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Analyzing the Feasibility of Photovoltaic Solar Systems in the Parking Area of Universitas Multimedia Nusantara: A PVSyst Simulation-based Investigation

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ABSTRACK

This article discusses the feasibility and economic sustainability of installing a solar power generation system in the back parking area of Multimedia Nusantara University (UMN). Against the backdrop of increasing energy needs and a commitment to reducing carbon footprints, this study evaluates the potential of solar energy as a sustainable solution. Using PVSyst simulation, the study assesses the performance of the proposed solar power generation system. The simulation results show that the system can produce 224 MWh of electricity annually, meeting 20% of the energy needs for buildings A and D at UMN. The required initial investment is Rp. 781,883,953.26. Financial analysis indicates the system's sustainability with an NPV of Rp. 4,380,435,791 and an IRR of 34.28%. Additionally, the installation of this system is estimated to reduce carbon emissions by 2775.513 tons.

***Keywords*:**

Feasibility study; PVSyst; Electricity; Carbon emission; Environmental.

Kata Kunci:

Studi kelayakan; PVSyst; Listrik; Emisi karbon; Lingkungan.

ABSTRAK

Artikel ini memaparkan kelayakan dan keberlanjutan ekonomi pemasangan sistem pembangkit listrik tenaga surya di area parkir belakang Universitas Multimedia Nusantara (UMN). Dengan latar belakang meningkatnya kebutuhan energi dan komitmen untuk mengurangi jejak karbon, studi ini mengevaluasi potensi energi surya sebagai solusi yang berkelanjutan. Menggunakan simulasi PVSyst, penelitian ini mengevaluasi kinerja sistem pembangkit listrik tenaga surya yang diusulkan. Hasil simulasi menunjukkan bahwa sistem tersebut dapat menghasilkan 224 MWh listrik setiap tahun, memenuhi 20% kebutuhan energi gedung-gedung A dan D di UMN. Investasi awal yang diperlukan adalah sebesar Rp. 781.883.953,26. Analisis finansial menunjukkan keberlanjutan sistem ini dengan NPV sebesar Rp. 4.380.435.791 dan IRR sebesar 34,28%. Selain itu, pemasangan sistem ini diperkirakan dapat mengurangi emisi karbon sebanyak 2775,513 ton.

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INTRODUCTION

Green building, or environmentally friendly building, is a concept or approach consisting of planning, construction, operation, maintenance, and demolition of a building that prioritizes

the minimal use of resources (Saputri & Achmad, 2023; Saputri & Dhaneswari, 2022). One way of planning a green building is by utilizing renewable natural resources such as solar energy as a substitute for the use of lighting or other electronic devices to reduce the carbon footprint in the surrounding environment (Ahram & Zakaria, 2023; Baxi, 2023).

Solar energy is harnessed by employing solar panels. Solar panels are semiconductor devices capable of converting light into electrical energy (Kumar et al., 2017; Saputri, Richard Stanlee, et al., 2023). This phenomenon is often referred to as the "photovoltaic effect," which occurs when light hits the solar cell layers, providing energy to the outermost electrons of the atoms in the solar cells, allowing the electrons to break free from their atomic bonds (ionization) ("Basic Photovoltaic Principles and Methods," 1982). These electrons then become electric current. Solar panels do not emit emissions, making them environmentally friendly and a renewable technology. The energy produced by solar panels is often referred to as solar energy. This energy is typically utilized as an alternative electrical power source for everyday use of goods or electronic devices.

Universitas Multimedia Nusantara (UMN) is one of the campuses that adhere to the principles of green building. However, the majority of electrical resources used on this campus still emit emissions into the environment. Therefore, a feasibility study was conducted on the use of Solar Power Generation Systems in the rear parking area for Building A as a substitute for the electrical power source for lighting in this building. The objectives of this research are to determine the feasibility of the Solar Power Generation system in the rear parking area of Universitas Multimedia Nusantara based on PVSyst simulations as an alternative energy source for lighting in Building A of UMN, to assess the reduction of carbon footprint through the use of solar power generation systems, and to analyze the financial feasibility of using solar power generation systems in the location of the rear parking area of Universitas Multimedia Nusantara.

Research on the simulation of solar power plant development potential has been frequently conducted for various locations. Of course, the software used also varies, ranging from RETScreen (Kartikasari et al., 2019; Saputri, Linelson, et al., 2023; Sihotang & Okajima, 2017), PVSyst (Çiftçi et al., 2020; Saputri, Linelson, et al., 2023; Siregar et al., 2020), Solar PV GIS (Sihotang & Okajima, 2017), and others. This research requires a good understanding of the requirements used, such as the selection of solar modules, inverters, and other components.

