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# Evaluation of Cloud to Ground Flash Density of 150 kV Transmission Line Between Parit Baru Substation and Senggiring Substation

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**ABSTRACT**

SUTT is a high voltage overhead line with a power of 70 kV - 150 kV to distribute electric power from the generating center to the substation or from substation to substation. The purpose of this study was to obtain modeling of lightning strike density on the 150 kV transmission line between Parit Baru substation and Senggiring substation using geostatistical approaches, namely IDW methods (Inverse Distance Weighted). In identifying the level of vulnerability to lightning strikes, Cloud to Ground lightning event data (2018–2020) is used. The aim of this research is to obtain the density pattern of lightning strikes on the 150 kV transmission line between the Parit Baru substation and the Senggiring substation. The process in ArcGIS 10.8 software aims to obtain lightning strike density and display the results of the lightning strike density map. Based on the results of data processing for 3 years, the highest density of lightning strikes occurred in 2019 in Segedong District at 54.52 strikes/km². Meanwhile, the lowest density of lightning strikes occurred in 2018 in East Mempawah District, amounting to 2.86 strikes/km². Based on the lightning strike density map per grid on the 150 kV transmission line between Parit Baru substation and Senggiring substation for 3 years, the results obtained for the highest lightning strike were 36 strikes/km² while for the lowest strike it was 1 strike/km². From this research, it was found that there were 15 transmission towers that passed a high density of lightning strikes with a strike range of 25–36 strikes/km² and the highest lightning strike occurred at tower number 31, number 30, and number 29, amounted to 36 strikes/km².

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## 1. INTRODUCTION

Indonesia, especially the island of Kalimantan is on the equator which receives sunlight all year round. This results in the growth of convective clouds, especially in the West Kalimantan region. The 150 kV transmission line is a high voltage overhead line with a voltage of between 70 kV to 150 kV which is used to distribute electrical power from the generating center to the substation or from substation to substation.

The 150 kV transmission line between Parit Baru substation and Senggiring substation are located in the Mempawah Regency area which is close to the equator area which has high evaporation and humidity so there is the potential for lightning and heavy rain. The purpose of this study was to obtain modeling of lightning strike density on the 150 kV transmission line between Parit Baru substation and Senggiring substation using geostatistical approaches, namely IDW methods (Inverse Distance Weighted). In identifying the level of vulnerability to lightning strikes, Cloud to Ground lightning event data (2018–2020) is used.

Lightning strike density is calculated from the number of lightning strikes per area studied. The more and more frequently lightning strikes occur at a location, the higher the lightning density. Lightning strike density can also be used to determine possible factors that influence lightning strikes in a location.

In this research, 150 kV transmission line route is used as research material by creating a map of the density of lightning strikes, so that we can find out what the density is or also the potential for lightning strikes that will occur on the SUTT route. It is hoped that this research will support efforts to minimize damage caused by lightning strikes.

## 2. LITERATURE REVIEW

### 2.1 Previous Research

Research conducted by Misael Septian Tanalepy, Danial, and Usman A. Gani. The 2022 Journal of Tanjungpura University Electrotechnical Students entitled "Mapping Analysis of Lightning Prone Areas Using the Kriging Method in the Surrounding Pontianak City Area" This research examines the mapping of lightning strike density in Pontianak City. The results of this research show that the density of lightning strikes that occur in the Pontianak area and its surroundings shows varying changes each year [1].

This scientific journal with the title " Determination of Flash Cloud – Ground DentityApproached by Geostatistic " written by Igosius Okqye examines lightning density in Pontianak City. In this research, it shows that the highest range of lightning strikes in Pontianak City is 5-20 strikes [2] .

The scientific journal with the title "Spatial Analysis of Lightning Strike Density in the Kulonprogo Regency, Special Region of Yogyakarta, 2012-2016" written by Adhysta Probosari Putri examines the density of lightning in the city of Yogyakarta. The results of this research are that events with high-medium variations in lightning density occur most frequently in Girimulyo District [3].

