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Renewable Energy Revolution: A Review of Innovative Strategies Towards Net Zero Emissions (NZE)

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Abstract

The Net Zero Emissions (NZE) program has become a common term since the 2015 Paris Climate Agreement. This program aims to reduce environmental pollution that can cause global warming. Energy is one of the sectors that is the focus of the NZE program implementation efforts. The energy transition is a very important program, especially related to the NZE Program issue and mitigation of the Greenhouse Gas effect. The energy transition program must focus on reducing carbon intensity and providing greater benefits to all households. Indonesia has committed to achieving NZE by 2060 or sooner. This study aims to examine the role of renewable energy in achieving the NZE program and analyze innovation strategies to accelerate the NZE program. This study uses the narrative literature review method to analyze information and literature. This study presents alternative solutions to the renewable energy transition issue in realizing NZE. Utilization of abundant renewable energy to replace fossil fuels and also electrification of the non-electricity sector can be priority solutions in realizing NZE. In addition, the development of Carbon Capture, Utilization, Storage (CCUS), and Green Hydrogen technologies is also very important for the industrial sector in mitigating the impact of greenhouse gases.

Keywords: Renewable Energy; Net Zero Emissions (NZE); Green Hydrogen; Greenhouse Gases

Introduction

Energy is a crucial element that contributes to economic activity, both as a user and as a driver of economic activity itself. Energy functions not only as a consumed good, but also has a significant role in innovation and technological development that is very necessary for economic growth. In addition to influencing economic progress, increased energy use can have a negative impact on environmental quality. The use of energy derived from fossil fuels can damage the environment and increase greenhouse gas emissions. Approximately 99% of greenhouse gas emissions are produced by energy use, while 1% comes from methane (CH4) and nitrous oxide (N2O), where high concentrations of carbon dioxide can cause global warming(Regina Citra Kurnia Pangestu & Anak Agung Ketut Ayuningsasi, 2024).

The phenomenon seen in Indonesia shows environmental degradation triggered by the industrial sector. Indonesia's First Periodic Update Report (BUR) noted that Indonesia's total greenhouse gas (GHG) emissions in 2012 reached 1,454 million

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MtCO2e (metric tons of carbon dioxide equivalent). The sectors that contributed the most were land use change and peatlands (47.8%), followed by the energy sector (34.9%), agriculture (7.8%), waste (6.7%), and IPPU (2.8%) (Directorate General of Climate Change Control, 2015). In addition, the highest carbon emissions from the energy sector in 2012 came from the industrial sector, with a total of 152 million tons of CO2 (KESDM, 2016). This indicates that the industrial sector produces significant emissions due to energy use in this sector (Pratama, 2022).

Global concerns about climate change and the growing urgency to reduce greenhouse gas emissions have driven the search for sustainable energy solutions. Renewable energy has emerged as one of the most promising alternatives to conventional fossil fuels, playing a critical role in efforts to reduce environmental impacts and achieve net zero (NET) emissions. Renewable energy sources, such as solar, wind, hydropower, biomass, and geothermal, provide clean and sustainable options for generating electricity, reducing carbon footprints, and increasing energy security(Khurshid et al. 2024). However, despite significant growth and technological advancements in renewable energy, the transition from fossil fuels to cleaner energy remains challenging. Issues such as intermittency, high initial investment costs, infrastructure limitations, and policy barriers continue to hinder global adoption. Nevertheless, the potential for renewable energy to play a significant role in addressing the climate crisis remains undeniable, especially as the global community intensifies its efforts to meet international climate commitments such as the Paris Agreement.

This paper aims to review different types of renewable energy technologies, highlighting their potential to reduce net emissions and contribute to a sustainable energy future. It will also explore the opportunities and challenges that countries face in adopting renewable energy globally. In particular, we will examine Indonesia's efforts to implement renewable energy solutions, focusing on the opportunities and challenges it faces in integrating renewable energy into its energy mix. Through this review, we aim to provide a comprehensive understanding of how renewable energy can drive the global transition to a low-carbon economy and help achieve net-zero emissions, focusing on global trends and local efforts in Indonesia.

