

# Barriers to ASEAN Renewable Energy: a Systematic Review and Bibliometric Analysis

Fidero Kuok<sup>a,\*</sup>, Soksreymeng Sdok<sup>a</sup>, Sotasing Ho<sup>a</sup>, I. Amal Muhamad<sup>b</sup>

<sup>a</sup>National Institute of Science, Technology and Innovation (NISTI), Cambodia

<sup>b</sup>Research Center for Advanced Material, National Research and Innovation Agency (BRIN), Indonesia

[kuok.fidero@misti.gov.kh](mailto:kuok.fidero@misti.gov.kh)

The advancement of green development in the Association of Southeast Asian Nations (ASEAN) has made significant progress to not only accelerate the energy transition but also en route toward achieving net zero emissions. This ASEAN paradigm shift toward alternative energy sources will reduce carbon emissions and ensure energy sustainability. So far, ASEAN member states (AMS) have made a remarkable achievement in increasing the use of renewable energy and diversifying energy sources to promote green economic growth. However, challenges still persist in various areas, such as political, economic, social, technological, legal, and environmental aspects. Addressing these challenges systematically is crucial for unlocking the full potential of renewable energy export and utilization in the ASEAN region while working towards carbon neutrality goals. Therefore, this study aims to comprehensively examine the critical barriers hindering ASEAN's development and deployment of renewable energy systems. Through systematic review and bibliometric analysis, insights into emerging trends of these barriers to the implementation of renewable energy, how they can be tackled, and priorities for actionable policies could be identified. Moreover, strategic options could be proposed to facilitate both the development and deployment of renewable energy systems. Furthermore, the findings of this study could inform relevant stakeholders, including policymakers, government agencies, academia, local authorities, and communities, about the importance of supporting ASEAN's greener energy policies and implementing effective strategies to maximize the benefits of future renewable energy targets in the region.

## 1. Introduction

Rising temperatures and prolonged droughts pose a threat to public health and lead to increased energy consumption, predominantly fueled by coal, oil, and gas, which are the major contributors to global warming and carbon emissions. Hence, all countries must reduce 50 % of carbon emissions by 2030 and achieve net zero emissions by 2050 (IEA, 2021). To reach these targets, adopting alternative energy sources, viz readily available renewable energy, is imperative. As such, ASEAN member states are actively pursuing clean energy development by implementing renewable and alternative energy technologies. For instance, Cambodia has already achieved a renewable energy share of 62 % from hydropower, solar, and biomass energy in its installed capacity as of the first quarter of 2023 (Rosalia et al., 2024). Similarly, Vietnam has made significant progress with a major project in renewable energy, contributing to 69 % of ASEAN's solar and wind generation (Rosalia et al., 2024). At the same time, the Philippines has initiated six floating solar farm projects with a combined capacity of 610 MW on a lake, among other initiatives (Rosalia et al., 2024). In the face of global warming, ASEAN views the challenge as an opportunity to embrace the green energy vision by utilizing renewable energy. It is anticipated that the use of this sustainable energy source will create more jobs and attract investments in clean technology development and energy infrastructure. Despite concerted efforts, the advancement of renewable energy in ASEAN is hindered by various obstacles, including national targets and plans for renewable energy, inadequate clean energy infrastructure, and incentives to attract international funding (Riansyah and Chalid, 2020). Additionally, the absence of mechanisms for technology transfer and geographical constraints impedes the deployment of renewable energy systems (Bai et al., 2023). This paper presents a systematic review and bibliometric analysis of barriers to renewable energy in ASEAN, aiming to offer a comprehensive overview of primary, driving, niche, and emerging barriers. So far, none of the studies have systematically

reviewed barriers to renewable energy in ASEAN, and as such, the present study seeks to provide insights for practitioners, researchers, and policymakers and provide input for the present development of the ASEAN renewable energy long-term roadmap.

