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Green technology's function in the production of renewable energy and mineral extraction

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ABSTRACT

The rise in the global population has led to an increase in energy requirements. In addition to the prospect of a future energy crisis resulting from the depletion of fossil fuel reserves, the provision of energy that continues to rely on nonrenewable resources, leads to a decline in environmental support capacity owing to CO_2 gas pollution. Bioenergy derived from microalgae is a potential future fuel source. Bioenergy development of microalgae is seen as having several benefits, including plentiful resources, ease of development, a high oil content with the potential to be produced as biofuels, the ability to grow in a variety of water and waste conditions, and the ability to cut CO_2 emissions. This research was conducted using a combination of literature analysis and prior study observations. The findings indicate that microalgae have enormous potential for development as bioenergy and may aid in the resolution of environmental issues, particularly those associated with the reduction of CO_2 emission gases and the decrease of pollutant levels in liquid waste.

Keywords: Energy crisis, Nonrenewable, Environmental, Microalgae, Bioenergy
Article type: Research Article.

INTRODUCTION

Indonesia has a large number of potential renewable energy sources. Some of them can be immediately applied in the country, such as bioethanol as a substitute for gasoline, and biodiesel to replace diesel, geothermal power, micro-hydro, solar power, wind power, and even garbage/waste which can be used to generate electricity. Almost all of these energy sources have been tried on a small scale in the country (Aryza *et al.* 2022). The spike in oil prices to US$ 90/barrel has affected economic activities in various parts of the world (Pertamina 2016; Aryza *et al.* 2022). In Indonesia, the momentum of the current fuel crisis (early 2023) is the right time to organize and seriously implement various potentials (Pertamina 2016; Aryza *et al.* 2022). Although it is currently very difficult to make a total substitution of fossil fuels, the implementation of renewable energy sources is very important to start immediately. Below we briefly discuss the various renewable energy sources. Green technological innovation strengthens Chinese green total factor productivity (Jiakui *et al.* 2023). In addition, since the drilling process is carried out using generator power, it causes air pollution that can interfere with the respiratory system (respiratory inorganics; Rosyidah *et al.* 2022). Why renewable energy? Renewable energy should be developed immediately nationally. If it remains dependent on fossil energy, this will pose at least three serious threats, as follows:

1. Depletion of known petroleum reserves (without the discovery of new oil wells)

2. Price increases/instability due to demand being greater than oil production, and
3. Greenhouse gas pollution (mainly CO_2) due to fossil fuel combustion.

Current CO_2 levels are said to be the highest for 125,000 years. While scientists are still debating the size of the oil reserves that can still be explored, the impact of CO_2 on global warming is agreed upon by almost everyone. This poses a serious threat to the life of living things on Earth. Therefore, the development and implementation of environmentally friendly renewable fuels need serious attention. In addition, the findings show that properly reducing economic and governmental barriers, encourage farmers to use biogas plants productively and substantially (Ali *et al.* 2023). The necessities of life for each individual in the community will certainly not be the same. To be able to fulfil the purpose of these needs, it is financed by the availability of funds or financial means (Sungkawaningrum *et al.* 2022). Government Regulations, i.e., PP No. 79/2014 and Presidential Regulation No. 22/2017 stipulate that by 2025 Indonesia should achieve a renewable energy mix of 23% of primary energy. Despite this ambitious target, renewable energy development has been slow. The renewable energy mix has only increased by 0.55% per year over the past few years, while it should grow at least 2-3% to achieve the set target. Several important policy implications are derived from the results to encourage financial globalization, green innovation technologies, renewable energy resources consumption, and environmental taxes (Ramzan *et al.* 2023). In maximizing the employment of new and renewable energy, the highest weight lies in renewable energy per tonne of FFB and using solid waste (empty shells and shells) as a substitute for fossil fuels of 45.5% each (Rosyidah *et al.* 2022).