Research Methods

The method used in this study is the Literature Review method. The method used to identify, review, and interpret all findings on a research topic. The source of the literature review study uses an electronic database, namely Google Scholar which is accredited or indexed from the Mendeley website. The search was carried out from November 30, 2024 to January 14, 2025. The data collected is in the form of primary literature. Where the data is data obtained from research journals. The selected research journals are journals with a maximum of 10 years of up-to-dateness, published, indexed, and in accordance with the research topic. The findings of the journal regarding the

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potential for developing renewable energy in achieving NZE and its application. The primary data that has been collected is processed descriptively based on journal findings and based on journal selection criteria, including: Maximum up-to-dateness of 10 years. Published nationally or internationally, using an electronic database, namely Google

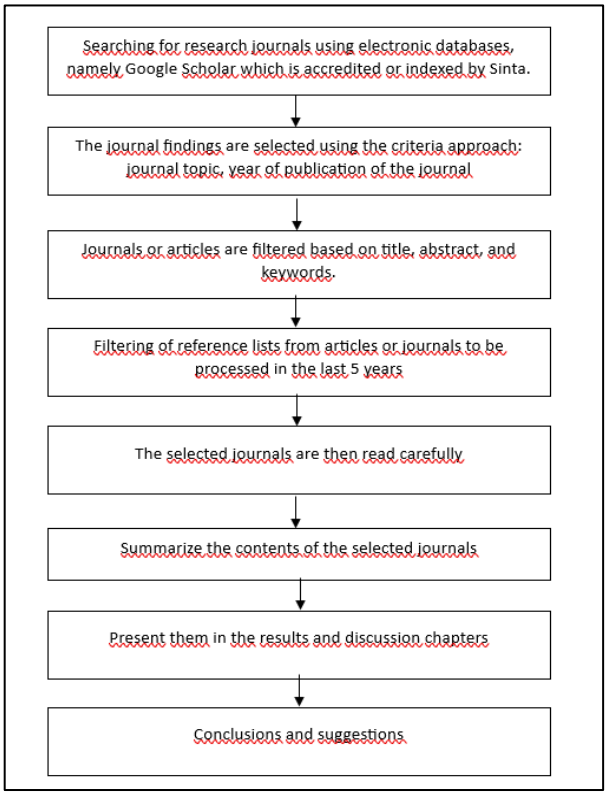

Figure 1 Research flow chart

Scholar which is accredited or indexed by the Mendeley website. In journal searches with the help of the internet with related keywords, namely Renewable energy, Net Zero Emission (NZE), Green hydrogen, Greenhouse gas. Then the retrieval of citations and bibliography uses the Mendeley site to facilitate adjustment. The research flow carried out in writing this literature review is written in the form of a chart.

Result and Discussion

Overview of Renewable Energy

Renewable energy refers to natural resources that can be naturally renewed in a relatively short time, such as sunlight, wind, rain, ocean waves, geothermal heat, and biomass. Compared to fossil fuels, renewable energy has a much lower environmental impact because it does not emit large amounts of greenhouse gases and does not run out if managed sustainably. The potential of renewable energy to reduce carbon emissions and facilitate the transition to a low-carbon economy makes it a key element in the global effort to combat climate change. However, despite the increasing use of renewable energy

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around the world, the transition from fossil fuels to clean energy is challenging. Issues such as dependence on weather conditions, high initial investment costs, limited infrastructure, and unfavorable regulations remain significant barriers. Nevertheless, the potential of renewable energy to help reduce emissions is very relevant, especially as more countries commit to achieving net zero (NET) emissions by the middle of the century.

