JIMESE
Journal of Innovation Materials, Energy, and Sustainable Engineering
JIMESE 2(2): 95–109
ISSN 3048-2380

Institute for Advanced Science, Social and Sustainable Future
MORALITY BEFORE KNOWLEDGE

Renewable energy development towards indonesia's energy transition: Technological innovations for a sustainable future

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Received Date: December 12, 2024 Revised Date: January 29, 2025 Accepted Date: January 30, 2025

ABSTRACT

Background: Global climate change has significantly impacted Indonesia, leading to various challenges such as water scarcity, the degradation of marine and land ecosystems, and food instability. These environmental issues are also affecting public health and the nation's economy. Increased frequency of natural disasters like floods, landslides, and droughts is resulting in agricultural losses, while rising sea temperatures and changing seawater composition threaten fishery resources. Addressing these issues is critical for both environmental preservation and strengthening Indonesia's economy. **Method**: This study employs a literature review approach to explore Indonesia's strategy for transitioning to renewable energy. By analyzing various sources and reports, the paper aims to understand the country's energy transition and the economic and environmental implications of continuing reliance on non-renewable energy. **Findings:** The study finds that Indonesia is facing significant negative impacts from climate change, which are expected to cause economic losses ranging from 0.66% to 3.45% of GDP by 2030. These impacts are particularly due to the use of non-renewable energy sources. Transitioning to renewable energy is viewed as a vital solution for mitigating these losses, but it requires collaboration from government bodies, communities, and the private sector. **Conclusion:** Efforts to mitigate climate change and adapt to its impacts are crucial for the sustainability of Indonesia's economy, public health, and environmental preservation. A transition to renewable energy is essential, but it requires concerted efforts from various stakeholders to ensure its success and address the broader challenges posed by climate change. **Novelty/Originality of this Study:** This study offers a comprehensive review of Indonesia's renewable energy transition strategy, providing new insights into how mitigating the impacts of climate change through renewable energy could contribute to economic sustainability. The analysis emphasizes the collaborative approach needed from multiple stakeholders to address the challenges of climate change and transition away from non-renewable energy sources.

KEYWORDS: climate; ecosystem; economy; Indonesia; renewable energy.

1. Introduction

Energy is one of the most essential and fundamental needs for all human activities, particularly in the context of carrying out economic activities and fostering global economic growth (Pambudi et al., 2023; Tsangas et al., 2022). The use of non-renewable energy sources from fossils has consequences, leading to an increase in greenhouse gases, air and water pollution, as well as a decline in overall environmental quality, contributing to climate change (Al Hakim, 2020; Aprilianto & Ariefianto, 2021; Pambudi et al., 2023). Citing from the Intergovernmental Panel on Climate Change, it was mentioned that climate change has had impacts on humans, ecosystems, and livelihoods worldwide (Tsangas et al., 2022). With

Cite This Article:
Fahmi, Y. (2025). Renewable energy development towards Indonesia's energy transition. *Journal of Innovation Materials, Energy, and Sustainable Engineering, 2*(2), 95-109. https://doi.org/10.61511/jimese.v2i2.2025.1488

the declining reserves of fossil energy sources, a transition to new renewable energy sources will occur to meet the increasing needs of energy consumption along with the growing human population (Pambudi et al., 2023; Ratnaningsih, 2022). The transition to new renewable energy is also undertaken as an effort to reduce the negative impact on the environment. According to the result of analysis of several world meteorological agencies and NASA data, it is concluded that the Earth's temperature is increasing sharply in an exponential manner. It is estimated that by 2025, the global average temperature change will reach 1.2 degrees Celsius. The energy sector is one of the major contributors to CO_2 emissions, which contributes to the rising global temperatures. In light of this, to support efforts in achieving global commitments to reduce greenhouse gas emissions, Indonesia must promptly shift its strategy from the use of unsustainable fossil energy towards renewable energy sources.

Perusahaan Listrik Negara (PLN), the state-owned electricity company in Indonesia, is set to undergo an energy transition through various efforts, including emphasizing decarbonization of fossil fuel-based power plants, increasing the capacity of renewable energy, and developing supporting infrastructure such as smart grids and control systems, as well as fostering a green ecosystem. This energy transition poses numerous challenges but also presents opportunities for our nation to achieve self-sufficiency, particularly in energy provision. Some of the actions taken by PLN among others is cancelling the construction of 13.3 GW of coal-fired power plants originally planned in the Electricity Supply Business Plan for the period of 2019-2028. This decision is expected to avoid approximately 1.8 billion tons of CO_2 emissions over the next 25 years. Furthermore, PLN also canceled 1.3 GW of coal-fired power plants that had already signed the power purchase agreements (PPA), which would prevent around 200 million tons of CO_2 emissions. Additionally, PLN replaced 1.1 GW of coal-fired power plants with renewable energy facilities, and 800 MW of coal-fired power plants with gas-fired power plants. These initiatives are aimed at reducing emissions by approximately 300 million tons of CO_2. The actions taken by PLN indicate a shift towards cleaner and more sustainable energy sources in Indonesia.

