TELKOMNIKA Telecommunication Computing Electronics and Control
Vol. 24, No. 5, October 2026, pp. 1827~1842
ISSN: 1693-6930, DOI: 10.12928/TELKOMNIKA.v24i5.27842

Development and assessment of grid-tied photovoltaic system of government facility in Bireuen Regency, Aceh, Indonesia, using system advisor model

Nelly Safitri[1], Musbar[2], Busra[3], Amri[4], Yuli Anisah[3]
[1]Department of Electrical Engineering, Politeknik Negeri Lhokseumawe, Aceh, Indonesia
[2]Department of Civil Engineering, Politeknik Negeri Lhokseumawe, Aceh, Indonesia
[3]Department of Commerce, Politeknik Negeri Lhokseumawe, Aceh, Indonesia
[4]Department of Information Technology Engineering, Politeknik Negeri Lhokseumawe, Aceh, Indonesia

Article Info

Article history:

Received Jan 30, 2026
Revised Jun 26, 2026
Accepted Aug 28, 2026

Keywords:

Government building
Grid-tied photovoltaic
Internal rate of return
Net present value
Payback period
Rooftop photovoltaic system
System advisor model
Techno-economic analysis

ABSTRACT

This research examines the technical and economic viability of a 275 kWp hybrid photovoltaic (PV) system intended for a government facility in Bireuen, Aceh. It specifically addresses the regulatory changes in Indonesia set in 2024, which eliminate net metering credits. The research was conducted to determine if a hybrid system that combines solar panels with battery storage could maintain its financial viability and structural stability in light of new circumstances demanding independence from the electrical grid. The employed methodology combined structural engineering with techno-economic modelling. An analysis of the building's portal frame was conducted using the demand-capacity ratio (DCR) to ensure compliance with wind load requirements of up to 40 m/s. Performance simulations were executed using the system advisor model (SAM) to evaluate energy outputs against a 240 kVA load profile. Key findings suggest that the system is both structurally sound and economically viable. The findings indicate that the proposed 275kW grid-connected PV system can effectively support the building's 240kVA load capacity, regardless of battery storage. Moreover, the financial assessment revealed a positive net present value (NPV) of approximately IDR 3.1 million, an internal rate of return (IRR) of 9.7%, which has a relatively short payback period of 9.3 years, suggesting that the project is financially sound.

Corresponding Author:

Nelly Safitri
Department of Electrical Engineering, Politeknik Negeri Lhokseumawe
Banda Aceh-Medan St., Buketrata, Punteut Mosque, Blang Mangat, Lhokseumawe City, Aceh, Indonesia
Email: nellysafitri@pnl.ac.id

1. INTRODUCTION

Renewable energy sources, especially solar and wind power, are gaining popularity because they provide clean energy and can be renewed naturally. Recently, there has been a significant increase in the use and exploration of clean energy resources due to growing global environmental concerns around the globe [1], [2]. A solar photovoltaic (PV) system is a key renewable energy technology that harnesses sunlight. The electricity generated by these solar panels depends on the sunlight available. During the day, there is plenty of sunshine to maximize their output; however, at night, the energy production drops significantly. Even though most electricity is used during the day, there is still a demand for it after dark. Grid-tied PV systems are the most common option for generating power and meet the growing energy demands. In these systems, any extra electricity produced can either be stored in batteries or sent directly to the electrical grid, depending on whether it's alternating current (AC) or direct current (DC) coupled. Grid-connected PV energy is a key renewable energy source that has been extensively studied. Energy storage technology plays a crucial role in addressing electricity shortages during peak demand times. There is a need to address financial and technical challenges in various energy storage solutions, such as thermal storage, pumped hydro storage, fuel cell storage, batteries, and supercapacitors [3]-[6].

Many countries have developed plans to boost renewable energy and mitigate the effects of global warming in response to rising energy demands. For example, countries like Austria, Finland, Sweden, and Australia aim to achieve renewable energy shares of 34%, 38%, 49%, and 20%, respectively, by the year 2020 [7]-[9]. Additionally, the cost of solar panels has significantly decreased over the past 35 years, dropping from \$75 per Watt to nearly \$0.75 per Watt. In contrast, the price of fossil fuels, such as coal, has risen by 13% since 2008. As a result, the installation of PV systems has become increasingly popular, with data indicating a 50% annual growth over the last five years. This is expected to reach 80% in the coming years [10], [11].

Bireuen Regency latitude is between 04° 53' 20.3'' and 05° 16' 25.8'' to the North and longitude between 96° 05' 30.1'' and 96° 19' 45.9'' to the East. Bireuen Regency spans an area of 1,797 square kilometers. It is located in a key spot within Aceh Province. The elevation ranges from 0 to 2,637 meters above sea level. Bireuen is a tropical area that experiences a monsoon climate. The land varies from coastal lowlands in the north to highlands and mountains in the south, which are part of the Bukit Barisan Mountains. Because of this, the eastern and northern parts tend to be drier than the western and southern regions. The Figure 1 shows a map of Bireuen Regency.

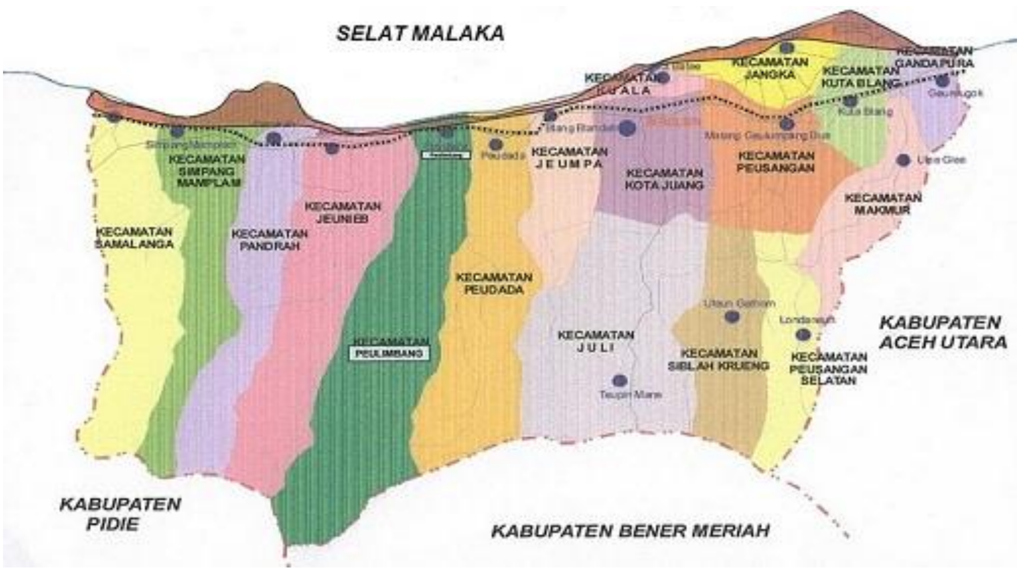


Figure 1. Administrative map of Bireuen Regency, Aceh Province, Indonesia, illustrating district boundaries and adjacent regions including Pidie Regency, North Aceh Regency, and Bener Meriah Regency

Several studies that mitigate both the grid-tied and stand-alone PV systems, respectively, are as follows. The grid-tied PV system, which partially supplies residential areas in Houghton, Michigan, and Tucson, Arizona, USA, Ovali [12] is discussed. The study that focuses on two specific areas with high solar radiation, namely Darab and Meybod, Razmjoo *et al.* [13] is discussed, which are located in Fars and Yazd provinces, respectively, in Iran. Another study, which is focused on the economic and environmental analysis of the grid-connected PV system for Dr. Hilla Limann Technical University in the Upper West Region in Ghana [14]. A case study that took place in Australia's outback that forecast the short-term PV in a diesel-PV-battery off-grid power supply system [15]. Mai *et al.* [16], a simulation study was conducted that mitigated the design of a 30 MWp grid-connected solar PV system in a rural area in Bangladesh. For modelling a battery into a grid-tied PV system, Mirletz and Guittet [17] have conducted the system improvement through a simulation model. Studies that have been carried out to explore off-grid PV systems used by residents in various cities in Indonesia and abroad are as follows. One study focused on designing and evaluating an off-grid PV system to meet the electricity needs of small homes in Indonesia, which requires about 1.61 kWh per day [18]. Another source discusses an off-grid PV system implemented in Kupang, Indonesia, noting that the electricity costs for this system ranged from $0.31 to $0.33 per kilowatt-hour, with an average cost of $0.30 per kilowatt-hour. Amiruddin *et al.* [19] presented a study on optimizing energy storage within Indonesia’s super grid. The performance of off-grid PV mini-grid systems in Sukabumi was examined using the PVSYST platform as detailed by Artiyasa *et al.* [20]. A case study conducted on Legundi Island evaluated how an off-grid hybrid solar system performed in a remote area [21]. Additionally, Awopone [22] has discussed the viability of an off-grid system that included PV panels, batteries, and diesel generators in Ghana, designed to serve 80 homes with a total electricity demand of 224.06 kWh per day. Also, a simulation study of a standalone PV solar power plant for a housing estate in Abuja, Nigeria [23].