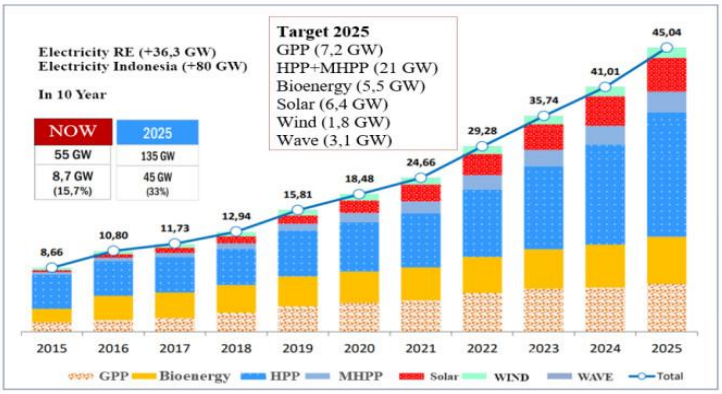

Fig. 1. Policies and laws in the application of renewable energy Indonesia: A review (Widya Yudha & Tjahjono 2019).

In 2022, the Ministry of Energy and Mineral Resources targets the share of renewable energy in the primary energy mix to reach 15.7%, along with the addition of renewable energy generation of 335 MW from rooftop solar power plants and 648 MW from other plants (Fig. 1; Diddy Rusdiansyah 2015; Pertamina 2016; Rumkel *et al.* 2018; Widya Yudha & Tjahjono 2019; Agatha Olivia & Resinta 2022). The investment in renewable energy is expected to reach USD 3.9 billion. The Indonesia Energy Transition Outlook (IETO 2023) reported from IESR found that the growth of the renewable energy mix of total primary energy decreased from 11.5% in 2021 to 10.4% in 2022 (Fig. 2). During the same period, the coal mix continued to rise from 39% to 43%. The study focuses on the role of country risks and renewable energy on the EF (Adebayo *et al.* 2023). This study conducted in one construction company in Indonesia which was facing several problems and many projects that already ended have delays (Andiyan *et al.* 2021).

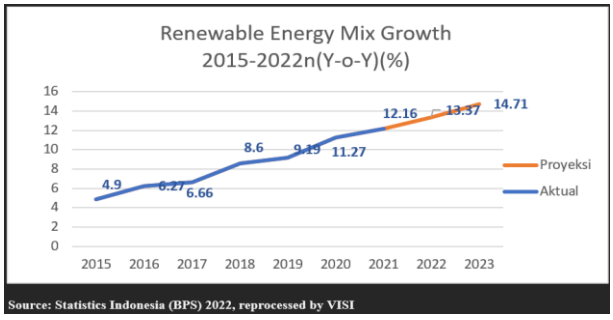

Fig. 2. Renewable Energy Mix Growth.

Biodiesel

Produced biodiesel is provided from fresh or used vegetable oils and animal fat. This fuel is biodegradable. When it is used as a component, it requires minimal changes in the engine. It is also a clean fuel compared to the diesel that it replaces (Ashok & Nanthagopal 2019). Vegetable oils can be combined with an alcohol to produce chemical compounds called esters. When these esters are used for fuel, they are called biodiesel (Knothe & Razon 2017). Glycerol (which is also used in pharmaceuticals and cosmetics) is produced as a by-product. Recently, biodiesel is produced through a process called "transesterification" (Orege *et al.* 2022; Kalita *et al.* 2022). In this process, vegetable oil (or animal fat) is first passed through a filter. Afterward, it is treated with alkali to remove free fatty acids, then combined with an alcohol (methanol) and a catalyst (sodium or potassium hydroxide). Triglycerides of oil perform a chemical reaction to form esters and glycerol, and later they are separated from each other and purified (Orege *et al.* 2022; Kalita *et al.* 2022).

Renewable Energies

Since 2020, the increase in the renewable energy mix has relied on the addition of renewable energy power generation capacity (Widya Yudha & Tjahjono 2019). After the success of B30, the addition of biofuel (BBN) has been relatively stagnant due to the delay in the implementation of B40. The delay occurred due to the elevation in the palm oil prices and the decline in fuel consumption due to the Covid-19 pandemic. IETO estimates that this year's investment achievement is only USD 1.4 billion or 35% of the target. Since 2018, the renewable energy investment target has never been achieved. Over the past five years, citing the Indonesia Sustainable Finance Outlook 2023, the average renewable energy investment has only reached USD 1.6 billion per year, or 20% of the total investment needed to achieve the 23% mix target in 2025 (IESR 2022). Financial inclusion, green innovation, energy efficiency and industrial production exhibited some effects on ecological footprints (Singh *et al.* 2023). The proposed system leverages high performance when compared to the existing models (Kumar *et al.* 2022).

