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MODELLING AND ANALYSIS OF THERMOELECTRIC AND OSCILLATING WATER SYSTEMS AS LOW CARBON EMISSION RENEWABLE ENERGY RESOURCES IN INDONESIA

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Abstract

Energy, as an inexhaustible phenomenon, transforms various forms to meet human needs. Some forms of energy are challenging to harness for reuse, necessitating a combination of energy generators to enhance electricity production from renewable sources such as heat and water. The utilization of Ocean Wave Energy Converter (OWC) emerges as one solution, harnessing the phenomena of waves and air pressure to drive generators. The generated electrical output does not have to be large, as long as it can produce heat through coils. This heat is then used to warm thermoelectric materials, generating electricity that can be stored in the Powerhouse Storage. A holistic approach is employed to harness renewable energy efficiently and sustainably to meet electrical needs.

Keywords: Energy, Thermoelectric, Wave Power Plant, OWC, Energy Alternative

Introduction

Transportation, serving as a means of travel, is a solution for reaching distant places. The use of natural gas as a fuel for operating vehicles has been one of the most efficient methods for several decades (Nedjalkov, Meyer, Göken, Reimer, & Schade, 2019). The utilization of non-renewable natural gas poses a challenge for all countries to compete in creating technology to regulate energy from renewable resources.

The Earth's energy sources come in various forms, and these forms are the result of natural phenomena driven by the planet's geological locations and conditions. Factors such as seasons, climate, wind direction, air temperature, sunlight angles, and the life that exists or has existed in a particular location contribute to these phenomena. This diversity in environmental resources and conditions provides a wide range of energy sources that can be harnessed.

Electricity itself serves as a highly usable energy source due to its flexibility in operating various devices, ranging from household appliances to powering vehicles and producing fuels like hydrogen through electrolysis. The occurrence of electricity is a result of the phenomenon of electron movement, generating various forms of new energy. This electron movement produces phenomena such as light, heat, and motion induced by magnetic fields. Light conversion, for example, can be observed in lighting devices, while

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heat is evident in appliances like irons and water heaters. Additionally, the force involving magnetic fields can be seen in mechanisms such as relays and generators.

In these days, 80% of the electricity generated is effectively produced using fossil fuels (Emilsson & Dahllöf, 2019). The power plants in Indonesia are still predominantly powered by Steam Power Plants and Solar to drive their generators. Based on PLN data from 2020 and 2022, the following information is obtained:

	PLTU	PLTGU	LTD	PLATO	PLTG	PLTP	PLTS	PLTB	
2020	29,7%	17,04%	5,16%	5,21%	4,05%	0,84%	0,04%		44.174,79 MW
2022	32,0%	17,7%	8,76%	5,66%	4,64%	0,91%	0,03%		44.939,88 MW

Table 1. Electricity production data by PLN for the years 2020 and 2022 (Perusahaan Listrik Negara, 2021).

Based on the above percentages, the remaining 40% comes from Independent Power Producers (IPP) with a power output of 69,039.6 MW in 2020 and 63,336.12 MW in 2022. Therefore, the calculated electricity production in 2022 is approximately 108,276 MW. Based on the above data, the use of wave power plant technology accounts for only about 5% - 6% of the overall electricity production in Indonesia. Although, according to the journal 'Determinants of Electricity Consumption in Indonesia' in 2022, Indonesia has positive electricity consumption data based on its GDP per capita and population in electricity consumption (Ayasyifa, 2022).

The methods employed in this journal involve modeling a system to generate electricity using thermoelectric and wave power plant technologies, with thermoelectric as a low-emission technology (Cepe, Ricafort, & Rosal, 2020);(Rodrigues, 2008). This method aims to reduce the use of combustible or carbon-fuelled materials to minimize the production of carbon dioxide (CO2), carbon monoxide (CO), and methane (CH4), which are currently the leading causes of greenhouse gas emissions worldwide (Wahyudi, 2016).

Despite Indonesia having the potential for the implementation of Renewable Energy Sources (RES), the current electricity generation is still predominantly dominated by coal and geothermal power (Lolla & Yang, 2021). Quoted from 'Indonesia defies global trend with more coal in the generation-mix,' Indonesia, from 2015 to 2019, utilized just over 30% of RES Hydro, about 4% from RES Wind, with the remainder using geothermal and coal. Indonesia itself became the most intensive coal producer during the COVID-19 pandemic.

