INTERNATIONAL JOURNAL OF RESEARCH AND INNOVATION IN SOCIAL SCIENCE (IJRISS)
ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue XXVI October 2025 | Special Issue on Education

Proposed Solar Energy Plan in NDDU-Glamang Campus

Edgar B. Manubag, PhD

Notre Dame of Dadiangas University

DOI: https://dx.doi.org/10.47772/IJRISS.2025.903SEDU0616

Received: 20 October 2025; Accepted: 31 October 2025; Published: 10 November 2025

ABSTRACT

This study explored the viability, economic potential, and environmental impact of implementing a solar photovoltaic (PV) system at Notre Dame of Dadiangas University – Glamang Campus (NDDU-GC). Using secondary data and institutional energy records, the research estimated that a 344-kW system, composed of 860 panels installed on a 1,723.459 m² rooftop, could generate between 450,775 and 565,020 kWh of electricity annually. The estimated installation cost was PHP 18.92 million, with projected annual savings of PHP 6.01 million based on prevailing electricity rates. The investment was projected to break even within three to five years. The transition to solar energy was also expected to reduce carbon emissions by over 360,000 kg per year, bringing notable environmental benefits, such as decreased fossil fuel reliance and lower greenhouse gas emissions. In addition to economic and environmental gains, the project supported local employment by requiring full-time maintenance personnel. The findings emphasized the potential of academic institutions to lead in clean energy initiatives and climate action. It was recommended that NDDU-GC expand solar adoption across additional campus facilities and use the project as a platform to strengthen environmental education. Promoting awareness through campus-wide campaigns, integrating sustainability topics into academic programs, and engaging both internal and external stakeholders were also encouraged. Finally, it was advised that system performance be continuously evaluated, and future innovations—such as energy storage or smart grid integration—be considered to enhance long-term efficiency and sustainability further.

Keywords: Solar PV system, energy generation, sustainability program

INTRODUCTION

The Problem and Its Setting

The global energy transition increasingly centers on solar power due to its potential to reduce reliance on fossil fuels. Falling costs of photovoltaic (PV) systems and increased investments have accelerated solar adoption worldwide. In 2023, solar energy capacity grew by 22%, with China, the U.S., and the EU leading in installations (IRENA, 2023). This trend is driven by global agreements such as the Paris Agreement and the UN Sustainable Development Goals (SDGs), which advocate for clean energy to combat climate change. Notably, China surpassed its 2030 renewable targets six years early (Le Monde, 2024), while the U.S. experienced a record 29% growth in solar installations (Vox, 2024). However, many developing countries still face financial and policy challenges in scaling solar projects (Time, 2024).

Technological innovations are improving the efficiency and accessibility of solar systems. Developments such as perovskite and tandem solar cells, along with bifacial panels, now achieve efficiencies beyond 30% (RatedPower, 2024). Coupled with energy storage solutions like lithium-ion and flow batteries, these systems help address solar intermittency and enhance reliability (GreenYellow, 2024). As a result, solar power has reached cost parity with conventional electricity in over 80% of markets globally (IRENA, 2024), making it an economically viable solution.

In the Philippines, high solar potential stems from abundant sunlight, with an average irradiance of 5–6 kWh/m²/day (DOE, 2023). The Renewable Energy Act of 2008 laid the groundwork for renewable adoption, but fossil fuels still dominate the energy mix. As of 2023, only 22% of the country's electricity came from renewable sources (DOE, 2023). Despite existing policies, limited infrastructure and investment continue to slow progress. However, universities are emerging as pioneers in solar adoption. For example, the University of the Philippines Manila expanded its solar installations, cutting costs and emissions (UP System, 2023). Central Luzon State University installed a 997-kW rooftop system that reduced electricity bills by 20% (CLSU, 2023), demonstrating the potential of solar in academic settings.

Economic feasibility remains one of solar energy's most substantial advantages. As PV system costs decline, institutions can achieve long-term savings while reducing operational expenses. Government incentives, including tax credits, net metering, and feed-in tariffs, further support financial viability (ERC, 2023). Additionally, the solar sector creates employment in manufacturing, installation, and maintenance, contributing to local economies (DOLE, 2023).

Notre Dame of Dadiangas University – Glamang Campus (NDDU-GC) has a strong opportunity to transition to solar energy. Rising electricity costs and dependence on non-renewables create financial strain. Installing a solar PV system could reduce long-term expenses and align with national climate goals. Enhanced solar technologies—such as bifacial and tandem panels—can boost system efficiency and reduce the levelized cost of electricity (NREL, 2023). With reliable energy storage options, solar systems at NDDU could provide a stable and sustainable power supply.

Beyond cost and reliability, solar energy plays a vital role in environmental sustainability. The energy sector accounts for nearly 73% of global greenhouse gas emissions (IPCC, 2023). Transitioning to renewables like solar is essential for meeting climate targets. A 100-kW solar system can offset around 96 metric tons of CO_2 annually (U.S. Environmental Protection Agency [EPA], 2023). Additionally, solar PV systems conserve water, unlike conventional power plants that require significant water resources (World Bank, 2023). By adopting solar, NDDU can reduce its carbon footprint, lower water usage, and contribute to biodiversity conservation.

Despite its promise, the main barrier to solar adoption at NDDU-GC is the high upfront investment. However, through strategic planning, partnerships with government and private stakeholders, and institutional commitment, these challenges can be overcome. A solar transition will not only provide economic and environmental benefits but also serve as a model for sustainability in higher education.

LITERATURE REVIEW

This literature review examines existing studies on solar energy implementation in academic institutions, focusing on system design, energy yield, and cost-efficiency. Insights from these studies will support the formulation of a sustainable and context-appropriate solar energy plan for the NDDU–Glamang Campus.

The transition to renewable energy sources, particularly solar energy, has been extensively studied due to its potential to provide sustainable, cost-effective, and environmentally friendly alternatives to conventional fossil fuels. Numerous studies have explored the efficiency, economic benefits, and environmental impact of solar energy in various sectors, including educational institutions. The growing global commitment to reducing greenhouse gas (GHG) emissions and mitigating climate change has further emphasized the need for cleaner energy sources. This literature review examines existing research on solar energy optimization outcomes, financial feasibility, and its role in environmental sustainability, providing a comprehensive foundation for assessing its implementation at NDDU-GC.

By analyzing relevant studies, this review aimed to contextualize the potential cost savings, energy conservation, and carbon emission reductions associated with solar power. Furthermore, it explores the broader environmental benefits by quantifying CO_2 reduction in terms of trees planted, cars' annual emissions avoided, waste and paper recycling, and reductions in fossil fuel dependency. Additionally, the review discusses the importance of renewable energy adoption in educational institutions, highlighting its role in enhancing energy efficiency, promoting sustainability awareness, and reducing operational costs. Through this literature review, the study establishes a strong theoretical basis for evaluating the feasibility and long-term benefits of solar energy adoption at NDDU-GC.

Solar Energy and Its Global Adoption

The global shift to solar energy is accelerating due to falling costs, higher efficiency, and supportive government policies. Solar PV capacity grew by 28%, led by China, the U.S., and Europe (IEA, 2023). Utility-scale solar is now cost-competitive with fossil fuels in many areas (BloombergNEF, 2024). Advances in storage technologies, like lithium-ion and solid-state batteries, have improved reliability and addressed intermittency issues (IEA, 2023).

In developing regions, off-grid solar systems have expanded energy access, especially in Africa and South Asia (World Bank, 2023). Programs like the World Bank's Scaling Solar have made large-scale solar more affordable and accessible. However, challenges remain. Fossil fuel subsidies, regulatory uncertainty, and supply chain issues—particularly for key materials like lithium and cobalt—continue to hinder broader adoption (UNEP, 2024; IEA, 2023).

Economic Benefits of Solar Energy

Solar energy offers well-established economic benefits, with many institutions achieving substantial cost savings and favorable return on investment (ROI). IRENA (2024) reports that solar has reached cost parity with conventional electricity in over 80% of global markets, allowing universities to reduce operational expenses and reallocate funds toward academics. Government incentives such as tax credits and net metering enhance its financial viability (U.S. Department of Energy, 2023).

Moreover, solar energy contributes to job creation in manufacturing, installation, and maintenance. The U.S. solar workforce grew by 11% in 2023, adding nearly 30,000 jobs (SEIA, 2023). In the Philippines, renewable energy programs have spurred employment and reduced fossil fuel dependence (Philippine DOE, 2024). Small businesses also benefit from integrating solar to support local economic development (World Bank, 2023).

Long-term savings further increase solar's appeal. According to NREL (2023), most institutions recover their solar investments within 5–7 years, followed by decades of reduced electricity costs, providing economic resilience in the face of energy price volatility (IRENA, 2024).

Energy Optimization Outcome of Solar Energy

Recent advances in solar energy systems have significantly improved energy optimization through innovations in technology and implementation strategies. Perovskite solar cells, which have risen from 3% efficiency in 2009 to over 25% today, now rival traditional silicon cells. Tandem cells combining perovskite and silicon exceed 30% efficiency (RatedPower, 2024). Bifacial solar panels, which capture sunlight on both sides, further boost energy production, especially in reflective environments, reducing the global levelized cost of electricity (Go Solar Trek, 2024).

Energy storage has also improved with technologies like flow batteries, offering durable and scalable storage for solar energy during low sunlight periods (GreenYellow, 2024). Governments are increasingly adopting solar power in public infrastructure. In the UK, solar panels on schools and NHS sites are projected to save thousands annually in energy costs (The Times, 2024).

In the Philippines, projects like the 150-MW agrovoltaic solar plant and the 120-MW General Santos Solar Power Project exemplify the country's push for renewable energy, combining energy generation with agricultural productivity and enhancing energy security (MindaNews, 2022; Global Energy Monitor, 2024).

Environmental Benefits of Solar Energy

Solar energy significantly contributes to lowering greenhouse gas (GHG) emissions and combating climate change. According to the Intergovernmental Panel on Climate Change (IPCC, 2024), the energy sector accounts for nearly 73% of global emissions, making a shift to renewables like solar power essential to meeting climate goals. A 100 kW solar PV system can offset about 96 metric tons of CO_2 annually (IEA, 2024). In addition to curbing emissions, solar energy helps reduce air pollution by limiting the use of fossil fuels such as coal and natural gas (UNEP, 2024).

Solar power also supports water conservation. Unlike fossil fuel plants, which consume large amounts of water for cooling, solar PV systems require minimal water, benefiting regions facing water scarcity (World Resources Institute, 2023). IRENA (2024) estimates that solar energy could cut global water withdrawals in the power sector by 30% by 2050.

Furthermore, solar projects promote biodiversity by reducing land degradation linked to traditional energy sources. To optimize land use and minimize ecological impact, innovative approaches like floating solar farms and agrivoltaics—where solar panels are integrated with farming—are gaining popularity (IEA, 2024; World Bank, 2023).

Solar Energy in the Philippines

Due to its equatorial location, the Philippines receives abundant solar irradiance, averaging 5.5 kWh/m²/day throughout the year (PAGASA, 2024), making it well-suited for solar photovoltaic (PV) systems. To address growing energy needs and promote sustainability, the government has implemented initiatives such as the Renewable Energy Act of 2008 and the Green Energy Auction Program (GEAP) to boost solar adoption (Department of Energy, 2024).

Despite these efforts, challenges like high upfront costs, regulatory barriers, and limited grid infrastructure—especially in remote areas—continue to slow progress (ADB, 2024). Nevertheless, improved access to financing, including subsidies and private investments, is helping drive adoption. Net metering schemes, for example, allow users to sell surplus energy back to the grid, enhancing the economic appeal of solar systems (IRENA, 2024).

Educational institutions are leading by example. Universities such as UP Diliman and Central Luzon State University have installed solar PV systems, cutting energy expenses and aligning with national renewable energy goals (Philippine News Agency, 2024). As more schools embrace solar, this trend may inspire broader adoption across other sectors, supporting both environmental and economic sustainability.

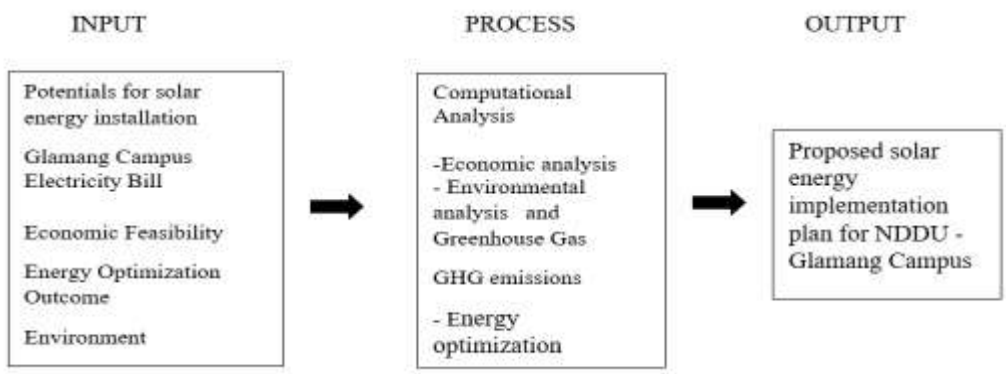
CONCEPTUAL FRAMEWORK

This study's conceptual framework, shown in Figure 1, evaluated the economic viability, energy optimization, and environmental sustainability of solar energy at NDDU-GC. Using computational analysis of existing data, it assesses the impact of solar implementation on electricity cost savings, operational efficiency, and CO_2 emission reductions.

