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HYDROELECTRIC POWER GENERATION SYSTEM IN TANGGARI (PLTA TANGGARI 2)

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ABSTRACT
The research objective of PLTA Tanggari 2 is to understand and analyze the hydropower system from energy generation to distribution to end consumers, both households and industries. This research aims to improve the efficiency and performance of the entire electricity generation and distribution system. The research methodology used in making this journal is to collect sources or information related to the topic of discussion, namely hydroelectric power plants. The study explores the utilization of hydropower in the Tondano watershed to address electricity needs in North Sulawesi. Tanggari 2 Hydropower Plant exemplifies this by harnessing the potential and kinetic energy of water through a dam on the Tondano River. With an extensive watershed area of 4,700 hectares and Lake Tondano at its core, this system is optimized to efficiently generate electricity for the entire region. The input-output dynamics of hydropower plants are crucial, detailing how water flow drives turbines, ultimately leading to electrical output. This research underscores the potential of watershed utilization as an accessible, economical, and sustainable energy source for broader regional electrification endeavors. The implications of this research extend to enhancing understanding and analysis of water-based power generation systems, from energy production to distribution to end consumers. By improving the efficiency and performance of these systems, there is a significant potential for sustainable energy solutions that can benefit both households and industries in the broader regional context of North Sulawesi.

Keyword: Water, Electricity, Turbine, Generator Usage.

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INTRODUCTION

Nature has a lot of potential for us to utilize well, one of which is by building dams to produce or generate electrical energy (Bayuanto et al., 2022). The construction of a Hydropower Plant requires a dam, waterways, turbines and generators (Dewanto et al., 2017). The Hydropower Plant utilizes the kinetic energy of water and gravity to rotate the turbine (Hakim et al., 2020). Turbines connected to generators will produce electrical energy.

One of them is in the North Minahasa area located at Tanggari 2. Tanggari Hydropower Plant has four generator units with a capacity of 37,000 kW. Each generator or unit has 9,250 kW. The construction of this hydropower plant has the aim of meeting the electricity needs of industries and households in the Manado, North Minahasa, Bitung and surrounding areas.

Looking at the capacity produced by the Tanggari Hydropower Plant to meet the electrical energy needs in the Manado, North Minahasa, Bitung and surrounding areas, which are quite extensive, there are several other power plants. Not only Tanggari Hydroelectric Power Plant, but there are also Tonsea Hydroelectric Power Plant, Kema PLTU (*Pembangkit Lisrik Tenaga Udara*, Air Power Generator) and several scattered PLTDs (*Pembangkit Listrik Tenaga Diesel*, Diesel Power

Plant). In the power generation system to its distribution, there are many existing systems and transmission lines to distribution.

From the explanation above, we will discuss the existing system in the power plant to the distribution to consumers, both households and industries. Discussing the existing system in the power plant from the turbine that drives the generator, which produces electrical energy then enters the voltage boosting substation (Step Up) to >110kV, enters the transmission line, then to the substation divider, then to the step-down transformer (Step Down) to 20kV which then enters the distribution line (Wibowo, 2018). On the distribution line, there is a voltage drop to 220/380Volt and then distributed to consumers; some are distributed without lowering the voltage, distributed with a 20kV voltage. Some are supplied using transmission lines to certain industries or consumers.

The research objective of Tanggari 2 Hydroelectric Power Plant is to understand and analyze the hydroelectric power generation system from energy generation to distribution to end consumers, both households and industries. This research aims to improve the efficiency and performance of the entire electricity generation and distribution system. The benefit of this research is to provide a better understanding of how Tanggari 2 Hydroelectric Power Plant contributes to meeting the electricity needs in the Manado, North Minahasa, Bitung, and surrounding areas. With a better understanding of this system, improvements can be made in electricity management efficiency, reducing power losses, and increasing the availability of electricity for communities and industries in that area.

