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Utilization of Lightning Energy As a Lightning Power Plant to Optimize Lightning Potential in Medan City

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Abstract. In addition to solar, wind, and water waves, there are other sources of energy that are renewable. Researchers are currently testing the use of these energies with a device that can draw electricity from the air. The new energy is electricity in the air that triggers the formation of lightning & lightning. The need for electrical energy is increasing day by day. Electrical energy supply in Indonesia itself is usually supplied from power plants such as Hydroelectric Power (PLTA), Air (PLTU), Solar (PLTS), Diesel (PLTD), and Geothermal (PLTG) whose existence still does not meet electricity needs. The type of research used is descriptive qualitative research by literature study use 10 journals. The purpose of this work is to utilize lightning as an energy source in order to maximize the potential of Indonesia's natural resources, especially in the city of Medan. The results show that lightning can be used as an alternative energy source, because lightning is a renewable energy and will not run out even if it is used continuously.

Keywords: *Lightning, Potential, Power Generation, Energy*

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INTRODUCTION

The need for electrical energy is increasing every day. Electrical energy supply in Indonesia itself is usually supplied from power plants such as Hydroelectric Power Plant (PLTA), Air (PLTU), Solar (PLTS), Diesel (PLTD), and Geothermal (PLTG) whose existence still does not meet electricity needs. Country. Based on data quoted from events that occurred in North Sumatra, the community must be harmed because of rotating power cuts that take up to 4 hours every day. The reason is the electricity deficit which reaches 400MW. This is due to the growth in the number of electricity users reaching 15% while the planned development is only 7.5%.

Based on the above problems, it is necessary to have alternative electrical energy to meet the electricity needs in an area. In addition to solar, wind, and water waves, there are other sources of energy that are renewable. The alternative energy source comes from lightning. Lightning is a common natural occurrence during the rainy season when the sky emits a brief burst of dazzling light. after that, there was a thundering roar. Lightning occurs due to a jump in static electricity in the ionosphere. Electric charge jumps occur when electric charges move together. This event is called discharge of static electricity. The emptying was indicated by a lightning strike. Electric charge can be dissipated by discharging. Discharge occurs when there is a way for electrons to flow from one charged object to another. The transfer of static electric charge from one object to another is called neutralization or discharge of static charge. Discharging is also known as grounding, because the charge is often discharged by means of channeling it to the ground. Discharge of static charge in the air can be so great that it creates the terrible sound we call thunder [1].

Physically, lightning is a phenomena that we may compare to a massive capacitor, with the earth serving as the second plate and the cloud acting as the first plate (which may be positive or negative). As we all know, a capacitor is a passive part of an electrical circuit that has the ability to store immediate energy. Intercloud lightning can also happen when two positively and negatively charged clouds are in close proximity to one another. Because of the potential difference between the cloud and the ground or with other clouds, lightning happens [2]. The process of the occurrence of charge on the cloud is because the particles that make up the cloud move continuously on a regular basis additionally, as they move, they will contact with other clouds, causing negative charges to accumulate on one side (either up or down) and positive charges to accumulate on the other. Negative charges (electrons) will discharge from the cloud to the ground or vice versa to attain equilibrium if the potential difference between the cloud and the earth is great enough. In this discharge process, air serves as the electrons' medium of passage. A sound explosion happens when electrons are able to cross the air insulation threshold. [2].

The rainy season is when lightning strikes most frequently because the air has a larger water content, which lowers the insulating power and facilitates easier current passage. Lightning may happen between clouds of differing charges because there are positively charged clouds and negatively charged clouds [4]. As previously stated, if the electric field between the cloud and the ground exceeds the penetrating power of the air, a charge will be released. This can be seen from the following formula:

$$E = kQ/r^2 \quad (1)$$

Where:

- Q = lightning tongue charge (Coulumbs)
- r = strike range from cloud to air
- k = constant

