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Economic analysis of solar panel at grand Indonesia

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ABSTRACT

Solar power has become one of the most potential resources in generating clean and sustainable electricity. In the last few decades, solar power technology has developed rapidly, especially in the field of solar panels. Solar panels use semiconductor materials such as silicon to convert sunlight radiation into electricity. On-grid solar power systems have become popular because they generate electricity while remaining parallel Syncron with PLN's power plants. This article discusses the economic analysis of installing solar roof panels in the PT GRAND Building Complex INDONESIA, on-grid solar power system design methodology, including building structure calculations, the area required for installing solar panels, solar panel sizes, sending controller settings, and inverter settings. investment that needs to be made and how many years will the capital be returned or Return Of Investment (ROI), Also describes the types of solar panels, namely monocrystalline, polycrystalline, and thin film solar cells (TFSC), as well as their advantages and disadvantages, The results of this study can provide a complete picture of how much profit is in installing solar roof panels, and modern solar power technology and its implementation on a large scale. Thus, this article is expected to contribute to scientists, engineers, and other stakeholders in the development and implementation of more effective and efficient solar power systems.

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INTRODUCTION

Installing solar panels on the roof of a building is a strategic step in utilizing new renewable energy and reducing dependence on conventional energy sources. With increasing awareness of the many and cost savings of energy, many building owners are turning to solar power systems. Regarding solar panels, there are several laws and regulations that need to be considered: Regulation of the Minister of Energy and Mineral Resources Number 2 of 2024. Description: This regulation replaces ESDM Regulation Number 26 of 2021 and regulates the use of Rooftop Solar Power Plants connected to the electricity network. (a) Main points of the regulation: (b) Installation capacity is not limited by PLN's installed capacity, but is based on the quota set. (c) Elimination of the

electricity import-export mechanism; electricity generated can only be used for personal interests. (d) Elimination of capacity fees for all types of PLN customers.

Law Number 30 of 2007 concerning Energy. This law regulates the management of energy resources in Indonesia, including renewable energy such as solar power. Provides a legal framework for the development and utilization of renewable energy, including the establishment of policies related to PLTS.

Law Number 39 of 2008 concerning the State Ministry, Regulates the organization and functions of the State Ministry, including the Ministry of Energy and Mineral Resources (ESDM). Establishes the ministry's responsibilities in managing energy resources, including the development of PLTS.

Regulation of the Minister of Energy and Mineral Resources Number 11 of 2021 concerning the Implementation of Electricity Business. Benefits of Installing Solar Panels: (1) Energy cost savings: Solar panels can significantly reduce electricity bills by utilizing sunlight as an energy source, (2) Environmentally friendly: Using renewable energy helps reduce carbon emissions and negative impacts on the environment, (3) Energy independence: Solar power systems allow buildings to be more independent in terms of energy supply.

The Ministry of Energy and Mineral Resources (ESDM) has issued Ministerial Regulation of ESDM Number 2 of 2024 concerning Rooftop Solar Power Plants (PLTS) on the Electricity Network of Holders of Electricity Supply Business Licenses for Public Interest (IUPTLU) which will come into effect on January 31, 20241. This regulation replaces Ministerial Regulation of ESDM Number 26 of 2021 concerning Rooftop Solar Power Plants. Key points of the new regulation: Quota System This new regulation mandates all IUPTLU holders to propose a five-year capacity quota for the installation of rooftop PLTS by their customers to the Directorate General of New and Renewable Energy. The installed capacity for rooftop systems will be determined by the relevant IUPTLU holder.

Elimination of the Export-Import Mechanism The export-import or net-metering electricity scheme for rooftop PLTS users has been eliminated. The electricity generated can now only be used for personal use. The previous import-export kWh meter was replaced with a sophisticated meter that must be installed, operated, and financed by IUPTLU holders for prospective Rooftop PLTS customers. Elimination of Capacity Fees The new regulation eliminates capacity fees for all types of PLN customers. The new regulation also introduces a new application procedure. Submission of new rooftop PLTS installation applications can be made from January to July. If the roof capacity is more than 500 kW in one system, the applicant must obtain an Individual Electricity Supply Business License (IUPTLS). If it is less than 500 kW, it is mandatory to submit a report to the Ministry of Energy and Mineral Resources or the relevant governor (Pranata, 2022). In this regard, a capacity analysis will be carried out according to land availability, as well as an analysis of production and financial/economic results.

