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HARNESSING THE SUN: ASSESSING THE IMPACT AND EFFICIENCY OF SOLAR PANELS AT SAINT LOUIS COLLEGE

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ABSTRACT

This study investigates the impact and operational efficiency of the solar photovoltaic (PV) system installed at Saint Louis College, focusing on reducing energy costs and carbon emissions. As part of the institution's broader sustainability initiatives, the solar PV system demonstrates the potential of clean energy integration in higher education. However, challenges related to seasonal variability and weather-dependent energy generation remain. A mixed-methods approach was employed to assess performance and identify areas for optimization – combining quantitative data on energy output, storage, and cost savings with qualitative insights gathered through stakeholder interviews and surveys. Conducted from December 12–16, 2024, in collaboration with the College Development and Sustainability Office, the case study revealed that the 200.34 kW system, installed in 2016 at the cost of Php 15,063,500, supplies roughly 33.3% of the college's total energy demand. Despite increased consumption due to on-site learning and new infrastructure, the system saves approximately Php 1,001,637.57 annually. With average maintenance costs of Php 92,500, the system remains financially viable and is projected to achieve a full return on investment by 2035. Key recommendations include appointing an in-house technical expert for timely repairs and enhancing system performance. The findings underscore solar energy adoption's financial and environmental advantages in academic institutions and suggest practical strategies for improved sustainability.

KEYWORDS: *Clean Energy, Solar Panels, Sustainable Practices, Energy Consumption, Financial Viability*

1. INTRODUCTION

The global shift toward renewable energy sources is a strategic response to mitigating climate change, with solar power emerging as one of the most viable alternatives. As nations transition to more sustainable energy models, solar energy contributes to environmental sustainability by reducing greenhouse gas emissions and minimizing reliance on fossil fuels. Its feasibility lies in its accessibility and suitability for widespread application (Stanford University, 2010).

Although the Philippines currently operates a limited number of solar power plants, its tropical climate and high solar irradiance make it an ideal candidate for solar energy development. In line with this, the Department of Energy (2020) has conducted investigations to advance the renewable energy sector, supported by government initiatives to enhance relevant policies.

In sustainable practices, educational institutions worldwide are increasingly adopting solar technologies. Installing solar panels in schools reduces electricity costs and enhances learning by exposing students to renewable energy concepts and technologies. According to the National Renewable Energy Laboratory (NREL, 2018), schools using solar energy benefit from both cost savings and environmental protection.

Research into the implementation of solar energy in academic institutions highlights its potential and challenges. Lottu et al. (2023) showcase global practices that reveal the environmental, economic, and educational benefits of integrating solar power in schools and universities. Altassan (2023) proposes a comprehensive framework for sustainable integration, stressing the need for behavioral change and recycling to maximize school solar energy's impact. Similarly, Cabotaje and Santos (2022) report improved learning conditions and administrative efficiency in rural schools adopting solar electrification.

At Saint Louis College, this global movement is mirrored in its installation of solar panels aimed at reducing environmental harm and managing energy consumption. These efforts align with the institution's commitment to incorporating green technologies into its infrastructure and promoting sustainable practices aligned with zero-waste goals.

Despite the increasing use of solar power in educational settings globally, localized research remains limited, especially in developing countries like the Philippines. Existing literature provides general overviews of solar energy's benefits, but institution-specific case studies—such as that of Saint Louis College—are crucial in addressing this research gap. Such studies offer valuable insights into the practical implementation, outcomes, and sustainability of solar energy systems in specific educational environments.

2. OBJECTIVES

This study examines the effectiveness of solar panel installations at Saint Louis College by assessing key factors, including the type of solar technology used, monthly electricity consumption, and annual system output. Financial considerations such as maintenance costs, deployment scale, and return on investment are also evaluated. The study aims to generate actionable insights for enhancing system performance and ensuring long-term sustainability and efficiency.

3. METHODOLOGY

3.1. Research Design

This study employed a mixed-methods research design, integrating both quantitative and qualitative approaches to evaluate the impact and efficiency of solar panel installations at Saint Louis College. The quantitative component involved statistical analysis to measure system efficiency and financial performance, including monthly energy production, storage capacity, maintenance expenditures, and return on investment. The qualitative component was analyzed narratively, focusing on stakeholders' experiences and perspectives regarding the implementation and operation of the solar panel system.

3.2. Sampling Design

The study engaged a **diverse group of stakeholders** from Saint Louis College, particularly those directly involved with the solar energy system. Participants included (2) facility managers, (2) administrative personnel, and (2) maintenance personnel whose roles provide valuable insights into the system's operation, performance, and maintenance.