Bireuen Regency holds great potential for solar energy due to its location in Indonesia, a tropical nation that receives abundant sunlight, averaging around 4.80 kWh/m^2 per day. This solar energy can be harnessed for a range of purposes, including large solar power plants, residential use, and specific applications like drying crops. The Bireuen government facility can effectively use solar energy by installing rooftop solar power systems. This is possible because the area has a great location in a tropical region close to the equator, with a Global Horizontal Irradiation (GHI) of 1696.2 kWh/m^2/year [24]. This GHI value positions the city as an area where PV systems will be highly feasible, and sunlight is strong and consistent all year round. Local research indicates that solar power plants in Bireuen can operate with high efficiency (over 85%), and the grid-tied PV system can be easily connected to the network utility.

This study seeks to fill these gaps by conducting a thorough evaluation of a proposed rooftop PV installation for a government facility in Bireuen Regency, Aceh, Indonesia. The region offers favorable conditions for solar energy implementation due to its tropical climate, an annual GHI of approximately 1,696.2 kWh/m^2/year, and a growing demand for sustainable electricity alternatives. However, effectively implementing large-scale rooftop PV systems in government structures necessitates not only an assessment of energy generation and financial viability but also an assurance of structural integrity in relation to local environmental factors. Consequently, this research combines structural engineering analysis utilizing the demand-capacity ratio (DCR) method with techno-economic simulations performed through the system advisor model (SAM). Additionally, it assesses the feasibility of a 275 kWp grid-tied PV system within Indonesia’s post-2024 regulatory landscape, where optimizing self-consumption and minimizing grid exports are becoming essential design priorities. By integrating structural, technical, and economic evaluations within a practical governmental framework, this study offers a viable model for advancing solar energy initiatives in public-sector buildings throughout Indonesia.

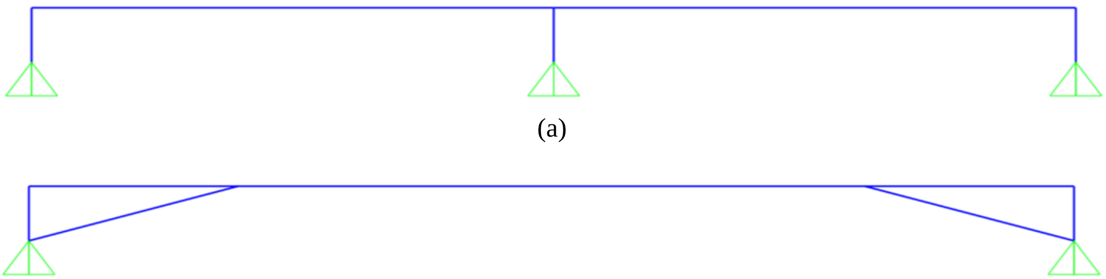
The structure of the paper is as follows. Section introduction describes the renewable energy use from global to local area alike Bireuen Regency. The topography is also described briefly. Section method details the proposed PV grid-tied system and the approach using the National Renewable Energy Laboratory-SAM (NREL-SAM). Section results and discussion describes the results of the grid-tied PV system, which is simulated through the SAM platform within the developed scenarios, namely, with and/or without a battery storage system. Eventually, the last section is the conclusion, which summarizes the conducted study.

2. METHOD

In this section, the authors put several considerations of the proposed grid-tied PV system, namely, weighing the roof structure to comprehend the load on the building so that a simulation of its frame structure can be carried out. Determining the appropriate size for the PV system, including all necessary components and their arrangement on the rooftop, and also examining the financial factors such as net present value (NPV), internal rate of return (IRR), and payback period. Then, the authors are also developing two scenarios, which are run through the SAM platform of NREL for the proposed grid-tied PV system.

2.1. Roof structure

To examine the roof structure, several aspects need to be considered, namely (i) description of structural elements, (ii) numerical model of structural elements, (iii) specifications of structural elements, and (iv) loading of structural elements [25]-[27]. After examining the condition of the roof frame on the existing Bireuen Regency government building, two designs for solar panel support frames are suggested. Figure 2(a) features a structure with three columns and multiple beam spans. Each column is designed to be 0.6 meters tall, and each beam span measures 5.0 meters in length. These dimensions have been chosen to create a portal configuration that effectively allows for the analysis of deflection behavior, joint rotation, and interactions between axial forces and moments that typically occur in steel frame systems. Figure 2(b) consists of a frame with two columns and one beam span; this model includes bracing on the second support to help reduce deformation and torsion in the beam. The configuration of the proposed frame structures is illustrated in Figure 2.



(a)

(b)

Figure 2. PV panel frame structure model: (a) model 1 and (b) model 2

During the numerical modeling phase, each structural part is represented by a steel profile commonly used in modern steel frame designs, as illustrated in Figure 3. In Model 1, the column is modeled with a 100×100×6×8 H profile because it has the right strength for both bending and axial loads needed for a medium-scale steel frame. The beam in this model uses a 100×100×4.5 hollow profile. For Model 2, the column, beam, and brace elements are designed just like in Model 1; however, the beams in the mid-span area use a 100×150×4.5 hollow profile instead. This hollow box-shaped profile offers good resistance to bending moments and has a symmetrical design that makes numerical analysis and stress distribution easier.

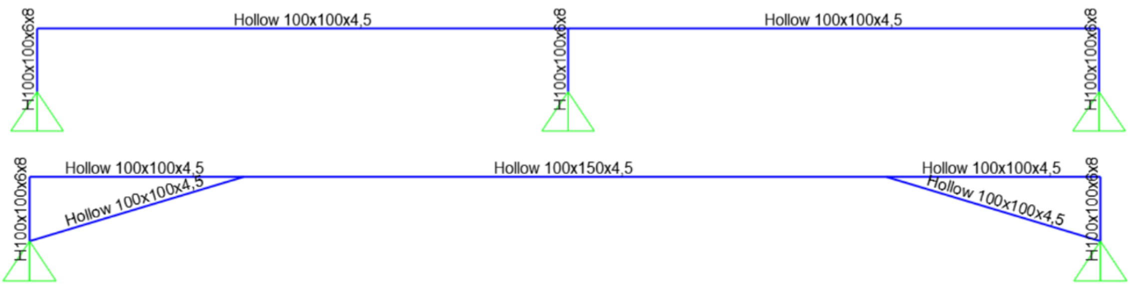


Figure 3. Numerical structure of models 1 and 2

All structural elements used in the modeling refer to ASTM A992 grade 50 steel [28], [29]. This type of steel is a standard material widely used in structural steel frame elements due to its good strength and ductility. Based on the standard specifications, the material has a minimum yield strength (Fy) of 345 MPa and an ultimate tensile strength (Fu) of 379 MPa. The use of this steel grade also ensures that the model provides a realistic depiction of structural behavior and is in accordance with the characteristics of steel materials commonly applied in steel building construction in the field.

In this study, the loads exerted on the portal structure comprise both dead load and wind load, which are determined in accordance with established structural loading standards. The dead load encompasses the self-weight of the steel frame portal components as well as the permanent load from the solar panels affixed to the structural system. The calculation of dead load adheres to SNI 1727:2020 [30], [31], which outlines minimum loads for designing buildings and other structures, mandating that all permanent structural and non-structural elements be accounted for as dead loads. Specifically, the weight of the solar panels imposes a uniform load of 30.21 kg/m² on the beam elements based on their installation configuration. In addition to the dead load, wind loads impact the structure from two orientations: pressure (positive pressure) and suction (negative pressure). For modeling purposes, a wind load intensity of 1.4 kN/m² is utilized, corresponding to a wind speed of 40 m/s. This value is derived from SNI 1727:2020 and informed by building aerodynamics principles articulated in ASCE/SEI 7-16 – minimum design loads and associated criteria for buildings and other structures [32]. It is important to note that solar panel systems mounted on open-frame structures experience increased wind loads due to enhanced uplift effects and localized turbulence. Consequently, in the model, wind loads manifest as a uniform pressure and suction load amounting to 292.58 kg/m² applied to the beam elements, as illustrated in Figure 4. The uniform application of these two types of loads across the beam elements ensures that the numerical model accurately captures the structural response under conditions analogous to those encountered in real-world solar panel installations. Therefore, the analysis generated reflects actual circumstances while adhering to both national and international loading requirements.