## 2. Methodology

The existing barriers to renewable energy in the ASEAN region were systematically reviewed for this holistic understanding, which would empirically contribute to the development of an ASEAN harmonized framework for the development and deployment of renewable energy systems. Figure 1 presents the flowchart describing the initial search and query stepwise process, database construction and screening, and in-depth systematic review. The present research questions were focused on the critical barriers to the implementation of renewable energy and actionable policies of emerging economies in the ASEAN region to address such barriers (See Table 1). Scopus database was used for the initial search and query in the second step by identifying the keywords in the titles of the document. Forty-five return articles from Scopus-indexed conference proceedings and journals in which the pre-identified keywords presented during 2019 – 2023 were used as the primary database. Note that searching and querying in the Scopus database were conducted using the Boolean operators to screen the returned documents. The search string of TITLE ((barrier\* OR issue\* OR challenge\* OR factor\*) AND (renewable OR green OR sustain\* OR clean) AND (energy) AND (Asia OR ASEAN OR Brunei OR Cambodia OR Indonesia OR Lao OR Malaysia OR Myanmar OR Philippines OR Singapore OR Thailand OR Vietnam)) was keyed in to build the primary dataset. In the present study, the Scopus database was queried with the "TITLE" string, and the validity and relevancy of journals were confirmed by reading the abstract, title, and keywords. Mendeley software was materialized to check unrelated or duplicate documents. The extracted documents were systematically reviewed in-depth in response to the pre-defined research questions (See Table 1). Bibliometric analysis of the co-occurrence network and the thematic map was then conducted using Bibliometric-Biblioshiny on the RStudio platform, as suggested by Aria and Cuccurullo (2017).

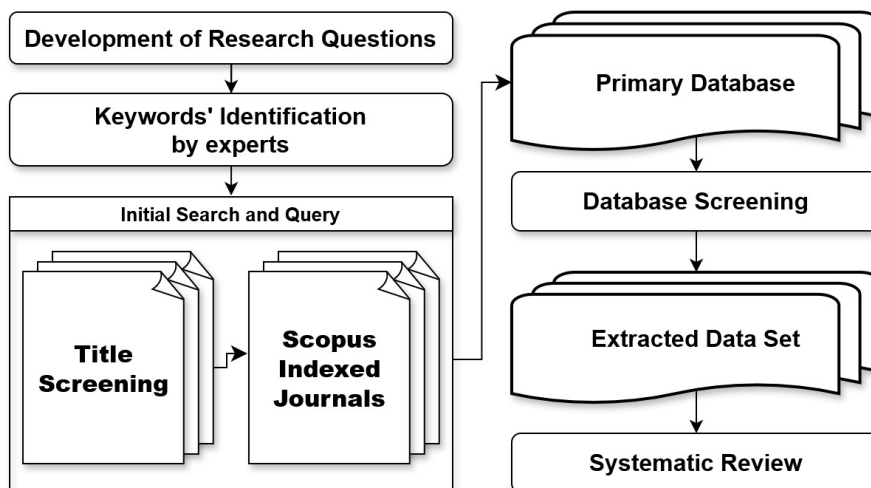


Figure 1: Systematic review processes

Table 1: Research questions on barriers to ASEAN renewable energy

Research Questions (RQ)
RQ1 What are the critical barriers to developing and deploying renewable energy systems in the ASEAN region?
RQ2 What are the co-occurrence network and thematic analysis of critical barriers to the implementation of renewable energy?
RQ3 How can these barriers be addressed and prioritized to inform actionable policies of emerging economies in the ASEAN region?
RQ4 What strategies can each nation and the ASEAN develop as a regional bloc to develop and deploy renewable energy systems?

