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Feasibility Study of the Development of Ground-Mounted Solar Plants in Indonesia's New Capital

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Abstract

Indonesia is building a new capital city in Penajam Paser Regency. The government aims to maximise the utilisation of low-carbon energy in the new capital. With a favourable location at the equator crossing, Penajam Paser Regency has a Global Horizontal Irradiance (GHI) index higher than Indonesia's regional average—1,753 kWh/m²/year—and a solar potential of 13,749 MW. Therefore, solar energy in this location has the potential to meet the city's total energy demand. However, the regency currently has no ground-mounted solar energy projects. Our study examines the technical feasibility of implementing ground-mounted photovoltaic (PV) power plants in Indonesia's new capital city. It explores the technical and economic aspects of providing clean electricity and represents the first study of ground-mounted PV systems in the region. We compare the simulation results of Helioscope and PV Syst for designing a ground-mounted PV system. We then analysed economic feasibility by comparing two possible tariffs, which are the ceiling price and system generation cost. We reveal that the optimal PV system design has a 14.79 MWp capacity, producing 22.4 GWh of electricity annually. This system can be developed using a Power Purchase Agreement (PPA) plan over a 25-year operational duration. Economic analysis yields an Internal Rate of Return of 22.99%, a Net Present Value of GBP 6,083,060, a payback period of 8.4 years, and a Levelized Cost of Energy of GBP 0.056/kWh.

Keywords:
solar energy, ground-mounted solar plant, new capital city of Indonesia, techno-economic analysis

1. Introduction

Indonesia's capital, Jakarta, faces urbanisation challenges such as rapid population growth, environmental degradation, and reliance on fossil fuels. To address these issues, the government has decided to relocate the capital to Penajam Paser Regency in East Kalimantan. The new capital will require an estimated 1,196 MW of electricity (MEMR, 2019). Renewable energy potentials in East Kalimantan are solar (13,479 MW), hydro (5,615MW), bioenergy (964 MW) and wind (212 MW) (Diskominfo Kaltim, 2022). Specifically, this regency has an average Global Horizontal Irradiance (GHI) range between 1,600 and 1,700 kWh/m² per year, or 4.8 kWh/m² per day, and enjoys 12 hours of sunshine per day (GSA, 2023).

The commissioning of ground-mounted solar plants can satisfy the electrical needs of the new capital city and help achieve renewable energy targets. However, the implementation of ground-mounted solar plants in this region remains negligible. There have been many feasibility studies on PV systems in Indonesia, but none have analysed the feasibility of ground-mounted solar plants in East Kalimantan. A feasibility study on PV systems in Kalimantan was conducted by Sunarso et al. (2020), mapping the potential and locations of utility-scale solar PV plants in West Kalimantan. Another study on utility-scale solar PV plants was conducted by Syanalia and Winata (2018), mapping the potential for on-grid solar PV in Bali. Other PV system studies in Indonesia focus on off-grid systems (Kanata et al., 2024), low-emission buildings (Silalahi et al., 2024), charging stations for electric vehicles (Indradjaja et al., 2020; Mohammad et al., 2020), solar PV rooftops (Nurliyanti et al., 2021), floating PV systems (Pranoto et al., 2022), PV market size (Al Irsyad et al., 2019), hybrid solar-wind energy systems (Bangun & Rosli, 2024), and the feasibility of PV rooftop assistance to reduce electricity subsidies for underprivileged communities (Nurliyanti et al., 2021).

Moreover, previous studies in Indonesia have mainly utilised Hybrid Optimization of Multiple Energy Resources (HOMER) and PVSyst for designing solar PV systems. For instance, Huda et al. (2024) used PVSyst to estimate electricity production from residential and farm-based PV systems in South Sumatra. Meanwhile, Kanata et al. (2024) used HOMER to assess the feasibility of an off-grid PV system on a small island in Lampung Province. Our search on the Scopus database using the keywords (TITLE-ABS-KEY ("feasibility study" OR "techno-economic") AND TITLE-ABS-KEY ("solar plant" OR "solar energy" OR "photovoltaic" OR "solar power") AND TITLE-ABS-KEY ("Indonesia")) on 14 January 2025 did not yield any studies utilising HelioScope. HelioScope is a web-based software designed to create PV systems. One of its key features is the ability to design PV systems rapidly and efficiently while maximising return on investment.

Thus, our study aims to fill this gap by offering two novelties. First, we evaluate the feasibility of ground-mounted solar plants from both technological and economic perspectives in Waru Sub-district, Penajam Paser Regency, the designated location for Indonesia's new capital city. We assess the potential limitations and impacts of developing ground-mounted solar plants in the new capital. Second, we compare the performance of PVSyst and HelioScope in designing PV systems by evaluating their simulation results. We employ a comprehensive qualitative methodology, incorporating a literature review and secondary data analysis, to evaluate the feasibility assessment outcomes of a ground-mounted solar installation in Penajam Paser. The research utilises photovoltaic simulation software, specifically Helioscope and PVsyst, to conduct comparative analyses of optimal design configurations and performance simulations. Our method involves determining the best solar power plant design from the two software programs and then calculating the economic feasibility of the best design. After that, we discuss the policy implications for potential challenges faced in developing the solar power plant. The significance of our study is to provide an economic feasibility reference for establishing a low-carbon city and providing essential insight for developing sustainable energy infrastructure in Indonesia, where significant solar potential remains untapped through the development of large-scale solar energy plants.

2. Methods and Materials

Figure 1 shows the analysis flowchart. Designing a large-scale grid-connected PV system necessitates considerable technical expertise to optimize both energy performance and cost efficiency. We undertook a comprehensive analysis of energy consumption data from 2020 to 2022. Then, we analysed with an assessment of the solar potential, considering updated irradiance and temperature data, as well as other critical factors such as tilt angle and grid connectivity.

