therefore, Pangasinan State University has sought for more energy to decrease electricity cost. When it comes to rooftop spaces and strength, the campuses consists of numerous buildings of different sizes, some were newly constructed and some were newly renovated. Generally, the roof space of current buildings on selected campuses were sufficient. Table 2 is the illustration of the findings in the four (4) campuses.

There were two types of solar panels which is Monocrystalline silicon and Polycrystalline silicon. For Pangasinan State University, the Solar Philippines Inc. suggested for two reasons which were their design elements, Monocrystalline silicon solar panel sort can help improved effectiveness and can also be produced as decorative panels. The recommended solar panel is 325 watts per piece with a perimeter of 1 meter by 2 meters, having a weight of 25 kilograms including its railings. The inverter to be utilized for Grid-tie solar set-up will be SMA brand which is German Technology and has been utilized at space satellites by the National Aeronautics and Space Administration (NASA).

A power purchase agreement is a contract where the power service provider commits to supply power to our campus for an agreed period of time and for an agreed price. Having an agreement, the Power Purchase Agreement between the Pangasinan State University and the Solar Philippines Inc., the Pangasinan State University has a lot of advantages. Table 3 is the proposed matrix of the agreement.

Month	Infanta	Urdaneta	Sta Maria	Binmaley	
January	28,326.90	99,430.92	88,471.14	106,775.23	
February	36,740.74	206,750.64	122,242.87	121,254.70	
March	33,027.34	250,180.91	138,035.06	110,539.81	
April	45,409.87	204,729.25	125,732.45	145,190.41	
May	39,365.95	285,598.92	143,870.37	132,521.55	
June	50,617.01	183,161.60	142,386.22	144,367.65	
July	35,717.86	165,994.69	114,917.81	137,706.52	
August	32,986.53	147,953.27	139,969.35	51,837.94	
September	37,571.50	207,576.58	170,592.32	121,782.33	
October	39,273.99	255,750.68	162,073.44	130,055.25	
November	49,486.49	181,621.67	101,213.05	124,438.67	
December	49,105.54	194,657.08	132,875.25	110,237.52	
Total	477,629.72	2,383,406.21	1,582,379.33	1,436,707.58	5,880,122.84
Capacity	30 kWp	150 kWp	120 kWp	120 kWp	420 kWp

Table 2. Summary of Findings in 4 Campuses

Aggregated Power Capacity	PPA Rate at 25 years term (PHP / kWh)	PPA Rate at 15 years term (PHP / kWh)
Less than 1 MW	5.25	6.89

Table 3.Proposed Power Purchase Agreement matrix

Advantages of Pangasinan State University once tied-up with the Solar Philippines for a period of 25 years as an example.

1. No capital outlay on the part of the campus and university.
2. No brown-out in the morning will be assured on selected campuses. Except for the scheduled preventive

maintenance annually. Preventive maintenance will be coordinated to this campus and it will be scheduled in the middle term, June or July and Saturdays or Sundays.

3. PSU will be the first state university in the Philippines to utilized Solar Power energy as the main source of electrical energy. PSU may enjoy applicable *incentives* or privileges under Republic Act 9513 otherwise known as the *Renewable Energy* Act *of* 2008. This is also in preparation for the Senate Bill No. 268, (currently on the third reading phase) the "Solar Energy in National Government Offices Act," which mandates all government agencies, "to build and retrofit" buildings and offices with the solar power system and the Senate Bill No. 1719 (newly proposed) that will promote the adoption of rooftop solar technology by residential, commercial, industrial and government end-users. There is also a house bill being proposed as a counterpart of the said Senate bills.
4. The lower rate of electrical power for a price of 5.25PHP per kilowatt-hour (kWh) compare to 11PHP per kWh of Central Pangasinan Electric Cooperative (CENPELCO), the current power provider of this campus. This is an immediate 52.27% saving on the electrical power cost of this campus.
5. This rate (5.25PhP per kWh) will be fixed for the next 25 years considering the rate of electrical power is escalating at 3.5% annually.
6. When it comes to the facility maintenance, Solar Philippines will undertake all necessary operation and maintenance, in short, PSU will be hustle free. Damage to the system force majeure will be rectified by the Solar Philippines so as to restore the system back to operational status. The Solar Philippines is a manufacturing plant of solar photovoltaic modules, therefore, it is very easy for them to replace those defective and damage solar panels.
7. At the end of the contract term, the installed solar power system will be turned over to Pangasinan State University.
8. PSU representatives and its students are always welcome to visit the factory of Solar Philippines in Batangas and its different solar farms located in any part of the country. OJT students particularly in Engineering, Industrial Technology, Information Technology, and Business Administration are also encouraged.
9. Tie-ups between PSU and Solar Philippines for academic endeavors can be explored as a way to promote and develop the Philippines' solar power industry.

In addition to the profile of Solar Philippines, the said company had already installed solar power systems to some SM Malls and Robinson Malls, developed solar farms in different areas in the country one of which is located in Calatagan, Batangas, sold electrical power to Meralco at a rate of 2.34PHP per kWh, developed off-grid system on the different island municipality entire the country.