### 3. Results and discussion

#### 3.1 RQ1: What are the critical barriers to developing and deploying renewable energy systems in the ASEAN region?

Renewable energy, being a pivotal solution to the pressing issue of climate change, faces a myriad of intricate obstacles in its path toward development and implementation. A significant hurdle frequently noted is the limited ability to translate policy into tangible, executable plans, which has been identified as a critical barrier (Yong et al., 2019). The convoluted government structure further complicates the decision-making process, hindering the formation of consensus among the various Ministries and agencies involved (Fajri et al., 2023). In addition, the financial sustainability of green energy initiatives is threatened by a lack of sufficient capital investment, and the current support mechanisms appear to fall short in their ability to draw in external funding (Budiato and Surjosatyo, 2021). Most ASEAN member nations rely heavily on fossil fuels (Budiarto and Surjosatyo, 2021) and extensive traditional energy facilities (Bai et al., 2023). This dependence creates a significant infrastructure gap, posing another major barrier to the transformation of ASEAN into a region powered by clean energy. Given these challenges, it becomes imperative for ASEAN to establish targets and development plans for renewable energy at both the national and regional levels. This strategic planning is crucial to overcome the barriers and accelerate the transition towards renewable energy (Riansyah and Chalid, 2020). The scarcity of natural resources (Riansyah and Chalid, 2020) and raw materials (Umar et al., 2021) pose significant obstacles to advancing renewable energy. It is important to note that the successful integration of renewable energy systems hinges on the active involvement of the local community in energy management (Novitasari et al., 2020), clear delineation of stakeholder roles (Khairudin et al., 2020), effective inter-agency communication (Novitasari et al., 2020). Despite regional efforts for human resource development, ASEAN still lacks skilled professionals in renewable energy (Tun et al., 2020). In particular, limited funding for research and development (Sambodo et al., 2022) and technology transfer (Lin et al., 2022) are other critical barriers to achieving the technological advancement of clean energy in the ASEAN region. While thriving for sustainable development, AMS emphasized other concerning barriers of life cycle impacts of renewable energy systems and geographical limitation (Bai et al., 2023) and the importance of balancing energy initiatives with ecological conservation (Sengpong and Wiwattanadate, 2022). For pragmatic implementation, it is essential to address legal barriers regarding inefficient processes and inadequate regulations, impeding the adoption of renewable energy (Bai et al., 2023) and bureaucratic inflexibility (Sambodo et al., 2022). This review highlights different barriers to ASEAN renewable energy at national and regional levels. It emphasizes the need for local solutions within AMS and a collaborative approach at the regional level to promote ASEAN sustainable energy development.

#### 3.2 RQ2: What are the co-occurrence network and thematic analysis of critical barriers to the implementation of renewable energy?

The conceptual structure of a co-occurrence network to map and cluster Keywords Plus in the extracted dataset was constructed using the bibliometric R-package (See Figure 2). Note that Keywords Plus refers to the words or phrases that were frequently found in the titles of references cited in an article. Keywords Plus co-occurrence network was used to identify significant barriers to ASEAN renewable energy, which AMS is keenly interested in promoting sustainable development. It is important to note that the development of renewable energy in ASEAN can be achieved by implementing policies that are effectively translated into actionable plans by all AMS (Fajri et al., 2023). Additionally, it is crucial to confirm national renewable energy targets (Riansyah and Chalid, 2020). The darker color in the co-occurrence network highlights significant economic challenges such as insufficient capital investment (Tun et al., 2020) and limited access to international funding and financing opportunities (Sambodo et al., 2022). Furthermore, attention should be given to these barriers viz social aspect (Senpong and Wiwattanadate, 2022), technological capabilities, including inadequate infrastructure for electric power transmission networks (Bai et al., 2023), and the impact of climate change (Tun et al., 2020). The thematic map was constructed using Keywords Plus and characterized by the relevance degree of centrality in the horizontal axis and development degree of density in the vertical axis. Note that the centrality was calculated as the degree of correlation among Keywords Plus, while the density measured the nodes' cohesiveness (Esfahani et al., 2019). The themes of "energy resource," "energy utilization," and "economic analysis" are situated in the lower right quadrant and are considered foundational and significant barriers to the development of renewable energy in ASEAN. Additionally, "alternative energy," "energy conservation and transitions," "energy policy," and "sustainable development" are positioned in the upper right quadrant, indicating that these themes are prominent barriers toward achieving ASEAN's shared vision. On the other hand, "decision making" and "sustainability" are categorized as niche themes of barriers with potential for systematic exploration and connection to critical barriers like energy policy. Notably, "energy management" and "electric power transmission networks" are located in the lower left quadrant as emerging barriers, underlining the importance of the ASEAN Power Grid as a regional power connection to support economic development and integration.

