Unpacking Indonesia's energy transition through a PESTEL analysis, for achieving Sustainable Development Goals

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Abstract. One of the objectives outlined in the Sustainable Development Goals (SDGs), specifically referred to SDGs Goal 7, aims to ensure universal access to affordable, reliable, sustainable, and modern energy. The targets associated with this goal involve guaranteeing access to energy services that are affordable, reliable, and modern, as well as increasing the proportion of renewable energy sources, enhancing energy efficiency, and advancing technology for service delivery. According to the Indonesia Sustainable Development Goals Indicators report of 2022, progress has been made in achieving SDGs Goal 7; however, additional efforts are required to attain a renewable energy composition of 24.8% by the year 2030. This study seeks to elucidate the ongoing energy transition in Indonesia by examining aspects related to sustainability, considering political, economic, social, technological, environmental, and legal (PESTEL) perspectives. The energy transition, characterized by the decarbonization of power plants, the advancement of renewable energy, and the cultivation of green ecosystems, signifies positive impacts not only on the economy but also on the environment and society

1 Introduction

Indonesia had an average economic growth of 5% from 2016 to 2019. Indonesia's economic growth saw a decline of -2.7% in 2020 but continued to recover, reaching a growth rate of 5.31% in 2022 [1]. Achieving economic growth increases demand for energy and increases global energy consumption. [2]. Not only that, energy is also needed to support the improvement of social welfare, such as poverty alleviation, healthcare, agricultural activities, infrastructure development, education, and other activities supporting basic needs. The provision of affordable, reliable, sustainable, and modern energy is one of the goals of sustainable development, also known as SDGS goal no. 7. However, energy demands place a strain on the environment, as most energy in Indonesia is still derived from fossil fuels, particularly coal, which contributes to climate change. Climate change has a significant impact on both human life and economic development. [3].

Indonesia has devoted itself to reducing emissions of greenhouse gases. At first, by 2030, Indonesia aimed to reduce greenhouse gas emissions by up to 29% on its own and 41% with international assistance [4]. But in 2022, Indonesia revised this target and aimed for a 31.89% emission reduction unconditionally and 43.20% conditionally, which strives to achieve net-zero emissions by 2060 or sooner. This will be in line with the Long-Term Low Carbon and Climate Resilience Strategy 2050 [5]. The Southeast Asian region, including Indonesia, has a relatively high climate vulnerability. The vulnerability of ASEAN is partially caused by its extensive coastline, which stretches over 173,000 km, and its dense population [2]. Furthermore, ASEAN is regarded as one of the world's most vulnerable regions due to its distinct geographic and climatic conditions, as well as its diverse economic, demographic, and social features [6]. Thus, in order to lessen the need for expensive future adaptation and disaster risk management in the ASEAN region, a swift reduction in GHG emissions is necessary [7].

The energy industry is one of the sectors aiming to lower greenhouse gas emissions. The second-largest source of greenhouse gas emissions in Indonesia is the energy sector, accounting for about 34.49% of total emissions after the land use and forestry (LUCF) sector at 50.13%, followed by the waste sector at 6.52% and IPPU at 3.15% [5]. The energy sector is expected to reduce its emission of greenhouse gases by 12.5% unconditionally, or 358 MTon CO2e, and 15.5% conditionally, or 446 MTon CO2e [5].

The strategy to reduce the energy sector's greenhouse gas emissions is through power plant decarbonization, renewable energy development, and a green ecosystem. Decarbonization could be accomplished by combining a higher level of energy system integration with a variety of renewable energy (RE) technologies [8].

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In 2021, Indonesia announced the General Plan for Electricity Supply (RUPTL) for the period 2021 – 2030. This RUPTL has the largest portion of Renewable Energy (RE) compared to the previous RUPTL and is used as a basis for achieving Carbon Neutral by 2060. In this RUPTL, the share of RE is targeted at 23% by 2025 and 24.8% by 2030 [9] and by 2050, the share of RE will reach 31% [5].

The installed capacity of all renewable energy sources as of the first semester of 2023 was 12.7 GW, or 15% of the total power generation [10]. To achieve a sustainable energy transition and to achieve the 23% renewable energy mix goal by 2025, many challenges are faced. These include substantial investment costs and the limited development of renewable energy technologies. Up to this point, the cost of energy generated from renewables is relatively higher compared to coal-derived energy. Net RE production and fossil fuel production might drop if energy costs for maintaining ecosystems are taken into consideration [11]. It has been suggested that rapid transition to 100% renewable energy might lower energy return on investment ("EROI") to levels below those mentioned in the literature as necessary to support complex, industrialized societies [12].