In Indonesia, the renewable energy potential is considered by many to elevate its position as one of the leading countries globally in the development of renewable energy (Adrian et al., 2023). The national energy policy set by Indonesian Government is set at ambitious target for optimal power mix of 23% in 2025 sourced from renewable energy sources and further incresed to 31% by 2050 (Tambunan et al., 2020). As part of the global effort to reduce Greenhouse Gas (GHG) emissions, the Indonesian government has committed in contributing to the reduction of these emissions. One crucial step that needs to be taken promptly is shifting from fossil fuels, which significantly contribute to CO_2 emissions, towards the new renewable energy. Renewable energy is the backbone in supporting national energy resilience due to the untapped potential of renewable energy sources. In Indonesia's energy sector, legal certainty, permits, and land acquisition pose challenges that hinder investments. Additionally, limited state budgeting results in less satisfactory support for renewable energy in Indonesia (Ratnaningsih, 2022).

Shifting to renewable energy is the key to significantly reducing GHG emissions. Renewable energy sources such as solar power, wind energy, biomass, and hydroelectricity have the potential to decrease reliance on fossil fuels. By adopting these technologies, Indonesia can reduce its carbon footprint while expanding access to sustainable, clean, and environmentally friendly energy. The transition to a low-carbon energy system using renewable energy has become a global policy agenda for climate change mitigation, promoting sustainable development, and ensuring a country's energy resilience. In some European and American countries, renewable energy is the primary source to support national energy resilience and sustainable economic sectors. Indonesia has a similar opportunity to develop renewable energy given its potential (Anggraini & Indah, 2021).

The Minister of Energy and Mineral Resources of the Republic of Indonesia, Arifin Tasrif, has stated that Indonesia needs up to USD 1 trillion worth of investments in the Renewable Energy sector (Hadi et al., 2022). In addition to changing from non-renewable

energy sources, it is important to prioritize energy efficiency and strengthen emission reduction policies across all economic sectors. These measures include improving efficiency in transportation, promoting sustainable agriculture, and developing environmentally friendly industries. Collaboration between the government, private sector, and civil society is crucial in bringing this transformation to realization. Previous analyses have shown that four dimensions will explain the concept of renewable energy as a social construction, which could serve as policy recommendations in the energy sector for the government to maintain the availability of energy supply in the strategic issue of national energy resilience (Anggraini, 2022).

Through these steps, Indonesia can play a more active role in combating global climate change. By shifting the energy paradigm from fossil to renewable sources, it is hoped that a positive long-term impact can be created in preserving the environment, preventing further impacts on the climate change, and ensuring economic sustainability for future generations. Among others, as cited from Misna (2021): the acceleration strategy for renewable energy includes; substitution of primary/final energy by continue using the existing technologies, namely B30, biohydrocarbon, and co-firing biomass/Refuse Derived Fuel (RDF) in Steam Power Plants, conversion of fossil primary energy by replacing generator technologies/converting diesel powered plants or steam power plants with renewable rnergy power plants, adding renewable energy capacity to meet new demand with a focus on solar power plants, and utilization of non-electric/non-BBN renewable energy (biobriquettes, biogas, and biomethane/bio-CNG).

Given by the potential available in Indonesia and the commitment to contribute to net zero emissions, this research will cover discussions on the renewable energy resouces potential in Indonesia. Using literature review, this research aims to elaborate the potential resources of renewable energy available in Indonesia and the challenges to fully utilize it. In addition to that, this research will discuss on Indonesia's commitment to net zero emissions and how the renewable energy policy will support its achievements.

2. Methods

This study was conducted using a journal review or literature review method by collecting journal articles, proceedings, books, and other scientific studies through Scopus and Google Scholar with a focus on renewable energy. The literature review research method is capable of integrating various results and perspectives from empirical research that reflects an understanding not only from one field but a combination of several fields of study (Snyder, 2019). This research is conducted though reviewing journals, articles, books, and related academic publications and syntesize the review in the discussion section. The approach used in this literature review is semi-systematic review. The semi-systematic review is designed to review topics that has been conceived by broad reseach group and by multi discipline studies (Snyder, 2019).

This study collected journal articles published between 2019-2023 using keywords such as 'renewable energy,' 'climate change,' 'energy,' and 'economics.' The articles were identified using Scopus and Google Scholar and then imported into the Mendeley reference management program to avoid duplications. Researcher manually reviewed the articles to ensure content alignment with the topic of renewable energy. Articles that are meeting the suitability criteria were further examined as potential materials for the study. Suitability criteria included: (1) the main topic of the article and journal is aligning with the theme of renewable energy and energy transition, (2) full accessibility of the article and journal for the researchers, (3) research document narrated in both Indonesian and English languages, and (4) research is related to the global development of renewable energy and adaptable as a reference for studies in Indonesia.

3. Results and Discussion

Energy is a fundamental component of the contemporary economic sector, serving as the backbone for all economic activities (Tsangas et al., 2022). The increasing trend of human population and technological advancements drive various social and economic behavioral changes, ultimately resulting in an increased demand for electricity consumption in general. In Indonesia, the highest consumption rate of energy based on the sector is led by transportation and industry sectors (Pambudi et al., 2023). Both of the sectors hold important role in supporting economy and human activities in general. Breakdown of the consumption per sector can be seen in table 1.

