Potential Study and Design of Solar Power Plant Using Weighted Overlay Method Based on Spatial Data in Sambas District

Pandu Lanang Turongo Jati¹, Zainal Abidin², Yandri²
¹Undergraduate Program Electrical Engineering, Faculty of Engineering, Universitas Tanjungpura, Pontianak, Indonesia
²Department of Electrical Engineering, Faculty of Engineering, Universitas Tanjungpura, Pontianak, Indonesia

Article Info

Received Feb 6, 2024
Revised Mar 27, 2024
Accepted Apr 26, 2024

ABSTRACT

This study uses the spatial data-based weighted overlay method to analyze and design an effective Solar Power Plant (PLTS) in Sambas Regency. Sambas Regency, located in the 3T (Disadvantaged, Frontier, Outermost) area and directly bordering Malaysia, faces the challenges of uneven electricity distribution and the growth of energy demand that continues to increase along with population growth. With significant renewable energy potential in West Kalimantan, especially solar energy reaching 20 GW, this research has relevance in providing sustainable solutions to support the region's energy needs. A GIS-based Weighted Overlay approach is used to determine the optimal location of PLTS by considering various parameters such as NDVI, NDBI, NDMI, LST, Slope, Rainfall, distance to PLN substation, and existing PLTS location points. The results of this mapping and analysis were then integrated into the technical design of the PLTS using PVSyst software. This research successfully overcomes practical obstacles, such as land protected by the Ministry of Environment and Forestry, by providing detailed solutions that can be implemented. With the continuous growth of energy demand in Sambas Regency, implementing utility-scale solar power plants is becoming increasingly urgent. This investment can be concluded as feasible through economic analysis that includes NPV, PI, IRR, and DPP. With the application of the right methodology, it is hoped that this research will make a real contribution to supporting Indonesia's efforts to achieve carbon-neutral targets and meet energy needs in border areas that are still unelectrified.

Keywords:
PLTS
Renewable Energy
Solar Power
PVSyst
Spatial

1. INTRODUCTION

World governments are committed to realizing a carbon-neutral economic scheme in the next 10 to 30 years [1]. Although carbon emissions in Europe and America have stabilized, in Asia and Africa, they have increased. According to NASA, the earth’s surface temperature in 2021 will increase by 0.85 degrees Celsius, triggered by global warming from various sectors, including the energy sector which contributed 71.5% of emissions in 2017 [2].

Indonesia has committed to reducing emissions by the 2060 Paris Agreement, especially in decarbonizing the energy sector. The emission reduction target of 314 million tonnes of CO2e by 2030 emphasizes the importance of Indonesia’s efforts to achieve carbon neutrality below 1.5°C [3]. The main focus is to accelerate
the use of new renewable energy, especially solar energy, which has great potential in Indonesia with 442 GW, but only around 10.4 GW has been implemented [4].

In West Kalimantan, the power system is still concentrated on one interconnected system and several isolated systems. Uneven electricity development makes some areas, especially those on the border such as Sambas Regency, dependent on electricity imports from neighboring countries. In addition, with the potential of solar energy in Sambas Regency, which is characterized by abundant sunlight, there is an opportunity to overcome the energy deficit. Sambas Regency, which is designated as a 3T area, has many villages that have not yet been electrified, exacerbating the growing energy demand.

With the potential for new renewable energy of 26,841 MW in West Kalimantan, especially from solar energy, which reaches 20 GW, projected energy needs are increasing. Therefore, this research focuses on studying the potential and design of solar power plants in Sambas Regency using the Weighted Overlay method based on spatial data and a GIS approach. This method involves determining a strategic location, conducting technical installation studies, and economic calculations using PVSyst software.

By facing the challenges of protected land and limited access to PLN substations, this research aims to find an effective solution in determining the location for PLTS construction. Thus, this research is relevant in supporting Indonesia’s efforts to achieve decarbonization targets and reduce unequal access to electricity in border areas. Specifically, its findings hold immense potential to revolutionize Indonesia’s decarbonization trajectory by facilitating deployment of sustainable energy infrastructure in previously inaccessible regions. This not only accelerates the nation’s transition towards clean energy but also addresses energy poverty in border areas, thereby fostering social equity and economic development.

