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Development of Rooftop Solar Power Plant (PLTS) on Parking Areas for EV Charging Station at Sumsel-8 Mine Mouth Power Plant

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Abstract. *The PLTU MT Sumsel-8, a coal-based power plant, has significant potential to implement renewable energy solutions to enhance energy efficiency and operational sustainability. One viable solution is the construction of a rooftop solar power plant (PV) in the parking area with an off-grid system. This system is designed with a capacity of 162 kWp to meet the electricity needs of supporting facilities at the power plant, as a charging facility for eletric vehicle (EV). In addition to generating clean energy, the installation of solar panels on the parking lot roof also provides additional benefits, including vehicle protection from solar heat and the optimization of previously underutilized land. However, before implementing this system, a comprehensive feasibility study is required, encompassing technical, economic, and environmental evaluations. Simulation results using Helioscope software indicate that the proposed PV system with the stated capacity can generate 225.413,2 kWh of energy per year. Considering the energy storage capacity of electric vehicles, the simulation results suggest that the energy production can provide enough charging capacity for 7 to 8 vehicles per day for vehicles with battery capacity 77 to 82,5 kWh and up to 23 vehicles per day for smaller capacity battery which is 26,7 kWh. This study is expected to offer recommendations for the implementation of rooftop PV at PLTU and contribute to the strategy for sustainable energy options in Indonesia.*

Keywords – *PV, Charging Station, Helioscope*

INTRODUCTION

The advancement of renewable energy utilization, consistently promoted by the Government of Indonesia through the establishment of national energy mix targets, has stimulated the emergence of various innovative technologies. In response, the industrial sector is increasingly required to implement continuous innovations in the application of renewable energy sources [1]. One form of such innovation is the utilization of vacant or underutilized spaces within industrial areas. A notable example is the deployment of solar power plants (PV) on building rooftops or canopy structures. Solar Power Plants (PV) are electricity generation systems that convert solar energy into electrical energy as their primary output [2].

Indonesia possesses vast solar energy potential, estimated at approximately 4.8 kWh/m² per day, equivalent to 112,000 GWp [3]. Nevertheless, the current level of solar energy utilization remains suboptimal. As of 2023, the installed capacity of rooftop PLTS systems had reached only around 140 megawatts (MW), far below the national target of 3.6 GW by 2025 [4]. To address this gap, the Government of Indonesia has issued new regulations aimed at accelerating rooftop PLTS adoption, particularly within the commercial and industrial sectors, through Ministerial Regulation No. 2 of 2024 concerning rooftop PV systems connected to public electricity networks [5].

The placement and application of PV systems have become increasingly diverse. In addition to serving as primary electricity sources, PV installations can provide lighting and function as charging stations for electric vehicles. Furthermore, when installed in public spaces, PV systems can serve as platforms for public education and the dissemination of renewable energy awareness [6].

Moreover, the deployment of PV systems enhances energy efficiency by harnessing solar resources that are freely available and sustainable. The energy generated not only reduces reliance on fossil fuels but also optimizes the utilization of previously unproductive areas, such as parking lot rooftops. This implementation additionally contributes to the mitigation of the urban heat island effect around parking areas, thereby improving user comfort [7].

The integration of PV with charging station infrastructure (CS) represents a promising strategy for emissions reduction, particularly when aligned with the increasing adoption of electric vehicles (EVs) and the establishment of Public Electric Vehicle Charging Stations (EV-CS). However, the development of solar-powered EV-CS infrastructure in Indonesia remains limited [7]. Given the growing number of Battery Electric Vehicle (BEV) users, the establishment of renewable energy-based SPKLUs is becoming increasingly critical. In response to these needs, the present study aims to propose the development of a PV system serving as an electric vehicle charging station, integrated within parking canopy structures in coal-fired power plant areas or other industrial sites.