These various incentive policies come in various forms. Call it tax relief, installation subsidies, to building regulations that require the use of solar panels on new buildings. All of this aims to ease the burden on people who want to switch to more sustainable energy sources. Regulations implemented by the government play a crucial role in regulating and supervising various sectors, including the technology sector. These regulations not only cover legal and security aspects, but also influence investment policies, data protection, and technological innovation in Indonesia.

In this study, an analysis will be conducted to calculate how much ROI (Return of Investment), when the return on investment from this installation will be, and how much profit from installing this solar panel. Thus, it will be determined how large the solar panel will be installed. In addition, the electricity needs in the building will also be determined.

RESEARCH METHOD

This study aims to analyze new renewable energy sources (EBV), especially solar panels. This writing method directly observes the installation location, analyzes the costs incurred in installing solar panels (PLTS), how much efficiency is obtained and how many years will the return on investment (ROI) from this installation investment.

The system that we will observe and analyze is the on-grid PLTS, which is a PLTS system that is connected to the main generator, namely PLN, where this system consists of a number of solar panels, inverters, network control units, and equipment that is connected without using batteries. This study uses a mixed method where the author assesses the performance of solar panels through measuring energy output (quantitative) and collecting and comparing it with the initial design or installation plan.

Research data uses secondary data where the secondary data used in this study is weather element data that has been measured. The data collection method is carried out with documentation, namely the data is taken from online data on the Meteorology, Climatology and Geophysics Agency website which includes data on 6 weather element variables, including: 1. Temperature of (v1) 2. Air humidity of (v2) 3. Rainfall of (v3) 4. Duration of sunlight of (v4) 5. Wind direction of (v5) 6. Wind speed of (v6).

Solar Panel Installation Analysis

The installation of solar panels was carried out in the PT Grand Indonesia business complex located at Jl. M.H. Thamrin No. 1, Central Jakarta, Jakarta 10310 (Figure 2) with a total installation of 1,450 kWP. Referring to the law that has been socialized by the Ministry of Energy and Mineral Resources in March 2024. In this study, an analysis will be carried out to determine the benefits of installing solar panels.

When choosing a location to install solar panels on a roof, there are several factors to consider to ensure optimum results. Here are some important factors to consider:

a. Roof Orientation

The installation of solar panels in the Jakarta area should face south. This is because: (a) Sun Position: In the southern hemisphere, including Jakarta, the sun moves from east to west and is higher in the sky during the day. By orienting the panels to the south, the panels will receive optimal sunlight throughout the day, (b) Energy Savings: Panels facing south will receive more solar radiation, thereby increasing energy conversion efficiency and producing more electricity, (c) Panel Orientation Theory: Studies show that orienting solar panels to the south can increase energy production by up to 25% compared to orienting to the east or west, (d) Tilt Angle: In addition to direction, the tilt angle also has an effect. Ideally, solar panels are installed at an angle that matches the latitude of the location to maximize their capture of sunlight.

If facing east or southeast, the panels will get sunlight in the morning, but lose sunlight in the afternoon, which can reduce the total daily energy production compared to facing south. Thus, for maximum efficiency, a south orientation is best in the Jakarta area.

The installation location on the roof of the building can be seen in Figure 1. And for the placement design, it can be seen in Figure 2.

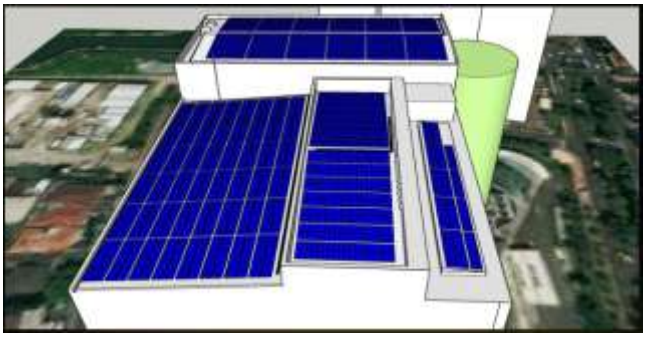

Figure 1. Location of the PLTS installation roof (PT Grand Indonesia)

Figure 2. design of installation location of PLTS panels

b. Roof Slope

The right tilt will ensure that the solar panels will be able to absorb sunlight optimally, according to the literature presented by several installers where the tilt with several considerations as follows: A tilt angle of 8-20 degrees is recommended to prevent waterlogging and for self-cleaning3. A minimum angle of 5 degrees is sufficient to capture sunlight efficiently1. Several sources suggest that a tilt between 10-30° is very helpful for efficiency5. For fixed solar PV arrays, the ideal tilt angle helps clean the solar PV modules when it rains, has conducted a PLTS installation analysis.