RESEARCH METHODS

Location from the simulation that will be used for the feasibility study is the rear parking area of Universitas Multimedia Nusantara such shown in Figure 1. Based on environmental observations around Building A, an empty area with potential for installing photovoltaic systems was found, located behind the parking area facing north. From morning until noon, there is no shading on this land, but in the evening, there is some shading from trees in the area. This land also has uneven parts, so leveling is required to install the photovoltaic system. The feasibility analysis of the photovoltaic system will be considered with a 20% electricity demand for Building A and/or Building D, commonly referred to as the P.K. Ojong-Jakob Oetama Tower.

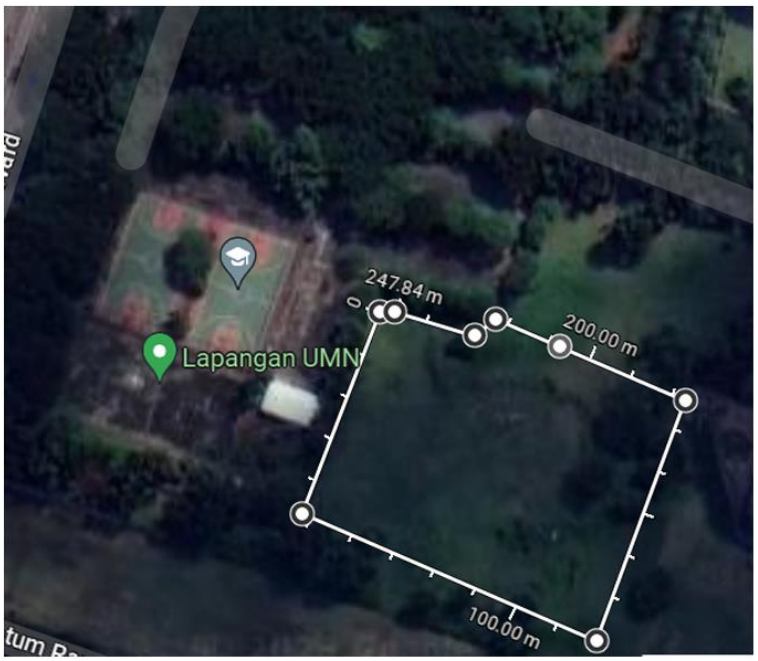

Figure 1. Calculation of the Rear Parking Area Layout

The collection of electricity usage data originates from the archives of Building Management at Universitas Multimedia Nusantara. Based on data obtained from the Building Management of Universitas Multimedia Nusantara, the total electricity consumption data is shown in Table 1.

Tabel 1. Total electricity consumption data

Periods	Electricity Consumption (kWh)		
	Off-peak hours	Peak hours	Total
January 2023	303,000	30,540	333,540
February 2023	293,940	32,040	325,980
March 2023	349,560	39,120	388,680

Based on the problem statement, the electricity usage data to be considered with the results of the simulated photovoltaic system in the PVSyst software is 20% of the total annual usage, thus calculations are made to determine the value of 20% from each building, assuming three months in Table 2 represent electricity usage throughout the year. Thus, the value of electricity consumption data of 20% from each building is 209,640 MWh per year or around 210 MWh per year.

Tabel 2. Annual electricity consumption data

	Electricity Consumption (kWh)		
Description	**Off-peak hours**	**Peak hours**	**Total**
Annual electricity consumption per building	946,500	101,700	1,048,200
20% of the annual electricity consumption per building	189,300	20,340	209,640

The simulation for solar panel installation will be carried out using PVSyst software. When the simulation starts, the location is changed to Universitas Multimedia Nusantara at the rear parking area. Then, a slope of 200 and azimuth of 0.20 or north direction is used. After that, the

type of solar panel and inverter to be used are selected. The type of solar panel used has 250 Wp and 24V, and the inverter used has 6000 W, 70-580V, and 50/60 Hz. Then, the area of solar panel installation is entered, which in this case is 850 m^2. Finally, a three-dimensional modeling of the photovoltaic system installation location along with its system and all objects with the potential to cast shadows is conducted. There are 20 solar panel modules installed in this model such as in Figure 2. Then, the simulation is run with the results is shown in the Figure 3.