2. LITERATURE REVIEW

Several similar research journals have existed before which are the materials for compiling this research final project. Research conducted by Abdulaziz Alhammad et al. (2022) journal MDPI, Basel, Switzerland. With the research title “Optimal Solar Plant Site Identification Using GIS and Remote Sensing: Framework and Case Study”. In Al-Qassim, Saudi Arabia, using the Multiple Criteria Decision Analysis (MCDA) and GIS methods to determine the optimal location of solar power plants. Integration of GIS, Random Forest classification, and Model Builder “is used to ensure the ideal location. The results show that 17.53% of the area is very suitable, with a production potential of 1905 kWh/kWp PVOUT. This method has the potential to be applied nationally and internationally [4]. Research conducted by Younes Noorollahi et al. (2020). Journal MDPI, Basel, Switzerland. The research titled “A Spatial-Based Integration Model for Regional Scale Solar Energy Technical Potential” Identified and evaluated the solar energy potential in Iranian Kurdistan. The results show a solar energy potential of approximately 691 MW for photovoltaics and 645 MW for CSP. This research also details the use of solar water heaters and potential material savings fuel. Future research will consider Renewable Energy Resources (RESs) and scenarios for increasing energy consumption in Kurdistan [5]. Research conducted by Shaimaa Magdy Habib et al. (2020). Journal Elsevier. Remote Sensing Applications: Society and Environment 18 100313. With the research title “Spatial modeling for the optimum site selection of solar photovoltaics power plant on the northwest coast of Egypt” conducted research in Egypt to determine the optimal location of solar power plants. GIS methods, remote sensing technology, and MCDM were used to consider techno-economic and environmental conditions. The results showed 24.9 % of the area is suitable for PLTS with potential solar radiation of 5.9 - 4.7 kWh/m2/day [6]. Research conducted by Nisa’ul Khusnawati and Abdi Pandu Kusuma (2020) journal Mnemonic. With the research title “Sistem Informasi Geografis Pemetaan Potensi Wilayah Peternakan Menggunakan Weighted Overlay” conducted research in Blitar, East Java, with a focus on mapping the potential of livestock areas using the Geographic Information System and the weighted overlay method. This research provides the first step in determining the optimal location for the area farm [7]. Research conducted by Hala A Effat and Ahmed El-Zeiny (2017) modeled potential zones for solar energy in El Fayoum, Egypt. This research used GIS and satellite data to delimit optimal sites for solar power generation. The results show that El-Fayoum has “potential for use as a solar power plant with annual average solar radiation reaching 1,445,097 Wh/m2/year [8]. From previous research study by mapping solar energy potential based on one region using spatial data, such as NDVI, NDMI, NDBI, Land Surface Temperature, Rainfall, Slope, and substation location points. The spatial data obtained will be processed with ArcGIS to determine the location of the most potential solar power plant development areas. After the most potential locations are identified, researchers design solar power plants (PLTS) using PVsyst to calculate the output energy produced and details of the materials used, such as solar
panels and inverters. In addition to the technical aspects, the research also includes an economic analysis of the solar power generation system.

3. METHOD

3.1. Load Growth and Projections of Electrical Energy Needs

Sambas Regency heavily relies on fossil fuel power plants, despite the presence of alternative sources like PLTD, PLTS, and PLTMH. The electrical networks are interconnected in a unified equatorial system. In 2021, PLN serves 164,785 customers, and the electricity demand, spanning households, industries, social agencies, and government, continues to rise annually. The escalating electricity load in Sambas Regency is projected to persist, guided by a 4.76% average yearly economic growth in West Kalimantan from 2015 to 2019 [9]. In response to the post-COVID-19 economic recovery, PLN projects electricity needs under optimistic and moderate scenarios. The projections also consider the development of Special Economic Zones, Industrial Areas, tourism, and potential large industrial customers, exemplified by the Semparuk Industrial Zone in Sambas Regency. To cater to the needs of these sectors, PLN must develop an electricity infrastructure aligning with clean energy principles outlined in RUPTL and Indonesia's commitment to carbon emission reduction.