The case study focuses on the Penajam Paser Regency, the location of Indonesia's new capital city, designed as a net zero carbon city. The regency covers a total area of 3,333.06 km² and is geographically positioned at 1°17'30.15" South Latitude and 116°30'49.67" East Longitude. Administratively, the regency is subdivided into four districts: Sepaku, Babulu, Waru, and Penajam. Among these districts, Waru demonstrates superior solar energy potential, exhibiting the highest Direct Normal Irradiance (DNI) and GHI indices of 1,211.7 kWh/m² and 1,719 kWh/m², respectively (GSA, 2023).

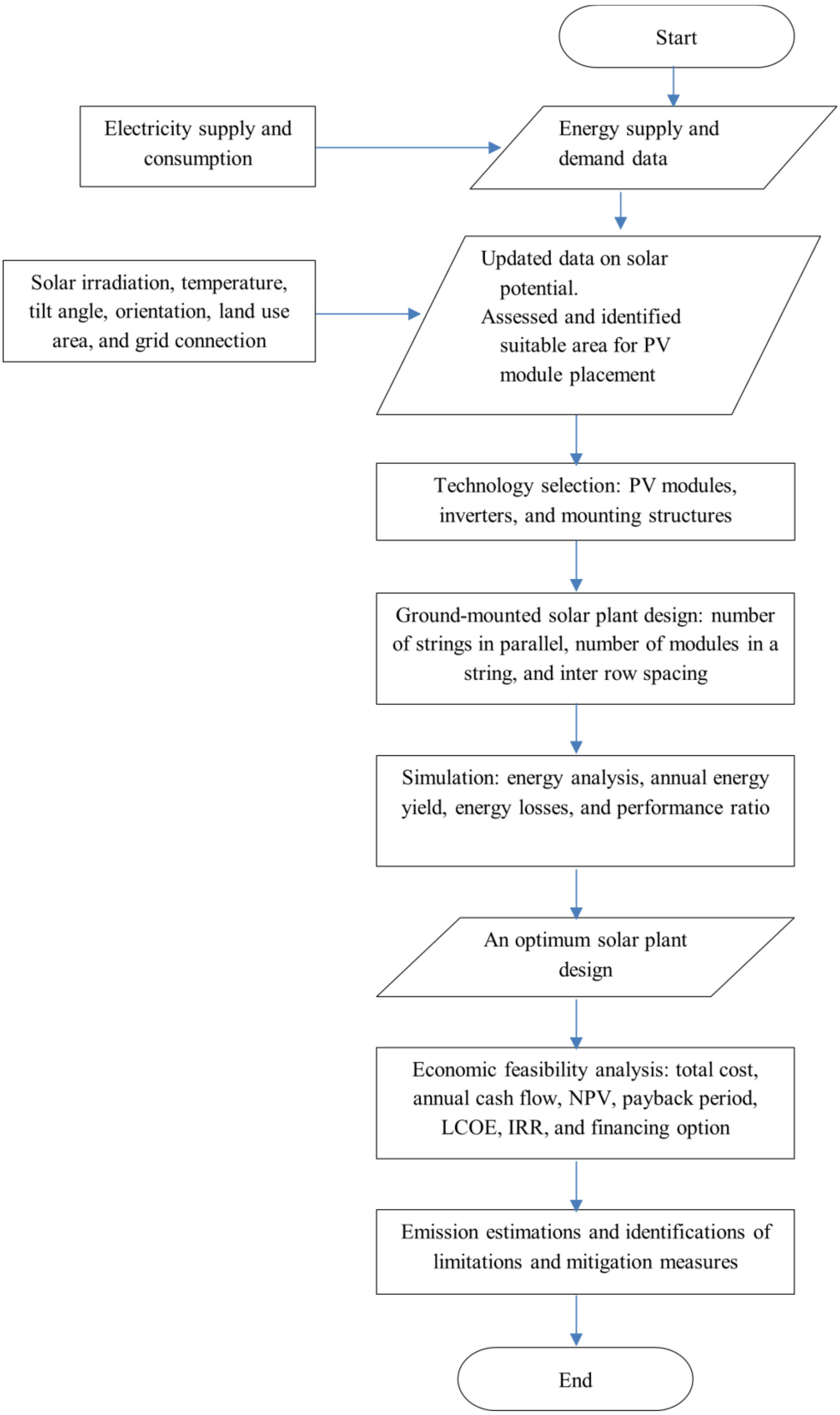

Figure 1. Analysis flowchart.

The design process for the ground-mounted PV system entailed several key steps. Initially, we selected the appropriate PV technology specifications. Following this, we developed and compared two distinct designs based on performance metrics, including energy yield, efficiency, and system reliability. Thereafter, we proceeded to evaluate its economic feasibility, considering factors such as capital costs, operational expenses, and potential financial returns.

2.1 Solar PV Design

The design process of ground-mounted solar power plants primarily involves the use of computer simulation software, which can calculate solar irradiance, shading losses, energy output, technical and economic feasibility, environmental impact, and generating three-dimensional (3D) models (Wijeratne et al., 2019). There are many software options available for solar energy system analysis (Buchatskiy et al., 2023). For example, Aurora Solar, which is cloud-based, allows collaborative analysis by multiple users from different locations. However, it is only applicable to private consumers. PV Syst offers the most comprehensive analysis features but has a complex interface that requires a higher level of technical knowledge to use effectively. Moreover, it is commercial software that is not freely available, and it cannot provide a proper single-line diagram (Buchatskiy et al., 2023; Vashishtha et al., 2022). In contrast, Helioscope is a web-based application that has a simple interface and can provide a single-line diagram, although its analysis features are not as extensive as those of PV Syst. Thus, we utilized two commercially available software tools—PV Syst and Helioscope—to determine the optimal design for the solar plant.

Table 1 presents a comparison of the advantages and disadvantages of these two commonly used software applications for designing PV systems. The essential data required for designing a solar PV system includes energy consumption metrics, solar potential assessments, and various economic assumptions, as detailed in Section 3.2. This data was sourced from government websites, journal publications, the Electricity State Company, and online reports. We did not undertake data verification and validation because we relied on secondary data. Therefore, we recommend that future studies improve upon our analysis method by incorporating primary data verification and validation processes.