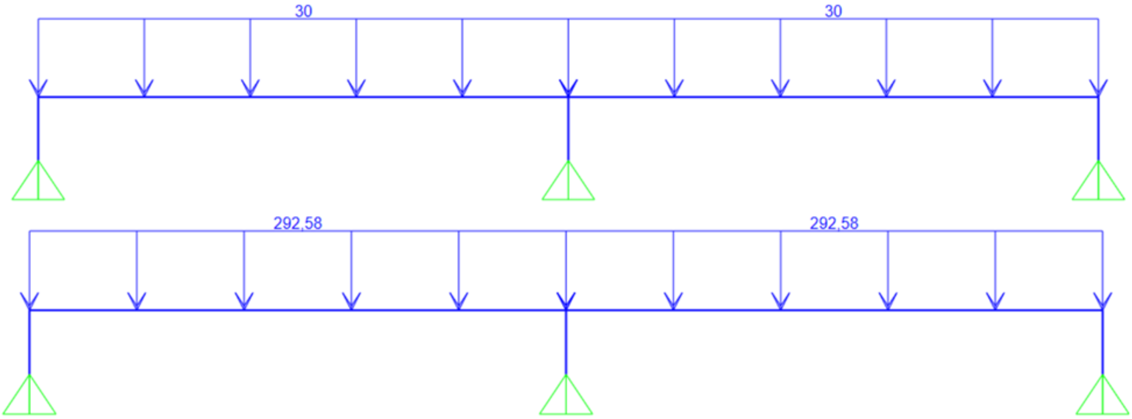


Figure 4. Dead load of solar panels and wind load (in kg/m)

2.2. Grid-tied PV system design and layout

To determine a rooftop PV system capacity, it relies on the average daytime energy consumption [33]. The primary objective is to ensure that the electricity produced aligns with the demand, thereby preventing excess generation from needing to be stored in batteries or wasted. This is particularly important given current regulations that restrict both the export and import of surplus electricity into the grid. In the planning phase of PV power installations, a design factor of 1.2 is commonly employed as a safety or efficiency multiplier to assess the necessary capacity of inverters or charge controllers in relation to the overall capacity of the solar panel array [34]. There are two primary considerations that arise regarding the application of the 1.2 design factor.

2.2.1. DC/AC ratio (inverter overclocking)

System designers typically opt to install a solar panel (DC) capacity that exceeds the inverter's (AC) capacity. The industry commonly adopts a ratio of 1.2 for this purpose. For a solar panel with a capacity of 275 kWp, an optimal inverter capacity would be approximately 200 kW. This approach is intended to reduce power losses associated with factors such as heat accumulation, dust accumulation, and cable inefficiencies, thereby enabling the inverter to function effectively at peak capacity for extended durations throughout the day.

2.2.2. Safety factor

When determining the specifications for protective components such as cables, breakers, or fuses, the National Electrical Code (NEC) advises incorporating a safety factor of 1.25; however, this is often simplified or adjusted to 1.2 in various practical scenarios. This precaution is vital to prevent overheating or tripping of components when solar panels produce peak current, which may occur during transient phenomena like cloud edge effects that temporarily elevate solar radiation levels.

$$PV\ system\ capacity\ =\ installed\ electricity\ capacity\ \times 1.2 \quad (1)$$

The advantages of this system include:
- A solution without electricity exports: under the 2024/2025 regulations [35], which no longer count electricity exports to the grid as a bill reduction, a hybrid system is the best solution because excess power is "stored" in the battery itself, rather than being discharged into the grid.
- Backup during power outages: unlike a purely on-grid system, which shuts down during a power outage, a hybrid system still functions as a giant uninterruptible power supply (UPS) to keep operations running.
- Peak load management (peak shaving): a battery can be used to supply energy during high grid electricity rates or when the building's usage is at its peak.

However, this system requires a higher investment than a traditional on-grid system, as battery costs can reach 30–50% of the total project. Furthermore, this system requires additional space (a temperature-controlled battery room) in addition to the approximately 1,800 m² panel area. This system provides significantly greater energy independence than a traditional on-grid system, especially for critical facilities that cannot afford power outages. Figure 5 illustrates the PV panels' layout and frame design.

2.3. Financial aspects

In the design and execution of investment projects, particularly within the energy sector, financial considerations are paramount as they constitute the fundamental basis for making investment choices. Grid-tied PV system power plant initiatives, despite their environmental benefits and contributions to sustainability, necessitate thorough financial assessments due to the significant initial capital outlay involved. Inadequate financial scrutiny can expose these projects to potential losses, even when they are technically and environmentally viable [36]. From a financial standpoint, investors and stakeholders need to have confidence that the economic returns produced by the project will not only recoup the initial investment but also yield an adequate rate of return that reflects the associated risks. Consequently, a systematic financial feasibility assessment is imperative to determine whether a solar power plant project can generate additional economic value and is viable for implementation. This analysis gains further importance when considering the time value of money, as future benefits must be evaluated in terms of their present value [37], [38].

Given the long-term nature of investments in solar power plants, employing a financial feasibility analysis that incorporates NPV, IRR, and payback period metrics is particularly relevant. These indicators furnish a comprehensive understanding of profitability, investment efficiency, and risk associated with returns on investment. A detailed financial analysis is anticipated to provide a robust foundation for assessing the viability of solar power projects, thereby facilitating rational and objective investment decisions aimed at promoting long-term economic sustainability [39].

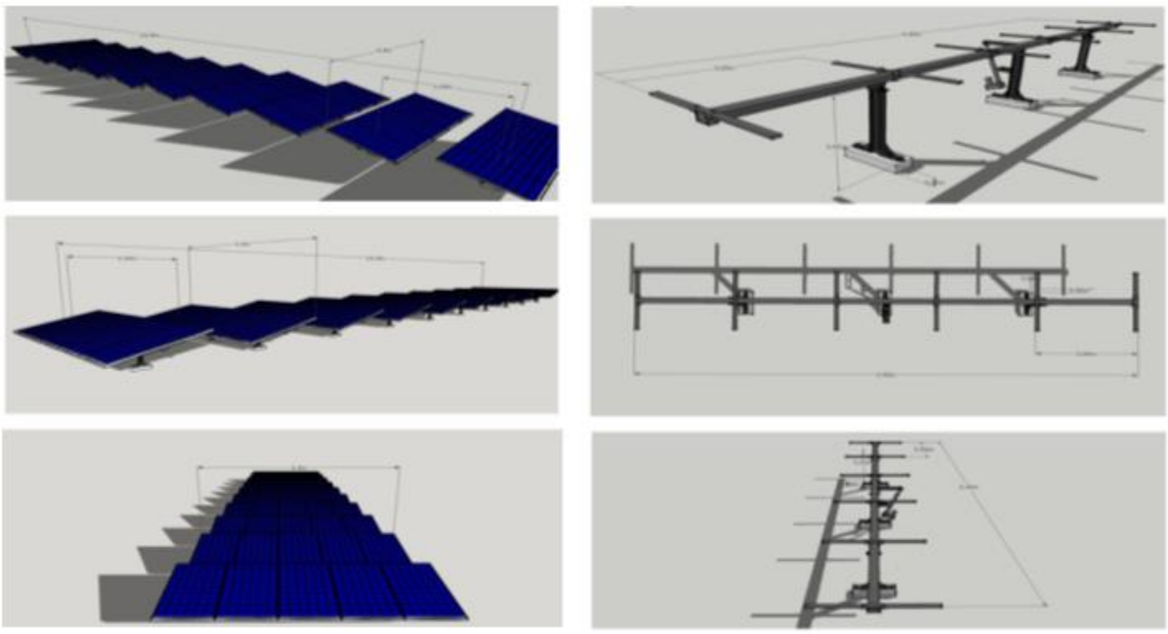


Figure 5. PV panels layout and frame design

2.4. SAM platform

The SAM of the NREL is a complementary desktop application designed for the techno-economic evaluation of energy technologies. This tool is utilized by project managers, engineers, policy analysts, technology developers, and researchers to explore inquiries regarding the technical, economic, and financial viability of power generation initiatives. SAM serves as a techno-economic feasibility model tailored for renewable energy initiatives. It is intended for a diverse array of users, such as project developers, system designers, policymakers, financial analysts, and academic researchers [17], [33], [40]. SAM features provide the variety of rooftop space available and allow users of the data to extract the total amount of ideal rooftop space available for PV, depending on their particular research questions. Providing the data in this manner allows for a greater range of research with various PV technologies, as well as the ability to adapt research with this data set as PV technology continues to become more efficient.

