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Renewable energy potential in Indonesia and climate change mitigation

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Abstract
Climate change is one of the biggest challenges and threats in this century experienced by various countries, including Indonesia. The threat of negative impacts from climate change forces the consumption of renewable energy to be increased substantially as something that must be done. Indonesia, a country with great renewable energy potential and various types of energy, such as wind, solar, geothermal, biomass, and water, can play a global role in the campaign to reduce the use of fossil fuels. There is no waste generated from renewable energy production; it also does not produce carbon emissions. Therefore, using renewable energy together with energy efficiency is the best choice, representing a safe, reliable, and, of course, can be immediately applied towards a green earth future with low carbon emissions so that can adequately resolve the problem of climate change impacts.

Keywords: renewable energy, global change climate, mitigation, Indonesia.

1. Introduction

One global issue that has been the subject of much study by researchers is global climate change, which is caused by natural or anthropogenic factors [1,2,3]. The tendency for large-scale changes in average long-term climate conditions, such as prolonged dry climates and changing to wetter climates, is the definition of global climate change. Natural ecosystems and their contents will experience changes caused by significant climate change, especially in terms of using natural resources, production, and economic activity. Several research results show that anthropogenic factors play a more substantial role than natural factors; one of the main causes is the increasing concentration of carbon dioxide, methane, nitrous oxide, and fluorinated gases, which have dramatically escalated [4.5.6]. Various international, regional, national, and local initiatives are being developed and implemented to limit and mitigate greenhouse effect concentration in the Earth's atmosphere in response to the possible impacts of global climate change, including in Indonesia. Ratifying the UNFCC in 1994 shows that Indonesia has long paid great attention to climate change. Indonesia's climate change mitigation policies are broadly stated in the RPJMN V 2020-2024, especially in National Priority 6, namely building the environment, increasing disaster resilience and climate change. Climate-resilient development is one of the sixth national priorities in the 2020-2024 National Medium-Term Development Plan. [7,8,9]. Like other countries that have concerns about sustainable development and climate change, Indonesia also chose to concentrate on developing renewable energy sources to reduce the impact of climate change due to increasing greenhouse gas emissions (GHGs).

Anthropogenic activities such as fossil fuel combustion, industrialization, deforestation, and the release of greenhouse gases into the atmosphere cause climate change. This causes several adverse effects on natural life, such as increased carbon dioxide emissions and increased average temperatures. Climate Transparency[10] reported that the most significant contributor of carbon dioxide (CO2) emissions in Indonesia is the electricity sector, with a proportion reaching 43% of total emissions in Indonesia, followed by the transportation sector (25%). The third largest contributor is the industrial sector, around 23%. The average air temperature in Indonesia in the period 1981-2000 reached a range of 26.3-26.6 degrees

Celsius (°C) and increased to 26.7 - 26.9 ^{0}C in the period 2000-2010. The temperature increases to 27.3^{0}C occurred in the period 2022-2023. The figure increased by 0.4°C compared to the previous year, which was 26.8°C. One effort to reduce the negative impacts of climate change is to promote using renewable energy in various aspects of life.

2. Materials and methods

The method used in this study is literature research, conducted by conducting a survey or review of previous research published in books, scientific articles, and other relevant sources related to renewable energy and global climate change. We reviewed the literature emerging from geography, political ecology, and history that deals with the connections between climate change and global climate change to understand further how renewable energy issues are linked to global climate change. In addition, we utilized Google Scholar to find the literature that explores these relationships, as it provides the most comprehensive coverage of the issues.

3. Results & Discussion

3.1Indonesia's Energy Mix

The highest percentage of the energy mix in Indonesia in 2023 is the coal still held, which is 41%. However, this percentage continues to decline from the previous year, which was 42%, Petroleum (30%), Natural Gas (16%), and renewable energy (13%). The percentage of new renewable energy (EBT) increased by 0.79% to 13.09% in 2023 (Fig. 1). In 2025, the Government of the Republic of Indonesia targets a 23% renewable energy mix.