3.2. Solar Energy Potential in Indonesia

Indonesia, with its tropical climate, benefits from high solar energy potential. The country is divided into two regions, namely the western and eastern regions. The Ministry of Energy and Mineral Resources of Indonesia reports that the Western Indonesia Region (KBI) receives solar irradiation with a potential of 4.5 kWh/m²/day. This translates to an average solar energy potential of 4.8 kWh/m²/day in Indonesia. This abundant potential serves as a compelling reason for the development of solar power plants (PLTS) in the country. Indonesia experiences stable sunlight intensity throughout the year, making it highly suitable for achieving optimal power generation.

3.3. Solar Power Plant

Solar Power Plants (PLTS) convert sunlight into electrical energy through solar cells on solar panels. Solar cells are made from a thin layer of silicon or other semiconductors. PLTS utilizes solar energy to produce DC electricity, which can be converted into AC electricity via an inverter if needed. As part of a new renewable energy source, PLTS is not limited in its use because the sun is abundant. PLTS is also considered an environmentally friendly power plant, with no noise, no rotating parts, and does not produce waste or gas emissions.

3.4. PLTS Component

3.4.1. Solar Module

Solar modules generally have around 36 cells connected in series in 4 parallel rows with an area ranging from 0.5 m² to 1 m². One module consists of several cells, when two or more modules are connected, it is called a panel [10].

3.4.2. Inverter

An inverter is an electronic device that converts DC electric current into AC. The DC voltage from solar panels is unstable according to the level of solar radiation. PLTS uses a single-phase inverter for small loads, while, a three-phase inverter or a system connected directly to the PLN network (grid connection) is generally used for large loads.

3.5. Solar Power Plant Design

In developing PLTS, it is necessary to estimate electricity needs as information for policymakers to consider various development aspects and risks. PLTS planning is very dependent on the intensity of sunlight, so calculations of the array area, power produced, the parallel series configuration of solar modules, the tilt angle of solar modules, and the temperature of solar modules are needed to achieve optimal power output.

3.6. Remote Sensing

Remote sensing is the science, technology, and art of obtaining information about objects, areas, or phenomena using sensors on vehicles (such as aircraft, satellites, etc.) which are then analyzed without direct contact [11].

Potential Study and Design of Solar Power Plant Using Weighted Overlay Method Based on Spatial Data in Sambas District (Pandu Lanang Turonggo Jati)
3.7. Citra Satelit 8

The Landsat satellite, which was first launched in 1972, went through several generations. The first generation carried a Returned Beam Vidicon (RBV) sensor, while the third generation, which continues to this day, is equipped with an Enhanced Thematic Mapper Plus (ETM+) sensor. Satellite The third generation of Landsat has a temporal resolution of 16 days and a spatial resolution of 30 meters. There is also the LDCM (Landsat Data Continuity Mission) satellite or Landsat 8, which was launched on February 11, 2013, as a continuation of the Landsat program since 1972 [12]. Landsat 8 carries an Onboard Operational sensor Land Imager (OLI) and Thermal Infrared Sensor (TIRS) with a total of 11 channels, of which 9 channels are on OLI and 2 channels (bands 10 and 11) on TIRS, have specifications similar to Landsat 7.

3.8. Spatial Data

3.8.1. Normal Difference Vegetation Index (NDVI)

NDVI is a combined value of several remote sensing image spectral bands that reflect the energy emitted by vegetation. This vegetation index wave indicates the size and number of plants in remote sensing images [13].

\[
\text{NDVI} = \frac{(\text{NIR} - \text{RED})}{(\text{NIR} + \text{RED})}
\]  

Information:
- NIR: Near infrared band (band 5 on Landsat OLI)
- RED: Red band (red light is band 4 on Landsat OLI)

3.8.2. Normal Difference Built-up Index (NDBI)

This research uses the built-up area index value resulting from image processing using the Normalized Difference Built-up Index (NDBI) transformation [14]. NDBI is a sensitive index for built-up or open land, used to calculate the built-up area because it is a transformation.

\[
\text{NDBI} = \frac{(\text{SWIR} 1 - \text{NIR})}{(\text{SWIR} 1 + \text{NIR})}
\]  

Information:
- SWIR: Short wave infrared (Band 5 on Landsat OLI)
- NIR: Near infrared band (Band 6 on Landsat OLI)

