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Techno-economic Analysis of a Grid-tied Rooftop Solar PV System for a Public Elementary School in Laguna, Philippines using HOMER Pro

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Abstract

Techno-economic analysis (TEA) is used to test the integration of renewable energy (RE) systems in existing facilities and off-grid areas. Public facilities such as schools with enough rooftop space and operating mostly during the day can potentially benefit from RE systems. Thus, this study performed TEA to find an alternative, cost-effective, grid-tied RE system for a public elementary school in Laguna, Philippines. TEA reveals that the most cost-effective system consists of a 55.3 kW solar PV, a 19.2 kWh battery storage, a 27.8 kW inverter, and a grid connection. This configuration yielded a net present cost (NPC) of Php5,898,483 and a levelized cost of energy (LCOE) of Php6.94 per kWh. This alternative system could reduce the grid electricity import of the school by 39,008 kWh and generate Php433,373 savings annually. These findings underscore the economic benefits of introducing RE-based power systems in existing facilities, particularly public schools.

Keywords: Renewable energy integration, energy savings, levelized cost of electricity, green buildings

Introduction

The transition to clean and sustainable energy sources is continuously being promoted worldwide (IRENA, 2020). One trend that emerged from this initiative is the integration of renewable energy (RE) systems in public and private facilities, and rural communities. One way to assess the technical and financial feasibility of RE systems is techno-economic analysis (TEA). This analysis involves the design of alternative power generation systems that serve a load demand, and the determination of a cost-effective system that lowers the levelized cost of energy (LCOE) and net present cost (NPC) (Guédez, 2016).

TEA has been used in several studies. Nurunnabi and Roy (2015) tested a grid-tied, solar PV, wind, battery, and converter hybrid system for a rural community in Khulna, Bangladesh. The system resulted in an LCOE that is 75% lower, and a reduction in NPC by $674,339.00. Pawar and Nema (2018) designed a system featuring a grid, solar PV, and converter in an administrative building in Maharashtra, India for which the LCOE went down by 68.4% and an NPC savings of $14,466.00 was projected. A grid, solar PV, wind, fuel cell converter, and battery system were also tested in the Koh Samui Islands in Southern Thailand (Chaichan et al., 2022), with results showing that the LCOE and NPC were reduced by 75% and $116M, respectively. In the same year, the study of Eze et al. (2022) on a grid, solar PV, wind, diesel, battery, and inverter system for the University of Nairobi, Kenya resulted in a lower LCOE of about

61%. Locally, a study by Lozano et al. (2019) in Gilutongan Island, Cordova, Cebu showed that a diesel and solar PV system reduced the LCOE by 70%. In 2021, Lemence and Tamayao showed that a grid, solar PV, and inverter system could serve as an alternative power source for a rural health unit in Los Baños, Laguna while lowering LCOE by 42%.

It is evident from previous studies that RE systems, particularly grid-tied solar PVs, can supply energy demands despite having a high RE fraction. Through TEA, these studies reveal that RE systems lower the LCOE by 35-75% and reduce grid purchase and electric bills. However, although these studies differed in target site (residential, rural, or industrial), most were focused on rural electrification and few have studied RE integration in urban facilities where energy loads and demands could be very different. As such, this study was focused on TEA of a potential RE system in a city government facility particularly a public school. A government facility was chosen as target site since government facilities can capitalize on the benefits that grid-tied solar PV systems can provide especially for the education sector. In the Philippines, the education sector settles its electric bill through its fund allotment for maintenance and other operating expenses (MOOE) which accounts for its highest budget allocation (DepEd, 2022). With potential savings projected via a well-executed and thorough TEA, the transition toward RE-based power systems can gain wider support from education administrators and policy makers.

Considering the ideal operating hours of public schools and the availability of rooftop space while addressing the problems of high electricity rates, a techno-economic design and analysis of an alternative grid-connected RE system using solar PV and energy storage under different implementation configurations for a public elementary school was performed. Specifically, the study sought to (1) determine the least cost RE system in terms of LCOE and NPC, (2) compare the performance of the RE system with and without battery energy storage, and (3) analyze the economic potential of the designed system against the grid-only system.

The project location is Calamba Elementary School located in Calamba City, Laguna. Currently with more than 3,500 students, the school has 77 regular classrooms, an administrative office, a canteen, a computer laboratory, and hallways that use electricity. The size of the school, its energy demand, and suitable roof spaces for solar installation are the primary considerations for selecting the school as study site.

Materials and Methods

The overall framework of the methodology was divided into three parts: data input, simulation, and output analysis. Input data included site conditions (e.g., load profile and energy demand), technological specifications (e.g., solar PV, battery, and inverter), environmental conditions (e.g., solar GHI, clearness index, and temperature), and economic parameters (e.g., interest and inflation rates) which were obtained from available and recent data. These were processed using HOMER Pro software, a widely utilized tool for the techno-economic evaluation of RE systems. Simulation results from HOMER Pro were examined and analyzed to determine the viability of a grid-connected RE system for the elementary school.

Data Inputs

Energy Demand and Load Profile

An energy survey is typically used to model the load profile of a system (Chisale et al., 2023; Hossain et al., 2017). This was done through interviews with the school authorities (i.e., principal, administrative officers, and teachers). Table 1 summarizes the results of this energy survey.