Regardless of the challenges, development must continue, and electricity must be affordable to all segments of society. Indonesia must carry out reforms both in terms of policies and regulations related to renewable energy, electricity prices, the conversion of coal power plants, and strategies for reducing greenhouse gas emissions. The energy trilemma, consisting of energy security, energy equity, and environmental sustainability [13], must still be considered during the energy transition. Energy supply management, infrastructure dependability, and energy's capacity to fulfill present and future demands are all included in the concept of energy security. Energy equity is ensuring that energy is affordable and physically available to all members of society. Environmental sustainability involves the provision of energy while preventing potential environmental damage. The energy transition process must ensure the availability, affordability, accessibility, and ownership of renewable energy and other economic resources for and by the community, including women, children, vulnerable populations, and minority groups.

The aim of this study is to determine the contributing factors influencing the acceleration of Indonesia's energy transition by examining six key areas: political, economic, social, technological, environmental, and legal aspects, concentrating on the advancement of the production of renewable energy. It is hoped that the study will help to clarify the challenges and barriers encountered in the effort to achieve sustainable development goals through energy transition.

2 Research Method

The PESTEL analysis approach is one method of analysis that can be used to identify the factors influencing an activity. An analytical tool for strategic business planning, PESTEL analysis offers a framework for comprehending the external factors affecting an organization or other kinds of entities [14]. PESTEL analysis is a useful tool for determining the variables that may affect a project's outcome. PESTLE analysis can serve as a foundation for identifying opportunities and threats that aid in SWOT analysis. A PESTEL framework primarily concerns six factors: political, economic, social, technical, environmental, and legal [15]. To ensure sustainable renewable development, the PESTEL analytical framework focuses on issues that business actors and policymakers need to manage. [16]. This framework is anticipated to aid in comprehending the dynamics of the issue and may serve as an introduction for new lines of research [17].

To conduct PESTEL, this study utilizes references from literature, scientific journals, and other documents related to energy transition activities. Figure 1 provides an explanation of each PESTEL analysis component [18].

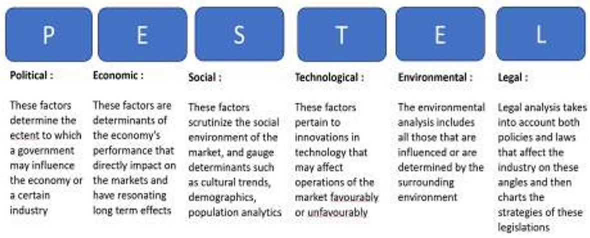

Fig. 1 PESTEL Analysis

2.1 Clean and Affordable Energy as Sustainable Development Goal

The Sustainable Development Goals (SDGs) are a new development agenda that promotes shifts towards toward human rights and equality-based sustainable development that propels social, economic, and environmental advancement. To ensure that 'No One Is Left Behind,' the SDGs are implemented using universal, integrated, and inclusive principles. With 17 goals and 169 targets, the Sustainable Development Goals (SDGs) seek to build on the work and accomplishments of the Millennium Development Goals (MDGs), which came to an end in 2015.

One of the SDGs, known as SDG 7, relates to clean and affordable energy. The objective of SDG 7 is to ensure access to affordable, reliable, sustainable, and modern energy for all. Goal 7 has 5 sub-targets related to ensuring energy access, the energy mix, energy efficiency, strengthening international cooperation in investment, and advancing technology to provide modern energy. The SDG 7 goal relates to economic aspects, meaning energy should be affordable for everyone; social aspects, implying that available energy should be modern and reliable; and environmental aspects, meaning energy provision must be sustainable and minimize its impact on the environment [19].

The goal of SDG 7 is one of the key and interconnected objectives to achieve various SDGs, including but not limited to health (SDG 3), eradicating poverty (SDG 1), combating climate change (SDG 13), and achieving gender equality (SDG 5), clean water and sanitation (SDG 6), productive opportunities (SDG 8), infrastructure/industrialization (SDG 9), sustainable cities (SDG 11), and sustainable consumption (SDG 12). However, in pursuing SDG 7, for instance, 7.2 related to the development of renewable energy infrastructure, must still consider aspects related to terrestrial and aquatic biodiversity (SDG 14 & 15).

