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A Cost Analysis And Capacity Simulation Of Rooftop Solar Power Plant For Household

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ABSTRACT
Rooftop Solar Power Plants (RSPPs) are a renewable energy solution that can re-duce dependence on fossil fuel-based energy sources. This study aims to analyze the costs and simulate the capacity of rooftop solar systems for household use, considering both technical and economic aspects. The methodology includes analyzing household energy needs based on daily electricity consumption, calculating the required RSPP sys-tem capacity, and simulating cost savings through the use of solar energy. Technical data such as solar panel capacity, system efficiency, and energy storage were analyzed using energy simulation software. The results indicate that installing rooftop solar systems can effectively meet household energy needs with high efficiency, particularly in areas with optimal sunlight intensity. From an economic perspective, the initial investment in RSPPs can be offset by long-term electricity cost savings, although the upfront installa-tion cost remains a major challenge. This study concludes that rooftop solar systems are a viable option to support sustainable energy transitions at the household level. Recom-mendations include enhancing system efficiency, reducing technology costs, and provid-ing government incentives to encourage wider adoption of RSPPs.

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INTRODUCTION

The increasing energy needs in Indonesia require sustainable energy solutions. Fossil energy sources that dominate the current energy mix have limited availability and negative impacts on the environment. Solar energy is one of the main alternatives due to its high radiation potential in Indonesia. Based on Presidential Regulation No. 22/2017 concerning the National Energy General Plan (RUEN) and Minister of Energy and Mineral Resources Regulation No. 49/2018, the use of rooftop PLTS is one of the government's priorities to increase the mix of new and renewable energy. The Indonesian region has quite large New and Renewable Energy (EBT) Potential, including mini/micro hydro of 450 MW, Biomass 50 GW, solar energy 4.80 kWh/m2/day, wind energy 3-6 m/sec and nuclear energy 3 GW. The latest EBT potential data was presented by the Director of New and Renewable Energy and Energy Conservation in a Focus Group Discussion event on Supply-Demand of New and Renewable Energy which was recently held by the ESDM Data Center. Presidential Regulation No. 22/2017 concerning RUEN, namely:

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1. New renewable energy mix target of 23% by 2025
2. To achieve this, one of the strategies undertaken is the use of solar cells, including:
   a. Enforcing the obligation to utilize solar cells of at least 30% of the roof area for all Regional Government buildings.
   b. Enforcing the obligation to use solar cells for a minimum of 25% of the roof area of luxury homes, housing complexes and apartments.

Based on the presidential regulation, it is clear that currently Rooftop Solar Power Plants (PLTS) are the utilization of New Renewable Energy recommended by the government. The purpose/benefit of developing Rooftop PLTS for the community and government is to save/reduce monthly electricity bills, open up community participation in the utilization and management of renewable energy, increase the role of EBT in the national energy mix, accelerate the increase in the utilization of solar energy, encourage the continuation of the domestic solar energy industry, increase EBT investment, increase energy independence and resilience, reduce Greenhouse Gas (GHG) emissions, increase employment. Solar Energy is a reliable and economical green energy in terms of available energy sources. There are 3 types of PLTS Systems that are commonly used, namely: On-Grid System, the system includes solar modules/panels, inverters, import-export kWh meters, PLN connections, and electrical load connections. Parallel to PLN

1. Off-Grid System, the system includes solar modules, batteries, inverters, solar panel controls, electrical connections and loads. Batteries to ensure the continuity of electrical energy.
2. Hybrid System, the system includes solar modules, inverter, hybrid control, generator, electrical connection and load. Parallel with generator, battery to maintain stability.

The increasing demand for electricity and the depletion of fossil fuel reserves have raised awareness about the importance of renewable energy sources. Rooftop Solar Power Plants (RSPPs) have emerged as one of the most promising solutions to meet household energy needs sustainably. By converting sunlight into electricity, RSPPs offer a clean and environmentally friendly alternative to traditional energy sources while reducing greenhouse gas emissions. In Indonesia, the potential for solar energy is substantial due to the country's geographical location, which provides consistent sunlight throughout the year. However, the adoption of RSPPs for household use remains limited, primarily due to the high initial investment costs and a lack of awareness about their long-term benefits.

This study aims to analyze the costs and simulate the capacity requirements of RSPPs for households. The focus is on determining the feasibility of utilizing rooftop solar systems to meet daily energy consumption needs while reducing electricity expenses over time. By evaluating technical and economic factors, this research seeks to provide insights into the potential benefits and challenges associated with implementing RSPPs in residential areas. The findings of this study are expected to contribute to the promotion of renewable energy adoption, support government initiatives toward energy sustainability, and provide households with practical guidelines for transitioning to solar power.

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Investment in Solar Power Plants (PLTS) is increasingly attractive to many parties, both individuals, companies, and countries. Along with the increasing global awareness of the importance of renewable energy and environmental sustainability, PLTS offers various advantages, both from an economic, social, and environmental perspective. Below, I will explain three main reasons why investing in PLTS is a smart choice.

