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Review of the Effectiveness of Roof-Mounted Solar Panels Compared to Wall-Mounted Residential Houses in South Sumatra Island, Indonesia

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Abstract
Solar energy, one of the most abundant and widely used renewable resources in the world, delivers an incredible amount of power. In just one hour, the amount of solar energy striking the Earth's surface is approximately 410-430 trillion joules, which exceeds the total energy consumption of all humans, estimated at around 400-410 trillion joules. This energy is widely utilized for household purposes. According to data from the Ministry of Energy and Mineral Resources, R-3 customers—those using electricity above 6,600 VA—have an average national consumption of 122 kWh per month. This electricity demand is still primarily supplied by PLN (State Electricity Company). Household electricity supply from PLN can be supplemented with solar power generated by solar panels. To optimize the use of available space, solar panels can be installed on rooftops or exterior walls of houses. In this journal, the author will review the effectiveness of solar panels installed on rooftops which called as Roof Mounted Solar Panel and exterior walls of residential houses or so called as Wall Mounted. The review focuses on the power production of solar panels placed in these different locations simultaneously at the same coordinates. The research is conducted using the Experimental Research Method.
Keywords: Solar Panel, Roof-Mounted, Wall-Mounted

Introduction
Solar panels, as a source of renewable energy, are widely used in residential homes. Based on the review conducted in this journal, it is expected that readers, especially homeowners, can understand the effectiveness of solar panels depending on their placement—whether on the roof or the exterior walls of the house. According to measurement data from BPS (Statistics Indonesia): (the number of households with a residential area per capita < 8 m²)/(the total number of households), the utilization of exterior wall surfaces as an alternative location for solar panels is necessary. This is a relevant choice because exterior walls are also generally exposed to sunlight. This utilization can be significant for those with limited roof space in their residential properties. Furthermore, it serves as an optimal option to accommodate the increasing electricity demands in this modern era (Kurniawan et al., 2022), (Nasution et al., 2020).

Solar Power Plant or Solar PV is a system that is used to convert the energy of sunlight into electrical energy by using the principle of the photovoltaic effect. Photovoltaic itself is a physical phenomenon that occurs in The surface of the solar cell (solar cell) when receive sunlight. Furthermore, the received light is converted into electrical energy. Thing This is due to the presence of photon energy light that liberates electrons – electrons so that it flows in the connection N and P type semiconductors that ultimately generating an electric current (Nurjaman & Purnama, 2022), (Hasibuan et al., n.d.). The solar panels consists of a large number of individual solar cells, which when exposed to sunlight produces some amount of usable electrical energy. Therefore, by increasing the number of individual solar cells in the solar panels the efficiency is increased(Abishek et al., 2019). Solar radiation energy can be changed into a direct electric current using thin layers of silicon (Si) pure or other semiconductor materials (Science & Outlook, 2020), (Nrartha et al., 2024). The types of solar panels are grouped based on the material of the solar cells that make them up. Next These are the types of solar panels: Monocrystalline solar panels have an efficiency of up to 14-17%, Polycrystalline It is a solar panel that has a random arrangement of crystals and Thin film solar (TFSC) (Darwin et al., 2020). The construction of this solar power plant requires Installation expenses are still expensive for now. Therefore, economic calculations are needed that include The amount of early investment that must be provided (Amin & Agus Nurtiyanto, 2024), (Mubarak et al., 2020).

The higher the solar radiation that hits the photovoltaic cell, the higher the electrical power produced (Syukri, 2010). Utilization of solar energy as an alternative energy source to overcome the energy crisis, especially petroleum, which

occurred since the 1970s has received considerable attention from many countries in the world. In addition to its unlimited amount, the utilization does not cause pollution that can harm the environment (Bow et al., n.d.). The use of sunlight is also very profitable because it does not require costs to obtain it, besides it is also environmentally friendly, what consumers must do is to design a tool to convert solar energy into energy that we can use every day, namely electrical energy (Amalia et al., 2022). The contribution of New and Renewable Energy is higher than conventional fossil fuel power plants. It is expected that this research will provide results that are in line with or more efficient than previous research (Homepage et al., 2023). Recently, a large number of investigations have been performed related to the renewable energy resources and its potentials and applications (Balabel et al., 2022). The use of solar panel energy in households can reduce the cost of electricity costs monthly. For example, the use of solar panels in a house of 86 m² can save electricity costs up to 52%. In addition, an initial investment for a solar panel system can be obtained return in a relatively short time, depending on daily energy consumption and cost installation (Dewi et al., 2025). Besides It is believed that the forecast consequences of solar panel yield can be used to assess Solar Panel Presentation (Sulistyowati et al., 2022), (Lukman et al., 2020).

