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COST- BENEFIT ANALYSIS ON INSTALLING SOLAR POWER ENERGY AT HIGHER EDUCATION INSTITUTION IN MINDANAO

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KEYWORDS

ABSTRACT

Utilizing green technology such as solar energy is one of the most significant counteractions of the agencies to minimize the effects of global warming for sustainability. This Higher Education Institution Administration is the landmark building of the greatness of this University. As such, it is just fitting that the start of the utilization of green technology especially solar energy will start from this building. Results showed that there is a significant economic effect in using Solar power energy at one of the Higher Education in Mindanao administration building compared to the present electrical utility or Electric Cooperative. With the initial expenditure of the University using solar energy with its existing electrical needs amounting to Php 9,183,961.00, the computed period that the Return on Investment (ROI) of the project in terms of the cost of supply and installation of the solar panel with respect to its monthly consumption can be felt is within sixty (60) months or five (5) years. And at the end of the 10th year, the University can have an approximate savings amounting to Php 12,364,553.42. The University can even save more after ten years, but the researcher only considered the ten (10) year period for ROI since it is the years in which full warranty of the PV solar panels is afforded. The Higher Education Institution can dramatically reduce its carbon footprint by purchasing electricity from clean, renewable energy. The environmental benefits brought about by this green technology has the greatest impact to the school populace which is priceless.

INTRODUCTION

1.1 Rationale

The world is now suffering from the greenhouse effect or global warming. A phenomenon that has currently gained the attention of all agencies and individuals all over the globe. The transition towards sustainable energy systems is of utmost importance to avert global consequences of climate change (Gulagi, Alcanze, Bogdanov, Esparcia Jr., Ocon & Beyer, 2021). Utilizing green technology is one of the most significant counteractions of the agencies to minimize the effects of global warming for sustainability. Solar energy is considered as one of the green technologies. This is why state universities and colleges (SUCs) will be venturing into these green technologies sooner or later.

This SUCs, is one of the first three (3) institutions accredited by the Accrediting Agency of Chartered Colleges and Universities in the Philippines (AACCUP) Incorporated with

Level II status. Its programs in Agriculture, Biology, Forestry, and Veterinary Education are CHED Centers of Excellence. More so, the Teacher Education and Mathematics are awarded as CHED Center of Development. It is now one of the ISO-certified institutions with 3-star Rating by the Quacquarelli Symonds (QS) International Rating. With the school's achievements and accomplishments, it never stops to find ways to venture into sustainable and green technology in this part of the country.

At present, the University's supply of electricity for the entire campus is provided by the Electric Cooperative. The cost of its electrical bill every month is amounting to Php 2,174,399.33 for the whole community, with the administration building monthly electrical bill of Php 193,038.93.

It's Administration is the landmark building of the greatness of this University. As such, it is just fitting that the start of the utilization of green technology especially solar energy will start from this building. Although solar energy is more efficient, it is costly. The high cost of power from solar panels has been a major deterrent to the technology's penetration to the peripherals (Borenstein, 2008). Hence, this paper presents the cost-benefit analysis of the utilization of solar energy in this administration building.

1.2 Statement of the Problem

The administration building has an average monthly bill of Php 193,038.93. In order to determine the cost benefits of transforming the electrical source of this building into a green technology that would be beneficial to the university, a cost-benefit analysis was conducted by solving how much is the initial expenditure of the university using solar energy with its existing electrical needs, the return of investment of this project in years; and if how much would the University save in ten (10) years after installation.

1.3 Objectives of the Study

1.3.1 General Objectives

This project aimed to determine the cost-benefit analysis of converting the administration building into an On Grid solar energy using solar panels.

1.3.2 Specific Objectives:

1.3.2.1 Determine the initial expenditure of the university using solar energy with its existing electrical needs;

1.3.2.2 Compute the Return of Investment of the project in terms of the cost of supply and installation of the solar panel with respect to its monthly consumptions; and

1.3.2.3 Determine if how much the administration can gain in terms of financial savings in ten (10) years after installation.

1.4 Scope

This research was conducted at one of the Higher Education Institutions Administration Building in Mindanao from March 2022 to May 2022. It determined the benefits of transforming the electrical source of the administration building into a green technology which is beneficial to the University. It focused only to the following:

1.4.1 Cost-benefit analysis of utilizing solar energy versus the actual electrical source from the Electric Cooperative;
1.4.2 Use the On-Grid complete package. This is a complete/supply and installation of solar panels to address the total demand of the administration building;
1.4.3 Assumptions: Solar operations of 24 days a month, and 10 hours daily from 8am-6pm; and
1.4.4 Maintenance, electrical permit, professional fees, and compliance for self-generating facility to the Cooperative and ERC were excluded.

REVIEW OF RELATED LITERATURE

This chapter presents the literature review of the projects on solar energy, cost-benefit analysis, and its related topics. The presentation is divided into two sections for a more specific discussion and review.

On Solar Energy Source

There are so many factors that need to be considered in deciding on what solar panel to be installed and if solar is much of the best option in a specific project (Glasnovic & Margeta, 2009). Whether the energy is used to power the electricity at a family's home, to water pumps, a building, renewable energy is becoming much popular, and one method is solar. Solar energy collection methods can be traced all the way back to 1767, when Horace de Saussure, a Swiss Scientist, built the world's first solar collector (Berinstein, 2001). In this section, studies on renewable energies related to solar energy are presented.