According to information and data obtained regarding energy consumption, Indonesia is still fully dependent on non-renewable energy sources such as oil, coal, and natural gas. On the other hand, the results of the implementation that has been carried out by the government to achieve the diversification of Renewable Energy (ET) still face various challenges. These challenges include technical and non-technical obstacles, as well as price competition with fossil energy which is usually more affordable, so that the development of ET is hampered. The results of energy diversification achieved through ET are only around 6.2% overall, with an annual growth of 0.39% (Adzikri et al., 2017).

This paper aims to provide an in-depth review of various renewable energy technologies and their potential to reduce carbon emissions. It will also explore the opportunities and challenges that countries face in adopting renewable energy on a global scale, particularly focusing on Indonesia's efforts to integrate renewable energy into its energy mix.

Types of Renewable Energy

Renewable energy can be divided into several types, each with different characteristics, advantages, and challenges. Here is an explanation of some of the main forms of renewable energy that are growing rapidly:

1. Solar Energy Solar energy harnesses sunlight to generate electricity through photovoltaic (PV) panels or for heating through thermal collectors. With significant cost reductions in recent years, solar energy has become one of the fastest growing renewable energy sources. This resource can be used in both large-scale and small-scale systems, offering flexible solutions to a variety of energy needs.
2. Wind Energy Wind energy is generated by converting the kinetic energy of the wind into mechanical power, which is then converted into electricity using wind turbines. Wind farms, both onshore and offshore, are gaining popularity due to their high efficiency. However, the erratic nature of wind energy, depending on wind speed, can cause problems with grid stability.
3. Hydropower Hydropower uses flowing water to generate electricity. Hydroelectric power has been used for over a century, and while large-scale hydropower plants can produce large amounts of energy, small-scale hydro systems also have great potential, especially for remote areas. However, large-

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scale hydropower projects often have significant ecological and social impacts, such as ecosystem changes and population displacement.

4. Biomass Energy Biomass energy comes from organic materials such as agricultural waste, wood, and other organic residues that can be converted into energy through combustion or fermentation. Biomass is a renewable alternative to fossil fuels, but it is important to ensure that biomass use does not compete with food production or lead to overexploitation of natural resources.
5. Geothermal Energy Geothermal energy harnesses heat from beneath the Earth's surface to generate electricity or provide direct heating. It is one of the most reliable and stable renewable energy sources, as it can operate year-round. However, its use is geographically limited to areas with significant geothermal activity, such as Indonesia and Iceland.

Global Trends and Renewable Energy Potential

Global trends show that renewable energy is increasingly being chosen as a solution to reduce dependence on fossil fuels and address climate change. According to the International Renewable Energy Agency (IRENA), global renewable energy capacity will exceed 3,000 GW by 2023, with solar and wind leading the way. Many countries, especially in Europe, North America and Asia, are increasing their investments in renewable energy, aiming to diversify their energy portfolios and reduce carbon emissions. In addition to environmental benefits, renewable energy also contributes to energy security and job creation. Falling technology costs, particularly for solar panels and wind turbines, have made renewables more competitive than fossil fuels, even without subsidies. This shift offers significant opportunities for developing countries, which have historically been dependent on fossil fuels (Aljashaami et al. 2024).

Based on the analysis results, a number of countries were identified as the ones that contributed the most to the renewable energy sector and sustainable city development between 1991 and 2021. The countries that occupy the top ten along with the number of publications are: the People's Republic of China, Italy, Canada, the United Kingdom, Turkey, Spain, the United States, Poland, Denmark, and Germany. In addition, there are other countries that also play a role in research related to renewable energy and sustainable cities, although their contributions are smaller. China, as one of the countries that is actively building low-carbon cities, is in line with the theme of renewable energy and sustainable cities. China has also prioritized energy transition programs at the city level to support climate change mitigation measures . In addition, the participation and awareness of urban communities are considered very important factors. Therefore, China is the country with the highest number of publications on renewable energy and sustainable cities (Hasanah et al., 2022).