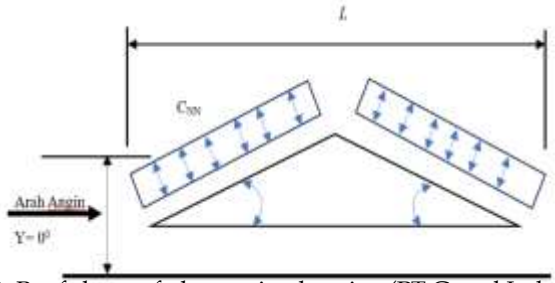

Figure 3. Roof shape of observation location (PT Grand Indonesia)

c. Shadow Potential

Ensuring there is no shadow from trees, or building roofs, because it is on the 11th floor of the Grand Indonesia mall, so there are no obstacles that can block sunlight from reaching the solar panels. Because the shadow can significantly reduce energy production.

d. Roof Type

The roof shape where the PLTS panel is installed is sloping with a suitable shape is the best choice for installing solar panels. At PT Grand Indonesia, where the roof material used is a corrugated metal roof, because it is exposed to the best sunlight and is relatively easy to install the panels.

e. Roof condition

Because the condition of the roof must be ensured to be good and strong so that it can withstand the load of the solar panels. Before installing solar panels, it must be ensured that the roof is in good condition and does not require repair. PT Grand Indonesia uses a structural consultant to calculate the strength of the roof to avoid accidents both in terms of the physical building and the impact on occupants.

The results of the analysis indicate that the roof conditions at PT Grand Indonesia meet the requirements and are safe for the load, then calculate the capacity to be installed and the area needed for this installation, the author calculates based on several literatures and papers made by BTI. installation of 2,522 panels, with a load of each panel, is a maximum of 60 kg, overall the roof of the building located on the 11th floor of the Grand Indonesia Mall with an area of 10,000 m2 is safe for the location of the PLTS installation.

f. Types of Solar Panels

By considering the right selection of equipment to be installed with the aim of being more effective and efficient so that the efficiency target can be achieved, it must follow the rules in accordance with the SNI ELECTRICITY FOR PUBLIC INTEREST. CHAPTER I GENERAL PROVISIONS Article 1 In this Ministerial Regulation, the following are defined as: 1. Power Generation System (Standards The rooftop solar power plant must adhere to specific technical standards including SNI IEC 61215-1: 2016; SNI IEC 61215-2: 2016; SNI IEC 61215-1-1: 2016 [14]) the following data on equipment to be installed (table no. 7) where the type of solar roof chosen is Monocrystalline Solar Cells, where the brand used is TRINA Solar panels with a capacity of each panel is 575 watts. While the inverter used is the Huawei ZTE brand with an efficiency of more than 99%.

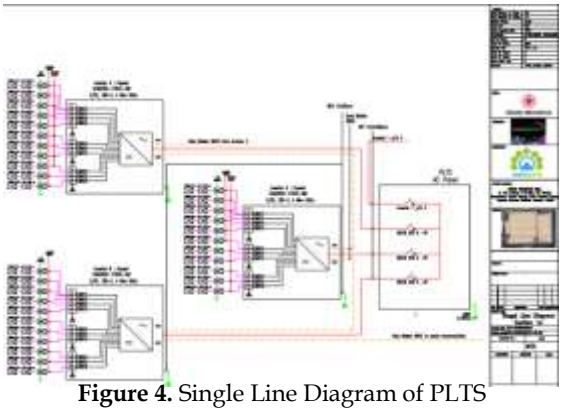

Figure 4. Single Line Diagram of PLTS

The location of the solar panel installation is on the 11th floor, while the panel position is on the 6th and 7th floors in the parking area, Figure 9 so it is necessary to design a termination system for the exiting panel, where we need to divide it into 2 outputs, because with an installed capacity of 1,450 kWP while each panel currently has a maximum load of only 800 kW, to avoid this

production being used elsewhere, there will be losses on the installation and transformer side, a single line diagram is made.

RESULTS AND DISCUSSIONS

Electricity Production Analysis

To calculate the electricity production produced, it is necessary to first find the energy potential from solar radiation in the Central Jakarta area, where the PLTS is installed, we can find this data at the Meteorology, Climatology, and Geophysics Agency (BMKG): BMKG provides meteorological data that includes solar radiation information.

