Modeling Photovoltaic System on Parking Area Using East-West Racking

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Abstract. Parking lots are land that is always available in every building or office. There are only a small number of parking lots in the educational institution that has a top or roof cover that can protect parked vehicles such as rain and sun. The parking lot can be used to become a solar ground mount. This study uses satellite imaging and modelling in buildings to measure the potential of the energy produced. Solar PV in the parking lot in this study has an energy potential of 370.6 MWh per year, with the number of PV modules installed 818. Energy generated from solar PV in the parking lot can be used to support activities in the surrounding area.

1. Introduction

Various kinds of vehicles passing by on the Sumatra Institute of Technology campus. Some of these things that need to be considered are places to accommodate vehicles from the entire ITERA academic community. Starting from lecturers, students, students, and others. There is a centralized place that is a safe and comfortable location. In this case, parking is a major component that is always thought of because it is useful for future needs. The current parking design at the Sumatran Institute of Technology does not use a roof, so vehicles in the parking lot are directly exposed to sunlight and can cause damage to the external material on the vehicle. The abundant source of solar energy in the parking lot can be utilized as electrical energy as a roof.

In the research [1], Nunes made a concept about solar parking that functions as a place to store and replenish electrical energy in electric car vehicles. This paper explains more about the solution to each problem for battery charging. Other research, namely [2] Awad, identified the problem of plug-in electric vehicles (PEVs) on the integration of electricity networks. The system studied by PEVs is implemented using solar parking. The purpose of this study is to maximize the price advantage of using PEVs in parking lots with no problems in other economic constraints.

In research [3], Zhang optimized the battery energy charging system at the location of the parking work area. In this study predicts battery charging schedules in parking areas with real-time information using a dynamic charging schedule scheme (DCSS). The use of DCSS can optimize battery charging efficiently and effectively. In research [4], Guo examines the solar parking system used in the form of distributed generation. In this study, the economic value limit is a major factor in charging batteries using solar PV on the parking roof. The results of this study can be refueled in full in a day can produce electricity equivalent to operating energy needs on the next day in real-time.

In his research [5], Umer designed a solar PV system using a carport at King Abdul Aziz University. This study uses parameters such as the shape of the roof that is only a single flat without two ends of solar PV that meet to form an angle. The optimal tilt angle in this study, which is 100, produces the highest energy efficiency.
2. Method and Materials
Solar PV, which is used as an absorber of sunlight and then converted into electrical energy, has more benefits to the environment, such as there is no air pollution like that of fossil plants. Indonesia is a country that is crossed by the equator with more solar radiation in figure 1 shows the potential of electrical energy from solar PV.

![Figure 1. Geographic Potential of Solar PV system on Indonesia [6]](image)

Figure 1 shows that Indonesia has an average of 3.8 kWh / kWp per day. This potential is very large to be utilized so that the target of the renewable energy mix of 23% in 2025 can be achieved. The electrical energy generated from solar PV is solar energy radiation captured on solar panels or solar PV.

2.1 Solar Radiance
In the absorption of sunlight using the total irradiance equation as follows [7]

\[ G_T = G_B + G_D + G_R \]  

Whether \( G_T \), \( G_B \), \( G_D \), dan \( G_R \) is a value from global total irradiance, Beam radiance, Diffuse radiance, dan reflected form ground irradiance. Meanwhile, to estimate the average radiation from sunlight using this equation.

\[ \frac{\bar{H}}{H_c} = a + b \cdot \frac{n}{\bar{N}} \]  

Where :
- \( \bar{H} \) = monthly average daily radiation on a horizontal surface
- \( H_c \) = average clear-sky daily radiation for location and month in question
- \( a + b \) = empirical constant
- \( n \) = monthly average daily hours of bright sunshine
- \( \bar{N} \) = monthly average of maximum possible daily hours of bright sunshine
The methodology used in this study is to calculate the amount of energy produced from the installed PV modules based on the installed quantity. Some things in the design of this research method are that the location used is a parking lot, which is often passed by two-wheeled vehicles and four-wheeled vehicles so that the PV is placed 3 to 4 meters above the ground. In this study, using a simulation on the Helioscope with assumptions in accordance with the solution to be applied.

- Measuring the area of placement or location of PV modules installed later.
- The shadow effect on PV installation by taking into account the distance between the PV module and other PV when installed.
- The location used is the main parking lot of lecturers and students located at the location (5.3578879657, 105.31379936299999) (GMT 7.0).
- The type of PV to be simulated installed is Ground Mount East-West Racking.