3.3. Instrumentation

Quantitative and qualitative data collection tools were utilized to assess solar panels' effectiveness comprehensively.
Quantitative data were gathered through numerical indicators such as energy consumption, solar power generation, maintenance expenses, and cost-benefit analyses. These figures were derived from the institution's solar monitoring system, which logs monthly energy output and storage, alongside a review of financial records detailing operational costs and savings.

For the qualitative aspect, **semi-structured interviews and surveys** were administered to facility managers and administrative staff. These instruments aimed to capture rich, descriptive feedback on their experiences and insights related to the solar panel system's daily management and long-term sustainability.

3.4. Data Collection Procedure

Quantitative data were collected through official institutional records, including monthly energy usage reports from the accounting office, output data from the solar monitoring system, and financial documentation on annual savings and maintenance costs.

In parallel, qualitative data were obtained through semi-structured interviews with facility managers, administrative staff, and maintenance personnel. These interactions provided nuanced understandings of operational challenges, perceived system efficiency, and overall satisfaction with the solar initiative.

A **comprehensive document review** was conducted, covering electric bills, performance monitoring reports, and financial projections to substantiate the data. A **site observation** was also performed to assess the physical state of the solar photovoltaic (PV) system, examine any structural issues, and evaluate current maintenance practices.

3.5. Geographical Scope

The research was conducted at **Saint Louis College**, located in Lingsat, City of San Fernando, La Union, where one of the researchers serves as an assistant instructor. To mitigate potential bias, the researcher strictly adhered to established ethical standards, maintained impartiality throughout the research process, and ensured that independent external reviewers objectively evaluated findings.

3.6. Statistical and Qualitative Analysis

Quantitative analysis utilized numerical indicators sourced from institutional records. Data included monthly energy consumption, solar power generation, maintenance expenses, and cost-benefit analyses. These were derived from Saint Louis College's solar monitoring system, accounting office reports, and financial documentation. Statistical tools were applied to identify trends and fluctuations in energy consumption and to compare projected versus actual savings from solar energy generation.

For qualitative analysis, semi-structured interviews and surveys targeted facility managers, administrative staff, and maintenance personnel. These methods aimed to capture descriptive feedback regarding operational challenges, system efficiency, and satisfaction with the solar initiative. Additionally, site observations assessed the physical state of the solar PV system, structural issues, and maintenance practices.
A comprehensive review of relevant documents, such as electric bills, performance monitoring reports, and financial projections, substantiated the collected data. This provided a strong foundation for understanding the broader impact of the solar panel installation.

The study was conducted at Saint Louis College in La Union. Rigorous ethical standards were upheld to ensure impartiality, and external reviewers were engaged to objectively evaluate the findings.

4. RESULTS

4.1. Solar Panel Investment

The solar panel system installation at Saint Louis College was completed on October 4, 2016, at a total cost of Php15,063,500. The project was successfully executed by WEnergy Global Pte Ltd, which was responsible for the design, supply, project management, construction, installation, and supervision of a 200.34 kWp grid-tied rooftop solar photovoltaic (PV) system. This investment marked a significant step toward the institution's commitment to sustainable energy practices and carbon footprint reduction.

4.2. Monthly Energy Consumption

Based on data obtained from the Accounting Office of Saint Louis College, there has been a noticeable increase in energy consumption from 2020 to 2024, as illustrated in Figure 1. This upward trend reflects the growing energy demand of the institution over the years. Monthly fluctuations are evident, which may be attributed to varying levels of campus activity

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across different academic periods. Notably, the highest monthly energy consumption was recorded in May 2024, reaching 153,888 kWh, signifying a substantial increase in energy usage.

The data shows that energy consumption began to rise significantly from January to February starting in 2021, with marked increases in 2023 and 2024. From March to June, a steady upward trajectory is observed each year, indicating high electricity usage, likely due to intensive academic and administrative operations. Similarly, consumption continues to climb from July to December, maintaining the general pattern of increasing energy demand.

It is important to note that from 2020 to 2022, the institution operated under online and blended learning modalities in response to the COVID-19 pandemic. Consequently, energy consumption during this period was relatively lower compared to 2023 and 2024, when on-site learning resumed after lifting pandemic restrictions. The increased usage was further amplified by the operation of a newly constructed 7-story building, which added significantly to the institution's overall energy requirements.