In Indonesia itself, the potential for utilizing renewable energy as a way out towards NZE is very large. Based on data from the Ministry of Energy and Mineral

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Resources (2019), Geothermal Sources and Reserves currently being studied on eight Indonesian islands, Indonesia has a geothermal potential of 23765.5 MW or 23.7 GB, the potential of which has currently been studied, although only 2.29 GW has been utilized. This data shows that there are several serious challenges that need to be addressed so that the potential can be used optimally (Solikah & Bramastia, 2024).

Challenges in Implementing Renewable Energy

Despite its enormous potential, several challenges must be overcome to accelerate the adoption of renewable energy worldwide:

1. Intermittency and Grid Integration Some renewable energy sources, such as solar and wind, are subject to weather conditions that can fluctuate. This challenges grid operators to ensure a reliable and stable energy supply. Developing energy storage systems and smart grids is essential to address this issue.
2. High Initial Investment Costs Despite the lower operating costs of renewable energy, building infrastructure for renewable energy, such as wind and solar power plants, requires large initial capital outlays. This can be a major obstacle, especially for developing countries with limited financial resources.
3. Technology and Infrastructure Constraints Developing the infrastructure needed to support renewable energy systems, such as energy storage facilities and modern transmission networks, requires significant investment. Furthermore, while renewable energy technologies continue to advance, further research and innovation are still needed to implement new technologies.
4. Policy and Regulatory Challenges Many countries still heavily subsidize the fossil fuel industry, hampering renewable energy development. Supportive policies, incentives and regulations are critical to driving the transition to clean energy. However, inconsistent or unsupportive regulatory frameworks continue to slow progress in some countries (Aprilianto & Ariefianto, 2021).

The transition to new energy is an inevitable step to meet energy needs. The government has provided policy support to accelerate the use of renewable energy, both in terms of permits, funding, and applications. However, it is hoped that this support will still consider environmental protection aspects, so that renewable energy truly becomes a sustainable, environmentally friendly energy source, and is equal to fossil energy in terms of reliability and stability of technology that can be widely applied (Manahara et al., 2023).

Current Renewable Energy Trends

The global renewable energy landscape is undergoing rapid transformation, driven by technological advances, falling costs, and a growing awareness of the urgent need to address climate change. As countries seek to meet carbon reduction targets and

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transition to more sustainable energy systems, renewables are taking center stage in the global energy discourse. One of the most prominent trends in renewable energy today is the significant reduction in the cost of technologies such as solar photovoltaics (PV), wind turbines, and batteries. These innovations have made renewables more economically viable and have spurred a wave of large-scale renewable energy projects around the world. According to a recent report from the International Renewable Energy Agency (IRENA), the cost of solar has fallen by more than 80% over the past decade, and onshore wind has followed a similar downward trajectory. These cost reductions have made renewables increasingly competitive with traditional fossil fuels, even in the absence of subsidies (Kadang & Windarta, 2021).

In line with these technological advances, the adoption of renewable energy is expanding, especially in countries seeking energy independence and sustainability. Countries in Europe, North America and parts of Asia are investing heavily in renewable energy, driven by environmental concerns and a desire to stimulate local economies through green job creation. In addition, the global shift towards renewable energy is driven by international agreements, such as the Paris Agreement, which have set ambitious targets for reducing greenhouse gas emissions. Another important trend is the growing interest in hybrid and decentralized energy systems. These systems combine multiple renewable energy sources—such as solar and wind—with energy storage technologies to ensure a continuous and reliable supply of energy, even when one source is unavailable. Microgrids, which are small-scale energy systems that can operate independently of the national grid, are also gaining popularity in remote and underserved areas, offering communities access to reliable, affordable energy(Abdullah & Subiyanto, 2018).