In this study, the authors developed two scenarios that can be run through SAM. The scenarios are the grid-tied PV system without battery storage and with battery storage. The flowchart in Figure 6 illustrates how each scenario runs in the simulation process. The flowchart illustrates the operational framework of a PV system that is integrated with battery storage and connected to the utility grid. The process initiates with the assessment of solar irradiance (W/m²) to evaluate the potential availability of solar energy. In instances where the measured solar irradiance is adequate, the PV system not only meets the power requirements of the load but also charges the battery concurrently. The DC generated is subsequently converted into AC by an inverter prior to being supplied to the load. This scenario emphasizes the preference for utilizing renewable energy while ensuring that the battery remains charged and ready for use. Conversely, if solar irradiance falls short, the system then assesses whether the utility grid is accessible. If grid access is confirmed, electrical power is drawn directly from it to satisfy load demands. However, in cases where grid availability is lacking, the system examines the state of charge (SoC) of the battery. When the SoC reaches or exceeds 80%, power to meet load requirements is provided from the battery through the inverter. If, on the other hand, the SoC drops below this predetermined threshold, monitoring will continue until sufficient energy resources become available. The process ends once all load demands are adequately addressed, thereby ensuring a dependable and prioritized energy supply that responds dynamically to solar availability, grid conditions, and battery capacity.

The load profile was derived from a comprehensive inventory of all electrical loads linked to the system, along with their respective operating schedules. The power usage for each load was documented and compiled on an hourly basis to assess the total load demand over the course of the day. When possible, real-time data from smart energy meters were employed to enhance precision. This resulting load profile acted as the key input for the energy management algorithm, facilitating optimal integration between PV generation, battery storage, and grid electricity in accordance with the operational framework illustrated in Figure 6.

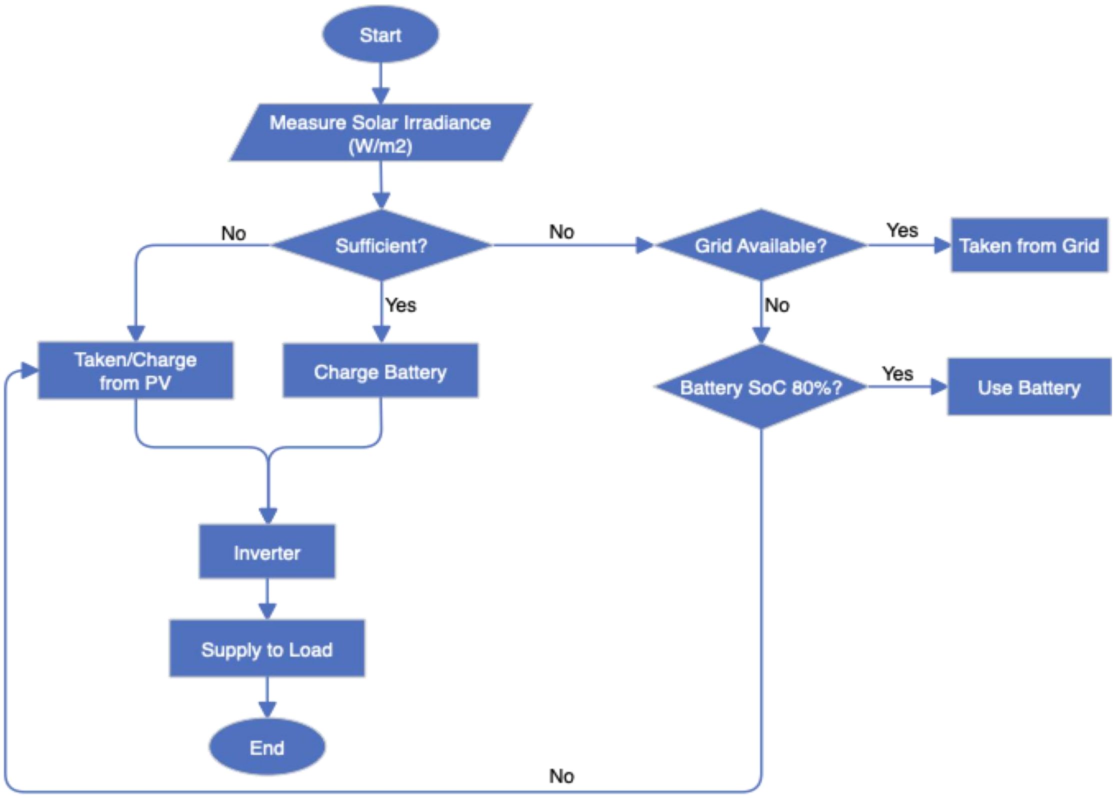


Figure 6. Flowchart of the developed scenario

3. RESULTS AND DISCUSSION

The results of this study were gained from the simulation of two developed scenarios provided and systematically arranged as mentioned in the previous section, which include the analysis of the roof structure, the analysis of the grid-tied PV system, and the analysis of the financial aspects. Table 1 summarizes the SAM input parameters and battery specifications.

Table 1. Summary of SAM simulation input parameters and battery specifications

Category	Parameter	Value	Unit
Site location	Location	Bireuen Regency, Aceh, Indonesia	-
Solar resource	GHI	1696.2	kWh/m²/year
Solar resource	Average solar irradiance	4.8	kWh/m²/day
PV system	System capacity	275	kWp
PV module	Module type	Longi Hi-MO 6	-
PV module	Module rating	550	Wp
PV module	Number of Modules	500 (approx.)	units
PV array	Tilt angle	10	degrees
PV array	Mounting type	Fixed rooftop	-
Inverter	Inverter capacity	200–275	kW
Inverter	DC/AC ratio	1.2	-
Load	Building connected load	240	kVA
Load	Load profile source	Hourly measured building demand	-
Grid	Grid connection type	Grid-tied	-
Grid	Export limitation	Zero-export policy	-
Battery	Battery technology	LiFePO4	-
Battery	Battery capacity	500	kWh*
Battery	Battery Round-trip Efficiency	90–95	%
Battery	Minimum State of Charge	20	%
Battery	Battery dispatch strategy	Peak shaving/self-consumption	-
Battery	Discharge threshold	SoC ≥ 80	%
Economic	Project lifetime	25	years
Economic	Electricity tariff	1,700	IDR/kWh
Economic	Initial investment (without battery)	3,850,000,000	IDR
Economic	Initial investment (with battery)	4,950,000,000	IDR
Economic	Annual electricity production	357,500	kWh/year
Simulation tool	Software version	NREL SAM (latest version used)	-

3.1. Roof structure analysis

The evaluation of structural performance was carried out utilizing the DCR parameter, a widely recognized approach for assessing the safety of structural components in relation to design loads. DCR is defined as the ratio of the internal force exerted on an element (demand) to its nominal capacity (capacity). A DCR value of less than 1.0 signifies that the element’s capacity can adequately support the applied load, whereas a value that approaches or exceeds 1.0 indicates that the element is in a critical or unsafe condition. Consequently, this parameter offers a quantitative assessment of structural reliability and serves as a fundamental criterion for determining the practical applicability of the structural configuration under real-world conditions. According to the analysis results presented in Figure 7, all column and beam elements within the portal for models 1 and 2 exhibited DCR values below the regulatory threshold of 1.0. This observation suggests that the structure maintains a sufficient safety margin against the combined effects of dead and wind loads as modeled in this investigation. Furthermore, the low DCR values observed in these elements imply that their structural response remains within elastic limits, without reaching material yielding or excessive deformation levels that could compromise overall system stability.