Materials & Methods

The author conducted this study to plan and compare the effectiveness of power output production between the roof and the exterior walls of the house. The process of creating a solar power generation system plan involves several stages that must be carried out (Riafinola et al., 2022). The technology for this energy conversion is well-established; reliable and very robust (Johnson et al., 2020).

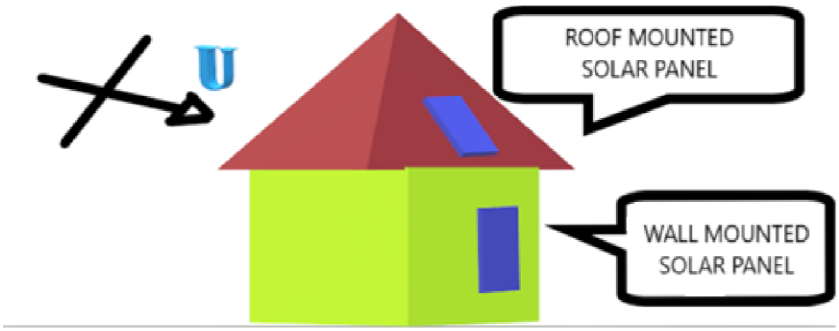

Figure 1. Placement of Solar Panels on Residential Houses

The author conducted the experimental research by planning and designing the placement of solar panels with an output power of 200 Wp. Each panel was placed on the roof at an inclination angle of 25° and on the outer wall mounted solar panel of the house facing north at an angle of 90°. Therefore, measurements will be carried out using the following setup:

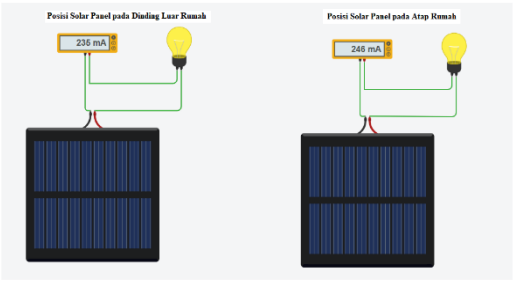

Figure 2. Measurement of Electric Current from Solar Panels in Residential Homes

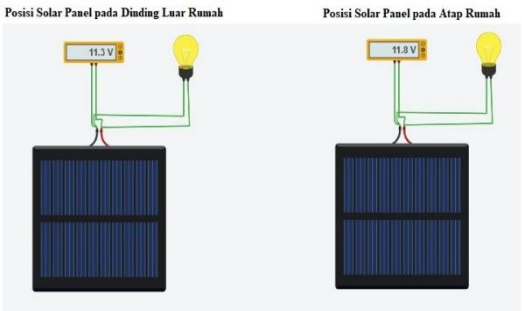

Figure 3. Measurement of Electric Voltage from Solar Panels in Residential Homes

The selected time for measuring the solar panel output is from 07:00 AM to 05:00 PM WIB we choose the time range of the experiment specifically. The output voltage of normal panels increases significantly at 8.30 AM, changing from 2 volts to 17.4 volts when Irradiance reaches 533 W/m2(Harahap et al., 2019). The output voltage will be stable until 3.30 PM when Irradiance starts to drown, with electrical current and voltage measurements taken every 30 minutes. The solar panel consists of several photovoltaic cells connected in a circuit, which is then connected to an external system. A solar panel system typically consists of several solar panels arranged together in an array or integrated system, allowing it to provide electricity to a connection with the required voltage. This study uses two Polycrystalline solar panels with a rated capacity of 200 WP each, placed on the roof and the wall of the house. The placement of the solar panels on the roof and the wall will result in a difference in the reception of sunlight intensity.