Environmental benefits are expressed in real-world equivalents, such as trees planted, cars taken off the road, and materials recycled, offering a tangible view of solar energy's impact. The study also equates energy optimization outcomes to practical metrics like gasoline saved, travel avoided, and devices powered.

Beyond environmental and financial gains, the framework highlights the role of solar energy in fostering sustainability awareness, community engagement, and educational opportunities. Ultimately, it supports the development of strategies to enhance solar adoption and long-term sustainability at the university.

Figure 1. Conceptual Framework



ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue XXVI October 2025 | Special Issue on Education

Statement of the Problem

This study explored how solar energy could help lower electricity costs, improve energy efficiency, and reduce environmental impact at NDDU – GC. It aimed to address these issues by answering the following questions:

1. What is the potential of NDDU-GC for solar energy installation with 1,723.459 square meter rooftop area in terms of:

   1.1 solar panel capacity;

   1.2 total power output;

   1.3 energy production; and

   1.4 cost of installation and return of investment (ROI)?

2. How does solar energy implementation contribute to reducing greenhouse gas (GHG) CO_2 emissions at the university?

3. What is the energy optimization outcome equivalent (Fuel & Energy Reduction) equivalent of the reduction of CO_2 emission in terms of:

   3.1 Car Travel Avoided;
   3.2 Gasoline Saved;
   3.3 Oil Barrels Avoided;
   3.4 Coal Burning Prevented;
   3.5 Laptop Charging;
   3.6 Washing Machine Loads; and Cement Production Avoided?

4. What is the environmental equivalent (Pollution & Emission Reduction) equivalent of the reduction of CO_2 emission in terms of:

   4.1. Number of Trees Planted;
   4.2 Number of Cars' Annual Emissions Avoided;
   4.3 Waste Recycled;
   4.4 Paper Recycling;
   4.5 Production of Plastic Bottles Avoided; and Meat Consumption Reduced?

5. What additional benefit can be derived from implementing solar energy systems in terms of job generation?

6. Based on the results of the study, what solar energy implementation plan can be proposed for the successful integration of solar energy?

Scope and Delimitations

This study focused on evaluating the economic viability, environmental sustainability, and energy optimization outcome impacts of solar energy adoption at NDDU-GC. Specifically, the study assessed the potential cost savings that can be achieved through the implementation of solar energy systems by analyzing electricity consumption data and financial projections. Additionally, it examined how solar energy adoption contributes to the reduction of greenhouse gas (GHG) emissions, particularly CO_2, within the university. The study also quantified the environmental benefits of CO_2 reduction by determining its equivalent impact in pollution and emissions reduction metrics, including the number of trees planted, cars' annual emissions avoided, waste recycled, paper recycling, plastic production avoided, and meat consumption reduced.

A key focus of this study was the assessment of the 1,723.459 square meter rooftop area of the Main Building at NDDU-GC for the potential installation of solar panels. This area presents a viable opportunity for harnessing solar energy to reduce electricity costs and promote sustainability significantly. The analysis considered the estimated solar panel capacity that can be accommodated within this space, the projected energy output, and the corresponding financial and environmental benefits of utilizing this renewable energy source.

Moreover, the study explored the energy optimization outcome impact of CO_2 reduction in terms of fuel and energy savings, measuring its equivalence in avoided car travel, gasoline saved, oil barrels avoided, coal burning prevented, laptop charging, washing machine loads, and cement production avoided. In addition to environmental and energy efficiency benefits, the research identified the potential community engagement opportunities that solar energy adoption may create within the university. Lastly, based on the findings, the study proposed a solar energy implementation plan for NDDU-GC to facilitate the successful integration of solar energy solutions.

This study was delimited to a computational analysis based on existing data and documents rather than experimental installations or field testing of solar panels. The financial and environmental projections relied on historical electricity consumption data, established conversion factors, and secondary sources such as industry reports and government publications. While the study considered various environmental benefits, it did not include social, behavioral, or policy-level analyses related to solar energy adoption. Additionally, the study did not account for variables such as weather fluctuations, potential future energy policy changes, or external economic conditions that may affect long-term financial projections.

Significance of the Study

This study will be significant to the following groups and individuals:

NDDU Administration. The findings of this study can provide the university administration with data-driven insights on cost savings and long-term sustainability. These insights can support informed decision-making in the continued adoption of renewable energy systems and the development of policies that enhance energy efficiency and institutional resilience (Al Garni et al., 2016).

Faculty and Researchers. Faculty and researchers can utilize the solar PV project as a platform for academic inquiry and curriculum integration. It enables the exploration of energy efficiency, environmental science, and engineering topics, contributing to interdisciplinary research and innovation in sustainability (Ayoub & Yuji, 2012).

University Staff and Employees. The reduction in operational costs resulting from solar energy adoption may create opportunities for reallocation of funds. This could support improvements in campus infrastructure, employee compensation, or professional development programs, thereby enhancing the work environment and institutional productivity.

Students. The integration of solar PV systems within the university campus enhances learning opportunities related to renewable energy, sustainability, and green technology. This exposure not only supports academic development but also promotes environmental awareness among students, encouraging eco-friendly behavior both on and off campus (Li et al., 2022).

Parents and Guardians. With operational savings, the university may achieve greater financial stability, potentially stabilizing or lowering tuition fees. This would make education more affordable and accessible to families, reinforcing the institution's commitment to inclusive and equitable learning opportunities.

Local Community. The study's outcomes may inspire community engagement in renewable energy efforts. As NDDU-GC leads by example, neighboring institutions and households may be encouraged to consider solar power solutions, fostering a culture of environmental responsibility and sustainable living within the region (Babatunde et al., 2019).

Government and Policymakers. The project supports national goals for energy sustainability. It offers a practical model for integrating renewable energy technologies in educational settings. Policymakers can reference this study in formulating strategies to promote clean energy adoption across public and private sectors (Hannan et al., 2018).

Private Sector and Investors. Solar PV implementation creates business opportunities for renewable energy providers, construction firms, and financial institutions engaged in green energy financing. The university's experience can guide future investments and partnerships in sustainable infrastructure.

Environmental Organizations. The reduction of carbon emissions and increased awareness brought about by the solar initiative align with global climate action efforts. Environmental organizations can use this case to advocate for stronger policies and community-level initiatives in renewable energy (IRENA, 2023).

Future Researchers. This study will serve as a valuable reference for future research exploring the financial viability, environmental impact, and long-term benefits of renewable energy in academic institutions. It can contribute to the growing body of knowledge on sustainability practices in the education sector.

METHODOLOGY

This study used computational analysis of existing data to assess the economic viability, energy efficiency, and environmental benefits of solar energy at NDDU – Glamang Campus. It relied on institutional records, journals, and official reports, focusing on energy output, sustainability, and carbon footprint reduction. No surveys or experiments were conducted; instead, the study analyzed available data to evaluate the potential of solar implementation.

Research Design

This study adopts a qualitative computational and document-based research design to analyze the economic viability, energy optimization outcome, and environmental sustainability of solar energy at Notre Dame of Dadiangas University – Glamang Campus. The research follows a quantitative, non-experimental approach, utilizing numerical data and documented case studies to assess solar energy performance. By focusing on secondary data, the study ensures a systematic evaluation of existing findings rather than conducting new empirical experiments. The computational analysis is based on verified datasets, industry reports, and scholarly literature, allowing for an objective and data-driven assessment of solar energy’s impact.

The research design prioritizes descriptive and analytical methods to interpret data related to energy conversion rates, sustainability indicators, and environmental benefits (Samaras et.al, 2008). In particular, this study examines solar energy’s role in reducing greenhouse gas emissions, decreasing reliance on fossil fuels, and mitigating environmental degradation. By assessing documented reductions in carbon footprints and improvements in air quality associated with solar energy adoption, the study highlights its contribution to environmental sustainability. Instead of direct field observations or experimental setups, this research relies on structured data analysis to quantify solar energy’s effectiveness within the university setting. By applying established methodologies from prior studies, this research aims to provide a comprehensive understanding of solar energy’s role in promoting cleaner energy solutions and reducing environmental impact.

Data Sources

This study relied solely on secondary data from existing literature, reports, and statistical records (Johnston, 2017). Since no surveys, interviews, or experimental research are conducted, the study does not involve human participants or respondents. Instead, the data sources—such as government energy reports, academic studies, and industry analyses—serve as the basis for evaluating solar energy’s efficiency, economic viability, and environmental impact.

However, if necessary, the study may specify criteria for selecting data sources, ensuring that only credible and relevant documents are used. These criteria may include the recency, reliability, and relevance of the sources about solar energy performance, particularly within the context of Notre Dame of Dadiangas University – Glamang Campus.

Research Instrument

The primary research instrument is data analysis and computational tools used to interpret secondary data from academic journals, government reports, industry publications, and institutional records (Garcia et.al, 2020). These tools facilitate the systematic assessment of solar energy efficiency, economic viability, and environmental impact through numerical computations and data interpretation.

Additionally, analytical frameworks serve as key instruments in evaluating solar energy's performance. These may include formulas for calculating energy conversion rates, carbon footprint reduction estimates, and efficiency comparisons based on documented solar power case studies. The study relies on structured data interpretation rather than direct measurements, ensuring an objective and evidence-based approach in assessing the role of solar energy at Notre Dame of Dadiangas University – Glamang Campus.

Data Gathering Procedure

This study followed a documentary and computational approach for data gathering, relying exclusively on secondary sources to assess the efficiency, economic viability, and environmental impact of solar energy at NDDU-GC. The first step in the data collection process involves identifying and selecting relevant literature, reports, and statistical records from credible sources such as academic journals, government agencies, renewable energy organizations, and institutional documents. These sources provide quantitative data on solar energy performance, energy conversion rates, and sustainability metrics, ensuring a well-founded analysis based on established research.

Once the relevant data sources are identified, the study systematically extracts and compiles numerical data related to solar energy efficiency, cost savings, and environmental benefits. Computational techniques are applied to interpret and analyze the collected data, focusing on key indicators such as power generation efficiency, reductions in carbon emissions, and the long-term sustainability of solar energy. This process ensures that the study presents objective, data-driven insights without the influence of subjective opinions or field-based observations.

Finally, the gathered data undergoes validation and cross-referencing to ensure accuracy and consistency. By comparing multiple sources and analyzing trends within documented studies, the research minimizes potential biases and discrepancies in the findings. The final dataset is then used for computational analysis, allowing the study to conclude regarding the feasibility and impact of solar energy implementation at Notre Dame of Dadiangas University – Glamang Campus. This structured data-gathering procedure ensures that verified and reliable secondary sources back all conclusions.

Data Analysis

The data collected in this study undergone quantitative computational analysis to assess the economic viability, energy optimization outcome, and environmental impact of solar energy at NDDU-GC. The analysis primarily involves extracting numerical values from existing literature, reports, and institutional records, which are then systematically examined to identify patterns and trends. Key metrics such as energy conversion rates, power output, and reductions in carbon emissions are analyzed to determine the overall effectiveness of solar energy as a sustainable solution. This computational approach ensures that all conclusions are based on factual and verifiable data rather than subjective interpretations.

Finally, the processed data underwent interpretation and synthesis to generate meaningful insights regarding the feasibility of solar energy implementation. The results are organized into key findings, illustrating the potential cost savings, energy efficiency, and environmental improvements associated with adopting solar technology. The analysis ensures a balanced perspective on solar energy's role at NDDU-GC. By following a structured data analysis process, the study provides a well-supported evaluation of solar energy's contributions to sustainability and economic efficiency.

Economic Analysis

The economic analysis of this study focused on evaluating the financial implications of solar energy adoption at NDDU-GC by analyzing electricity costs and projected long-term savings. Monthly electricity consumption and cost data were obtained from NDDU-GC's facilities department to assess the institution's current energy expenses. This baseline data provides a comprehensive understanding of the university's electricity demand, helping determine the potential financial benefits of transitioning to solar energy. By identifying peak consumption periods and overall energy usage trends, the study establishes a foundation for estimating cost reductions through renewable energy integration.

Additionally, financial projections were conducted using industry-standard methods to calculate key financial metrics, such as long-term savings. By providing a data-driven financial outlook, this economic analysis ensures that decision-makers at NDDU-GC have a clear understanding of the potential savings and sustainability benefits of transitioning to solar energy.