The procedure carried out in carrying out research as follows:

1. Choosing a parking lot that is used as a research simulation area
2. Choose the type of PV that will be used to apply to the area
3. Designing the installation of PV in the form of a roof so that it can adjust the conditions on the ground
4. Determine the direction of the tilth and azimuth in the designed Solar PV
5. measure the potential power and electrical energy produced

2.2 Solar Parking Design

Figure 2 shows the design of the solar PV placed on the parking area with the concept of a paired roof. This solar PV design has a length of 4 meters with a width of 1 meter mounted with a slope of 15°.

![Figure 2 Design of Solar Rooftop Parking System east-west racking](image)

In figure 2 looks design for the roof using solar PV can protect the vehicle underneath directly from the sun's radiation other than that. Energy concerning solar PV can be absorbed directly and converted into energy.

3. Result and Discussion

The results of this study using modeling and simulation using a helioscope obtained several data references and images as follows. The first data is in table 1, which shows the energy output and solar radiation power factor per month and year.

Table 1 shows the maximum radiation from the sun in September, while the minimum value is found in February. This sunlight is still data from satellite or even weather station data that exist at the location of the research object. In the plan of the array (POA), the same value is obtained from the previous solar radiation or GHI so that the energy produced is also to enter the grid system or is needed in real conditions, which is 30,000 kWh.

In the next discussion, that is found in Figure 3. Figure 3 shows the design of the total solar rooftop placement in the parking lot using the azimuth 900 direction. This design provides a design that resembles a tunnel covered by a solar PV rooftop.
Table 1. Solar PV energy from Parking Area

| Month   | GHI (kWh/m²) | POA (kWh/m²) | Shaded (kWh/m²) | A nameplate (kWh) | Grid (kWh) |
|---------|--------------|--------------|-----------------|-------------------|------------|
| January | 126.5        | 124.7        | 124.4           | 33,146.4          | 28,672.2   |
| February| 117.5        | 115.5        | 115.2           | 30,759.3          | 26,635.6   |
| March   | 144.2        | 142.1        | 141.7           | 37,882.6          | 32,491.2   |
| April   | 135.3        | 133.3        | 132.9           | 35,523.9          | 30,541.3   |
| May     | 134.0        | 131.9        | 131.6           | 35,124.5          | 29,973.1   |
| June    | 123.8        | 121.8        | 121.4           | 32,387.8          | 27,635.2   |
| July    | 130.1        | 128.1        | 127.8           | 34,066.7          | 29,248.0   |
| August  | 138.6        | 136.7        | 136.3           | 36,411.4          | 31,351.9   |
| September| 145.3       | 143.1        | 142.7           | 38,137.2          | 32,766.7   |
| October | 137.5        | 135.4        | 135.0           | 36,078.4          | 30,889.2   |
| November| 117.9        | 116.3        | 116.0           | 30,909.1          | 26,745.8   |
| December| 126.4        | 124.6        | 124.3           | 33,113.6          | 28,582.3   |

From the picture, it can be seen that the position of the solar PV is mounted longitudinally from the west and east. The design used uses solar PV as a roof for cars, cars, or vehicles that will be parked later under the PV system. The height of the installed PV system is 3 meters. This longitudinal design optimally conditions it to get a higher performance ratio value of 79.9%, with each panel measuring 4x1 meters. In the following figure is shown about the three-dimensional shape of the roof shape designed using solar PV. From this figure, the total PV installed is as many as 818 PV modules. The energy produced during the year is 355.5 MWh, and energy per day is 1,259.8 kWh / kWp. The performance of Solar PV is 81.1% exceeding the 80% performance standard. Figure 4 shows the appearance of each corner of the solar PV.
The three-dimensional image shows the Solar PV used to adjust the vertex and intersection between each PV so that it looks like an ordinary building roof. The green roof indicates 100% sun absorption in that position. The following table shows the electrical power generated from the simulation using a PV system designed. In Figure 4, the level of absorption of sunlight is shown to be greener. The image means the greater the absorption power of solar energy available in solar PV.

4. Conclusion
From the results of this study obtained a simulation of modeling using Solar PV in the parking area with the form of east-west racking roofs, azimuth 90º, and the number of modules as much as 818 produces 1259.8 kWh / kWp energy with annual electricity production of 355.5 MWh. Solar PV system modeling in the system obtained a performance ratio of 81% so that in terms of absorption of solar energy is very feasible to be applied as a power plant in the area of the Sumatran Institute of Technology. The shape of the roof model used in this study has drawbacks such as modules that must be installed horizontally so that in its implementation, it forms like a carport roof and requires a large investment. It is expected that in subsequent studies, the real form of research modeling becomes a prototype to become a teaching material or practicum for students and the researcher.

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