METHODS

The method used in this study is a quantitative method with a simulation approach through software. The design of the construction that will be used for the solar PV system uses 2 (two) software, namely Helioscope for simulation of placement and ideal conditions to avoid shadows (shading) from surrounding buildings as much as possible as well as predicted results of energy production. Helioscope is a web-based software developed by Folsom Labs to design solar power generation systems. This device allows the calculation of the potential output of PV power by taking into account various important parameters such as: roof area, roof slope, shadow potential to location azimuth[8]. The helioscope will be used to get a simulation of energy production results so that it can be technically calculated to compare electric vehicles that can be charged per unit of time.

The next software used is Autocad to help design the design of the canopy and the laying of the solar power plant so that it can be aesthetically and functionally adequate. The design was made by paying attention to the area of available locations and general data on the dimensions of battery-based electric vehicles. The dimensions and area of the placement area were calculated through field surveys as well as observation of potential shadows (shading). The research flow chart is as follows:

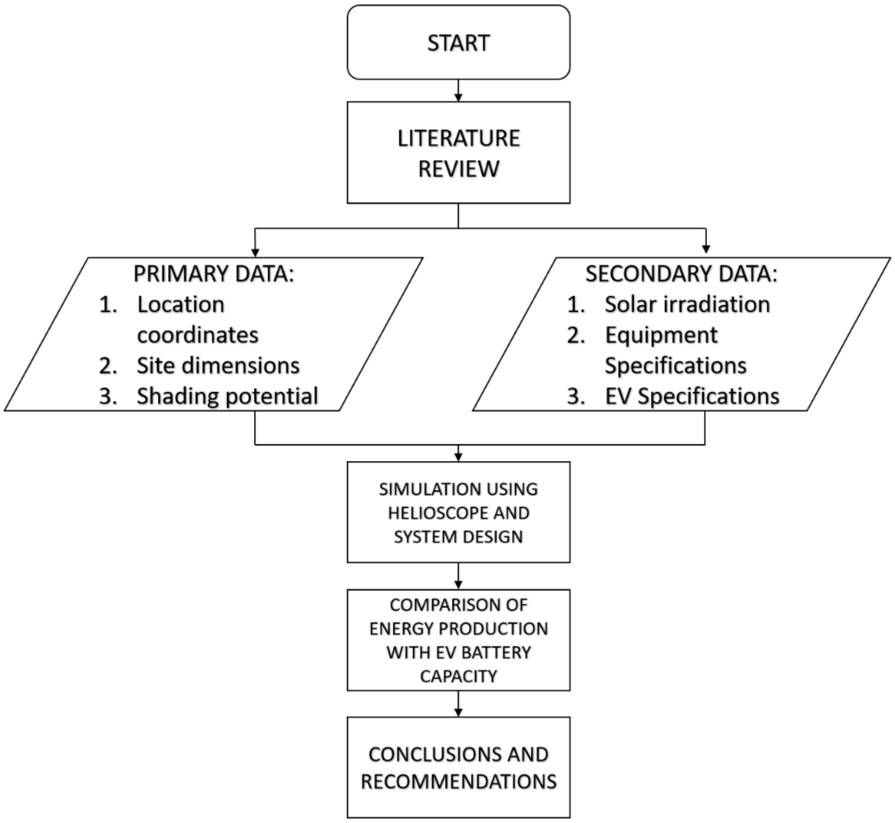

Figure 1. Research Flowchart

RESULTS AND DISCUSSION

A. The System Design Results

The research location is situated in the parking area of the Sumsel-8 Coal Power Plant office, with boundary coordinates ranging from a latitude of 3°50'27.74"S and a longitude of 103°48'18.11"E to a latitude of 3°50'29.65"S and a longitude of 103°48'17.48"E. The designated area is currently an open parking space without canopy facilities. The shape of the area is rectangular. The detailed measurements of the area are presented in Table 1. Furthermore, field observations revealed that to accommodate the flow of incoming and outgoing vehicles, certain areas must remain unobstructed, thereby reducing the potential area available for canopy installation with solar PV rooftops, as illustrated in Figure 2.