Environmental Analysis

The study evaluated the greenhouse gas (GHG) emissions associated with NDDU-GC by estimating its baseline carbon emissions based on current electricity consumption. Using an emissions factor of 0.8 kg CO_2 per kWh (IRENA, 2023), the study calculates the total CO_2 output generated by the university's electricity usage. This provides a clear assessment of the institution's carbon footprint and serves as a reference for measuring the potential reductions achievable through solar energy implementation. By transitioning to solar power, the university can significantly lower its reliance on fossil-fuel-based electricity, directly decreasing its CO_2 emissions and contributing to environmental sustainability.

Beyond direct CO_2 reductions, the study also quantified other environmental benefits using recognized environmental metrics. These include equivalents such as the number of trees planted, the number of cars' annual emissions avoided, waste recycled, paper recycling, the production of plastic bottles avoided, and the reduction of meat consumption. These comparative metrics translate carbon emission reductions into tangible, real-world environmental impacts, making it easier to visualize the broader sustainability benefits of solar energy. By integrating these measures, the study highlights how solar power adoption at NDDU-GC can positively contribute to global efforts in reducing pollution, conserving natural resources, and mitigating climate change.

Energy Optimization Outcome Analysis

In addition to greenhouse gas (GHG) emissions reductions, the study also quantified the energy-saving impact of solar energy adoption at NDDU-GC. By replacing conventional electricity with solar power, the institution can significantly reduce its dependence on fossil fuels, leading to measurable energy conservation. To provide a clearer understanding of these benefits, the study utilizes key energy-saving metrics that translate reduced electricity consumption into tangible equivalents.

Metrics such as the equivalent car travel avoided, gasoline saved, oil barrels avoided, coal burning prevented, laptop charging, washing machine loads, and cement production avoided were used to quantify the impact of energy conservation. These indicators offer a practical perspective on how solar energy implementation contributes to reducing the demand for non-renewable energy sources. By using these standardized comparisons, the study highlights the broader implications of solar power adoption, reinforcing its role in promoting energy efficiency and sustainable resource management at NDDU-GC.

Ethical Considerations

This study adhered to strict ethical guidelines to ensure the integrity, accuracy, and responsible use of data in evaluating the efficiency, economic viability, and environmental sustainability of solar energy at NDDU-GC. Since the research is based on computational analysis using existing data and documents, ethical considerations focus on data confidentiality, accuracy, and responsible reporting. The study ensures that all data used, including electricity consumption records, financial projections, and environmental impact metrics, are obtained from credible and authorized sources. Any confidential information provided by the university is handled with strict privacy measures, and no sensitive institutional data is disclosed without proper authorization.

Additionally, the study, maintained objectivity and transparency in data analysis and reporting. All calculations, projections, and environmental equivalencies are derived using recognized industry standards and validated methodologies to prevent misrepresentation of results. There is no manipulation, fabrication, or intentional bias in data interpretation, ensuring that the study presents accurate and reliable findings. Furthermore, proper citation and acknowledgment of all sources, including emissions factors, environmental metrics, and financial models, are upheld to maintain academic integrity and prevent plagiarism. By following these ethical guidelines, the study ensures that its findings contribute responsibly to the discourse on sustainable energy solutions.

RESULTS AND DISCUSSIONS

This section presented the findings of the study, which analyzed the economic viability, efficiency, and environmental impact of adopting solar energy at NDDU – GC. Based on computational analysis, the results highlighted potential cost savings, reductions in greenhouse gas emissions, and improvements in energy efficiency. The discussion also linked these findings to broader sustainability goals, compared solar energy with conventional power sources, and emphasized its long-term environmental and financial benefits. Recommendations for future strategies were also provided.

Assessment of NDDU-GC's Solar Energy Potential

To assess the potential solar energy installation on the 1,723.459 square meter rooftop area shown in Figure 3 at NDDU-GC, estimate the number of solar panels that can be accommodated and the corresponding energy output.

Solar Panel Capacity Calculation

- Standard solar panel size: ~2 square meters per panel
- Panel efficiency: ~400W per panel (typical for modern panels)
- Estimated number of panels: $\frac{1{,}723.459\ \mathrm{m}^2}{2\ \mathrm{m}^2/\mathrm{panel}} = 860$ panels

The analysis of the 1,723.459-square-meter rooftop at NDDU-GC revealed strong potential for solar energy generation. Based on a standard panel size of 2 m² and a typical panel capacity of 400 W, the rooftop can accommodate approximately 860 panels, totaling 344 kW in system capacity.

The analysis confirmed that the 1,723.459 m² rooftop of NDDU–GC can support around 860 solar panels, yielding a total capacity of 344 kW. This demonstrates that the campus has adequate space for a substantial solar installation. Using 400W high-efficiency panels maximize energy output within the available area, making the system both practical and cost-effective. The results justify the feasibility of reducing electricity costs while advancing the university's sustainability goals.

The result supports NDDU-GC's goal of becoming a sustainable institution. It provides a solid foundation for further analysis of its economic and environmental impact.

The findings suggested that NDDU–GC has strong potential to transition toward renewable energy through solar power integration. With the ability to install a 344-kW solar system, the campus can significantly reduce its reliance on conventional electricity sources, resulting in long-term cost savings and lower carbon emissions. This supports institutional efforts aimed at achieving environmental sustainability and energy efficiency. Moreover, the study highlights the viability of using existing infrastructure for green technology, which can serve as a model for other academic institutions aiming to adopt clean energy solutions.

Total Power Output:

- Number of Panels x power output of each panel
- 860×400W=344,000W (or 344-kW)

The computed total power output of 344,000 watts (344-kW), derived from installing 860 solar panels rated at

400 watts each, confirms the substantial energy-generating potential of the NDDU-GC. This capacity represents the maximum instantaneous output the system can produce under optimal conditions, indicating that the university can generate a significant portion of its daily electricity needs through solar energy.

The calculated total system capacity of 344-kW, based on the installation of 860 solar panels rated at 400-W each, clearly demonstrates the energy-generating potential of the NDDU–GC rooftop. This output reflects the maximum power the system can produce under optimal sunlight conditions, confirming the adequacy of the available rooftop space for a large-scale solar installation. The analysis is grounded in standard engineering principles and solar energy metrics, validating the practicality and efficiency of utilizing solar power to meet a substantial portion of the campus's energy needs.

This result also serves as a critical baseline for estimating daily and annual energy production, cost savings, and environmental benefits. It highlights the practicality of utilizing the campus's available rooftop area to transition toward clean and sustainable energy sources.

The computed total output of 344,000 watts (344-kW) from 860 installed 400W solar panels confirms the substantial solar energy potential of NDDU–GC. This figure represents the system's peak capacity under ideal conditions, supporting the conclusion that a significant portion of the campus's daily electricity demand can be met through solar power. The analysis is justified by standard engineering calculations, aligning with real-world solar installation benchmarks and demonstrating both the feasibility and practicality of this renewable energy solution (Solar Energy International, 2004).

The findings imply that NDDU–GC can harness solar energy as a reliable and sustainable power source. With a potential output of 344-kW, the university can significantly reduce its reliance on traditional electricity sources, resulting in lower operational costs and a reduced environmental impact. This positions the campus to become a model for green energy adoption in educational institutions, highlighting the broader relevance of integrating renewable technologies into school infrastructure.

Energy Production

- Average solar radiation in the Philippines: ~4.5 kWh per square meter per day
- Daily energy production:344 kW×4.5 hours=1,548 kWh/day
- Annual energy production:1,548×365≈565,020 kWh/year

Based on an average of 4.5 peak sun hours per day in the Philippines, the proposed 344 kW solar PV system at NDDU-GC is estimated to generate approximately 1,548 kWh of electricity daily, translating to about 565,020 kWh annually. This level of energy production demonstrates the system's capacity to supply a substantial portion of the university's electricity needs, thereby reducing its reliance on the local grid and fossil fuels.

The estimate is grounded in realistic solar irradiance data and reflects typical operating conditions for solar systems in the region. These figures are crucial for calculating financial savings, environmental impact, and return on investment, thereby reinforcing the system's viability as a long-term, sustainable energy solution.

Based on an average of 4.5 peak sun hours per day in the Philippines, the proposed 344 kW solar PV system at NDDU-GC is estimated to generate approximately 1,548 kWh of electricity daily, or about 565,020 kWh annually. This energy production capacity demonstrates the system's potential to meet a substantial portion of the university's electricity needs, significantly reducing its dependence on the local grid and fossil fuels. These estimates are grounded in realistic solar irradiance data, reflecting typical operating conditions for solar energy systems in the region. The calculated output is crucial for assessing financial savings, environmental benefits, and return on investment, reinforcing the feasibility of the solar PV system as a long-term, sustainable energy solution for the university.

The findings indicate that the proposed 344-kW solar photovoltaic (PV) system at NDDU-GC has the potential to generate a substantial amount of electricity, thereby reducing the university's reliance on the local grid and

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue XXVI October 2025 | Special Issue on Education

fossil fuels. With an estimated annual energy production of 565,020 kWh, the system can offset a substantial portion of the campus's electricity consumption, resulting in lower energy costs and a reduced environmental footprint. This underscores the broader implications of integrating renewable energy in educational institutions, not only in terms of operational savings but also as a step toward achieving sustainability and environmental responsibility goals.

Additionally, these findings highlight the feasibility of solar power as a long-term energy solution in the region, where solar irradiance levels are favorable for consistent energy generation. The implementation of such systems can serve as a model for other institutions, demonstrating that solar energy can contribute to both financial savings and environmental sustainability, aligning with global trends in renewable energy adoption.

The study confirms that the 344-kW solar PV system proposed for NDDU-GC can generate approximately 565,020 kWh annually, providing a significant portion of the university's electricity needs. With the potential to offset a substantial amount of energy consumption, this system offers an effective solution for reducing reliance on the local grid and fossil fuels. The results validate the technical and economic viability of solar energy as a long-term, sustainable power source for the campus, supporting both cost savings and environmental sustainability goals. The findings position NDDU-GC as a potential leader in renewable energy adoption within educational institutions, reinforcing the importance of integrating solar power into the region's energy mix.

Cost and Return on Investment (ROI)

- Estimated installation cost: ~$1,000 per kW or P55,000.00 per kW344× P55, 000.00= P18,920,000.00
- Potential savings (assuming P10 per kWh energy cost):565,020×10= P 5,650,200 million PHP/year
- Payback period: (P18,920,000.00)/(P5,650,200.00)=3.35 years = 3-5 years (including maintenance)

The financial evaluation of the installation reveals an estimated cost of P55,000.00 per kilowatt (kW), totaling approximately P18,920,000.00 for a system with a capacity of 344 kW. This figure provides a clear picture of the initial capital required for the investment.

In terms of savings, the system's potential benefits are significant. Assuming an energy cost of P10 per kilowatt-hour (kWh), the total potential annual savings would be approximately P5,650,200.00. This reflects the annual savings that could be achieved by adopting the system, a crucial factor in determining the investment's financial viability.

The payback period, which indicates the time it takes for the savings to recover the initial investment, is approximately 3.35 years. This result suggests that the system will pay for itself in a relatively short period. Considering that the payback period can range from 3 to 5 years, including potential maintenance costs, this investment presents a promising opportunity with a quick return.

The financial evaluation of the proposed 344 kW solar PV system reveals an estimated installation cost of P55,000.00 per kilowatt (kW), leading to a total capital expenditure of approximately P18,920,000.00. This figure outlines the initial investment required for the solar energy system, providing clarity on the financial commitment involved.

In terms of potential savings, the system offers substantial financial benefits. With an energy cost of P10 per kilowatt-hour (kWh), the system could save the university approximately P5,650,200.00 annually. These savings demonstrate the economic advantage of adopting solar energy, which plays a key role in evaluating the long-term financial feasibility of the system.

The calculated payback period is approximately 3.35 years, indicating that the system will recover its initial investment within a relatively short timeframe. This period falls within the typical range of 3 to 5 years, considering potential maintenance and operational costs. The quick payback period enhances the investment's attractiveness, suggesting a high return on investment and confirming that the adoption of solar energy is not only environmentally beneficial but also financially viable in the near term.

INTERNATIONAL JOURNAL OF RESEARCH AND INNOVATION IN SOCIAL SCIENCE (IJRISS)
ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue XXVI October 2025 | Special Issue on Education

The findings suggest that the proposed 344 kW solar PV system at NDDU-GC not only offers a sustainable energy solution but also presents a sound financial investment. With an estimated annual savings of approximately P5,650,200.00, the system provides the university with significant cost reductions, which will be realized in a relatively short payback period of about 3.35 years. This financial advantage is crucial for justifying the initial investment and demonstrates the long-term viability of solar energy as a cost-effective alternative to traditional power sources.

The short payback period further strengthens the argument for adopting solar energy, making it an attractive option for institutions seeking to reduce operational costs while advancing their sustainability goals. In addition, the reduced dependence on the local grid and fossil fuels aligns with global environmental priorities, reducing the campus's carbon footprint and contributing to the broader effort of promoting renewable energy.

These findings have broader implications for other educational institutions and organizations considering similar energy transitions. The results highlight the feasibility of integrating solar power as a reliable, cost-effective, and environmentally responsible energy solution in the region.