As seen from Table 1, the school's power consumption is high during weekdays only, particularly during the daytime. On weekends, the school only consumes electricity at night. Lastly, the school has comparably lower consumption during its 2-month summer break in the absence of regular academic activities.

Table 1. Usage of electrical appliance in the school during weekdays, weekends, and the summer break

LOAD DESCRIPTION		QTY.	POWER RATING (W)	USAGE
Facility	Appliances			
WEEKDAYS				
Classrooms	Lighting Fixtures	462	36	6am-7am
	Electric Fan	308	50	7am-4pm
	LED TV	77	28	7am-4pm
	Laptop	77	20	7am-4pm
Administrative Office	Lighting Fixtures	6	36	8am-5pm
	Electric Fan	1	50	8am-5pm
	AC Unit	1	746	8am-5pm
	Computer	3	100	8am-5pm
Computer Laboratory	Computers	20	100	1pm-4pm
Canteen	Lighting Fixture	4	36	7am-4pm
	Electric Fan	2	50	7am-4pm
	Refrigerator/Cooler	4	150	7am-4pm
Security Lighting	Lighting Fixture	30	36	6pm-6am
WEEKENDS				
Security Lighting	Lighting Fixture	30	36	6pm-6am
SUMMER BREAK (July and August)				
Administrative Office	Lighting Fixtures	6	36	8am-5pm
	Electric Fan	1	50	8am-5pm
	AC Unit	1	746	8am-5pm
	Computer	3	100	8am-5pm
Security Lighting	Lighting Fixture	30	36	6pm-6am

Using the energy survey data, HOMER Pro generated the school's daily and monthly load profiles shown in Figures 1A and 1B, respectively. On average, the school consumes around 141 kWh/day and 5.87 kW of power. The school also has a very low load factor of 15%. This is mainly because of the contrast between the high power demand during daytime and the low power demand during nighttime.

RE Resource

To calculate the power production of the solar PV system, solar global horizontal irradiation (GHI) and clearness index data were obtained from the National Renewable Energy Laboratory (NREL) National Solar Radiation Data Base (NSRDB). The average solar GHI exposure of the school is 4.97 kWh/m^2/day, which peaks at 6.0284.97 kWh/m^2/day in April. Figure 2A shows the available solar GHI in the location of the school (14^{o}12'37.68" N, 121^{o}10'4.30" E).

Meanwhile, temperature data was also included in the study to consider its effect on solar power production. The National Aeronautics and Space Administration (NASA) Prediction of Worldwide Energy Resources (POWER) database was used to model the average temperature data in Calamba and results are shown in Figure 2B.

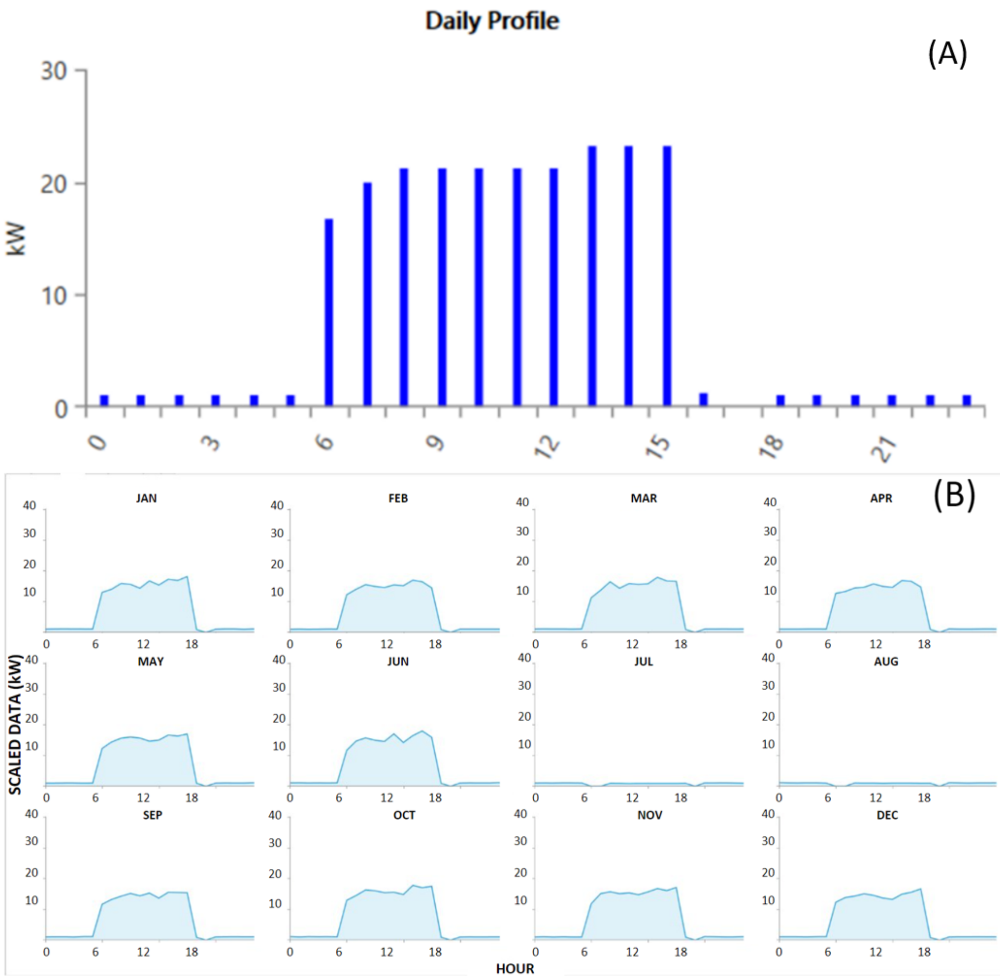

Figure 1: *(A) Weekday and (B) monthly daily load profiles of the school generated using HOMER Pro*

System Components

The model components identified in the study were based on the typical components offered by local solar power installers in the Philippines. Their prices were set based on average current market prices. Furthermore, all other associated installation costs were set within the range provided by local solar power installers.