The study of Arevalo, Cano, and Jurado (2002) focused on supplying the energy demand of the islands in the Galapagos with renewable sources, analyzing possible scenarios based on the current electricity system. The results of their study showed that energy flows, costs and long-term energy balances (2050), with 100% renewable energy from several wind and photovoltaic combinations. They found that the demand forecast has a precision of 98.12% with the mean score error of 0.013%.

In 2021, group of researchers from Kazakhstan, utilized a tool allowing them to model complex energy system transition. Their findings revealed that the transition to 100% renewable and sustainable energy based system is possible even for the case of Kazakhstan where severe climate conditions with energy intensive industry (Bogdanov, Gulagi, Fasihi & Breyer, 2021).

On the same year, researchers from Germany conducted a study entitled, "Open model-based analysis of a 100% renewable and sector-coupled energy system: The case of Germany in 2050. Their model results showed that it is very feasible to have a 100% renewable-based and sector-coupled system for electricity and building heat in their country. The investment capabilities and component costs will depend mainly on the varied parameters of what is being developed. Also, they found out that the annual investment costs vary from 17.6 to 26.6 euro per year for generators which are volatile while the costs ranges from 23.7 to 28.8 euros per year for heat generators. In their sensitivity analyses, they found that they can maximize the system's flexibility and lower the cost of investment due to storage and grid expansion, all these were done using this open model (Maruf, 2021).

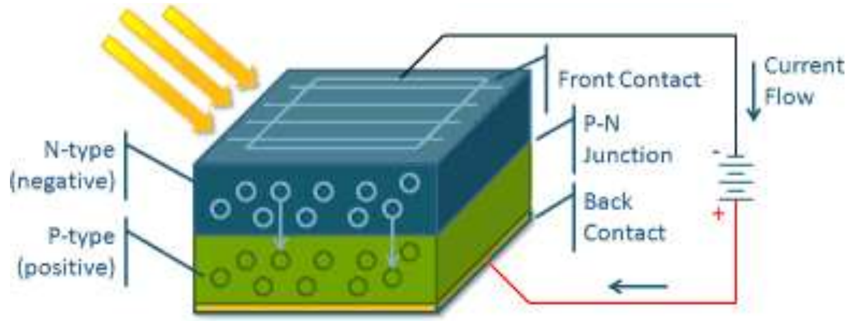
In Portugal in that same year, Doepfert and Castro (2021) proposed a techno-economically optimized energy system for countries whose output of their hydropower energy generations vary from year to year. Their research as inspired by the fact that when these energies become renewable, there are challenges that may arise due to varied energy generation outputs. For this study, they proposed to use an energy simulation tool enegrgyPLAN so that the existing conditions of Portugal will be zeroed in. As such, they discovered that the future system of Portugal that would cover 75% of its energy demand will rely strongly on wind and solar power. Moreover, the results indicated that Portugal SunGas will be used to balance the supply and demand and it must build up electrolyzer capacities of 4.2 Gw and SynGas capacities of 2.4 GW. They reported that a system cost between 22 and 35% cheaper compared to that of the reference model. Furthermore, it is expected that the basic energy demand will decrease from 253 TWh to more or less 150 TWh while the demand for electricity will rise from 49 TWh to more or less 110 TWh.

Similarly, Jacobson (2021) conducted a research on the correlation between building heat demand and wind energy supply and how it helps to avoid blackouts. This research was made due to the fact that wind and energy supplies both depend on the same weather. He stressed that building demands should be modeled dependably with future renewable energies. In this paper, Jacobson emphasized that no model up to present that calculates the future thermal loads which will be consistent to future renewable energy sources, that is why, he examined the grid stability of 143 countries in 24 world regions. He found that correlation between building heat loads and wind energy supply is strong even in aggregated over large, cold regions. On the other hands, moderate correlations were found elsewhere and no association existed in some tropical islands and some small countries. More so, he found that solar and wind power supplies were negatively correlated, showing that these two renewable energy sources are complementary. With these, it was recommended that both power sources be built, where possible, to decrease variation in output arising from installing only one of them (Jacobson, 2021).

Unlike the ones cited in this section, this research project looked into the cost-benefit analysis of installing solar energy at the administration building of Central Mindanao University. Other researchers cited here are wider in scope and high sounding, however, this study is contextualized in the University where the output of this project may inspire the administration to look into the possibility of transitioning to renewable energies one building at a time.

How Solar Panels (or PV Modules) Work

Solar panels are made up of dozens of individual cells called photovoltaic cells (or PV cells or solar cells). PV cells are treated with different materials on each side to create an imbalance of electrons from one side of the cell to the other. When rays of sunlight (photons) contact PV cells, electrons in the cells are knocked loose and begin moving, creating direct current (DC) electricity. Positive and negative wires connected to the sides of the cells allow the electrical current to be directed toward whatever you want to charge or power. Photovoltaic is just a compound word meaning "voltage from light".



