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The Benefits of Clean and Affordable Energy for National and State Life

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Abstract: *The average electricity consumption per capita in Indonesia in 2023 was 1,285 kWh per year, or approximately 3.53 kWh per day. Meanwhile, the average household consumption of LPG gas for cooking was around 4–5 cylinders of 3 kg per month, equivalent to about 11.4 kg of gas per month for small households. Both energy types generally originate from fossil fuels. With the continuously growing population, energy demand will inevitably increase, leading to potential depletion of natural fuel resources and environmental degradation if reliance on fossil-based energy continues. This study aims to analyze energy transition strategies aligned with Sustainable Development Goal 7 (SDG 7): Ensure access to affordable, reliable, sustainable, and modern energy for all. The method employed is a critical literature review, analyzing national energy policies and integrating them with academic findings on sustainability dilemmas. The results show that large-scale implementation of renewable energy (RE), while supporting SDG 7 and SDG 13 (Climate Action), also generates significant trade-off conflicts. These conflicts—centered on the dependency on critical material supply chains and the environmental impacts of renewable infrastructure—potentially undermine SDG 12 (Responsible Consumption and Production) and SDG 15 (Life on Land). Therefore, transitional solutions must go beyond decarbonization, emphasizing product life-cycle sustainability, strengthening the circular economy, and promoting public education on alternative energy sources (such as induction stoves and biogas) to ensure a truly just and environmentally friendly energy transition.*

Keywords: *Energy Transition, Renewable Energy, SDGs, Sustainability Dilemma, Circular Economy*

Abstrak: Ketersediaan energi yang terjangkau, andal, dan berkelanjutan merupakan pilar fundamental bagi ketahanan nasional dan kesejahteraan masyarakat Indonesia. Data tahun 2023 menunjukkan konsumsi listrik per kapita Indonesia mencapai 1.285 kWh per tahun, dengan ketergantungan signifikan pada bahan bakar fosil, khususnya batu bara untuk pembangkit listrik. Di sektor rumah tangga, konsumsi LPG untuk memasak rata-rata 4-5 tabung 3 kg per bulan, merepresentasikan beban subsidi dan kerentanan pasokan. Penelitian ini bertujuan untuk menganalisis strategi transisi energi Indonesia yang selaras dengan Sustainable Development Goal (SDG) 7, sekaligus mengidentifikasi dan memetakan dilema keberlanjutan (*trade-offs*) yang muncul dari implementasi Energi Baru Terbarukan (EBT) secara masif. Metode yang digunakan adalah studi literatur kritis terhadap kebijakan nasional, laporan lembaga internasional, dan temuan akademis mutakhir. Hasil penelitian mengungkapkan bahwa meskipun EBT krusial untuk mencapai SDG 7 (Energi Bersih dan Terjangkau) dan SDG 13 (Aksi Iklim), adopsinya menimbulkan konflik keberlanjutan yang kompleks. Konflik ini terutama terkait dengan rantai pasok material kritis (seperti litium, kobalt, nikel) untuk teknologi EBT, yang berpotensi melanggar prinsip SDG 12 (Konsumsi dan Produksi Bertanggung Jawab) due to dampak lingkungan dan sosial dari penambangannya. Selain itu, pembangunan infrastruktur EBT skala besar berpotensi menyebabkan fragmentasi habitat dan konflik lahan, sehingga bertentangan dengan SDG 15 (Ekosistem Daratan). Kajian ini menyimpulkan bahwa transisi energi yang sukses memerlukan pendekatan yang melampaui dekarbonisasi, dengan mengintegrasikan prinsip ekonomi sirkular untuk mengelola limbah EBT, memperkuat edukasi masyarakat tentang alternatif energi bersih (kompor induksi, biogas), dan mengembangkan kebijakan yang didukung indikator keberlanjutan holistik yang mencakup aspek lingkungan, sosial, dan ekonomi sepanjang siklus hidup teknologi. Rekomendasi kebijakan diarahkan pada penciptaan sistem energi yang tidak hanya bersih dan terjangkau, tetapi juga adil dan tangguh, guna mendukung pembangunan nasional yang berkelanjutan.