Radiation data

According to the Indonesian National Coordinating Agency for Surveys and Mapping, the number of islands in the archipelago is 13,466, of which 922 are permanently inhabited. The country has a total area of 1,904,569 km2, from 6° N to 11° S and from 95° E to 141° E (Dang, 2018). The map of Indonesia is presented in Figure 2. Indonesia has a tropical climate with two seasons, namely the rainy season and the dry season where the rainy season occurs from December to March while the dry season occurs from June to September (Handayani et al., 2015). The average temperature of Indonesia in coastal areas is 28 °C and in higher mountainous areas is 23 °C. The average rainfall is 238.35 mm/month (Dang, 2018). The temperature and length of daylight hours are relatively constant throughout the year due to the stability of solar radiation, so solar energy can be a reliable energy source as a solution to energy problems in Indonesia.

Table 1. Radiation data

Month	Unit
Jan	4.8
Feb	5.1
Mach	5.5
Mar	5.7
Apr	5.8
Mach	5.5
May	5.3
Jun	5.5
Mach	5.6
Jul	5.6
Aug	5.3
Mach	4.9

Source: Sustainability Report of PT Pertamina (Persero) 2020

The solar radiation value in Central Jakarta varies throughout the year as seen in Table. 11 above. The following is an estimate of the average daily radiation value (in kWh/m²/day) from January to December:

Monthly Production Analysis

Determine the area of solar panels to be installed in square meters (m²) at PT Grand Indonesia, namely 2,522 panels with a size of 1.8 m² per panel, so the minimum area required is: 7264 m2, Because maintenance access is needed to be installed in each lane, the total area required is 10,000 m2. Based on the data above, we can calculate the production of solar panels to be installed using the formula:

Energy (kWh) = Average Daily Radiation (kWh / m² / day) × Area (m²) × Panel Efficiency We will analyze the production of solar panels, in one day, we take the calculation in March according to the Table. 11 can help us calculate the production analysis of PLTS: (a) Average daily radiation: 5.5 kWh/m²/day, (b) Panel area: 7264 m², (c) Solar panel efficiency: 15% (0.15), So the calculation is: Energy = 5.5 × 7264 × 0.15 = 5,993 kWh/day

Table 2. Monthly production analysis

Mount	Average Daily Radiation	Capacity of PLTS	Solar power efficiency 15%	Total days	Total production of PLTS	Total Efficiency IDR/kWH
	kWh/m2/day	kWh	0.15		kWH	1,036
Jan	5	7,264	0.15	31	162,132	167,933,580
Feb	5	7,264	0.15	28	155,595	161,162,065
Mach	6	7,264	0.15	30	179,784	186,216,672
Mar	6	7,264	0.15	31	185,777	192,423,894
Apr	6	7,264	0.15	30	189,590	196,373,945
Mach	6	7,264	0.15	31	185,771	192,423,894
May	5	7,264	0.15	30	173,246	179,445,156
Jun	6	7,264	0.15	31	185,777	192,432,894
Mach	6	7,264	0.15	30	183,053	189,602,429
Jul	6	7,264	0.15	31	189,155	195,922,510
Aug	5	7,264	0.15	30	173,246	179,445,156
Mach	5	7,264	0.15	31	165,510	171,432,196
				Total	2,128,643	2,204,806,427

Calculate the electricity production results for each year

Calculating Monthly Energy, To calculate monthly or yearly energy, multiply the daily energy by the number of days in the month or year. Example for March (31 days): Monthly Energy = 6,210 kWh/day×31 days ≈ 192,532 kWh/month

Economic Analysis

By conducting an open tender to find the best price offer, this is also based on calculations that have been made by several Journals so that we follow the calculation method and economics of installing this PLTS, [18], [19], [20] We determine the Bill of Quantity as in Table 12 where this Bill Quantity is our reference in determining the total investment BUDGED of IDR 22,302,120,000.

