SINTHOP: Media Kajian Pendidikan, Agama, Sosial dan Budaya
Volume 4, Number 1, January-June 2025
E-ISSN: 2986-8475 | DOI: 10.69548/sinthop.v4.i1.36.103-112

OPPORTUNITIES AND CHALLENGES IN ACCELERATING RENEWABLE ENERGY TRANSITION: A CASE STUDY OF LHOKSEUMAWE, ACEH, INDONESIA

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Abstract

Indonesia faces a growing energy demand amid increasing environmental and economic challenges, particularly due to its continued reliance on fossil fuels. While national policies and international commitments have set ambitious targets for renewable energy adoption, implementation at the local level remains limited. This study aims to explore the opportunities and challenges of accelerating renewable energy transition policies in Lhokseumawe, Aceh, using a qualitative case study approach. Data were collected through semi-structured interviews, field observations, and document analysis involving key stakeholders and local communities. The findings reveal that although Lhokseumawe has substantial renewable energy potential and widespread public utility coverage, local efforts are hampered by insufficient funding, regulatory ambiguities, technical capacity gaps, and deeply rooted traditional practices such as informal oil drilling. Nonetheless, positive developments are observed in the form of local energy planning initiatives, public-private partnerships, and increasing community engagement. This research underscores the need for stronger local government authority, innovative financing, and community empowerment to bridge the gap between national policy ambitions and local realities, providing practical insights for Indonesia's just and inclusive energy transition.

Keywords: *Energy Governance, Policy Implementation, Sustainable Development, Aceh, Urban Energy, Public Participation*

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A. Introduction

The world is currently witnessing a dramatic surge in energy demand, a trend that is particularly pronounced in developing countries like Indonesia (International Energy Agency, 2023). However, this growing need is not being matched by the sustainable availability of energy resources. To date, the vast majority of Indonesia's energy supply relies on fossil fuels—primarily oil, coal, and natural gas—which continue to dominate the national energy mix despite global concerns about their environmental and economic impacts. In Indonesia, the consequences of fossil fuel dependency are increasingly apparent. The burning of fossil fuels not only contributes to severe air pollution and climate change, but is also closely linked to deforestation, overconsumption, and a host of environmental problems (Nasution et al., 2023). Extreme weather events, such as the

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DOI: 10.69548/sinthop.v4.i1.36.103-112

El Niño-induced droughts and reduced rainfall, have further highlighted Indonesia's vulnerability to climate change. Geopolitical instability and fluctuating global oil prices exacerbate the problem, putting additional pressure on the state budget through rising energy subsidies for fuel, electricity, and LPG.

Recent data from the Special Task Force for Upstream Oil and Gas Business Activities (SKK Migas) reveal a worrying trend: Indonesia's oil production has been steadily declining over the past six years, forcing the country to rely heavily on crude oil and fuel imports to meet national demand (IPA, 2024; Mardiansyah, 2024; Setiawan, 2024). This growing import dependency threatens energy security, economic stability, and, ultimately, the country's long-term development prospects (Rudiany, 2020). Meanwhile, although Indonesia possesses significant reserves of coal, oil, and natural gas—as well as immense potential in renewable energy sources such as solar, hydro, wind, geothermal, and biomass—these resources remain underutilized (Primadita, 2022).

Recognizing these challenges, the Indonesian government has taken decisive steps to promote a transition towards renewable energy. The National Energy Policy (KEN), Government Regulation No. 79 of 2014, and Presidential Regulation No. 22 of 2017 (RUEN) have all established ambitious targets for increasing the share of renewables in the national energy mix, in line with international commitments such as the Paris Agreement (Kholiq, 2015). Yet, despite a clear regulatory framework, significant barriers remain at the local and regional levels, where policy implementation is often hampered by limited funding, unclear regulatory mandates, and low public awareness.