2.2 National Grand Energy Strategy

The Indonesian government has established the National Energy General Plan through Presidential Regulation of the Republic of Indonesia Number 22 of 2017. This regulation encompasses the energy management plan to achieve the targets of the National Energy Policy. The National Energy General Plan (RUEN) is designed for the period until 2050. Within the RUEN, the Indonesian government has set a renewable energy mix target of at least 23% by the year 2025 and at least 31% by the year 2050.

Within the National Energy General Plan (RUEN), the electricity generation sector is projected to be the largest contributor to emissions in the energy sector. According to the modeled outcomes for achieving the targets of the national energy policy, a reduction in greenhouse gas emissions is estimated at 34.7% by 2025 and 58.3% by 2050. The reduction in greenhouse gas emissions outlined in the RUEN aligns with Indonesia's Enhanced Nationally Determined Contribution (NDC), set at 31.89% by 2030. On the other hand, Indonesia also targets zero emissions by 2060 or even sooner [5].

Table 1 Modeling of Renewable Energy Development 2015-2050

Energy (MW)	2015	2020	2025	2030	2050
Geothermal	1,438.5	3,109.5	7,241.5	9,300	17,546
Hydro	4,826.7	5,615.2	17,986.7	21,989.4	38,000
Mini-micro hidro	197.4	1,000	3,000	3,800	7,000
Bioenergy	1,671.0	2,500	5,500	9,600	26,000
Solar	78.5	900	6,500	14,200	45,000
Wind	3.1	600	1,800	7,040	28,000
Other RE	372.0	2,433	3,125	3,722.4	6,100
Total	8,587.2	16,157.7	45,153.2	69,651.8	167,646

Source : RUEN Indonesia [20]

The establishment of power plants using renewable energy in Indonesia includes geothermal, hydro, small and micro-hydro, bioenergy, solar, wind, and other renewable energy power plants, with a target capacity for renewable energy power plants of approximately 45.2 GW by 2025 and around 167.7 GW by 2050. The modeled outcomes of primary renewable energy development from 2015 to 2030 can be observed in Table 1.

2.3 Electricity Supply Business Plan

The Indonesian government, through PT PLN (Persero), issued the Electricity Supply Business Plan for 2021-2030 via the Minister of Energy and Mineral Resources of the Republic of Indonesia Decree Number 188.K/HK.02/MEM.L/2021. RUPTL is a guide for creating supply-side and demand-side electricity systems in PLN's business sectors [16]. The previous RUPTL of 2019-2028 was revised in the drafting of this RUPTL, with the latest RUPTL taking into account the uncertainty in demand caused by the COVID-19 pandemic.

In the latest RUPTL, the projected economic growth of Indonesia is assumed to be 4.9% per year, which is lower than the previous RUPTL of 6.4% per year. With a target of having a 23% renewable energy mix by the end of 2025, the total capacity of new renewable energy power plants planned for construction is 20,923 MW, or 51.6% of all new power plants. This RUPTL includes additional urban waste-sourced power plants. The renewable energy potential in Indonesia can be seen in Table 2.

Table 2 Renewable Energy Potential in Indonesia

Energy	Potention (MW)	Installed Capacity (MW)	Utilization
Geothermal	29,544	1,438.5	4.9%
Hydro	75,091	4,826.7	6,4%
Mini-micro hidro	19,385	197.4	1%
Bioenergy	32,654	1,671	5,1%
Solar	207,898 (4,8 kWH/m2/ hari)	78,5	0,04%
Wind	60,647 (≥ 4m/s)	3.1	0.01%
Tidal	17,989	0.3	0.002%

Source : RUEN Indonesia [20]

3 Result and Discussion

It is expected that the PESTEL analysis employed in this study will contribute to a better understanding of the barriers and difficulties encountered in energy transition activities. The findings of the analysis can be used to develop strategies for meeting targets such as energy mix, emission reduction, and SDG 7 targets.

In SDG 7, there are several targets related to the energy transition. According to SDG 7.1, "universal access to modern energy or electrical energy", everyone on the planet has access to sustainable energy sources. Raising the proportion of renewable energy in the energy mix, or SDG 7.2, encourages policymakers to address a number of issues related to the production of electricity, energy security, sustainable growth, and the decrease of carbon emissions in our environment. It also links well with other goals, like the use of renewable energy resources [21]. The Sustainable Development Goals (SDGs) 7.3, which aims to improve global energy efficiency, include developing technological innovation methods that can positively impact energy efficiency. [22].