Figure 2. Blueprint of NDDU - Glamang Campus Rooftop – Main Building

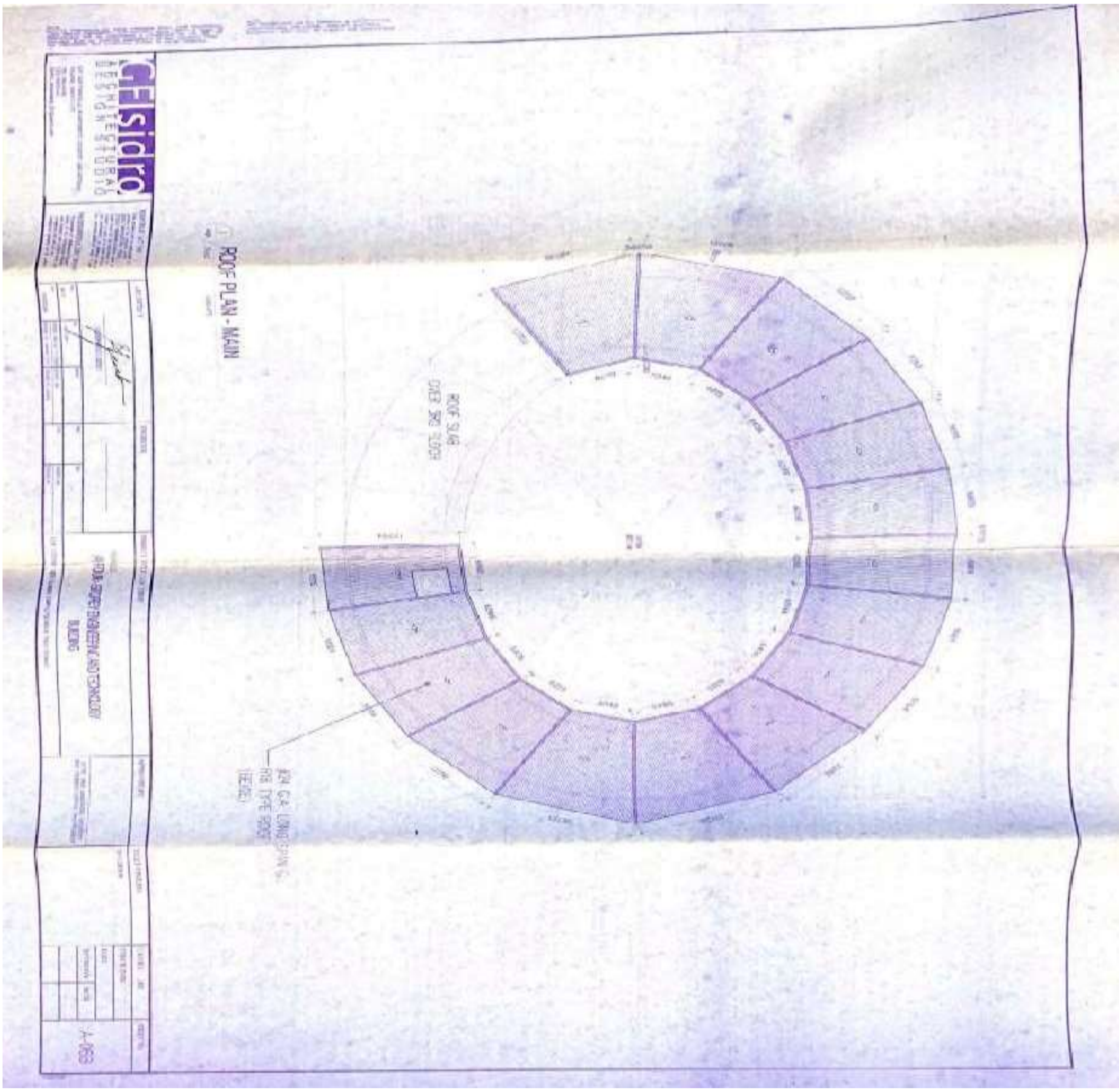
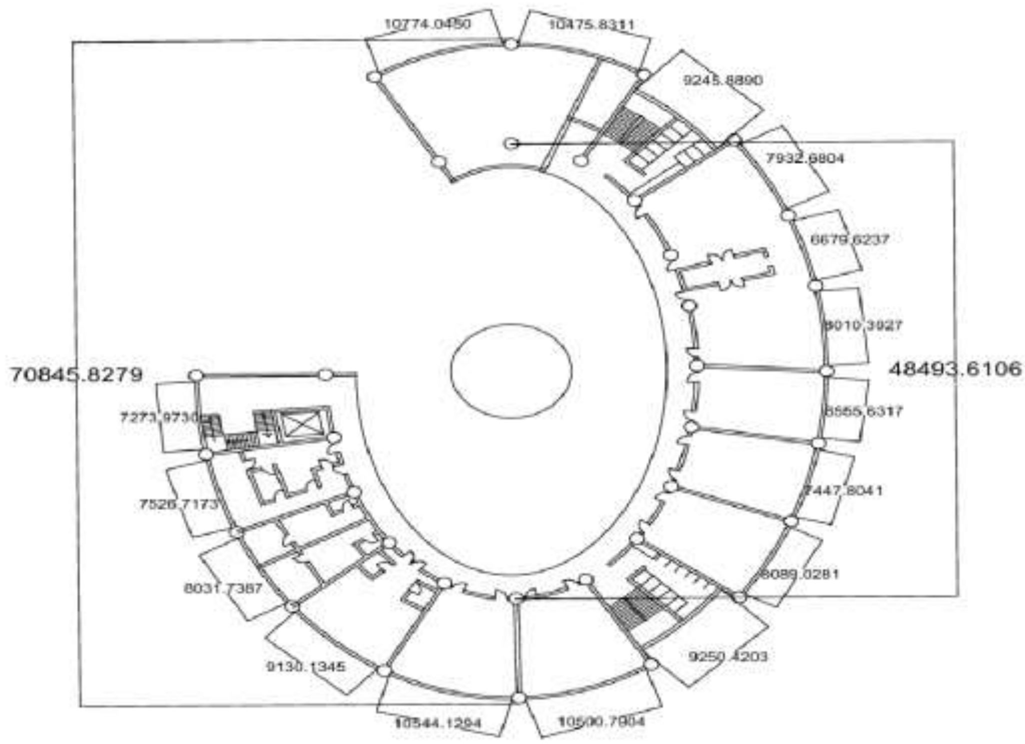


Figure 3. NDDU - Glamang Campus with a rooftop area of 1,723.459 square meters



The solar energy adoption cost savings

Current Electricity Cost:

NDDU-GC's current electricity consumption is 20,000 kWh per month. The electricity rate is PHP 13.33 per kWh.

Monthly electricity cost:

Monthly electricity cost=20,000 kWh×PHP13.33/kWh=PHP 266,600

Annual electricity cost:

Annual electricity cost=PHP266, 600×12=PHP 3,199,200Thus, NDDU-GC currently spends PHP 3,199,200 annually on electricity.

Solar Energy Contribution:

The electricity a 344 kW solar PV system can generate annually (in kilowatt-hours)

Formula Reference:

The general formula used for estimating solar PV energy generation is:$E = P \times H \times PR$

where
E = Energy output (kWh)

P = System size (kW)

H = Solar irradiance ($kWh/m^2/day$)

PR = Performance ratio (typically 0.75–0.85, depending on system losses)

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue XXVI October 2025 | Special Issue on Education

This formula is commonly used in solar PV design and assessment, including tools such as PVWatts (by NREL) and HOMER Energy Modeling Software.

Identify Key Variables

System Size (Power Output): 100 kW

Average Solar Irradiance in the Philippines (Peak sun hours/day): 4.5 hr/day

Performance Ratio (PR): 80% or 0.80 (accounts for system losses, inefficiencies, and environmental factors) Days in a Year: 365 days

Calculate Daily Energy Generation

The formula gives the energy output of a solar PV system:

Energy Output (kWh/day) = System Size × Solar Irradiance ×Performance Ratio=344 kW × 4.5 hr/day ×0.80 =1,235 kWh/day

Calculate Annual Energy Generation

Multiply the daily energy output by 365 days:

Energy Output (kWh/year) = 1235 kWh/day ×365 days/year=450 775 kWh/year

A proposed 344 kW solar PV system is expected to generate 450,775 kWh of electricity annually.

Annual savings from solar energy:

Annual savings=450,775 kWh×PHP13.33/kWh=PHP 6, 008, 830.75

Thus, the annual savings from implementing the solar system would be PHP 6,008,830.75.

Impact of Solar Energy Implementation on Greenhouse Gas (CO_2) Emission Reduction at NDDU-GC

NDDU-GC currently uses 240,000 kWh of electricity annually. According to the International Renewable Energy Agency (IRENA, 2020), the emissions factor for electricity in the Philippines is approximately 0.8 kg CO_2 per kWh.

Annual CO_2 emissions from current electricity use:

CO_2 emissions=Annual electricity usage in kWh× Emission Factor of 0.8 kg CO_2/kWh

CO_2 emissions=240,000 kWh×0.8 kg CO_2/kWh=192,000 kg CO_2

Thus, NDDU-GC’s current electricity use generates 192,000 kg CO_2 annually.

Solar Energy Offset:

The proposed solar PV system is expected to generate 450,775 kWh of electricity annually, which will offset a portion of the CO_2 emissions generated by NDDU-GC's current electricity use.

CO_2 emissions offset:

CO_2 offset= Electricity generated in kWh× Offset factor of 0.8 kg CO_2/kWh

CO_2 offset= 450,775 kWh×0.8 kg CO_2/kWh=360,620 kg CO_2

Thus, the solar system will reduce NDDU-GC's CO_2 emissions by 360,620 kg CO_2 annually.

Current Emissions: NDDU-GC's current electricity consumption results in approximately 192,000 kg of CO_2 emissions annually.

The proposed solar PV system is expected to offset approximately 360,620 kg of CO_2 annually, making a significant contribution to NDDU-GC's climate goals. By reducing reliance on fossil fuels, the system helps decrease the university's carbon footprint, aligning with global efforts to combat climate change.

This environmental benefit also enhances NDDU-GC's sustainability profile, serving as an example for other institutions and reinforcing its commitment to green practices. Overall, the system plays a key role in supporting NDDU-GC's sustainability initiatives and promoting cleaner energy solutions.

The solar initiative supports the Philippines' goal to reduce greenhouse gas (GHG) emissions by 70% by 2030, as stipulated in the Paris Agreement (Philippine DOE, 2008). By implementing solar energy, NDDU-GC not only contributes to national sustainability efforts but also sets a powerful example for other institutions to follow.

The proposed solar PV system is expected to offset approximately 360,620 kg of CO_2 annually, making a significant contribution to NDDU-GC's climate goals. By reducing reliance on fossil fuels, the system helps lower the university's carbon footprint, aligning with global efforts to mitigate climate change. This environmental benefit is essential not only in advancing the university's sustainability initiatives but also in enhancing its sustainability profile.

The system further demonstrates NDDU-GC's commitment to green practices, serving as a model for other institutions. Ultimately, the adoption of solar power plays a pivotal role in supporting NDDU-GC's sustainability efforts, reinforcing its dedication to cleaner energy solutions.

The findings indicate that the proposed solar PV system will significantly reduce NDDU-GC's carbon emissions by offsetting approximately 360,620 kg of CO_2 annually. This reduction is a crucial step in the university's efforts to combat climate change, aligning with global sustainability goals. The integration of renewable energy not only supports the university's climate commitments but also enhances its environmental reputation, positioning NDDU-GC as a leader in promoting green practices.

By decreasing dependence on fossil fuels, the system contributes to lowering the campus's overall carbon footprint. This environmental impact serves as a model for other educational institutions, demonstrating the feasibility and importance of adopting renewable energy solutions to meet sustainability objectives. The implementation of solar power will have lasting positive effects, both in terms of environmental stewardship and in encouraging further adoption of clean energy within the region.

The study confirms that the proposed 344 kW solar PV system at NDDU-GC offers significant environmental and financial benefits. With the potential to offset approximately 360,620 kg of CO_2 annually, the system aligns with the university's sustainability goals while reducing its reliance on fossil fuels. The estimated annual savings of P5,650,200.00, coupled with a payback period of just 3.35 years, make this investment financially viable.

This solar energy solution not only supports NDDU-GC's climate goals but also enhances its sustainability profile, positioning the campus as a model for other institutions. The system plays a crucial role in advancing cleaner energy practices, reaffirming the university's commitment to environmental responsibility and long-term sustainability.

Energy optimization outcome (Fuel & Energy Reduction) equivalent to the reduction of CO_2 emission.

Car Traveled Distance Avoided

To determine how far an average car would travel (equivalent distance travelled) to emit 96,000 kg CO_2.