3.8.3. Normal Difference Moisture Index (NDMI)

The surface moisture index (NDMI) is used to evaluate moisture variations in a landscape [15]. NDMI has a positive relationship with NDVI, namely the higher the NDVI, the higher the NDMI value, and vice versa. This is caused by dense vegetation which increases the humidity and water content.

\[
\text{NDMI} = \frac{(\text{NIR} - \text{SWIR} 1)}{(\text{NIR} + \text{SWIR} 1)}
\]  

Information:
- NIR: Near infrared band (Band 5 on Landsat OLI)
- SWIR: Short Wave Infrared (Band 6 on Landsat OLI)

3.8.4. Land Surface Temperature

Remote sensing satellite sensors can record spectral reflections per pixel that reflect the characteristics of the earth’s surface, including phenomena invisible to the human eye such as temperature. Thermal Infrared Sensors, such as those of Landsat 8, can acquire various temperature levels on the earth’s surface. Research This also uses Landsat 5 satellite imagery to obtain Land Surface Temperature (LST) data in 2009. The LST processing in this research considers the emissivity of objects, which is determined by the type of object and the270reeness of vegetation as measured by the Normalized Difference Vegetation Index (NDVI). Positive NDVI indicates areas with dense vegetation, while negative values indicate areas without vegetation with high emission levels [16], [17], [18], [19].

\[
\text{LST} = \frac{T_B}{1 + \left(\Delta T_B/\rho\right)\ln e}
\]
3.8.5. Slope

The slope and length of the slope are significant topographic elements that influence surface flow and erosion. Slope, expressed in degrees or percent, influences the amount and speed of surface runoff and the water transport energy. Steeper slopes tend to increase erosion because they increase the run off and speed up its speed. This factor can also cause more soil grains to splash when it rains. The slope of the slope can be measured in percent or degrees. The shape of the slope, whether convex or concave, influences the width of erosion, where erosion tends to be wider on convex slopes [20].

3.8.6. Climate Hazards Group Infrared Precipitation with Station Data (CHIRPS)

This rainfall data was obtained from the Climate Hazards Group Infrared Precipitation with Station data (CHIRPS), a combination of global climatology, satellite-based rainfall estimates, and in-situ observations. CHIRPS uses data from a variety of sources, including quasi-global geostationary thermal satellite observations, the Tropical Rainfall Measuring Mission (TRMM) 3B42 product, rainfall atmospheric models from NOAA CFS, and rainfall observation data from national or regional Meteorological agencies such as the Meteorology Climatology and Geophysics Agency in Indonesia. The CHIRPS data used covers 36 years (1981-2022) with processing through the Cropping, Merging, Calculating and Mapping stages. The use of current data aims to maximize the calculation of extreme values [21].

3.9. Economic Feasibility

Economic feasibility analysis aims to ensure the economic sustainability of a project through evaluating effectiveness, timeliness, and use of funds and resources. A project is considered feasible if it provides better or similar benefits at lower costs than alternative options. This analysis involves shadow prices (price/accounting price) and considers overall social costs and benefits. In contrast to financial analysis, economic feasibility analysis does not take into account taxes or reduce profits and adds the amount of subsidies to the price if any. The methods used include Net Present Value (NPV), Profitability Index (PI), Internal Rate of Return (IRR), and Discounted Payback Period (DPP).

3.10. Geographic Information System (GIS)

Geographic Information Systems (GIS) are computer-based systems that focus on geographic information about a region. It is designed to process, organize, store, manipulate, display, and analyze data with spatial information (spatial reference) [22]. With their intricate capabilities, GIS not only provides a comprehensive understanding of geographic phenomena but also facilitates informed decision-making processes across various fields such as urban planning, environmental management, and disaster response.

3.11. Weighted Overlay

Weighted overlay method, namely spatial data analysis using the technique of overlaying several raster maps related to factors that influence the assessment of the vulnerability of a problem. This method is useful for solving problems with many criteria, such as optimal location selection or suitability modeling. The Weighted Overlay function is integrated into ArcGIS and allows the combining of various inputs in the form of grid maps with weighting (weighted factors) [4].

\[ Z = \frac{(w_1 \times c_1) + (w_2 \times c_2) + \ldots + (w_n \times c_n)}{w_1 + w_2 + \ldots + w_n} \]  

Information:
- \( Z \) = Result class.
- \( W \) = Weight (rank).
- \( C_n \) = parameter class from 1 to n.