MATERIALS AND METHODS

The author applied a qualitative research method with a literature review approach in this study according to Creswell & Creswell (2017). A literature review is a research approach based on non-numerical data, which can be in the form of text and images, and the results are then filtered to explain and interpret. This research was conducted using literature sources such as journals, books, theses, research reports, and scientific articles whose sources are valid and reliable.

RESULTS AND DISCUSSION

The Ministry of Energy and Mineral Resources (ESDM) targets that by 2023, New Renewable Energy and Energy Conservation (EBTKE) infrastructure that has a direct impact on society will continue to be encouraged, including the construction of 31,075 units of Public Street Lighting - Solar Power (PJU-TS), the construction of 3 units of Micro Hydro Power Plants (PLTMH), as well as 7,500 units of Electric Power Distribution Equipment (APDAL; Pertamina 2016; Widya Yudha & Tjahjono 2019; Putro 2022; Agatha Olivia & Resinta 2022). Director General of EBTKE in the Ministry of Energy and Mineral Resources revealed that the infrastructure development is intended for communities that are difficult to reach by electricity networks (Diddy Rusdiansyah 2015; Rumkel *et al.* 2018; Widya Yudha & Tjahjono 2019; Putro 2022; Agatha Olivia & Resinta 2022). "The plan is to build 12 units of Integrated Solar Power Plant (PLTS), so this is a centralized PLTS that is off the grid. So there is a PLTS, and also a network to the community directly. Sentiment analysis is a way to automatically understand and process text data to figure out how someone feels about an opinion sentence (Rijal *et al.* 2023). This year experienced an increase in the capacity of power plants sourced from New Renewable Energy (EBT) of 368.5 MW. So it will take considerable investment. Thus, based on information that we already know where the project is and when it will be completed, it costs an investment of USD 1.799 billion. For Non-Tax State Revenue (PNBP) from the EBTKE Sub-sector this year, the target set is Rp 1.811 trillion, whereas in 2022 the achievement of EBTKE PNBP increased up to Rp 2.326 trillion. Meanwhile, the implementation of the biodiesel fuel mixture program from 30% to 35% or B35 is targeted at 12.99 million kiloliters (KL), and the application of B35 itself into diesel fuel (BBM) began February 2022. Seventhly, pedestrian paths were provided comfortably in the dormitory environment to reduce vehicle use. Finally, planting the grasses and using paving blocks were performed in the landscape area around the dormitory to reduce rainwater runoff and maintain water supply around the site (Munawaroh *et al.*

2022). Given the reduction of Greenhouse Gas Emissions (GHG), it was said that this year's reduction plan was 116 million tons of CO_2. Meanwhile, the final energy intensity reduction was 0.8 SBM per billion rupiahs. On the New Renewable Energy (EBT) mix, it was also said that the target in 2023 was 17.9%. This is based on the National Medium-Term Development Plan (RPJMN) from Bappenas RI. For 2023 the target was 17.9%, so it should be like that (Fig. 3).

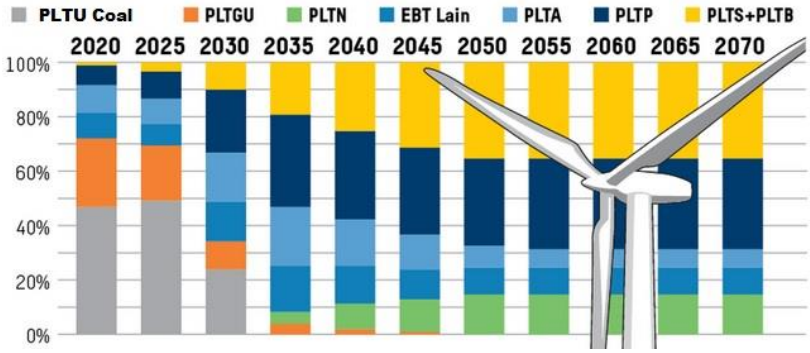

Fig. 3. Share of technology in electricity Supply (Zero Emissions Scenario 2060) (Source: Indonesia Low Carbon Development Report).

1. **The target for the renewable energy mix in 2025 is 23%.**

To encourage the use of renewable energy by 2025 and support the commitment to achieve the Nationally Determined Contribution (NDC) by 2030, Indonesia requires a large budget, which reaches 167 billion USD (source: Renewable Energy Investment Financing Mechanism Report by Bappenas and GGGI; Agatha Olivia & Resinta 2022; Greengrowth 2023).