1. Solar PV

The solar PV component used was the JAM72S20 450/MR half-cell module with a rated maximum power and module efficiency of 450W and 20.3%, respectively. Meanwhile, the derating factor and component lifetime used for the solar PV was 80% and 25 years, respectively. The average capital cost of the solar PV system was set to be P40,313.80 per kW. On the other hand, the operating and maintenance (O&M) cost was assumed to be 1% of the capital costs, which was around P403.14 per year (Ja Solar Technology Co., Ltd., n.d., Lemence & Tamayao, 2021, Asamoah et al., 2022).

The rooftop of the school's multi-purpose covered court was chosen as site for the installation of the solar PV system due to its larger available area (9.92 m x 33.00 m) compared with other structures in the school. Considering solar panel dimensions of 2.11 m x 1.05 m, the maximum

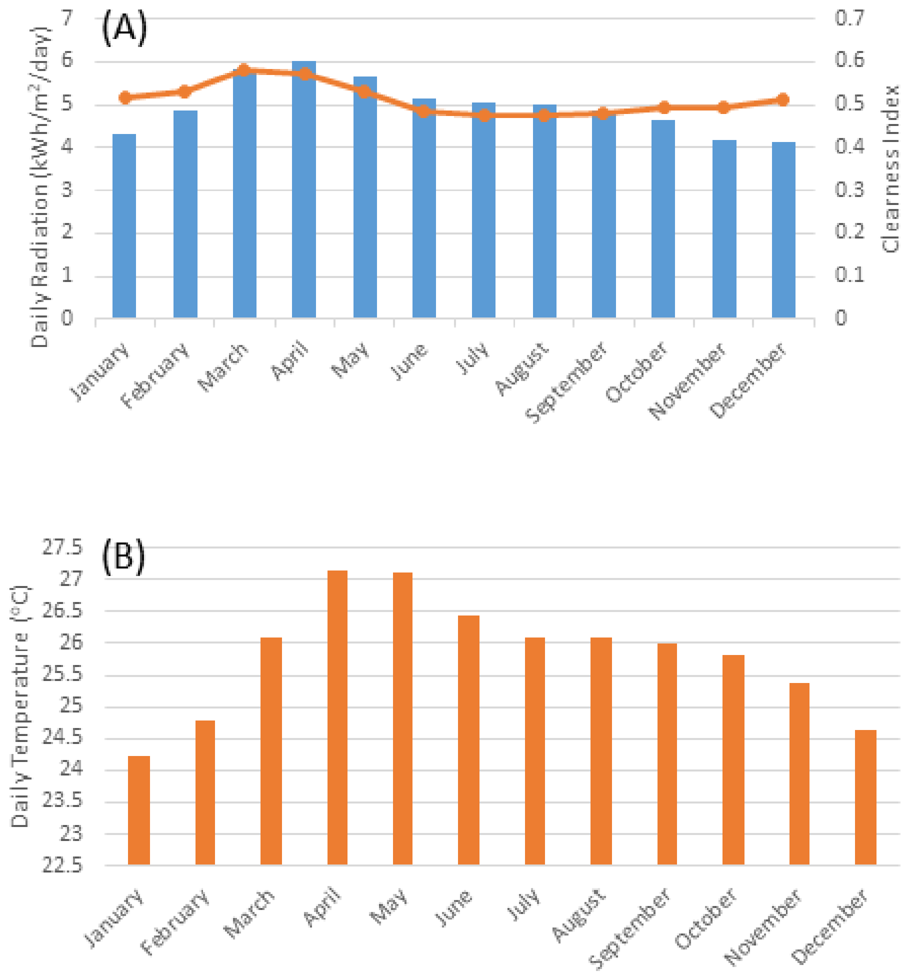

Figure 2: *(A) Monthly average solar GHI, and (B) monthly average temperature*

Sources: A - Sengupta et al., 2018; B - NASA-LaRC, (n.d.) in Calamba, Laguna, Philippines

allowable solar PV capacity that can be installed in the rafter is 60.750 kW. This serves as the upper limit constraint in the simulation.

2. Battery Energy Storage

The battery energy storage component considered in the study was the BSL BATT B-LFP 48-100PW with a nominal voltage of 48V, round-trip efficiency of 98%, and maximum discharge and charge currents of 100A and 50A, respectively. The minimum state of charge (SOC) of the battery is 20%. The service lifetime of the battery is 15 years. The capital cost of the battery model was estimated to be P99,642.32 per piece. Replacement cost was set equal to capital cost, while operation and maintenance cost was assumed zero (BSLBATT, n.d.).

