Study Sedimentation Rate of PLTU Pulang Pisau Due to Jetty Modification in Efforts to Improve Production Capacity

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Abstract. Pulang Pisau Steam Power Plant (PLTU) is one of the plants that is used to fulfill the electricity needs of the people in Central Kalimantan Province. By using coal as a source of steam production, the Pulang Pisau PLTU has a capacity of up to 2 x 60 MW. Such a large population growth cannot be avoided and it is therefore denied that the Pulang Pisau PLTU is deemed to require additional production capacity. One alternative that can be given is to increase the amount of fuel capacity, namely coal that can be accommodated. By changing the design of the existing jetty, it is expected that ships with larger capacities can lean on the Pulang Pisau power plant pond. In this study, an analysis of sediment volume rate in the existing condition jetty and two alternative jetties in the PLTU river basin area, where the modeling is done using MIKE21. The results of the existing jetty modeling show the sedimentation volume that was line up for 12 months at 9550.017 m³, while the sedimentation volume of alternative jetty 1 and 2 produced for 12 months respectively were 917.444 m³ dan 8616.040 m³. The first alternative jetty is more efficient in dealing with sediment in terms of increasing production capacity. The alternative jetty is considered to be able to maintain the determined vessel draft and not cause excessive sedimentation impacts in the Pulang Pisau power plant area.

Keywords: Production Capacity, Jetty Modification, Sedimentation Rate

1. Introduction

Electricity is one of the energies that are important and needed by human life. Population and economic growth make the demand for electricity supply continue to increase. To meet the increasing electricity demand, the efforts that have been made by PT. The State Electricity Company (PLN) is the construction of Steam Power Plants (PLTU) in several locations throughout Indonesia. One of them is the construction of the Pulang Pisau PLTU. Pulang Pisau PLTU is one of the most important community power plants in
Central Kalimantan province. Located at coordinates 2°49'15.17"S and 114°12'23.41"E, Buntoi Village, Kahayan Hilir District, Kuala Kapuas Regency, Central Kalimantan. The Steam Power Plant (PLTU) that has been built has a capacity of 2x60 MW, fueled by coal, which distribution is obtained through water transportation, namely barges/barges.

The need for electricity in each region each year is very dependent on population growth, therefore it needs proper handling so that the negative impact can be avoided by the community. As in Central Kalimantan, population growth is not matched by the addition of new power plants that can operate. So that the addition of electricity production capacity is needed to meet the electricity needs of the local community.

One of the alternatives offered is changing the existing jetty by modifying the jetty. It is hoped that modifying the existing jetty, can increase the number of raw materials that can be accommodated so that ships with large capacities can dock in the PLTU's pumpkin pool. In general, the problems that will be encountered in modifying the pier are related to the sedimentation that occurs. Simply put, the sedimentation process is caused by wind and water moving from one place to another, eroding the soil and then depositing it in one place continuously. The sedimentation process depends on the shape of the flow pattern, morphology, salinity and density, water discharge, fluctuations in water level, temperature, and several other factors (Wibowo, 2009). Like the Pulang Pisau PLTU, the pier that will be modified will also have the potential to change the soil structure in the PLTU's pumpkin pool area within a certain period. Therefore, it is important to do a sediment analysis to prevent and minimize the process of sedimentation or abrasion. In this final project, with the help of software, namely MIKE21, a modeling of the sedimentation rate in the PLTU area will be carried out. This study will compare the volume of the existing jetty and three alternative jetty designs due to currents and waves that occur. The results of this study are to determine which design is most suitable for the needs of the Pulang Pisau PLTU to increase production capacity which is also related to the sedimentation rate that occurs.

2. Methodology

2.1. Literature Study
The literature study was carried out to obtain references related to the topic of discussion so that in the work of the final project one can have a view before doing the analysis. Literature studies can be obtained from books, journals, and the internet related to sedimentation. In addition, Mike21 software was also studied to do modeling at the study site (Huda, 2021).

2.2. Data collection
The data used in this task are secondary in the form of bathymetry maps, wind data, soil data, rainfall data, tidal data, and current velocity data.