The scientific journal with the title "Analysis of Contour Mapping and Lightning Density with Lightning 2000 and the Kriging Method in Surabaya in 2000" written by Iga Puspitasari, Supardiyono examines lightning density in the city of Surabaya. This research examines the density of lightning in the city of Surabaya. Based on research that has been carried out using the Kriging method, the results of lightning data processing analysis in the Surabaya City area show a very high isocheraonic level. The density of lightning strikes that occur in Surabaya can be said to be very large, namely 12 strikes/km$^2$ [4].

Research conducted by Intan Dwi Septiani, Usman A. Gani, and Managam Rajagukguk. The 2021 Journal of Electrical Engineering, Tanjungpura University entitled "Mapping Analysis of Lightning-Prone Areas in PontianakCity Using the Simple Additive Weighting Method". This study examines the mapping of lightning-prone areas in Pontianak City by analyzing the level of threat, vulnerability, and vulnerability to lightning strikes in Pontianak City.In identifying the level of vulnerability to lightning strikes, two factors are needed, namely the threat factor using Cloud to Ground (CG) lightning incident data and the vulnerability factor using data on population density and land area for houses and buildings. The method used to analyze these two factors in this study uses the Simple Additive Weighting (SAW) method to obtain the level of lightning strike sub-districts in the Pontianak area which is depicted on a map using ArcGIS10 software [5].

Research conducted by Fitridayanti Hidayat, Muliadi and Riza Adriat. The 2018 Prism of Physics entitled "Characteristics and Relationship of Cloud to Ground Lightning Activity with Rainfall (Case Study of Pontianak Cityand Surroundings)" explain that Cloud to Ground (CG) lightning type is lightning that has a direct impact on activityhuman. The lightning data used is lightning detector data and rainfall derived from BMKG Supadio Station and Mempawah Climatology Station. Methods used in this study i.e. the Spearman correlation method to find out the relationship between the two variables. The results of his research shows the highest correlation value, namely in the Pontianak Maritime Station area with a value of r = 0.417 and the lowest correlation value occurred in the Segedong area with a value of r = 0.159, a low correlation value shows that lightning events and rainfall that occur do not tend to be long and clouds convective that does not produce heavy rain and lightning [6].

Research conducted by Muhammad Lutfi Firdaus, Nasiah, and Uca. The 2021 Journal of Environmental Science entitled "Spatilateral Study of Cloud to Ground Lightning Strikes in Gowa Regency in 2017-2019" explain that this type of research is descriptive quantitative, analyzed spatiotemporal which aims to: determine the density of Cloud to Ground (CG) lightning strikes, as well as areas and times that have very high CG lightning strikes based onterrestrial aspects (elevation and land use) and rainfall in Gowa Regency 2017-2019. The data analysis stage used ArcGIS 10.4.1 and Microsoft Excel 2013 software to present the results visually (maps, charts, and graphs). The research results obtained in 2017 and 2018 that the lightning strike density was very high in Tombolo Pao District. Whereas in 2019 Sumba Opu and Tombolo Pao District had a very high lightning strike density [7].

Research conducted by Merlyn Elsyani, Muliadi and Riza Adriat. The 2022 Journal of Geofisika Univeristy of Tanjungpura entitled "Mapping of Lightning Strike Density in Pontianak City and Kubu Raya Regency" explain that this study aims to determine the density of lightning strikes in each sub-district for each sub-district year in Pontianak City and Kubu Raya Regency based on lightning strike density value. The obtained lightning strike densityvalue will be presented in the form lightning strike density map based on IDW interpolation method. Based on the results of calculations for five years, it is obtained that the density value. The highest lightning strike occurred in Terentang District, namely in 2016 at 45.89 times / km$^2$. While the lowest lightning strike density value occurred in Batu Ampar District with a value of 2.41 times/km$^2$ in 2017 [8].

Research conducted by Elsartika Putri Yulia, Nurhidayah, Rustan, and Annisa Fauziah . The 2023 Journal of fisika Jambi Univeristy entitled "ANALYSIS Analysis of Cloud to Ground Lightning Stroke Density

Based on Geographic Information Systems in the Tanjung East Jabung Region " explain that The results obtained were that the average annual lightning density was 8 strikes/km2 with the highest density of up to 189 strikes/km2 occurring in Sadu sub-district as an area close to the open sea. Based on aspects of the earth's surface, it was found that the density of cloud to ground lightning strikes that occurred in the East Tanjung Jabung area did not increase with increasing altitude [9].