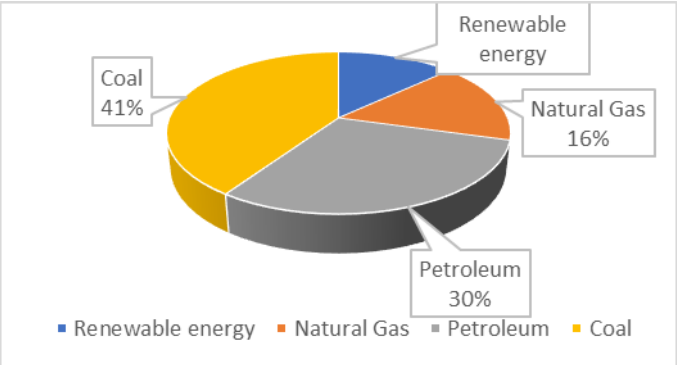

Fig. 2: Energy mix in Indonesia in 2023, where the position of renewable energy is still low

3.2 Renewable Energy Sources in Indonesia

Renewables can also replace fossil fuels to reduce greenhouse gas emissions. According to an analysis from the International Renewable Energy Agency (IRENA), Indonesia's renewable energy potential is estimated to reach 3,692 gigawatts (GW), including potential from solar, wind, water, biomass, geothermal, ocean currents, and so on. More specifically, Indonesia has a solar energy potential of around 2,898 GW, offshore wind energy of around 589 GW, and water energy or hydropower potential of 94.6 GW. In addition, Indonesia has the largest geothermal potential in the world, namely 23.4 GW.

Although the potential for renewable energy in Indonesia is very large, the fact is that the installed capacity of renewable energy in Indonesia is still very minimal, which is around 10.5 GW or only around 0.3% of the existing potential. For example, the realization of installed solar energy capacity is only around 0.2 GW, onshore wind energy is around 0.2 GW, and PLTP from geothermal energy is only 2.3 GW. This shows that there is still a lot of renewable energy potential that has not been utilized properly in Indonesia

Figure 2 presents the renewable potency and the achieved capacity (in MW) of renewable energy sources in Indonesia

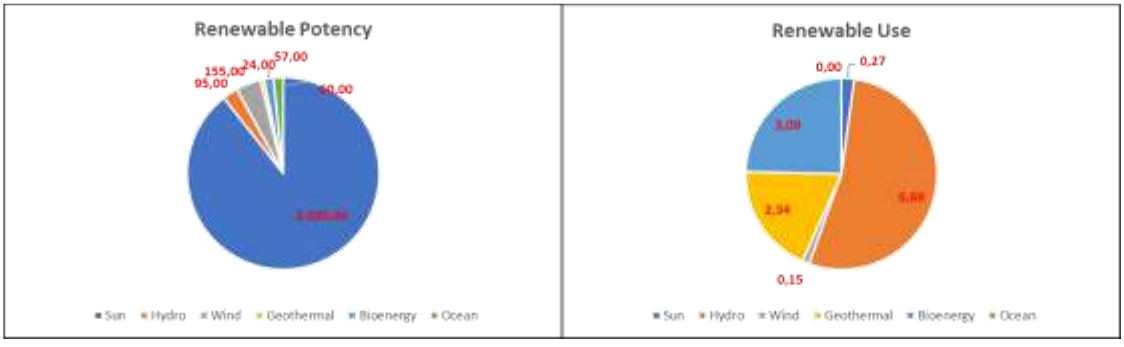

Fig. 1: Renewable energy potency and achieved capacity (in MW) in Indonesia [11] (Source of Ministry of Energy and Mineral Resources, available at https://ebtke.esdm.go.id/post/2023/02/06/3420/miliki.potensi.ebt.3.686.gw.sekjen.rida.modal.utama.jalankan.transisi.energi.indonesia)