In general, the number of solar panels is calculated based on the ratio between the total energy requirement E_{total} and the daily energy production per panel E_{panel}.

$$n = \frac{E_{total}}{E_{panel}}$$

The total energy requirement E_{total} is calculated as the ratio between the daily electricity consumption E_{daily} and the efficiency of the solar energy system η_{system}.

$$E_{total} = \frac{E_{daily}}{\eta_{system}}$$

The daily energy production per panel E_{panel} is calculated by multiplying the peak power of the solar panel P_{panel} (in kWp) by the peak sunlight hours per day H_{peak} (in hours).

$$E_{panel} = P_{panel} * H_{peak}$$

Table 1. The comparison of PV analytical tools (Umar et al., 2018; Wijeratne, 2019; PV Syst, 2023; Buchatskiy et al., 2023; Vashishtha et al., 2022).

Analytical tools	Advantages	Disadvantages
PV Syst 7.4	• Performed with Carbon Balance Tool, especially for grid-connected PV systems. • Combining ground-mounted solar plant designs with grid-connected systems proved to be highly suitable. • Incorporates meteorological data from PVGIS and NASA databases. • Offers a diverse range of photovoltaic technology options, including modules, inverters, and mounting structures. • Provides robust technical and economic analysis. • Utilises the Carbon Balance Tool, particularly for grid-connected PV systems.	• Cannot provide a proper single-line diagram. • Only applicable to private consumers. • Requirements of higher technical knowledge and experience. • Complex, less user-friendly for beginners. • Small display.
Helioscope	• User-friendly interface with direct internet connectivity (web-based tool). • Provides a 3D PV layout with comprehensive PV technology design and grid connection capabilities for both DC and AC voltage. • Assesses estimated energy production, accounting for losses due to weather and climate variations.	• The software did not support comprehensive economic analysis. It should be manual input for variables related. • There was no further environmental calculation for PV system design. • Incapability to support comprehensive economic analysis, requiring manual input for specific related variables. • Incomplete environmental calculation for PV system design.

2.2 Economic Analysis

Economic analysis plays a crucial role in evaluating the feasibility of ground-mounted solar plant projects. The analysis can ascertain the project's economic viability and gain a comprehensive understanding of the various cost components involved. These cost components are categorized into three main variables: System Cost, Capital Cost or Bills of Quantities (BOQ), and Operations and Maintenance (O&M) Cost (Wijaretne et al., 2019; Ullah et al., 2023). System Cost encompasses the expenses related to the infrastructure and equipment. BOQ pertains to the detailed estimation of the material and labour costs. The O&M cost includes the ongoing expenses required to ensure the plant's efficient functioning over time. Ullah et al. (2023) highlighted four primary methods for conducting financial evaluations of solar projects. These methods include Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period, and Levelized Cost of Energy (LCOE). Each method offers a different perspective on assessing the financial performance and long-term sustainability of the project.

NPV determines the economic feasibility of the project based on an examination of both revenues and costs. In a broad context, a positive NPV signifies the feasibility and financial advantages of a project, whereas a negative NPV indicates the opposite. Conversely, a zero NPV suggests that the project's revenues can only offset the initial capital investment (Andersson, 1992). The NPV formula is as follows:

$$NPV = \sum_{n=0}^{N} \frac{C_n}{(1 + d_{nominal})^n}$$

where C_n : after-tax cash flow in year n
d : discount rate
N : analysis period of the year

The Internal Rate of Return (IRR) is commonly utilised to evaluate the profitability of investments (Rodrigues et al., 2016). The IRR serves as a key indicator that should be compared to an interest rate. The magnitude of the IRR is directly proportional to the investment's appeal, expressed as a percentage. In other words, a higher IRR signifies a more advantageous investment opportunity.

The Payback Period, on the other hand, measures the amount of time (in years) required to recover the total cost of the investment. Projects with shorter payback periods are generally viewed with greater confidence and perceived as less risky (Andersson, 1992). The Payback Period formula is as follows:

$$Payback\ Period = \frac{Initial\ investment\ cost}{Annual\ Savings}$$

Another method to evaluate the feasibility of the solar plant project in Penajam Paser Regency involves comparing the LCOE estimations of PV systems with and without battery cost, which is IDR 1,069/kWh or GBP 0.056/kWh (Setiawan et al., 2021). LCOE represents the minimum cost at which electricity can be sold throughout the project's lifespan to reach the break-even point. The LCOE formula is as follows:

$$LCOE = \frac{-C_0 - \frac{\sum_{n=1}^{N} C_n}{(1 + d_{nominal})^n}}{\frac{\sum_{n=1}^{N} Q_n}{(1 + d_{real})^n}}$$

2.3 Data and Assumptions

The economic analysis involved comparing two pricing scenarios for two photovoltaic system designs. The scenarios examined include the system generation cost and the ceiling price, with detailed assumptions outlined in Table 2. To promote ground-mounted solar plants, the Indonesian government has implemented two key regulations.

Table 2. Data and assumptions for economic analysis (Bank Indonesia, 2023; MEMR, 2020; IESR, 2022).

Parameter	Value
System size	≥ 1 - 20 MW
Analysis Period	25 years
Inflation Rate	4 %
Interest Rate	5.75 %
Ceiling Price	4.96 cent USD/kWh or 0.04 GBP/kWh
System Generation Cost	9.07 cent USD /kWh or 0.074 GBP/kWh

The first regulation, MEMR Regulation No.4/2020, governs land-based solar projects with capacities ranging from 1 to 20 MW. This regulation enforces system generation costs per kWh, which vary based on the GHI index, ranging from USD 0.06 to USD 0.20/kWh. The national average generation cost is USD 0.0705/kWh.

The second regulation, Presidential Regulation No.112/2022, introduces a ceiling price for on-grid solar plants. This regulation divides pricing into two stages: projects operating for less than 10 years and those running between 11 and 25 years. The rates vary by province to accommodate regional differences in solar resource availability and economic conditions (IESR, 2022).