A gasoline-powered passenger vehicle emits about:

- 2.31 kg CO_2 per liter of gasoline (EPA estimate)
- 8.89 kg CO_2 per gallon of gasoline (since 1 gallon = 3.785 liters)
- Average fuel economy: 22 miles per gallon (mpg) or 9.41 km per liter

Car Traveled Distance Avoided = CO_2 offset x Factor

$$= \frac{96000\text{kg } CO_2/\text{year}\left(\frac{9.41\text{km}}{\text{liter}}\right)}{2.31 \text{ kg } CO_2/\text{liter}}$$

$$=391{,}065 \text{ km/year}$$

Equivalent: A reduction of 96,000 kg CO_2 is equivalent to removing the emissions from an average gasoline car traveling approximately 391,065 km/year (about 243,008.6 miles/year).

The calculated results show that a reduction of 96,000 kilograms of CO_2 emissions is equivalent to preventing a typical gasoline-powered car from traveling approximately 391,065 kilometers (243,009 miles) in a year. This conversion provides a tangible and relatable interpretation of carbon emissions, helping stakeholders and the general public visualize the environmental impact of CO_2 reductions. According to estimates from the U.S. Environmental Protection Agency (EPA), a typical gasoline-powered car emits approximately 2.31 kilograms of carbon dioxide (CO_2) per liter of gasoline consumed. With an average fuel efficiency of 9.41 kilometers per liter, this translates to about 0.2455 kilograms of CO_2 emitted for every kilometer traveled. Using this data, the total CO_2 reduction of 96,000 kilograms can be converted into a tangible metric by dividing it by the per-kilometer emission rate. The result is an equivalent avoided distance of approximately 391,065 kilometers.

This distance is remarkably significant. It is equivalent to driving around the Earth's equator nearly 9.8 times, considering the Earth’s circumference is about 40,075 kilometers. It also corresponds to roughly 15 coast-to-coast trips across the United States, each averaging about 4,184 kilometers. Furthermore, this distance represents more than 20 years of average annual driving for a single vehicle, assuming a global average of 19,000 kilometers per year. Presenting the reduction in CO_2 emissions in this way makes the impact more concrete and easier to grasp.

Translating CO_2 emission reductions into the equivalent distance not traveled by a car offers a relatable and impactful way to communicate the importance of climate action. Organizations and institutions working toward reducing their carbon footprints can use this form of measurement to demonstrate their progress more effectively. When people understand how emissions relate to everyday activities—like driving—it becomes easier to connect with the data on a personal level.

This approach not only improves public understanding but also encourages meaningful behavioral changes. For example, individuals may be more inclined to drive less or use public transportation when they recognize the environmental benefits. Furthermore, it supports the promotion of carbon offset programs and justifies the investment in green technologies and practices by showing clear, measurable outcomes.

The findings underscore the urgent need to prioritize transportation reforms as part of broader climate action strategies. Since the transportation sector is one of the leading contributors to CO_2 emissions, shifting toward more sustainable alternatives can have a significant impact. Promoting the use of electric vehicles powered by renewable energy, expanding public transportation systems, and encouraging carpooling or cycling can substantially reduce emissions over time.

Additionally, the data on car travel distance avoided can be a valuable tool for supporting various sustainability initiatives. Universities, corporations, and government agencies can incorporate this metric into environmental reports, policy advocacy, and awareness campaigns. It provides a clear, understandable benchmark that strengthens the case for carbon-neutral transportation and enhances public support for climate policies.

The calculated equivalent of 391,065 kilometers of car travel avoided through a reduction of 96,000 kilograms of CO_2 emissions offers a compelling narrative for sustainability efforts. It bridges the gap between abstract carbon metrics and real-world impact, illustrating how carbon reductions can be achieved through practical actions like reducing vehicle use. By making climate data more tangible and relatable, this approach can effectively mobilize support for environmental initiatives and promote widespread adoption of sustainable practices. Based on the results indicating that a reduction of 96,000 kilograms of CO_2 emissions is equivalent to preventing a gasoline-powered vehicle from traveling approximately 391,065 kilometers annually, it is strongly recommended that institutions, organizations, and communities prioritize initiatives that reduce carbon emissions, particularly from transportation-related sources. This could include encouraging the use of fuel-efficient or electric vehicles, promoting carpooling programs, and investing in sustainable public transportation infrastructure.

Gasoline Consumption Saved Burning 1 gallon of gasoline emits 8.89 kg CO_2.

Calculation: Gasoline Consumption Saved = CO_2 offset x Factor = 360,620 kg CO_2 /8.89 kg CO_2/gallon =40,565 gallons of gasoline Equivalent: Saving 40,565 gallons of gasoline per year.

The solar PV system at NDDU-GC is estimated to offset 360,620 kg of CO_2 annually, equivalent to saving 40,565 gallons of gasoline per year. This is based on the emission factor that burning 1 gallon of gasoline produces 8.89 kg of CO_2.

This significant reduction in gasoline consumption highlights the environmental benefit of adopting solar energy, decreasing reliance on fossil fuels, and contributing to lower CO_2 emissions. The savings in gasoline underscore the solar system's potential to support sustainability efforts and reduce the campus's carbon footprint.

The proposed solar PV system at NDDU-GC is expected to offset 360,620 kg of CO_2 annually, equivalent to saving 40,565 gallons of gasoline. This highlights the significant environmental impact of the system in reducing fossil fuel reliance and lowering the campus's carbon footprint. The results underscore the system's effectiveness as both an environmentally and financially viable solution for the university.

The study shows that the proposed solar PV system at NDDU-GC will reduce CO_2 emissions by 360,620 kg annually, equivalent to saving 40,565 gallons of gasoline. This highlights the significant environmental impact of transitioning to renewable energy. The findings highlight the potential of solar energy in reducing reliance on fossil fuels, supporting global climate goals, and enhancing the university's sustainability efforts.

The study confirms that the proposed 344 kW solar PV system at NDDU-GC offers both substantial environmental and financial benefits. By offsetting 360,620 kg of CO_2 annually, the system makes a significant contribution to reducing the campus's carbon footprint, equivalent to saving 40,565 gallons of gasoline per year. Additionally, the system provides a viable financial solution, with a payback period of approximately 3.35 years and annual savings of P5,650,200.00.

Next steps should include a detailed financial analysis, explore funding options, and develop a maintenance plan to ensure long-term performance. Additionally, NDDU should integrate this project into its sustainability strategy and serve as a model for other institutions to follow.

Oil Barrels Saved

Burning 1 barrel of crude oil emits 430 kg CO_2.

Calculation:Oil Barrels Saved = CO_2 offset x Factor

=360,620 kg CO_2/430 kg CO_2/barrel=839 barrels of oil

Equivalent: Avoiding the burning of 839 barrels of oil.

The study reveals that the proposed solar PV system at NDDU-GC will offset approximately 360,620 kg of CO_2 annually. When translated into the equivalent amount of oil consumption avoided, this CO_2 reduction is equivalent to saving 839 barrels of crude oil. This is based on the emission factor that burning one barrel of crude oil produces 430 kg of CO_2.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue XXVI October 2025 | Special Issue on Education

This comparison highlights the substantial environmental impact of the solar system, underscoring its role in reducing reliance on fossil fuels and mitigating carbon emissions. By avoiding the burning of 839 barrels of oil each year, the solar PV system contributes to the global effort to decrease oil consumption and its associated environmental harm. These findings highlight the effectiveness of solar energy in promoting cleaner, sustainable energy practices, not only for NDDU-GC but as an example for other institutions to follow in reducing their carbon footprints.

The proposed solar PV system at NDDU-GC will offset 360,620 kg of CO_2 annually, equivalent to saving 839 barrels of crude oil, based on the emission factor of 430 kg CO_2 per barrel.

This demonstrates the system's significant environmental impact by reducing fossil fuel consumption and carbon emissions. The savings highlight solar energy's effectiveness in replacing polluting energy sources, supporting both financial viability and sustainability goals for the campus.

The study shows that the proposed solar PV system will offset 360,620 kg of CO_2 annually, equivalent to saving 839 barrels of crude oil per year. This highlights the significant environmental benefits of adopting solar energy, which reduces reliance on fossil fuels and supports global sustainability goals.

The results suggest that NDDU-GC can serve as a model for other institutions, demonstrating the potential of solar power to contribute to a cleaner, more sustainable future.

The study confirms that the proposed 344 kW solar PV system at NDDU-GC will provide substantial environmental and financial benefits. By offsetting 360,620 kg of CO_2 annually, the system significantly reduces the campus's carbon footprint, equivalent to saving 839 barrels of crude oil each year. Additionally, the system offers substantial financial savings, with a payback period of approximately 3.35 years.

This initiative aligns with NDDU-GC's sustainability goals, supports global climate efforts, and demonstrates the viability of solar energy as an effective solution for reducing reliance on fossil fuels. The findings position the university as a leader in renewable energy adoption, setting an example for other institutions to follow in promoting cleaner, more sustainable energy practices.

Coal Burning Prevented

Burning one metric ton of coal emits 2,460 kg CO_2.Calculation:

Coal Burning Prevented =CO_2 offset x Factor

=360,620 kg CO_2/2,460 kg CO_2/ton

=784 tons of coal

Equivalent: Avoiding the combustion of 784 metric tons of coal.

The study indicates that the proposed solar PV system at NDDU-GC will offset approximately 360,620 kg of CO_2 annually. This is equivalent to preventing the combustion of 784 metric tons of coal, based on the emission factor of 2,460 kg CO_2 per ton of coal.

This result underscores the significant environmental benefit of adopting solar energy, as coal is one of the most carbon-intensive fossil fuels. By avoiding the use of 784 tons of coal annually, the university significantly reduces its contribution to greenhouse gas emissions. This reinforces the role of renewable energy systems in combating climate change and advancing sustainable energy practices in academic institutions.

The projected CO_2 offset of 360,620 kg from the proposed solar PV system corresponds to the avoidance of approximately 784 metric tons of CO_2 emissions from coal combustion. This calculation utilizes the standard emission factor of 2,460 kg CO_2 per ton of coal, clearly illustrating the significant environmental value of the system.

Preventing the burning of such a large quantity of coal highlights the effectiveness of solar energy in reducing harmful emissions. It justifies the system not only as a clean energy solution but also as a practical measure to align NDDU-GC with global efforts to cut carbon pollution and adopt sustainable energy alternatives.

The finding that the solar PV system can prevent the burning of 784 metric tons of coal annually underscores its significant environmental benefits. This implies a substantial reduction in harmful emissions, contributing to cleaner air and a healthier campus environment.

NDDU-GC can play a significant role in addressing climate change by reducing its reliance on high-emission energy sources. This reinforces the value of investing in renewable energy, not only for cost savings but also for long-term environmental sustainability.

Laptop charging avoided

Charging a laptop emits 0.028 kg CO_2 per charge.

Calculation: Laptop charges avoided =CO_2 offset x Factor

=360,620 kg CO_2 / 0.028 kg CO_2/charge

=12,879 286 laptop charges

Equivalent: 12.88 million laptop charges avoided.

The study estimates that the proposed solar PV system at NDDU-GC will offset 360,620 kg of CO_2 annually. This is equivalent to avoiding approximately 12.88 million laptop charges, based on an emission factor of 0.028 kg CO_2 per charge.

This comparison illustrates the practical, everyday impact of the system's carbon savings. Framing the offset in terms of avoided laptop charges makes the environmental benefit more relatable and underscores the scale of emissions reduction. It highlights how widespread and consistent energy use, such as routine device charging, can significantly contribute to carbon emissions, and how solar energy can effectively mitigate that impact.

The annual CO_2 offset of 360,620 kg from the proposed solar PV system is equivalent to avoiding approximately 12.88 million laptop charges, using the standard emission factor of 0.028 kg CO_2 per charge. This comparison highlights the substantial reduction in emissions achieved by the system.

By translating the carbon offset into a familiar activity, the result becomes more tangible and relatable, particularly in an academic setting where device usage is high. This further justifies the adoption of solar energy as an effective means to lower emissions from everyday electricity consumption, reinforcing both its environmental and educational value.

The finding that the proposed solar PV system could offset the equivalent of 12.88 million laptop charges annually highlight its relevance to academic environments like NDDU-Glamang Campus. It implies that the university can significantly reduce carbon emissions from routine energy use, especially in technology-driven settings.

This reinforces the practicality of renewable energy in supporting both environmental goals and the digital needs of the institution, positioning solar power as a sustainable solution for modern educational facilities.

Emissions avoided from loads of laundry from Washing Machines

A washing machine cycle emits 0.6 kg CO_2 per load.

Calculation:

Emissions avoided from loads = CO_2 offset x Factor

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue XXVI October 2025 | Special Issue on Education

=360,620 kg CO_2/0.6 kg CO_2/load

=601,034 loads of laundry

Equivalent: Avoiding emissions from 601,034 loads of laundry.

The study estimates that the proposed solar PV system at NDDU-GC will offset 360,620 kg of CO_2 annually. This offset is equivalent to avoiding the emissions from approximately 601,034 loads of laundry, based on an emission factor of 0.6 kg CO_2 per load.