Table 3. Economic analysis

Year's	Production PLS	Rate Cost PLN	Production PLS	Paralel Cost	Total Production
	kWh	IDR	IDR	PLN	IDR
1	2,135,398	1,061	2,265,657,363	90,122,182	2,175,535,181
2	2,111,447	1,061	2,240,245,476	90,122,182	2,150,123,294
3	2,087,765	1,061	2,215,118,612	90,122,182	2,124,996,430
4	2,064,348	1,061	2,190,273,573	90,122,182	2,100,151,391
5	2,041,194	1,061	2,165,707,200	90,122,182	2,075,585,018
6	2,018,300	1,061	2,141,416,366	108,146,618	2,033,269,748
7	1,995.663	1,061	2,117,397,981	108,146,618	2,009,251,363
8	1,973,279	1,061	2,093,648,990	108,146,618	1,985,502,372
9	1,951,146	1,061	2,070,166,369	108,146,618	1,962,019,751
10	1,929,262	1,061	2,046,947,133	108,146,618	1,938,800,515
11	1,907,623	1,061	2,023,988,326	129,775,942	1,894,212,384
12	1,886,227	1,061	2,001,287,028	129,775,942	1,871,511,086
13	1,865,071	1,061	1,978,840,351	129,775,942	1,849,064.409
14	1,844,152	1,061	1,956,645,438	129,775,942	1,826,869,496

15	1,823,468	1,061	1,934,699,467	129,775,942	1,804,923,525
16	1,803,016	1,061	1,912,999,643	155,731,131	1,757,268,512
17	1,782,793	1,061	1,891,543,208	155,731,131	1,735,812,077
18	1,762,797	1,061	1,870,327,431	155,731,131	1,714,596,300
19	1,743,025	1,061	1,849,349,612	155,731,131	1,693,618,481
20	1,723,475	1,061	1,828,607,083	155,731,131	1,672,875,952
21	1,704,144	1,061	1,808,097,205	186,877,357	1,621,219,848
22	1,685,031	1,061	1,787,817,368	186,877,357	1,600,940,011
23	1,666,131	1,061	1,767,764,992	186,877,357	1,580,887,635
24	1,647,443	1,061	1,747,937,526	186,877,357	1,561,060,169
25	1,628,966	1,061	1,728,332,447	186,877,357	1,541,455,090
26	1,610,695	1,061	1,708,947,262	224,252,828	1,484,694,434
27	1,592,629	1,061	1,689,779,503	224,252,828	1,465,526,675
28	1,574,766	1,061	1,670,826,731	224,252,828	1,446,573,903
29	1,557,103	1,061	1,662,086,537	224,252,828	1,427,833,709
30	1,539,639	1,061	1,633,556,534	224,252,828	1,409,303,706
			Total	4,474,530,290	53,515,482,465

Analysis of kWh and Nominal Production Calculation Results in 30 Years of Operation

CONCLUSION

Based on the analysis conducted, several key points can be concluded: Energy sustainability: Installing rooftop solar panels provides access to a sustainable and environmentally friendly energy source, helping to mitigate the impacts of climate change. Energy Cost Savings: Solar power systems can significantly reduce electricity costs. While the initial investment may be high, long-term savings and potential government incentives can make it more profitable. Increased Property Value: Properties equipped with solar panels often have a higher resale value, appealing to buyers who care about the environment and energy efficiency. Installation Challenges: Despite its many benefits, installing rooftop solar panels faces challenges such as initial costs, space constraints, and varying regulations in each region. Awareness and education about this technology are essential to overcome these barriers. Technological Innovation: Advances in solar panel technology, including increased efficiency and reduced costs, will continue to facilitate the adoption of this system in various types of buildings.

Installing rooftop solar panels on buildings is an effective solution to utilize renewable energy sources, reduce dependence on fossil fuels, and contribute to reducing carbon emissions. Based on the analysis conducted, several important points can be concluded: With a total investment of IDR 22,302,120,000 and a kWH production of 22,302,120,000/month in the first 5 years and gradually decreasing by 1% per year, there will be a return on investment (ROI) in the 11th year, so that with an estimated production age of up to 30 years, the 12th year and beyond are the benefits of investing in installing PLTS. Energy sustainability: Installing rooftop solar panels provides access to sustainable and environmentally friendly energy sources, helping to mitigate the impacts of climate change. Energy Cost Savings: Solar power systems can significantly reduce electricity costs. While the initial investment may be high, long-term savings and potential government incentives can make it more profitable.

Adopting solar panels at home not only provides economic benefits, but also contributes significantly to environmental conservation. The long-term strategic advantages of solar panels are Carbon Emission Reduction, Natural Resource Conservation, Improved Air Quality.

Increased Property Value: Properties equipped with solar panels often have a higher resale value, appealing to buyers who care about the environment and energy efficiency. Thus, installing rooftop solar panels is a strategic move that benefits not only the building owner but also the wider

community and the environment. The decision to invest in a solar power system should be based on a careful analysis of local conditions, solar radiation potential, and long-term costs and benefits.

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