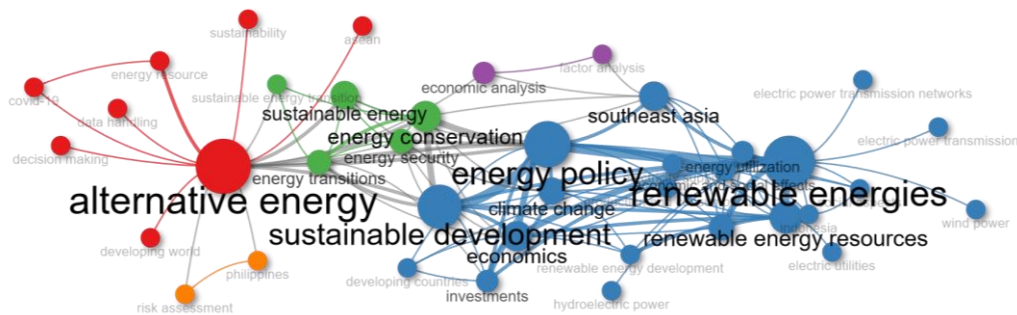


Figure 2: Co-occurrence network of Keywords Plus

**3.3 RQ3: How can these barriers be addressed and prioritized to inform actionable policies of emerging economies in the ASEAN region?**

Toward sustainable development, it is crucial to focus on and overcome economic and financial barriers as primary challenges (See Figure 3). Addressing these economic barriers involves exploring funding alternatives beyond traditional credit, such as corporate bonds and private investments from both local and global markets, with transparent pricing mechanisms to encourage greater private sector involvement; in addition, the establishment of long-term funding options should be aligned with policy reforms and regulatory actions to provide enduring financial tools and incentives for investments in renewable energy (Nguyen, 2023). The success of policy reforms hinges on mobilizing public support and addressing social barriers to adopting new technologies by ensuring energy supply quality and reliability (Sulaeman et al., 2021), and this could be possible only by fostering collaboration among scientists of various disciplines. Keywords Plus, "Sustainability," positioned in both motor and niche themes of barriers, indicates that ASEAN countries view sustainable development as a pivotal factor for regional growth (see Figure 3). To achieve this goal requires a strategic approach to managing environmental quality, particularly in reducing carbon emissions. Therefore, it is an opportunity for AMS to explore carbon trading and incentivize the use of renewable energy in factories through measures like tax exemptions, green subsidies, feed-in tariffs, and tax rebates, among others (Shang et al., 2022). The emerging theme in energy management highlights the need to focus on developing human capital, including a skilled workforce, technical expertise, and specialized personnel, through investments in vocational training programs (Bertheau et al., 2020). Moreover, it is crucial for ASEAN to establish a monitoring portal to track and assess the advancements in renewable energy utilization (Malahayati, 2020). Furthermore, another emerging barrier, the "electric power transmission networks," could be tackled by improving technological capabilities through investments in research and development of innovative and cost-efficient technologies and facilitating technology transfer to local firms engaged in renewable energy production (Khan and Gunwant, 2023).

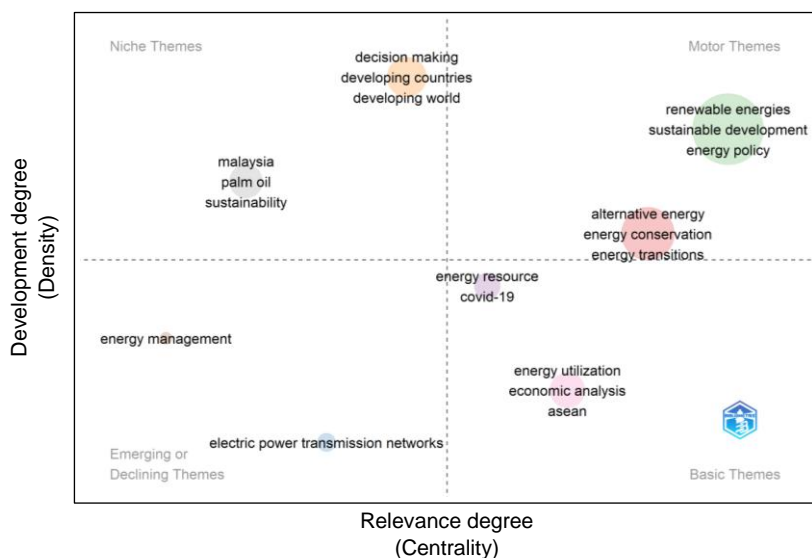


Figure 3: Thematic map of critical barriers to the implementation of renewable energy