3. Results and Discussions

3.1 Ground Mounted Solar Plant Design

Figure 2 shows that the energy supply for the Waru Subdistrict steadily increased over three consecutive years (2020–2022) (PLN, 2021; BPS, 2022b). Notably, electricity generation in 2022 was approximately twice that of 2020. The electricity for Waru Subdistrict was sourced externally from Penajam Paser Regency, with the majority coming from non-renewable energy power plants. In contrast, as shown in Figure 3, the electricity consumption in the subdistrict was lower than the supply. The highest consumption was recorded in 2022, at 5,000 MWh. Consequently, there was a substantial surplus of electrical supply suitable for integrating a ground-mounted solar plant into the grid. Our energy analysis is based on simulations using Helioscope and PV Syst, with the assumption that energy consumption in Waru Sub-district in 2022 was 5,000 MWh.

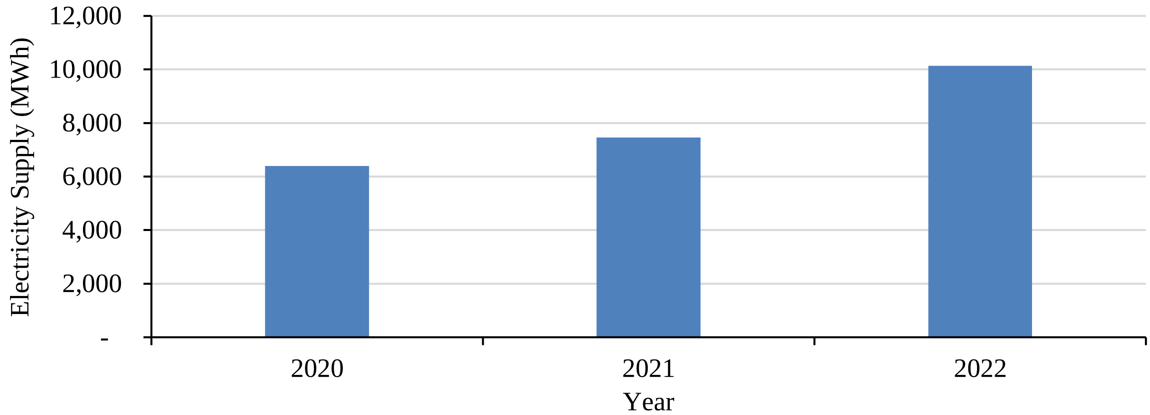

Figure 2. Electricity supply to Waru Sub-district. (PLN, 2021; BPS, 2021b).

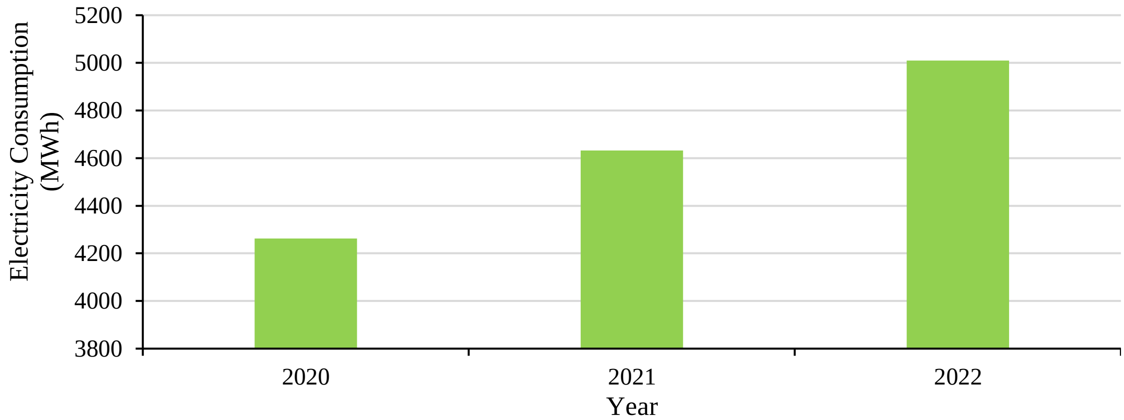

Figure 3. Electricity consumption in Waru Sub-district (PLN, 2021; BPS, 2021b).

The site, situated at -1.3878° South and 116.6212° East, with an elevation of 9 meters, enjoys 12 hours of sunlight daily and an average temperature of 27 °C (see Figure 4). The annual average solar irradiation is 4.7 kWh/m²/day (1,719 kWh/m²/year) according to GSA (2023). Simulations using PV Syst and Helioscope indicate slightly higher values of 5.07 kWh/m²/day (1,815 kWh/m²/year), highlighting the site's strong solar potential. The site features a tilt angle of 5 degrees facing south;

however, simulations suggest that a 15-degree tilt angle would optimise performance (refer to Figure 5).

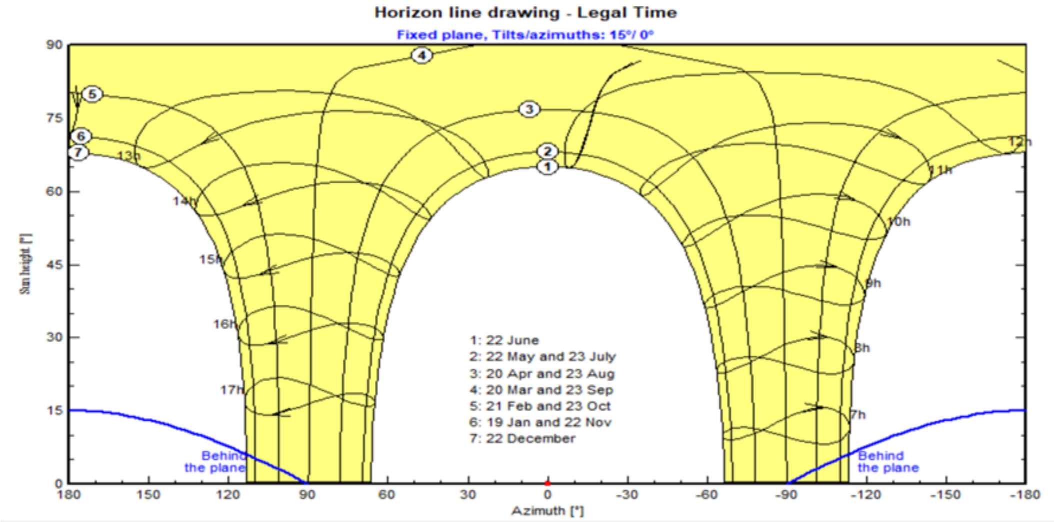

Figure 4. Solar horizon profile of Waru Sub-district (PV Syst; 2023).