Several factors influence the enhancement of solar panel efficiency, with temperature being a critical determinant. The temperature of solar panels is influenced by several elements, such as ambient temperature, temperature coefficient, wind speed, and installation type. Hence, it is crucial to lower the temperature of the panels in order to optimize their power generation(T et al., 2024). Therefore, on our attempt to test the wall mounted solar Panel it is mostly cooler than roof mounted solar panel however the shading might be the issue for the wall mounted solar panel for electrical power production by itself.

The intensity of sunlight is also influenced by the amount of radiation that reaches the solar panels, such as the influence of the atmosphere, namely dust, water vapor, and other gases in the form of shadows (shaded)(Ramli et al., 2022). Partial shading has a more significant effect on PV module, the shaded part or cell will have considerable temperature rise and failed in the cell(Setiawan et al., 2019). The placement of solar panels must consider the direction of the sun and the distance between panels. The right distance between panels will maximize the optimization of energy production because it minimizes the shading effect(Dhiyah Ayu et al., 2024). Therefore, we chose to test in the north because our test location is located below the equator.

The first step is to define the case study and the surrounding building's location, height, setbacks, etc. Second, is the accurate estimation of the incident solar irradiation received by the building in order to identify the solar potential of the facades and roof. Third, calculate the solar access and the shadow occlusion created by surrounding buildings, as the shadows from the surrounding buildings can have a negative effect on the amount of solar radiation reached on the PV system. Finally, the architectural suitable area for integration considering limitations due to the constructions, also the use of existing surfaces for additional purposes(Abu Qadourah et al., 2022). Another aspect that would be a consideration is Eco-friendly architectural designs based on an energy harvesting principle can produce optimal energy(Choi, 2022).

This study therefore focuses on solar energy and building integration technology and application in the

residential building, and explored a new way and thinking for the close combination of the solar technology and residence(Obodoh et al., 2024). Regarding to this location, an overview of the aspects of temperature and rain is important. According to one of the solar panel distributor websites in Indonesia, mentarisolarled.com, so that solar panels can work optimally, Environmental estrangement means that the position of the solar cell installation site must be rich in sunlight. Environmental estrangement could be around the solar panels that will be installed surrounded by trees or tall buildings, so that sunlight can work optimally. This must be anticipated by placing solar panels higher than environmental disturbances(Wandari et al., 2021). The intensity of solar radiation fluctuates due to weather conditions, and environmental temperature affects the radiation reaching the surface of solar cells(Rifky, R Sirodz, 2020).

Weather and the amount of irradiance received by the PV panels are more influential on the power output and efficiency measured in this study; therefore, those two factors significantly affect PV performance(Nurjanah et al., 2021), The amount of solar energy produced by a solar cell device is determined by the position and tilt of the panel towards the direction of the incoming sun(Ramli et al., 2022).

The solar panel system consists of components with a working principle that is not complex. The simplest device consists of two different materials with distinct electronic properties (one with an excess of electrons and the other with a deficit of electrons) to drive the conversion of photons into electrons using the photoelectric effect. In the solar panel system, there are two layers of silicon that form a photovoltaic cell, enabling the generation of free electrons or holes in the molecular structure where electrons can bind again. Photon energy greater than the energy bandgap of the semiconductor can excite electrons to move from the valence band to the conduction band. The energy of the electron-hole pairs that exceed the bandgap energy will be released as thermal energy of the electrons. This energy is derived from the photon energy, which has been converted into electricity equivalent to the bandgap energy. The input data obtained is the intensity of sunlight, while the output data of this system includes the electrical voltage and current values.