Research conducted by Michelle Jenneth Mailoor, Guntur Pasau and Maria D. Bobanto. The 2018 Journal of Mathematics and Natural Sciences Univeristy of Sam Ratulangi entitled "Lightning Distribution Mapping for Manado Region in 2013 and 2014" explain that output from this research is contour map in Manado city area. Based on outputfrom processed data, we got data that the highest lightning event happened in October 2013 that is 6.540 event and inMay 2014 that is 7.330 lightning event. Highest CG+ lightning distribution located in Wenang Districts and there is no CG+ lightning event in 4 districts which is Tikala, Paal Dua, Singkil and Tuminting Districts [10].

Research conducted by M. Fakhrul Islam Masruri and Aditya Setyo Rahman. The 2019 National Seminar onGeomatics entitled "Spatial Analysis of Lightning Events at Bogor City in 2017 and its Correlation with Monsoon and Rainfall" explain that This research discusses the distribution of lightning in Bogor during 2017 to determine which areas are most vulnerable to lightning. The lightning data used was obtained from BOLTEK lightning detectorrecord at Bandung Geophysical Station during 2017. And rainfall data obtained from Citeko Meteorological Station data. Spatial analysis to determine the lightning-prone areas used is the interpolation of the kriging method. The resultsshowed that South Bogor Subdistrict was the most vulnerable area for lightning. Then the highest incidence of lightning in the transition season and there has not been found a positive correlation between the incidence of lightningwith rainfall [11].

Research conducted by Yosita Cecilia. The 2023 University of Islam Negeri Walisongo Semarang entitled "Analysis of Lightning Strike Density in Banten Province For The Period July 2020 – June 2021" explain that the method used is the Inverse Distance Weightning (IDW) interpolation method, using QGIS software version 3.14. Thisstudy aims to determine the level of vulnerability of lightning strikes based on the comparison of population density.The results of the regression test obtained a significance value of 0.546 which shows that the number of population density affects lightning strikes but is not significant [12].

Research conducted by Napitupulu, Janter et al. The 2021 Journal University of Darma Agung entitled "Study of Ground Wire Protection Failure Against Lightning Strikes on 150 kV Transmission Lines" explain that The installation of ground wire as a protective phase wire must be correct, so that a good protection system will be obtained. Because with good protection, the possibility of failure of protection against lightning strikes will also be smaller. In this way, the number of disturbances on transmission lines due to lightning strikes is also reduced [13].

Research conducted by Nurhaidi, Ringga. The 2016 Journal of Electrical Engineering, Tanjungpura University entitled "Determining the Optimum Arrester Location at the 150 kV Siantan Substation (GI) Using Optimization Methods". Based on analysis results in 2015, the number of lightning strikes on the transmission network was approximately 30 times. Therefore, a protection device is needed to protect this transmission network. The main protection against lightning strikes on transmission networks is lightning rods. Where in choosing a reliable arrester to use, pay attention to the arrester identifier/rating value that is suitable for use at the Siantan 150 kV substation [14].

The 2012 Journal of Electrical Engineering, Hasanuddin University entitled "Analysis of the Lightning Protection System (Lightning Performance) in the 150 kV SUTT System in South Sulawesi". Based on analysis results in 2012, Tropical lightning strike parameters are used to evaluate the lightning performance of existing overhead lines. Repairs using conventional methods include repairing the grounding system, ground wire, protective corners, adding insulators and lightning arresters. Repairs using special methods are carried out using conventional systems which are optimal but still require better protection. EMT installation is prioritized in areas with high strike density and on several towers leading to the main substation [15].

Research conducted by Sadewa Purba Sejati. The 2019 Indonesian Geography Magazine entitled "Comparison of the Accuracy of Inverse Distance Weighting and Kriging Methods in Groundwater Table Depth Mapping" explain that to determine the accuracy of the IDW method in the mapping of the water table. The accuracy of interpolation generated from the IDW method was obtained by observing the parameters of root mean square error (RMSE). Based on study results, the best interpolation model for the IDW method was obtained using power (p) with value 3. The results showed that Kriging method was more accurate compared to the IDW method. RMSE generated by Kriging method has lower yet higher validity [16]

## 3. RESEARCH METHODOLOGY

### 3.1 Place and Time of Research

This research was conducted in 4 districts, namely East Mempawah, Sungai Pinyuh, Segedong, and Jongkat dan approximately 4 months (starting from August to November 2023).