3.12. Research Methodology

3.12.1. Research Location

The research will be conducted in Sambas Regency, located in the province of West Kalimantan, Indonesia. Sambas Regency is characterized by its diverse geography, encompassing coastal areas, lowlands, and some hilly terrain. Its geographical location near the equator endows it with abundant sunlight throughout the year, making it particularly suitable for solar energy harnessing initiatives.

Furthermore, Sambas Regency’s proximity to the equator ensures consistent solar irradiance levels, which is a crucial factor in determining the solar energy potential of a region. The ample availability of...
sunlight presents a favorable environment for the implementation of solar power systems, including photovoltaic (PV) panels and solar thermal technologies.

3.12.2. Research Material

The material taken in this research is secondary data, namely sunlight intensity data from the Global Solar Atlas as well as spatial supporting data such as NDVI, NDMI, NDBI, Land surface temperature, Rainfall, Slope, Main Substation Location Points (GI), and PLTS Location Points Existing.

3.12.3. Equipment Used

This research uses several tools such as laptops, cellphones, Microsoft Office, PVsyst software, QGIS, and ArcGIS software.

3.12.4. Research Method

The research method used in this study is described in a flowchart as outlined in Figure 1 as follows:

- **Data Collection**
  - NDVI
  - NDMI
  - NDBI
  - Land surface temperature
  - Rainfall
  - Slope
  - Substation location point
  - PLTS Location Existing

- **Overlay**

- **Scoring and weighting**

- **Conducting technical design of PLTS using PVsyst software**

- **Analyzing investment costs**

- **Conclusion**

Figure 1. General Research Flowchart

a. **Study of Literature**

The literature study was carried out by searching for and studying supporting theories from journals and books regarding the technical design of solar power plants (PLTS) and using ArcGIS software to process spatial data in determining potential locations.
b. Data Collection
Data collection involves various sources, with NDVI, NDMI, NDBI and Land Surface Temperature (LST) parameters taken via remote sensing using Landsat 8. Rainfall data is obtained from CHIRPS, slope data comes from Digital Elevation National, the substation location point obtained from ESDM One Map, and Existing PLTS data takes coordinate points via Google Earth.

c. Data Processing
Analysis of measurement data is aligned with the theory used, followed by data processing and evaluation. Spatial data processing is carried out using ArcGIS software to determine potential PLTS locations based on parameter weights using the weighted overlay method, producing a map of the distribution of solar energy potential. After determining the potential location, the PLTS technical design is carried out using PVsyst software to calculate the energy output and materials needed to build the PLTS.

d. Planning
Technical design using PVsyst software based on location points from the solar energy potential map resulting from spatial data processing using ArcGIS. The output includes the energy output and specifications of the PLTS materials used.

e. Conclusions and Recommendation
From this analysis, a map of solar energy potential and PLTS energy output from potential locations in Sambas Regency was concluded. Economic analysis is also provided to support government decision-making.

4. RESULTS AND DISCUSSION
Based on the research method used, results will be obtained from spatial data processing, technical design simulation results, and economic feasibility analysis. Using the weighted overlay method to analyze the potential of solar power plants based on spatial data and conducting technical studies of solar power plant design using software such as Google Earth and PVsyst.

4.1. Analysis of the PLTS Potential Study Map using the Weighted Overlay Method
After processing the spatial data with ArcGIS using variables such as NDVI, NDMI, NDBI, LST, Rainfall, Slope, substation point, and Existing PLTS, it is overlaid with the following equation:

\[
\text{Total Score} = (5 \times \text{LST score}) + (4 \times \text{Substation Point Score}) + (3 \times (\text{NDVI score} + \text{NDBI score})) + (2 \times \text{Slope Score}) + \text{Rainfall Score} + \text{NDMI score}
\]

Based on several spatial variables used to determine the potential of the Solar Power Plant (PLTS) in Sambas Regency. So, the following map of the potential for solar power generation is obtained.

![Map of Potential Solar Power Plants in Sambas Regency](image)

The map shows three classifications of PLTS potential in Sambas Regency: low potential (19–37), medium potential (38–55), and high potential (56–74). The score range for each class is determined by calculating class intervals.