In addition, the role of digital technologies, such as artificial intelligence (AI), the Internet of Things (IoT), and blockchain, is becoming increasingly important in optimizing the generation, distribution, and consumption of renewable energy. Smart grids, which use real-time data to balance supply and demand, help integrate renewable energy more effectively into the national grid. In addition, AI and machine learning are being used to improve predictive maintenance and energy management, ensuring the efficiency and reliability of renewable energy infrastructure (Sihombing & Wirapraja, 2019). Despite these encouraging trends, challenges remain. Intermittency and energy storage remain significant constraints, particularly for solar and wind, which are dependent on weather conditions. However, the expansion of energy storage technologies is increasing the reliability and flexibility of renewable energy sources, allowing them to play a more prominent role in meeting global energy demand. Another challenge lies in the policy and regulatory landscape, where inconsistent support for renewables across regions can slow the adoption of clean energy solutions(Xu et al. 2024).

In various parts of the world, such as Southeast Asia, which has great potential for renewable energy resources (outside of solar panels and wind energy) that have not

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been fully utilized. For example, there are some of the best micro-hydro power plants in the world, especially in Indonesia, Myanmar, and several countries in the Indochina peninsula (Laos, Cambodia, and Vietnam), as shown in Figure 1. Indonesia and the Philippines also have quite large geothermal potential, and can be exploited economically using technology. This region also holds significant ocean energy potential, especially in archipelagic countries such as Indonesia, the Philippines, and Singapore, although there is no detailed mapping of it. There is also an abundant flow of bioenergy throughout the region, with a variety of raw material options available, such as agricultural residues, livestock waste, and plantation waste products. Figure 1. Distribution of Renewable Energy Potential in ASEAN. On the other hand, the management challenges for renewable energy electrification are still a hot topic in renewable energy policy discussions, where institutions (public, private, financial, and academic) are interconnected and considered most responsible for the speed of implementation of the renewable energy application process. Loorbach (2007) emphasized that it is very difficult to predict the functions and roles of institutions responsible for accelerating the implementation of renewable energy, due to its impact on a country's macroeconomic system and microeconomic level as well as the interconnectedness of bureaucratic networks and government institutions(Puariesthaufani et al., n.d.)

In conclusion, current trends in renewable energy reflect a positive and dynamic shift towards a more sustainable and resilient energy future. While the transition to a fully renewable energy grid is challenging, the rapid pace of technological innovation, supportive policy frameworks, and increasing public and private sector investment are paving the way for a cleaner, greener, and more energy-secure world.

Indonesia's Renewable Energy Transition

Indonesia, as one of the largest and most populous countries in Southeast Asia, is endowed with a wealth of natural resources that position it as a potential leader in renewable energy. With an archipelago of more than 17,000 islands, Indonesia enjoys abundant solar, wind, geothermal, hydro and biomass resources. The country’s geographical advantages, particularly its position along the Pacific Ring of Fire, make it one of the world’s most promising locations for geothermal energy production. In addition, Indonesia’s vast land area and high solar radiation make it well-suited for large-scale solar photovoltaic installations. However, despite these favorable conditions, Indonesia has struggled to fully exploit its renewable energy potential, largely due to a combination of economic, political and infrastructure challenges.

However, according to the Government's records through the National Energy Council (DEN), the highest percentage of energy mix in Indonesia in 2023 is still held by coal , which is 40.46%. However, this percentage continues to decline from the previous year which was 42.38%. Based on DEN data, the highest percentage of energy mix in 2023 is still dominated by Coal (40.46%), Petroleum (30.18%), Natural Gas (16.28%),

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EBT (13.09%). The percentage of new renewable energy (EBT) increased by 0.79% to 13.09% in 2023. However, this realization is still below the target set at 17.87%. In the Paris Agreement, Indonesia pledged to reduce greenhouse gas emissions at the national level with a target reduction of 29% to 41% by 2030, taking into account the business-as-usual (BAU) scenario . The Paris Agreement involves the energy sector, logging, and adaptation to climate change. (SolarKita , 2021). Indonesia has also ratified the Paris Agreement on October 25, 2016 through Law Number 16 of 2016 concerning "Ratification of the Paris Agreement to the United Nations Framework Convention on Climate Change"(Lahope et al., n.d.).