Table 1. Total energy consumption per sector (in million BOE)

Energy Type	Total
Transportation	388,417.945
Industry	317,568.463
Household	148,985.796
Commercial	43,484.632
Others	10,788.136
Total	909,244.973

(Pambudi et al., 2023)

With the current trend of growing electricity consumption needs, it is estimated that the global electricity demand will double by the year 2050 (Atems & Hotaling, 2018). Cunningham dan Cunningham (2010) describe development as an improvement in the quality of human life, and sustainability as living with renewable resources without disrupting the ecological processes that support human life. Sustainable development is a combination of these two ideas, where the current generation can meet its needs in the present without jeopardizing the ability of future generations to meet their needs. Energy sources, as one of the key drivers of the economy, need to maximize the potential use of alternative energy to meet demands. Indonesia has committed to reduce greenhouse gas emissions by transitioning to renewable energy (Harris & Ramadhan, 2022).

3.1 Potential sources of renewable energy

The types of renewable energy are generally categorized into six types based on their naturally available sources on Earth (Sorensen, 2011). Indonesia, with the advantageous of it's geographical position along the equator line, archipelagic characteristics, and diverse natural landscapes, has significant potential for a mix of all six types of renewable energy sources. The six types of renewable energy sources, as cited by Sorensen (2011) are solar energy is derived from the sun's rays, containing significant potential for generating electricity (photovoltaic energy) or heat (solar thermal energy).

To produce electricity using photovoltaic energy, a device in the form of solar panels made of semiconductor materials is required. These panels collect solar cells, arranged to effectively absorb sunlight. Geographically, Indonesia is crossed by the equator, making solar energy resources abundant, with an average solar radiation intensity of around 4.8 kWh/m2 per day throughout the country (Alim et al., 2023). Perusahaan Listrik Negara (PLN), the national company for electricity provider, has sated in their business plan that Indonesia has potential to produce more than 207 GW from solar energy source (Tambunan et al., 2020).

3.1.1 Hydro energy source and bioenergy source

Hydropower, also known as water energy, is generated from the movement of water that rotates turbines. Water possesses potential energy when at rest and kinetic energy when in motion. Both forms of energy rotate turbines to produce mechanical energy. The

mechanical energy generated from the turbine's rotation is then converted into electrical energy. The hydropower potential is highly abundant in Indonesia, reaching up to 75,000 MW and is distributed across all islands (Shofiyah et al., 2023). In recent development, river water and waterfalls have been identified as potential sources of hydropower. In addition to river and rainfall, with 62% of the area being ocean, Indonesia also has significant potential water power plant using tidal and wave energy

Bioenergy is derived from biomass, which consists of relatively young organic materials originating from plants or animals, including industrial waste from agriculture, plantations, forestry, livestock, and fisheries. Bioenergy, as a renewable energy source, can be utilized as an alternative energy source to meet the needs in the transportation, industrial, and household sectors (Al Hakim, 2020; Pambudi et al., 2023). According to the 2021 performance report from the Ministry of Energy and Mineral Resources, Indonesia has a bioenergy potential of 32,653.8 MW distributed across all provinces (Pambudi et al., 2023).

3.1.2 Wind energy source and geothermal energy source

Wind energy is generated from the movement of the wind, which drives turbines. Wind energy is one of the abundant and widely distributed energy sources in Indonesia. The Indonesian government aims to generate 7 GW of energy from wind power plants with an installed capacity of 2.2 GW by the year 2030 (Pambudi et al., 2023). To achieve this target, Indonesia plans to build wind power plants in several regions, including Garut, Sukabumi, and Jeneponto.

Geothermal energy is produced from the natural heat beneath the Earth's surface, originating from the heating of rocks and water along with other elements contained in the Earth's heat and stored in the Earth's crust. The utilization of geothermal heat for electricity began in Indonesia in 1983 with the start of operations of the geothermal power plant (Al Hakim, 2020). Indonesia is located in the Ring of Fire region, making its geographical area home to 40% of the world's geothermal reserves (Anggraini, 2022). According to data from the Geological Agency of the Ministry of Energy and Mineral Resources in December 2020, the total estimated geothermal potential in Indonesia is recorded at 23.7 GW (Al Hakim, 2020; Pambudi et al., 2023).

3.1.3 Nuclear energy source

Nuclear energy is generated from the reactions between particles within the atomic nucleus. The source of nuclear energy is the binding energy of free particles. Nuclear energy is derived from low-carbon energy sources using uranium and thorium as raw materials, which are radioactive elements (Pambudi et al., 2023). According to the data from the national energy balance analysis report for the year 2021 by the National Energy Council, Indonesia has 81,091 tons of uranium resources and 140,411 tons of thorium reserves. (Pambudi et al., 2023).

Table 2. Energy balance in Indonesia, 2021

Fuel Type	Primary Energy Supply	Power Plant	Final Energy Consumption (Industry)	Final Energy Consumption (Transportation)	Final Energy Consumption (Household)	Final Energy Consumption (Other)
Coal	558.782	470.962	87.820	0	0	0
Oil	133.009	17.512	25.776	388.157	2.657	10.788
Natural Gas	324.608	83.804	88.841	0.066	0.308	0.701
Hydro	45.948	45.948	0	0	0	0
Geothermal	29.533	29.533	0	0	0	0
Solar Energy	0.789	0.789	0	0	0	0
Wind Energy	1.071	1.071	0	0	0	0
Biofuel	65.567	0	0	0	0	0
Biogases	0.180	0	0	0	0.180	0

(Pambudi et al., 2023)

Indonesia energy consumption is still heavily dependent on non-renewable sources. In 2021, coal is being the biggest contributor to electricity generation totaling 470.962 million BOE (Pambudi et al., 2023). The balance of Indonesia energy in 2021 is shown in table 2. From this data, it is shown that despite of the availability of renewable energy sources, it is still not fully utilized by the sectors. Hydro energy source being the highest energy source contributor with 45.948 million BOE (Pambudi et al., 2023).