3. Inverter

For the inverter component, the SUN 5K-SG04LP1-EU was used in the study, which has a 5 kW rated AC output power and 96.5% efficiency. The service lifetime of the inverter is 15 years. Capital and replacement cost was estimated to be P10,805.62 per kW. The O&M cost was also assumed nil (Ningbo Deye Inverter Technology Co., Ltd., n.d.).

4. Grid

The school is connected to a utility grid of the

Manila Electric Cooperative (MERALCO) under the Business – General Service A classification. The grid purchase price was set at P11.11 per kWh based on a 12-month average retail electricity rate.

Project Inputs

The annual capacity shortage was set at 0% to simulate a no-load-loss condition. Meanwhile, the inflation rate was set at 6.30% based on a 12-month average data from the Philippine Statistics Authority. On the other hand, the interest rate was set at 10% based on the recommended discount rate of the National Economic Development Administration (NEDA) for evaluating project viability. Finally, the project lifetime was assumed to be 25 years.

HOMER Pro Simulation

HOMER Pro was used to run the simulations employing relevant input parameters. HOMER Pro is the flagship software of HOMER Energy that primarily addresses the complexities of feasibility analyses of RE systems. The software determines solutions that can meet the technical requirements of a RE system based on annual capacity shortage and rooftop space constraints. This is done by calculating an energy balance between the load demand of the school and available power from the RE system. Each technically feasible solution is then evaluated for their economic performance. Finally, HOMER identifies the most economical solutions with the lowest net present cost (NPC) (HOMER Energy, n.d.).

Techno-economic Analysis (TEA)

The goal in TEA is to determine the performance of a particular technology and subsequently assess its value. This analysis framework allows decision-makers to objectively evaluate the feasibility of a certain technology considered for implementation by weighing benefits against risks and costs (U.S. Department of Energy [DOE], n.d.). For RE projects, TEA mainly involves determining the NPC and LCOE. These parameters provide important baseline information about the potential of a RE project over a specific project lifetime (National Renewable Energy Laboratory [NREL], n.d.).

In this study, TEA was used to determine the lower-cost RE solution between two different system configurations described in Table 2.

Table 2. *RE-based solutions considered in the study*

CASE	DESCRIPTION OF THE SYSTEM
A	Least cost system design with battery storage
B	Least cost system design without battery storage

Case A is composed of solar PV-inverter-grid setup with battery storage. Meanwhile, case B is composed of the setup but without battery storage. The comparison of the two cases can help determine the impact of adding a battery storage component to the system. The two cases were analyzed based on their techno-economic merits, particularly on their respective solar output production, battery performance, and grid energy import behavior. Results of analyses were used to decide which RE system configuration to select and compare with the existing system.

Comparison of the least-cost RE system with the existing grid-only power system was based primarily on NPCs and LCOEs. Also, the projected monthly electricity expenses from each system was quantified. For the RE system, other investment parameters such as payback period, internal rate of return (IRR), and return on investment (ROI) were also calculated. The techno-economic parameters used in the study are discussed further in the succeeding subsections.

Net Present Cost

The net present cost (NPC) of the system corresponds to the total lifetime cost of the system. NPC was calculated by taking the difference between the total lifetime expenditures of the system (i.e., capital, replacement, and O&M costs) and the accumulated income of the system (i.e., salvage value). HOMER chooses solutions with the lowest net present cost to determine the most cost-effective system configuration (HOMER Energy, n.d.).

Levelized Cost of Energy

The levelized cost of electricity (LCOE) determines the average cost of electricity on a per kilowatt-hour basis. This allows economic benchmarking between systems with different load demands. HOMER calculates the LCOE by dividing the total annualized cost of the system by the total electrical load served, as shown in Equation 1 (HOMER Energy, n.d.).

$$LCOE = \frac{C_{ann,tot}}{E_{served}} \quad \text{(Equation 1)}$$

where:

$LCOE$	is the Levelized Cost of Energy (P/kWh)
$C_{ann,tot}$	is the total annualized cost of the system (P/year)
E_{served}	is the total primary electrical load served in the system (kWh/year)

RE Fraction

The renewable energy fraction (f_{ren}) quantifies the penetration of power coming from RE sources in the system. In this study, f_{ren} corresponds to the percentage penetration of solar PV since it is the only RE component in the system. Equation 2 shows how f_{ren} is calculated (HOMER Energy, n.d.).

$$f_{ren} = 1 - \frac{E_{nonren} + H_{nonren}}{E_{served} + H_{served}} \quad \text{(Equation 2)}$$

where:

f_{ren}	is the renewable fraction
E_{nonren}	is the nonrenewable electrical production
H_{nonren}	is the nonrenewable thermal production
H_{served}	is the total thermal load served

Because the RE system has no thermal load and utilizes only solar photovoltaics, thermal production and thermal load can be disregarded in the calculation.

Other Economic Indicators

Simple and discounted payback periods, ROI, and IRR are other economic indicators by which the economic viability of the least-cost RE system and the existing grid-only system can be compared. The payback period determines the number of years needed to break even with the amount of investment made. Meanwhile, the ROI pertains to the efficiency of the investment in relation to its cost. Finally, the IRR indicates the annual growth rate of the project (HOMER Energy, n.d.). Figure 3 illustrates the flowchart of the steps implemented in the study.