1. Solar energy is one of the most abundant and unlimited renewable energy sources in the world. The sun shines on the Earth every day with energy far exceeding humanity's current energy needs. Every hour, the sun sends enough energy to Earth to meet global energy needs for an entire year. This solar energy potential provides a strong reason to invest in Solar Power Plants (PLTS). Solar power plants have the advantage of resource sustainability. Unlike fossil fuels that are increasingly depleting and potentially damaging to the environment, solar energy is available in very large quantities and can be used for thousands of years to come without the risk of running out. Therefore, by investing in solar power plants, we not only get long-term financial benefits but also contribute to the sustainability of the planet. The abundant availability of solar energy is very relevant in areas with good exposure to sunlight throughout the year, such as in Indonesia. Tropical countries like Indonesia have great potential to develop and utilize solar energy optimally, both for domestic and industrial needs.
2. One of the main reasons to invest in solar power is the potential for long-term energy cost savings. Solar Power Plants can reduce dependence on conventional energy sources such as electricity from PLN whose tariffs tend to increase over time. The use of solar panels allows for independent energy production, which can reduce operational costs, especially for the industrial and business sectors. In addition, the cost of installing a solar PV system has decreased significantly in the last decade. Solar panel technology continues to improve and become more efficient, while the price of solar panels and energy storage systems (such as batteries) has also become more affordable. The initial investment to install a solar PV system may requirequite a large cost, but in the long term, the operational and maintenance costs are relatively low. In addition, with incentives and support from the government for renewable energy, investment costs can be further minimized. For household consumers, installing a solar power system can significantly reduce electricity bills. In some cases, people can even sell excess energy generated by solar panels to the electricity grid (net metering), allowing them to earn additional income. Thus, this investment can generate sustainable profits for years to come. For companies or industries, the use of solar power plants can improve the company's image as a pioneer in social and environmental responsibility, which will attract investors and consumers who care about sustainability. In addition, energy cost savings can increase profit margins and company competitiveness.
3. The biggest advantage that can be gained from investing in solar power is its impact on the environment. Solar power does not produce harmful greenhouse gas emissions or air pollution, which are major problems with fossil fuel use. Using solar energy helps

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reduce dependence on fossil fuel power plants, which have long been the main cause of global warming and climate change. By shifting the use of fossil fuels to renewable energy, PLTS makes a major contribution to efforts to reduce negative impacts on the environment. According to data from the International Renewable Energy Agency (IRENA), the renewable energy sector, including solar energy, is able to significantly reduce carbon emissions and is key to achieving global greenhouse gas emission reduction targets. Investment in solar power plants also provides social benefits that are no less important. The growth of the renewable energy sector, including solar power plants, opens up new job opportunities, both in the solar panel manufacturing sector, installation, and maintenance. This has the potential to create thousands of new sustainable jobs and boost the local economy, especially in areas with large solar energy potential. In addition, the use of renewable energy supports the sustainable development goals (SDGs), especially in terms of providing clean and affordable energy, reducing poverty, and maintaining the environment.

Investing in Solar Power Plants (PLTS) offers various advantages that are not only financially beneficial, but also have a positive impact on the environment and society. With abundant renewable energy potential, long-term energy cost savings, and positive contributions to sustainability, PLTS is a smart investment choice for the future. Moreover, with the advancement of technology and the decrease in production costs, as well as the support of government policies that increasingly support renewable energy, solar power plants are becoming more affordable and worthy of consideration. In facing the challenges of climate change and the need for sustainable energy, investment in solar power plants is a proactive step that can provide long-term benefits, both financially and socially.

Thus, investing in solar power is not only about personal gain, but also about contributing to greener, cleaner and more sustainable development for future generations. In reality, until now there are still very few people who utilize solar energy, this is because the readiness of the PLN network for interconnection is still hampered, the long return on investment for installing Rooftop PLTS, the high SLO costs for Rooftop PLTS and the high initial investment costs for installation, where industrial consumers who are on-grid to the PLN network are charged a capacity charge and an emergency energy purchase fee. Based on the implementation and research conducted on Rooftop PLTS, a calculation of investment and savings on monthly bills was made, it is hoped that it can be a reference in the management and utilization of renewable energy, especially household-scale Rooftop PLTS.