### 3.2 Research Data

The data used in this research, data 150 kV transmission line between Parit Baru substation and Senggiring substation in the form of Shapefile, including lightning strikes data in 2018 until 2020 obtained from BMKG Pontianak, and data on the area of each district in East Mempawah, Sungai Pinyuh, Segedong, and Jongkat sourced from BPS Mempawah Regency.

Can be seen in Figure 1 which shows a map of the 150 kV transmission line between Parit Baru main substation and Senggiring main substation which passes through 4 districts, namely East Mempawah Districts, Sungai Pinyuh Districts, Segedong Districts, and Jongkat Districts.

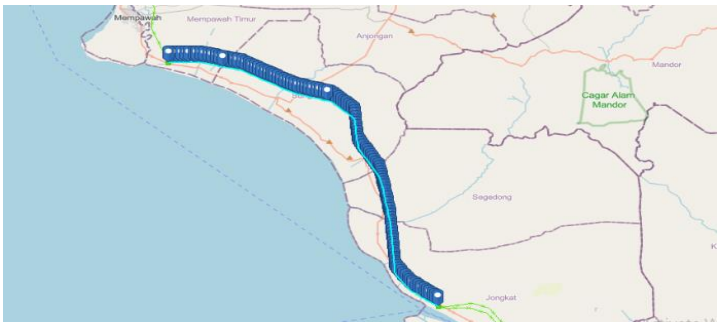


Figure 1. Map of the 150 kV transmission line between Parit Baru substation and Senggiring substation

### 3.3 Tools

1. Google Earth Pro *Software*
2. ArcGIS 10.8 *Software*
3. Microsoft Excel 2013 *Software*
4. Laptop Acer Aspire E 14

### 3.4 Research Methods

1. Literature Studies

   The author conducted a literature study by searching for and collecting basic theories. Literature studies were carried out through journals, several references on the internet, and books in the Untan engineering library.
2. Collecting Data

   The author conducted a direct review of BMKG as a place to collected data that will be needed in the process of modeling the density of lightning strikes in 150 kV Transmission Line Between Parit Baru Substation and Senggiring Substation within 3 years, namely 2018, 2019, and 2020.
3. Processing Data

   Processed to be serialized using Microsoft Excel 2013 to obtain monthly data in years. The data obtained is then processed. The aim of this processing is expected to make it easier to present the data to be more informative and also make it easier to process the ArcGIS 10.8 software and display the map results.

### 3.5 Variabel or Data

After conducting research, the following data were obtained:

1. Lightning strike data for 2018 – 2020 on the 150 kV transmission line between Parit Baru substation and Senggiring substation
2. Lightning data per grid on the 150 kV transmission line between Parit Baru substation and Senggiring substation
3. Lightning strike density data on the 150 kV transmission line between Parit Baru substation and Senggiring substation

### 3.6 Flow Chart of Research

In conducting research, a research framework is used to make research easier, starting with conducting a literature study by searching for and collecting basic theories. Literature studies were carried out through journals, several references on the internet, and books in the Untan engineering library.

Next, collected SHP data (vector data used to store the location, shape and attributes of geographic features) of the 150 kV transmission line between Parit Baru substation and Senggiring substation, and collecting lightning strike data, made direct observations at the Meteorology, Climatology and Geophysics Agency (BMKG) as the location Retrieving research data and collecting data that will be needed in the process of compiling a lightning strike density map

Process data according to application needs in the form of KML, CSV, and Excel formats. Serializing data on monthly lightning strike events in a year from 2018-2020 using Microsoft Excel software. Input SHP data, Create a grid on SHP, Calculate the density of lightning strike. Processing data in ArcGIS 10.8 software. Lightning strike density map, show in Figure 2.