Indonesia has numerous alternatives for renewable energy sources that, if utilized effectively, can reduce dependence on the limited fossil fuels. The development of renewable energy utilization plan, given Indonesia's current geographical conditions and the support of several power plants established in various regions, holds significant potential to be implemented (Pambudi et al., 2023). Data from the National Energy Balance analysis report for the year 2021 by the National Energy Council, as cited in the study by Pambudi et al., (2023) state that Indonesia has a potential of 419 GW for renewable energy, detailed in Table 3. The utilization of these renewable energy sources requires government commitment, investments, and further technological development to ensure their effectiveness and contribute to global climate change mitigation efforts.

Table 3. Potential sources of renewable energy in Indonesia

Energy Source	Potential (GW)
Hydroenergy	75
Geothermal Energy	23.7
Bioenergy	32.6
Solar Energy	207.8
Wind Energy	60.6
Micro-Hydro	19.3
Total	419

(Pambudi et al., 2023)

During the span of 2018-2021 the production of renewable energy sources power plant has increasing trend due to the rising production from solar, geothermal, and hydro power plant (Pambudi et al., 2023). The utilization of solar power plant (Figure 1a), water, and geothermal (Figure 1b) show upward trends indicating the transition process is taking action and GHG emissions reduction is happening.

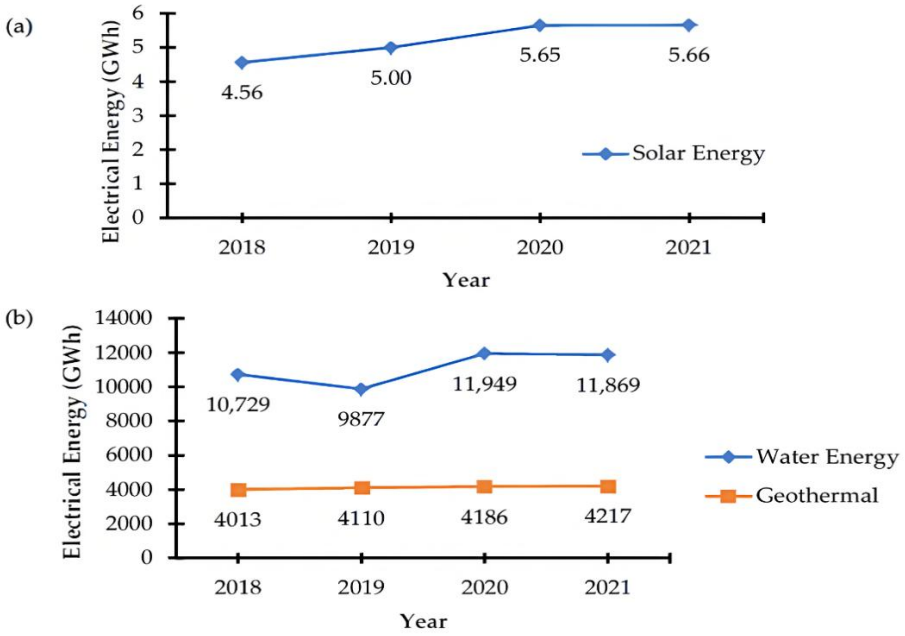
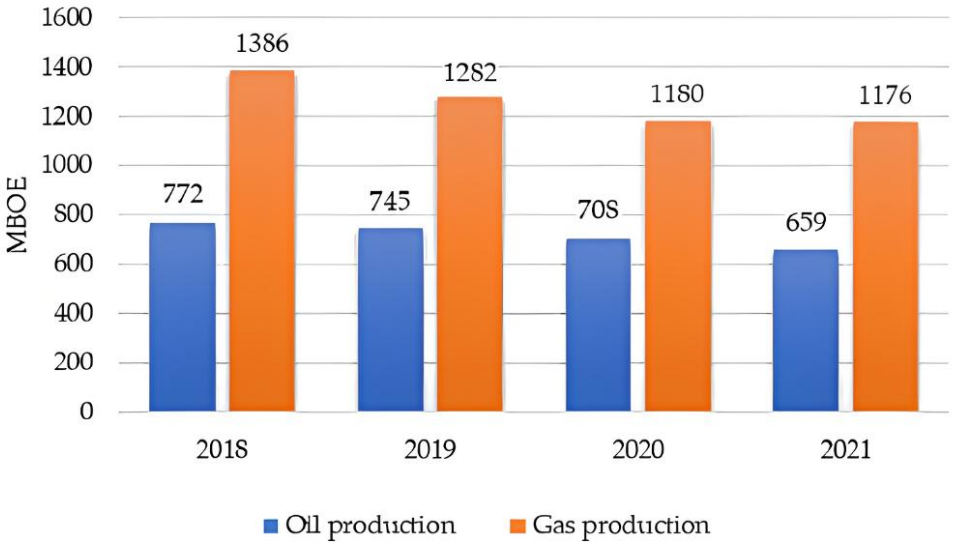