Results and Discussion

Least-cost RE System Design

HOMER simulation identified two techno-economically feasible RE system configurations. These configurations include case A (solar PV-inverter-grid-battery) and case B (solar PV-inverter-grid-no battery). Figure 4A shows the least-cost solutions for these configurations.

Simulation results show that the solar PV and inverter components in cases A and B are almost identically sized to be around 55 kW and 27 kW, respectively. Consequently, the corresponding production profiles are also marginally different (Table 3). The only significant difference between the two is the four pieces of battery storage component for case A.

The performance of the solar PV system for case A and case B are also almost identical. Case A can produce 76,885 kWh/year which is only 982 kWh/year higher than case B. This small difference in performance is observed because the two solutions were evaluated using the same environmental conditions. As such, the performance of the two solutions vary only minimally, with case A registering a slightly higher rated capacity.

There is, however, a significant difference in the economic evaluation outcomes of case A

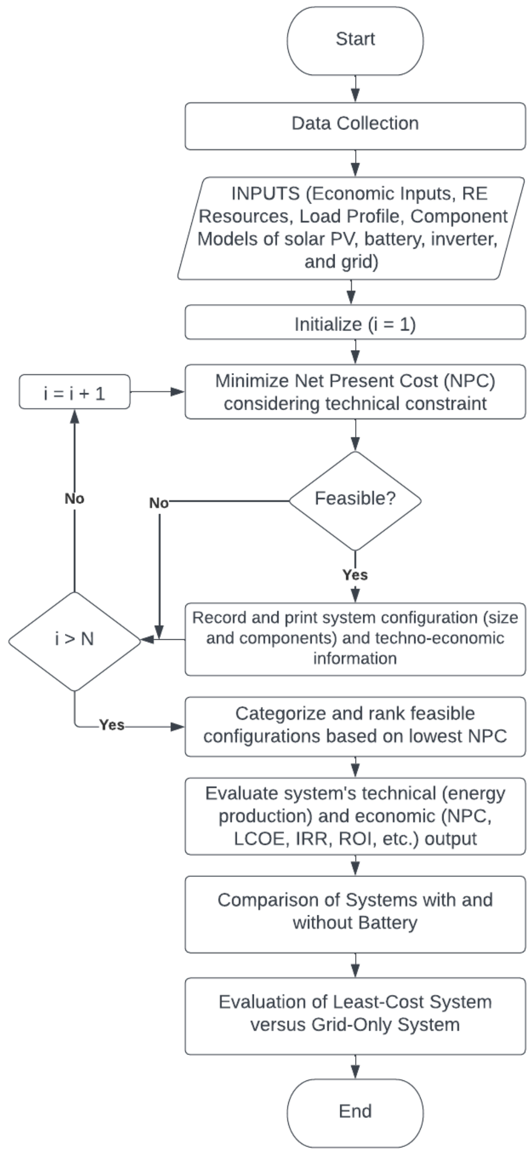

Figure 3: *Flowchart of methodology of the study*

and case B despite them having almost identical solar PV production profiles (Table 4). Case A, or the solution with battery storage, recorded an NPC of P5,898,483.92 and an LCOE of P6.94/kWh. These values are lower by P409,653.37 and P0.48/kWh compared with the NPC and LCOE, respectively, of case B. Also, the f_{ren} of case A (75.8%) is higher by 11% relative to case B. These results suggest that case A has a better techno-economic potential than case B. For this reason, cases A and B were analyzed further to determine how deployment of a battery storage affects the overall feasibility of the RE system.