Table 1. The Measurement Details of Canopy PV Area

No	Description	Measurement
1	Length	55 meter
2	Width	19 meter
3	Total Wide	1.045 m^2
4	Total Perimeter	148 meter
5	Wide Used	+ 820 m2
6	Perimeter Used	+ 120 meter

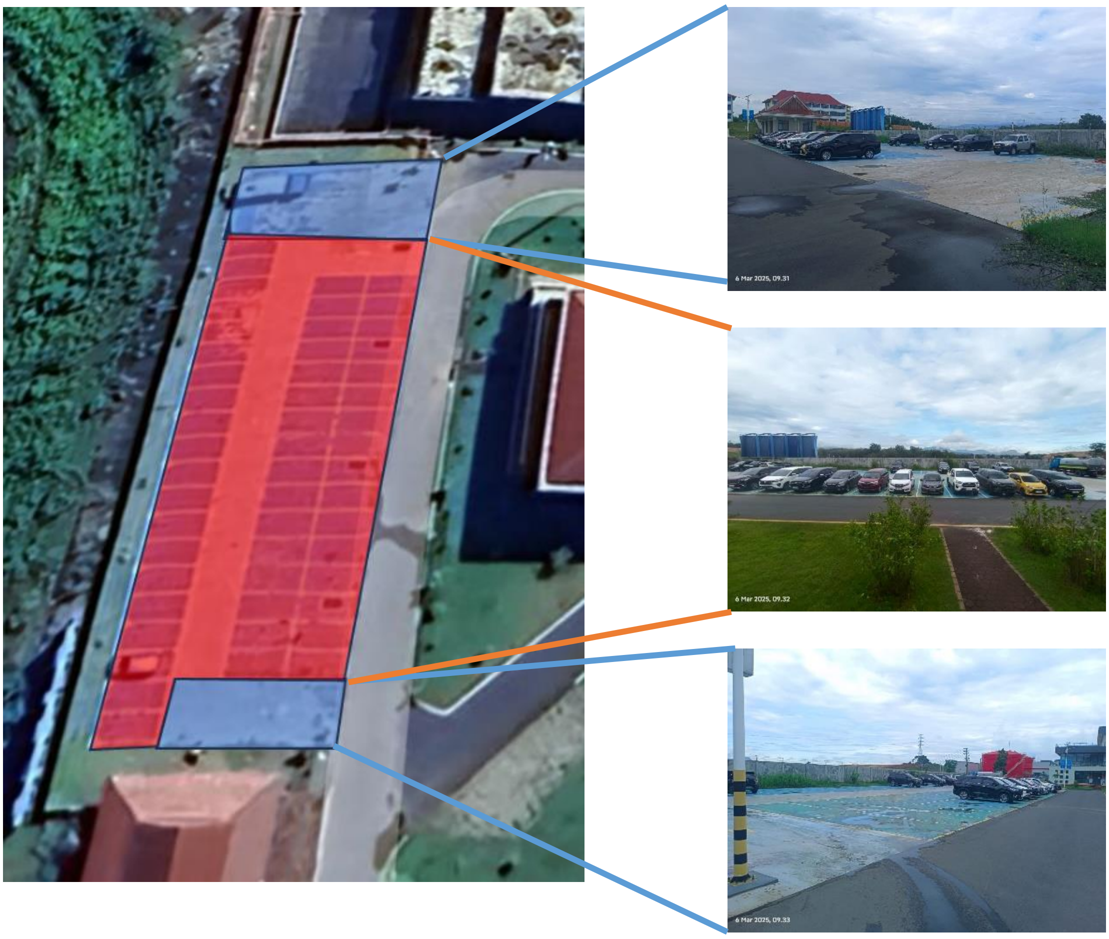

Figure 2. Available Area Potency Justification
Whereas red zone indicates available area for PV placement, whilst the blue zone indicates non available area (undisturbed zone)

Paying attention to the available area, it is planned to use solar panels with a capacity of 575 Wp to then calculate the estimated installed capacity. The details of the dimensions and description of the solar panels that will be used in the design are presented in table 2.