3.1 Political Aspect of Clean Energy Development

A solid foundation for ensuring the success of energy transition initiatives is created by political will expressed in policies. The current policies established by the Indonesian government include expediting the dismantling of coal-fired power plants, prioritizing renewable energy-based developments, regulating the sale and purchase prices of electricity from renewable energy power plants, and providing government support in fiscal and non-fiscal forms. The government has set the cancellation of all coal-based power plant development plans in the latest RUPTL and will retire coal power plants generating 1.1 GW and replace old oil-based power plants totaling 3.6 GW. However, the construction of new coal power plants is still permissible under certain conditions: the plant development plan was set before 2021, integration with industries aimed at increasing the value of natural resources, inclusion in National Strategic Projects, commitment to reducing greenhouse gas emissions by at least 35% within a 10-year period and operating until at most 2050.

The Indonesian government intends to divide the development of renewable energy between the public and private sectors in RUPTL 2021−2030. The share of the private sector in the overall electricity demand is expected to be 56.3%, with renewable energy accounting for 51.6% of the total. This policy encourages private sector participation in energy transition activities. One of the main factors of Indonesia's energy transition is the role of the private sector.

The challenge for developing countries like Indonesia regarding energy is the increasing access to energy for the population and fulfilling the growing demand for energy among those who currently have access to it [23]. One obvious advantage of private investment in the energy sector is that it gives the government the flexibility to direct its meager financial resources toward other economically distressed areas and deal with those problems. Additionally, this aids in transferring the risks related to funding and managing energy projects [24].

The current government policies can be said to be moving in a direction aligned with achieving clean energy. In previous policies before 2021, the Indonesian government still focused on fossil fuels, especially coal. In the PLN RUPTL 2019−2028, the energy mix in 2025 was 54.6% coal, 22% natural gas, 23% renewable energy, and 0.4% oil [25]. Two scenarios are established in the PLN RUPTL 2021-2030: optimal and low-carbon scenarios, both of which still consider achieving 23% renewable energy starting in 2025[9]. The optimal scenario still considers the least-cost principle, so the coal energy mix remains at around 64%. In the low-carbon scenario, the coal energy mix is 59.8%, achieved by increasing biomass co-firing and gas utilization. When balanced with the operation of geothermal and hydroelectric power plants, the renewable energy mix will reach 24.2% by 2030 [9]. The changes in the energy mix in RUPTL 2021-2030 show a strong commitment from the government towards achieving sustainable, clean energy.

3.2 Economic Aspect

Indonesia's economy is projected to continue growing and is targeted to become an advanced country by 2045. For this reason, Indonesia needs a tremendous amount of energy, however, it must not harm the environment in any way. The government needs to develop a viable financing plan if the energy transition is to proceed without causing severe economic downturns or disrupting social stability, which could potentially affect the country's political order [26].

It will be challenging for Indonesia to make the shift from fossil fuels to renewable energy sources because, until now, fossil fuels have remained the primary source of electricity generation. Currently, the cost of producing electricity from renewable sources is higher than the cost of producing electricity from fossil fuels. The production costs listed in the National Energy General Plan (RUEN) can be seen in Table 3. To guarantee that the cost of electricity derived from sustainable sources is affordable, the right investment strategies and technological innovations are required.

Table 3 National Electricity Supply Cost in 2015

Renewable Energy		Fossil Fuel	
Power Plant	Cost (Rp/kwh)	Power Plant	Cost (Rp/kwh)
Solar	8,786	Diesel	3,992
Geothermal	1,058	Combine-cycle	1,843

Hydro	388	Open Cycle	806
		Coal-Fired	661

Source : RUEN Indonesia [20]

The government sought to bring in USD 33.5 billion in the energy sector by 2022, with USD 17 billion going into oil and gas, USD 7.6 billion going into power, USD 5 billion going toward coal and minerals, and USD 3.9 billion going toward renewable energy. [27]. However, according to the IESR 2023 report, only 35% of the USD 3.9 billion target was attained as an investment in the third quarter of 2022.