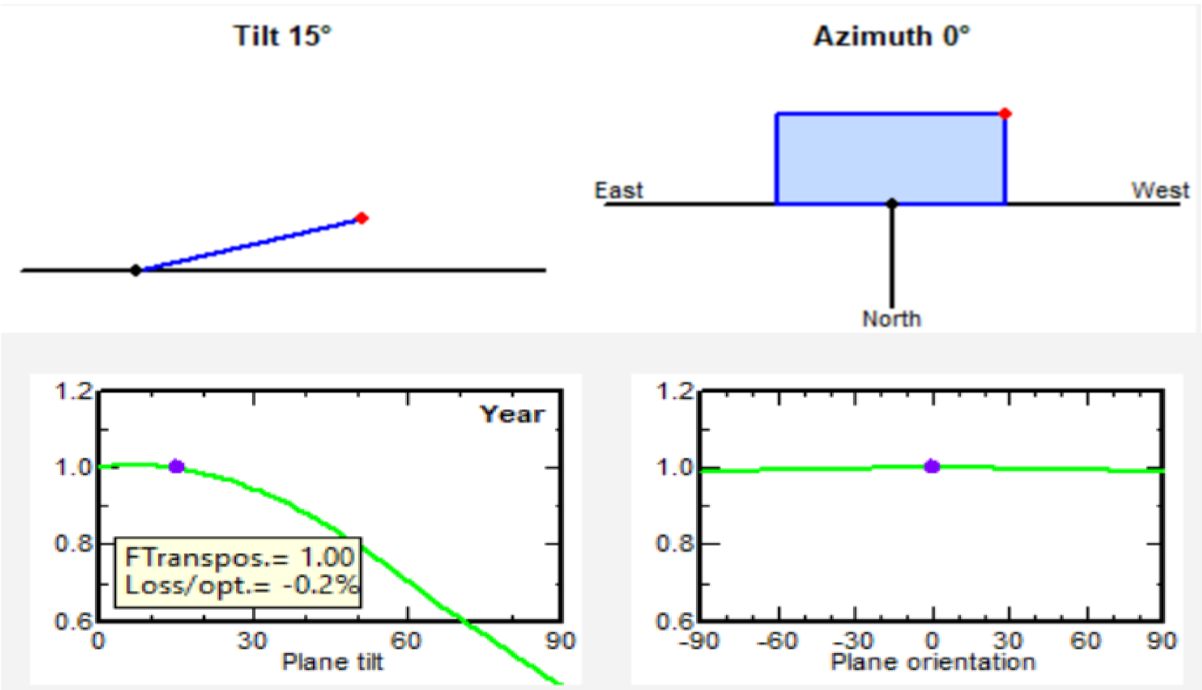

Figure 5. Optimum tilt angle for Waru Sub-district (PV Syst, 2023).

The proposed ground-mounted solar plants will occupy 7 hectares of reclaimed coal mining land owned by the government. The site is grid-connected, with plans to integrate two 30 MVA substations during the initial phase of PV system construction, starting in 2024 (PLN, 2022). Table 3 compares the simulation results from Helioscope and PVSyst. Our design uses a Helioscope to divides the 70,000-square-meter area into five segments. The design details for the ground-mounted solar plant, which was created with a helioscope, are illustrated in Figure 6. The design consists of 12,760 PV modules with a total installed capacity of 7 MWp, distributed across five distinct field segments. Solar panels are arranged in 751 parallel strings, with 17 modules per string and an inter-row spacing of 2.4 meters. These modules are connected to 234 DC/AC inverters.

The annual AC energy production is approximately 8.74 GWh. July produces the highest output due to 12-hour sunshine durations, while January and February see the lowest output due to the rainy season. The projected DC energy generated from PV arrays is 9 GWh, with an annual energy yield of 1,245.5 kWh/kWp. Over 25 years, the cumulative energy yield totals 218.5 GWh, offsetting 175% of energy from the installed modules. System losses include 6.8% due to temperature and less than 2.5% from AC systems and inverters. The solar plant achieves a performance ratio of 80.3%.

In contrast to Helioscope, PV Syst 7.4 solely shows a single-line design implemented in one area, as depicted in Figure 7. Using the same land area, simulation results from PV Syst 7.4 indicate that this design is more optimal and capable of producing double the power (14.79 MWp) compared to the Helioscope. Additionally, the PV Syst design includes 27,144 PV modules arranged in a configuration of 2,088 parallel strings, with each string consisting of 13 modules, all connected to 455 inverters.

Table 3. Technology selection and simulation results for each PV software (PV Syst and Helioscope, 2023).