Indonesia, as a maritime nation, has the potential for the implementation of a Hydropower/Wave Power Plant, especially in the islands of West Sumatra, South Java, and South Bali, which directly border the Indian Ocean. These areas are recommended for the installation of Hydropower/Wave Power Plants (Thahlil & Singgih, 2022). Those areas are part of the Ring of Fire, where hundreds of volcanoes are present, capable of causing wave movements that are not solely dependent on wind motion.

The next technology is Thermoelectric, which was proposed by Thomas Seebeck (Pollock, 2018). The thermoelectric technology is implemented in various applications,

and to harness its benefits, several infrastructures and supporting technologies are required to maximize its energy output. For example, solar panels are needed to generate the necessary energy for the thermoelectric technology.

Some of the problematical statements from the Thermoelectric Generator are mentioned below: a) The optimal temperature range to achieve significant efficiency in TEG (Mamur, Dilmaç, Begum, & Bhuiyan, 2021). b) The need for installation platforms and technical knowledge among stakeholders to promote the utilization of TEG in the context of renewable energy. c) The absence of cost-effective and highly efficient technology features for insulation. d) Low-power electronic devices using this energy source. e) Poor heat dissipation on the hot side during pressure sublimation (Sigalingging, 2022). f) The potential for operational failure of entire TEG modules with minimal impact.

The discussion of this journal revolves around modeling the potential crossbreeding between two technologies to achieve maximum energy output based on theories that allow the scheme to work according to its potential. Thermoelectric is a conceptual implementation derived from the Seebeck Effect, referring to the phenomenon where an electric current occurs when two conductive materials at different temperatures are kept in contact (Gogoc & Data, 2022). It is implemented more effectively by using conductive materials with valences of 7 and 3 in their electron configuration.

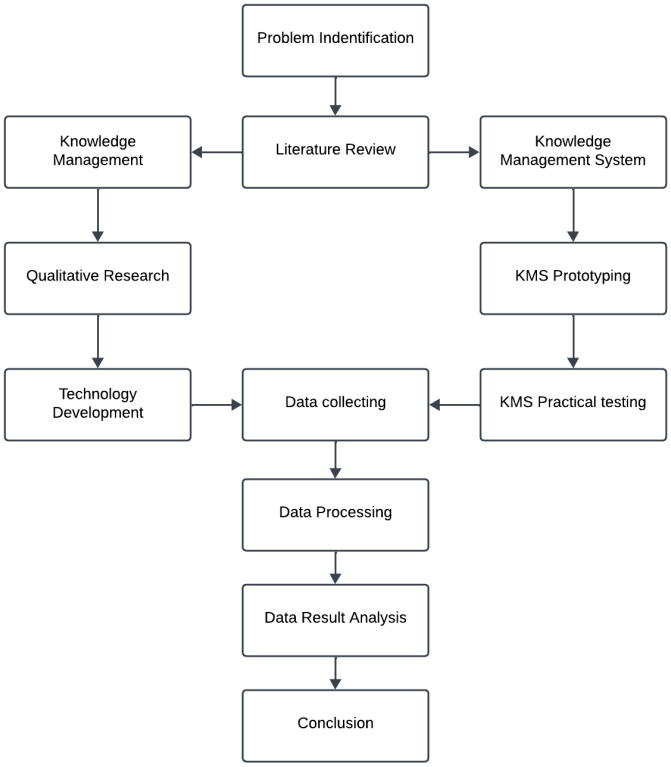
Based on the Octet Rule, states that the stability of an element is achieved when an atom with electrons in its outermost shell has a total of 2 or 8 (Keller & Hermanns, 2023). This can be achieved by heating two different types of alloys, causing a continuous flow of electric current. This is due to the difference in potential between the negative and positive sides of the two alloys when one side is heated, and the other side is cooled (Huo & Guo, 2022).

This can be achieved by heating two different types of alloys, causing a continuous flow of electric current. This is due to the difference in potential between the negative and positive sides of the two alloys when one side is heated, and the other side is cooled. Wave Power Plants can be used to generate electricity by employing Oscillating Water Column technology. This technology utilizes the concept of air pressure caused by the motion of waves on a cone-shaped tube (or in other forms) to drive a turbine or generator (Farrok et al., 2020).