METHOD

The research methodology used in making this journal is to collect sources or information related to the topic of discussion, namely PLTA (*Pembangkit Listrik Tenaga Air*, Water Power Plant). In reviewing this paper, we used library research methods by critically and in-depth studying library materials that are relevant to materials such as books and journals that are suitable as references.

RESULTS AND DISCUSSION

Each type of power plant has a different way of working, but has the same purpose, namely as a producer of electricity (Nagifea, 2022). Most power plants use generators as producers of electrical energy. Power plants that use generators such as hydropower, PLTU (*Pembangkit Listrik Tenaga Uap*, Steam Power Plant), PLTD (*Pembangkit Listrik Tenaga Diesel*, Diesel Power Plant), PLTP (*Pembangkit Listrik Tenaga Panas*, Thermal Power Plant), PLTMH (*Pembangkit Listrik Tenaga Mikro Hidro*, Micro Hydro Power Plant), PLTG (*Pembangkit Listrik Tenaga Gas*, Gas Power Plant), PLTB (*Pembangkit Listrik Tenaga Biomassa*, Biomass Power Plant) and many more (Hasibuan et al., 2023). In contrast to PLTS (*Pembangkit Listrik Tenaga Surya*, Solar Power Plant) (which converts sunlight energy into electrical energy using solar panels (Evalina et al., 2021).

In principle, hydropower utilizes the potential energy of water by utilizing the potential energy and kinetic energy of water to rotate turbines connected to generators (Farhan, 2021). From the generator, the mechanical energy produced by the rotation of the turbine is converted into electrical energy. The hydroelectric power plant or PLTA (*Pembangkit Listrik Tenaga Air*, Water Power Plant) built-in Tanggari, Tanggari Hydroelectric Power Plant has four generator units, and each generator or unit has a capacity of 9,250kW; in other words, Tanggari Hydroelectric Power Plant has a combined capacity of 37,000 kW from each existing unit.

Components in Hydropower

The components in hydropower are in the form of a dam, rapid pipe or tunnel (penstock), turbine, generator and travel (Sauri et al., 2022). The dam has a function to hold water on a large scale to be used to rotate the turbine (Sugiharto, 2018). Turbines require a large enough water supply and must be available at all times, so a dam is needed to store water. The dam also produces water kinetic energy by utilizing the potential energy needed to rotate the turbine.

The rapid pipe or tunnel (penstock) serves as to channel or as a water supply line from the dam to the turbine (Sofiah & Hakim, 2020). The position and placement of the tunnel also affect the kinetic energy of water and potential energy. This tunnel has a special slope and diameter that has been calculated according to the required slope and diameter.

Turbines function to convert the kinetic energy produced by water into mechanical energy. Water hitting the corners of the turbine pushes the turbine with water kinetic energy so that it can rotate the turbine. The water that rotates the turbine produces mechanical energy that is used to rotate the generator.

Generators have a very important function in every power plant (Aribowo et al., 2020). Generators convert mechanical energy into electrical energy. In this way, the turbine can rotate the generator to change energy. The turbine is connected to the generator using a shaft and gearbox.

The generator has two parts, namely the rotor and stator. The turbine rotation rotates the rotor, which makes the magnetic coil in the generator rotate so that there is a movement of electrons in the winding, which then produces electrical energy. The rotor is an iron wrapped around a cable that forms a coil that wraps around the rotor so that the rotor can produce electrical energy, forming nine north poles and south poles. In the generator, there are Automatic Voltage Regulator (AVR) poles; if the AVR electrifies the existing poles with an excitation current, a magnetic field will arise (Anthony, 2020).

Transformer stands for transformer. Transformers increase and decrease voltage. Every power plant uses a type of voltage booster transformer, commonly called a step-up transformer. After increasing the voltage, it enters the transmission line. Transmission channels electrical energy from power plants to existing substations. Before entering the transmission line, the electric current is synchronized first with the existing electric current because, in the transmission line, all the power plants have their electric current combined and then channeled.