2. **Potential utilization of renewable energy of 417.8 GW**

Studies from the Ministry of Energy and Mineral Resources state that the large potential of renewable energy is the capital of national energy security (Fig. 4; Diddy Rusdiansyah 2015; Pertamina 2016; Widya Yudha & Tjahjono 2019; Putro 2022; Agatha Olivia & Resinta 2022; Greengrowth 2023). We have the potential to utilize 417.8 GW of renewable energy from:

- Ocean 17.9 GW
- Geothermal 23.9 GW
- Bioenergy 32.6 GW
- Wind power 60.6 GW
- Hydropower 75 GW
- Solar power 207.8 GW

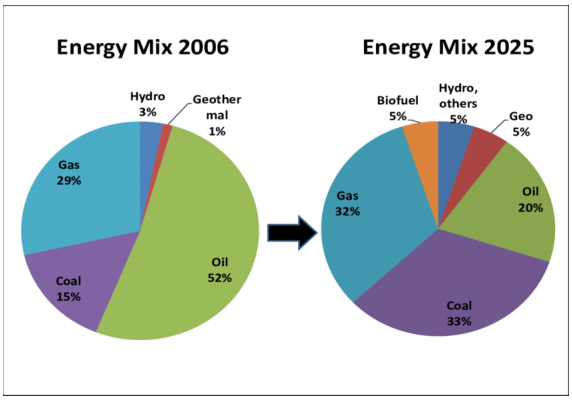

Fig. 4. Indonesia's Mix Energy Policy.

3. **Indonesia is the most promising country in Southeast Asia**

Indonesia is a country with high economic growth when compared to several other countries in the Southeast Asian region, and has great opportunities to encourage the development of renewable energy investment, as well

as being included in the list of 40 attractive countries for renewable energy investment (source: Index RECAI; Pertamina 2016; Agatha Olivia & Resinta 2022; Greengrowth 2023).

4. Green financing facility as an alternative source of funding

Currently, green finance facilities are used as an alternative source of funding for low-carbon investments, including investments in the development and construction of renewable energy facilities (Agatha Olivia & Resinta 2022; Greengrowth 2023).

5. Launching green sukuk as an effort to mobilize international funding for climate projects in Indonesia

The Indonesian government issued regulations on green bonds and green sukuk in 2017. Furthermore, the Indonesian government launched a USD 3 billion green sukuk in 2018 (Agatha Olivia & Resinta 2022; Greengrowth 2023). Indonesia has a large potential for renewable energy, including 450 MW of mini/micro hydro, 50 GW of biomass, 4.80 kWh/m^2/day of solar energy, 3-6 m/s wind energy, and 3 GW of nuclear energy(Darwanto 2008; Excitonindo 2010; AD 2015; Pertamina 2016; Rumkel *et al.* 2018; Widya Yudha & Tjahjono 2019; Erdiwansyah *et al.* 2020; Agatha Olivia & Resinta 2022). The latest EBT potential data was presented by the Director of New Renewable Energy and Energy Conservation in a Focus Group Discussion on Supply-Demand of New Renewable Energy recently organized by Pusdatin ESDM (Darwanto 2008; Excitonindo 2010; Diddy Rusdiansyah 2015; Pertamina 2016; Rumkel *et al.* 2018; Widya Yudha & Tjahjono 2019; Erdiwansyah *et al.* 2020). Currently, the development of EBT refers to Presidential Regulation No. 5 of 2006 concerning National Energy Policy (Darwanto 2008; Excitonindo 2010; Diddy Rusdiansyah 2015; Pertamina 2016; Erdiwansyah *et al.* 2020; Putro 2022). The Presidential Regulation states that the contribution of renewable energy in the national primary energy mix in 2025 is 17% with a composition of 5% biofuels, 5% geothermal, 5% biomass, nuclear, water, solar, and wind, and 2% liquefied coal (Darwanto 2008; Excitonindo 2010; Diddy Rusdiansyah 2015; Pertamina 2016; Rumkel *et al.* 2018; Widya Yudha & Tjahjono 2019; Erdiwansyah *et al.* 2020; Putro 2022). For this reason, the steps to be taken by the Government are to increase the installed capacity of Micro Hydro Power Plants to 2,846 MW in 2025, the installed capacity of Biomass to 180 MW in 2020, the installed capacity of wind (PLT Bayu) of 0.97 GW in 2025, solar 0.87 GW in 2024, and nuclear 4.2 GW in 2024 (Fig. 5). The total investment absorbed by renewable energy development until 2025 is projected at 13,197 million USD (Diddy Rusdiansyah 2015; Pertamina 2016; Rumkel *et al.* 2018; Erdiwansyah *et al.* 2020; Putro 2022).