In November 2022, Indonesia collaborated with the Asian Development Bank (ADB) to establish the Energy Transition Mechanism (ETM), a program focused on enhancing energy infrastructure development and accelerating the transition to net zero emissions (NZE) by 2060, or an accelerated timeline, with principles of fairness and affordability. The platform asserts that it will enable Indonesia to experience a "just transition." By this, it means that ETM will not only assist in the retirement of coal plants but will also uphold the principle of a just transition, which calls for an equitable and fair energy transition [28].

Indonesia has received an investment aid of $20 billion at the G20 summit through the Just Energy Transition Partnership (JETP). JETP is a scheme supported by countries within the International Partners Group (IPG), such as France, Germany, the UK, the US, and the European Union, to assist South Africa in decarbonization efforts and support South Africa's economic transition to cleaner energy sources. The main feature of JETP is its emphasis on a fair transition in investment plans and funding [29].

However, the challenge facing Indonesia is ensuring that investments for accelerating this energy transition proceed effectively and reach the goal of keeping the maximum increase in global temperature to 1.5ϵC. According to the ISER 2023 report, the growth of renewable energy in Indonesia decreased from 11.5% in 2021 to 10.4% in 2022. The reasons behind this standstill include inadequate progress in enhancing the conducive environment, uneven enforcement of policy and regulatory frameworks, protracted PPA discussions, and post-acquisition hold-ups with regard to environmental permits and licenses. Additionally, the goal of restricting the maximum increase in global temperature to 1.5ϵC is not being met [27].

In September 2023, the government officially inaugurated a carbon market as a form of carbon value governance. A carbon market is a framework that manages the ownership records and/or trading of carbon. [30]. The carbon market provides potential financing opportunities for corporations that take the initiative to reduce carbon. The proceeds from carbon trading will be invested in environmental conservation efforts. The commitment to reduce carbon by companies becomes more valuable.

The implementation of a carbon market in Indonesia still faces numerous challenges. There is a need to enhance capabilities and deepen the understanding of policymakers and stakeholders regarding regulations and carbon trading mechanisms to ensure the market of carbon operates effectively. The carbon market is expected to strengthen the carbon emission reduction ecosystem in Indonesia and support sustainable financing mechanisms towards a low-carbon economy.

3.3 Social Aspect

The population growth in Indonesia from 2021 to 2022 was 1.13%, and the per capita energy consumption in 2021 to 2022 was 29.54%. Indonesia's energy needs are met by various sectors such as industry, transportation, households, commercial, and other sectors, with a total energy consumption in 2022 of 1,185,555,334 BOE (Barrel Oil Equivalent). The energy demand until 2022 is still dominated by coal.

The energy transition must not create new issues and needs to adhere to human rights principles, including women's and children's rights, as well as safeguarding human rights defenders and environmental sustainability. This includes applying the principle of informed consent without coercion based on initial information. To meet the other requirements of the sustainable development goal of eradicating poverty, enhancing human health, promoting equality in education, and saving women and children, access to electricity or modern energy is likewise essential. [31]. Active community involvement in the energy transition is crucial to ensuring that energy management in Indonesia is aimed at maximizing societal well-being.

The development of new power plants will have socio-economic impacts on the community. People will have job opportunities as workers in the project activities or establish new businesses, such as eateries or providing accommodations for workers. Furthermore, in the long term, the energy transition will drive environmental improvements like reducing air pollution and potentially enhancing public health.

In Indonesia's development of renewable energy sources, the government also utilizes unproductive land, such as the use of water body surfaces that have not been utilized so far. For instance, the construction of the 145 MW Cirata Solar Power Plant that utilizes the surface of the Cirata Reservoir. With this utilization strategy,

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potential social conflicts related to land use conversion can be minimized.

Another potential utilization of renewable energy sources is rooftop solar panels. The implementation of rooftop solar panels presents an opportunity to maximize the contribution of the public and businesses to invest in the decarbonization process. Figure 2 shows the number of PV customers in Indonesia, indicating an increasing interest in PV every year.

