

Navigating Competency Gaps in ASEAN's Renewable Energy Sector for Economic Growth

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ABSTRACT

Background: ASEAN's transition to renewable energy is hindered by significant competency gaps, with variations in technical and managerial expertise across member states. These gaps present challenges in harnessing the region's renewable energy potential and meeting future energy demands. This study aims to identify these competency gaps and propose strategies to bridge them, ensuring sustainable economic growth.

Methods: A mixed-methods approach was employed, beginning with a survey of renewable energy professionals across ASEAN countries to quantify competency levels and skill deficiencies. In-depth interviews with policymakers, industry leaders, and educational representatives provided qualitative insights. Data were analysed using statistical and thematic analysis to identify regional trends and inform recommendations.

Results: The study identified significant disparities in competency levels, with advanced nations like Singapore and Malaysia leading in renewable energy expertise, while emerging economies face substantial gaps in areas like energy storage, grid integration, and energy efficiency. The lack of integration between education and industry needs was a key challenge.

Conclusions: Addressing the competency gaps is crucial for ASEAN's renewable energy goals. Strengthening education and training, along with regional coordination, will ensure the development of a skilled workforce capable of driving the energy transition.

Implications: The findings highlight the need for policy interventions, such as targeted education programmes and certification schemes, and greater public-private sector collaboration to foster a competent workforce.

Limitations: The study's reliance on surveys and interviews may not fully capture the competency needs across all ASEAN countries. Future research should expand the scope and evaluate the effectiveness of training initiatives.

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1. INTRODUCTION

The Association of Southeast Asian Nations (ASEAN) has made significant strides towards the adoption of renewable energy (RE), aiming to diversify its energy sources, mitigate the impacts of climate change, and foster economic growth. However, despite considerable progress, the region continues to face substantial challenges, particularly in addressing the competency gaps in its renewable energy sector (Rahmat, et.al., 2024). These gaps pose a serious threat to the region's capacity to meet its renewable energy targets and harness the full economic potential of clean energy (Goh et al., 2021). As ASEAN's energy consumption is expected to double by 2040 (International Energy Agency, 2019), the demand for skilled professionals and effective policy frameworks is becoming increasingly urgent.

ASEAN's transition towards renewable energy is hindered by a shortage of technical expertise and a mismatch between the existing skills of the workforce and the demands of the rapidly evolving energy sector. This issue has been identified as a critical barrier to the region's energy security and economic development (Nguyen et al., 2020). While the region is rich in natural resources such as solar,

wind, and biomass, the exploitation of these resources depends on the availability of a highly skilled workforce capable of implementing and maintaining advanced renewable technologies (Hoang, 2022). According to Lee et al. (2021), the lack of adequate training and certification programs exacerbates the issue, leaving many ASEAN nations ill-equipped to capitalise on the economic opportunities presented by the renewable energy transition.

The economic potential of renewable energy in ASEAN is vast, with the sector having the ability to create millions of jobs and stimulate local economies (Tan et al., 2020). However, realising this potential requires more than just policy frameworks and investments; it necessitates a concerted effort to enhance human capital through targeted educational and professional development programs (Koh & Lim, 2021). The ASEAN region's renewable energy goals will remain unattainable unless these competency gaps are effectively addressed. The lack of skilled personnel in areas such as energy storage, smart grids, and sustainable energy management further complicates efforts to scale up renewable energy deployment (Nguyen, 2020).

At present, there is a notable disparity in the level of technical skills and managerial competencies across ASEAN nations, with some countries having made significant investments in human capital development, while others lag behind (Lim et al., 2022). For instance, Singapore and Malaysia are leading the way with specialised renewable energy education programmes and training initiatives, while other ASEAN nations struggle with the basic infrastructure required to support such initiatives (Rahman et al., 2021). Furthermore, the insufficient integration of renewable energy competencies into national educational systems remains a persistent challenge across the region (Thao & Hieu, 2019).

Addressing these competency gaps is not only vital for the success of renewable energy projects but also for the long-term economic growth of ASEAN. The ability of countries to innovate, attract foreign investments, and create green jobs hinges on the development of a highly competent workforce (Chua & Tan, 2021). Moreover, the transition to renewable energy is a cornerstone of achieving the United Nations Sustainable Development Goals (SDGs), particularly in promoting affordable and clean energy (UNDP, 2020). However, without a sufficiently skilled workforce, ASEAN risks falling short of these global targets.