One of the major obstacles hampering Indonesia's renewable energy transition is its heavy reliance on fossil fuels, particularly coal, which currently dominates the country's energy mix. In recent years, coal has accounted for more than 60% of Indonesia's total electricity generation. The country's reliance on cheap coal-fired power generation has created a deeply entrenched energy infrastructure that is difficult to change. In addition, Indonesia has significant coal reserves, which have fueled the economy and provided substantial revenues through exports. This economic dependence on coal presents a major challenge to transitioning to cleaner energy sources, as it would require restructuring an established and profitable sector (Rebecca et al., 2023)

In addition to the challenges posed by fossil fuel dependence, Indonesia's renewable energy sector faces several infrastructure constraints. The country's energy distribution network remains underdeveloped, especially in rural and remote areas where access to electricity is limited. Indonesia's archipelagic nature adds complexity to energy distribution, requiring the construction of additional transmission networks and energy storage systems to connect renewable energy sources on different islands to the national grid. In some cases, renewable energy sources such as solar and wind are located far from urban centers, making it difficult to get electricity to where it is needed most. In addition, the lack of adequate grid infrastructure and energy storage capacity limits the effective integration of renewable sources, such as wind and solar, into the national grid.

To address these challenges, the Indonesian government has set ambitious targets for renewable energy adoption. In 2017, the government announced its goal of achieving 23% of its energy mix from renewable sources by 2025, with plans to increase this to 31% by 2050. These targets are part of a broader effort to reduce greenhouse gas emissions and meet Indonesia's climate commitments under the Paris Agreement. While these goals are laudable, achieving them will require significant changes in energy policy, infrastructure development, and investment in technology (Zahira & Fadillah, 2022).

One promising area for Indonesia's renewable energy transition is geothermal energy development. With an estimated 40% of the world's geothermal reserves, Indonesia has the potential to become a global leader in this sector. The government has taken steps to promote geothermal energy by offering incentives and regulatory support, but progress has been slow due to the high initial capital costs and long development

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timelines associated with geothermal power plants. In addition, environmental and social issues related to land use and indigenous peoples' rights sometimes hinder the development of geothermal projects (Ahluriza & Harmoko, 2021).

Solar energy also presents significant opportunities for Indonesia, especially in rural areas where off-grid solutions can be implemented. Solar installations can be implemented relatively quickly and at a lower cost compared to other renewable energy technologies. In recent years, Indonesia has seen an increase in the adoption of rooftop solar panels, especially in urban areas. However, the potential for large-scale solar farms remains largely untapped, as the country's regulatory environment and financing mechanisms do not fully support the rapid expansion of solar energi (Haramaini, 2024).

Wind energy resources in Indonesia are quite abundant, so it is very possible to establish a Wind Power Plant. Research conducted by the National Institute of Aeronautics and Space (LAPAN) shows that there are 35 locations in Indonesia that have wind speeds exceeding 5 m/s at a height of 50 meters. The best locations include the areas of West Nusa Tenggara, East Nusa Tenggara, the south coast of Java, and the south coast of Sulawesi. In the National Energy General Plan (RUEN), it is estimated that the wind potential throughout Indonesia reaches 60,647.0 MW with a wind speed of around 4 m/s (Hasan & Widayat, 2022).

In addition to these niche resources, Indonesia is increasingly looking at biomass and waste-to-energy projects as part of its renewable energy strategy. Biomass, derived from agricultural residues such as palm oil waste and wood chips, is a renewable resource that can be used to generate electricity and reduce reliance on fossil fuels. Indonesia's significant agricultural sector provides an abundant supply of biomass feedstock, which can be converted into energy. Waste-to-energy projects are also gaining attention as a solution to waste management and renewable energy production, particularly in urban centers with high levels of waste (Hidayati & Ekayuliana, 2022).

To achieve its renewable energy targets, Indonesia must overcome several critical barriers. The main problem is the lack of funding for renewable energy projects, especially in rural areas. The government has introduced various incentive programs, including feed-in tariffs and tax breaks for renewable energy investors, but these programs have not been enough to attract the level of investment needed. In addition, policy uncertainty and regulatory barriers continue to hamper private sector participation in renewable energy development.