4.3. Annual Solar Energy Generation

According to WEnergy Global, the 200.34 kWp grid-tied rooftop solar photovoltaic (PV) station installed at Saint Louis College has an estimated annual generation capacity of 255,022 kWh. This accounts for approximately 33.3% of the institution's total annual energy consumption, translating to an estimated annual reduction in electricity expenses of around Php 2.1 million.

However, based on the actual generation rate provided by LUECO (La Union Electric Cooperative) from 2016 to 2024 shown in Table 1, the average annual savings achieved by the institution is approximately Php 1,001,637.57. This discrepancy is attributed to the higher projected generation rate initially estimated by WEnergy Global compared to actual performance data.

Despite observed fluctuations in solar energy generation, the system continues to contribute significantly to annual financial savings. Variations in power costs play a crucial role in determining the magnitude of these savings, underscoring the need for continuous monitoring of energy market trends. The findings highlight the importance of regular system assessments and present opportunities for upgrades or maintenance interventions to enhance or sustain solar energy output and financial efficiency.

4.4. Annual Operating and Maintenance Cost

The annual operating and maintenance costs of the solar PV system installed at Saint Louis College encompass several components, including monitoring and diagnostics, cleaning, routine and preventive maintenance, system upgrades, major repairs, and insurance. While the institution could not provide actual annual expenditure records, the cost estimates presented in Table 2 are based on financial calculations and projections from WEnergy Global.

According to Table 2, the solar PV system's average annual operating and maintenance cost from 2016 to 2020 is estimated at Php 92,500.00. Over time, the observed increase in operational and maintenance costs suggests that more frequent and intensive maintenance efforts are required as the system ages. This trend indicates that regular servicing and upkeep activities are being conducted, essential to preserving the efficiency and longevity of the solar PV infrastructure.

Despite the gradual rise in operating and maintenance costs, the financial savings generated from solar energy production continue to outweigh these expenses. This demonstrates a favorable cost-to-benefit ratio, reinforcing that the solar PV system remains cost-efficient and financially sustainable over the long term.

4.5. Extent of Solar Panel Deployment

According to the College Development and Sustainability Office (CDSO), the rooftop solar PV station is mounted on Fr. Roger Tjolle, CICM Senior High School Building. Seven hundred fifty-six (756) photovoltaic panels and ten (10) grid-tied inverters are installed shown in Figure 2. The flow of electricity is for the consumption of the whole institution and, when needed, allows excess electricity to be fed back into the national grid. With a grid-tied inverter, the rooftop solar PV station is grid interactive.

During an interview with the maintenance team of the rooftop solar PV station, it was revealed that a third-party service provider conducts the equipment monitoring. This provider notifies the institution of any issues with the solar panels, and they are responsible for carrying out the necessary repairs. There is a recommendation to hire an in-house solar panel expert to ensure immediate repairs, eliminating the wait time for third-party interventions.

A site visit to the rooftop solar PV station uncovered a minor deflection in the roofing where the panels are installed. This defect allows rainwater to seep through and reach the classrooms below. In response, the Campus Development and Sustainability Office (CDSO) is redesigning the roofs of other buildings to ensure they can safely support additional solar panels.

With the expansion of new buildings and the installation of TVs and air-conditioning units in all rooms at Saint Louis College (SLC), a proposed plan is to add more rooftop solar PV stations on campus.

4.6. Benefits and Return on Investment

The researcher also made projected data for the annual savings from solar energy generation for return of investment calculations shown in Table 3. The researcher used an exponential projection of data based on the data from 2016 to 2024. Exponential projection is used so that the average power cost annually varies exponentially. In Table 3, despite the fluctuations, the overall projection indicates that solar energy offers substantial financial savings over conventional energy sources. The table also shows that the investment will be returned by 2035. This table suggests that the investment in solar technology demonstrates the financial viability of the

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solar OV system, helping to offset initial installations and ongoing maintenance costs.

5. SUGGESTIONS

To enhance the efficiency, sustainability, and financial benefits of the solar PV system at Saint Louis College, several measures can be implemented. Employing an in-house solar panel expert would ensure immediate and efficient maintenance, reducing reliance on third-party services and minimizing downtime. Establishing a comprehensive maintenance schedule that includes regular assessments, cleaning, and upgrades is crucial for sustaining system performance and addressing wear and tear. Expanding the rooftop solar PV stations is also recommended, especially given increased energy consumption; such expansion should be strategically planned and structurally supported to optimize available space.