Variables	Helioscope	PV Systs 7.4
PV module specification	Jinkosolar Monocrystalline Silicon 545Wp 35 V,21,3% Efficiency	
Inverter specification	Sunny SMA string inverters 430 - 800 V	
Mounting structure	Triangular Mounting Structure	
Inter row spacing (m)	2.4	2.4
Land area (m^2)	70,000	70,000
Number of PV clusters	5	1
Number of PV modules	12,760	27,144
Capacity (MWp)	7	14.79
Number of parallel strings	751	2,088
Number of inverters	234	455
AC energy production (GWh/ year)	8.74	22.49
System performance ratio (%)	80.3	83

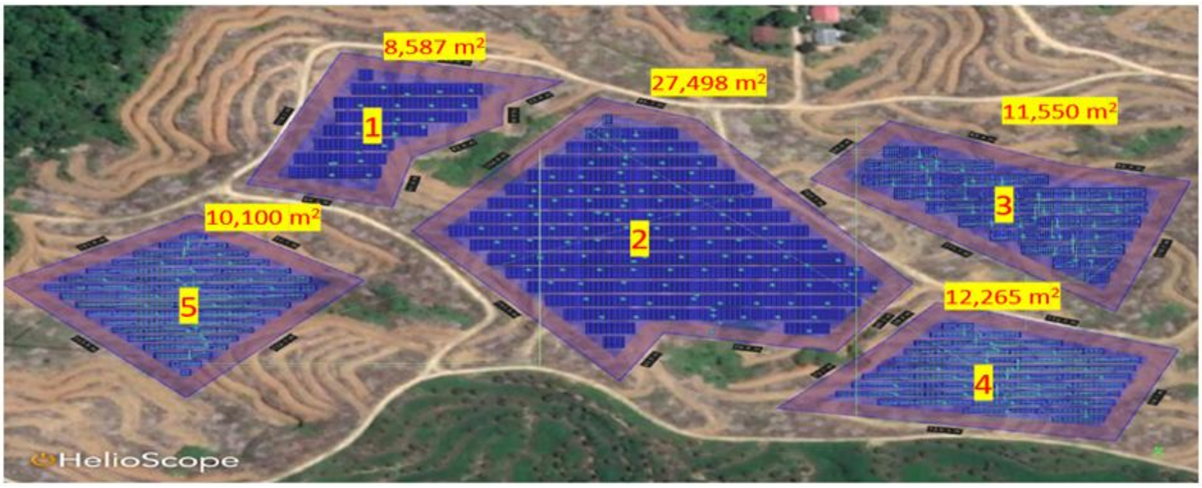

Figure 6. Ground-mounted design with Helioscope (Helioscope, 2023).

Figure 7. Solar plant single-line design using PV Syst (Google Earth Pro, 2023; PV Syst, 2023).

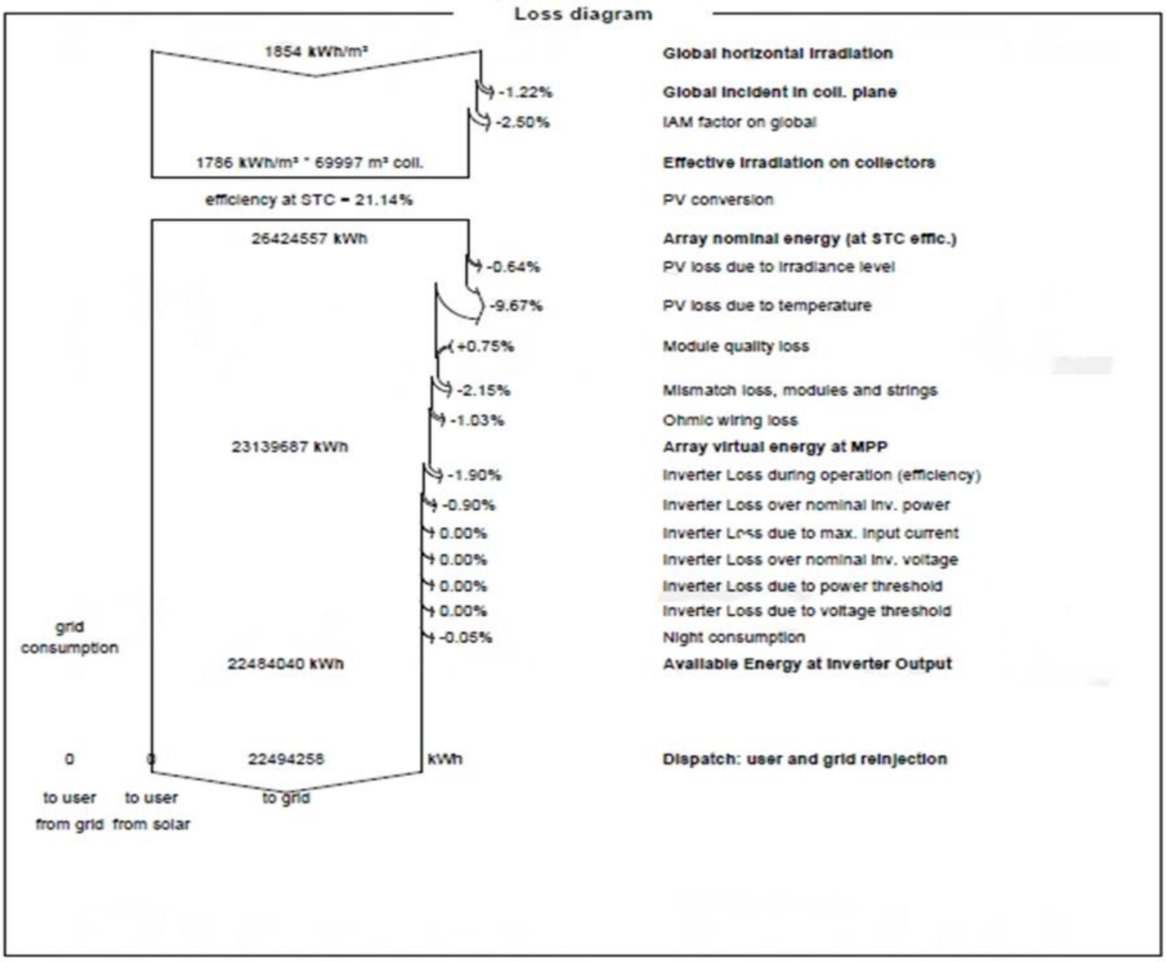

Figure 8. Loss diagram for ground-mounted solar plant (PV Syst, 2023).