The potential difference of an electric charge at a point around the charge is expressed as absolute potential or simply electric potential. The electric potential of an electric charge q at a point a distance r from the charge can be expressed as follows:

$$V = kq/r \quad (2)$$

From the above equation it appears that the electric potential can be expressed in terms of the electric field strength, namely:

$$E = kq/r^2 \quad (3)$$
$$E = k\ q/r\ 1/r \quad (4)$$
$$E = v\ 1/r \quad (5)$$
$$V = E\ r \quad (6)$$

The greater the charge, the potential difference between the cloud and the ground will increase so that the greater the electric field that occurs. If the electric field generated exceeds the strength of the air-to-ground penetrating field, there will be a discharge (discharge) at that time, lightning or lightning strikes [5].

Seeing the above phenomenon, the use of lightning can be done as an alternative energy source, because lightning is renewable energy and will not run out even if it is used continuously. If the amount of water that comes from the cloud is known, then the total energy of a thunderstorm can be calculated. In a moderate thunderstorm, the energy released is up to 10,000,000 kilowatt hours (3.6×10^{13}) joules, which is equal to the power of a 20 kiloton nuclear bomb. Huge thunderstorms can be 10 to 100 times more powerful. An average-sized lightning strike has the energy to power a 100-watt light bulb for more than 3 months. An average-sized lightning strike contains an electrical power of 20,000 amps. A welder uses 250-400 amps to weld steel. Lightning travels at 150,000 km/s, or half the speed of light, and is 100,000 times faster than the speed of sound. This voltage difference in the flow of electricity between the cloud and the ground has an electric current of millions of volts. A single lightning strike has an energy of approximately 20,000 Ampere [6].

This enormous lightning electrical energy has the potential to be developed as an alternative power plant. The discovery of lightning as an electric current was first popularized by Benjamin Franklin in 1752 through his controversial kite experiment proposal. Franklin proposed hanging a Leyden vessel, a device for storing electric current, on the silk of a kite that was flown when the weather was thunderstorm. The development of technology and human life has allowed many theories and technologies for the development of the use of lightning as an alternative energy source [7]. Therefore, the author makes a research study to determine the use of lightning and the working principle of lightning utilization technology so that lightning can be utilized optimally.

METHODS

Method Approach

The research method used by researchers in this study is a qualitative approach with a descriptive method. "Research methodology is a regularly structured method or technique used by a researcher to collect data/information in conducting research that is tailored to the subject/object being studied" [8].

Sugiyono [9] defines qualitative research methods as those that examine natural objects with the researcher serving as the primary instrument, combining various data collection techniques, conducting inductive data analysis, and emphasizing meaning rather than generalization in the results.

With the help of the researcher as a crucial tool, qualitative research aims to disclose a holistic-contextual phenomena by collecting data from natural settings. When doing qualitative research, a different study strategy is used, and the results are not calculated or produced by statistical methods. We emphasize the process of qualitative

research as well as its relevance from the viewpoint of the issue since it is descriptive in character and typically uses an inductive style of analysis. [10].

Data Collection Technique

The type of research used in this study is a literature study by reviewing 10 journals related to the usefulness of lightning as power generation energy. The results of various literature reviews will be used to identify what benefits, and what should be done in an effort to use lightning as a power generator, especially in the city of Medan.

The data obtained will be analyzed by descriptive analysis method. Descriptive analysis method is done by compiling the data and facts obtained and then analyzed so as to provide the required information.

RESULTS AND DISCUSSION

Power Crisis and Benefits of Lightining Power

Massive electrostatic discharges, such as lightning, occur between electrically charged areas of clouds or between a cloud and the Earth's surface. A lightning flash, which is referred to as a strike if it impacts something on the ground, helps the charged regions of the atmosphere momentarily balance themselves. A cloud to another cloud (intra-cloud or IC), a cloud to a cloud (CC), and lastly a cloud to the ground (CG) are the three main varieties. Thunder is usually followed by lightning, however distant lighting may be visible but be too far away to be audible [11].

The world's most pressing concern is the power crisis. There have been several inventions and ideas, but those innovations have been in danger due to the lack of energy supplies. One such choice that nature provides for us is the power of lightning. Lightning is known to create enormous amounts of electricity [12].