Kata kunci: *Transisi Energi, Energi Terbarukan, SDGs, Dilema Keberlanjutan, Ekonomi Sirkular, Ketahanan Energi Nasional, Kebijakan Energi.*

Introduction

Energy plays an undeniable role as a key driver of a nation's socio-economic development. In the context of Indonesia, an archipelagic nation with a population of over 270 million and sustained economic growth, the availability of affordable, reliable, and modern energy is an absolute prerequisite for sustaining industrialization, improving the quality of healthcare and education services, and ultimately reducing inequality and poverty. Equitable energy access is fundamental to improving the Human Development Index (HDI) and creating quality jobs.

Globally, the energy transition discourse has gained significant momentum, driven by two main forces: first, the urgency to mitigate the increasingly real and threatening impacts of climate change, with the energy sector being a major contributor to global greenhouse gas emissions; and second, awareness of the limitations of non-renewable fossil fuel resources, which create geopolitical and economic vulnerabilities for countries that rely on them [1].

However, the reality in Indonesia shows that dependence on fossil fuels remains very high and dominates the national energy mix. Data from the Ministry of Energy and Mineral Resources [2] indicates that per capita electricity consumption in 2023 reached approximately 1,285 kWh per year, the majority of which is still supplied by coal-fired power plants (PLTU). Meanwhile, in the household sector, dependence on LPG (Liquefied Petroleum Gas) for cooking remains very high, with average consumption ranging from 4-5 3 kg cylinders per month per household [3]. This consumption pattern not only burdens the state budget through massive energy subsidies but also creates vulnerabilities due to dependence on imports and fluctuations in global commodity prices.

This structural dependence on fossil fuels poses a multidimensional threat. From an energy security perspective, Indonesia is at risk of an energy crisis as domestic fossil fuel reserves deplete and dependence on imports increases. From an environmental perspective, the exploitation and consumption of fossil fuels have contributed significantly to air pollution, greenhouse gas emissions, land degradation, and biodiversity loss. Therefore, the transition to a clean and renewable energy system is no longer merely an option but a strategic imperative to ensure the future of a sovereign, independent, and sustainable nation and state.

In response to this global challenge, the international community, through the United Nations (UN), adopted the 2030 Agenda for Sustainable Development, with 17 Sustainable Development Goals (SDGs). SDG 7 specifically targets "ensuring access to affordable, reliable, sustainable and modern energy for all" [1]. This target has three main pillars: (1) Universal access to modern energy services; (2) Significantly increasing the share of renewable energy in the global energy mix; and (3) Increasing the rate of global energy efficiency. SDG 7 does not stand alone; it is closely linked and interconnected with other SDGs, such as poverty eradication (SDG 1), good health (SDG 3), quality education (SDG 4), economic growth (SDG 8), and addressing climate change (SDG 13).

Despite growing global and national commitments to New and Renewable Energy (NRE), in recent years a critical debate has emerged among academics and practitioners challenging the assumption that renewable energy is inherently "sustainable" in the full sense [4, 6]. The increased production of renewable energy technologies, such as solar panels, wind turbines, and batteries for electric vehicles, requires critical materials (such as lithium, cobalt, nickel, and rare earth metals), whose mining processes in various parts of the world often have serious social and environmental impacts, including ecosystem damage, water pollution, and human rights violations. This creates a "sustainability dilemma," or a complex trade-off between achieving one SDG and another.

Against this backdrop, this study has three main objectives: To analyze the strategies and achievements of SDG 7 implementation in Indonesia in overcoming dependence on fossil fuels. To identify and explore the trade-off dilemmas that arise between achieving SDG 7 and other SDGs, particularly SDG 12 (Responsible Consumption and Production) and SDG 15 (Life on Land), as a consequence of the massive implementation of renewable energy. To formulate holistic and systemic policy recommendations to ensure that the energy transition in Indonesia involves not merely changing energy sources, but truly transforming the system toward true, equitable, and environmentally sound sustainability.