Comparison of Systems with and without Battery

Battery Energy Storage Performance

HOMER determined the optimal characteristics of the battery storage component

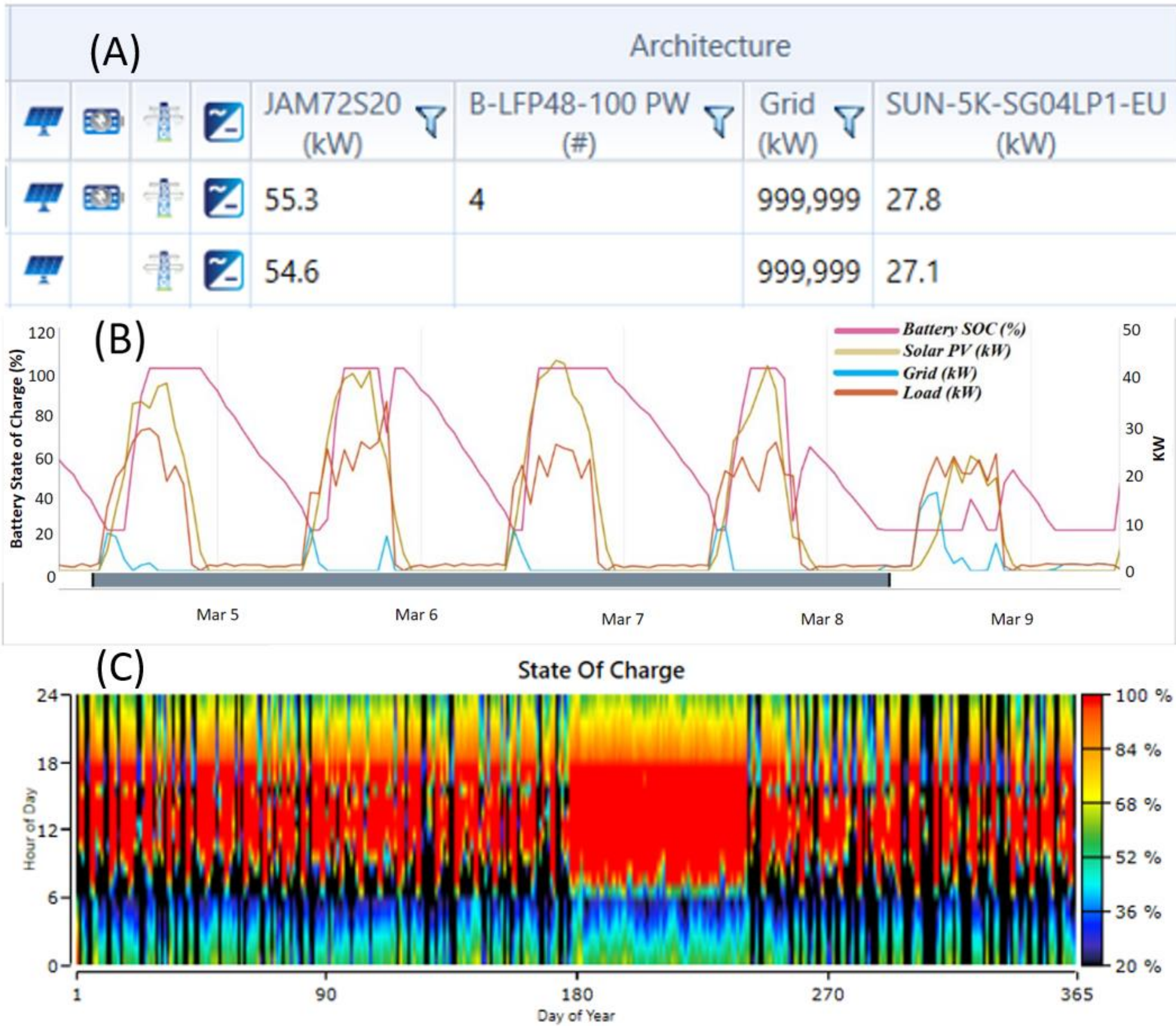

Figure 4: *(A) Size of RE system components in cases A and B; (B) system behavior relative to the load demand; and (C) state of charge (SOC) of the battery through time*

Table 3. *Solar PV system performance of case A and case B*

PARAMETER	CASE A (W/ BATTERY)	CASE B (W/O BATTERY
Rated Capacity (kW)	55.3	54.6
Maximum Output (kW)	48.4	47.7
Mean Power Output (kW)	8.78	8.66
Capacity Factor (%)	15.9	15.9
Mean Energy Output (kWh/day)	211	208
Annual Energy Production (kWh/year)	76,885	75,903

Table 4. *Main performance metrics of case A and case B*

CASE	NPC (PHP)	LCOE (PHP/kWh)	RE Fraction, f_{ren} (%)
Case A	5,898,483.92	6.94	75.8
Case B	6,308,137.29	7.42	64.8

of case A to be 19.2 kWh nominal capacity, 15.4 kWh usable nominal capacity, and 2.61 hours of autonomy. It is important to emphasize that these values indicate that the battery bank capacity is small relative to the system load demand. This characteristic can be observed from Figures 4B and 4C.

Figure 4B shows the behavior of the system on typical days. The battery is typically charged up to 100% during the day. The solar PV output exceeds the school's energy demand during this period. Hence, surplus electricity is generated, which effectively charges the battery.

Interestingly, the system can hold stored energy until around 6 p.m. on most days a year (Figure 4C). From 6 p.m. onwards, stored energy is discharged to its minimum SOC of 20% until 6 a.m. the following day when the cycle repeats. There could be virtually no electricity imports at night even if solar power is no longer available since the battery component is used to supply security lighting loads only during the night (Tables 1).

Import of Grid Electricity

As alluded to in the previous discussion, the battery component of case A could offset the system's reliance on the grid to provide electricity during the night. Figures 5A and 5B illustrate the difference in grid electricity import of case A and case B.

Noticeably, the concentration of pigments from 6 p.m. to 6 a.m. is significantly thinner for case A compared with case B. This indicates that the RE system with battery storage imports substantially less energy from the grid than the system without it. Also, the reduction in imported grid electricity occurs at night in case A when the battery is typically discharging energy.

Meanwhile, Table 5 summarizes the grid imports of the two configurations in each month. The import of electricity is substantially lower in case A compared with case B for all months. Moreover, there is almost no grid import in case A in July and August or the typical 2-month academic vacation of the school.

In total, case A would require importing 12,457 kWh/year of grid electricity while case B would need 18,095 kWh/year. On average, case A has 470 kWh/month or 5,637 kWh/year less grid energy purchase than case B. Hence, it is evident that the battery allows the RE system to increase self-consumption by cycling more solar power for later use thereby reducing reliance on grid electricity.

Cost Breakdown

The addition of battery storage in the system for case A would increase the capital and replacement costs of the system. However, the additional investment made for batteries allowed the O&M costs to be reduced significantly.