The need for electrical energy continues to increase so that it is necessary to provide electrical energy from renewable energy sources. Medan City is a metropolitan city that demands sufficient energy supply. Electrical energy has become an important part of humans. Almost all lines of human life require electrical energy to facilitate everything, which is supported by increasingly rapid technological developments. Electrical energy so far mostly uses non-renewable energy, namely from fossils [13].

Models for New Energy Production

This work has provided two suggestions for an experimental power plant design that need further investigation, in addition to emphasizing some minor practical uses. Both of them mimic power production after natural processes. [14].

Benjamin Franklin invented the lightning rod concept in 1749 and made significant advancements toward a dependable system about 1760. A lightning rod's main function is to deflect lightning strikes and create a low-resistance path to the earth [12]. Application of voltage pulses to the lightning rod's tip with the assumption that their results will increase the conductor's attractive radius [15].

Particle Collisions for Charge Separation

Through interactions between different-sized ice particles and supercooled water, thunderstorm clouds actively produce high electrical charge separation. Collisions and induction are involved in this process. Thunderstorms efficiently transform some of the kinetic energy of the wind into electrical energy over the course of many hours to days.

As it can only catch a portion of each blow, an induction system may provide a limited amount of flexibility. The option of catching electricity resulting from a storm's regional shift in surface voltage rather than the hit itself also exists. There would be a lot of inducting stations put up for regional storm collection. Each would only be able to catch a little quantity of power, but if there were many more locations, that may be beneficial [16].

Both volcanic eruptions and thunderstorms are examples of natural events that use interactions between wind and materials to separate charges in order to function as power producers. Particle collision generators are one possible design for a charge separator that take use of the wind and particle environment..

Dusty Plasma Fusion Reactor

Ball lightning is a dusty or grain plasma. Fusion of lighter elements likely occurs inside ball lightning. More work could be done to explore artificial ball lightning formation and properties, especially what lends it stability, what forms its shell and how different chemistries of included material influence its properties.

Electricity Tapped by Lightning Arrester

Devices like horns and arresters for transmission lines that aid open and stop circuits in the event of an overvoltage are examples of infrastructure protection against lightning [14]. Sources of lightning provide more electricity than other types of energy. It will be profitable to exploit this renewable lightning energy source for human needs. In general, natural disasters like lightning are a frequent concern in my area. Because lightning produces such a high voltage, it is squandered in the earth. For our daily needs, we must utilise this energy as electricity.

Fit several lightning or catchers to the roofs of tall buildings, trees, and towers, among other places. Each lightning arrester is connected to a common transducer that is positioned at a specific location by a copper wire of suitable thickness. When lightning strikes, a large amount of electricity is captured by the lightning arrester and is sent through the circuit's conducting feeder or cable. Then, the capacitors C1, C2, and C3 are supplied with this DC voltage. These capacitors, which are utilized in HT lines, have a large capacitance range. As a result, the charged batteries or capacitors serve as a DC voltage source and supply the load with electricity for daily use [12].

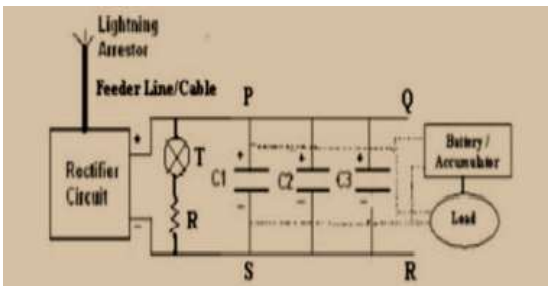

Figure 3.1. Electricity Tapped By Lighting Arrester [12]

Power of Lightning

There are around 1,200 thunderstorms active on Earth at any given time, and 100 lightning strikes are thought to occur over our globe every second. An average lightning bolt has a voltage of over 15 million volts, which rapidly warms the air around it to over 60,000 degrees, and in some cases, over 100,000 degrees. Because of this, a strong thunderstorm's overall energy can be more than the energy produced during an atomic explosion [12]. Lightning that occurs in general has several parameters, including; [17].

a. The local load displaced is 150-300 Coulomb.
b. The peak current achieved is 100–200 kA
c. Lightning charge 50–100 Coulomb.
d. Current rise steepness (in/s) 100–200 kA/ms.