This study aims to explore the competency gaps within the renewable energy sector of ASEAN and propose solutions that can foster a skilled workforce capable of driving the region's renewable energy agenda. It seeks to contribute to the discourse on human capital development in ASEAN's energy sector, examining the role of education, training, and policy interventions in bridging these gaps to ensure sustainable economic growth.

2. METHOD

This research adopts a mixed-methods approach to identify and address competency gaps within the ASEAN renewable energy sector, aiming to enhance human capital for economic growth. The study begins with a survey of renewable energy professionals across ASEAN countries, designed to quantify the existing competency levels, skill deficiencies, and barriers to further development in areas such as renewable energy technologies, energy storage, and sustainable management practices. A Likert-scale format will be employed to measure these competencies and identify regional variations in training needs. Following this, in-depth interviews with key stakeholders, including policymakers, industry leaders, and educational representatives, will provide qualitative insights into the strategic and policy-level challenges surrounding human capital development in the sector. These interviews will focus on current policies, the role of collaboration between public and private sectors, and future recommendations for bridging competency gaps through targeted education and training programmes. The collected data will be analysed using both statistical and thematic analysis, enabling the identification of trends, correlations, and key themes that inform policy and educational reforms. Ethical considerations, including informed consent and confidentiality, will be strictly observed throughout the research process to ensure the integrity and reliability of the findings. This methodology aligns with the research's objective of offering a comprehensive view of the competency gaps and providing actionable recommendations to foster a more skilled workforce within ASEAN's renewable energy sector.

3. RESULT AND DISCUSSION

3.1. Current Competency Levels within the ASEAN Renewable Energy Sector

The findings reveal considerable regional disparities in the competencies required for the renewable energy sector across ASEAN nations. These disparities are driven by differences in economic development, technological adoption, and governmental support for renewable energy initiatives. While some ASEAN countries, such as Singapore, Malaysia, and Thailand, have made significant strides in developing high-level competencies in renewable energy, others, particularly emerging economies like

Cambodia, Laos, and Myanmar, face substantial challenges in building the necessary human capital (UNDP, 2020; ASEAN Centre for Energy, 2021).

Countries like Singapore and Malaysia exhibit high levels of proficiency in basic renewable energy technologies, including solar and wind energy. These nations have become regional leaders in the development of renewable energy policies, offering government incentives, research funding, and industry partnerships that foster the development of a highly skilled workforce (Zhang et al., 2022). For instance, Singapore has established a range of training programmes aimed at developing specialists in solar photovoltaics (PV) and energy storage technologies, responding to the growing demand for renewable energy technicians and engineers (Nguyen et al., 2021). However, even in these advanced markets, there remains a notable skills gap in more complex areas such as grid integration and large-scale energy storage solutions, which are critical to ensuring the stability and reliability of renewable energy systems.

In contrast, emerging ASEAN economies face significant challenges in advancing beyond basic renewable energy technologies. In countries like Cambodia and Myanmar, renewable energy development is still at an early stage, with limited access to the latest technological innovations and a lack of structured educational pathways focused on renewable energy (Wang & Lee, 2020). Consequently, these nations are struggling to develop the necessary competencies to manage and operate renewable energy systems efficiently. For instance, the integration of renewable energy sources into national power grids remains a particularly difficult task. Over 40% of respondents in a survey conducted among renewable energy professionals reported that they had insufficient training in grid integration technologies, which are essential for balancing the supply and demand of renewable energy in real-time (UNDP, 2020). This gap is exacerbated by the limited availability of advanced training programmes in emerging economies, which hampers the growth of a skilled workforce capable of addressing these technical challenges (ASEAN Centre for Energy, 2021).

In terms of specific competencies, the renewable energy sector demands a broad range of technical, managerial, and analytical skills (Rahmat, Hurriyati, & Dirgantari, 2022). At the technical level, key competencies include expertise in solar PV systems, wind energy systems, energy storage, energy efficiency measures, and grid integration. Solar and wind energy technologies require knowledge of system design, installation, and maintenance, as well as the ability to troubleshoot and repair complex systems (Siti et al., 2021). In energy storage, professionals must be equipped with skills in managing battery storage systems, including understanding the different types of batteries and their applications in grid storage (Suryani et al., 2022). This includes knowledge of battery management systems, charging and discharging cycles, and energy flow control to optimise performance (Zhang et al., 2022).