A stark example of these challenges can be seen in Aceh, particularly in the city of Lhokseumawe and villages like Buket Pala, where illegal oil drilling has become deeply entrenched as a primary livelihood for many local residents. Despite frequent accidents, fires, and even fatalities, such high-risk activities persist, driven by poverty, limited access to education, and the absence of effective alternative livelihoods. The informal exploitation of old oil wells—known locally as *leles minyak*—has become an economic lifeline, with profits often shared across the community, but at significant cost to both safety and the environment. Environmental pollution, land degradation, and recurring accidents are now part of daily reality in these areas, exposing the limitations of existing regulatory oversight and social protection. At the same time, local governments play a critical role in the national energy transition agenda. Through legal instruments such as the Regional Energy General Plan (RUED) and various local regulations (Qanun), provincial and district governments are tasked with translating national policy into actionable, context-sensitive strategies. However, the effectiveness of these efforts depends heavily on local capacity, funding mechanisms, regulatory clarity, and—crucially—public participation.

Most prior research has focused on national policy or technical aspects of renewable energy deployment, with little attention given to how local realities—such as informal energy economies, community dependence on risky livelihoods, and the uneven distribution of public infrastructure—shape the prospects for sustainable energy transitions (De Laurentis & Pearson, 2021; SEADS, 2025). There is, therefore, a pressing

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need for studies that bridge this gap by examining the complex interplay between national policy frameworks and local implementation, using empirically-rich case studies that capture ground-level dynamics (Jaelani et al., 2017; Jazuli & Wibowo, 2020). This paper addresses this need by exploring the opportunities and challenges in accelerating renewable energy transition policies in Indonesia, with a specific focus on Lhokseumawe, Aceh. The study aims to answer two central questions: (1) What are the main obstacles to the effective implementation of renewable energy transition policies at the local level? (2) What opportunities and practical pathways exist for local governments and communities to contribute meaningfully to this transition?

B. Method

This study employed a qualitative case study approach to explore the multifaceted realities of renewable energy transition in Lhokseumawe, Aceh. A qualitative approach was considered the most suitable because it enables an in-depth and nuanced understanding of social, economic, and policy dynamics that are often missed in quantitative studies (Creswell, 2016). The philosophical foundation of the research is post-positivism, which recognizes that knowledge is constructed through the interaction between the researcher and the research participants (Moser & Korstjens, 2017). This paradigm allows the researcher to interpret and understand local phenomena in a way that is both contextual and reflective of participants' experiences.

Primary data for this research were collected through semi-structured interviews with a purposively selected group of stakeholders, including local government officials, community leaders, operators of traditional oil wells, and residents of Buket Pala Village. These interviews were designed to gather diverse perspectives on energy transition policies, as well as the motivations and challenges faced by individuals involved in energy-related activities. Field observations were also conducted at relevant sites, providing firsthand insights into local practices, environmental conditions, and socio-economic dynamics. Throughout the fieldwork, detailed notes and photographs were taken to document significant findings. To complement primary data, secondary sources such as policy documents, official reports from energy agencies, published research articles, and media coverage were analyzed. The integration of multiple data sources and methods reflects the principle of triangulation, which is essential for enhancing the validity and credibility of qualitative research findings (Denzin & Lincoln, 2018).

Participants for interviews and observations were selected based on their involvement in local energy activities, their roles in local policy implementation, and their residence in areas affected by both renewable energy projects and illegal drilling. This purposive sampling strategy was intended to ensure that the voices of those most directly impacted by energy transition policies were adequately represented. All data collected were analyzed using narrative analysis, a method that emphasizes the identification of themes, stories, and patterns within qualitative data. This approach is particularly well-suited to capturing the lived experiences of communities and the complex interplay between policy and practice at the local level. Data coding and theme identification were

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conducted systematically, and key findings were validated through participant feedback and peer discussions.

C. Results and Discussion

1. Energy Governance in Lhokseumawe City

Lhokseumawe City, located in the lowlands of northern Sumatra at an average elevation of 24 meters above sea level, occupies a total area of 181.06 km². Geographically, it lies between 04°54' North and 05°18' South latitude, and between 96°20' and 97°21' East longitude. By the end of 2020, Lhokseumawe was administratively divided into four sub-districts: Muara Satu (55.90 km²), Muara Dua (57.80 km²), Banda Sakti (11.24 km²), and Blang Mangat (56.12 km²). This strategic location on the eastern coast of Sumatra, directly bordering the Strait of Malacca to the north and surrounded by North Aceh Regency, positions Lhokseumawe as a vital node for distribution and trade in Aceh and connects it to major cities such as Medan and Banda Aceh.