DC electricity from the sun is great, but nearly all home appliances run on alternating current (AC) electricity. This is why an inverter – whose job is converting DC to AC – is needed in most home solar panel systems.
We have a more in-depth overview on our blog of how solar panels work with more detail on how the photovoltaic process works, how PV cells work together to create different voltages, and on understanding the various ratings on solar panels' technical spec sheets.

There are lots of ways to make use of solar electricity. One of the simplest is to charge small electronic devices, like cell phones and music players, with lightweight, portable PV modules. Solar panels can be used individually or wired together to form a solar array. For larger electrical loads, there are two main types of systems for providing electrical power to homes, cabins and offices, etc.: stand-alone battery based systems (also called "off-grid" systems) and grid-tied systems (also known as "grid-interactive" or "utility-interactive"). You'll want to decide which system is best for your needs by reading more about both.

Solar Panel Installation as A Cost-Efficient Solution
Using solar energy to provide electricity to business operations will be less costly compared to traditional power plants. Once a solar panel system has been installed in establishment, significant decrease of monthly electricity bill is very evident. Solar panels require little maintenance and some of its advantages are High Return on Investment. One of the most common misconceptions in going solar is the high cost of installation. The truth is that going solar could yield high returns in the long run. Second is the Increase Your Property's Value. Commercial properties with solar panel installations also have a relatively higher resale value.

Going solar will allow a company to build a green image in the market. The brand advocates—clients who are satisfied with both product or service and the change fostering—will spread the good news about how the company are saving the environment through your efforts of going solar. This, in turn, helps the business through more sales opportunities. Benefits are: Enjoy Several Incentives. Business establishments that opt to install a solar energy system can enjoy perks that matter—rebates and tax breaks. As a solar energy user, company is allowed to send back the excess energy company produced in exchange for a refund. At the same time, they can also benefit from tax breaks under the Renewable Energy Act of 2008. Other benefits are: High return on investment due to lower electric bills and cheaper maintenance costs Reliability, sturdiness, and durability—no moving parts means less noise and fewer chances of a breakdown, the absence of carbon emissions; just clean energy all year round. Second is Optimize Your Day-to-Day Operations. With all the money the company can save from using the energy of the sun, they may be able to allocate larger funds to other aspects of their business. By going solar, they likely gain more flexibility with their finances and scale their company with ease.

On Cost-Benefit Analysis

Solar photovoltaic (PV) panel energy costs have been a significant impediment to the technology's market penetration. However, proponents like (Borenstein, 2008) argued that conventional analyses overlooked a large number of the benefits of solar PV. While some of these benefits are external to the environment and security, others occur within electricity markets. In his paper, he attempted to conduct a more comprehensive market valuation of solar photovoltaic (PV) energy. He accounted for the fact that solar PV panels generate a disproportionate amount of energy during times of peak demand and increased line losses. He found that the degree to which solar PV production is timed to maximize its value is highly dependent on the extent to which wholesale prices peak with demand, which in turn is dependent on the system's reserve capacity. In a typical US system with significant excess capacity, he found that favorable timing increases the value of solar PV production by 0% – 20%, but if the system is run with a greater reliance on price-responsive demand and peaking prices, the premium value of solar PV is in the 30% – 50% range. Solar photovoltaic (PV) energy is also argued to have increased value within an electrical grid, as it is generated close to the end-user, potentially lowering the cost of transmission and distribution investments. However, his analysis indicated that actual solar photovoltaic system installation in California has not resulted in a significant reduction in the cost of transmission and distribution infrastructure, and is unlikely to do so in other regions. Then, he combined these adjustments to the solar PV power valuation with cost calculations to determine the market value of solar PV. Even after accounting for timing and transmission advantages, the market benefits of installing current solar PV technology are estimated to be significantly less than the costs. The difference is so large that even when current plausible estimates of the value of greenhouse gas reductions are included, the net social return on solar PV installation today remains negative (Borenstein, 2008).

According to Borenstein (2008), on-site generation was argued to provide an additional economic benefit that is frequently overlooked in cost analyses. Power generated at central stations requires significant investment in transmission and distribution infrastructure, which could be avoided if more energy was generated on-site. Thus, valuing solar PV electricity production by comparing it to the average cost of generating electricity and ignoring potential savings in transmission and distribution infrastructure will tend to undervalue PV power. Few would argue against this view, at least in terms of transmission, but the magnitudes of these effects have not been quantified in a systematic manner. The use of solar PV production data in conjunction with wholesale price data in his paper estimated the actual value of solar PV power and the degree of bias that results from overlooking the favorable time pattern of PV production and the reduced demand for transmission and distribution capacity. This is the economics aspect of solar photovoltaic energy, incorporating the effects of other factors.

In 2011, Ramadhan and Naseeb conducted a study on the cost-benefit analysis of implementing photovoltaic solar system in the state of Kuwait. In their paper, they ascertained the economic viability and economic feasibility of implementing solar photovoltaic energy in the State of Kuwait. It was discovered that the beneficial characteristics of solar radiation in Kuwait significantly contribute to the feasibility of solar system implementation. The LCOE of a 1 MW station is estimated to be around $0.20/kWh at the current price of $5/W and 15% efficiency. This LCOE is only feasible at oil prices of around $100/barrel. When the value of reclaimed energy resources used to generate conventional electricity and the cost of reducing CO2 emissions are considered, the true economic cost of a photovoltaic system's levelized cost of energy (LCOE) decreases significantly. Due to their preliminary economic analysis, the researchers recommended that Kuwait implement photovoltaic technology.