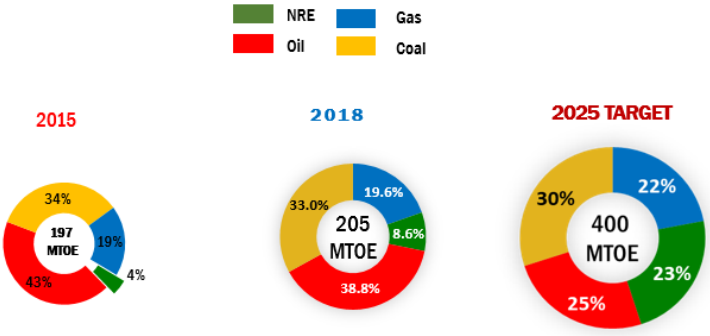

Fig. 5. The urgency of the New and Renewable Energy Law in Indonesia.

Efforts made to develop biomass are to encourage the utilization of agricultural and forestry industry waste as an energy source in an integrated manner with the industry, integrate biomass development with community economic activities, encourage the manufacture of biomass energy conversion technology and support businesses, and the increased research and development on the utilization of waste including municipal waste for energy (Darwanto 2008; Excitonindo 2010; Diddy Rusdiansyah 2015; Rumkel *et al.* 2018). Efforts to develop wind energy include developing wind energy for electricity and non-electricity (water pumping for irrigation and clean water), developing simple wind energy technology for small scale (10 kW) and medium scale (50 - 100 kW), and encouraging manufacturers to mass produce small and medium scale SKEA (Darwanto 2008; Excitonindo 2010; AD 2015; Rumkel *et al.* 2018; Putro 2022). It was surprising to find evidence of the studies developing Islamic economics and its principles, welfare, and economic democracy based on Pancasila (Guritno *et al.* 2023). Solar

energy development includes the utilization of PLTS in rural and urban areas, encouraging the commercialization of PLTS by maximizing private involvement, developing the domestic PLTS industry, and encouraging the creation of efficient funding systems and patterns by involving the banking world (Darwanto 2008; Excitonindo 2010; Rumkel *et al.* 2018; Putro 2022). To develop nuclear energy, the steps taken by the government are to conduct socialization to gain public support and to cooperate with various countries to improve technological mastery. The research concludes that the internal critical values, innovation, mindset, and moral enforcement inherent in sharia accounting are appropriate for anti-corruption accounting schemes (Arwani *et al.* 2022). The steps taken for micro hydro development are to integrate the MHP development program with community economic activities, maximize the potential of irrigation channels for MHP, encourage the domestic micro hydro industry, and develop various effective partnerships and funding patterns. To support renewable energy development efforts and programs, the government has issued a series of policies and regulations including: (i) Presidential Regulation No. 5/2006 on National Energy Policy; Law No. 30/2007 on Energy; Law No. 15/1985 on Electricity; Government Regulation No. 10/1989 as amended by Government Regulation No. 03/2005 on Amendment to Government Regulation No. 10/1989 on Electricity (Darwanto 2008; Excitonindo 2010; Diddy Rusdiansyah 2015; Erdiwansyah *et al.* 2020; Aryza *et al.* 2022); At the time of 03/2005 on the Amendment of Government Regulation No. 10 of 1989 on Electricity Supply and Utilization and Government Regulation No. 26/2006 on Electricity Supply and Utilization, Minister of Energy and Mineral Resources Regulation No. 002/2006 on Medium Scale Renewable Energy Power Plant Business, and Minister of Energy and Mineral Resources Decree No. 1122 (Darwanto 2008; Excitonindo 2010; AD 2015; Widya Yudha & Tjahjono 2019; Erdiwansyah *et al.* 2020); K/30/MEM/2002 on Small Scale Distributed Generation (Pertamina 2016; Widya Yudha & Tjahjono 2019); Currently, the RPP for New and Renewable Energy is being drafted, which contains regulations on the obligation to provide and utilize new and renewable energy and provide convenience and incentives (Fig. 6).