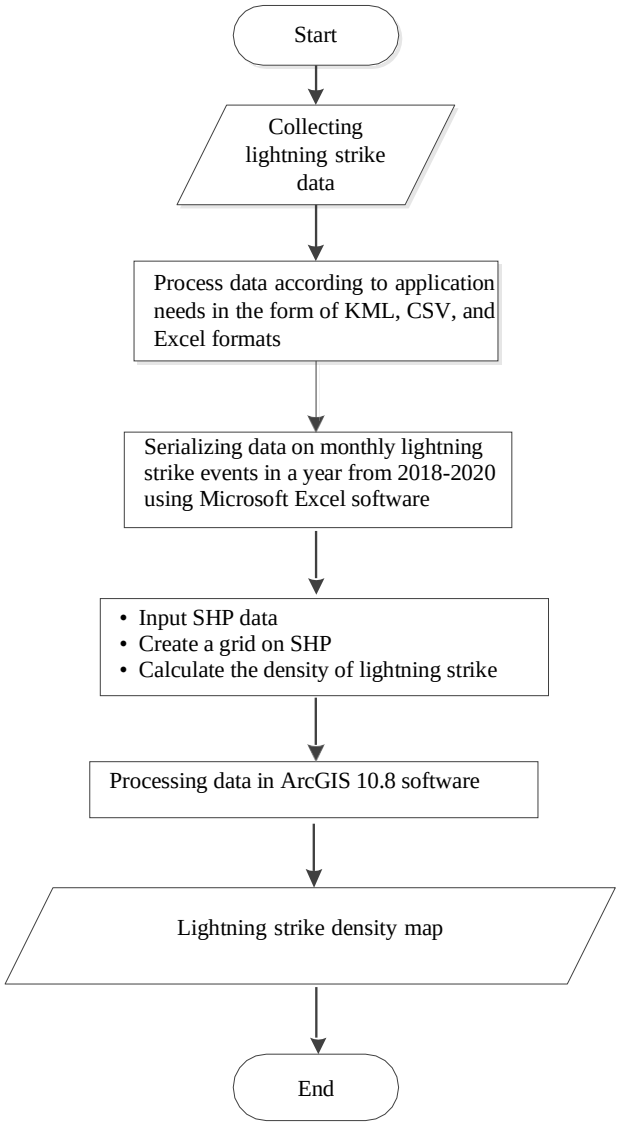


Figure 2. Flow chart of research

## 4. RESULTS AND DISCUSSION

### 4.1 Results of Research

#### 4.1.1 Density of Lightning Strikes

The 150 kV transmission line between Parit Baru substation and Senggiring substation passes through 4 sub-districts following data on lightning events for 3 years (2018-2020) in the Districts of East Mempawah, Sungai Pinyuh, Segedong and Jongkat obtained based on the results of data processing using ArcGIS 10.8 software.

Table 1. shows that in 2018, Segedong District was the area with the highest lightning strike density value of 39.09 strikes/km², while the area with the lowest lightning strike density value was in East Mempawah District at 2.86 strikes/km². Then for 2019, the highest lightning strike density value occurred in Segedong District at 54.52 strikes/km², while the lowest value occurred in East Mempawah District at 4.1 strikes/km². Furthermore, for 2020, the highest lightning strike density value occurred in Segedong District at 53.3 strikes/km², while the lowest value occurred in East Mempawah District at 3.58 strikes/km². The following is data on the density of lightning strikes in 4 districts:

Table 1. Density of lightning strikes

| Districts | Density of Lightning Strikes (Stikes/km$^2$) | | |
|---|---|---|---|
| | 2018 | 2019 | 2020 |
| East Mempawah | 2,86 | 4,1 | 3,58 |
| Sungai Pinyuh | 6,44 | 8,27 | 8,28 |
| Segedong | 39,09 | 54,52 | 53,3 |
| Jongkat | 18,96 | 25,62 | 19,2 |

### 4.1.2 Lightning Strike Data on The 150 kV Transmission Line Between Parit Baru Substation and Senggiring Substation

Based on the results of lightning data processing, the following is displayed the total number of lightning strikes per grid on the 150 kV transmission line between Parit Baru substation and Senggiring substation for 3 years, namely 2018, 2019 and 2020. In 2018 the number of lightning strikes that occurred on the 150 kV transmission line between Parit Baru substation and Senggiring substation was 2019 strikes. In 2019 the number of lightning strikes that occurred on the 150 kV transmission line between Parit Baru substation and Senggiring substation was 2281 strikes. In 2020, the number of lightning strikes that occurred on the 150 kV transmission line between Parit Baru substation and Senggiring substation was 2100 strikes, show in Figure 3.