Another challenge is the need for comprehensive infrastructure development. For renewable energy to play a more prominent role in Indonesia's energy mix, significant investment is needed in both transmission networks and energy storage solutions. Smart grid technologies, which can optimize the distribution of energy from renewable sources, should be prioritized. In addition, expanding energy storage capacity to balance intermittent renewable energy generation with consumption will be critical to maintaining grid stability and ensuring reliable electricity supply (Tiara et al., 2023).

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There are also social and environmental considerations to consider. Indonesia's transition to renewable energy must ensure that the benefits of clean energy are distributed equitably, especially to rural and underserved communities. Furthermore, the development of renewable energy projects, especially geothermal and hydropower, must carefully address issues of land rights, environmental protection, and community engagement to avoid conflict and ensure sustainable growth.

In conclusion, Indonesia's renewable energy transition presents significant challenges as well as substantial opportunities. The country's abundant natural resources provide a strong foundation for a cleaner, more sustainable energy future. However, overcoming the barriers of limited infrastructure, fossil fuel dependence, regulatory issues, and financing gaps will require coordinated efforts from the government, private sector, and civil society. With the right policies, investments, and innovation, Indonesia has the potential to become a regional and global leader in renewable energy, contributing to carbon emission reductions and achieving global climate goals.

Various Innovative Strategies In Realizing NZE

The procurement of Green Hydrogen as an alternative fuel source for FCEV electric vehicles is a step taken by the Indonesian government to achieve the previously set GHG emission reduction target. With Indonesia's great potential in the field of renewable energy power generation, this opens up opportunities for Indonesia to become a producer of Green Hydrogen . However, in its implementation, Green Hydrogen still faces several challenges, including the lack of regulations to regulate various aspects of the Green Hydrogen industry in this country(Dissanayake and Kularatna-Abeywardana 2024). The use of Green Hydrogen produced through renewable energy sources can support decarbonization efforts and create energy independence due to its dependence on renewable energy power plants. Currently, Indonesia has been able to produce 51 tons of hydrogen through Green Hydrogen The first Plant (GHP) in Indonesia that utilizes 100% renewable energy sources (PLN, 2023). This success shows the great potential that Indonesia has in using Green Hydrogen as the main fuel source for FCEV-based vehicles (Al-Basith & Devara, 2024).

In addition to the development of Green Hydrogen, the CCUS (Carbon Capture Utilize and Storage) can also be advanced as an acceleration step towards NZE. CCUS is a method used to reduce CO2 emissions produced by various sectors, especially in the oil and gas industry(Jiang et al. 2024). CO2 captured from the air can then be stored underground and also used to increase output from the oil and gas industry while reducing pollution in Indonesia. Challenges faced in developing CCUS in Indonesia include unclear government regulations, costs required for development, and infrastructure and the environment in the CO2 storage area. The opportunity to develop CCUS in Indonesia is quite large because there are storage locations in old wells that are no longer used. However, efforts are needed to socialize the safety and security of CCUS operations to

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the Indonesian people. The advantages of CCUS for sustainable development include job creation, extending the life of existing infrastructure, reducing operational costs for energy supply, and increasing knowledge to support innovative economic growth (Zaemi & Rohmana, 2021).

Conclusion

Net Zero Emission is an important step to reduce carbon emissions that have a negative impact in the future . One step to achieve NZE is the energy transition from fossil fuels to renewable energy. The potential of Renewable Energy is very large along with current technological advances. Various countries in the world are also enthusiastic about participating in this program. Renewable Energy that can be developed can come from water, wind, geothermal, biomass energy. The development of NzeE in Indonesia itself is still in development because the fossil energy mix is still dominant. Various challenges have caused a slowdown in
this transition process. Hands such as investment and financing needs, government regulations and inadequate human resources and technology.

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