2.3. Data processing
The data that has been obtained is processed first before being inputted in the data Mike21 software. The data that must be processed into time series are such as wind data, climate and weather data, tidal data. The data is entered into the modeling parameters using MIKE21 (Huda, 2021).

2.4. Modelling with Mike21 Software Software
In modeling, it takes a simulation (domain) that shows the calculated area and the boundary of the calculated area to be included in the MIKE21 Software. Then input the specified parameters and determine the number of simulation time steps to be modeled (Huda, 2021).
2.5. Validation
Validation is carried out to match the output results of the modeling with tidal data. The purpose of this validation is to find out how many error values occur when modeling is carried out. Once valid, the next step is to perform flow simulations and sediment simulations.

2.6. Discussion
In the discussion, several analyzes will be carried out, namely the comparison of output running software mike21 in the form of sedimentation volume that occurs between the existing condition jetty and also from two modified jetty options. An analysis of the two modified designs was also carried out, namely which design was the most appropriate and optimal for overcoming sedimentation concerning increasing production capacity.

2.7. Conclusions and Suggestions
Conclusions are drawn based on the formulation of the problem that has been made and suggestions are made so that further research can be carried out better than previous research.

2.8. Data Collection

2.8.1. Bathymetry
The bathymetry map used in this final project is derived from secondary data, which is a bathymetric topographic map for September 2019. The bathymetric map from the measurements will be presented with a scale of 1:749 m (A3), with a contour interval of 0.5 meters.

Figure 1. Flow Chart
2.8.2. Wind Data
The wind data obtained from secondary data is wind data for 5 years from January 1, 2014, to September 30, 2019, from the Meteorology, Climatology and Geophysics Agency (BMKG) at Tjilik Riwut Station. The wind data used is the daily average data which has a time interval of every 24 hours.

2.8.3. Climate and Weather Data
The climate & weather data used are rainfall intensity data in the area under review. The data obtained is secondary data for 5 years from January 1, 2014, to September 30, 2019, from the Meteorology, Climatology and Geophysics Agency (BMKG) at Tjilik Riwut Station.
2.8.4. River Flow Discharge
The modeling was carried out in 2018 in June and November. Due to the limited data available, using the linear regression method it will be known how much the Kahayan river discharge will be in 2018.

| Estuary          | 2000 (m³/s) | 2002 (m³/s) | 2004 (m³/s) | 2006 (m³/s) | 2010 (m³/s) |
|------------------|-------------|-------------|-------------|-------------|-------------|
| River of Light   | 1037.71     | 998.55      | 1040        | 1359        | 1770        |

Table 1. Pulang Pisau PLTU River Discharge

2.8.5. Flow Data
Current data obtained from secondary data shows that current data collection was carried out at four location points on the banks of the Kahayan River in 2012 and carried out for 4 days, namely June 14-17.
2.8.6. Tide Data

In this final project, the tidal data used is derived from the 2018 and 2012 Indonesian Archipelago Tidal List (Validation) issued by the Hydro-Oceanography Service (Dishidros) of the Indonesian Navy.

| Location | Coordinate | Time  | Date  | Current Flow (m/s) |
|----------|------------|-------|-------|-------------------|
| Point 1  | x = 189357.84, y = 9687610.82 | 09.00 | 14 June | 0.54 |
|          |            | 12.00 | 14 June | 0.52 |
|          |            | 15.00 | 14 June | 0.44 |
| Point 2  | x = 189361.4, y = 9687733.19 | 09.00 | 15 June | 0.57 |
|          |            | 12.00 | 15 June | 0.56 |
|          |            | 15.00 | 15 June | 0.55 |
| Point 3  | x = 189359.79, y = 9687823.35 | 09.00 | 16 June | 0.38 |
|          |            | 12.00 | 16 June | 0.39 |
|          |            | 15.00 | 16 June | 0.39 |
| Point 4  | x = 189392.33, y = 9687965.04 | 09.00 | 17 June | 0.61 |
|          |            | 12.00 | 17 June | 0.55 |
|          |            | 15.00 | 17 June | 0.48 |

**Table 2. Kahayan River Flow Data Table**

**Figure 6. Current Flow of Point Locations**
2.9. Validation
After the modeling simulation has been carried out, so that the modeling is deemed capable of representing the actual environmental conditions, then data validation is carried out to determine the accuracy of the model that has been made. Model validation is done by comparing the current and tidal data from existing secondary data and with the data from the modeling that has been done using Mike21 software. Elements of current velocity and water level elevation that are useful for data validation can be identified using a data extraction program (.dxm). by inputting the coordinates of the point to be reviewed, then the current and tidal data will come out according to the time step that has been determined. The location points whose current velocity is validated include four location points obtained from secondary data around the power plant.