In addition, integrating energy-saving measures like energy-efficient appliances and smart energy management systems would significantly reduce wastage and improve overall efficiency. It is equally important to stay informed about energy price changes and market trends to adjust procurement strategies and maximize savings. Addressing structural issues, such as roof deflections, is imperative to maintaining the installation's safety and performance while ensuring new buildings are designed to support future solar PV installations effectively.

Raising awareness among the campus community about the benefits of solar energy and sustainable practices can foster cooperation and support for renewable energy initiatives. Conducting long-term studies to monitor the system's performance and cost-effectiveness, while exploring complementary renewable energy sources like wind or battery systems, will further enhance energy sustainability. Establishing a long-term financial plan to budget for maintenance and upgrades can ensure the system's financial viability over time. Lastly, seeking funding, grants, and incentives from government programs and private partnerships can help offset costs and bolster the institution's sustainability efforts.

6. CONCLUSION

The rooftop solar photovoltaic (PV) system installed at Saint Louis College in 2016, with an investment of Php15,063,500, has made notable contributions to environmental sustainability and financial efficiency. With a capacity of 200.34 kWp, comprising 756 photovoltaic panels and ten grid-tied inverters, the system supplies approximately 33.3% of the institution's total energy requirements, generating average annual savings of Php1,001,637.57—despite fluctuations in electricity rates and increased post-pandemic energy demand.

While annual maintenance costs, averaging Php 92,500, have gradually increased due to system aging, these remain significantly lower than the financial benefits of solar energy generation. This affirms the system's cost-effectiveness and role in advancing the institution's sustainability goals. Based on current projections, the initial investment is expected to be fully recovered by 2035; at this point, the institution will benefit from positive net cash flows and long-term economic and environmental gains.

To further optimize the performance and sustainability of the solar PV system, it is recommended that the institution employ a dedicated in-house solar panel technician to ensure timely and expert maintenance. A comprehensive and regular maintenance schedule should also be implemented to preserve system efficiency and extend lifespan. Addressing structural concerns, such as roof deflections, is essential to ensure the continued safety and performance of the installation. Additionally, expanding the existing solar infrastructure is necessary to meet the institution's increasing energy demands, particularly with the operation of newly constructed campus facilities.

Using energy-efficient technologies like intelligent systems may reduce electricity consumption and enhance monitoring capabilities. Regular performance evaluations and financial reviews inform system upgrades and strategic enhancements. The institution should seek external funding or government grants to support future expansions and technological improvements. Finally, fostering sustainability awareness within the campus community and exploring other renewable energy sources will strengthen Saint Louis College's long-term environmental initiatives.

In conclusion, the solar PV system at Saint Louis College represents a sustainable investment that reduces operational costs and reinforces the institution's commitment to environmental stewardship and energy resilience.

7. TABLES AND FIGURES

Table 1. *Annual* Solar Energy Generation and Savings of Saint Louis College from 2016 to 2020

Year	kWh Solar Energy Generation	Average Generation Rate (Php)	Saving (Php)
2016	227,537	5.3645	1,220,622.24
2017	226,702	4.7193	1,069,874.75
2018	225,868	5.3920	1,217,880.26
2019	225,035	4.9057	1,103,954.20
2020	224,202	4.2721	957,813.36
2021	223,371	4.2552	950,488.28
2022	222,539	3.4988	778,619.45
2023	221,706	3.5426	785,415.68
2024	220,872	4.2109	930,069.90
Average			**1,001,637.57**

The average generation rate is based on LUECO – Generation Charge (http://www.luecoinc.com/)

Table 2. *Annual Operation and Maintenance Cost on Solar PV Panels of Saint Louis College from 2016 to 2020*

Year	Operation and Maintenance Cost (Php)
2016	80150
2017	83000
2018	85950
2019	89000
2020	92150
2021	95400
2022	98750
2023	102250
2024	105850
Average	**92,500**

Table 3. *Financial Calculation on Benefits and Return on Investment of Solar PV Stations in Saint Louis College*