Harvesting Lightning Energy

Due of the difficulties in measuring it, indirect approaches are utilized to estimate the electrical energy produced by lightning. The energy discharged by lightning has been estimated using a variety of ways in the past. The first method uses estimates of the electrostatic charge transferred, potential difference, and the charge regions that each individual lightning flash crossed, respectively [18].

Energy harvesting as a field looks at modest amounts of energy stored for low energy applications, for example, in wearable electronics. Three of the five authors found in this category are coauthors on a single paper related to alternating current (AC) energy capture in systems with mechanical or radiofrequency (RF) transducers [14].

We need a device that can sustain such high voltage in order to capture and harvest lightning energy, which is nearly impossible because the capacitor would be destroyed by the high voltage. It is necessary to convert these high voltage currents first into low voltage current. Numerous step-down transformers can be used to accomplish this. The basic function of step down transformers is to convert high voltage current to low voltage. The capacitor can then be used to store the current voltage once it has been lowered [19].

Building A Lightning Harnessing Power Plant

This concept may not be as practical as it once was. The main limiting factor in implementing a lightning arrester scheme like this is the inability to be able to store large amounts of electricity for later use. However, new Utility Scale Battery technology or other energy storage technologies such as Flywheel or Capacitors can be used to store large amounts of electricity captured from lightning, for later grid use. Obviously, lightning rod power generation will only be practical in areas that frequently experience thunderstorms, such as in Indonesia.

How difficult is it to build a lightning rod circuit to capture lightning storm electricity periodically? Making a power generation system that could resist the powerful waves produced by lightning strikes would really be the largest challenge, but even that appears doable with current technology and materials. Engineers in electrical and architectural design can find innovative ways to make it work.

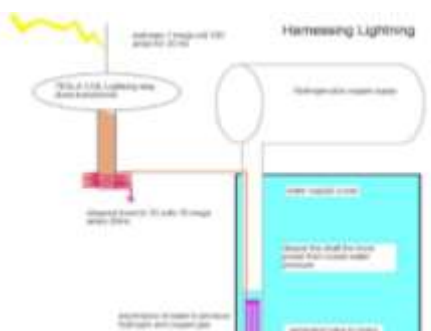

Figure 3.2. A Lightning Harnessing Power Plant [11]

Past Examples

Steve LeRoy is one person who has tried to harness the energy of thunderstorms. He was able to use the energy from a brief artificial lightning flash produced by the alternative energy company AEHI to power a 60-watt light bulb for 20 minutes, but he was unable to store the energy for later use. The energy in a thunderstorm is similar to that of an atomic bomb, according to research by Martin A. Uman, co-director of the Lightning Research Laboratory at the University of Florida, yet attempts to harness lightning energy from the ground are "hopeless" (Komolafe, Akinnubi & Olabisi, 2017).

Issues Faced

Another big challenge when trying to harvest energy from lightning is the impossibility of predicting when and where a thunderstorm will occur. Even during a storm, it's hard to tell exactly where the lightning will strike. A relatively easy method is direct harvesting of atmospheric charge before it turns into lightning. However, to collect a reasonable amount of energy requires a very large construction, and it is relatively difficult to take advantage of the very high voltages generated with reasonable efficiency.

CONCLUSION

Massive electrostatic discharges, such as lightning, occur between electrically charged areas of clouds or between a cloud and the Earth's surface. Utilizing lightning can be done as an alternative energy source, because lightning is renewable energy and will not run out even if it is used continuously. There are various alternatives in capturing electricity into a useful energy source for our lives. For example, with Building A Lightning Harnessing Power Plant, and so on that are considered capable of Harnessing Power Plants with lightning.

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