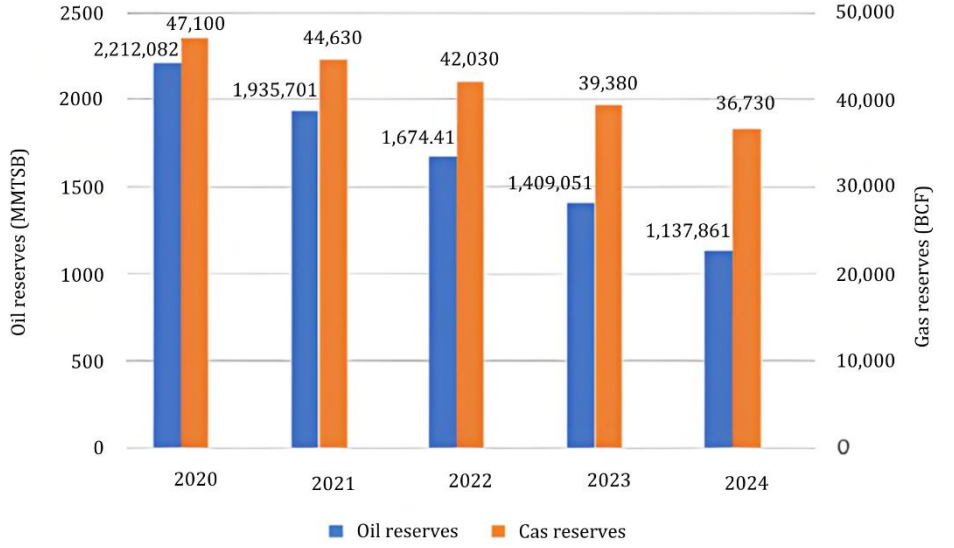
Fig. 1. (a) Solar energy production 2019-2021 trend; (b) Water and geothermal energy production 2019-2021 trend.
(Pambudi et al., 2023)

3.2 Challenges in optimizing the potential of renewable energy sources

The needs of energy sources graphic trend to serve the economic activities and cope with human population in increasing over the years (Pambudi et al., 2023; Sofyan et al., 2022; Tsangas et al., 2022). Indonesia has been heavily dependent on the fossil sources of energy despite of the potential available. In Figure 2a, shown the downward trend of oil and gas production from 2018-2021 caused by the natural decline from the nature and inability to find new large scale reserves (Pambudi et al., 2023). While in Figure 2b, the graphic of oil reserves trend is also declining and it is estimated that the remaining oil reserve in 2024 will left at 1137.86 MMSTB (Pambudi et al., 2023).



(a)



(b)

Fig. 2. (a) Gas and oil production 2018- 2021, (b) gas and oil reserves 2020-2024 (Pambudi et al., 2023)

Transitioning to renewable energy sources is much needed steps to anticipate the possibility of further deterioration to the environment which might possibly cause the insufficient energy supply. However, the sustainability of the renewable energy sources depends on various factors, including public perception and the availability of investment funds (Tsangas et al., 2022). Generally, the sustainability challenges of the renewable energy industry are divided into five elements: political, economic, social, technical, and environmental. This indicates that the fulfillment of energy needs and the utilization of

renewable energy sources cannot be viewed from a single perspective but involves a study that encompasses various interrelated aspects. Table 4. presents various potential challenges faced in the sustainability of the renewable energy industry.

Table 4. Challenges in optimizing the potential of renewable energy sources

Element	Challenges
Politic	Conflict risk
	Policy instability
	Need for deeper research and innovation for policy determination
Economy	Income equality to access energy
	Long-term stability to support renewable energy schemes
	Uncertainty/complexity of investment regulations
	Tax policies
	Limited investment funding sources
	Involvement of local communities to participate in funding and gain economic benefits
Social	Job creation
	Local communities participation
	Gender equality in participating and benefiting from access to energy
	Improving public's knowledge of renewable energy sources
Technical	Availability of necessary materials for exploring renewable energy sources
	Limited skills for technical aspects and logistical fulfillment
Environment	Environmental impact of renewable energy projects that need to be assessed further

(Tsangas et al., 2022)

Globally, these challenges are faced by every country in optimizing the renewable energy industry. Indonesia also faces these challenges. In line with the significant potential of the renewable energy mix in Indonesia, efforts to optimize its utilization come with various challenges. Lestari, (2021) wrote that there are four issues related to the renewable energy mix enhancement program in Indonesia (Ratnaningsih, 2022). First is the obstacles related to regulations and policies regarding the use of renewable energy at the national policy level. The government has outlined some positive outcomes where 15 out of 34 provincial policy stakeholders have formulated Regional Energy General Plans. However, the lack of harmony in regulations issued by the Ministry of Energy and Mineral Resources with regulations built sectorally hampers the potential for increased investment. The lack of harmony in regulations came from the different perspectives of the focus in regional versus national. Regional governments match their regulations based on the regional conditions and needs, while the national government taking all regions consideration into the regulations.

Second is the issue of outdated data which causing the required data for investors to not accurately reflect the actual conditions and affect investment decisions. Third is the dependency on grant funds from government programs. Involvement of private investors will support the fulfillment of funding needs. And the last issues is limited support, especially funding, from the government for research and development activities. As important as a good planning can be, research and development is fundamental aspect to support the good practices of exploring renewable energy sources and its utilization.