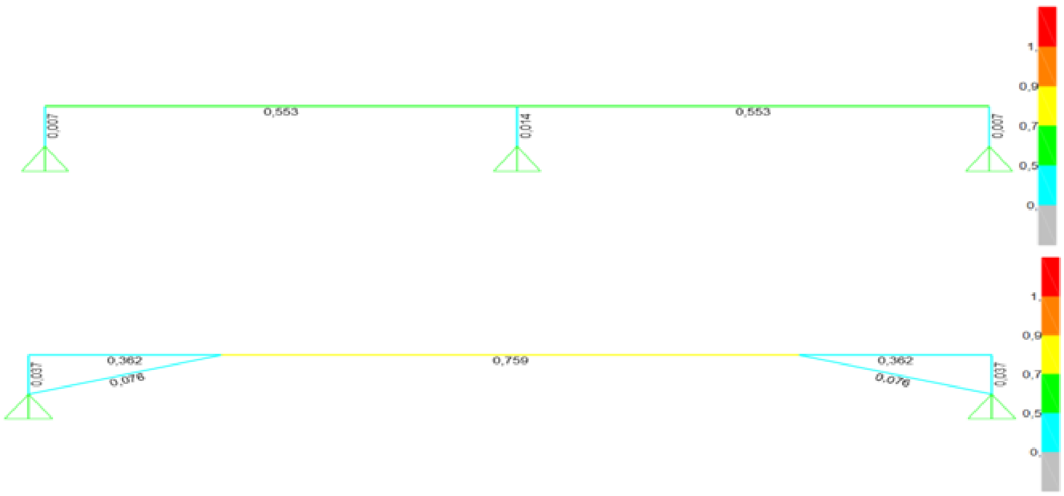


Figure 7. DCR

3.2. Grid-tied PV system sizing analysis

In the proposed design for the PV system, the installed electricity capacity of the Bireuen Regency government facility is 240KVA. Thus, the proposed PV system capacity is calculated in (2).

$$PV\ system\ capacity\ =\ 240kVA\ \times 1.2 = 275kWp \tag{2}$$

The 275 kWp capacity is classified within the medium to industrial scale category and possesses the capability to generate substantial energy outputs suitable for factories, commercial establishments, or communal areas. This capacity was selected based on an anticipated daily energy production ranging from approximately 1,100 to 1,375 kWh (assuming an average of 4–5 hours of effective sunlight per day in Indonesia), leading to an estimated annual energy yield between 400 and 500 MWh. Additionally, fulfilling component requirements entails approximately 50 solar panels if utilizing modules rated at 550 Wp each. Typically, multiple large string inverters are employed in parallel configurations such as two inverters rated at 100 kW each or four rated at 50 kW each to meet the total required capacity. Alternatively, one could deploy a single inverter unit rated at 200 kW.

The roof area necessary for this installation is estimated to be around 2,000 m² (with the assumption that each kWp necessitates roughly 7 m² of space, inclusive of maintenance access). Table 2 presents appropriate configurations for solar panels corresponding to various capacities, along with details regarding land requirements. Main components (estimated scale 275 kWp):

- PV panels: approximately 460–500 modules (assuming 550–600 Wp per panel).
- Hybrid inverter: several large inverter units connected in parallel (e.g., 5 units × 55 kW or 3 units × 100 kW) capable of regulating bidirectional power flow.
- Battery system (BESS): Lithium ($LiFePO_4$) batteries with customized capacity. For this scale, battery cabinets with capacities of hundreds of kWh are typically used.
- Controller (BCR/EMS): energy management system to optimize when to charge the batteries or use PLN electricity.

Table 2. Detailed requirements of the rooftop area

Parameter	Specifications
Available roof area	Assuming a sun-tracker model, with one 10-meter span (optional)
Panel type	Longi Hi-MO 6 550W (2.278 × 1.134 m)
Number of panels	5 panel → 2.75 kW (per string)
Array area	20,502 m² (9 × 2,278 m²)
Roof type	Flat concrete (slab)
Designed wind speed	40 m/s
Tilt angle	10° (optimal)

3.3. Simulation results

The parameters that are shown when the simulation runs for the developed scenarios are the annual irradiance of Bireuen Regency, the annual electricity, both from the grid and from the system, and the annual load profile. Figure 8 illustrates the daily variations of GHI and diffuse horizontal irradiance (DHI) throughout each month of the year in Bireuen Regency. In every month analyzed, both GHI and DHI display a bell-shaped daily trend, commencing with an increase in the early morning hours, reaching their peak around solar noon (approximately between 11:00 and 13:00), and subsequently declining as evening approaches. Throughout all months, GHI consistently surpasses DHI values, highlighting the predominance of direct and circumsolar radiation in the overall solar resource, while diffuse radiation contributes a smaller yet notable fraction. The maximum GHI values typically range from 600-700 W/m², whereas peak DHI values are comparatively lower, generally falling between 300-500 W/m². Seasonal fluctuations are distinctly evident. Elevated irradiance levels are observed from March to August, with maximum GHI peaks occurring during the mid-year months, indicative of favorable solar geometry and diminished atmospheric attenuation. Conversely, reduced irradiance intensities are noted from November to January, when both GHI and DHI peaks decline likely attributable to increased cloud cover and seasonal climatic patterns. The temporal patterns of the DHI curves closely resemble those of GHI but exhibit flatter peaks, signifying a greater influence from atmospheric scattering and cloud conditions. Months characterized by higher fractions of DHI suggest an increase in diffuse radiation, which is typically linked to partially cloudy skies.

The load profile of the government facility of Bireuen Regency as can be seen in Figure 9, illustrates a distinct single-peaked annual trend characterized by low values at the start of the year, followed by a significant increase that culminates in a peak around mid-year, and subsequently experiences a decline as the year concludes. This pattern is commonly observed in systems affected by seasonal variables, including climatic conditions, operational cycles, or patterns of energy consumption.

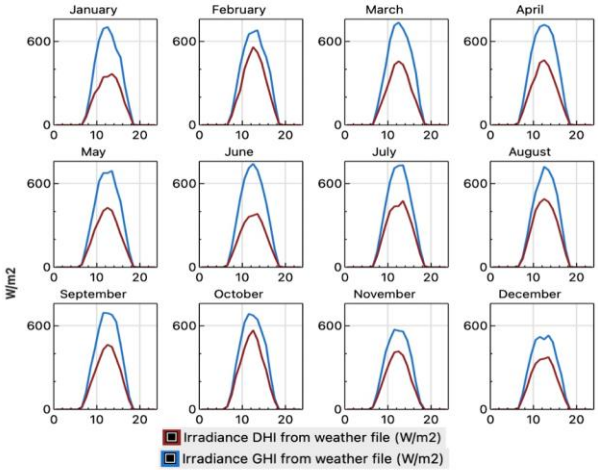


Figure 8. Annual irradiance

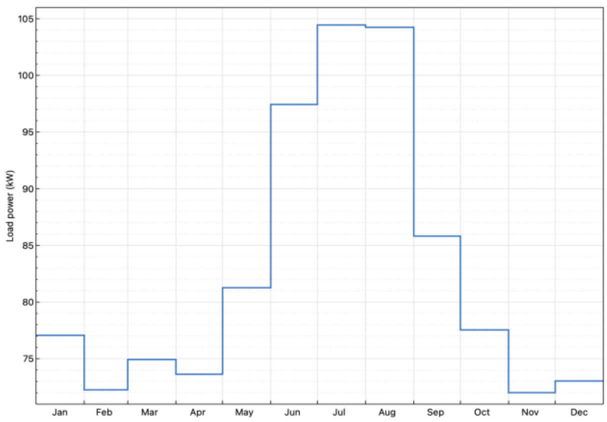
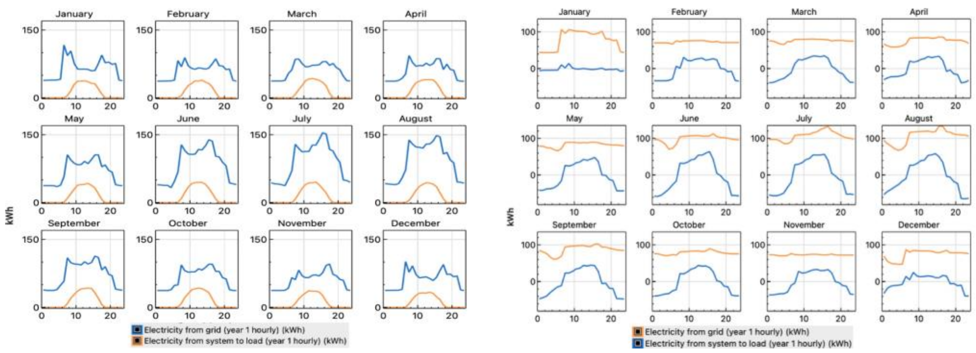


Figure 9. Load profile

Based on the proposed scenarios, it is possible to implement a hybrid system on a rooftop solar power plant with a capacity of 275 kWp, because the energy solution combines the advantages of an on-grid system and a system using batteries. The 275 kWp hybrid system operates with three complementary energy sources, namely, (i) priority 1 (solar): electricity from the solar panels directly supplies the load during the day; (ii) priority 2 (battery): excess energy is stored in the battery. if the sun is low (cloudy or evening), the battery supplies the load; and (iii) priority 3 (grid/generator): if the battery is empty and solar production is low, the system automatically draws power from the grid or turns on the generator as a last resort.