Working System on Hydroelectric Power Plant (PLTA)

The dam holds water to be used as a turbine rotator by utilizing the potential energy and kinetic energy of water (Zain, 2019). The dam can also be referred to as the lungs in hydropower because the dam functions as a water reservoir on a very large scale because the turbine requires a large and very large water discharge for the long-term (Rizka Felly & Ars, 2022). At the bottom of the dam, there is a rapid pipe or tunnel that channels water from the dam to the turbine.

The three hydropower plants in the Tondano watershed have interconnected intakes and outputs. Starting from the Old Tonsea Hydroelectric Power Plant, then there is the Tanggari 1 Hydroelectric Power Plant and then the Tanggari 2 Hydroelectric Power Plant. These three hydropower plants have intakes and outputs that are connected, starting from the output of the Old Tonsea Hydroelectric Power Plant connected to the Tanggari 1 Hydroelectric Power Plant intake, the Tanggari 1 Hydroelectric Power Plant output is connected to the Tanggari 2 Hydroelectric Power Plant intake.

The rapid pipe or tunnel (penstock) not only has a function as a distributor of water from the dam to the turbine but also has a function to increase the kinetic energy of water by placing the rapid pipe with a certain slope and diameter so as to increase the kinetic energy of water. The placement and size of the rapid pipe greatly affect the rotation of the turbine later. The higher the slope of the rapid pipe placement and the larger the diameter, the greater the kinetic energy of the water that will rotate the turbine, and the faster the turbine rotation will be.

Tanggari 2 hydropower plant has a rapid pipe or tunnel with a length of 1,825M. The intakes are connected to the output of the Tanggari 1 hydropower plant. The rapid pipe at Tanggari 2 hydropower plant has a waterfall height of 137.1 meters and a minimum-maximum water level of 458.8 to 459.8 MASL.

The turbine rotates because the kinetic energy of the water pushes the corners of the turbine, causing it to move around. The turbine converts the kinetic energy generated by water into mechanical energy. From the rotating turbine, the turbine is connected to the generator using a shaft and gearbox to channel mechanical energy from the turbine to the generator.

The type of turbine used in Tanggari 2 Hydropower Plant is the Francis Turbine (Bouvier Hydro/Francis Vertical). This type of turbine is most widely used in Indonesia. The way this turbine converts water kinetic energy into mechanical energy by using a rotating wheel that is driven by water kinetic energy. This type of turbine is commonly used for waterfall heights between 20-400 meters.

The generator converts mechanical energy from the turbine into electrical energy. Tangari 2 Hydropower Plant has four turbines and generators, each with a capacity of 9,250kW, for a total capacity of 37,000kW. The generator is run and then synchronized with the voltage, but before t at, the voltage coming out of the generator is increased using travel.

Travo, or transformer at Tanggari 2 Hydroelectric Power Plant, uses a type of voltage-boosting transformer commonly called a step-up transformer. The voltage coming out of the generator is increased using a step-up trans ormer. The voltage coming out of the generator is then increased to 70kV and 150k. After raising the voltage then the electric current is synchronized to be ombined into the 70kV interconnection system for Minahasa, Manado and Bitung. At the same time, 150kV is combined into the system for Kotamobagu.

The m in purpose of synchronization is to obtain large power, which combines the supply of electric current from several power plants. After that, the synchronized electric current enters the distribution line system, such as the Minahasa, Manado, Bitung and Kotamobagu systems.

CONCLUSION

PLTA (*Pembangkit Listrik Tenaga Air*, Water Power Plant) is a power plant that utilizes the kinetic energy of water as the main source in this plant. In the discussion above, we can find out the system system and also the ca acity of the four power plant units in Tanggari 2. So, each turbine and generator unit in Tanggari 2 has a capacity of 9,250k each, which in total is 37,000 kW. We can learn about the system that works on hydropower, starting from the dam, fast pipe or tunnel (penstock), turbine, generator and transformer. In addition, we can also find out about the working system at Tanggari 2 H hydropower Plant.

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