3.3 Indonesia's commitment in achieveing net zero emission

Indonesia is participating in the commitment to reduce global emissions, and in its implementation, Indonesia needs to make efforts to accelerate the energy transition to support the realization of Net Zero Emission by 2060 (Shofiyana et al., 2022). The roadmap towards Net Zero Emission (NZE) is a long-term plan that defines strategic steps to gradually reduce Greenhouse Gas (GHG) emissions until reaching a point where the amount of emissions produced is balanced with the amount absorbed or reduced from the environment. A NZE roadmap typically includes several crucial stages, as illustrated in

Figure 3. The roadmap in Figure 3 is also in line with the material presented in the Climate Change and Net Zero Emission Technical Training organized by the Human Resources Development Center for Electricity, New and Renewable Energy, and Energy Conservation in January 2023(Yulianto & Madya, 2023).

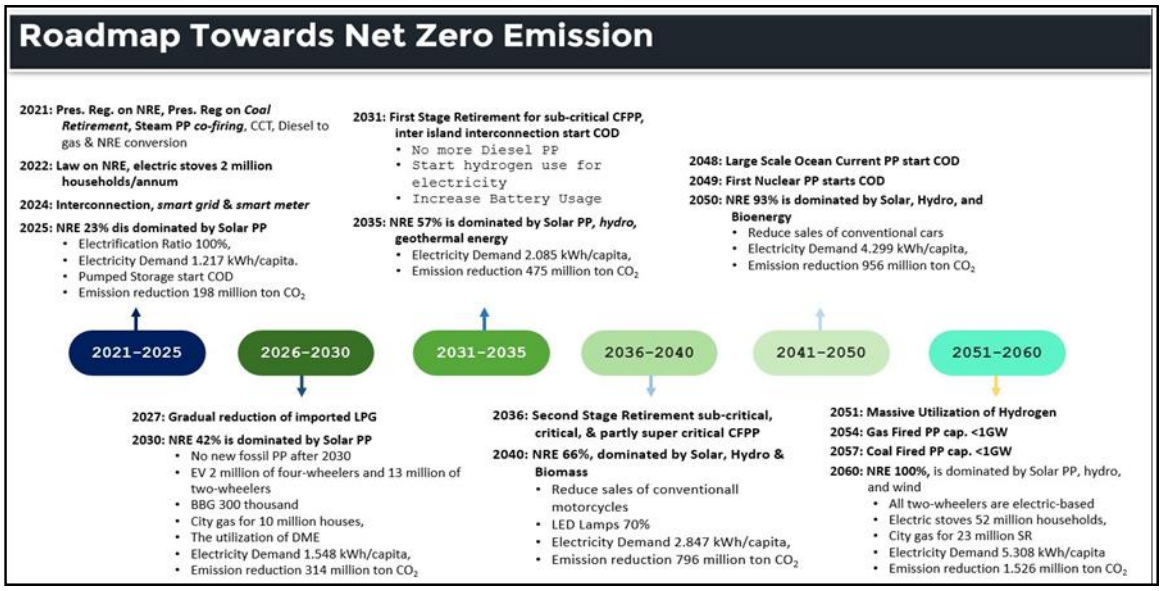


Fig. 3. Roadmap towards net zero emission energy sector

The Indonesian government stated that it will continue its efforts to achieve the target of a 23% share of new and renewable energy by 2025, despite the achievement reaching only 11.5% by 2020 (Samsurizal et al., 2021). The roadmap for the development of clean and renewable energy power plants is a detailed strategic guide to direct the development of environmentally friendly energy infrastructure. The main goal of this roadmap is to significantly increase the capacity of the renewable energy power plants and expand its outreach in providing clean, affordable, and sustainable energy supply. There are six key steps in the renewable energy power plants development roadmap which are; identify locally available renewable energy sources, set target and scheduling, infrastructure and technology improvements, supporting policy and regulation, education and training, and evaluation and continuous improvement.

In identifying locally available renewable energy sources, the roadmap should consider and specify the most suitable renewable energy sources based on local conditions, such as solar, wind, hydro, biomass, and geothermal energy potentials. This allows for the determination of the optimal type of renewable energy power plants according to local needs and potentials. By setting targets and scheduling, the roadmap should have clear targets for the development of renewable energy power plants capacity in the short, medium, and long term. Scheduling the construction of renewable energy power plants projects is crucial to securing a stable energy supply. Then, the infrastructure and technology improvement step is a crucial step to support the roadmap development. The roadmap should take into account the development of necessary infrastructure, such as transmission networks, energy storage systems, and cutting-edge technologies that support the efficiency and productivity of renewable energy power plants.

The roadmap should also be supported by policies and regulation. Policies supporting the development of PLT EBT, including tax incentives, favorable tariffs, and regulations encouraging private sector investment in renewable energy power plants development, are essential. The roadmap should also include education and training programs for the workforce involved in the development, installation, and maintenance of renewable energy power plants. This is crucial to ensure the availability of skilled labor. Then finally evaluation and continuous monitoring should be well planned. Periodic monitoring and evaluation will ensure that renewable energy power plants projects proceed as planned.

Strict monitoring is also necessary to guarantee the quality and reliability of the implemented renewable energy power plants systems.

Minimum Energy Performance Standards (MEPS) are regulations containing specifications with a set of performance requirements for energy-using equipment. MEPS effectively limit the maximum amount of energy that can be consumed by a product (Anggono et al., 2016). Energy conversion programs and the implementation of MEPS for the transportation and industrial sectors are crucial steps in directing the transition towards more efficient and clean energy usage. This can be achieved by implementing a series of policies and initiatives to reduce fossil energy consumption, adopt eco-friendly technologies, and introduce minimum performance standards for energy efficiency in key sectors.