Indonesia's energy status

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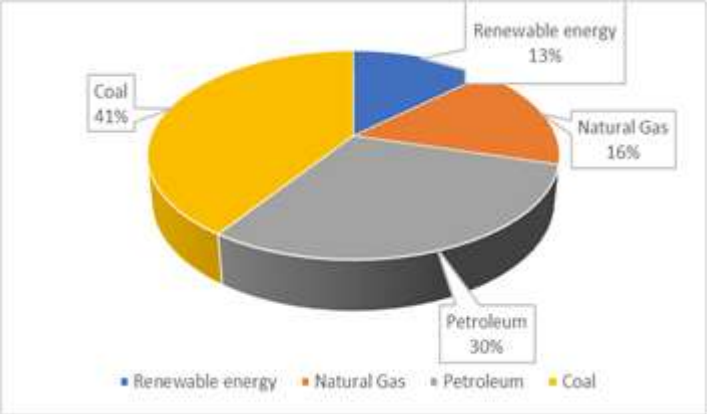

Fig. 2: Energy mix in Indonesia in 2023, where the position of renewable energy is still low

4. A Renewable Energy in Indonesia

Solar Energy

To convert solar energy into electrical energy that can be used to supply electricity to homes, buildings, or other facilities, a Solar Power Plant (PLTS) system is used. The PLTS system is a series of solar panels, inverters, cables, and other components needed to generate and manage electrical energy from sunlight. Currently, in Indonesia, there are only 4 PLTS, including (1) PLTS Cirata, the largest floating PLTS in Southeast Asia with an installed capacity of 192 MWp. (2) PLTS Likupang is located in Wineru Village, Likupang Timur District, North Minahasa Regency, North Sulawesi Province. Around 64,640 solar panels are built on a 29-hectare solar field at this location. PLTS Likupang has an installed capacity of 21 MWp, which supports electricity in the PLN Sulutgo (North Sulawesi-Gorontalo) network. (3) Oelpuah PLTS is located in Oelpuah Village, Kupang Tengah District, Kupang Regency, East Nusa Tenggara. This PLTS has an installed capacity of 5 MWp consisting of 22,008 solar modules in an area of 7.5 hectares. (4) The Coca-Cola Amatil Company installed a PLTS covering an area of 72,000 meters on the roof of the Coca-Cola company factory in Cikarang, West Java. The installed capacity of the rooftop PLTS in the company reached 7.2 MWp. Compared to the enormous potential for solar energy in Indonesia, the existence of the PLTS above is still not optimal. Several technical or social obstacles have slowed the development of PLTS construction in Indonesia.

Wind energy

One of the largest sources of renewable energy in Indonesia is wind energy, which is found throughout the country. However, the potential for wind energy in each region is certainly different. The magnitude of wind energy potential is highly dependent on wind speed. The higher the wind speed in an area, the greater the potential. As reported in the 2022 Indonesian Energy Outlook released by the National Energy Council (DEN), Indonesia has a 154.9 gigawatts (GW) wind energy potential. Wind energy can generate electricity through wind power plants (PLTB). PLTB is a renewable power plant with intermittent or fluctuating energy sources.

Despite the significant wind energy potential, the current utilization of wind energy in Indonesia remains low. The Handbook of Energy & Economic Statistics of Indonesia 2021 reports that the total installed capacity of PLTB in Indonesia is a mere 157.41 megawatts (MW). Of this, 153.83 MW is connected to the PLN network, while 3.58 MW operates off-grid.

Currently, Indonesia's wind energy infrastructure is relatively modest. The largest wind power plant in the country is the Sidrap PLTB, located in South Sulawesi, with a capacity of 75 MW [12]. This is followed closely by the Jeneponto PLTB, also in South Sulawesi, with a capacity of 72 MW [13].

Geothermal

Geologically, Indonesia's position as a country crossed by the Pacific Ring of Fire means that it has abundant geothermal energy potential. However, its utilization as a renewable energy source still needs to be higher. With the potential of geothermal energy in Indonesia reaching around 23.4 GW, the installed capacity of geothermal power plants (PLTP) will be around 2.3 GW until the end of 2023[14].

Geothermal energy has several advantages over other energy sources. Although geothermal development requires a large initial investment, this source has competitive generation costs. Geothermal energy, in addition to its economic advantages, provides a stable and reliable energy source, contributing to energy security. Unlike coal, oil, and natural gas, geothermal energy is not affected by international fuel price fluctuations, further enhancing its appeal. Another advantage of geothermal energy is that it does not require large land areas in its production process and is not dependent on the weather. In addition, geothermal's operating and electricity generation costs are recorded as being among the cheapest. The average operating cost of national power plants in 2021 was recorded at IDR 1,391 per kilowatt hour (kWh). Meanwhile, the average operating cost of PLTP in 2021 was IDR 107.15 per kWh or around 7.70 percent of the average operating cost of national power plants.