In 2016, another author, Parmar conducted a cost-benefit model for solar systems over on-grid conventional energy which has demonstrated that photovoltaic energy is unquestionably effective in residential systems. The statistical analysis he used in the model to quantify the cost and benefit components was dependent on the system parameters. He found that the benefits of a solar powered system are heavily dependent on the location of the installed system as well as a number of special factors such as weather, average solar peak hours, manpower cost, utility energy prices, and government incentives. He presented an extensive review of previous research studies which revealed that end users do not understand the economics of installing residential solar systems. As a result, in Parmar’s study, he provided effective guidelines for outlining uncomplicated financial models for solar system adoption. Through economic sensitivity analysis, he compared the net project benefits and total investment costs over a 20-year period. Return on investment, net present value, benefit cost ratio, and annual benefit cash inflows were all used in his analysis. He discovered the carbon emissions reduced for each residential system of varying capacities using data from the United States Energy Administration on carbon emissions. He added that the cost-benefit model will almost certainly increase investments from low and medium-income homeowners.

Consequently, in Parmar’s research model, he computed the following results after statistically evaluating the three energy systems, namely: 1) the 12.5kW solar system is the most cost-effective and long-term energy source for residential systems in Texas, California, New Mexico, New York, Hawaii, and Massachusetts. These findings is based on system parameters such as annual solar savings, payback periods, CO2 emission reductions, and benefit cash inflows; 2) solar installations reduce reliance on on-grid conventional systems by 75-80%. Due to the significant payback period rates and return on investments, this reduction has a direct impact on the annual savings. These economic characteristics are developed using geographical performance indicators such as utility energy prices, average peak hours per day, and construction costs. 3) Because of benefit cash inflows and overall capital gains on investment, end customers or residential homeowners can expect a rate of return of 10% per year. According to the manufacturers, the warranty period for solar or hybrid systems is approximately twenty years, which has an impact on the internal rate of return. He calculated the maximum carbon emissions avoided in this decision-making model based on the source of power generated in each state. The avoided carbon 75 emissions contribute to the benefits component and outline compelling guidelines for environmental authorities; 4) Using rooftop solar systems has also significantly reduced the cost of energy over time, as end customers experience high-efficiency energy savings. The benefit-cost ratios, which are listed in the summary table below, determine this efficiency rate; 5) This model also includes recommendations for homeowners who generate more energy than they need from their solar systems. Low and medium-sized investors can certainly negotiate with their respective utilities for excess energy produced and favorable energy rates. This is known as "net metering," and it benefits homeowners by allowing them to produce more solar energy; and 6) The resale value of the home rises by about 15-20%, adding to the financial benefits of installing solar panels.

On Financial Analysis, the United States of America Agency for International Development prepared a report on the cost-benefit analysis (CBA) of off-grid solar investments in East Africa (USAID, 2017). CBA assesses the impact of its investments using two financial analyses. The first is related to the investment's incremental impact. In three of the four projects, it is assumed that the project would not have taken place if USAID funding had not been available.
As a result, the incremental impact of USAID's investment is assumed to be the grant money less the total financial cost. In the case of one of the four projects, USAID funding accounts for only 1% to 5% of cash inflows in any given year, so the incremental impact of this investment is the additional grant cash flow for those years, implying that this company's operational expenses and customer revenue would have remained unchanged in the absence of USAID assistance. This gives this company an additional NPV of $4.1 million over the grant's lifetime.

The second type of analysis is concerned with the financial viability of each investment. Private sector firms must be financially sustainable in order for the off-grid solar market to scale up and operate independently of donor assistance. This means that revenues exceed costs on the company's cash flow statement at an acceptable rate of return to investors. Our analysis reveals that only one of the four projects is potentially financially sustainable, that two have a negative net present value (NPV), and that the fourth did not provide the financial records required to make an assessment, despite the fact that the separation of costs and prices suggests that it is unable to cover all expenses (e.g. cost of goods sold and soft costs). This analysis is the focus of the remainder of this section. One of the companies had planned to use USAID assistance to cover the cost of goods sold, with in-kind contributions and customer revenue covering the remaining costs. This company is estimated to have a financial NPV of approximately -$90,000 and a negative internal rate of return after accounting for sales revenue, USAID, and in-kind contributions (IRR). These negative financial returns were caused by low revenue inflows and high capital expenses related to the company's cost of goods sold. These estimates indicate that a significant increase in customer prices and/or a significant reduction in total installation costs would be required in order for this company's local operations to be financially sustainable.

It is important to note, however, that the DIV award funded a pilot of a new PAYG model for low-income households in remote areas, so the low financial returns were expected. Similarly, another company has a nearly -$-113,000 negative financial NPV as a result of a sales revenue stream that barely covers the cost of goods sold. Total revenues before grant contributions were barely above zero, and razor-thin sales margins were insufficient to cover the cost of salaries and other expenses. However, it is important to recognize that non-profit organizations with mandates to serve customers on the low end of the income distribution, who frequently live in remote areas, will inevitably face financial challenges.