In the transportation sector, the energy conversion program focuses on transitioning from fossil fuel vehicles to electric vehicles or low-emission vehicles. This includes incentives to promote the use of electric vehicles, the development of charging infrastructure, and the reduction of emissions from both public and private transportation.

Meanwhile, in the industrial sector, the energy conversion program aims to improve the efficiency of production processes and reduce dependence on fossil energy. This may involve adopting renewable technologies to meet industrial energy needs, using advanced energy management systems, and developing more environmentally friendly production processes. The implementation of MDEP for the industrial sector requires setting minimum energy efficiency standards, integrating green technologies into production processes, and campaigns to raise awareness about the importance of energy efficiency among industry stakeholders. One of the strategies addressing the energy conversion program carried out by PLN is the dedieselization program which aiming in reducing the use of diesel powered plants and utilizing the renewable energy produced from photovoltaic (Adrian et al., 2023). This will combine the diesel, photovoltaic and batery hybrid system to produce electricity that can be used to fulfill the industrial needs.

3.4 Renewable energy law and policy in Indonesia

The units within the Ministry of Energy and Mineral Resources, Secretariat of the Directorate General of New, Renewable Energy, and Energy Conservation (in Indonesian is abbreviated as EBTKE) that can assist in the preparation of official travel orders is the finance and general affairs department (Mulyati & Fajarita, 2018). Strengthening regulations related to new and renewable energy is crucial in accelerating investment in the energy transition. This involves a series of steps aimed at creating a legal environment that supports, encourages, and directs investments toward cleaner and sustainable energy sources. Firstly, strengthening new and renewable energy regulations involves the formulation of clear and consistent policies that support the development of renewable energy. This includes regulations on fiscal incentives, favorable tariffs, or subsidy schemes that encourage investments in renewable energy projects. Secondly, these regulations should encompass mechanisms that reduce administrative barriers and bureaucracy in the licensing process as well as land acquisition for new and renewable energy projects. The optimization of the performance of units under the Directorate General of New, Renewable Energy, and Energy Conservation (in Indonesian, is abbreviated as DJEBTKE), in particular, continues to be pursued through the implementation of Presidential Instruction of the Republic of Indonesia Number 7 year 1999 concerning the Performance Accountability of Institutions. This aims to make the organizational units under DJEBTKE more independent in managing state revenue potentials within their responsibilities. Additionally, they are required to oversee task implementation and conduct evaluations of performance achieved in each period (Manik & Coenraad, 2015).

Strengthening regulations for the development of renewable energy through a bill is a crucial and strategic step in advancing the energy sector towards sustainability. Through a comprehensive bill, Indonesia can establish a solid legal foundation to facilitate the growth and investment in renewable energy. A bill that strengthens renewable energy regulations

should clarify the policies and support mechanisms needed to promote the development and utilization of renewable energy sources. This includes providing financial incentives, tax exemptions, subsidies, or easy access to capital for renewable energy projects. Furthermore, the bill should integrate increased targets for the use of renewable energy in the national energy system, provide legal certainty for investors, and offer guidance on efficient licensing procedures for renewable energy projects. Based on Law Number 30 of 2007, energy is defined as the ability to perform work, which can take the form of heat, light, mechanics, chemistry, and electromagnetism. Energy sources are entities capable of producing energy, either directly or through conversion or transformation processes. New energy sources refer to those generated by new technologies, whether from renewable or non-renewable sources, including nuclear, hydrogen, coal bed methane, liquified coal, and gasified coal. Renewable energy sources are generated from sustainable energy resources if managed properly, including geothermal, wind, bioenergy, solar radiation, flowing and falling water, and the motion and temperature differences in layers and seas (Paul, 2023).

The inconsistency between the renewable energy bill and the concept of green legislation is evident, as this law should ideally be used to combat climate change and depleting resources. However, the inclusion of the term "new energy" in the renewable energy bill opens the door to non-sustainable energy sources such as coal and nuclear power. This inconsistency poses a significant problem, as coal energy worsens environmental quality in terms of water, soil, and air, while nuclear energy is considerably more hazardous to humans. Such issues infringe upon constitutional rights outlined in Article 28 H (1) and Article 33 (4) of the 1945 Constitution of the Republic of Indonesia and contradict the directives of the Paris Agreement (Parvez et al., 2023).

The renewable energy bill must formulate concrete steps to encourage research, innovation, and technology transfer necessary to enhance the efficiency and effectiveness of renewable energy sources. Additionally, the role of the private sector, civil society, and local governments in the development of renewable energy should be recognized and accommodated in this bill. Strong collaboration among various stakeholders can be a crucial driver in accelerating the development of renewable energy infrastructure nationwide. With a robust and supportive renewable energy bill, Indonesia has a significant opportunity to attract the necessary investment for an energy transition, reduce dependence on conventional energy sources, and strengthen its position as a leader in utilizing renewable energy to achieve sustainable development goals. The efforts for the development of renewable energy include the six steps which are drafting a level playing field for renewable energy, implementation of Electricity Supply Business Plan for the period of 2019-2028, creation of new markets for energy, developing biofuel and greenfuel concept, developing policy for large-scale procurement, and implementing dieselization strategy (Sutijastoto, 2020).