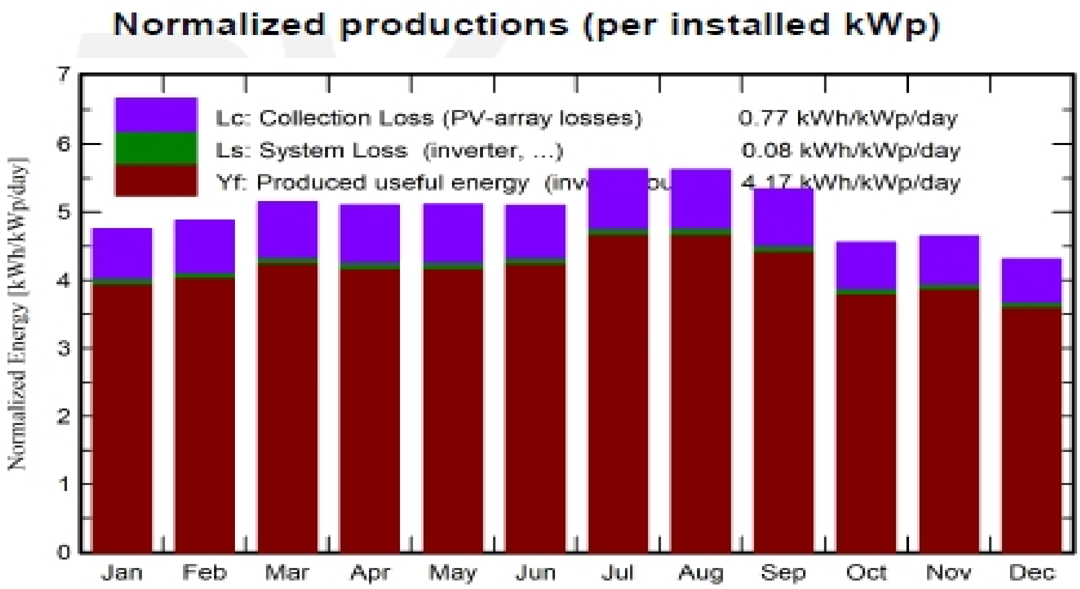

Figure 9. Normalised energy diagram (PV Syst, 2023).

The simulation results indicate that the total AC energy produced and injected into the grid is approximately 22.49 GWh over one year. The monthly energy balance has a stable performance ratio of 83% for the PV system. The electricity generated from DC voltage will be 22.9 GWh, with PV production potentially reaching 1,521 kWh/kWp per year. The lifetime energy yield of this PV system is estimated to be around 562.35 GWh.

Given that no PV system can reach 100% efficiency, it is crucial to assess and account for various losses during energy analysis. Figure 8 shows a reduction in the overall efficacy of the ground-mounted solar plant. Approximately 9.7% of PV loss was due to temperature, while losses in inverters, modules, and strings were under 2.5%. Paudel et al. (2021) point out that system loss analysis using PV Syst can be divided into two types: collection losses (within the PV module) and system losses (involving inverters, wires, etc.). These losses can be described through the normalised energy diagram in Figure 9. The percentage of collection losses was higher than system losses (0.77 kWh/kWp/day compared to 0.08 kWh/kWp/day). In conclusion, PV Syst 7.4 provides the most optimal design for a ground-mounted solar plant to meet the electricity demands of the New Capital City. This study aims to expand on the economic analysis derived from the PV Syst simulation.

3.2 Economic Analysis Results

The initial step in the economic analysis involves an in-depth assessment of the project's capital and investment distribution, as outlined in Table 4. The total investment required for the project is GBP 12.8 million. Additionally, the O&M costs for the 1st year amount to GBP 215,500. With an assumed inflation rate of 4% for subsequent years, the average annual operating cost over the 25-year lifespan is estimated to be GBP 358,987. The cumulative cash flow (see Figure 10) shows a negative trend during the first seven years of the operation. However, after this period, there is a continuous and steady increase in value, culminating in an amount exceeding GBP 6 million by the end of the project.

The comparison of different cost systems—including NPV, IRR, and Payback Period—using the ceiling price and generation cost system for 25-year project operations is detailed in Table 5. The IRR and NPV indicators are positive, with a moderate payback period. Using the ceiling price, the LCOE calculation is 0.056 GBP/kWh. This value aligns with the typical LCOE for solar energy without batteries in Indonesia, according to Setiawan et al. (2021). Additionally, the solar plant project is more appealing when utilising the ceiling price, as it results in an IRR value higher than bank credit interest rates and a payback period of less than ten years.

Table 4. Cost breakdown for the ground-mounted solar plant (PV Syst, 2023).

Components	Values (GBP)
Installation Costs	
PV Modules	9,500,400
Inverter	455,000
Engineering Design and Analysis	7,000
Installation	2,879,124
Insurance	10,000
Taxes	10,000
Sub Total Installation Cost	**12,861,524**
Operating Cost	
Salaries	250,000
Maintenance	65,500
Subsidies	-200,000
Taxes	100,000
Sub Total Operating Cost	215,500
Including Inflation (4%)	**358,987**