As of 2023, Indonesia has 14 Geothermal Power Plants with a total capacity of 2.3 GW. The largest installed capacity is at the geothermal power plant center in Sarulla, North Sumatra, with an impressive 330 MW; while the smallest installed capacity is in Ulumbu, East Nusa Tenggara, at 10 MW. The largest geothermal power plants are found in West Java Province, span around 6 locations, and have a total installed capacity of 1194 MW.

5. Bioenergy

Indonesia's bioenergy potential is enormous as a future energy source. Bioenergy can replace fossil fuels in almost all areas, such as transportation, electricity, industry, and households. Using bioenergy, especially biomass products,

can be a better energy source to increase the electrification ratio and is projected to help improve national energy security.

Bioenergy is produced from various organic materials called biomass, such as wood, charcoal, animal waste, and other manures for heat and electricity production and crops for liquid biofuels. Most biomass is used in rural areas for cooking, lighting, and heating, usually by poor people in developing countries.

The potential for bioenergy from biomass in Indonesia is significant—it's huge. It is equivalent to 56.97 GW of electricity, and by 2060, more than 700 GW of renewable energy power plants will be built in Indonesia, of which 60 GW will come from bioenergy power plants. This optimistic outlook for renewable energy in Indonesia is a testament to the country's commitment to a sustainable future. The biomass cofiring program for existing coal-fired power plants (CFPP) will optimize biomass utilization for power generation. Cofiring has been implemented since 2020, with a blending rate of 1% to 15% depending on the type of boiler and the availability of raw materials. In the first semester of 2023, cofiring was implemented in 36 locations out of the planned 42 locations. This produced 325 GWh of green energy, which reduced emissions by 321 ktCO2. The total biomass used in the power plant is 306 kilotons.

6. Water Energy by Small-scale Hydropower (SHP)

Water Energy or Hydropower is energy produced by the movement of water that rotates a turbine. This source of energy from water flow is most often used in Indonesia by utilizing river water flow, one of which is in the form of a dam; however, large-scale dams often cause environmental and social problems such as leaks, waterlogging, residential relocation, and rejection from the community [15,16]. In Indonesia, Small-scale hydropower (SHP) has been used as an energy source since the Dutch Occupation Era (1980-1920). During that period, 400 SHPs were built [17]. In 2017-2021, SHP power plants with a total capacity of 1682 MW were installed [18]. In total, 27 micro hydropower plants were already built in 2023, with a total installed capacity of 93.76 MW [19].

7. Role of Renewable Energy in Climate Change

The International Climate Report states that global carbon emissions increased by 1.1% from 2022 to 45.1 billion tons in 2023. Land use change processes, including deforestation, emissions from oil and gas, and coal, contribute to carbon emissions.

The same thing also happened in Indonesia, which showed that the use of fossil fuels, land conversion, and deforestation contributed to high carbon emissions that triggered climate change in Indonesia in 2022. The Global Carbon Project report shows that the amount of carbon produced by Indonesia increased by 18.3 percent in 2022 to 728.9 metric tons. The increase in emissions was attributed to land conversion, deforestation, and the use of fossil fuels, especially coal. Indonesia has abundant renewable energy sources: wind, water, geothermal, biomass, and solar. There are many advantages to be gained from these renewable energy sources, and these resources never run out; can replace dependence on currently used fossil energy resources. Significantly, RE can reduce heavy environmental burdens such as carbon emissions.

8. Conclusions

To obtain a cleaner and greener earth environment, the government has to support all sectors' dependence on fossil fuels, which somebody must reduce. Therefore, the government and the private sector must support renewable energy use in its development to make changes in the energy mix more optimal. Where there are restrictions on carbon emissions, this change causes the development of renewable energy to be a challenge for future energy scenarios towards a more excellent sustainable energy supply. The abundance and variety of types of renewable energy in Indonesia make it possible to expand the energy supply and develop its technology.

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