Table 6 shows that the grid cost of case A is P2.3 million which is about 86% of the total O&M costs. Meanwhile, the grid cost of case B is P3.3 million or about 90% of the O&M costs. The grid and O&M cost of case A is significantly cheaper because it only allows a 24.2% grid power penetration, which is 11% lower compared with case B. With these findings, case A was chosen as the least-cost RE system design in this study because it increased solar PV self-consumption, reduced grid electricity import, and reduced O&M costs which altogether afforded better NPC, LCOE, and RE fractions compared with case B.

Least Cost RE System (Case A) vs Grid-Only System

The least cost RE system configuration (Case A) consists of a 55.3-kW solar PV, 19.2-kWh battery storage, 27.8-kW inverter, and grid. Table 7 shows its corresponding NPC and LCOE as well as those of the existing grid-only system.

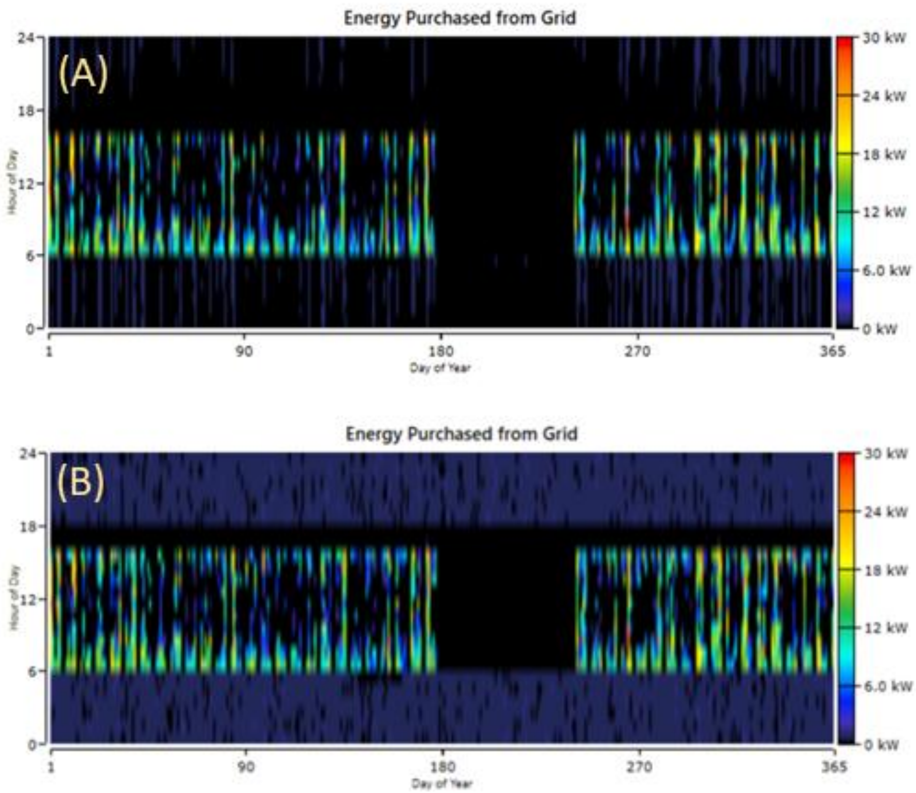

Figure 5: *Energy purchased from the grid in an RE system configuration under (A) case A, and (B) case B*

Table 5. *Monthly grid electricity import*

SIMULATION MONTH	GRID ELECTRICITY IMPORT (kWh)		Difference (kWh)
	Case A (w/ battery)	Case B (w/o battery)	
January	1,612	2,080	468
February	1,190	1,603	413
March	1,035	1,539	504
April	593	1,162	569
May	1,040	1,550	510
June	1,318	1,819	501
July	1	400	399
August	2	413	411
September	1,153	1,648	495
October	1,375	1,869	494
November	1,728	2,132	404
December	1,410	1,879	469
AVERAGE	1,038	1,508	470
ANNUAL	12,457	18,095	5,637

Table 6. *Capital, replacement, and O&M costs*

COST TYPE	CASE A (W/ BATTERY)	CASE B (W/O BATTERY)
Capital Cost (P)	2,926,050.10	2,491,536.37
Replacement Cost (P)	417,178.16	174,130.17
O&M Cost (P)	2,654,021.35	3,683,695.55
Grid Costs (P)	2,285,862.92	3,320,237.59

Table 7. *Comparison of main economic indicators of the RE system and the grid-only system*

PARAMETER	SOLAR PV + BATTERY + GRID + INVERTER (CASE A)	GRID-ONLY
NPC (P)	5,898,483.92	9,443,490.75
LCOE (P/kWh)	6.94	11.11

The NPC and LCOE of case A are significantly lower than those of the grid-only system. In terms of NPC, case A is cheaper by about P3.5 million. Similarly, the LCOE of case A is more affordable by P4.17/kWh. Based on these values, the solar PV-battery-inverter-grid system design is the most economical solution.

The difference in NPC and LCOE values between the RE system and the grid-only system mainly comes from the reduction of monthly grid electricity purchases by the school. Figure 6 summarizes the monthly grid purchase of the two systems.

The proposed RE system significantly lowers the grid reliance of the school in meeting its energy needs. In a grid-only setup, the school imports about 4,600 kWh to 5,300 kWh of electricity monthly. These values can be significantly reduced to just about 500 kWh to 1,700 kWh per month by implementing the proposed RE system.