Drafting a level playing field for renewable energy which includes: (a) revising regulations and laws to support the development of renewable energy, (b) infrastructure cost compensation, (c) government bearing the costs of exploration to drilling for geothermal energy, (d) compensation for external costs. Supporting the Implementation of Electricity Supply Business Plan for the period of 2019-2028 indicates the commitment to a shift towards cleaner and more sustainable energy sources in Indonesia. PLN, as the only permitted provider for electicity in Indonesia, plays a crucial role in providing electricity to households, businesses, and industries in Indonesia. As part of its responsibilities, PLN is involved in various initiatives, including efforts to transition to cleaner and more sustainable energy sources as stated in their business plan.

Supporting the creation of new markets for energy by conducting a development of renewable energy to support the creation of new economic centers including enhancement of community-based economy using pellets and biomass by utilizing sub-optimal lands and development of maritime economic clusters. In addition to this it also includes development of a resource-based renewable energy model for large-scale power plant projects such as development of hydroelectric power plants for nickel smelters as battery raw material. Synergy with regional development plans for strategic planning is also important to support

the new maket creation for energy, for example: the development of geothermal-based ecotourism in Flores and Labuan Bajo, East Nusa Province. Ensuring a synergy with state owned company for strategic infrastructure project such as dam construction by PT Pembangkitan Jawa Bali, a subsidiary company of PLN, and geothermal power plant construction by partnership of Pertamina Geothermal Energy and PLN Gas and Geothermal. Another new market creation can also include development of the Nusantara Solar Energy Project through synergy with relevant Ministries/Agencies, Ministries, State-Owned or Regional-Owned Enterprises, and the private sector.

Developing the biofuel and greenfuel concept as part of efforts to reduce dependence on fossil fuels and mitigate the environmental impact of traditional energy sources. Both biofuel and greenfuel play a crucial role in sustainable energy transitions and efforts to combat climate change. Also to support the implementation of renewable energy it is also important to develop a policy for large-scale procurement of renewable energy power plant which enables the access to efficient technology and access to competitive funding.

Finally, implementing dieselization strategy, which involves converting 5,200 diesel power generation units to new renewable energy-based power generation in 2,130 locations throughout Indonesia will also enhance the market for renewable energy. This replacement is expected to convert up to 2 GW energy within the following three years since 2023. The conversion of diesel power plants to renewable energy-based power plants will be carried out in three stages. The first stage will be conducted at 200 diesel power plant locations with a total capacity of 225 MW. The second stage, carried out until reaching a capacity of 500 MW, and the third stage will be implemented up to a potential of 1,300 MW. The initial stage of dieselization is divided into two clusters: the Sumatra, Kalimantan, Java-Madura Cluster, and the Sulawesi, Maluku, Papua, and Nusa Tenggara Cluster. The main challenge of the dieselization program is the numerous power plants that are scattered in remote areas. Therefore, appropriate strategies are needed, both economically and technologically.

4. Conclusions

Energy is a fundamental component to support the livelihood of human, serving as the backbone for all economic activities. The increasing trend of human population and technological advancements drive various social and economic behavioral changes, ultimately resulting in an increased demand for electricity consumption in general. Indonesia has been and still dependent to fossil sources of energy to accommodate the energy consumption needs. However, Indonesia possess huge potential of renewable resources with 419 GW potential in 2021. Data shows that there are increas of renewable energy sources utilization in the span of 2018-2021 from hydro, geothermal, and water energy sources.

Typically there are challenges of the renewable energy industry to be sustained which includes: political, economic, social, technical, and environmental elements. This indicates that the fulfillment of energy needs and the utilization of renewable energy sources cannot be viewed from a single perspective but involves a study that encompasses various interrelated aspects. With the ambitious national target set by the Indonesian government to reduce GHG emsissions and sources mix for energy, transition is essential and needs clear planning.

In order to enhance the effective implementation of the ongoing renewable energy program and ensure that activities funded by foreign aid can be successfully carried out, Indonesia needs to develop a well-structured and straightforward plan for harnessing the potential of renewable energy. Especially to achieve the 2060 net zero emission targets, this plan is essential to support the strategy implementation. Development of a clear and measurable work plan within a specified timeframe to implement the renewable energy program is crucial. Detailed identification of existing infrastructure and the selection of renewable energy that aligns with the characteristics of the region, while ensuring it does

not create new carbon emissions, will help advance the agenda for transitioning to a cleaner environment. Throughout this process, the involvement of all stakeholders and the implementation of supportive regulations will be key to the success of the program.

Acknowledgement
Author would like to express our sincere gratitude to the editorial team and reviewers for their invaluable contributions in evaluating and reviewing this scientific article. Their insightful comments, constructive feedback, and meticulous assessment have significantly enhanced the quality and rigor of this work.

Author Contribution
This research was solely conducted by Y.F., who was responsible for conceptualization, literature review methodology, data collection, analysis, and manuscript preparation. The author developed research ideas, gathered and reviewed relevant studies, and conducted a literature study to analyze community participation in mangrove conservation. The author also drafted, revised, and finalized the manuscript.

Funding
This research did not utilize external funding.

Ethical Review Board Statement
Not available.

Informed Consent Statement
Not available.

Data Availability Statement
Not available.

Conflicts of Interest
The author declare no conflicts of interest.

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