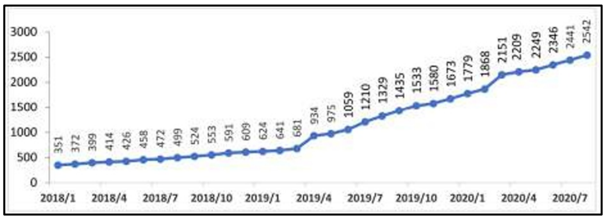

Fig. 2. The quantity of Indonesian PV rooftop consumers as of August 2020 [32]

The Indonesian government has issued regulations regarding grid-connected rooftop solar panels. The regulation stipulates that customers wishing to install rooftop solar panels must have an electricity supply business permit.When not operated by a state-owned enterprise, the installation capacity of rooftop solar panel systems is constrained by the local electricity systems, as stipulated by the holder of the Electricity Business License for Power Plants. This is quite contradictory to the government's goal, where they aim to encourage private sector and public participation in installing rooftop PV systems, yet the regulations established by the government make this implementation challenging.

3.4 Techology Aspect

In order to reach the 2025 energy mix target, Indonesia relies on hydro, geothermal, biomass, and solar PV energy sources. Among these, solar PV is becoming more competitive due to its short construction period. However, electricity supply from solar PV is intermittent as it heavily relies on weather conditions. To ensure the availability of energy from solar PV, an energy storage system is required to support these installations. This makes the production cost of non-hydro renewable energy sources high. An important first step in Indonesia's adoption of solar energy is the evaluation of solar potential. [33].

Indonesia's location in a tropical region offers significant potential for the development of solar power plants. However, the construction of a solar power plant requires a considerable amount of land. According to a national energy general plan report, Indonesia has an average solar PV potential of 4.80 kWh/m^2/day [34]. In 2030, there's a planned installed capacity of 65 GW for solar power plants, indicating the need for extensive land. Almost 70% of Indonesia's land comprises productive areas used for agricultural and plantation activities [35]. Apart from their terrestrial uses, solar power plants are also capable of being implemented in aquatic environments, which relates with Indonesia's distinct geographical features as an archipelagic country [33]. Using floating solar plants offers a number of noteworthy advantages, such as being land-free, helping to reduce water evaporation [36], effectively inhibiting the growth of unwanted vegetation like water hyacinth, and improving overall power production efficiency through the use of a cooling system.

The renewable energy development in Indonesia until 2030 will be dominated by hydroelectric and solar power plants. However, the domestic components for the infrastructure development are still limited. According to Indonesian Ministry of Industry Regulation Number 54/M-IND/PER/3 of 2012 regarding Guidelines for the Use of Domestic Products for Electricity Infrastructure Development, the Domestic Component Level (TKDN) for combined goods and services in the construction of hydropower plants ranges from 47% to 70%. The TKDN in order to build a solar power plant ranges from 43% to 53%. To ensure the achievement of TKDN, an adequate supply chain system is necessary. Currently, components for RE generation, particularly for solar power plants, are not produced domestically. If possible, the costs required are higher compared to importing. The government needs to create a roadmap for Indonesia to produce affordable domestic RE components and have competent labor in RE technology.

Positive effects of renewable energy include lowering greenhouse gas emissions, investing economically in energy resources, and preserving energy security [37]. However, there are drawbacks to renewable energy as well. These include the high cost of building infrastructure, low energy conversion efficiency, reliance on seasonal, daily, weekly, and monthly weather patterns, and environmental concerns. [37]. Not only that, research and development on renewable energy integration for electricity generation has been prioritized in order to meet SDG-7 requirements. One such project is the creation of a hybrid renewable energy microgrid, which must be affordable, dependable, and sustainable. [38]. Overall, there is room for progress in RE and energy-efficient technology in Indonesia, which will improve the country's ES.

3.5 Environmental Aspect

RE is one of the most important indications of ES's environmental dimension. RE contributes most favorably to environmental sustainability by lowering carbon footprints and carbon-based emissions. The estimated emission reductions achievable through the energy mix target achievement can be observed in Table 4.

Table 4. Projected BAU and Emission Reduction for Energy Sector

Scenario	GHG Emission Level 2030	GHG Emission Reduction	
	MTon CO_2-eq	MTon CO_2-eq	% of Total BaU
BaU	1,669	-	-
CM1	1,311	358	12.5%
CM2	1,223	446	15.5%

Note : BAU = Business As Usual, CM 1 = counter measure 1 (Unconditional mitigation scenario), CM 2 = counter measure 2 (Conditional mitigation scenario)
Source : Enhanced Nationally Determined Contribution Republic of Indonesia

The development of renewable energy sources must consider other environmental impacts besides emission reduction. The construction of a concentrated solar plant will increase land use conversion. The construction of such technology causes drastic changes in soils [39]. The natural biological soil crusts and vegetation are destroyed, and the soil close to the collector fields is disturbed [40]. According to several studies, the environment benefits from floating photovoltaics (PV), which reduces changes in land use and forest loss, erosion, runoff, bird death rates, water evaporation from lakes, algae growth, and microclimate change [41]. However, more research is needed in this area, and floating PV systems must be evaluated locally taking into account all environmental factors. Cofiring biomass in coal power plants will cut emissions, particularly CO_2 and SOx, as wood biomass typically has lower sulfur content [16]. However, the current availability of biomass is still limited, and processing is required before biomass can be used as fuel.