### 3.4 RQ4: What strategies can each nation and the ASEAN develop as a regional bloc to develop and deploy renewable energy systems?

One of the most competitive regions, ASEAN is known for its vibrant and diversified markets, economic structure, and diverse cultures. Given this diversity with vast opportunities for investment and different geographical conditions, a multifaceted approach is required for each ASEAN member state to develop and deploy renewable energy systems, and these approaches from all AMS should be aligned to harmonize ASEAN regional efforts. As indicated in Figure 3, economic analysis with a proper financial plan should be addressed at the national level. As such, each AMS should consider implementing specific financial supports such as subsidies, tax breaks, and, most importantly, incentives for research and development in green technology and energy efficiency (Sambodo et al., 2022). For example, financial support for waste-to-energy initiatives (Senpong and Wiwattanadate, 2022) and oil palm waste conversion (Umar et al., 2021) should be promoted to tackle waste management and energy demand. Secondly, developing clean energy infrastructure is critical for each AMS, and this nationwide development requires tremendous investment (Bai et al., 2023) and political commitment (Yong et al., 2019). Further focus should also be extended to energy storage solutions such as batteries (Novitasari et al., 2020) and pumped hydro systems (Tambunan et al., 2020). AMS should also strengthen policies on renewable energy integration and incentives for renewable production (Wijayanti et al., 2021), while public engagement and awareness are vital for community understanding and support to address health and environmental concerns (Bai et al., 2023). As a regional bloc, ASEAN should foster and strengthen cooperation initiatives among member countries, for example, the establishment of a regional portal for monitoring and evaluating renewable progress (Malahayati, 2020), setting up platforms for technology transfer and collaborative research to leverage technological advancement (Tun et al., 2020). Non-traditional regional financial support and investment mechanisms (Umar et al., 2021) for cross-border projects and human capital and capacity development (Khan and Gunwant, 2023) on renewable energy should be further explored. Personal communication with the central bank reveals the ongoing progress of translating the ASEAN Taxonomy for Sustainable Finance into local AMS contexts and conditions. Sustainable finance in renewable energy is expected to be implemented by next year. This finding calls on AMS policymakers to prioritize and allocate more resources to research and development for renewable energy technology and establish a dedicated technical working group for regional sustainable finance toward achieving ASEAN net zero.

## 4. Conclusions

This study provides a comprehensive overview of the barriers to renewable energy adoption in the ASEAN region by utilizing bibliometric analysis to identify key themes and emerging trends. Through a systematic review, the study uncovers the significant barriers faced in developing and implementing renewable energy systems in ASEAN countries, using co-occurrence networks and thematic analysis to shed light on potential solutions. The findings prioritize and propose actionable policies that could drive ASEAN regional economic growth and integration. By illustrating the motor and niche themes, this study guides future investigations and encourages collaborative efforts to enhance decision-making processes for renewable energy utilization. The present finding also emphasizes the urgent need to address the shortage of skilled experts, technicians, and technological capabilities to deploy renewable energy systems successfully. The study fills in the research gap and advocates the use of a holistic analysis framework such as Political, Economic, Social, Technological, Legal, and Environmental (PESTLE) analysis integrated with decision-making models to systematically understand the interdependency and multifaceted challenges of these critical barriers for future research. With such a framework, ASEAN-wide strategies and interventions can be proposed to facilitate the successful development of renewable energy initiatives across the region.

## Acknowledgments

The authors acknowledge the financial support of JASTIP for this study and the in-kind contribution of the Ministry of Industry, Science, Technology & Innovation, Cambodia.

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