The illustration presented in Figure 10(a) shows monthly hourly energy profiles that contrast the electricity sourced from the grid with the electricity provided to the load by the system throughout a year. The data reveal a predominant solar contribution during daytime hours, exhibiting significant seasonal fluctuations. Notably, grid electricity consistently compensates for deficits during nighttime and periods of low generation, particularly in months characterized by reduced solar availability. The illustration presented in Figure 10(b) the output of the system is closely linked to both the duration and intensity of sunlight. Throughout nighttime hours, the system continually consumes power for recharging purposes. Although the energy production peaks during July and August, it remains insufficient to meet the significant rise in building energy demand primarily for cooling which leads to the highest reliance on grid power coinciding with the peak output of the system.



(a) (b)

Figure 10. Annual energy from grid and PV system: (a) without battery and (b) with battery

The novelty of this work lies in the combination of structural engineering evaluation and techno-economic analysis within a unified assessment framework for the implementation of rooftop PV systems in public-sector buildings. This research assesses the feasibility of a large-scale rooftop PV system in light of Indonesia's recent zero-export policy, which necessitates an emphasis on maximizing self-consumption as a key design goal. Consequently, this study presents a multidisciplinary framework that concurrently addresses structural integrity, energy generation, battery usage, grid interaction, and financial practicality for applications within government facilities.

3.4. Financial aspects analysis

This study examines the development of a grid-connected PV system with a capacity of 275 kWp and an anticipated operational lifespan of 25 years. The system is engineered to produce electricity by employing solar modules as its fundamental component, which convert solar energy into electrical power. This generated electricity is subsequently processed through an inverter to align with the requirements of the electrical grid. The initial investment for the project encompasses all expenses related to the acquisition of primary and auxiliary equipment, construction and installation processes, as well as testing and commissioning activities. Upon becoming operational, the solar power facility incurs significantly lower operation and maintenance (O&M) costs in comparison to traditional fossil fuel-based power plants. The foundational assumptions and financial parameters are derived from several key premises outlined in Table 3.

Table 3. Assumptions for calculating financial aspects

Description	Without battery	With battery
Plant capacity	275 kWp	275 kWp
Electricity production	357500 kWh/year	357500 kWh/year
Tariff	IDR 1700	IDR 1700
Monthly benefit	IDR 50,660,000	IDR 50,660,000
Annual benefit	IDR 607,920,000	IDR 607,750,000
Project span	25 years	25 years
Investment/kWp	IDR 14,000,000	IDR 18,000,000
Investment value	IDR 3,850,000,000	IDR 4,950,000,000
Savings (%)	61%/mo	61%/mo

A project is considered feasible if the NPV is positive, indicating that the project is capable of providing added economic value. If the IRR is greater than the discount rate or cost of capital, the project is considered feasible. The payback period indicator provides an overview of the project's liquidity risk level. A sensitivity analysis is conducted to test the project's resilience to changes in assumptions, specifically changes in annual economic benefits of ±10%. Thus, the required initial investment and cost allocation per component for 275 kWp. Table 4 lists the cost portion of the proposed 275kWp grid-tied PV system with and without battery storage. Table 5 illustrates the financial viability of the grid-tied PV system, both with and without battery storage.

Although the battery system requires higher upfront costs, it delivers higher returns, faster payback, and better long-term profitability. In contrast, the system without a battery remains financially viable but shows lower economic resilience and slower capital recovery, making it less optimal from a long-term investment perspective. To further evaluate the resilience of the 275 kWp hybrid system, a straightforward sensitivity analysis is conducted to examine how variations of ±10%–20% in critical financial parameters affect the project's feasibility. The initial investment emerges as the primary risk factor, as battery expenses can constitute between 30% and 50% of total project costs. A 20% increase in capital expenditure (CAPEX) would significantly jeopardize the current NPV of IDR 3.1 million. Since benefits are derived from bill reductions due to self-consumption rather than energy exports, the project's robustness is maintained even amidst moderate fluctuations in tariffs. With an IRR of 9.7%, the project exhibits a moderate sensitivity to changes in discount rates; it remains viable as long as the cost of capital does not exceed this threshold.

Table 4. Cost portion of the proposed 275kWp grid-tied PV system

Components	Portion (%) without battery	Cost (IDR)	Portion (%) with Battery	Cost (IDR)
PV panels	55%	2,117,500,000	45%	2,227,500,000
Inverter	12%	462,000,000	10%	495,000,000
Mounting structure	10%	385,000,000	8%	396,000,000
DC and AC cable	6%	231,000,000	5%	247,500,000
Protection and combiner	5%	192,500,000	4%	198,000,000
Monitoring system	2%	77,000,000	2%	99,000,000
Installation and commissioning	7%	269,500,000	6%	297,000,000
Engineering and project management	3%	115,500,000	3%	148,500,000
Baterai (BESS)	–	–	17%	841,500,000
Total	100%	3,850,000,000	100%	4,950,000,000

Table 5. Financial viability of the grid-tied PV system

Financial aspects	System with battery	System without battery
NPV (IDR)	3,183,019,000	1,872,093,681
IRR (%)	13	9.7%
Payback period	7 years	9.3 years

Assumptions regarding battery lifetime and replacement can be made by considering their operational lifespan, while the overall PV system is designed for a 25-year operational lifespan; however, batteries typically possess a shorter cycle life. To enhance battery longevity, the system is configured to initiate discharge only when the SoC reaches or exceeds 80%. Should the SoC fall below this level, discharge will cease to safeguard the battery cells. Although the initial investment per kWp increases from IDR 14 million to IDR 18 million with the inclusion of batteries, it is essential to incorporate replacement costs into the long-term O&M budget to uphold the "zero-export" benefit throughout the project's 25-year duration. Additionally, assumptions include providing a temperature-controlled environment for battery storage to mitigate degradation risks associated with Bireuen's tropical monsoon climate.

To enhance the realism of the long-term economic evaluation, the financial analysis incorporated considerations for component degradation and replacement expenses. PV modules undergo gradual performance decline over time as a result of factors such as environmental exposure, thermal cycling, and material aging. In alignment with industry standards and manufacturer warranties, an annual degradation rate of 0.5% for PV systems was assumed throughout the project's 25-year duration. As a result, the annual electricity output is expected to diminish progressively from its initial value of 357,500 kWh per year. The $LiFePO_4$ battery technology was developed due to its extended cycle life and compatibility with tropical climates. Although the overall project duration extends to 25 years, it is anticipated that the battery system will necessitate replacement after approximately 12 years of service. Consequently, a battery replacement cost amounting to 70% of the original investment was factored into Year 12 of the financial model. This assumption takes into account projected reductions in future battery prices while also considering installation and replacement costs.

A sensitivity analysis was performed to evaluate the project's resilience under varying economic and technical conditions. Five critical parameters were identified due to their substantial impact on financial performance: CAPEX, electricity tariff rates, annual energy production levels, battery replacement costs, and discount rates. Each parameter was adjusted by ±10% and ±20% relative to a baseline scenario while keeping all other variables constant. The findings reveal that CAPEX is the most significant factor affecting project feasibility; a 20% increase in investment costs markedly diminishes NPV and prolongs payback periods. Electricity tariffs are identified as the second most sensitive parameter since project revenues are closely tied to reductions in purchased grid electricity. Variations in annual energy production due to weather fluctuations or system degradation also have considerable implications for profitability. Battery replacement costs exert a moderate influence on economic performance, whereas changes in discount rates primarily affect long-term cash flow valuation.