Year	kWh Consumption	Average Generation Rate (Php)	Saving (Php)	O&M Cost (Php)	Inverter Replacement (Php)	Insurance (Php)	Purchase Price (Php)	Net Cashflow from 2016 to Year (Php)
2016	227,537	5.3645	1,220,622	80150		32050	15063500	-13,955,078
2017	226,702	4.7193	1,069,875	83000		32050		-13,000,253
2018	225,868	5.3920	1,217,880	85950		32050		-11,900,373
2019	225,035	4.9057	1,103,954	89000		32050		-10,917,469
2020	224,202	4.2721	957,813	92150		32050		-10,083,855
2021	223,371	4.2552	950,488	95400		32050		-9,260,817
2022	222,539	3.4988	778,619	98750		32050		-8,612,997
2023	221,706	3.5426	785,416	102250		32050		-7,961,882
2024	220,872	4.2109	930,070	105850		32050		-7,169,712
2025	220,039	3.9033	858,874	109600		32050		-6,452,488
2026	219,207	4.0175	880,662	113450	104650	32050		-5,821,976
2027	218,373	4.0172	877,248	117450	104650	32050		-5,198,878
2028	217,542	4.2237	918,839	121600	104650	32050		-4,538,339
2029	216,731	4.1788	905,667	125900	104650	32050		-3,895,272
2030	215,884	4.3677	942,926	130350	104650	32050		-3,219,396
2031	215,054	4.3469	934,816	134950	104650	32050		-2,556,230
2032	214,225	4.5317	970,807	139700	104650	32050		-1,861,823
2033	213,395	4.5007	960,425	144600	104650	32050		-1,182,699
2034	212,565	4.6904	997,005	149700	104650	32050		-472,094
2035	211,736	4.6613	986,963	154950	104650	32050		223,219
2036	210,908	4.8483	1,022,553	160400	104650	32050		948,672
2037	210,084	4.8197	1,012,544	166050	104650	32050		1,658,466
2038	209,262	5.0079	1,047,956	171900	104650	32050		2,397,822
2039	208,441	4.9787	1,037,768	177950	104650	32050		3,120,940
2040	207,620	5.1667	1,072,701	184200	104650	32050		3,872,741

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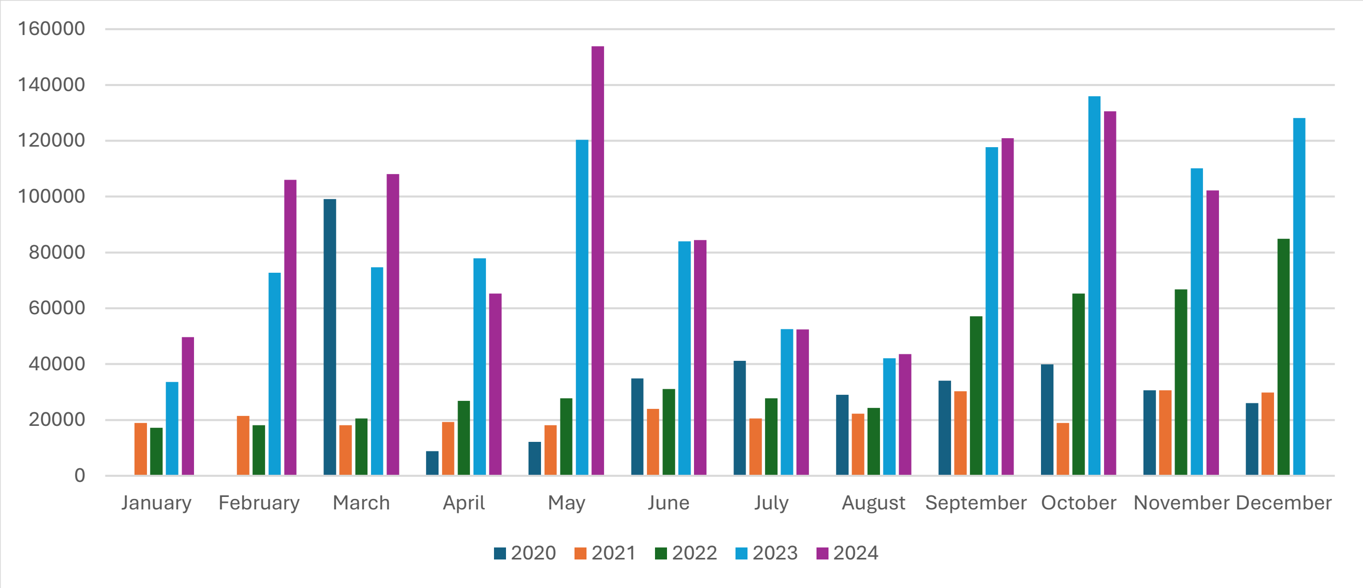

Reference: Monthly Electrical Bill of Saint Louis College

Figure 1. ***Monthly Energy Consumption of Saint Louis College from 2020-2021***

Source: Google Maps

Figure 2. ***Satellite Image of the Solar PV Station in Saint Louis College***

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