Research Method

This research adopts a qualitative approach with a focus on a critical literature review design. This method was chosen based on its unique ability to go beyond mere description of existing findings. This study actively evaluates, critiques, synthesizes, and constructs original arguments from a variety of academic and non-academic sources. The goal is to generate a comprehensive and in-depth understanding of the complexities of the energy transition issue in Indonesia and the fundamental dilemmas surrounding its sustainability, as outlined in reference [8].

Data Sources and Credibility

The data used is secondary data carefully collected from credible sources, which are grouped into three main pillars. First, Policy Documents and Official Reports from key institutions, including the SDGs report from BAPPENAS, strategic documents such as the Indonesian Energy Outlook [2] and the National Energy General Plan (RUEN) from the Ministry of Energy and Mineral Resources, as well as authoritative reports from global organizations such as the United Nations (UN) [1] and the International Energy Agency (IEA) [9]. Second, Publications from Think Tanks and NGOs that present independent analysis and critical complementary data, such as reports from the Institute for Essential Services Reform (IESR) [3] and the World Bank [10]. Third, Internationally Reputable Academic Journals, where the literature search is focused on leading databases (Scopus, ScienceDirect, Google Scholar). To ensure relevance and credibility, this study limits its focus to publications in the 2018-2024 period from renowned journals such as Nature Sustainability [7] and Energy Research & Social Science [4], using specific keywords such as "energy transition Indonesia", "SDG 7 trade-offs", and "critical materials sustainability".

Systematic Data Analysis Process

The collected data was analyzed in depth using thematic argumentative synthesis techniques through four systematic stages. The initial stage is Problem Mapping, which identifies and categorizes the main challenges of the energy transition in Indonesia into techno-economic, policy, social, and environmental dimensions. Next, a critical Policy Evaluation is conducted on government programs related to the implementation of SDG 7 (e.g., induction stove programs, Rooftop Solar Power Plants) to assess their consistency with broader sustainable development principles. The next crucial stage is Conflict Identification and Analysis (Trade-offs), which aims to reveal points where achieving the clean energy target (SDG 7) has the potential to harm the achievement of other SDGs, especially SDG 12 (Consumption and Production) and SDG 15 (Terrestrial Ecosystems), with a particular emphasis on the impacts of critical material supply chains and land use. The final and culminating stage of the analysis is Recommendation Formulation, which develops strategic and applicable policy suggestions, based on the synthesis of findings, to mitigate the negative impacts of the identified trade-offs, thereby ensuring the realization of a truly sustainable and equitable energy transition.

Results and Discussion

The Indonesian government has demonstrated a strong political commitment to achieving SDG 7 through a series of concrete policies, regulations, and programs focused on its three main pillars. Efforts to achieve universal access to modern energy have shown significant progress, with the electrification ratio steadily approaching 100%. The strategy implemented includes not only grid extension to remote areas but also innovative off-grid solutions, such as the installation of centralized solar power plants (PLTS) and micro-hydro power plants (PLTMH) for communities in geographically remote areas. Regarding clean cooking fuels, the government transitioned from kerosene to 3-kg LPG cylinders in the previous era and is now promoting a transition program to electric (induction) stoves and the development of biogas at the household and community scale, particularly in rural areas with abundant organic waste from livestock and agriculture [5]. This program aims not only to reduce the burden of LPG subsidies and dependence on imports, but also to provide cleaner, healthier, and more self-sufficient energy alternatives for communities.

To accelerate the share of renewable energy in the national energy mix, the government has set an ambitious target in the National Energy Plan (RUEN), namely 23% by 2025. Various supporting policies have been issued, including fiscal and non-fiscal incentives to attract investment in the renewable energy sector. At the implementation level, the development of large-scale renewable energy power plants continues to be accelerated, such as the Floating Solar Power Plant (PLTS Terap) in the Cirata Reservoir (with a capacity of 192 MWp, the largest in Southeast Asia), the development of Geothermal Power Plants (PLTP), and Wind Power Plants (PLTB). Downstream, the Rooftop Solar Power Plant (PLTS) program for the household, commercial, and industrial sectors is being encouraged through net-metering regulations, which enable consumers to become prosumers (producers and consumers) and reduce their electricity bills. These measures are considered crucial for reducing carbon emissions from the electricity sector and mitigating the risk of future fossil fuel shortages.