_Potential Study and Design of Solar Power Plant Using Weighted Overlay Method Based on Spatial Data in Sambas District (Pandu Lanang Turonggo Jati)_
Potential Study and Design of Solar Power Plant Using Weighted Overlay Method Based on Spatial Data in Sambas District (Pandu Lanang Turonggo Jati)

\[
C = \frac{x_n - x_1}{k}
\]

(6)

Information:
- \(C\) = Class width/interval
- \(K\) = Number of classes
- \(x_n\) = Largest observation value
- \(x_1\) = Smallest observation value

Each potential area has the following areas.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Wide (Hektare)</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Potential Area</td>
<td>47.068,40</td>
<td>19 – 37</td>
</tr>
<tr>
<td>Medium Potential Area</td>
<td>520.122,35</td>
<td>38 - 55</td>
</tr>
<tr>
<td>High Potential Area</td>
<td>5.623,68</td>
<td>56 - 74</td>
</tr>
</tbody>
</table>

Areas with high potential, such as Sambas, Tangaran, Pemangkat, and Tebas, have been identified. However, the Lumbang sub-district in Sambas Regency is considered the most suitable for designing PLTS because it has good potential and is close to a main substation, making construction and interconnection to the PLN grid easier. The PLTS planning location was determined based on a study of PLTS potential using spatial data.

![Figure 3](location_of_potential_plts_sambas_regency.jpg)

4.2. PLTS Performance Simulation

The installation of PLTS in Sambas Regency, based on the results of spatial data processing using ArcGIS software, resulted in a PLTS design with a capacity of 12.06 Megawatt peak (MWp). The climate data used in the design came from PVSyst by determining the coordinates of the PLTS installation location.

4.2.1. PLTS Design Simulation Result

The following are the simulation results obtained from the PLTS design using PVSyst software in Sambas Regency, shown in Figure 4.
In the design of PLTS, the Tilt and Azimuth used are $10^\circ$ and $180^\circ$ (facing South). By using 18,000 solar panels, the total capacity of PLTS reaches 12.06 MWp, requiring 100 inverters with a total capacity of 10,000 kWAC. The results of the PLTS system design show a $P_{nom}$ ratio or AC DC ratio of 1.206.

The graph in the figure shows the nominal power produced by solar panels each month and indicates the loss rate of the solar panels and inverter. The performance ratio reached 82.46%, indicating that the system operates well with an effective proportion of energy exported to the network after calculating operational energy losses. The report results also recorded specific production of 1434 kWh/kWp/year.
Based on simulations, a 12.06 MWp PLTS system can produce 17,293 MWh of energy every year. The highest production was recorded in July with 1,720 MWh, while the lowest production occurred in December with 1,095 MWh.

4.2.2. Loss Diagram Simulation

The simulation results show the loss diagram of the PLTS system which involves various factors. For example, the energy that can be received by PV cells per square meter decreases due to factors such as the placement of solar panels (0.2%), reflections on solar panels (1%), dirt (3%), and shadow factors (0%). After various factors are considered, the effective energy received by the collector is 1671 kWh/m². Other parameters, such as temperature (9.2%) and other simulation factors, also contribute to the total losses. Even though the energy that can be generated reaches 20,184 MWh, after experiencing losses, the effective energy that can be connected to the grid is 17,293 MWh.

4.2.3. Result of Economic Analysis of PLTS System

Each economic analysis method used in evaluating the feasibility of a Photovoltaic Solar Power Plant (PLTS) investment in Sambas Regency plays a crucial role in assessing the viability and potential profitability of the project. In the context of evaluating PLTS investment in Sambas Regency, these economic analysis methods collectively provide a comprehensive assessment of the project’s financial viability and potential returns. Positive NPV, PI greater than 1, and IRR exceeding the cost of capital indicate favorable investment prospects, while a shorter DPP suggests quicker recovery of the initial investment. By integrating these analyses, decision-makers can make informed investment decisions and ensure the sustainability and profitability of the PLTS project in Sambas Regency.