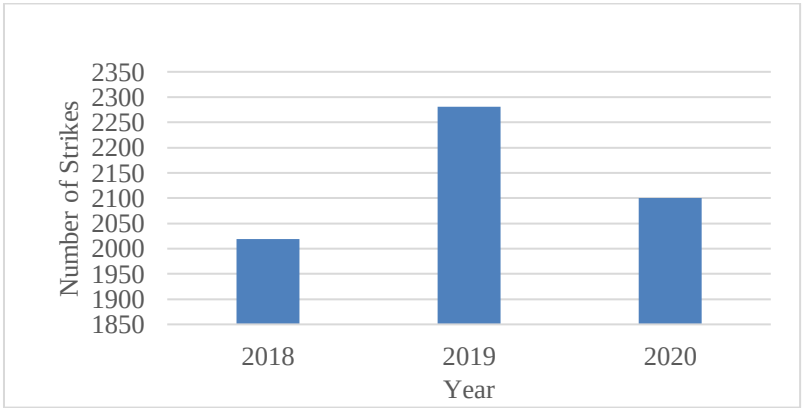


Figure 3. Graph of the number of lightning strikes in 2018 – 2020

### 4.1.3 Average Number of Lightning Strikes

There are 138 grids, this number of grids was obtained from the results of data processing using ArcGIS 10.8 on the 150 kV transmission line between Parit Baru substation and Senggiring substation. Each grid has an area of 1 km$^2$ and each grid has its own coordinate point.

Based on the results obtained, in 2018 the maximum number of lightning strikes occurred on the AE22 grid, namely 44 strikes. Meanwhile, the minimum lightning incidents occurred on grids L3, M10, 015, and P14, namely 0 strikes. In 2019, the maximum number of lightning strikes occurred on the AD24 grid, namely 46 strikes. Meanwhile, the minimum incident occurred on grid P14, namely 0 strikes. In 2020, the maximum number of lightning strikes occurred on the AE21 grid, namely 43 strikes. Meanwhile, the minimum incident occurred on grids L3, L7, M10, and M11, namely 0 strikes.

### 4.1.4 Lightning Strike Density Map Per Grid

From the results of processing lightning strike data using ArcGIS 10.8 software, results were obtained in the form of a lightning strike density map per grid on the 150 kV transmission line between Parit Baru Substation and Senggiring Substation.

Based on Figure 4, it shows that there are 138 grids. This number of grids was obtained from the results of data processing using ArcGIS 10.8 on the 150 kV transmission line between Parit Baru Substation and Senggiring Substation. Each grid has an area of 1 km$^2$ and each grid has its own coordinate point. The following is a pattern of lightning strikes per grid from the existing average data for the 150 kV transmission line between Parit Baru Substation and Senggiring Substation, shown in Figure 4 along with a legend showing the centeroid, grid and density of lightning strikes in each color pattern. It can be seen from the grid that there are several different colors in each grid. The colors on the map indicate the classification of the number of strikes in each grid. Level 1 is marked in green, level 2 is yellow and level 3 is red.

The grid in this research shows the place or location of lightning events. At level 1, the number of grids in this group is 66 grids, while the number of lightning strikes that occur is 420 strikes. At level 2 there are 44 grids, while the number of lightning strikes that occurred was 878 strikes. And at level 3 there are 28 grids, while the number of lightning strikes that occurred in this group was 835 strikes. From the data obtained, the results obtained for the highest lightning strike were 36 strikes/km² while for the lowest strike it was 1 strike/km².