Efforts to improve energy efficiency are being implemented through several approaches. First, the implementation of Minimum Energy Performance Standards (MES) for household electronic appliances, such as air conditioners, refrigerators, and LED lights, has proven successful in significantly reducing national energy consumption. Second, smart grid initiatives and the digitalization of the electricity network have begun to be implemented to optimize electricity distribution, reduce losses, and integrate intermittent renewable energy sources into the system more efficiently. Third, in the industrial sector, energy audit programs and energy management systems are being implemented to encourage efficiency and operational cost savings, while simultaneously contributing to increasing the competitiveness of the national industry.

While progress in renewable energy implementation is commendable, critical findings from this study reveal that widespread renewable energy adoption creates serious sustainability dilemmas, creating conflicts or trade-offs with other Sustainable Development Goals. Supply chains for renewable energy technologies, particularly solar panels, wind turbines, and energy storage batteries, rely heavily on critical materials such as lithium, cobalt, nickel, and rare earth elements.

Environmental and Social Impacts of Mining: The mining process for these materials is often highly energy- and water-intensive, and leads to massive soil and water pollution due to mine tailings [6, 7, 10]. For example, cobalt mining in the Democratic Republic of Congo has been linked to human rights violations and hazardous working conditions, including child labor. Such practices clearly contradict the principles of responsible consumption and production.

Waste and Life Cycle Challenges: Solar panels and lithium-ion batteries have a limited lifespan (typically 20-25 years for solar panels, 8-15 years for batteries). Without adequate and sophisticated recycling and waste management systems, electronic waste (e-waste) from renewable energy equipment will become a significant new environmental problem in the future [8, 11]. Currently, the recycling infrastructure and technology for renewable energy components, particularly solar panels, are still in development and have not been widely implemented, including in Indonesia. Large-scale renewable energy infrastructure development, such as solar farms and wind farms, requires extensive land allocation.

Habitat Fragmentation and Biodiversity Loss: Land conversion for these projects has the potential to cut off wildlife migration corridors, disrupt animal behavior, and cause habitat fragmentation, which can ultimately lead to a decline in biodiversity [7]. Large-scale hydropower development often floods forest areas and wetlands with high ecological value.

Land Use Conflicts: Land acquisition for large renewable energy projects has the potential to trigger social conflicts with local and indigenous communities who depend on the land for farming, hunting, or cultural rituals. This creates tension between clean energy goals and community rights and the preservation of terrestrial ecosystems.

The Risk of "Green Colonialism": The dependence of developed countries on critical material supplies from developing countries can create new, inequitable forms of economic dependency. In this dynamic, the economic value added from advanced processing and manufacturing of renewable energy technologies is often not shared equally by raw material-producing countries, potentially reinforcing global inequality (SDG 10) [6].

Just Transition: The energy transition risks causing structural unemployment if workers in fossil fuel sectors (such as coal and oil mining) are not prepared with adequate reskilling and upskilling programs to transition to jobs in the new green energy sector. If not managed well, the transition could actually exacerbate unemployment and socio-economic disparities in regions that have historically relied on fossil fuel industries, thus contradicting the spirit of SDGs 8 and 10.

To address this complex sustainability dilemma, Indonesia's energy transition approach must go beyond the simplistic narrative of replacing fossil fuels with renewable energy sources. A holistic and systemic approach is needed that considers the entire life cycle of energy technologies. Design for Sustainability: Renewable energy technologies must be designed from the outset with consideration for ease of repair, upgrades, recycling, and reuse of their components (design for disassembly and recycling).