Before installing the Solar Power Plant components, it is necessary to calculate how much power is needed and the quantity of Solar Power Plant components needed to meet daily power needs. The following are the stages of Solar Power Plant planning:

The input electrical power is obtained from the intensity of sunlight radiation, which is determined by the following equation (Rifky, R Sirodz, 2020):

$$P_{in} = I_v \cdot A \quad (1)$$

The output electrical power is obtained from the measurement of electrical voltage and current, calculated using the equation (Rifky, R Sirodz, 2020):

$$P_{out} = V \cdot I \quad (2)$$

The placement of the solar panels on the roof and walls of the building visualizes the position of the solar panels in the Building-Integrated Photovoltaics (BIPV) system model. The solar panels operate from the morning (07:00) until the

afternoon (17:00) WIB, with measurements taken every 30 minutes. The data consists of the intensity of sunlight radiation, which will be collected as input data. The output data, in the form of electrical voltage and current, is measured using a voltmeter and ampere meter.

Results and Discussion

The solar panels installed on the roof and wall, facing north, provide measurement data as follows. The research findings, in the form of raw data that has been processed and discussed, are divided into three sections of discussion:

1. **Placement of the Solar Panel on the Roof**: This section presents the research data displayed in Table 1. From the table, it can be observed that the radiation values received by the solar panel, and the placement of the solar panel on the wall, are shown in Table 2. This serves as a comparison between the two placements of the solar panel and the efficiency between both placements. This study was conducted in the city of Palembang on December 29, 2024, where the intensity of sunlight during that month was sufficient to operate light electronic devices. The intensity ranged from 50-100 watts, serving as an example for charging devices such as mobile phones, tablets, laptops, and emergency lamps. However, the test load for this study consisted of two 100-watt light bulbs.

Table 1. Solar Cell Performance Measurement (Roof)

Time	P_{in} (watt)	Voltage (V)	Current (A)	P_{out} (watt)	E_{ff} (%)
07.00	846,72	11,7	4,42	51,68	6,10
07.30	1223,2	11,8	7,19	84,88	6,94
08.00	808,92	11,9	9,53	113,36	14,01
08.30	1288,24	12	10,95	131,36	10,20
09.00	1489,32	12,1	12,82	155,16	10,42
09.30	905,68	12,2	8,48	103,48	11,43
10.00	955,6	12,3	9,82	120,76	12,64
10.30	987,32	12,3	10,38	127,72	12,94
11.00	1395,56	12,5	14,11	176,32	12,63
11.30	1669,24	12,6	15,23	191,96	11,50
12.00	1539,2	12,8	14,77	189	12,28
12.30	573,04	13,2	6,21	82	14,31
13.00	756	12,7	12,16	154,44	20,43
13.30	876,96	12,6	9,87	124,32	14,18
14.00	1150,64	12,6	10,17	128,12	11,13
14.30	734,84	12,3	6,30	77,44	10,54
15.00	695,52	11,9	4,62	54,92	7,90
15.30	264,6	11,8	2,06	24,32	9,19
16.00	343,24	11,6	2,43	28,16	8,20
16.30	213,2	11,4	1,64	18,72	8,78
17.00	22,68	11,1	0,31	3,4	14,99
Maks	1669,24	13,2	15,23	191,96	20,43
Min	22,68	11,1	0,31	3,4	6,10
Rata-rata	892,37	12,16	8,26	101,98	11,46

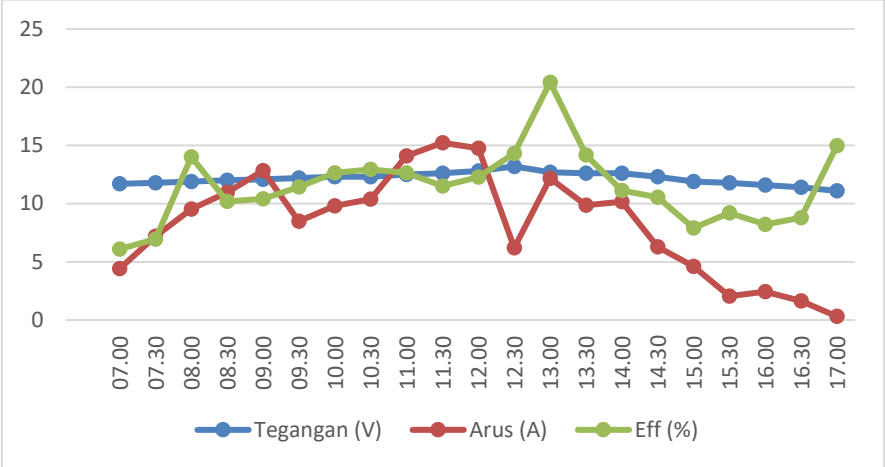

Figure 4. Comparison of Voltage, Current, and Efficiency of Solar Panels on the Roof of the House