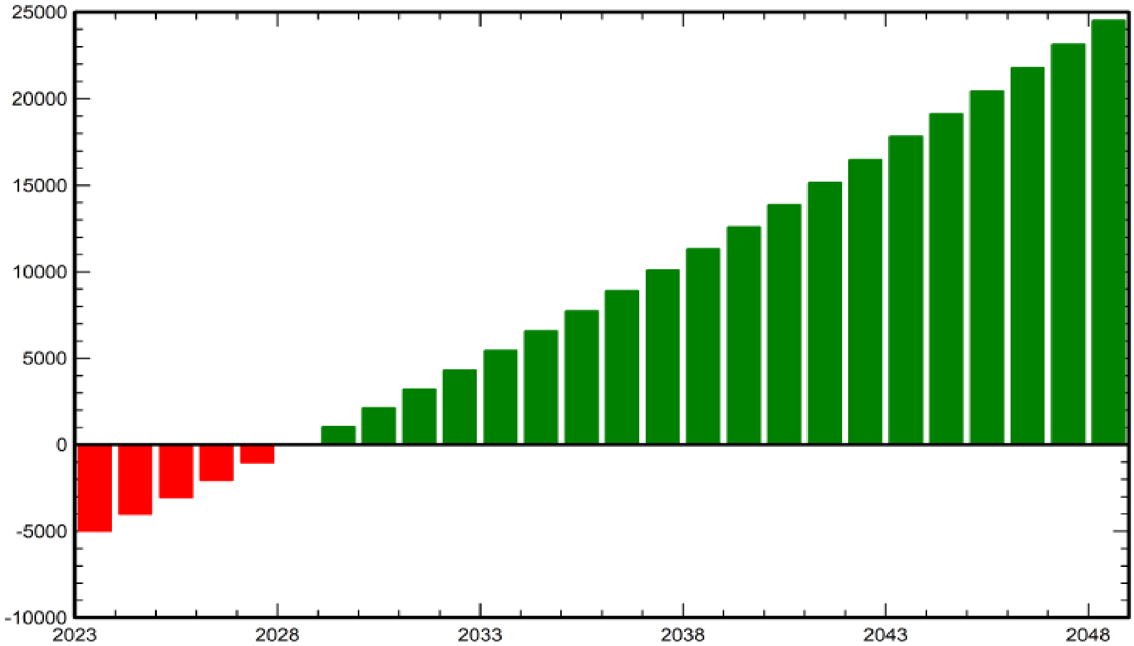

Figure 10. Cumulative cash flow diagram of the project (PV Syst, 2023).

Table 5. Economic calculation result.

Type of Cost	Price (GBP)	Total System Cost (GBP)	IRR (%)	NPV (GBP)	PP (Year)
Ceiling Price	0.04	899,770	22.99	6,083,060	8.4
System Generation Cost	0.074	1,664,575	43.04	10,736,114	10

3.3 Discussions

The solar plant project in the new capital city demonstrated significantly higher environmental sustainability compared to coal plants. The ground-mounted solar plant designed in Waru Sub-district produced approximately 22.49 GWh per year. The life cycle emission (LCE) from this system is estimated at around 26,885.25 $tCO_{2\text{-eq}}$. Meanwhile, an LCE from the electricity grid is around 734 gCO_2/kWh, so this ground-mounted solar plant with an annual system degradation of 1% over the 25-year project lifespan could reduce CO_2 emissions by as much as 339.78 million $tCO_{2\text{-eq}}$.

However, the implementing of the solar plant design in the Waru Sub-district faced certain restrictions and challenges. The design uses a conventional triangular mounting structure with monofacial modules, limiting solar energy absorption efficiency. Additionally, the project's location in a mining area with soft, sandy soil poses structural risks for the 27,144 installed modules. High temperatures (up to 30°C) near the equator also contribute to unavoidable energy losses.

To overcome these challenges, a bifacial design using heat-resistant thin-film PV modules (Copper Indium Gallium Selenide technology) could be implemented, as suggested by Ud-Din Khan et al. (2022). This design offers improved efficiency (11–12%) and increased energy production compared to monofacial systems. Pole-mounted structures would better suit the uneven terrain of mining areas (Mibet Energy, 2021). Furthermore, bifacial systems can be adapted to various orientations, enhancing their practicality and energy output (Solar Square, 2022).

Understanding the variations in solar radiation during the day leads to intermittent conditions affecting the balance between supply and demand in PV power generation. As penetration levels increase, concerns regarding reliability and grid stability arise (Poddar et al., 2023). Therefore, integrating a PV plant with substantial energy storage facilities at the designated location is a suitable solution for ensuring grid stability and maintaining the balance between electricity supply and demand in the new capital city. The excess energy generated by the PV plant can be effectively stored for later use during periods of high demand, particularly when experiencing intermittent power supply.

4. Conclusions

Indonesia envisions its new capital city as a zero-carbon city, necessitating the massive development of renewable energy power plants, including large-scale solar PV plants. However, the feasibility of large-scale solar PV plants in the new capital city has not yet been assessed. Therefore, our study is pioneering work analysing the feasibility of PV systems in East Kalimantan by comparing the performance of two common software tools for designing PV systems. In this study, we utilised PV Syst and HelioScope to design ground-mounted solar plants in the new capital city. Our results indicate that the PV system designed with PV Syst may produce 562.35 GWh over its lifespan, whereas the PV system designed with HelioScope is projected to generate 218 GWh during the same period. Based on these findings, we conducted a techno-economic analysis for the PV system designed using PV Syst.

The proposed PV plant in Penajam Paser Regency addresses key sustainability goals of availability, affordability, and acceptance. Using PV Syst 7.4, an optimal monofacial solar plant design with a 14.7 MWp capacity and 27,440 modules was identified, producing 22.4 GWh of electricity annually. The project is economically viable, boasting a payback period of under ten years and a return on investment exceeding Indonesia’s interest rate (5.75%). Although the costs are slightly higher than those of coal plants, the project offers significant environmental benefits and profitability through a power purchase agreement (PPA) with PLN. As contributions, our study can aid Indonesia in further developing ground-mounted solar plants across large areas or provinces to achieve green energy goals. In this context, we provide an initial assessment for a more comprehensive feasibility study of constructing large-scale solar PV systems in Indonesia’s new capital city.

Our study has several shortcomings. Firstly, we did not undertake data verification and validation because we relied on secondary data. Consequently, we recommend that future studies improve upon our analysis method by incorporating primary data verification and validation processes. Furthermore, our study could be enhanced by incorporating photovoltaic (PV) battery storage and micro-hydro systems to bolster the stability and resilience of the energy supply for Indonesia’s new capital city. Future research should also explore bifacial PV designs, heat-resistant thin-film modules, and battery energy storage solutions. Additionally, an analysis of regulatory reforms should be conducted to streamline renewable energy pricing and facilitate long-term Power Purchase Agreements (PPA) for stable revenue.

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