The city's climate in 2020 was characterized by average temperatures ranging from 22°C to 34°C, humidity between 81% and 87%, air pressure between 1,009 mb and 1,011 mb, and average rainfall of around 117 mm. Since its establishment as a city in 2001—following its expansion from North Aceh Regency—Lhokseumawe has grown from three to four sub-districts and now encompasses 68 villages. Blang Mangat is the largest in terms of village numbers (22 villages), followed by Banda Sakti (18), Muara Dua (17), and Muara Satu (11).

Population growth in Lhokseumawe has been steady, reaching an estimated 203,284 people in 2022 with a growth rate of 0.77% over the previous year. The city exhibits an average population density of 1,057 people per square kilometer, but there is significant variation: Banda Sakti is the most densely populated district (6,962 people/km²), while Blang Mangat is the least (481 people/km²). This sustained population growth is closely linked to urban development, necessitating enhanced accessibility and public facilities.

The city's built-up land has increased markedly, from 22.1% to 26.29% in recent years, reflecting significant growth in residential, commercial, and transportation infrastructure. For example, in Banda Sakti, approximately 70.46% of the area is developed, with the remainder consisting of fields, dry lands, grasslands, and uncultivated land. However, this expansion has led to a notable decrease in green open spaces. The accelerated development of housing and supporting infrastructure has resulted in a more even distribution of the population and a growing demand for urban services.

Urban facilities—particularly in trade, administration, and office spaces—are concentrated in the city center and along major transportation routes, underscoring the critical role of road infrastructure and accessibility in shaping urban growth patterns. Importantly, coverage of essential public utilities such as clean water, telephone, and electricity networks is now nearly universal throughout Lhokseumawe's developed areas. These trends highlight the dual challenge facing Lhokseumawe: while urban and economic development bring improved services and opportunities, they also place

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increasing pressure on sustainable energy management and urban planning. The ability of local governance to balance growth with the preservation of environmental quality and efficient energy use will be crucial for achieving the city's long-term sustainability and supporting the broader renewable energy transition agenda.

2. Physical Development of the City of Lhokseumawe

The physical development of Lhokseumawe City has been predominantly shaped by continuous population growth, resulting in an increasing need for new spaces to support residents' daily activities and interactions. This expansion has necessitated the conversion of previously agricultural or undeveloped land into residential, commercial, and public areas. The pattern of urban growth in Lhokseumawe is strongly influenced by accessibility, with major housing developments and individually constructed homes emerging primarily along well-connected roads. This trend is evident across all major sub-districts—Blang Mangat, Muara Satu, Muara Dua, and Banda Sakti—where both developer-driven and private home construction have transformed the landscape.

Much of the land used for this expansion was previously inherited or utilized as rice fields. Its transition into residential areas has also fostered the development of supporting facilities and services, such as retail shops, educational institutions, and essential public infrastructure. Notably, the presence of subdivided land around these new neighborhoods has made property more accessible to both developers and individual buyers. Additionally, similarities in residents' professional backgrounds have created distinct community identities and contributed to the attractiveness of certain locations for new housing.

Accessibility remains a major determinant in the selection of residential areas. Proximity to main roads not only accelerates physical expansion but also stimulates local-scale commercial activity, with shops and service providers naturally clustering around newly developed zones. In Banda Sakti and Muara Dua, for example, the influence of accessibility is further enhanced by the presence of a state university, which has driven the development of student boarding houses, photocopy shops, and convenience kiosks to meet student and community needs.

A closer examination of built-up area distribution reveals that Banda Sakti sub-district has experienced the highest percentage of land development, particularly in public facilities and utilities, when compared to Muara Dua and Blang Mangat. Conversely, population density growth in Blang Mangat has outpaced that of the other sub-districts, largely due to its proximity to employment centers such as hospitals, higher education institutions (including Lhokseumawe State Polytechnic), and government offices.