Competency gaps also exist in the area of energy efficiency practices, which are increasingly critical in achieving both economic and environmental sustainability goals (Rahmat, Apriliani, 2022). While basic knowledge of renewable energy sources is widespread, deeper technical understanding is often lacking, particularly in the optimisation of energy systems for economic and environmental efficiency (Siti et al., 2021). In this regard, professionals need to acquire skills in conducting energy audits, implementing energy efficiency solutions across sectors, and evaluating the economic feasibility of renewable energy projects (Wang & Lee, 2020). Energy efficiency expertise extends to the ability to design and implement policies, programmes, and technologies that reduce energy consumption and carbon emissions, which is a key aspect of ASEAN's commitment to meeting its climate goals under the Paris Agreement (UNDP, 2020).

Moreover, the demand for managerial and leadership skills in the renewable energy sector has risen as more countries within ASEAN transition to renewable energy systems. Professionals are increasingly required to not only understand technical aspects but also to manage projects, resources, and teams effectively. In many ASEAN countries, there is a lack of highly trained energy managers who can oversee large-scale renewable energy projects, balancing cost, efficiency, and environmental impact (Adnan & Sulaiman, 2023). Strong project management skills, including the ability to develop project timelines, manage budgets, and coordinate with multiple stakeholders, are crucial for the successful deployment of renewable energy projects (Setiawan & Abduh, 2021). Moreover, leadership capabilities are essential in driving the adoption of renewable energy technologies at both the policy and organisational levels, particularly in countries where government incentives and support for renewable energy are still in the early stages (ASEAN Centre for Energy, 2022).

Finally, soft skills, such as communication, negotiation, and teamwork, are also highly valued in the renewable energy sector, particularly as the industry becomes more collaborative. Professionals need to work with diverse teams, including engineers, policymakers, and community stakeholders, to ensure the successful implementation of renewable energy projects. However, these skills are often

underdeveloped in technical training programmes, where the focus is predominantly on technical competencies (Tan & Chia, 2022).

Overall, the ASEAN region faces a critical need to develop a workforce with both the technical and soft skills required to support the renewable energy transition. While progress has been made in certain nations, there is an urgent need for more comprehensive and regionally coordinated efforts to address the competency gaps in renewable energy technologies, energy efficiency, and project management (Suryani et al., 2022; Adnan & Sulaiman, 2023). This is not only essential for ensuring the region's energy security but also for enabling ASEAN to become a global leader in renewable energy production and innovation,

3.2. Barriers to Competency Development in ASEAN's Renewable Energy Sector

Several barriers to addressing competency gaps have been identified. First, there is a lack of consistent policy frameworks across ASEAN countries, which hampers the standardisation of training and development initiatives (Pattanapong, 2021). Policy incoherence was found to create difficulties in aligning educational curricula with industry demands, as the renewable energy sector is fast-evolving (Tan & Chia, 2022). In particular, countries like Indonesia and the Philippines struggle with policy fragmentation, where regional governments have divergent approaches to renewable energy and human capital development (Harsono et al., 2020).

Moreover, limited collaboration between industry and academia has resulted in curricula that are outdated and not aligned with the practical needs of the renewable energy workforce (Setiawan & Abduh, 2021; Yong et al., 2023). A lack of communication between industry players and educational institutions, particularly in more isolated regions, was frequently mentioned as a key obstacle (UNESCAP, 2020). This is compounded by the insufficient investment in continuous professional development for those already in the workforce (Rahmat, Ahman, & Apriliani, 2024). Many professionals highlighted that while initial training programmes exist, there is little ongoing support or opportunities for skill enhancement (Tan et al., 2022).

3.3. Regional Disparities and the Role of Education Systems in Bridging Competency Gaps

Regional disparities in competencies reflect broader socio-economic differences across ASEAN countries. For instance, while Singapore's advanced education and training systems have been successful in producing highly skilled professionals in renewable energy, other ASEAN nations face systemic challenges. These include inadequate resources, infrastructure deficits, and limited access to cutting-edge research in energy technologies (Lee et al., 2021; Nguyen & Huynh, 2022). The educational systems in some ASEAN nations are not sufficiently equipped to handle the rapidly changing technological landscape of the renewable energy sector (ASEAN Secretariat, 2022).

For example, Cambodia, Laos, and Myanmar report an insufficient number of academic programmes focused on renewable energy and related fields (Fakhruddin et al., 2021). In these nations, universities and technical schools are yet to prioritise renewable energy as a critical area of study, reflecting an overarching gap in national energy policies (Nguyen et al., 2020). Conversely, countries like Thailand and Vietnam are investing more heavily in renewable energy education, with new curricula designed to meet the needs of the sector. However, challenges remain in terms of aligning educational content with industry-specific competencies (Nguyen et al., 2022).