4. CONCLUSION

This research assessed the technical and financial viability of a 275 kWp rooftop grid-connected PV system, both with and without battery energy storage, for a government facility located in Bireuen Regency. The evaluation was carried out through a comprehensive analysis that included structural assessment, system sizing, energy performance simulation, and economic appraisal. The analysis of the roof structure indicated that all components meet safety standards, as evidenced by DCR values remaining below the permissible threshold. The outcomes of the PV system sizing and simulation revealed that Bireuen Regency has significant solar potential, characterized by stable daily irradiance patterns and enhanced solar availability during the mid-year months. The system is poised to make a substantial contribution to the facility's electricity consumption, particularly during daytime hours. Seasonal and hourly assessments indicate that while PV generation effectively decreases reliance on grid power, peak electricity demands, especially during cooling periods in mid-year, still require backup from the grid. From a financial standpoint, both configurations are deemed economically feasible, as demonstrated by positive NPV, satisfactory IRR, and acceptable payback durations. Notably, the battery-integrated system surpasses its non-battery counterpart by providing higher NPV, elevated IRR, and a reduced payback period. Despite incurring higher initial investment costs, incorporating battery storage boosts energy self-consumption, enhances load management capabilities, and fortifies long-term economic resilience. The primary scientific contribution of this research lies in the establishment of a dual-validation framework that effectively integrates concepts from electrical engineering and structural mechanics within a "zero-export" regulatory context. This work notably advances the discipline by providing a quantitative assessment of DCR associated with solar retrofitting on large-scale industrial buildings, thereby setting a new technical standard for safety-oriented solar energy deployment. In light of these outcomes, policymakers should consider implementing subsidies or tax incentives for battery storage components to mitigate the elevated initial expenses associated with hybrid systems, which would facilitate the more rapid adoption of decentralized energy solutions. Additionally, for practical application, project developers should give precedence to conducting localized structural assessments as an essential step before solar installation to guarantee long-term operational safety and adherence to regulatory standards.

ACKNOWLEDGMENTS

The authors would like to thank the Director and Vice Director of Cooperation and Information System Affairs at Politeknik Negeri Lhokseumawe for choosing them as consultants for the project to design and install a rooftop grid-tied solar PV system at a government facility in Bireuen Regency, Aceh Province, Indonesia.

FUNDING INFORMATION

The study is funded by the Government Facility of Bireuen Regency in Aceh Province, Indonesia, along with Politeknik Negeri Lhokseumawe. This funding is for a project that involves evaluating and setting up a rooftop solar panel system at the Government Facility in 2025.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Nelly Safitri	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Musbar	✓	✓		✓		✓	✓	✓		✓				
Busra	✓	✓		✓		✓	✓	✓		✓				✓
Amri		✓				✓		✓		✓			✓	✓
Yuli Anisah					✓			✓		✓			✓	✓

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors state that there is no conflict of interest.

DATA AVAILABILITY

The authors of this article have provided the evidence supporting the available findings in https://drive.google.com/drive/folders/1Isho9EpNdB7e7vBmdSIcuWIBZnKE-dsw?usp=share_link

REFERENCES

[1] M. N. Lakhoua, N. Walid, and C. Atef, "System Analysis of a Hybrid Renewable Energy System," *International Journal of Electrical and Computer Engineering (IJECE)*, vol. 4, no. 3, Jun. 2014, doi: 10.11591/ijece.v4i3.5880.

[2] M. K. Panjwani, *et al.*, "Hybrid concentrated photovoltaic thermal technology for domestic water heating," *Indonesian Journal of Electrical Engineering and Computer Science (IJEECS)*, vol. 16, no. 3, p. 1136, Dec. 2019, doi: 10.11591/ijeecs.v16.i3.pp1136-1143.

[3] S. Vavilapalli, S. Padmanaban, U. Subramaniam, and L. Mihet-Popa, "Power Balancing Control for Grid Energy Storage System in Photovoltaic Applications Real Time Digital Simulation Implementation," *Energies*, vol. 10, no. 7, p. 928, Jul. 2017, doi: 10.3390/en10070928.

[4] G. Swaminathan, V. Ramesh, S. Umashankar, and P. Sanjeevikumar, "Investigations of Microgrid Stability and Optimum Power Sharing Using Robust Control of Grid Tie PV Inverter," *Lecture Notes in Electrical Engineering*, pp. 379–387, Oct. 27, 2017. doi: 10.1007/978-981-10-4286-7_37.

[5] W. H. Tang *et al*., "A composite voltage stability index for integrated energy systems based on L-index and the minimum eigenvalue of reduced Jacobian matrix," *International Journal of Electrical Power & Energy Systems*, vol. 141, p. 108136, Oct. 2022, doi: 10.1016/j.ijepes.2022.108136.

[6] A. Castillo and D. F. Gayme, "Grid-scale energy storage applications in renewable energy integration: A survey," *Energy Conversion and Management*, vol. 87, pp. 885–894, Nov. 2014, doi: 10.1016/j.enconman.2014.07.063.

[7] European Union Committee, *The EU's Renewable Energy Target and the Revision of the Emissions Trading System: Follow-up Report*, 16th Report of Session 2008–09, HL Paper 123. London, U.K.: The Stationery Office Limited, Jul. 2009. [Online]. Available: https://publications.parliament.uk/pa/ld200809/ldselect/ldeucom/123/123.pdf

[8] G. Resch *et al*., "Study on 2030 Renewable Energy and Energy Efficiency Targets in the European Union," *European Renewable Energies Federation , European Renewable Energies Federation: Brussels, Belgium*, 2023. [Online]. Available: https://eref-europe.org/wp-content/uploads/2022/09/Final-Report-Study-on-2030-RES-and-Energy-Efficiency-Targets-TU-Wien-EREF-26-August-2022-final.pdf

[9] M. Almuni, T. Dauwe, I. Moorkens, R. J. Saarikivi and M. Tomescu, *Renewable Energy in Europe 2020: Recent Growth and Knock-on Effects*, ETC/CME Report 7/2020. Copenhagen, Denmark: European Topic Centre on Climate Change Mitigation and Energy (ETC/CME), Dec. 2020. [Online]. Available: https://www.eionet.europa.eu/etcs/etc-cme/products/etc-cme-reports/etc-cme-report-7-2020-renewable-energy-in-europe-2020-recent-growth-and-knock-on-effects

[10] W. Hemetsberger, S. Dunlop, and M. Schmela, "Global Market Outlook for Solar Power 2025-2029," Brussels, Belgium: SolarPower Europe, May 2025. [Online]. Available: https://www.solarpowereurope.org/insights/outlooks/global-market-outlook-for-solar-power-2025-2029/detail

[11] "Solar PV Panels Market (2024 - 2030)," USA, 2024.

[12] S. B. Ovali, "Design and Simulation of A Residential PV-Battery System," A Magister Thesis Report, Michigan Technological University, Michigan, USA, 2016.

[13] A. Razmjoo, A. Ghazanfari, P. A. Østergaard, and S. Abedi, "Design and Analysis of Grid-Connected Solar Photovoltaic Systems for Sustainable Development of Remote Areas," *Energies*, vol. 16, no. 7, p. 3181, Mar. 2023, doi: 10.3390/en16073181.

[14] S. Issaka, A. Galyuoni, H. A. Mumin, and J. A. Akanbasiam, "Design and Assessment of a Grid-Connected Photovoltaic System for Dr. Hilla Limann Technical University: Economic and Environmental Analysis," *International Journal of Engineering and Science Invention (IJESI)*, vol. 12, no. 3, pp. 201-209, 2024.

[15] T. Jamal, C. Carter, T. Schmidt, G. M. Shafiullah, M. Calais, and T. Urmee, "An energy flow simulation tool for incorporating short-term PV forecasting in a diesel-PV-battery off-grid power supply system," *Applied Energy*, vol. 254, p. 113718, Nov. 2019, doi: 10.1016/j.apenergy.2019.113718.

[16] D. H. Mai, H. D. Le, T. V. Pham, and A. T. Pham, "Design and Performance Evaluation of Large-Scale VLC-Based Indoor Positioning Systems Under Impact of Receiver Orientation," *IEEE Access*, vol. 8, pp. 61891–61904, 2020, doi: 10.1109/access.2020.2984027.