Only one firm had a positive financial NPV and modified IRR. Although the company's financials have the potential for positive gains, there are some important considerations to make about this type of business model and USAID's contribution. When a company's financial success is the result of significant equity financing, grant contributions are likely to be a very small percentage of total cash inflows, implying that these companies would be profitable even without USAID's assistance. Furthermore, the projected profitability of this model is contingent on reducing the soft costs associated with in-country operations; if the company is unable to reduce total costs sufficiently, its financial NPV may be negative. It is not surprising that many grantees did not achieve financial sustainability during the grant period, especially given that the majority of these investments were in the pilot phase. In fact, it is a good justification for providing grant funding if the social welfare impacts are positive and/or there is a good potential for financial sustainability. Some businesses are making changes to their operations in order to improve their bottom line.

Solar companies are growing by developing high-end, aspirational products that are out of reach for many rural residents, even when financing is available. Additional efforts are being made to reduce the soft costs of marketing, distributing, installing, and maintaining solar products, but it is unclear whether any of the companies have achieved significant reductions on a per-customer basis.

Finally, any changes to the existing trade regime that provides tariff and tax exemptions for renewable energy products would have a negative impact on the financial sustainability of any solar company operating in East Africa. When evaluating the financial impact of each USAID solar investment, one final and critical variable to consider is the average beneficiary cost to FNVP ratio – a metric that attempts to capture the financial value created per beneficiary as a result of USAID's investment. The FNVP per beneficiary ranged from.50 to 4.66 among the companies profiled in this analysis (meaning that for every US dollar invested by USAID, anywhere from $0.50 to $4.66 was created for each customer). From this vantage point, it appears that USAID's solar investments produce the most financial value when invested in smaller solar providers.

Economic Evaluation

USAID (2017) utilized consumer surplus estimates which are used by the World Bank and other institutions to capture the economic benefits of fossil fuel and renewable energy projects by estimating the social welfare impact of increasing energy consumption and lowering prices. They proposed that the difference between the consumer's maximum willingness to pay and what the consumer actually pays is used to calculate consumer surplus. The willingness to pay for light can be estimated through survey analysis by estimating how much it costs to purchase a certain number of lighting products (e.g., kerosene, candles, battery-powered flashlights, etc.) and how many lumens the average person consumes from these lighting products.

They found that the highest quality PV systems produced the greatest consumer surplus at an individual household level, depending on the product in question and the customer payment plan. Given the significant increase in lumen output as a result of their solar investment, the customers of these companies are expected to earn the highest consumer surplus.

To arrive at the overall economic estimates, the USAID investment was subtracted from the aggregate consumer surplus estimates, as well as the incremental financial gain/loss. At the project level, the company producing the highest-quality solar home product generated the most economic gain, totaling $14.8 million, owing to the large number of customers reached through their distribution system and the large household consumer surplus. In total, USAID investments generated $17.1 million in net wealth, including $15.7 million for Tanzania, $1.2 million for Uganda, and $178.521 for Rwanda.

The USAID (2017) identified limitations and critical assumptions regarding this project. When performing cost-benefit and beneficiary analyses, it is frequently necessary to make certain assumptions, especially when there are significant data limitations. The level of validity attributed to the final result is influenced by the uncertainty inherent in those assumptions. Furthermore, by identifying critical assumptions, a sensitivity analysis can be performed to determine the impact each of these variables has on the final result. Finally, it provides decision-makers with a list of variables to consider when making future investments and/or include in monitoring and evaluation plans. The following are the main assumptions and limitations that apply to all CBA models:

i) Total Energy Use – Without Solar: Some companies used ex-ante and ex-post household surveys to determine total energy consumption for comparable households that did not purchase solar products. A baseline household survey for those living off-the-grid was used to estimate energy use in the "without" scenario for one country's household energy use estimates. This assumes that the energy consumption profiles of different companies' non-solar customers are similar, whereas higher-end PV customers are likely to use more energy and have a higher income.

ii) Total Energy Use – With Solar: Some companies' surveys included total energy consumption for households that used their products, while others did not. As a result, the analysis made conservative assumptions about the percentage reduction in traditional energy use (e.g., kerosene, battery-powered torches, and so on) when households switch to the latter companies' solar products. These assumptions were based on survey results as well as secondary research on similar project evaluations.

iii) Cost-Benefit Analysis Time Horizon: The cost-benefit model reflects the core logic of project alternatives by comparing the incremental results of households that purchase solar products to those that do not. CBA models typically account for these savings over time based on the useful life of the primary capital investment. The CBA models employ a 5-year time horizon because it was determined that solar products would have an average useful life of this length. However, results for a 3-year and 7-year time horizon are included in the models to demonstrate how this assumption affects the final results.

iv) Attribution: In performing CBA on investments, USAID does not use multiplier effects; in other words, it does not attempt to capture the benefits and costs of successive rounds of spending. This is due to the fact that multiplier effects are frequently speculative and context-specific. Furthermore, there must be a solid base of evidence linking USAID's direct investment to subsequent activities, including a detailed list of all related cost and benefit flows. Below is a justification for the assumptions about total product counts for each solar provider.

v) Discount Rate: In order to compare investments across countries, the model assumes a financial and economic discount rate of 12%. The 17 financial discount rate for customers and the weighted average cost of capital for each of the firms, on the other hand, may be significantly different from 12 percent.

vi) Economic Analysis: The economic analysis does not take into account all of the variables that could affect the net present value of these projects. For starters, environmental externalities are not considered.