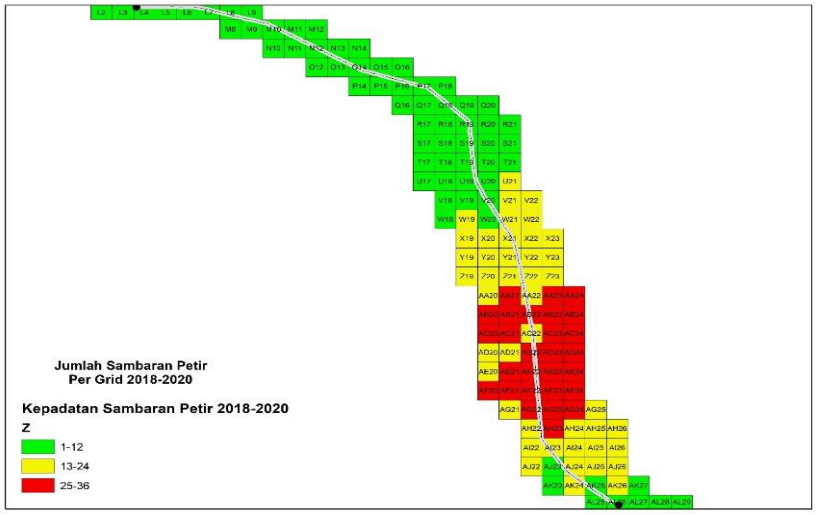


Figure 4. Lightning strike density map display

### 4.2 Discussion of Results

The number of lightning strikes and transmission towers for 3 years can be seen in Figure 5. Based on Figure 5 showing a graph of lightning strike data at tower locations, there are 128 tower points. At tower point number 1, the number of lightning strikes was 8. Meanwhile, at tower point number 128, the number of lightning strikes was 4.

From the graph below, it can be seen that the highest number of lightning strikes is 36 strikes/km², which is on grid AE22 which is at a coordinate point between 109.165516 (longitude) and 0.128405 (latitude), on this grid there are 3 tower location points, namely tower no.31 which is at a coordinate point between 109.1673 (longitude) and 0.132 (latitude), tower no.30 is at a coordinate point between 109.1677 (longitude) and 0.1287 (latitude), and tower no.29 is at a coordinate point between between 109.1678 (longitude) and 0.1254 (latitude). Meanwhile, the lowest lightning strike is 1 strike/km², which is on grid L7 (109.018516 (longitude) and 0.314605 (latitude)), and grid L8 (109.028316 (longitude) and 0.314605 (latitude) ). On the L7 grid there are 3 tower location points, namely no. 119, no. 118, and no. 117, while on the L8 grid there are 4 tower location points, namely no. 116, no. 115, no. 114, and no. 113.

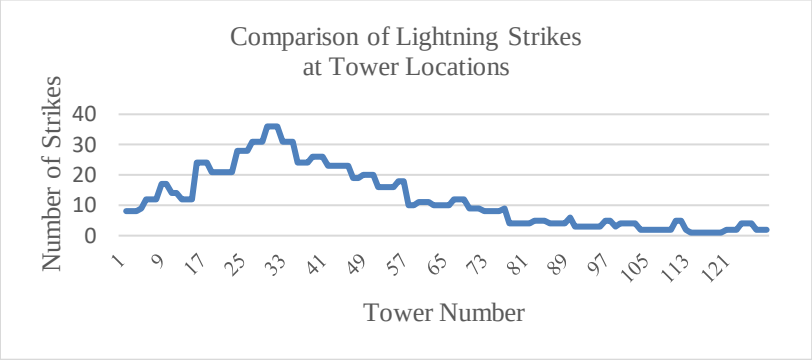


Figure 5. Lightning strike data graph at tower location

Based on Table 2, it shows that the towers are at level 3, with a strike range of 25-36 strikes/km². It can be seen in the table that there are 15 towers that have a high strike density.

Table 2. Towers that pass high lightning strike densities

| Tower | *Grid* | Lightning strike density / years / km² | Level |
|---|---|---|---|
| 40, 39, 38 | AB22 | 26 | 3 |
| 34, 33, 32 | AD22 | 31 | 3 |
| 31, 30, 29 | AE22 | 36 | 3 |
| 28, 27, 26 | AF22 | 31 | 3 |
| 25, 24, 23 | AG22 | 28 | 3 |

Based on Figure 6, it shows tower points that pass through a high density of lightning strikes. These towers are located in Segedong District and Jongkat District which have high lightning activity. The results of the discussion are that the number of lightning strikes in Jongkat District is 3000 to more than 4000 strikes, while in Segedong District it is generally in the very high category with the number of lightning strikes ranging from 6000 to more than 8000 strikes, and the number of 150 kV SUTT towers in Segedong District is 18 towers. much less than the towers in Jongkat District, which total 36 towers. Meanwhile, the number of 150 kV SUTT towers in East Mempawah District is 16 towers and the number of towers in Sungai Pinyuh District is 58 towers. Towers located in East Mempawah District and Sungai Pinyuh District tend to show low lightning strike patterns, this can be seen in the lightning strike density map per grid in Figure 4. However, if you look at the Segedong District area, it tends to show a moderate lightning strike pattern, while in Jongkat District it shows a high tendency for lightning strikes, this can be seen in Figure 6.