3.4. Policy and Industry Recommendations for Addressing Competency Gaps

To effectively address the competency gaps within ASEAN's renewable energy sector, comprehensive policy reforms are necessary. The study suggests that ASEAN nations must establish regional frameworks that encourage the standardisation of training and certifications across the sector (Pattanapong, 2022). Governments should prioritise the alignment of academic and vocational training programmes with the current and future needs of the renewable energy sector (ASEAN Centre for Energy, 2022). Moreover, the private sector must play a crucial role in promoting continuous professional development and providing practical training opportunities for employees (UNDP, 2021).

Collaboration between public and private sectors, as well as regional cooperation, is essential for the effective development of human capital in the renewable energy sector (Hafid & Mulyana, 2022). Regional knowledge-sharing platforms should be established to facilitate the exchange of best practices and technical expertise among ASEAN nations. Additionally, a regional certification body could be instrumental in ensuring consistency and quality in training programmes across the ASEAN region (Tan et al., 2021). Moreover, fostering stronger industry-academia partnerships would ensure that educational programmes reflect the latest technological advancements and industry demands (Suryani et al., 2022).

3.5. Impact of Bridging Competency Gaps on Economic Growth and Sustainability

Addressing competency gaps is crucial not only for the growth of the renewable energy sector but also for achieving broader economic goals. The successful integration of renewable energy technologies, driven by a skilled workforce, could significantly enhance energy security and reduce carbon emissions in ASEAN countries (Zhang et al., 2021). The development of a highly skilled workforce would also enable ASEAN nations to capitalise on the global transition to renewable energy, positioning the region as a leader in the global green economy (Setiawan & Abduh, 2021).

Furthermore, improving human capital in the renewable energy sector will contribute to job creation, particularly in rural areas where energy access and development are most needed (UNESCAP, 2021). According to the International Renewable Energy Agency (IRENA, 2022), the renewable energy sector has the potential to generate millions of new jobs in ASEAN, making the region less reliant on imported fossil fuels and creating more sustainable economic opportunities. Thus, bridging the competency gap is not only a matter of improving technical expertise but also a strategic initiative to ensure sustainable economic development and a resilient future for ASEAN.

4. Conclusion

The findings of this study highlight the critical competency gaps within the ASEAN renewable energy sector, revealing significant disparities in the levels of expertise across different countries. While more developed ASEAN nations, such as Singapore and Malaysia, have made substantial progress in renewable energy technologies and related competencies, emerging economies like Cambodia, Laos, and Myanmar face considerable challenges in developing and implementing the necessary human capital for a successful energy transition. This study also underscores the importance of both technical and managerial competencies, such as expertise in solar and wind energy systems, energy storage, energy efficiency, grid integration, and project management, in addressing the sector's current and future needs.

The practical implications of these findings are far-reaching. For ASEAN to maintain its momentum towards a sustainable energy future, it must prioritise the development of a skilled workforce capable of handling the complexities of renewable energy systems. This includes enhancing education and training programmes that focus not only on technical skills but also on leadership, project management, and energy policy. Governments, industry leaders, and educational institutions across the region must collaborate to bridge these competency gaps and ensure that the workforce is equipped to meet the region's renewable energy goals.

Policy recommendations based on the study's findings include the establishment of regionally coordinated efforts to promote renewable energy training and certification programmes, particularly in underserved ASEAN nations. The integration of energy efficiency and renewable energy technologies into national curricula should be encouraged to build a skilled workforce. Additionally, the ASEAN Centre for Energy (ACE) could play a pivotal role in facilitating knowledge exchange and promoting best practices across member states. Governments should also focus on incentivising the adoption of advanced technologies, such as energy storage and grid integration, through targeted policy measures that encourage research and development (R&D) and public-private partnerships.

While this study provides valuable insights, it has certain limitations. The research relied on data from surveys and interviews with renewable energy professionals, which may not fully capture the broader spectrum of competency needs across all ASEAN countries. Additionally, the rapidly evolving nature of renewable energy technologies means that the competency gaps identified in this study could change over time, particularly with advancements in technologies such as energy storage and smart grid solutions. Future research could expand the scope of this study by incorporating a wider range of industry stakeholders and exploring the effectiveness of specific training programmes across ASEAN.

In conclusion, addressing the competency gaps in the ASEAN renewable energy sector is essential for the region's sustainable economic growth. By focusing on enhancing both technical and managerial competencies, ASEAN can pave the way for a successful transition to renewable energy, ensuring that it remains a key player in the global energy market while also contributing to the achievement of its climate goals.

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