The accuracy formula is needed to invalidate the current and tidal patterns, the goal is that the margin of error that occurs can be controlled and acceptable. In this case, the MAPE (Mean Absolute Percentage Error) and RMSE (Root Mean Square Error) formulas are used in this final project. Mean Absolute Percentage Error (MAPE) is calculated using the absolute error in each period divided by the actual observed value for that period. Then, average the absolute percentage error. This approach is useful when the size or magnitude of the forecast variable is important in evaluating the accuracy of the forecast. MAPE indicates how big the forecast error is compared to the real value. By using the formula below, the percentage error of the average current speed between the secondary data and the modeling results is obtained.

\[
MAPE = \left( \frac{1}{n} \sum \frac{|Actual - Forecast|}{|Actual|} \right) \times 100\%
\]

In current validation using the error percentage formula and the magnitude of The error above then obtained a value of 15.82% (Good Forecasting) and the magnitude of the error value is 0.096 m/s. For graphs and tables of comparison of the average current velocity from secondary data and modeling results, it can be seen as below:
3. Result And Discussion

Pulang Pisau PLTU is located at coordinates 2°49'15.17"S and 114°12'23.41"E, Buntoi Village, Kahayan Hilir District, Kuala Kapuas Regency, Central Kalimantan. The location of the final project shown in the image below was obtained by citing satellite imagery from Google Earth in 2019. Where the observation area is the mouth of a river located in the Jl. Tingang Menteng, Mintin, Kahayan Hilir, Pulang Pisau Regency, Central Kalimantan 74873.

![Location of Pulang Pisau PLTU](image)

3. Result And Discussion

Figure 8. Graph of Comparison of Flow Speed Locations 1 and 2

![Location Current Ratio 1](image)

Figure 9. Graph of Comparison of Flow Velocity Locations 3 and 4

![Location Current Ratio 3](image)
Table 3. Modeling Flow Validation

| Location | Study (m/s) | Modeling (m/s) | Error Percentage | Error Magnitude |
|----------|-------------|----------------|------------------|-----------------|
| Point 1  | 0.54        | 0.42           | 0.23             | 0.02            |
|          | 0.52        | 0.44           | 0.15             | 0.01            |
|          | 0.44        | 0.42           | 0.04             | 0.00            |
| Point 2  | 0.57        | 0.42           | 0.26             | 0.02            |
|          | 0.56        | 0.39           | 0.30             | 0.03            |
|          | 0.55        | 0.40           | 0.27             | 0.02            |
| Point 3  | 0.38        | 0.43           | 0.12             | 0.00            |
|          | 0.39        | 0.44           | 0.13             | 0.00            |
|          | 0.39        | 0.44           | 0.12             | 0.00            |
| Point 4  | 0.61        | 0.52           | 0.14             | 0.01            |
|          | 0.55        | 0.52           | 0.06             | 0.00            |
|          | 0.48        | 0.52           | 0.08             | 0.00            |
| Average  | 0.50        | 0.45           | 15.82            | 0.096           |

Tides from secondary data (DISHIDROS) and modeling results with MIKE21 were also validated so that the accuracy could be accepted as close to the actual river flow conditions at the study site. The way to validate the tide is the same as the method of validating the current velocity above. Tidal validation was carried out only on samples for three days. With the same error formula, the percentage error value is 1.02% (Highly Accurate Forecasting) for the tides in the east monsoon for three days and an error value of 1.66% (Highly Accurate Forecasting) for the tides in the west monsoon for three days.

The output results from the modeling simulations that have been carried out are in the form of tidal values, current velocity, and current movement patterns at each coordinate, and several time steps are entered. From this current movement pattern, it is possible to know the pattern of sediment movement, so that it can be used as consideration for planning the layout of coastal building designs. The following are the results of the modeling that has been carried out.