Households that use solar home systems reduce their reliance on traditional polluting lighting sources such as kerosene, which emits a significant amount of CO2 equivalent emissions for the level of light output. These CO2 reductions could be estimated and then valued using a carbon social cost. If positive environmental externalities are included, then negative externalities, such as environmental damage from silica mining to create the PV panel, or the manufacture and disposal of batteries, are also appropriate. The negative externalities, on the other hand, would be much more difficult to estimate. The study also disregards any potential health and educational benefits of using solar lights. Indoor use of kerosene lamps can cause respiratory problems, so reducing kerosene use should improve health. Meanwhile, a child who has access to more hours of high-quality light may spend more time studying. While these connections appear to be clear, empirical evidence on these outcomes is mixed. We can assume that this study represents lower-bound estimates of the NPV and IRR because these factors were not included.

On analysis of sensitivity, USAID (2017) espoused that it is critical to examine the model's sensitivity to the critical assumptions (i.e., changes in key variables and parameters) discussed in the previous chapter. This is accomplished through the use of one-way and two-way tables that show how the final result changes with changes to the values of specific parameters while holding everything else constant.

The above literature cited encouraged the researcher to finally pursue the aforementioned project. Knowing that the literature discussed wider scope, it is still of an advantage to start something small and appreciate its significant impact to the community.

METHODOLOGY

3.1 Conceptual Framework

The cost-benefit analysis on installing solar energy at one of the HEI’s Administration Building involved the concepts shown below. The data gathering served a vital role in attaining the objectives of the study. This included the theoretical potential, technical potential and financial viability. The data collected served as the basis for the significance of each objective. Figure 1 below illustrates the conceptual framework of this proposed project.

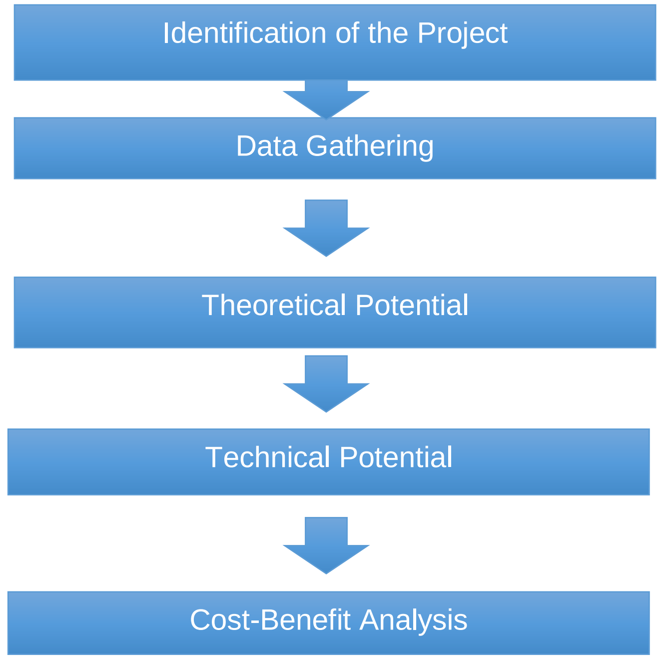


Figure 1. Cost-Benefit Analysis Framework of the Project

3.2 Methods

Based on the Cost-benefit Analysis Framework presented earlier, there were series of activities implemented in this project as follows:

3.2.1 Identification of the project
3.2.2 Data Gathering
3.2.3 Theoretical Potential
3.2.4 Technical Potential
3.2.5 Cost-Benefit Analysis

3.2.1 The Identification of the Project

This University started as a farm school and is one of the oldest Universities in the southern Philippines. Since then, it has improved its infrastructure and equipment. With the addition of new equipment, there is an increase in electrical load.

The School's administration building is the heart of the University where it has eleven (11) big offices who are the frontlines of the University who are responsible for financial planning, record keeping and billing, personnel, and physical distribution within an organization. This was the main reason why this project focused on the change of energy source of this building from electrical to solar energy. More so, it could present the financial viability of this project.

3.2.2. Data Gathering

In this phase, the researcher gathered the necessary data as he requested and as per approval by the University President. Data collection method like requesting a copy of their electric bills of the whole school's facilities/buildings specifically the administration building from the Electric Cooperative for at most 6 months was very necessary to get the average figure of the data. From the billing statements, the monthly average consumptions in kilowatt hour (KWhr), average monthly bill and the rate per kilowatt hour (KWhr) were identified. Secondly, the researcher identified the phase connection of the administration building, number of days per month, and the specific hours per day operation. Third the roof area of the building was checked in order to determine the possibility of any features that can shade any panels during the day. These data were very necessary for the suppliers to identify the number of solar panels and all specifications for their supply and installations. The last but not the least was to get the sample actual reading of the administration building from 6:00pm to 8am (14 hours) to get the average monthly bill from the existing electric utility.

3.2.3. Theoretical Potential

The researcher evaluated and validated the roof area of the administration building where the structure of the solar panels will be set. Constraints were considered like the roofs elevation, structures, position with respect to the direction from the sun, number of hours exposed to the sun daily and the trees and buildings around that might affect its suns exposure and its efficiency.