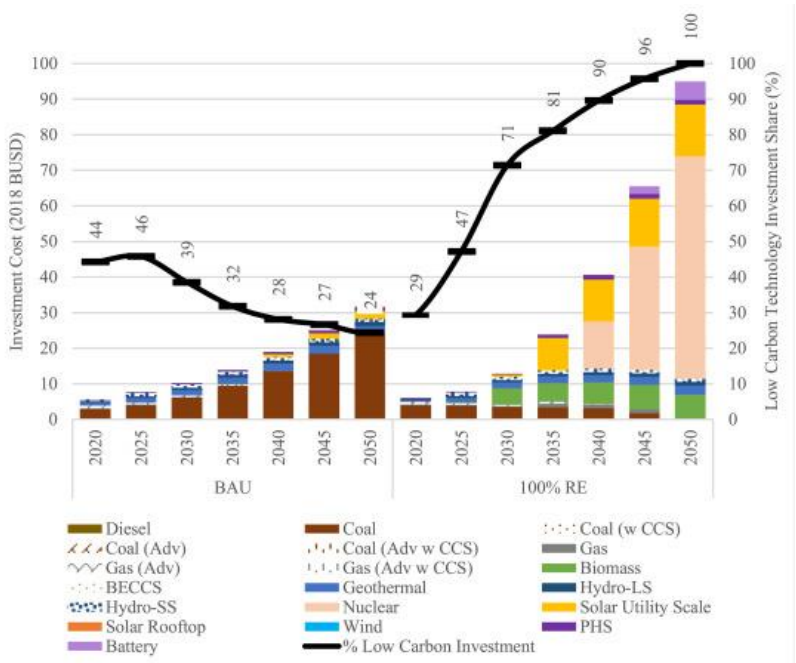

Fig. 6. Pathway toward 100% renewable energy in Indonesia's power system by 2050.

As a national agenda, Indonesia's energy transition is one of the efforts to maintain energy security and realize a green economy in Indonesia. The energy transition also demonstrates Indonesia's commitment to expanding access for affordable and clean technologies in order to drive a sustainable and greener economic recovery. So that, the Government has increased the target composition of New and Renewable Energy (EBET) in the energy mix to 23% by 2025 and 31% by 2050 (Darwanto 2008; Excitonindo 2010). Indonesia has the potential to utilize EBET sources, for example, the development of the Green Industrial Park in North Kalimantan whose energy source is the Kayan River. The hydropower potential of the Kayan River is estimated at 11-13 gigawatts. Indonesia also has other green energy in the form of geothermal. Geothermal potential in Indonesia is among the largest in the world with hundreds of potential points spread across Indonesia (Pertamina 2016). Based on data from the

Ministry of Energy and Mineral Resources, the geothermal potential in Indonesia is around 23.4 gigawatts with an installed PLTP capacity of 2.3 gigawatts, so Indonesia is in second place in the world after the United States in utilizing geothermal as electricity (Widya Yudha & Tjahjono 2019; Putro 2022; Agatha Olivia & Resinta 2022). Geothermal energy is good energy generated from magma in the bowels of the earth in volcanic areas. Hot steam and high pressure emitted from wellhead production can be utilized to drive steam turbines in geothermal power plants or used directly to dry agricultural products. Geothermal energy is clean energy that is sustainable if managed properly. Geothermal plays an increasingly important role in decarbonization programs to support clean energy. Geothermal utilization is in line with one of the principles in the Bali Compact agreed at the 2022 Indonesia G20 Presidency, i.e., efforts to diversify the energy system and mix, and reduce emissions from all energy sources. Renewable energy characteristics significantly influence electrolyzer performance (Kojima *et al.* 2023).