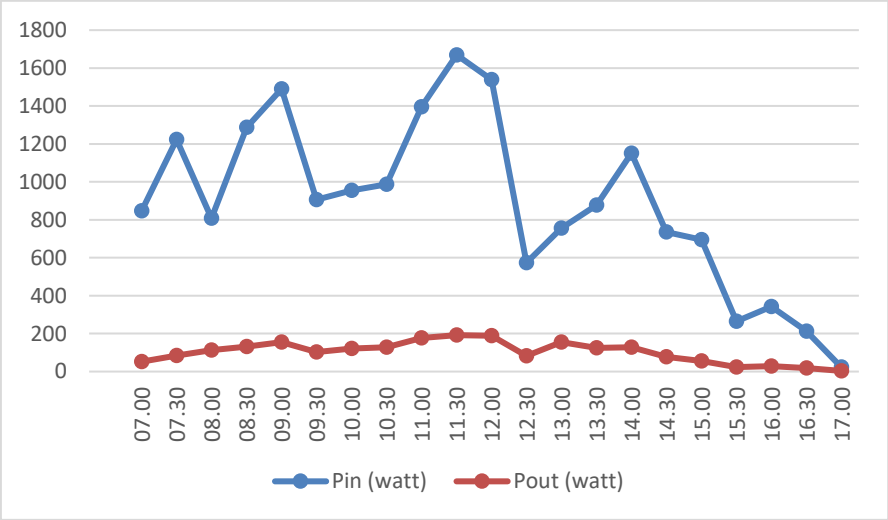

Figure 5. Comparison of Input Power and Output Power of Solar Panels on the Roof of the House

Table 2. Solar Cell Performance Measurement (Wall)

Time	P_{in} (watt)	Voltage (V)	Current (A)	P_{out} (watt)	E_{ff} (%)
07.00	846,72	11,12	4,54	50,48	5,96
07.30	1223,2	11,21	3,17	35,52	2,90
08.00	808,92	11,31	4,15	46,88	5,80
08.30	1288,24	11,40	4,66	53,08	4,12
09.00	1489,32	11,50	4,36	50,12	3,37
09.30	905,68	11,59	3,12	36,12	3,99
10.00	955,6	11,69	3,22	37,64	3,94
10.30	987,32	11,69	3,77	44,08	4,46
11.00	1395,56	11,88	3,74	44,36	3,18
11.30	1669,24	11,97	4,61	55,2	3,31
12.00	1539,2	12,16	4,96	60,28	3,92
12.30	573,04	12,54	3,00	37,64	6,57
13.00	756	12,07	4,20	50,68	6,70
13.30	876,96	11,97	3,41	40,84	4,66
14.00	1150,64	11,97	3,14	37,64	3,27
14.30	734,84	11,69	3,05	35,64	4,85
15.00	695,52	11,31	2,31	26,12	3,76

15.30	264,6	11,21	1,05	11,76	4,44
16.00	343,24	11,02	1,67	18,44	5,37
16.30	213,2	10,83	0,93	10,08	4,73
17.00	22,68	10,55	0,16	1,64	7,23
Maks	1669,24	12,54	4,96	60,28	7,23
Min	22,68	10,55	0,16	1,64	2,90
Rata-rata	892,37	11,55	3,20	37,34	4,60