Table 2. PV Parts Details

Nr	Description	Brand	Type	Dimension	Capacity
1	PV Module	Jinko	JKM575N-72HL4	2278 x 1134 x 30 mm[9]	575 Wp
2	Inverter	Deye	SUN-50K-SG01HP3-EU-BM4	527 x 894 x 294 mm[10]	50.000 W

After obtaining data on the area of the potential area and dimensions of the solar panel, the estimated number of solar panels can be calculated using the equation of the comparative area of the perimeter area divided by the area of the solar panel[11]:

$$\Sigma\, panel = \frac{\text{A area (Area Total Wide)}}{\text{A panel (PV Wide)}} \quad (1)$$

The area of the perimeter, after deducting the non-disruptable sections, is approximately 820 m², while the surface area required for one solar panel with a capacity of 575 Wp is 2.58 m². Thus, the estimated number of panels that can be installed is approximately 317.429 units, equivalent to 317 panels. This estimation does not yet account for the detailed design, the distance between panels, or the potential shading from surrounding structures. The canopy design was developed by considering the average height of typical vehicles, resulting in a height of 3.55 meters and a width of 5 meters. The tilt angle of the canopy is designed at 5° to minimize the accumulation of dust and to maximize rainwater runoff [12]. The detailed canopy design is illustrated in Figure 3 below:

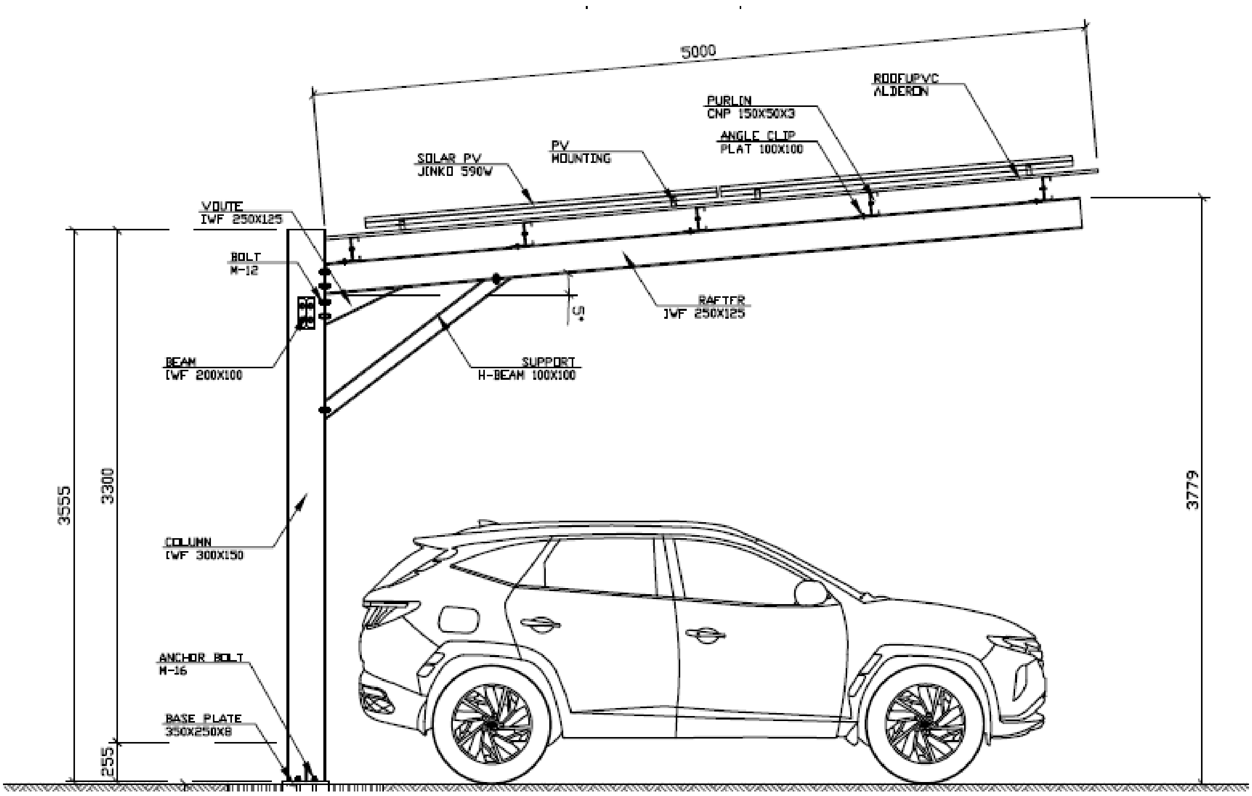

Figure 3. Canopy Design of PV Details

B. Energy Production Yield Simulation

The projection of energy production was calculated using the Helioscope software. The parameters considered include: the types of equipment used (solar panels and inverter), shading potential from nearby buildings, azimuth and tilt angle of the solar panel installation, as well as secondary irradiation data. Following the planning process, a difference was observed between the manually estimated and actual number of panels that could be installed, due to the necessity of providing spacing between canopies to optimize vehicle movement lanes. The total number of solar panels that can be installed is 276 units, with a total capacity of 158.7 kWp. The layout of the solar panel placement is illustrated in Figure 4.

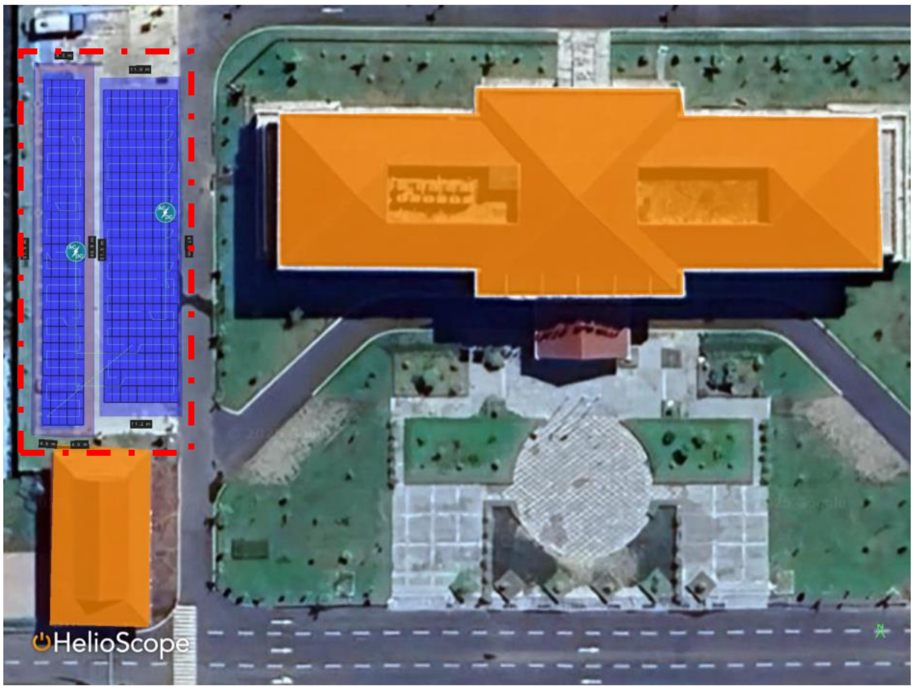

Figure 4. Solar panel placement is indicated by the area outlined in red, while the shading potential from surrounding buildings is shown in yellow.

The simulation results show that over the course of one (1) year, the total energy production reached 225,413.2 kWh, with an average monthly production of 18,784.43 kWh. The highest monthly production, amounting to 20,742.4 kWh, occurred in March, while the lowest production was recorded in February with 14,575.5 kWh. This variation is significantly influenced by the solar irradiation levels during those months. The summary comparison between GHI and rooftop PV system production on a monthly basis over one (1) year is presented in Figure 5.