Increased clean energy electricity capacity

The growth of the renewable energy mix in Indonesia decreased from 11.5% in 2021 to 10.4% in 2022. This decline is due to the obstruction of the biodiesel program. The increase in renewable energy power generation capacity is also very small compared to the addition of 4 gigawatts (GW) of power plant capacity in Java in 2022. This is a result of the post-pandemic economic recovery that still relies on fossil fuels (Gunawan 2023). To achieve the 2030 emission target, the government needs to take several strategic steps to accelerate the addition of renewable energy capacity (Gunawan 2023). At first, the government should immediately revise the Electricity Supply Business Plan (RUPTL) to be in line with the new commitments stated in the E-NDC document (Pertamina 2016). Secondly, the development of renewable energy power projects should begin in 2023 and continue through 2025 to be operational before 2030 (Gunawan 2023). As global support for Indonesia's energy transition efforts increases, 2023 could be a golden year to boost the growth of the renewable energy mix (Gunawan 2023). Some of the clean energy projects that will begin operations in 2023, include the Patuha geothermal power plant in West Java (55 megawatts/MW), the Peusangan hydroelectric power plant in Aceh and Asahan in North Sumatra (45 MW and 174 MW), and the Cirata floating solar power plant in West Java (145 MW; Gunawan 2023). To encourage other renewable energy projects, the government needs to provide incentives in the form of tax deductions, as well as clarify and simplify the licensing process for renewable energy investments (Gunawan 2023). In addition, regulations and incentives for rooftop solar panel installations in residential areas and offices should be improved to stimulate public interest in using clean energy (Gunawan 2023).

Development of green hydrogen industry

Green hydrogen is a fuel produced from renewable energy (Gunawan 2023). This energy plays an important role in cutting emissions in industrial sectors that find it difficult to electrify their machinery, e.g., the steel, cement, fertilizer, and heavy equipment industries. Impact of renewable energy supply, green energy investment, environmental tax, and economic growth on green technology innovation (Tiwari *et al*. 2023). In Indonesia, the development of the green hydrogen industry is still at a very early stage. In a roadmap document towards net-zero emissions that have not yet been legalized, the government set a target of 328 MW of green hydrogen production capacity by 2030 and then jumped to 52 GW by 2060. However, the implementation of this green hydrogen development plan is still constrained by high production costs and limited supporting infrastructure. The constraints of green hydrogen development in Indonesia should be overcome by 2023 by taking some initial steps. Firstly, the government needs to develop a detailed roadmap for the development of the national green hydrogen industry and supporting policies. This step is important to help achieve competitive production costs and attract domestic and foreign investment. Secondly, pilot projects should be realized immediately to demonstrate that the hydrogen industry is economically viable. This year is the starting point for Pertamina's plan to produce green hydrogen on a pilot scale with a capacity of 100 kg per day in the Ulubelu Geothermal Working Area (WKP), Lampung (Gunawan 2023).

Downstream nickel industry into electric car batteries

In the era of energy transition, nickel is a vital commodity, since it is one of the main raw materials for making electric vehicle batteries. Indonesia is one of the countries with the largest nickel reserves in the world (21 million tons; Gunawan 2023; Pertamina 2016). Unfortunately, most nickel is still exported in the form of raw materials

or ore. To increase the value of nickel commodities, Indonesia began to limit nickel ore exports to fulfil its ambition to become the "king" of the world's electric vehicle battery manufacturers. However, this policy has stumbled over a dispute with the European Union (Gunawan 2023). The government should move forward to achieve this ambition, while resolving the nickel dispute with the European Union (Gunawan 2023). This is because a vibrant domestic nickel processing industry can trigger a sustainable economy, as well as support the program to convert motor vehicles to electric ones. So far, the government's efforts to process nickel have been half-hearted (Gunawan 2023). Currently, nickel ore is only processed into semi-finished goods with little added value. By 2023, the government needs to immediately formulate a road map for nickel processing that is directed and focused on the final goal, i.e., electric battery products or electric vehicles (Gunawan 2023). By boosting at least 3 aspects of the energy transition, Indonesia has the opportunity to achieve the net zero emission target by 2050 under the Paris Agreement. The hope is that national economic growth can also be sustainable.

CONCLUSION

The current energy situation once again teaches us that serious and systematic efforts to develop and implement renewable energy sources to reduce dependence on fossil fuels need to be done immediately. The use of renewable and environmentally friendly energy sources also means saving the environment from various adverse impacts caused by the use of fuel. Several renewable and environmentally friendly energy sources can be applied immediately in the country, such as bioethanol, biodiesel, geothermal power, solar power, micro-hydro, wind power, and garbage/waste (Aryza *et al.* 2022). Cooperation, coordination between technical departments as well as support from industry and the community are very important to realize the implementation of these renewable energy sources.

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