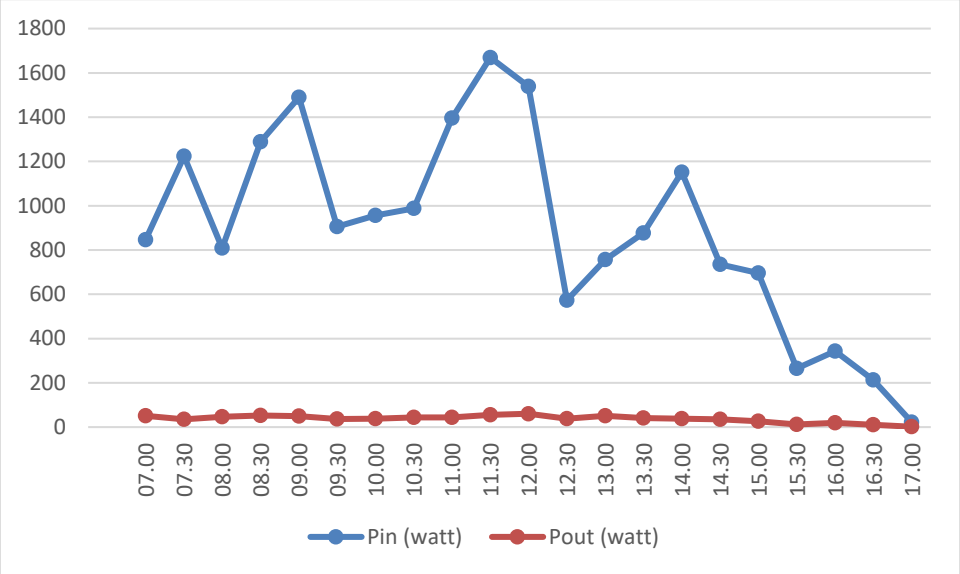

Figure 6. Comparison of Voltage, Current, and Efficiency of Solar Panels on the Wall of the House

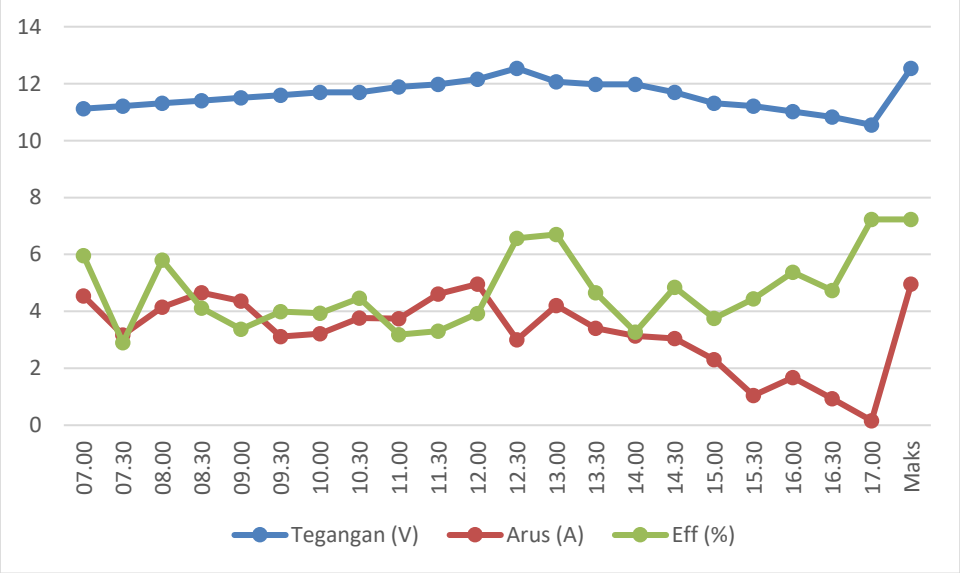

Figure 7. Comparison of Input Power and Output Power of Solar Panels on the Wall of the House

Conclusions

The solar panel installed on the roof with a 25° tilt angle demonstrates a higher average efficiency compared to the one installed on the outer wall with a 90° tilt angle. The average efficiency on the roof is 11.46%, while on the wall, it only reaches 4.60%. The solar panel on the roof produces more consistent electrical power throughout the day as it receives more optimal sunlight exposure, especially during the afternoon. This research was conducted in Palembang, where the sunlight intensity is high enough to support the operation of light electronic devices. Placement on the roof is more ideal for areas with similar sunlight intensity. Although the efficiency is lower, the installation of solar panels on the outer wall of the house can still be an alternative to meet electricity needs for homes with limited roof space. This study emphasizes the importance of considering the installation location of solar panels to maximize energy efficiency, with the main recommendation being to install them on the roof for optimal results.

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