This comparison helps put the scale of the carbon savings into perspective by relating it to an everyday daily activity, such as doing laundry. With laundry being a significant source of energy consumption in many households and institutions, the avoidance of over 600,000 loads of laundry illustrates the substantial impact that renewable energy, such as solar power, can have in reducing carbon emissions from everyday activities.

This result highlights the importance of integrating sustainable energy solutions, such as solar photovoltaic (PV) systems, into university operations as part of a broader commitment to environmental responsibility.

The projected CO_2 offset of 360,620 kg from the proposed solar PV system equates to avoiding the emissions from 601,034 loads of laundry, using the standard emission factor of 0.6 kg CO_2 per load. This highlights the large-scale impact that adopting renewable energy can have on reducing everyday carbon emissions.

By framing the CO_2 offset in terms of avoided laundry loads, the result becomes more relatable, demonstrating how solar energy can effectively reduce emissions from everyday activities in academic settings. The analysis justifies the system as a practical and impactful solution for the university to lower its overall carbon footprint while contributing to broader sustainability goals.

The finding that the solar PV system can offset the emissions from 601,034 loads of laundry annually underscores its significant environmental impact in everyday operations. By reducing carbon emissions associated with common activities, such as washing laundry, the system demonstrates how renewable energy can contribute to lowering the carbon footprint of institutional operations.

This also highlights the broader potential for solar energy to reduce emissions in other areas of daily life, making it a practical and relatable tool for achieving sustainability goals. NDDU-GC, by adopting solar power, can serve as an example of how even small shifts in energy sources can lead to large-scale environmental benefits.

Cement Production Avoided

Producing one metric ton of cement emits 600 kg CO_2.

Calculation:

Cement Production Avoided = CO_2 offset x Factor=360,620 kg CO_2/600 kg CO_2/ton

=601 metric tons of cement

Equivalent: Avoiding the production of 601 metric tons of cement.

The study calculates that the proposed solar PV system at NDDU-Glamang Campus will offset 360,620 kg of CO_2 annually, which is equivalent to avoiding the production of approximately 601 metric tons of cement. This estimation is based on the emission factor of 600 kg CO_2 per ton of cement produced.

This result emphasizes the environmental significance of the system, as cement production is one of the most significant sources of industrial CO_2 emissions. By preventing the production of 601 metric tons of cement, the system demonstrates its potential to reduce industrial emissions, which are typically harder to mitigate compared to other sectors. This not only contributes to NDDU's sustainability goals but also reflects a broader effort to reduce carbon footprints in the construction and manufacturing industries.

The CO_2 offset of 360,620 kg from the proposed solar PV system is equivalent to avoiding the production of 601 metric tons of cement, based on an emission factor of 600 kg CO_2 per ton of cement. This comparison highlights the substantial impact that the system can have on reducing industrial emissions, particularly from cement production, which is a major contributor to global carbon emissions.

By framing the CO_2 savings in terms of avoided cement production, the analysis makes the environmental benefits of solar energy more tangible and accessible. It emphasizes its role in addressing difficult-to-reduce emissions from industrial sectors. The results provide strong justification for the adoption of solar PV systems, positioning them as key tools for achieving both local and global sustainability goals.

The finding that the proposed solar PV system could offset 360,620 kg of CO_2 annually, equivalent to avoiding the production of 601 metric tons of cement, underscores its substantial environmental impact. Cement production, a primary industrial source of CO_2 emissions, contributes significantly to global carbon footprints. By reducing the need for cement production, the system aligns with broader efforts to mitigate industrial emissions.

This result highlights the potential for renewable energy systems, such as solar power, to mitigate the environmental impact of sectors traditionally reliant on fossil fuels. The implications are far-reaching, suggesting that solar energy can contribute not only to the sustainability of educational institutions but also to broader industrial initiatives aimed at reducing carbon emissions.

Environmental Equivalents of CO_2 Reduction: Trees, Cars, Waste, and Consumption Metrics

Trees Planted

One mature tree absorbs about 22 kg CO_2 per year.

Calculation:

Trees Planted = CO_2 offset x Factor

=360,620 kg CO_2 / 22 kg CO_2/tree/year

=16,392 trees

Equivalent: Planting 16,392 trees to absorb the same amount of CO_2 in one year.

The solar PV system at NDDU-Glamang Campus is projected to offset 360,620 kg of CO_2 annually. This is equivalent to the CO_2 absorption of approximately 16,392 mature trees, with each tree absorbing 22 kg of CO_2 per year. This comparison effectively illustrates the environmental benefit of the solar installation in terms of a widely recognized and relatable natural process—tree planting.

The result emphasizes the significant impact that renewable energy can have in mitigating climate change. While planting trees is a traditional method for carbon offsetting, the solar PV system offers a more scalable and immediate solution to reducing CO_2 emissions. This comparison not only highlights the environmental impact of the solar energy system but also reinforces the broader need for multi-faceted approaches to sustainability. By offsetting CO_2 emissions that conventional energy sources would otherwise release, the solar system serves as a crucial tool in reducing the campus's carbon footprint and enhancing its sustainability profile.

The solar PV system at NDDU-Glamang Campus can offset 360,620 kg of CO_2 annually, equivalent to the absorption of 16,392 trees, with each tree absorbing 22 kg of CO_2 per year. This comparison highlights the significant environmental impact of the system, demonstrating its effectiveness in reducing carbon emissions in a scalable and immediate manner. While tree planting is a valuable long-term strategy, the solar PV system offers a faster, more efficient method for carbon offsetting, making it a practical and impactful solution for achieving

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue XXVI October 2025 | Special Issue on Education

sustainability goals on campus.

The finding that the proposed 344 kW solar PV system at NDDU-Glamang Campus can offset 360,620 kg of CO_2 annually, equivalent to the absorption of 16,392 trees, demonstrates the significant environmental impact of adopting renewable energy. This result highlights the potential of solar power to replace traditional energy sources that significantly contribute to carbon emissions. The comparison to tree planting provides a relatable context for understanding the scale of CO_2 reduction, showcasing how renewable energy systems can play a crucial role in mitigating climate change in a manner that is immediate, scalable, and measurable.

This finding underscores the importance of transitioning to cleaner energy sources, providing a viable solution to reduce carbon footprints, particularly in institutional settings such as universities. It also reinforces the value of sustainable infrastructure investments in achieving long-term environmental goals and serves as an encouraging example for other institutions to consider renewable energy solutions.

The proposed 344-kW solar PV system at NDDU-GC has the potential to significantly reduce the university's carbon footprint by offsetting 360,620 kg of CO_2 annually. This is equivalent to the carbon absorption of 16,392 mature trees, illustrating the substantial environmental impact of adopting solar energy. The system provides an immediate and effective means of reducing CO_2 emissions, aligning with NDDU's sustainability goals and contributing to global efforts to combat climate change.

The results confirm the feasibility of solar energy as a cost-effective and impactful solution for universities and other institutions seeking to minimize their environmental impact while supporting sustainable development.

Car Emissions per Kilometer Avoided

The average passenger car emits 0.168 kg of CO_2 per kilometer, based on U.S. EPA estimates for gasoline-powered cars.

Total Distance Equivalent, Given a CO_2 reduction of 360,620 kg:

Car Emissions per Kilometer Avoided = CO_2 offset x Factor

=360,620 kg CO_2/0.168 kg CO_2/km

=2,146,546.6 km

Equivalent to avoiding the emissions from driving 2,146,546.6 km

The study calculates that the proposed solar PV system at NDDU-GC can offset 360,620 kg of CO_2 annually. This is equivalent to avoiding the emissions from driving approximately 2,146,546.6 kilometers in an average passenger car, based on an emission factor of 0.168 kg CO_2 per kilometer.

This result helped to contextualize the environmental impact of the solar PV system by comparing it to the emissions associated with car travel, a familiar daily activity. The avoidance of over 2.1 million kilometers driven highlights the significant reduction in carbon emissions that can be achieved by using renewable energy sources. Given that transportation is a significant contributor to global CO_2 emissions, this comparison underscores the importance of solar power in mitigating emissions from other sectors, such as transportation, in a meaningful and measurable way.

The result also emphasized the effectiveness of solar power in mitigating carbon emissions in academic settings, where it can serve as a key solution to reducing overall environmental impact.

The CO_2 offset of 360,620 kg from the proposed solar PV system is equivalent to avoiding the emissions from driving approximately 2,146,546.6 kilometers in an average passenger car, based on the emission factor of 0.168 kg CO_2 per kilometer. This calculation is significant because it places the environmental impact of the solar system in terms of a familiar activity—driving—making the benefits more relatable and tangible.

By framing the CO_2 savings in terms of avoided car emissions, the analysis highlights the substantial contribution that renewable energy can make in reducing transportation-related emissions. This is particularly relevant in regions where transportation is a significant source of carbon emissions. The comparison highlights the potential for solar power to help mitigate emissions in sectors beyond electricity generation, further justifying the solar PV system as an effective and scalable solution for reducing a university's carbon footprint.

The finding that the proposed solar PV system can offset 360,620 kg of CO_2 annually, equivalent to avoiding the emissions from 2,146,546.6 kilometers of driving, demonstrates the powerful environmental impact of renewable energy. Transportation, particularly gasoline-powered vehicles, remains one of the most significant contributors to global carbon emissions. By equating the system's CO_2 reduction to car emissions avoided, the study makes the environmental benefits of solar energy more accessible and relatable to everyday activities.

This result suggests that solar energy, particularly in academic institutions, can make a significant contribution to reducing transportation-related carbon footprints, which are often challenging to mitigate through other means. By adopting solar power, NDDU-GC could not only reduce its emissions but also set a positive example for other institutions to consider renewable energy as part of their sustainability strategies.

Equivalent Number of Cars' Emissions Avoided

The average gasoline car emits 4.6 metric tons (4,600 kg) of CO_2 per year, based on EPA data, assuming an annual distance of 22,530 km.

Calculation:

Number of Cars' Emissions Avoided = CO_2 offset x Factor

=360,620 kg CO_2/4,600 kg CO_2/car/year

=78.39 cars

Equivalent to avoiding the emissions from 79 cars

The proposed solar PV system at NDDU-GC is projected to offset 360,620 kg of CO_2 annually. This is equivalent to avoiding the emissions produced by approximately 79 average gasoline-powered cars. Based on EPA data, each car emits approximately 4.6 metric tons (4,600 kg) of CO_2 annually, assuming an average annual distance driven of 22,530 kilometers.

This result highlights the substantial environmental impact of the solar system by framing its benefits in terms of everyday activities, such as driving a car. By avoiding the emissions from 79 cars, the solar PV system not only contributes significantly to the campus's sustainability goals but also provides a clear and relatable benchmark for understanding its effectiveness in reducing carbon emissions.

This comparison underscores the role of renewable energy in mitigating emissions from transportation, a significant contributor to global CO_2 levels. It also illustrates how an institution like NDDU-Glamang Campus can leverage solar energy to offset emissions typically associated with the transportation sector.

The result, showing that the proposed 344 kW solar PV system at NDDU-GC could offset 360,620 kg of CO_2 annually, equivalent to the emissions of 79 average gasoline cars, provides a concrete understanding of the system's environmental impact. This calculation is based on EPA data, which estimates that an average gasoline-powered car emits 4.6 metric tons (4,600 kg) of CO_2 annually, assuming 22,530 kilometers of driving per year.

By comparing the CO_2 offset to car emissions, the analysis highlights the practical, real-world benefits of the solar system in reducing greenhouse gas emissions. The calculation is valuable because it relates to an everyday activity (driving), making the system's impact more relatable and tangible. It provides a valuable benchmark for assessing how the solar energy system aligns with broader sustainability goals, especially in addressing emissions from the transportation sector, which is one of the most significant contributors to CO_2 pollution.

This result justifies the implementation of solar energy as an effective tool not only for reducing emissions within the campus but also for setting an example in the community, demonstrating the viability of renewable energy in reducing carbon footprints associated with high-emission activities, such as car travel.

The solar PV system at NDDU-GC can offset 360,620 kg of CO_2 annually, equivalent to the emissions of 79 gasoline-powered cars. This highlights the crucial role of renewable energy in reducing carbon emissions, particularly from high-emission sectors such as transportation.

The results show that even localized initiatives, such as a university campus adopting solar power, can make a substantial contribution to sustainability goals. It also highlights the potential for such systems to serve as models for broader adoption of renewable energy, inspiring other institutions to reduce their carbon footprints.

Recycling Waste Instead of Landfilling

Recycling one metric ton of mixed waste saves about 1,220 kg CO_2.

Calculation:

Recycling Waste = CO_2 offset x Factor

=360,620 kg CO_2/1,220 kg CO_2/ton

=295,590 tons of waste recycled

Equivalent: Recycling 295,590 metric tons of waste instead of landfilling it.

The proposed solar PV system at NDDU-GC is projected to offset 360,620 kg of CO_2 annually, which is equivalent to recycling 295,590 metric tons of mixed waste instead of sending it to a landfill. This comparison highlights the significant environmental benefits of the solar energy system in a context that is familiar and impactful.