Figure 11. Water Level Elevation, Flow Velocity and Flow Direction East Season
From the results of tidal modeling and current velocity patterns in the east and west monsoons above, it can be analyzed if the dominant current movement comes from north to south. The current movement pattern can then be used as a reference in making alternative jetty design layouts to reduce the impact of sedimentation that occurs.

In the first alternative jetty design, modifications are given in the form of increasing the length of the building on the jetty. The addition of the length of this building is made parallel to the main jetty. With this design, it is intended to increase the production capacity of coal distribution that can be accommodated. The total length of the added jetty is 82.5 m from the main jetty. After being modified the jetty has a berth area of 165 m so that it can be loaded ± 2 times more ships than the previous capacity. The ship used is a ship with the same draft, namely a ship that has a draft as high as 1-2 meters.

![Figure 12. Water Level Elevation, Flow Velocity and Flow Direction West Season](image)

From the simulation results of Mud transport modeling, it is known that there are differences in the bottom profile of the water (bed level) from before and after modeling. This means that there is a change in the bathymetric contour during the 30-day simulation period. These changes can be seen as follows.

![Figure 13. Layout Plan Design 1 and 2](image)
In the bottom contour drawings for each condition, it can be seen that the study location has changed the bottom profile of the waters. Changes in the basic profile of the waters can occur due to the process of silting (sedimentation) or due to scouring (erosion). Factors that affect the process of sedimentation or siltation include the movement of currents and tides. In this study, sediment changes were observed based on changes in the bed level change located around the jetty of the study location. Observations were made by comparing changes in the bottom profile of the waters after modeling simulations for 30 days with the research object of the existing jetty and the two alternative jetties described above.

In determining the magnitude of the sedimentation volume rate that occurs, software is needed to perform these calculations because the bottom contour of the waters is not symmetrical whose calculations are obtained through numerical integration methods, namely Simpson and trapezoidal. Surfer 16 is an application that will be used to determine the volume that occurs in the Pulang Pisau PLTU area. This

**Figure 14.** Bed Level Contours in Early, East Season and West Season Existing Jetty

**Figure 15.** Bed Level Contours in Early, East Season Existing Jetties and West Season Alternative 1

**Figure 16.** Bed Level Contours in Early, East Season Existing Jetties and West Season Alternative 2
sediment volume calculation aims to find out which form of jetty is more effective in increasing production capacity as well as minimizing the amount of sediment transported by the current.

In calculating the volume using Surfer 12, the input from this software is in the form of x (Easting), y (Northing), and z (Elevation) coordinates. These coordinates are obtained from bed level change data from the MIKE21 mud transport modeling results which are then modeled using the cut and fill volume integration method so that the sediment volume can be known. The coordinate area used for volume calculation is as shown in Figure 17.

After calculating the sediment volume, a comparison between alternative designs is carried out. The purpose of the comparison between alternative jetty designs is to determine which design is the most optimal to minimize sedimentation that occurs at the study site, namely the Pulang Pisau PLTU as well as its relation to increasing production capacity.

### Table 4. Accumulated Volume for Several Conditions in 12 Months

| No. | Comparison Design Jetty | Sedimentation Volume (m3) | Condition |
|-----|--------------------------|---------------------------|-----------|
| 1   | Existing                 | 9550.017                  | Sediment  |
| 2   | Alternative 1            | 917.444                   | Sediment  |
| 3   | Alternative 2            | 8616.040                  | Sediment  |

### 4. Conclusion

Based on this research, the following conclusions can be drawn: In the jetty of the existing Pulang Pisau PLTU, the prediction of accumulation of sedimentation volume that occurs in the 12th month around the study site is 9550.017 m³. In alternative jetties 1 and 2, the predicted accumulation of sedimentation volume that occurs in the 12th month around the study site is 917.444 m³ and 8616.40 m³ respectively. Of the two alternative designs given, the second alternative jetty is the most optimal alternative design because it has the difference between the contours of the riverbed (after adding sediment) and the largest draft of the ship, which is 2.9 m. It also has accumulated sediment volume for 12 months which is 8616.04 m³. This alternative design can also increase the coal capacity that the wharf can accommodate up to 10,000 DWT.
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