[17] B. Mirletz and D. Guittet, "Recent Improvements in PV+Battery Modeling in NREL's System Advisor Model," *National Laboratory of the Rockies (NLR)*, 2022. [Online]. Available: https://www.nlr.gov/docs/fy22osti/83677.pdf

[18] I. Taufiqurrohman, "The Assessment of Off-Grid Photovoltaic (PV) Systems for Rural Electrification in Indonesia." *3rd International Conference of Integrated Intellectual Community (ICONIC)*, 2018. doi: 10.2139/ssrn.3201095.

[19] A. Amiruddin, R. Dargaville, and R. Gawler, "Optimal Integration of Renewable Energy, Energy Storage, and Indonesia's Super Grid," *Energies*, vol. 17, no. 20, p. 5061, Oct. 2024, doi: 10.3390/en17205061.

[20] M. Artiyasa, M. Natsir, and B. Ozsut, "Design and Performance Analysis of OFFGRID PV mini-grid systemsSimulation PVSYST in Sukabumi, West Java, Indonesia," *International Journal Engineering and Applied Technology (IJEAT)*, vol. 6, no. 1, pp. 33–39, May 2023, doi: 10.52005/ijeat.v6i1.82.

[21] N. Azman and R. Sulistiawan, "Design and performance evaluation of an off-grid hybrid solar system in a remote location: A case study of Legundi Island," *MethodsX*, vol. 12, p. 102716, Jun. 2024, doi: 10.1016/j.mex.2024.102716.

[22] A. K. Awopone, "Feasibility analysis of off-grid hybrid energy system for rural electrification in Northern Ghana," *Cogent Engineering*, vol. 8, no. 1, Jan. 2021, doi: 10.1080/23311916.2021.1981523.

[23] A. C. Ohajianya, "Simulation and Analysis of a Standalone PV Solar Power Plant for a Housing Estate in Abuja, Nigeria," *International Journal of Renewable Energy Research (IJRER)*, no. V32i3, 2023, doi: 10.20508/ijrer.v13i3.14148.g8796.

[24] The World Bank, *Global Solar Atlas: Aceh, Indonesia Solar Resource and Photovoltaic Power Potential Report*. Washington, DC, USA: The World Bank, Sep. 3, 2026. [Online]. Available: https://globalsolaratlas.info/

[25] International Association of Certified Home Inspectors, How to Perform Roof Inspections, 6th ed. Boulder, CO, USA: Inspector Outlet, 2021. [Online]. Available at: https://www.nachi.org/accredited-home-inspection-school.htm
[26] S. Akar and J. Cook, *Introduction to Residential Rooftop PV Permitting,* NREL, 2025.
[27] A. S, A. Aziizudin, A. Purnomo, D. A. Halim, C. W. Yogiswara, and S. D. H. Putra, "Analysis of Rooftop Solar Power Plant Development Potential in Magelang City: A Case Study of Office Buildings, Universities, and Hotels," *Journal of Renewable Energy and Mechanics (REM)*, vol. 8, no. 01, pp. 10–26, Mar. 2025, doi: 10.25299/rem.2025.20775.
[28] E. Lardic, *ArcelorMittal IPE Sections Catalogue*. ArcelorMittal International, 2021.
[29] M. Murray, T. Thornton, S. Rowell, and C. Grey, "Dynamic material properties of Grade 50 steel : effects of high strain rates on ASTM A992 and A572 Grade 50 steels," *Engineer Research and Development Center (U.S.)*, Aug. 2023. doi: 10.21079/11681/47445.
[30] American Society of Civil Engineers, "Minimum Design Loads and Associated Criteria for Buildings and Other Structures," *American Society of Civil Engineers (ASCE)*, 2017. doi: 10.1061/9780784414248.
[31] G. G. Deierlein, A. M. Reinhorn, and M. R. Willford, "Nonlinear structural analysis for seismic design," *NEHRP seismic design technical brief 4*, pp. 1-36, 2010. [Online]. Available: https://bpb-us-e1.wpmucdn.com/blogs.rice.edu/dist/4/872/files/2018/05/NIST-NEHRP-Nonlinear-Structural-Analysis-for-Seimsic-Design-NIST-GCR-10-917-5-15wux56.pdf
[32] National Research Institute for Earth Science and Disaster Resilience (NIED). *Strong-motion Seismograph Networks (K-NET, KIK-net)*. 2021. [Online] Available at: https://www.kyoshin.bosai.go.jp/
[33] J. Melius, R. Margolis, and S. Ong, "Estimating Rooftop Suitability for PV: A Review of Methods, Patents, and Validation Techniques," *NREL*, 2013.
[34] J. Mondol, "Sizing of grid-connected photovoltaic systems," *SPIE Newsroom*, 2007, doi: 10.1117/2.1200704.0612.
[35] Ministry of Energy and Mineral Resources of The Republic of Indonesia, *Decree of the Minister of Energy and Mineral Resources of the Republic of Indonesia Number 2 of 2024.*, Ministry of Energy and MIneral Resources of The Republic of Indonesia, 2024.
[36] D. S. N. Sofyan, "Project Financing Strategy For On-Grid Solar Pv Installation In The Cement & Construction Material Industry (Case Study: Pt Cibinong Bangun Sarana, West Java, Indonesia)," (Thesis Final Project) Institut Teknologi Bandung, Bandung, 2025.
[37] Z. Serat, S. A. Z. Fatemi, and S. Shirzad, "Design and Economic Analysis of On-Grid Solar Rooftop PV System Using PVsyst Software," *Archives of Advanced Engineering Science*, vol. 1, no. 1, pp. 63–76, Jul. 2023, doi: 10.47852/bonviewaaes32021177.
[38] E. Tarigan, "Financial Analysis of Solar Rooftop PV System: Case Study in Indonesia," *International Journal of Energy Economics and Policy*, vol. 13, no. 3, pp. 15–19, May 2023, doi: 10.32479/ijeep.14214.
[39] M. I. G. Laras and M. A. Farras, "Techno-Economic Study of Solar Panel Implementation as the Alternative Energy Source in Mataram City," *Asian Journal of Social and Humanities*, vol. 3, no. 11, pp. 2067–2081, Aug. 2025, doi: 10.59888/ajosh.v3i11.608.
[40] P. Gilman, "SAM Photovoltaic Model Technical Reference," *Office of Scientific and Technical Information (OSTI)*, May 2015. doi: 10.2172/1215213.

BIOGRAPHIES OF AUTHORS

Nelly Safitri currently she is an Associate Professor at Electrical Engineering Department, Politeknik Negeri Lhokseumawe, Indonesia. Successfully completed her Master and Doctoral degree at Curtin University of Technology, Western Australia in Electrical and Computer Engineering Department in 2007 and 2016, respectively. Her area of interests is renewable energy, power system, and smartgrid. She can be contacted at email: nellysafitri@pnl.ac.id.

Musbar currently he is an Associate Professor at Civil Engineering Department of Politeknik Negeri Lhokseumawe, Indonesia. He received his Bachelor's degree in Civil Engineering from Syiah Kuala University, Indonesia. His Master's and Doctoral degrees in Civil Engineering are from Bandung Institute of Technology, Indonesia. His research interests are in the areas of structural simulation and modeling, steel and concrete structures, and earthquake structures. He can be contacted at email: musbaribrahim@pnl.ac.id.

Busra currently he is an Associate Professor at Commerse Department of Politeknik Negeri Lhokseumawe, Indonesia. He also serves as the head of the Applied Islamic Finance Master's Program. He obtained his Master's degree from Gajah Mada University in 2005 and later earned his Doctorate in 2018 from Syiah Kuala University in Banda Aceh, where he conducted a dissertation centered on the empowerment analysis of underprivileged communities in Aceh. He is concentrating his research efforts on topics related to green economics, poverty alleviation, and green finance. He can be contacted at email: busra_pnl@yahoo.com.

Amri currently he is an Associate Professor at Information Technology Engineering Department of Politeknik Negeri Lhokseumawe, Indonesia. He is majoring in Information Technology and Computers, accomplished his Masters at Institut Teknologi Sepuluh Nopember in 2005. Currently he is pursuing his Doctorate at Syiah Kuala University, Aceh, Indonesia. He can be contacted at email: amri@pnl.ac.id.

Yuli Anisah completed her Master of Management program at the Faculty of Economics, Syiah Kuala University in 2011 with a thesis entitled “The influence of product attributes on notebook purchase intention in Lhokseumawe City”. Currently, she is a permanent lecturer in the Commerse Department of Politeknik Negeri Lhokseumawe, focusing her research on creative economy development and community empowerment. She can be contacted at email: yulianisah.pnl@gmail.com.