The use of renewable energy sources typically minimizes emissions in a favorable way, but it's important to ensure that in the provision of electricity from renewable sources, all aspects are considered to minimize environmental impact. Each renewable energy development in Indonesia involves an Environmental Impact Assessment (AMDAL) document used to identify social and economic impacts on the environment. This document serves as one of the mitigations to minimize the environmental impact arising from energy transition activities.

3.6 Legal Aspect

In supporting energy transition activities, the Indonesian government has issued several regulations that as shown in Table 5.

Table 5 Regulations Related to the Energy Transition

No	Peraturan
1	Presidential Regulation Number 112 of 2022 concerning the Acceleration of Renewable Energy Development
2	Presidential Regulation Number 98 of 2021 concerning Carbon Economic Value
3	Ministry of Finance Regulation Number 103 of 2023 concerning Fiscal Support through the Funding and Financing Framework to Accelerate Energy Transition in the Electricity Sector
3	Minister of Energy and Mineral Resources Decree Number 14.K/TL.04/MEM.L/2023 regarding the Approval of Greenhouse Gas Emission Limits from Coal-Fired Steam Power Plants Connected to the National Electricity Grid of PT Perusahaan Listrik Negara (Persero) - Phase One
4	OJK (Financial Services Authority) Regulation Number 14 of 2023 concerning Carbon Trading through the Carbon Exchange
5	Ministry of Energy and Mineral Resources Regulation Number 26 of 2021 concerning Rooftop Solar Power Plants Connected to the National Electricity Grid of Licensed Electricity Providers for Public Interest
6	Ministry of Energy and Mineral Resources Regulation Number 4 of 2020 on the Second Amendment to Minister of Energy and Mineral Resources Regulation Number 50 of 2017 on the Utilization of Renewable Energy Sources for Electricity Provision
7	Ministry of Energy and Mineral Resources Regulation Number 53 of 2018 on the First Amendment to Minister of Energy and Mineral Resources Regulation Number 50 of 2017 on the Utilization of Renewable Energy Sources for Electricity Provision
8	Ministry of Energy and Mineral Resources Regulation Number 50 of 2017 on the Utilization of Renewable Energy Sources for Electricity Provision

As per regulations, the Indonesian government has issued numerous laws as the legal foundation for implementing the energy transition. However, in the context of developing renewable energy plants, the challenge lies in the multitude of licenses required. For instance, in the case of constructing the 145 MW Floating Solar Power Plant (PLTS) in Cirata, 19 permits are needed, ranging from the planning phase to operational permits. Similarly, for the Batang Toru Hydropower Plant (PLTA), 47 licenses are necessary. The obligation to fulfill these requirements and permits contradicts the goal of accelerating the energy transition. Not only does the complexity of bureaucracy involve multiple sectors and institutions, but the time required for issuing these permits is also considerably lengthy.

4 Conclusion

The energy trend of the future is renewable energy. Therefore, energy transition activities must be carried out to achieve sustainable development for the community. The prospect for renewable energy sources in Indonesia is enormous. All stakeholders, including the public, business community, academic community, and government, must support energy transition initiatives. Indonesia has shown steps in the energy transition, both in terms of the policies issued and the development of new renewable power plants.

The challenges faced in energy transition activities include the need for significant and appropriate investments to achieve the goal of providing reliable, modern, and affordable clean energy, as well as the carbon-neutral target by 2060. Another challenge is the lack of supporting infrastructure for renewable energy sources and the scarcity of domestic renewable energy technology, necessitating innovation related to the energy transition supported by human resource competence. Enhancing partnerships between the private sector can also drive the acceleration of the energy transition, but a clear partnership scheme and investment roadmap are needed for precise objectives. Public awareness and increased understanding of clean energy and climate change impacts are also necessary to promote environmentally friendly lifestyles.

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