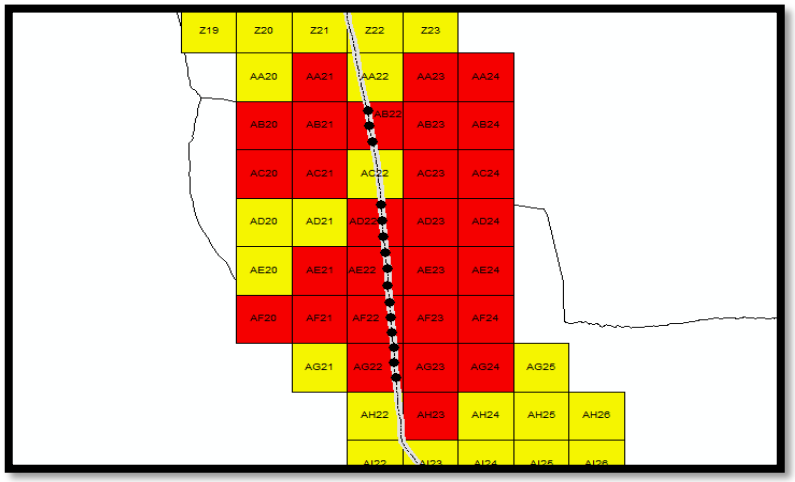


Figure 6. Tower that passes through a high density of lightning strikes

### 4.3 Discussion or Recommendations

The 150 kV transmission line between Parit Baru substation and Senggiring substation which passes through a high density of lightning strikes has a high probability of interference and damage to electrical equipment. Disturbances due to lightning surges on transmission lines will cause disruption to the conductor wires, so there needs to be lightning protection on the transmission line. The following are recommendations for lightning protection on the 150 kV transmission line between Parit Baru substation and Senggiring substation, namely:

1. Ground wire installation on transmission towers (Ground Steel Wire)
   GSW will protect the phase wire from lightning strikes.
2. Lowering the shielding angle on the transmission tower
   By installing the ground wire high enough above the phase wire, the angle of protection will be smaller within the limits of possibility without making the pole expensive.
3. Install Transmission Line arrester (TLA)
   TLAs are installed at transmission substations to protect equipment from fault currents and lightning strikes.
4. Using additional lightning protection equipment
   To complete lightning protection on the 150 kV transmission tower, here are several additional equipment:
   1) Lightning Rod, Install a lightning rod at the top of the tower to catch lightning and channel lightning current to the ground safely. Lightning rod provide an easy conductive path for lightning currents to the ground.
   2) Grounding Grid, use an efficient grounding grid around the tower to strengthen the grounding system and reduce ground resistance.
   3) Lightning Resistant Insulator, ensure that the insulator used has sufficient resistance to lightning to avoid damage.
   4) Arching Horn, arching horn is installed to protect the isolator, so that if a flashover occurs, the isolator coupling is not damaged.

## 5. CONCLUSION

Based on the results of data processing for 3 years (2018-2020), the highest density of lightning strikes occurred in 2019 in Segedong District at 54.52 strikes/km². Meanwhile, the lowest density of lightning strikes occurred in 2018 in East Mempawah District, amounting to 2.86 strikes/km². Based on the lightning strike density map per grid on the 150 kV transmission line between Parit Baru substation and Senggiring substation for 3 years, the results obtained for the highest lightning strike were 36 strikes/km² while for the lowest strike it was 1 strike/km². From this research, it was found that there were 15 transmission towers that passed a high density of lightning strikes with a strike range of 25–36 strikes/km² and the highest lightning strike occurred at tower number 31, number 30, and number 29, amounted to 36 strikes/km².

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