METHOD

The method used is to design a solar power plant with a capacity of 1300 watts that will support the need for electrical energy for household loads. This is shown in the following block diagram:

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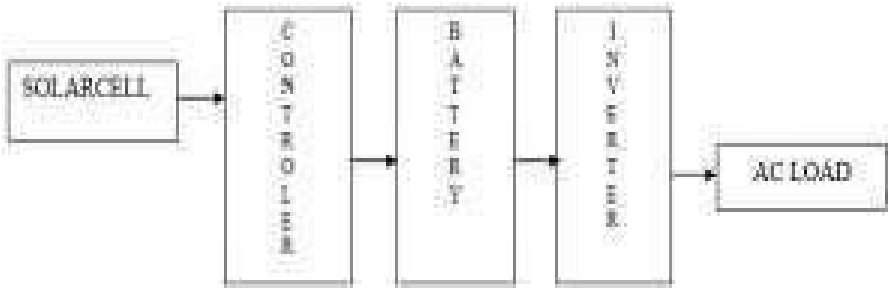

Figure 1. Block Diagram of Solar Power

Plant With the following description:

1. Solar cellor Photovoltaic, which is a device that functions as a medium for receiving solar radiation to produce electrical energy which will be stored in a battery.
2. Controller,namely a device used as a gateway to connect solar cell devices for battery charging.
3. Battery,functions as a store for current obtained from the sun to be distributed to the load. Inverter,namely as a tool to change DC current in the battery so that it can be used for AC current in the load.
4. AC Load,namely the electrical load, power of 1300 Watts.

The specifications of the materials used are as follows 2 solar cells, 250 Wp each

1. Solar Charge Controller 1 piece 12 or 24 Volt 45 Amper
2. 2 batteries, each 100Ah
3. Inverter 1 piece 1200 Watt
4. Maximum load that can be used is 960 Watts

Figure 2. 250 Wp Solarcell

Rooftop PLTS work begins with the following stages:

1. Erecting/placing solar cells on the roof
2. Connecting batteries in series
3. Making electrical connections to the load
4. Assembling all materials in a closed network
5. Conducting PLTS testing to load
6. Finished

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Figure 3. Materials and Testing of PLTS

From this test, load usage data was obtained as in table 1 below:

Table 1. Load Type and Power Used

No	Load Type	Quantity	Power Usage (Watts)
1	Light	9 pieces	134
2	Refrigerator	1 piece	120
3	Dispenser	1 piece	85
4	Magic Com	1 piece	68
5	1 piece fan		72

From the data obtained, it can be seen that the total power used is 604 Watts.

RESULT AND DISCUSSION

Solar energy comes in the form of heat and light. Energy in the form of heat can be used directly or indirectly. Light is another form of energy emitted from the sun, Light is converted into electrical energy using solar modules called Photovoltaic (PV) modules or solar panels. Protons from sunlight hit electrons in the PV cell, providing enough energy for some electrons to move from the semi-conductor junction and causing electrical pressure caused by an electrical imbalance, too many negatively charged electrons on one side of the junction, and too many positive charges on the other side. When electrons flow from one side to the other, the pressure will decrease. This happens when there is an interconnection between the cells. When the cells are connected to each other, a solar module is created that produces Direct Current (DC), for the use of Alternating Current (AC), an inverter is used.

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Rooftop PLTS Investment Costs

The investment costs for an Off-Grid type Rooftop PLTS are as follows:

Table 2. Rooftop PV Investment Costs

No	Type Material	Amount	Price (Rupiah)	Total Price a (Rupiah)
1	Solar module 250 Wp	2 fruit	2,500.000	5,000,000
2	Battery Luminous 100 Ah	2 fruit	2,200.000	4,400,000
3	Inverter 1200 Watt	1 fruit	1,300.000	1,300,000
4	Solar Source Charge	1 fruit	1,200.000	1,200,000
5	Cable		128,000	128,000
TOTAL INVESTMENT				**12,028,000**

Electricity Cost Comparison

Comparison of electricity costs before and after installing Rooftop PLTS per month can be seen in the table below:

Table 3. Comparison of Electricity Load Costs

Cost of Expense Electricity	Month I	Month II	Month III
Before Utilization	400.000	-	-
After	300.000	250.000	272.000

From the table, it can be seen that there is a saving in electricity costs during the three-month observation, and the savings are not constant, this is influenced by the use of non-constant loads and the sun/weather conditions at that time. If calculated, the average cost of electricity costs per month after utilizing Rooftop PLTS is:

Electricity Cost = ∑ Monthly Cost / 3 = 822,000/3 = Rp.274,000,-/month
So the difference in electricity costs before and after = 400,000 – 274,000 = Rp.126,000,-/month If the difference is calculated for 1 year then:
The total difference = 126,000 x 12 = Rp.1,512,000,- which we can save.

So in a rough calculation the initial investment will be returned in the 10th year, namely: 1,512,000 x 10 = Rp.15,120,000,- From the data obtained, it can be seen that the total power used is 604 Watts

CONCLUSION

Conclusion of this paper are: Solar power plants are environmentally friendly power plants. Solar power plants require large investment costs and require a long time to return the investment capital. Rooftop solar power plants are not yet capable of becoming the main energy source because battery capacity is not yet sufficient to store electrical energy. Rooftop solar power plants are able to save electricity costs by around 31.5%. Weather conditions affect battery charging time.

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