Net-metering is, according to the distribution utilities in the province of Pangasinan namely Pangasinan Electric Cooperative III (PANELCO III) for PSU – Urdaneta City Campus and Sta. Maria Campus, Central Pangasinan Electric Cooperative (CENPELCO) for PSU – Binmaley Campus, and the Pangasinan Electric Cooperative I (PANELCO I) for PSU – Infanta Campus, specified as a consumer-based RE policy process in which electricity produced by a qualified end-user (QE) from an appropriate on-site solar photovoltaic installation and delivered to the local distribution grid can be used to offset electricity supplied to the end-user by the DU. The net-metering idea implemented in the Philippines provides the owner and user of such plant with a two-fold advantage. The electricity produced at the Solar PV Plant is used for the own power consumption of the plant owner.

Excess power is exported to the distribution grid and the DU with its average generation cost is refunded. For instance, in the CENPELCO grid, the average cost of generation in December 2018 was 5.82PHP per kWh. The cost of generation was about 50 percent of the total energy cost charged to a private household consuming 300 kWh per month, which in December 2018 was, for example, 11.13 PhP per kWh. The difference between the price of generation and the complete retail charge consist of extra charges for transmission, distribution, supply, metering, system losses, taxes, etc. These additional retail price components will not be reimbursed for the excess power exported to the grid to the owner of a net-metering solar PV plant. This means that the monetary value of a kWh produced for own consumption is approximately twice as high as the monetary value of a kWh exported to the grid from the point of view of a net-metering plant owner. With regard to optimizing the economic balance of an investment in a Solar PV plant under the net-metering business model, this means that the size of the plant should be as close as possible to the maximum capacity that can be absorbed by the own consumption of the plant owner.

The application of the net-metering model is in general limited to installed Solar PV facilities with a capacity of not more than 100-kilowatt peak (kWp) per kWh meter. According to the IRR of the RE Act, it is mandatory for DUs to enter without discrimination upon end users' request into net-metering agreements with qualified end users who intend to install a Solar PV rooftop system, subject to technical and economic factors, such as the DU's metering technical standards for the Solar rooftop PV system. QE in this sense are those DU customers who are in good credit when their electric bills are compensated to their DU.

There are many non-financial benefits to take into account. Interviews with various Campus and University Officials helped identify and explore these non-financial benefits. The University desires to be a leader in sustainability and the efficient use of energy resources. A large scale solar project would help the University achieve leadership in this field. Furthermore, a large solar project would help reinforce the University's goal of incorporating sustainability into teaching and learning. The University wants to encourage sustainability in everyday life, and solar projects would be a noticeable signs to the students, staff, faculty, and other stakeholders of the University. The University expects to build a sustainable society that moves beyond simply operational sustainability. Moreover, a solar project would help improve the University's picture and branding. As students become more aware of environmental issues, having a renewable energy project on campuses would help draw in these students. A solar project at the campuses can also demonstrate to students how a business can operate in an environmentally responsible manner. By leading by example, the University can encourage the consciousness of its learners on the environmental impact of any industries they may join in the future. Finally, having a solar project on University would motivate further research on solar energy by students and faculty, potentially leading the way for advancements in solar technology.

Conclusion and Recommendation

This study has explored the feasibility and associated benefits of Pangasinan State University particularly PSU - Urdaneta City Campus, Sta. Maria Campus, Binmaley Campus, and Infanta Campus, installing a solar PV rooftop system. This study has demonstrated that while solar energy can be used to supply up to 57% of the campuses' current electricity needs, it would be a very costly project. Such a project would sum up to five million nine hundred thousand (P5, 900,000.00) pesos and produce electricity at a cost amounting to 5.25 pesos per kWh. This project would utilize the available space on buildings' rooftop on the selected campuses. Additionally, this sort of project would take roughly 9.5 years to break-even. This payback period, however, might be waived if the University would have a Power Purchase Agreement with the Solar Philippines, Inc. Entering into this contract could make the

University save a lot when it comes to electricity bills.

This study also surveyed many of the solar power installation's non-financial advantages. Among these advantages is the lessening in carbon dioxide emissions related to a solar energy project and the associated reduction of the University's environmental impact. Moreover, a solar energy project could contribute to achieving the University's objective of being a leader in sustainability and energy resource efficiency. In addition, having a solar campus project would aid the University integrate sustainability into the culture of learning and teaching. It is important not to neglect the symbolic importance of a solar installation project on campuses. Furthermore, the chance of practical teaching could assist Pangasinan State University to become a leader in future solar systems development. Pangasinan State University would also take advantage of improved branding and marketing opportunities to assist attract prospective learners to join the university by installing a large scale solar power system.

The University is suggested to undertake the installation on campuses of a Solar PV Rooftop system based on the information gathered and analyzed in this research.

In all its building, the University should also continue to pursue energy efficiency improvements. The University should assist its student, staff, faculty, and other stakeholders to encourage behavioral changes. The use of electricity can be further decreased by promoting individual employees to switch off lights when not needed and increase the air-condition units' thermostats.

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