3.2.4. Technical Potential

The researcher computed the achievable capacity (KW), generation (kWh), and suitable area (m^2) of a particular generation technology given system performance and topographic, environmental, and roof-use constraints. Technical potential provided an upper-boundary estimate of the renewable energy development potential in a particular area. Further analyses supported that there was technical potential to evaluate renewable energy potential.

The researcher gathered the data to be used for the estimation of the technical potential capacity of the solar technology available for development after accounting for topographic limitations, land-use constraints, and system performance. The researcher identified the feasible areas, and other necessary data needed for experts to do the technology-specific system modeling calculations. The technical potential assessment enabled the initial identification of study area which was technically capable of supporting high-quality resource development.

3.2.5. Cost-Benefit Analysis

The researcher determined the cost-benefit analysis primarily by getting the average monthly consumption of the building in the last six months. Those data came from the billing statement of the Electric Cooperative. By pro-rating, the researcher only considered the time from 8:00 o'clock in the morning am to 6:00 o'clock in the evening

(10 hours) when the solar energy would only be used. The total cost of the supply and installation of the solar panels was determined by the experts. Using the Department of Energy Philippine Yearly average price increase of 3.4%, the researcher computed for the yearly estimated savings up to 10 years after comparing with the existing cost per month of the administration building utilizing the current electric utility bill.

RESULTS AND DISCUSSION

This section presents the results and discussion of the project. The presentation is made in accordance to the order of the objectives as presented in the previous chapter of this paper.

Table 1. Summary for School's Utilities connected to the Electric Cooperative

Month and Year	Consumed kWh	Billing Amount
September 2021	161,879.00	1,816,473.99
October 2021	171,581.00	2,148,746.81
November 2021	179,598.00	2,260,250.74
December 2021	164,338.00	2,134,147.48
January 2022	166,593.00	2,399,004.51
February 2022	167,408.00	2,287,772.46
Average	168,566.17	2,174,399.33

kWh Price: Php 12.89

Table 1 presents the summary of the school's utilities connected to the cooperative and the bill per month from September 2021 to February 2022. As seen from the table, the highest energy consumption was recorded in November 2021 and the lowest was in December 2021. This monthly bill implies that the in December, there was less electric consumption. This may be explained by the number of holidays that fall during the Christmas season.

Based on the data above, all school's utilities' average monthly energy consumption for the last six months was 168,566.17kWh, or a monthly bill of Php 2,174,399.33. It is also estimated that the rate is Php 12.90/kWh.

Table 2. Summary for Old Admin Building/UCC connected to the Electric coop.

Month and Year	Consumed kWh	Billing Amount
September 2021	18,880.00	158,163.66
October 2021	16,360.00	201,947.97
November 2021	17,080.00	212,215.40
December 2021	13,600.00	174,211.29
January 2022	16,600.00	221,717.17
February 2022	14,720.00	189,978.11
Average	16,206.67	193,038.93

kWh Price: Php 11.91

Table 2 shows the summary of the old administration building consumption and billing from September 2021 to February 2022. As reflective on the said table, the highest energy consumption was recorded in the month of September while the lowest in December 2021. As presented earlier, this can be implicated on the number of holidays that fall in the month of the Christmas season.

Considering one of its utilities, specifically the administration building where the focus of this study, the average consumption per month of this building is 16,206.67 kWh which constitutes 9.61% of the whole school's utilities with an average monthly bill of Php 193,038.93.

Table 3 (see next page) shows the sample actual readings of the administration building from April 26, 2022, 6:00pm to April 30, 2022, 8am. It only shows that the average daily consumptions from 6pm to 8:00am is 98.18 kWh and 621.98kWh from 8am to 6:00pm. The 98.18kWh was used to determine the estimated energy and the monthly bill from the Electric Cooperative, which was deducted from the monthly billing to calculate for the return on investment (ROI).

Table 3. Sample Actual Readings of the Administration/UCC Building (14 hours)

No. of Read-ings	Date	Readings (kWh)	Difference (kWh)	Multiplier	Used (kWh)	Ave.kWh 6pm-8:00am/day (14 hours)	Ave.kWh 8am-6:00pm/day (10 hours)	Total Ave. kWh/day
1	April 25, 6:00 pm	35,388.40				98.18	621.98	720.16
2	April 26, 8am	35,390.85	2.45	40	98.18			
3	April 26, 6:00 pm	35,406.40	15.55	40	621.82			
4	April 27, 8am	35,408.76	2.36	40	94.55			
5	April 27, 6:00 pm	35,424.04	15.27	40	610.91			
6	April 28, 8am	35,426.49	2.45	40	98.18			
7	April 28, 6:00 pm	35,442.27	15.75	40	631.20			
8	April 29, 8am	35,444.78	2.51	40	100.4			
9	April 29, 6:00 pm	35,460.38	15.6	40	624			

10	April 30, 8am	35,462.87	2.49	40	99.6			

Table 4 reveals the on grid data from 6:00 o'clock in the evening to 8:00 o'clock in the morning.