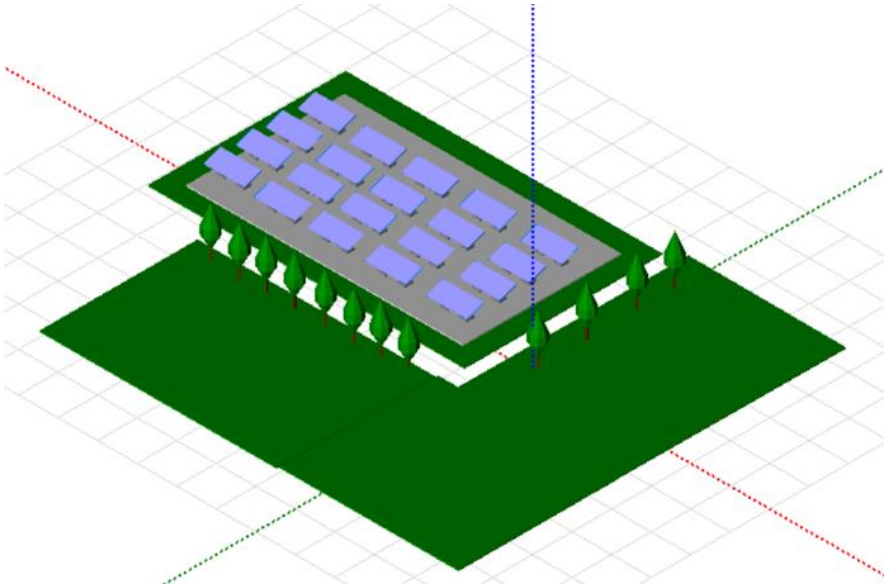

Figure 2.The 3D model of the photovoltaic system

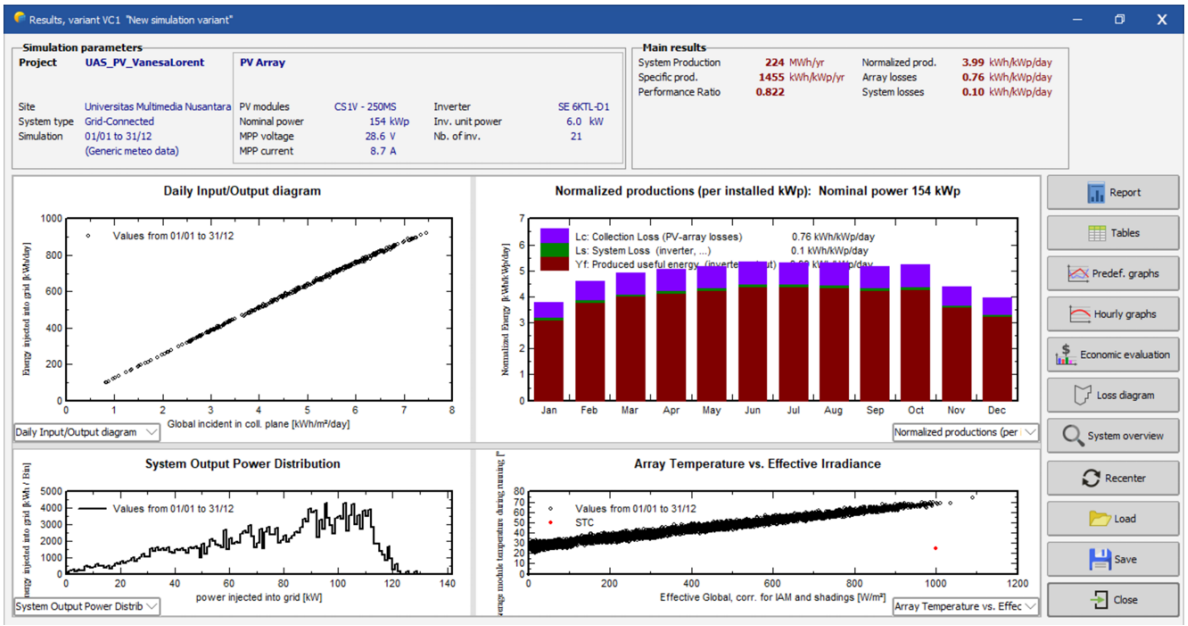

Figure 3.The Simulation Results of Photovoltaic System

RESULTS AND DISCUSSION

The results and discussion sections contain the results of data analysis (not raw data). Presentation can be assisted with tables or graphs and must be accompanied by an explanation or giving meaning to the analysis results. Then the discussion contains a discussion of research results regarding previous research, theory, or established knowledge, accompanied by references. Research results can be supported, unsupported, or even contradictory.

Technical Analysis

Based on the results of the PVSyst simulation that has been conducted, the installation of a solar photovoltaic system in the rear parking lot of UMN within one year can yield a specific electricity energy output of 1455 kWh/kWp/year or 224 MWh per year, with array losses of 0.76 kWh/kWp/day and system losses of 0.10 kWh/kWp/day. This system also has a performance ratio of 0.822. The location used has relatively minimal shading, which facilitates smoother production. The shading present at this location comes from trees in the parking area. Therefore, this location is strategic for installing a photovoltaic system for either building A or building D (P.K. Ojong-Jakob Oetama Tower), as it is close to both buildings. With the installation of this system, carbon footprint can be reduced by 2775.513 tons.