Within Banda Sakti, the growth of built-up land is most pronounced in villages and urban neighborhoods like Mon Geudong, Kutablang, Keude Aceh, and Simpang Empat, where the average developed land area consistently exceeds 10 hectares. Key infrastructure projects have further accelerated this trend: for example, the transformation of swamp land in Keude Aceh and Mon Geudong into a sports complex (Tunas Bangsa Stadium) and office buildings, as well as the development of the Islamic Center, the

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Lhokseumawe Mayor's Office, and an intercity/provincial bus terminal in Kutablang. In summary, the acceleration of physical development in Lhokseumawe is driven by the city's need for economic, administrative, and educational infrastructure, with sectoral growth occurring in all directions—north, south, west, and east. The most significant land development has taken place in the Banda Sakti sub-district, especially in central urban areas, reflecting a pattern of urbanization that is both dynamic and responsive to the evolving socio-economic needs of the city's population.

3. Understanding the Direction of Energy Management Policy

Indonesia's energy management policy is firmly grounded in a series of comprehensive legal and strategic frameworks. Central to this structure is Law Number 30 of 2007 concerning Energy, which mandates the formulation of the National Energy General Plan (RUEN) as a blueprint for national energy development (Adellea, 2022). The National Energy Council (DEN) is specifically tasked with preparing RUEN, drawing on the foundations laid out by the National Energy Policy (KEN), as stipulated in both Article 12 and Article 17 of the law. The National Energy Policy itself, as formalized by Government Regulation Number 79 of 2014, articulates clear objectives aimed at achieving national energy resilience, independence, and the support of sustainable national development.

Key goals outlined in the KEN include setting targets for energy supply and consumption, improving energy elasticity and intensity, optimizing the electrification ratio, and maximizing the use of domestic energy resources. These objectives reflect a paradigm shift—viewing energy not merely as a commodity for export, but as a crucial driver of national progress, technological development, job creation, climate change mitigation, and environmental protection. Building upon these principles, the RUEN and the National Electricity General Plan (RUKN) serve as operational roadmaps, offering cross-sectoral strategies and detailed forecasts of energy supply and demand through 2050. Importantly, RUEN provides not only a framework for national energy management but also serves as a guideline for the creation of Regional Energy General Plans (RUED) at the provincial and local levels. The ultimate aim is to foster energy independence, guarantee widespread and equitable access, promote integrated and sustainable management of resources, and enhance the capabilities of domestic industries and technology.

Despite the ambitious scope of these policies, significant implementation challenges remain. The government, for instance, set an ambitious target of achieving a 100 percent electrification ratio by 2022. By 2020, Indonesia's electrification ratio had reached 99.2%, a remarkable achievement in itself. However, this progress is uneven: four provinces still report electrification rates between 90% and 95%, and in East Nusa Tenggara, the figure stands at only 80%. Achieving full electrification across the archipelago is a complex task, hindered by geographic barriers, dispersed settlements, and infrastructure limitations—particularly in the so-called 3T regions (frontier, remote, and disadvantaged areas). These realities underscore the ongoing need for flexible,

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context-sensitive approaches and robust policy support to ensure that the benefits of national energy policy are fully realized at the local level.

4. Enhancing the Function of Local Government in the Framework for Putting Renewable Energy Use Policy into Practice

New renewable energy is now being looked at by many countries around the world. Saudi Arabia with oil reserves that will not run out in 200 years has also invested in new renewable energy (Ubaid & Gulrez, 2025). The development in Indonesia, renewable energy development is progressing quite slowly. The inefficiency of renewable energy sources and their high cost in comparison to fossil fuels are constant grievances. Research on renewable energy is a top priority for Indonesia. In addition to making renewable energy more efficient, supporting technologies should be developed. Research to improve renewable energy's ability to meet energy demands hasn't been a top priority, though. Policy breakthroughs that are needed include the provision of subsidies. Subsidies should be prioritized for renewable energy, not fuel oil. Another breakthrough needed is funding. Although clean and long-term, renewable energy is not cheap. Innovative funding schemes are needed.

The government actually has a number of funding schemes for the regions. However, with the design at the center, funding allocations sometimes do not match regional needs. What has to be promoted right now is a regional general plan in the energy sector to promote greater usage of new renewable energy. Furthermore, financial plans must create avenues for the private sector to participate. Actually, there are a number of initiatives that local governments can undertake to promote the growth of renewable energy, including the production of biodiesel, the use of biofuels in automobiles, and the development of solar power as a renewable energy source. However, these local government steps must be supported by a fiscal policy climate that favors the renewable energy industry. In addition, regulations are needed that govern the renewable energy business to stay within the corridors set by the central government.