On average, the RE system can reduce grid import by 3,250 kWh per month or 39,008 kWh per year. The simulation estimates that, because of this reduction, the monthly savings from electricity bills of the school can reach an average of P36,114 per month or P433,373 per year based on the P11.11 kWh retail rate of electricity from MERALCO (average from February 2022 – January 2023). This corresponds to a 76% reduction in electricity expenses.

Finally, other economic indicators were also calculated. The simple and discounted payback years are 7.12 years and 8.32 years, respectively. In comparison, most solar installations in the country have simple payback years between 6 years to 7 years (Department of Energy, n.d.) Meanwhile, the IRR and ROI are 12.90% and 9.40%, respectively. These IRR and ROI values are considered attractive for RE projects (Lemence & Tamayao, 2021; Asamoah et al., 2022). Therefore, the proposed RE system can provide definite techno-economic value for the school as an alternative power source. Since the system capacity is below 100 kW, the economic indicators can still be improved by integrating the system with a net metering program.

The study was primarily conducted to design a cost-effective alternative power system suitable to the assets available and power consumption demand of a public school. The study simulated different RE system configurations to determine which design has the best economic potential.

Through TEA, it was found that the least cost design consists of solar PV, inverter, and grid with battery energy storage component. Despite batteries being expensive, the simulation deemed it more economical to utilize this technology to offset grid costs during the night when solar power is not available. In other words, the cost of acquiring and utilizing batteries for the school is less than the additional grid costs if it is not included in the RE system. This result is possible only because of the unique load profile of the school wherein its energy demand is extremely high during the day and extremely low during the night.

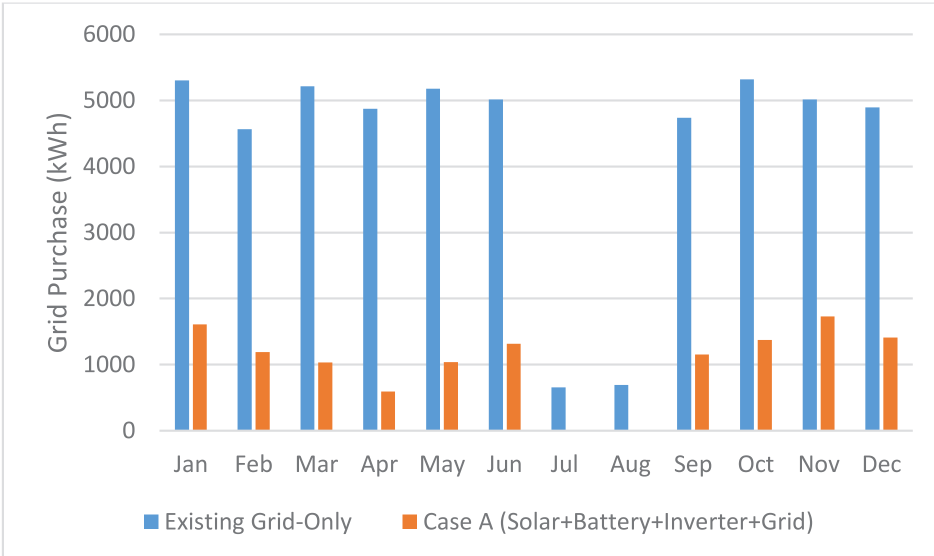

Figure 6: *Monthly grid electricity purchase under grid-only and RE system scenarios*

Since the demand is very low at night, a small battery bank is already sufficient to supply load requirements. Hence, the cost of battery acquisition is offset considerably. Additionally, this energy consumption characteristic allows the design to have an economically large solar PV capacity since most of the load of the school is coincidental with the availability of solar power during the day. These conditions made the utilization of a battery bank in the system optimal.

In contrast, most studies do not find economic value in adding battery storage in grid-connected systems (Asamoah et al., 2022; Chisale et al., 2023) because the systems evaluated do not have a very polarized load profile similar to that of a school. Hence, it is more economical for these types of systems to rely on grid power when solar power is not available.

Furthermore, the proposed solar PV, inverter, grid, and battery design have significant economic potential in comparison to the existing grid-only power system of the school. The benefits found in this study can be further compounded by extending this project to all the other public schools in the country. This is because most public schools have similar characteristics in terms of load consumption behavior and available assets such as rooftops of covered courts and other school buildings. Ultimately, this has the potential to provide the education sector a lot of savings which may be used to fund other development needs.

The study recommends future studies to investigate other schools with different levels of energy demand. Other types of facilities with a more variable load profile can also be investigated to test the effectiveness of RE systems. The incorporation of more battery-integrated grid-tied systems can also be evaluated for such facilities. Furthermore, the impacts of the net metering program on the techno-economic output of grid-tied systems for schools can also be studied.

Conclusion

This study determined the most economical RE system that fits the load demand of a public elementary school in Laguna, Philippines. Results showed that a grid-tied, solar PV with battery and inverter has a lower LCOE compared with the existing grid-only system. Consequently, the RE system resulted in lower grid importation and energy savings. Overall, the TEA performed using HOMER Pro was able to come up with an alternative power system that incurs lower costs and could supply all the energy requirements of the public elementary school.

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