Recycling, a well-known strategy for reducing carbon emissions, saves about 1,220 kg of CO_2 per metric ton of waste. By equating the CO_2 offset to the amount of waste recycled, we can better understand the magnitude of impact that the solar PV system has in terms of mitigating environmental harm. This result emphasizes the role that renewable energy plays in not only reducing direct emissions from electricity consumption but also in fostering a more sustainable future by reducing reliance on landfills, which contribute to greenhouse gas emissions.

The result that the proposed 344 kW solar PV system at NDDU-GC can offset 360,620 kg of CO_2 annually, equivalent to recycling 295,590 metric tons of mixed waste, provides a clear and impactful perspective on the environmental benefits of solar energy. By comparing CO_2 offset with waste recycling, a widely recognized essential environmental practice, the scale of the impact becomes more tangible for stakeholders. Recycling one metric ton of waste saves approximately 1,220 kg of CO_2, making the total offset by the solar system substantial, which highlights the efficiency and scalability of solar energy in reducing the carbon footprint.

This analysis emphasizes that the solar PV system offers a practical and measurable solution for reducing emissions. It serves as a reminder that renewable energy sources, such as solar power, not only provide clean energy but also contribute significantly to sustainability by reducing CO_2 emissions, comparable to other efforts like recycling and waste management.

The findings demonstrate that the adoption of solar energy at NDDU-GC can make a substantial contribution to reducing CO_2 emissions. The recycling comparison emphasizes the effectiveness of the system in addressing environmental issues. The results show that the solar PV system's environmental impact is comparable to other standard sustainability practices, such as recycling, and reinforce the importance of integrating renewable energy into comprehensive sustainability strategies.

The implication is clear: the university's transition to solar energy can significantly reduce its carbon footprint and contribute to broader climate action efforts. It further illustrates how the campus can lead by example in promoting eco-friendly practices, not only through its energy consumption but also by adopting a holistic approach to environmental stewardship.

The proposed 344-kW solar PV system at NDDU-GC has the potential to offset 360,620 kg of CO_2 annually, which is equivalent to recycling 295,590 metric tons of mixed waste instead of landfilling it. This result underscores the substantial environmental impact of the solar energy system, demonstrating its potential to significantly reduce the university's carbon footprint and contribute to efforts aimed at mitigating climate change.

Recycling Paper

Recycling one metric ton of paper saves about 1,818 kg CO_2.

Calculation:

Recycling Paper = CO_2 offset x Factor =360,620 kg CO_2 / 1,818 kg CO_2/ton

=198.36 tons of paper recycled

Equivalent: Recycling 198.36 metric tons of paper instead of producing new paper.

The study shows that the proposed 344 kW solar PV system at NDDU-GC will offset approximately 360,620 kg of CO_2 annually. This CO_2 offset is equivalent to recycling 198.36 metric tons of paper, rather than producing new paper. This comparison offers a tangible way to understand the environmental impact of solar energy by relating it to a widely recognized activity (paper recycling) that is known for its ecological benefits.

Recycling paper saves 1,818 kg of CO_2 for every metric ton of paper recycled, so the total CO_2 offset by the solar system (360,620 kg) mirrors the environmental benefit of recycling nearly 200 tons of paper. This highlights the effectiveness of solar power not only in generating renewable energy but also in making a significant contribution to reducing carbon emissions. Just as recycling paper reduces the need for raw materials and lowers energy consumption in paper manufacturing, the solar PV system helps eliminate the need for electricity generated from fossil fuels, thereby cutting CO_2 emissions.

This analogy also strengthens the understanding of how solar energy fits into broader sustainability practices. The impact of the solar system can be easily visualized by comparing it to a familiar action, such as recycling, making it more transparent how renewable energy can contribute significantly to a university's climate goals. This result underscores the significant role of solar power in reducing carbon footprints and promoting sustainable practices at the university.

The proposed 344 kW solar PV system at NDDU-GC is projected to offset 360,620 kg of CO_2 annually, which is equivalent to recycling 198.36 metric tons of paper instead of producing new paper. This comparison helps contextualize the environmental impact of the system, making it more relatable by linking it to a widely understood action (paper recycling) that is beneficial to the environment.

Recycling paper is a well-recognized method for reducing carbon emissions, as it conserves natural resources and reduces the energy required for paper production. By comparing the CO_2 offset of the solar PV system to this process, we can appreciate the significant role that solar energy plays in reducing carbon emissions, comparable to other sustainable practices, such as recycling. This analysis further emphasizes the positive environmental contribution of the solar system, making a compelling case for the university's transition to renewable energy.

The findings demonstrate the substantial environmental benefits of installing a solar photovoltaic (PV) system at NDDU-GC. The equivalence to recycling nearly 200 metric tons of paper highlights the system's impact in reducing carbon emissions. The findings suggest that by shifting to solar power, NDDU-GC can significantly reduce its carbon footprint, aligning with global efforts to mitigate climate change.

Moreover, these findings also underscore the crucial role that renewable energy plays in promoting sustainability. Just as recycling paper conserves natural resources and energy, so too does solar energy by displacing fossil fuels and reducing the university's reliance on non-renewable energy sources. The interpretation of these results shows that solar power, much like paper recycling, is an effective and scalable method for reducing greenhouse gas emissions.

The proposed 344-kW solar PV system at NDDU-GC offers substantial environmental benefits, with an estimated annual CO_2 offset of 360,620 kg. This amount of CO_2 reduction is equivalent to recycling 198.36 metric tons of paper instead of producing new paper. The comparison helps visualize the environmental impact of the solar system, demonstrating its significant contribution to reducing carbon emissions and supporting sustainable practices at the university.

Avoiding Plastic Bottle Production

Producing one plastic water bottle (500 mL) emits 0.0828 kg CO_2.

Calculation:

Avoiding Plastic Bottle Production = CO_2 offset x Factor

=360,620 kg CO_2 / 0.0828 kg CO_2/bottle

=4,355,314 bottles

Equivalent: Avoiding the production of 4,355,314 plastic bottles.

The study's results highlight the substantial environmental benefits of the proposed 344 kW solar PV system at NDDU-GC, particularly in terms of CO_2 emissions avoided. By offsetting 360,620 kg of CO_2 annually, the system achieves an impact comparable to avoiding the production of 4,355,314 plastic bottles.

Each 500 mL plastic bottle emits approximately 0.0828 kg of CO_2 during its production process. Using this factor, the study calculates that the CO_2 offset by the solar system is equivalent to preventing the manufacture of over 4.35 million plastic bottles. This comparison highlights the significant environmental benefits of the solar energy system, including reduced waste and a lower overall carbon footprint associated with plastic production.

The avoidance of plastic bottle production aligns with global efforts to reduce plastic waste and the carbon emissions generated throughout the production lifecycle of plastic goods. This finding not only reinforces the importance of transitioning to renewable energy but also illustrates the broader positive environmental impact that can result from sustainable energy initiatives. By avoiding the production of millions of plastic bottles, the solar system at NDDU-GC will contribute to reducing both plastic waste and the carbon emissions that drive climate change.

Reduction in Meat Consumption

Producing 1 kg of beef emits 27 kg CO_2.

Calculation:

Reduction in Meat Consumption = CO_2 offset x Factor

=360,620 kg CO_2 / 27 kg CO_2/kg beef

= 13,356.30 kg of beef

Equivalent: Avoiding the production of 13.36 metric tons of beef.

The study reveals that the solar PV system at NDDU-GC can offset approximately 360,620 kg of CO_2 annually. This offset is equivalent to avoiding the production of 13.36 metric tons of beef, considering that the production of 1 kg of beef emits 27 kg of CO_2.

This finding highlights the substantial environmental impact of meat production, particularly beef, which is recognized for its high carbon footprint resulting from factors such as land use, feed production, and methane emissions from cattle. By reducing or avoiding meat consumption, particularly beef, the solar energy system indirectly contributes to addressing the environmental costs associated with meat production.

The equivalent of avoiding the production of 13.36 metric tons of beef highlights how shifting to renewable energy not only reduces carbon emissions from electricity generation but also helps mitigate broader environmental issues linked to food production. This comparison highlights the importance of sustainable practices across various sectors and industries, demonstrating how efforts to adopt renewable energy align with global objectives for mitigating climate change.

The study's results provide compelling justification for the environmental benefits associated with installing a solar PV system at NDDU-GC. The 360,620 kg of CO_2 offset annually by the solar system can be directly compared to a range of activities with significant environmental impact, such as the avoidance of beef production. The equivalence of 13.36 metric tons of beef production avoided highlights the magnitude of the carbon savings and the importance of adopting renewable energy as part of broader sustainability strategies.

The study considers realistic and standard factors for CO_2 emissions, including the carbon footprint of beef production (27 kg CO_2 per kilogram of beef) and the energy savings achieved through solar energy generation. By reducing its reliance on fossil fuels and the local electricity grid, the solar PV system helps the university reduce its carbon footprint and contribute to global efforts to mitigate greenhouse gas emissions.

Job Generation Benefits of Solar Energy System Implementation

The installation of the solar PV system is expected to generate jobs, including roles in installation, maintenance, and operation. These jobs provide local employment and contribute to the economy during and after installation.

Computation of Manpower Needed for Maintenance of a 334 kW Solar PV System

To determine the number of workers required for maintenance, the researcher utilized industry standards and labor estimates.

Key Assumptions

Standard maintenance labor requirement: 0.02 labor-hours per watt per year

System size: 334 kW = 334,000 W

Total maintenance labor needed annually

Total Labor-Hours per Year $=334{,}000\times0.02$

$=6{,}680$ labor-hours per year

Work hours per day: 8 hours per worker

Workdays per year: Assume 250 workdays (excluding weekends and holidays)

Compute Manpower Requirement

Workers Needed = Total Annual Labor-Hours/ Work Hours per Worker per Year

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume IX Issue XXVI October 2025 | Special Issue on Education

$= 6,680/(8\times250)$

$= 3.34$ workers (Say four workers)

The calculation of the workforce needed to maintain the 334-kW solar PV system reveals that four full-time workers are required annually. This estimate is based on the total annual labor-hours (6,680 hours) divided by the work hours per worker per year (8 hours per day × 250 days), resulting in a need for approximately 3.34 workers. Rounding up, the system would require four workers for effective operation and maintenance.

This workforce requirement suggests that the solar PV system can be managed with a small team, making it a cost-effective solution in terms of labor. With four full-time staff members, NDDU-GC can ensure the system operates efficiently throughout the year, supporting both the operational needs of the system and the university's sustainability objectives.

Proposed solar energy plan in NDDU-Glamang Campus

The increasing global demand for clean and sustainable energy sources has led educational institutions to explore environmentally responsible alternatives to conventional power generation. In line with this worldwide trend and its commitment to sustainability, Notre Dame of Dadiangas University - Glamang Campus is embarking on a transformative initiative to adopt solar energy. This Solar Energy Implementation Plan outlines a systematic and strategic approach to the gradual integration of solar power on campus, aiming to decrease reliance on fossil fuels, reduce energy expenses, and promote environmental responsibility.

This plan not only outlines the technical and logistical considerations necessary for the successful integration of photovoltaic systems but also emphasizes the broader benefits to the university community and the environment. By shifting to solar energy, the university aims to harness the abundant sunlight available in the region, particularly in General Santos City, which enjoys high solar irradiance levels throughout the year. This geographic advantage provides a solid foundation for achieving energy self-sufficiency and climate responsibility.

The document further elaborates on the phases of implementation, ranging from feasibility assessment and financial planning to installation, monitoring, and long-term evaluation. In doing so, it aims to ensure that the transition to renewable energy is efficient, financially viable, and sustainable over the long term. Moreover, the plan envisions the university as a model for other academic institutions in the Philippines to adopt renewable energy, promoting a culture of environmental consciousness, innovation, and a proactive response to the climate crisis.

Objectives

To guide the successful implementation of solar energy at Notre Dame of Dadiangas University – Glamang Campus, this plan identifies specific objectives that align with the institution’s sustainability goals. These objectives serve as the foundation for decision-making, resource allocation, and the overall direction of the project, ensuring that both environmental and economic benefits are realized throughout the transition to renewable energy.

Reduce dependency on conventional energy sources by integrating solar power.

- Lower electricity costs through renewable energy savings.
- Minimize greenhouse gas (GHG) emissions to contribute to environmental sustainability.
- Enhance awareness and engagement within the university community on sustainable energy practices.
- Develop a model that can be replicated by other institutions considering solar energy adoption.

Phased Implementation Strategy

To ensure a systematic and efficient transition to solar energy, this implementation plan adopts a phased approach. Each phase is designed to address specific components of the project—from initial assessments to full-scale deployment and evaluation—allowing for informed decision-making, effective resource utilization, and continuous improvement. This step-by-step strategy minimizes risks and ensures that the university's shift to renewable energy is both technically sound and financially sustainable.