Table 4. On Grid Data from 6pm-8am

	Consumption in kWh	Amount at a Rate of 12.9/ kWh	Amount in 31 days operation
Ave. kWh/14 Hrs	98.18	1,266.52	Php 39,262.18

As shown in Table 4, the consumption of the administration building during on Grid data from 6pm-8am is 98.18 kWh. With this consumption, and an assumption of Php 12.9/kWh, the building has a computed monthly (31 days) bill of Php 39,262.18 which is supplied by the Electric Cooperative.

Table 5. Supply and Installation of a three Phase On-Grid Solar System (GT-150K without net metering)

Item	Description	Quantity	Unit
1	PV SOLAR PANELS – Monocrystalline Solar Panel, 450watts-550watts	150	KW
2	SOLAR INVERTER – On-Grid Solar Inverter	150	KW
3	MOUNTING SYSTEM – Aluminum Railing System for PV Solar Panels	1	Lot
4	WIRING & PROTECTION KIT – 4mm2 Twin PV Wires w/ Conduit, Circuit Breakers and Surge Protection Device for AC & DC	1	Lot
5	CONTINGENCIES – Delivery, Tools, Consumables and Contingencies	1	Lot
6	INSTALLATION – Labor, Technical Supervision, Testing & Commissioning	1	Lot

Table 5 shows the details of the descriptions, quantity, and unit for the supply and installation of a three Phase On-Grid Solar on the administration building.

Based on Php 13.00/Kwh, GT-150K is capable of saving around Php 146,250.00 to Php 225,000.00 Monthly. The Solar Electric Plan, Electrical Permit, Professional Fees, and Compliance for Self-Generating Facility to Electric Cooperative and ERC are excluded in the price quotation. A warranty of ten (10) years PV Solar Panels, five (5) Years on Grid-Tie Inverter, and five (5) years on workmanship

Table 6. Quotation with the expected ROI

Suppliers	Quoted Amount	Average Amount	No. of Months	No. of Years
1	9,400,000.00			
2	8,780,000.00	9,183,961.00	60	5
3	9,371,883.00			

The average quotations of supplier 1,2 and 3 in Table 6 is Php 9,183,961.00. Given the average monthly bill of the administration building which is Php193,038.93, and the average monthly consumption from 6 pm-8 am, 31days/month amounting to Php 39,262.18, the difference is Php 153,776.75 per month. With this computation, the return on investment (ROI) can be felt in 60 months or five years onwards.

Table 7. Solar Panel cost, Savings and the Return of Investment

Year	Solar Panel Cost and Savings	DOE Phil. Yearly ave. price increase (3.4%)	Yearly Estimated Savings
0	9,183,961.00		
1	7,338,640.00	1,845,321.00	1,845,321.00
2	5,430,578.09	62,740.91	1,908,061.91
3	3,457,642.07	64,874.11	1,972,936.02
4	1,417,626.22	67,079.82	2,040,015.84
5	691,750.16	69,360.54	2,109,376.38
6	2,872,845.34	71,718.80	2,181,095.18
7	5,128,097.75	74,157.24	2,255,252.42
8	7,460,028.75	76,678.58	2,331,931.00
9	9,871,245.40	79,285.65	2,411,216.65
10	**12,364,443.42**	81,981.37	2,493,198.02

Table 7 presents the solar panel cost of investment and the yearly average price increase of 3.4% by the Department of Energy (DOE) Philippines and the estimated yearly savings. As shown, the University needs an initial investment of approximately Php 9.2M to install solar energy in the administration building. The results show that by the fifth year, the University can already recover the investment, and at the end of a 10-year period, the university can have an approximate savings amounting to Php 12,364,553.42 excluding the environmental benefits that the solar energy offers to the CMU community.

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

Based on the findings of this project, there is a significant economic effect in using Solar Power Energy at the school's administration building compared to the present electrical utility of the University from the Electric Cooperative. With the initial expenditure of the University using solar energy with its existing electrical needs amounting to Php 9,183,961.00, the computed period that the Return on Investment (ROI) of the project in terms of the cost of supply and installation of the solar panel with respect to its monthly consumption can be felt is within sixty (60) months or five (5) years. And at the end of the 10th year, the University can have an approximate savings amounting to Php 12,364,553.42. The University can even save more after ten years, but the researcher only considered the ten (10) year period for ROI since it is the years in which full warranty of the PV solar panels is afforded.

Aside from a very significant approximate savings of Php 12,364,553.42 in ten (10) years, the school can dramatically reduce its carbon footprint by purchasing electricity from clean, renewable energy. The environmental benefits brought about by this green technology has the greatest impact to the CMU populace which is priceless.

5.2 Recommendations

Based on the aforementioned conclusions, the following recommendations were given:

This school is encouraged to allocate a budget for the conversion of the administration building energy electrical source to solar energy as presented in this project.

The administration building is illustrated as an initial step for school to transform itself to eco-friendly electrical source. The administration may also adopt a gradual use of solar energy to other school utilities and even to their respective homes. Although the initial cost of purchasing a solar system is fairly high, the institution can save considering its monthly savings in a few years. This is an essential part of the country's low emissions development strategy and is vital to addressing the challenges of climate change, energy security, access to energy, and sustainability.

With this project as a model, this Higher Education school may serve as prime mover of change to other SUC's and Local Government Units (LGUs) in the Province by adopting eco-friendly energy source (solar energy) and other quality renewable energy sources.

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