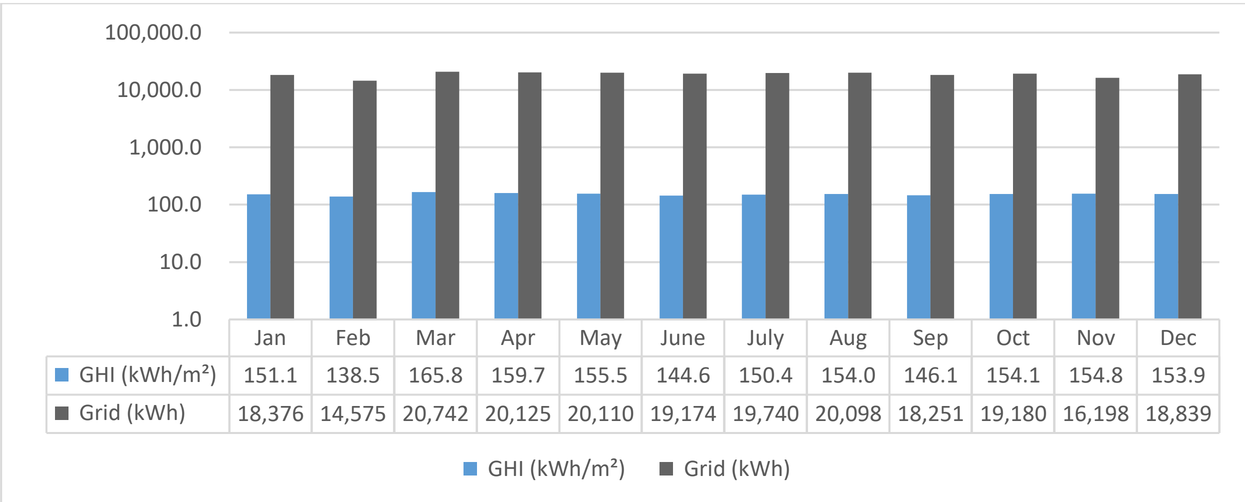

Figure 5. Graph comparing energy production with Global Horizontal Irradiance (GHI)

Considering the planned function of the solar power plant (PV) development for use in charging stations (EV-CS), the production data will be compared with the battery capacity of electric vehicles to assess the charging capability of the system. The data will be calculated using the following equation:

$$\text{Charging Capacity} = \frac{\Sigma\ \text{Energy Yield}}{\text{Battery Capacity}} \quad (2)$$

The calculation of the energy charging capability from the canopy solar power plant production for several types and brands of electric vehicles in Indonesia, after being calculated using equation (2), shows that the average daily charging capacity for the Ioniq 5, Leaf, and Seal models is between 7.5 to 8 vehicles, while for vehicles with smaller battery capacities, such as the AirEV, the result is 23 vehicles per day. The results of these calculations are shown in Table 2 below:

Tabel 2. The EV Specification List Compared with PV Charging Capacity

Nr	Type	Brand	Range (km)	Battery Capacity (kWh)	Energy Yield (kWh)	Charging Capacity (car per year)	Charging Capacity (car per day)
1	Air EV	Wuling	up to 300	26,7[13]	225.413,2	8.442,4	23,1
2	Ioniq 5	Hyundai	448	77,4[14]	225.413,2	2.912,3	8,0
3	Leaf	Nissan	170	80[14]	225.413,2	2.817,7	7,7
4	Seal	BYD	550,4	82,5[15]	225.413,2	2.732,3	7,5

CONCLUSIONS

The results of the calculations and simulations for the development of the canopy solar power plant (PLTS) with a capacity of 158.7 kWp show an annual energy production of 225,413.2 kWh. Energy production is highly influenced by the Global Horizontal Irradiance (GHI) conditions, with the highest monthly energy production of 20,742.4 kWh occurring in March, while the lowest production occurred in February, with 14,575.5 kWh.

This energy production is sufficient to meet the charging needs of electric vehicles, with the daily charging capacity for electric vehicles with battery capacities of 77 to 82.5 kWh being approximately 7.5 to 8 vehicles per day. Meanwhile, for vehicles with smaller battery capacities, such as 26.7 kWh, the result is 23 vehicles per day. Given these results, further research is needed to account for the addition of energy storage facilities, such as batteries. These facilities are necessary to manage situations where not all of the energy generated by the PLTS can be absorbed. Additionally, a comparison of emission parameters should also be conducted to evaluate the potential benefits of transitioning to electric vehicles.

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