In addition, the strengthening of local government authority must be clarified. It is anticipated that local governments will be better equipped to support national development goals in the energy sector as a result of this authority expansion, particularly the target percentage of new and renewable energy in the energy mix as part of the effort to lower greenhouse gas emissions. Additionally, capacity building needs to go hand in hand with local governments' increased authority. In the framework of fostering as well as strengthening regional capacity, the central government facilitates the issuance of Norms, Standards, Procedures and Criteria (NSPK) that must be guided by the regions. Because when receiving responsibility in the form of greater authority in the energy sector, regions can contribute more to initiatives aimed at assisting in the accomplishment of national development goals, especially in supporting the success of the energy transition policy.

Strengthening regional authority in this sector is also a concern of a number of Regional Governments because a number of problems related to regional authority in this

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sector are that energy conservation programs have not been included in the Regional Government Law, the suitability of regional activity indicators that must be achieved with limited authority, the absence of reward-punishment mechanisms, and the absence of objects of authority in the energy sector. Therefore, in order to maximize the role of the regions, the Presidential Regulation must increase authority in the new and renewable energy sector. Through a variety of solutions, the Lhokeumawe City area nevertheless actively contributes to reaching the energy mix target despite current constraints. For example, compiling energy transition models/projections in the user sector, energy transformation and solar energy supply. Future targets will develop solar PV projects in government offices, industries and schools as well as the utilization of developing biomass and biogas.

Referring to the problems found, the Central Government should play a greater role in issuing regulations and standardization than in managing applicative licensing. Regions are also given the flexibility to use the budget for EBT infrastructure according to regional potential, not limited by nationally uniform regulations which in the regions have minimal or even no potential. Because the role of the region is very important as well as being the front-liner of renewable energy development because it is an agency that understands the needs as well as conditions in the field. But besides that, the energy transition policy program should not forget the role of communities or people at the grassroots, especially for the development of micro-scale technology. Because currently the potential for renewable energy development is still very broad and has many benefits for the community. Furthermore, not only from the point of view of climate change mitigation, renewable energy development is also considered to have the potential as an option help strengthen the local economy in the future.

D. Conclusion

This study highlights both the progress and persistent challenges in accelerating the renewable energy transition in Lhokseumawe, Aceh. While Indonesia has made significant policy commitments to sustainable energy—evidenced by the adoption of the National Energy Policy (KEN), RUEN, and alignment with the Paris Agreement—the effective implementation at the local level remains constrained by a combination of regulatory, financial, technical, and social barriers. The analysis of Lhokseumawe's energy governance and physical development demonstrates how rapid urban expansion and demographic growth have driven increased energy demand, yet the reliance on traditional, fossil-based energy sources persists. Despite comprehensive public utility coverage and the presence of substantial renewable energy potential, these resources remain underutilized due to limited local funding, regulatory ambiguity, and insufficient public awareness. Moreover, deeply rooted practices such as informal oil drilling continue to pose safety and environmental risks while providing critical livelihoods for local communities.

At the policy level, the mechanisms for translating national strategies into effective local action are not yet fully optimized. The development of regional energy

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plans (RUED) and the enactment of local regulations represent important steps, but must be supported by stronger authority, clear guidelines, innovative financing models, and continuous capacity building at the regional level. Strengthening local government roles and empowering communities are crucial, as local actors are best positioned to understand context-specific needs and to foster sustainable change. Practical opportunities exist, especially through partnerships with the private sector, targeted fiscal incentives, and the integration of community-driven micro-renewable initiatives. To capitalize on these opportunities, it is imperative that both national and local governments coordinate closely to ensure flexible policy implementation, inclusive public participation, and effective knowledge transfer. In conclusion, the acceleration of the renewable energy transition in Lhokseumawe—and Indonesia more broadly—requires not only robust regulatory frameworks and technological advancement, but also a holistic approach that values collaboration, local empowerment, and sustained investment in public awareness. By bridging the gap between national ambition and local action, Lhokseumawe has the potential to serve as a model for effective, inclusive, and resilient energy transition in the region.

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