Wave Power Plants are used to generate electricity and heat through coils designed to warm thermoelectric materials. The utilized Wave Power Plants can come in various forms such as OWC (Oscillating Water Column), Pelamis, Duck, and Buoy (Sugianto et al., 2017). Electricity wound around not only generates a magnetic field but also produces heat due to the resistance hindering the flow of electricity. This is also implemented in several household appliances such as irons, water heaters, and toasters that utilize induction as a heat conductor.

Research Methods

The research method used is the Knowledge Management System, which involves identifying the problem, conducting a literature review, and carrying out qualitative research to collect data on the latest technology and practices. Data collection is done through quantitative methods such as energy usage data, and qualitative methods are employed to gather information on technological developments, utilization, and their feedback through natural phenomena. Subsequently, modeling will be created through processing and analysis, including variables such as energy consumption, energy needs, and technology usage.



Picture 1 Research Steps Plan

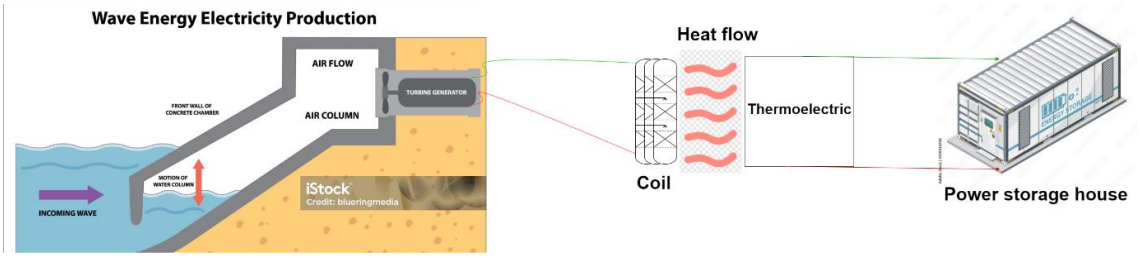
Throughout this research, the study's focus is directed toward identifying factors needed for the implementation of new funding. The keywords used for the search are Thermoelectric, Wave Power Plant, Coil, and Electric Generator. The search sources used in the qualitative research are 1) Scopus.com. 2) Mendelay.com. 3) Google Scholar. 4) Science Direct. 5) Research Gate.

The data extraction process is carried out by categorizing several variables from various sources to focus on the research object under investigation. The basis of this search is categorized by: 1) Published journals after 2019. 2) PLN's journal reports. 3) Journals about Alternative energy. 4) Indonesia's energy grid system storage. 5) Journals about Indonesian electricity generators.

The results of data extraction will be grouped into 3 categories to create a model, as mentioned: 1) Existing Technologies. 2) Electricity Consumption Needs. 3) Risks or Feedback from Modelling Results.

Results and Discussion

The utilization of the combined technology between OWC and Thermoelectric is expected to enhance electricity production by harnessing the heat generated through the electric current in the coil produced by OWC and heating one side of the thermoelectric. The outcome of the discussion for the modeling process is a scheme that combines three technologies to generate a new source of electricity that is cleaner and cost-effective. This involves leveraging technology and natural phenomena.



Picture 2 Modelling Electricity System Grid

The electricity production from thermoelectric is determined by the number of cells installed in the facility, the temperature gradient created, and the cooling provided on one side. The electricity production generated by heating one side at a temperature of 24°C and cooling one side at -10°C is approximately 1 watts. With 6 layers of thermoelectric, it can produce an energy output of around 500 Watts at a temperature of 152°C.

The amount of heat produced through the electrically powered coil can generate temperatures of 700 to 1000°Cover a specific period. Implementing more layers can increase electricity production to meet urban electricity needs due to its size and economic cost. The dimensions for a 6-layer Thermoelectric are 75cm x 24cm x 18cm.

Conclusion

Energy is a tangible form that never depletes; instead, it transforms its shape when subjected to action. The energy undergoes various transformations to meet needs, but some forms of energy, once dissipated, are challenging to harness again. Therefore, a combination of energy generators is needed to enhance electricity production through renewable raw energy sources such as heat and water, producing new and more flexible forms of energy, like electricity.

By utilizing OWC, which harnesses the phenomena of waves and air pressure to drive a generator, the generated electricity doesn't need to be large as long as it can produce heat through a coil. This heat will then warm the thermoelectric material to generate electricity for the Powerhouse Storage.

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