Based on the simulation data, the electrical energy generated by the system annually is 224 MWh per year. According to data from UMN Building Management, the usage of 20% of the electrical energy per building within the range per year is approximately 210 MWh per year. Therefore, the installation of a solar power system at this location is feasible to implement..

Economical Analysis

Based on the simulation conducted using PVSyst software, it is known that an investment of at least Rp. 781,883,953.26 is required to install this solar power system. As seen in Figure 4, the total cost of the required solar panels is Rp. 575,186,505.15, Rp. 18,107,448.11 is needed for the inverter, other components amount to Rp. 26,000,000.00, installation costs (including installation costs for each inverter and solar panel, etc.) are Rp. 32,590,000.00, with a 11% tax and insurance cost of Rp. 130,000,000.00, resulting in the total installation cost of this solar power system.

Furthermore, in Figure 4, operational costs per year are calculated. Based on the operational cost simulation, it is Rp. 62,337,440.31 per year, obtained from operating costs + loan annuities. The maintenance cost is Rp. 26,621,489.62, and insurance cost is Rp. 30,000,000.00, both of which are operating costs. According to Figure 4, this system has a Net Present Value (NPV) of Rp. 4,380,435,791 and an Internal Rate of Return (IRR) of 34.28%. Furthermore, based on its payback period, all investments will be recovered within the next three years. In this calculation, the inflation rate per year is 1%.

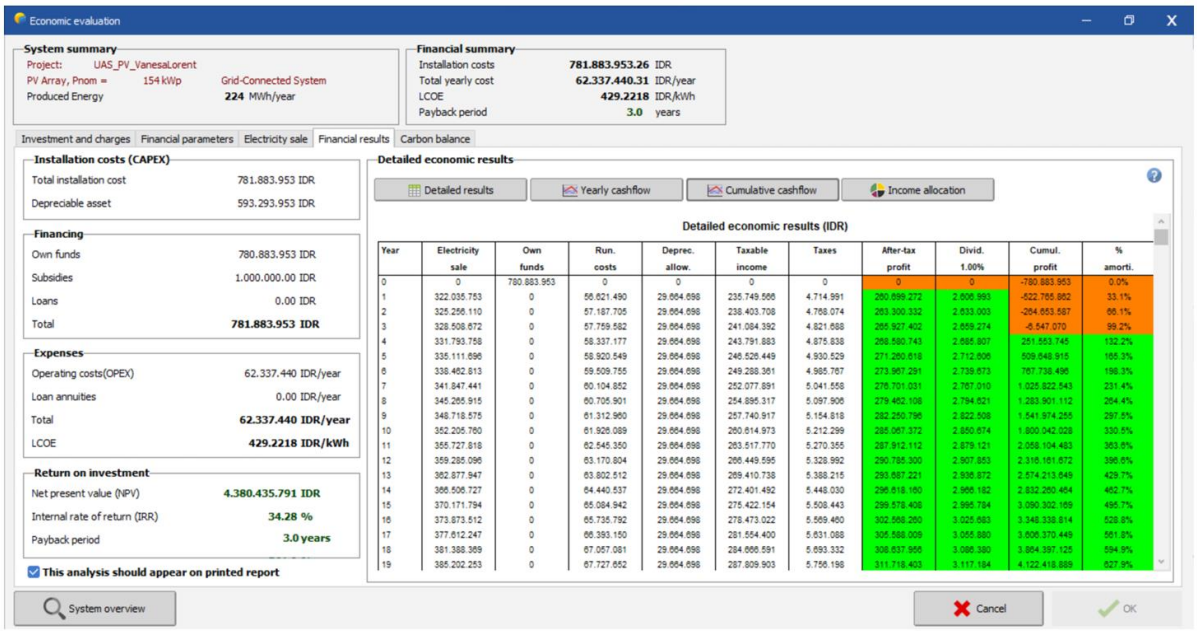

Figure 4.The Cost Installation of Photovoltaic System

CONCLUSION

Based on the results of the PVSyst simulation, it can be concluded that the installation of a solar power system at the back parking lot of Universitas Multimedia Nusantara is feasible. This is because the electrical energy generated by the solar power system per year can already meet the target, which is 20% of the electricity usage of buildings A or D, amounting to 210 MWh, and it can also reduce carbon emissions by 2775.513 tons. Although a significant initial investment of Rp. 781,883,953.26 is required for the installation of this solar power system.

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