<table>
<thead>
<tr>
<th>No</th>
<th>Feasibility Analysis</th>
<th>Eligibility Criteria</th>
<th>Investment Analysis Results</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Net Present Value (NPV)</td>
<td>Feasible (NPV &gt; 0); Not Feasible (NPV&lt;0)</td>
<td>Rp64,056,807,908</td>
<td>The investment is worth making, because the NPV value is greater than 0</td>
</tr>
<tr>
<td>2</td>
<td>Profitability Index (PI)</td>
<td>Feasible (PI &gt; 1); Not Feasible (PI &lt; 1)</td>
<td>1,40</td>
<td>The investment is worth making, because the PI value is greater than 1</td>
</tr>
<tr>
<td>3</td>
<td>Internal rate of Return (IRR)</td>
<td>Eligible (IRR &gt; I (Interest Rate)); Not Eligible (IRR &lt; I (Interest Rate))</td>
<td>10,52%</td>
<td>The investment is worth making, because the IRR value is greater than the interest rate.</td>
</tr>
<tr>
<td>4</td>
<td>Discounted payback period (DPP)</td>
<td>Feasible (DPP value is smaller than the life of the project); Not Feasible</td>
<td>11 Years</td>
<td>The investment is worth making, because the DPP value is smaller than the life of the project.</td>
</tr>
</tbody>
</table>
In the analysis of Ground Mounted PLTS investment in Sambas Regency, four methods are used, namely NPV, PI, IRR, and DPP. The NPV method shows a positive value of IDR 64,056,807,908, indicating the feasibility of the investment. The PI method gives a value of 1.40, exceeding 1, thus also indicating the feasibility of the investment. The IRR reached 10.52%, higher than the benchmark interest rate (5.75%), confirming the feasibility of the investment. In addition, the DPP method shows a value of 11 years, which is smaller than the project life of 25 years, so the investment is also feasible. Thus, through the four methods, several economic analyses such as Net Present Value (NPV), Profitability Index (PI), Internal of Return (IRR), and Discounted Payback Period (DPP). At the same time, by analyzing the potential of the region and conducting technical studies, the investment in utility-scale PLTS in Sambas Regency is considered feasible.

5. CONCLUSION

Based on the results and discussion of potential study data, design, and economic analysis of utility-scale PLTS in Sambas Regency, the following is a summary of the conclusions. Potential studies are carried out by utilizing spatial data such as NDVI, NDMI, NDBI, Land Surface Temperature, Slope, Rainfall, Main Substation Location Point, and Existing PLTS Location Points. The results of the clarification of PLTS potential in Sambas Regency are divided into Low Potential Areas (47,068.40 Ha), Medium Potential Areas (520,122.35 Ha), and High Potential Areas (5,623.68 Ha). The selection of the PLTS area was based on the total score from spatial data processing and the distance to the main substation in Lumbang District, Sambas Regency. Measurements on Google Earth show an area of 13 Ha, with a potential utility-scale PLTS capacity of 12.06 MWp. PLTS with a capacity of 12.06 MWp uses 18,000 Trina Solar solar modules, with a tilt angle of 10° and an azimuth of 180° (facing South). Using 100 Sungrow inverters can produce 17293 MWh of electrical energy. So, the initial investment cost for utility-scale PLTS in Sambas Regency is IDR 159,397,862,580. Operational and maintenance costs per year are IDR 1,593,978,626, with a total of IDR 20,869,558,413 for 25 years.

The PI method gives a value of 1.40, confirming the feasibility of the investment. In addition, the DPP method shows a value of 11 years, which is smaller than the project life of 25 years, so the investment is also feasible. Thus, through the four methods, several economic analyses such as Net Present Value (NPV), Profitability Index (PI), Internal of Return (IRR), and Discounted Payback Period (DPP). At the same time, by analyzing the potential of the region and conducting technical studies, the investment in utility-scale PLTS in Sambas Regency is considered feasible.

ACKNOWLEDGEMENTS

The author thanked the chairman and academic civitas of the Faculty of Engineering Universitas Tanjungpura and all the parties involved in preparing this journal, especially parents. The results of this research may be of benefit to both the author and the reader.

REFERENCES

Potential Study and Design of Solar Power Plant Using Weighted Overlay Method Based on Spatial Data in Sambas District (Pandu Lanang Turonggo Jati)