Development of the Domestic Recycling Industry: The government needs to encourage investment, research, and development of efficient and economical recycling technologies for solar panels, lithium-ion batteries, and wind turbine components. This will create new value chains, reduce dependence on imported raw materials, minimize environmental pressures from primary mining, and prevent the future accumulation of renewable energy waste [11]. Circular Business Models: Encourage the adoption of circular business models such as product-as-a-service (such as solar panel rentals) or second-life applications (for example, using used electric car batteries for stationary energy storage systems in homes or buildings).

Comprehensive National Campaign: Massive education on the importance of energy efficiency, the benefits of clean energy, and how to adopt it needs to be intensified through various media channels, both traditional and digital. Technical Training and Mentoring: Provide practical training to communities, especially in rural and remote areas, to build, operate, and maintain small- and medium-scale renewable energy systems, such as biogas from livestock manure or micro-solar power plants.

Incentives for Energy-Saving Behavior: Provide incentives, both fiscal and non-fiscal, for households and industries that invest in energy-efficient and renewable energy technologies, such as rooftop solar power plants or equipment with energy-saving labels. Rigorous Strategic Environmental Assessment (KLHS): Every large-scale renewable energy project, whether on land or offshore, must undergo a comprehensive and participatory KLHS process to identify, assess, and mitigate socio-environmental impacts from the planning stage.

Multidimensional Sustainability Indicators: Develop and implement a monitoring and evaluation system that focuses not only on metrics of installed renewable energy capacity and CO_2 emission reductions, but also on indicators such as material recycling rates, land footprint, local employment, impacts on biodiversity, and the distribution of economic benefits to local communities. Fair and Equitable International Cooperation: Indonesia must actively participate in international diplomatic forums to promote equitable governance of critical materials trade, adequate technology transfer from developed countries, and accessible financing for investments in the circular economy and clean energy technologies.

Conclusion

In closing this lengthy and in-depth analysis, it can be concluded that Indonesia's journey towards a clean and affordable energy system is both inevitable and a major challenge fraught with complexity. This document has clearly outlined that national dependence on fossil fuels, reflected in significant levels of household electricity and LPG consumption, has created vulnerabilities in various areas, from energy security and fiscal stability to environmental sustainability. In this context, Sustainable Development Goal (SDG) 7 serves as a crucial compass for guiding strategic steps in the energy transition, as evidenced by various government initiatives to expand electricity access, accelerate New and Renewable Energy (NRE), and improve energy efficiency.

However, a central finding of this critical review is the recognition that the energy transition is not a linear and conflict-free process. Efforts to achieve one sustainability goal (SDG 7) can actually create side effects that undermine other sustainability goals. The trade-offs resulting from renewable energy production and infrastructure development—especially those related to the environmentally damaging exploitation of critical materials (conflicting with SDG 12) and land conversion that threatens biodiversity (conflicting with SDG 15)—must no longer be ignored. Likewise, social and economic justice must be a primary consideration to prevent new inequalities and ensure that no one is left behind in this transition process.

Therefore, the strategic implication is that Indonesia must adopt a systemic, integrative, and inclusive approach to the energy transition. This approach must go beyond a purely technical narrative about energy source replacement and incorporate other critical dimensions. First, strengthening the circular economy in the renewable energy industry must be a national priority, by encouraging innovation in material recycling to close the material loop and minimize waste. Second, community education and empowerment are key to generating demand and active grassroots participation in building a clean energy ecosystem, from the household to the community level. Third, the policy framework needs to be strengthened with multidimensional sustainability indicators capable of capturing the full impacts of an energy project and ensuring the principle of transitional justice for all levels of society, including workers in the fossil fuel sector and indigenous communities.

By embracing this complexity and taking bold and visionary steps, the energy transition will no longer be merely a government program but a national movement. Ultimately, a sustainable, resilient, and equitable energy system will form a solid foundation for Indonesia's energy sovereignty, national economic resilience, and environmental preservation for future generations. This is the energy sector's real contribution to realizing a more prosperous, advanced, and sustainable nation and state.

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