Phase 1: Feasibility Assessment and Site Selection

The first phase of the implementation process focuses on evaluating the technical and logistical viability of integrating solar energy systems within the campus. This involves a comprehensive assessment of current energy consumption patterns, identification of optimal installation sites, and analysis of regional solar potential. By establishing a solid foundation through data-driven insights and structural evaluations, this phase ensures that subsequent steps are grounded in practical feasibility and aligned with the university's energy needs.

- Conduct an energy audit to determine current electricity consumption and peak demand.
- Identify suitable locations for solar panel installations, such as rooftops and open land areas.
- Evaluate solar irradiation levels in the region using PAGASA solar resource data.
- Assess the structural integrity of buildings to support the installation of photovoltaic (PV) systems.

Phase 2: System Design and Financial Planning

Following the feasibility assessment, the second phase centers on the detailed design of the solar power system and the development of a robust financial framework to support its implementation. This stage involves determining the appropriate system capacity based on energy demands, evaluating cost-efficiency through financial modeling, and exploring funding options such as grants, incentives, and partnerships. Careful planning during this phase ensures that the solar energy project is both technically optimized and economically sustainable.

- Determine the optimal capacity of the solar PV system based on energy needs.
- Conduct a cost-benefit analysis to estimate long-term financial savings.
- Secure funding through government incentives, grants, and private partnerships.
- Obtain necessary permits and approvals from local energy regulators.

Phase 3: Procurement and Installation

With the system design and financial plans in place, Phase 3 focuses on acquiring high-quality solar equipment and executing installation activities. This stage involves selecting reliable suppliers, ensuring compliance with safety and performance standards, and overseeing the physical installation of the solar panels and related infrastructure. Proper implementation during this phase is critical to achieving system reliability, operational efficiency, and long-term performance.

- Select high-efficiency solar panels and inverters from reputable suppliers.
- Ensure compliance with national and international safety and performance standards.
- Install monitoring systems to track energy generation and consumption.
- Implement proper grid integration to ensure seamless power distribution and optimal system performance.

Phase 4: Monitoring and Evaluation

The final phase of the implementation plan focuses on the ongoing assessment of the solar energy system's performance to ensure it meets the intended energy, financial, and environmental objectives. This includes real-time monitoring of energy output, routine maintenance, and the analysis of cost savings and environmental impact. Continuous evaluation not only supports system optimization but also provides valuable insights that can inform future improvements and serve as a reference for other institutions pursuing similar initiatives.

- Regularly assess system performance through real-time monitoring.
- Conduct periodic maintenance to ensure optimal efficiency.

- Analyze energy savings, cost reductions, and environmental impact.
- Publish reports and case studies to share insights with the academic community.

Projected Benefits

The implementation of solar energy at Notre Dame of Dadiangas University – Glamang Campus is expected to yield a range of significant benefits. These outcomes extend beyond cost savings and energy efficiency, contributing to the university's broader goals of environmental sustainability, operational resilience, and community engagement. This section outlines the anticipated economic, ecological, and educational impacts that reinforce the long-term value of transitioning to renewable energy.

- Economic Viability: Reduction in electricity costs, leading to long-term financial savings.
- Efficiency: Increased energy reliability with solar power supporting university operations.
- Environmental Sustainability: Reduction in carbon footprint through decreased fossil fuel consumption.
- Community Engagement: Educational programs on renewable energy are offered to students and faculty.

CONCLUSION

The study concluded that the NDDU-Glamang Campus (NDDU-GC) possesses significant potential for solar energy generation due to its expansive 1,723.459 m² rooftop. With the ability to accommodate approximately 860 high-efficiency 400W solar panels, the campus could produce a total system output of 344 kW. This finding validates the technical and spatial feasibility of implementing a large-scale solar power system at the university, offering a sustainable solution for reducing electricity costs while promoting environmentally responsible operations.

The solar energy system's potential to offset 360,620 kg of CO_2 annually further highlights the substantial environmental benefits it provides, equating to significant reductions in carbon emissions. This contribution supports the university's commitment to sustainability and energy efficiency, aligning with broader global efforts to reduce reliance on fossil fuels and mitigate climate change.

RECOMMENDATIONS

Based on the study's findings, the following recommendations are made for NDDU-GC:

1. Proceed with Implementation:

   - It is highly recommended that NDDU-GC move forward with the development and installation of the 344 kW solar PV system. This system will substantially reduce the university's electricity costs and contribute to its long-term sustainability goals.

2. Conduct Detailed Feasibility and Financial Analysis:

   - Before full implementation, a detailed feasibility study should be conducted, including a cost-benefit analysis to assess financial investment, system maintenance, and expected savings. This will help gauge the return on investment and identify potential challenges.
   - A financial model should also include a clear analysis of upfront costs, expected savings, and the system's payback period, estimated at around 3.35 years.

3. Secure Funding and Partnerships:

   - NDDU-GC should explore funding options, such as applying for government incentives, grants, or collaborating with renewable energy providers. These partnerships could reduce the financial burden and offer technical expertise throughout the project.

4. Develop a Maintenance Plan:

   - A comprehensive maintenance strategy should be put in place to ensure the solar system operates at peak efficiency for years to come. Regular performance monitoring is essential to maximize the long-term benefits of the system.

5. Integrate the Initiative into the University's Sustainability Strategy:

   - The solar power project should be integrated into NDDU-GC's broader sustainability efforts, showcasing the institution's commitment to reducing its carbon footprint. Additionally, the university can serve as a model for other educational institutions, promoting the value of renewable energy adoption.

6. Promote Environmental Awareness:
   - NDDU-GC should incorporate the solar power system into environmental awareness campaigns. Using relatable metrics, such as the CO_2 offset equivalent (e.g., avoiding emissions from 601,034 loads of laundry or 2,146,546 km of driving), will help the community understand the tangible impact of their efforts.

7. Explore Future Expansion:

   - In the future, NDDU-GC could explore expanding the solar system's capacity, including energy storage solutions to optimize energy use and enhance the system's efficiency across campus operations.

By adopting these recommendations, NDDU-GC will not only reduce its energy costs but also take a crucial step toward becoming a leader in sustainability in the educational sector, setting a positive example for other institutions to follow in the transition to renewable energy solutions.

REFERENCES

1. Al Garni, H. Z., Kassem, A., Awasthi, A., Komljenovic, D., & Al-Haddad, K. (2016). A multicriteria decision making approach for evaluating renewable power generation sources in Saudi Arabia. Sustainable Energy Technologies and Assessments, 16, 137–150. https://doi.org/10.1016/j.seta.2016.03.006
2. Asian Development Bank. (2024). Challenges and opportunities in renewable energy deployment in Southeast Asia. https://www.adb.org
3. Ayoub, N., & Yuji, N. (2012). Application of analytical hierarchy process for the evaluation of renewable energy sources in Jordan. Energy Policy, 45, 331–342. https://doi.org/10.1016/j.enpol.2012.02.013
4. Babatunde, O. M., Munda, J. L., & Madzivhandila, T. S. (2019). The impact of renewable energy use on sustainable economic development: A case of solar energy adoption in South Africa. International Journal of Energy Economics and Policy, 9(5), 191–198. https://doi.org/10.32479/ijeep.8135
5. BloombergNEF. (2023). Solar energy reaches cost parity in global markets. Bloomberg New Energy Finance.
6. BloombergNEF. (2024). New energy outlook 2024. Bloomberg Finance L.P.
7. Central Luzon State University (CLSU). (2023). CLSU installs 997-kilowatt rooftop solar system. CLSU News.
8. Department of Energy (DOE). (2023). Philippine Energy Situationer 2023. Department of Energy, Republic of the Philippines.
9. Department of Energy (DOE). (2024). Green Energy Auction Program (GEAP). Republic of the Philippines. https://www.doe.gov.ph
10. Department of Labor and Employment (DOLE). (2023). Employment opportunities in the renewable energy sector. DOLE Reports.
11. Energy Regulatory Commission (ERC). (2023). Net metering and renewable energy incentives. Government of the Philippines.

12. García, R. A., Díaz, J. M., & Blanco, C. J. (2020). Computational tools for data analysis in energy and environmental research: A practical approach. Renewable and Sustainable Energy Reviews, 130, 109956. https://doi.org/10.1016/j.rser.2020.109956
13. Global Energy Monitor. (2024). General Santos Solar Power Project. https://globalenergymonitor.org
14. Go Solar Trek. (2024). Bifacial solar panels and global efficiency gains. https://gosolartrek.com
15. GreenYellow. (2024). Advancements in energy storage technologies. GreenYellow Insights.
16. GreenYellow. (2024). Innovations in solar energy storage. https://greenyellow.com
17. Hannan, M. A., Begum, R. A., Abdolrasol, M. G., Hossain Lipu, M. S., Mohamed, A., & Rashid, M. M. (2018). Review of baseline studies on energy policies and indicators in Malaysia for sustainable development. Renewable and Sustainable Energy Reviews, 94, 551–564. https://doi.org/10.1016/j.rser.2018.06.041
18. Intergovernmental Panel on Climate Change (IPCC). (2023). Climate Change 2023: Mitigation of Climate Change. IPCC Sixth Assessment Report.
19. Intergovernmental Panel on Climate Change. (2024). Climate change 2024: Mitigation of climate change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar6/wg3/
20. International Energy Agency (IEA). (2023). Renewables 2023: Analysis and Forecast to 2028. IEA Publications.
21. International Energy Agency. (2024). Renewables 2024: Analysis and forecast to 2029. https://www.iea.org/
22. International Renewable Energy Agency (IRENA). (2023). Renewable capacity statistics 2023. IRENA.
23. International Renewable Energy Agency (IRENA). (2024). Global trends in solar energy. IRENA.
24. International Renewable Energy Agency (IRENA). (2024). Renewable energy market analysis: Southeast Asia. https://www.irena.org
25. International Renewable Energy Agency. (2024). Renewable energy market analysis: Global outlook 2024. https://www.irena.org/
26. Johnston, M. P. (2017). Secondary data analysis: A method of which the time has come. Qualitative and Quantitative Methods in Libraries, 3(3), 619–626. https://qqml-journal.net/index.php/qqml/article/view/169
27. Le Monde. (2024). China surpasses 2030 renewable goals ahead of schedule. Le Monde International.
28. Li, H., Wang, X., Zhang, Y., & Liu, J. (2022). Environmental education and pro-environmental behavior: A case study of university students in China. Journal of Cleaner Production, 333, 130161. https://doi.org/10.1016/j.jclepro.2021.130161
29. MindaNews. (2022). Agrovoltaic solar plant planned in General Santos. https://mindanews.com
30. National Renewable Energy Laboratory (NREL). (2023). High-efficiency solar technologies. U.S. Department of Energy.
31. National Renewable Energy Laboratory. (2023). Photovoltaic system payback and lifetime performance. https://www.nrel.gov/
32. PAGASA. (2024). Solar radiation data. Philippine Atmospheric, Geophysical and Astronomical Services Administration. https://www.pagasa.dost.gov.ph
33. Philippine Department of Energy. (2024). Renewable energy development program. https://www.doe.gov.ph/
34. Philippine News Agency. (2024). Universities go solar to cut energy costs and promote sustainability. https://www.pna.gov.ph
35. RatedPower. (2024). Perovskite and tandem solar cell breakthroughs. https://ratedpower.com
36. RatedPower. (2024). Technological innovations in solar PV. RatedPower Solar Insights.
37. Samaras, C., & Meisterling, K. (2008). Life cycle assessment of greenhouse gas emissions from plug-in hybrid vehicles: Implications for policy. Environmental Science & Technology, 42(9), 3170–3176. https://doi.org/10.1021/es702178s
38. Solar Energy Industries Association. (2023). National solar jobs census 2023. https://www.seia.org/
39. Solar Energy International. (2004). Photovoltaics: Design and installation manual. New Society Publishers.
40. The Times. (2024). UK expands solar installations on schools and NHS sites. https://thetimes.co.uk

41. Time. (2024). India's solar ambitions face policy and financial challenges. Time Magazine.
42. U.S. Department of Energy. (2023). Solar incentives and policy support. https://www.energy.gov/
43. U.S. Environmental Protection Agency. (2023). Greenhouse gas equivalencies calculator. https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator
44. United Nations Environment Programme. (2024). Global trends in renewable energy investment 2024. https://www.unep.org/
45. United Nations. (2015). Transforming our world: The 2030 Agenda for Sustainable Development. United Nations General Assembly.
46. University of the Philippines System (UP System). (2023). UP Manila's solar project expansion reduces carbon footprint. UP System News.
47. Vox. (2024). U.S. sees record growth in solar energy. Vox Energy Reports.
48. World Bank. (2023). Scaling solar: Accelerating solar power in emerging markets. https://www.worldbank.org/
49. World Bank. (2023). Scaling solar: Empowering markets and communities. https://www.worldbank.org/
50. World Bank. (2023). Solar energy and water conservation: Global trends. World Bank Publications.
51. World Resources Institute. (2023). How solar power can help address water scarcity. https://www.wri.org