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Decarbonization of ASEAN: An Engineering Approach

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***Abstract*—ASEAN is poised to ascend from being the world's fifth largest economy to the fourth position by 2030. Rapid economic growth fuelled by accelerated industrialization and urbanization is taking place yet there is a growing sense of regional responsibility to address pressing environmental concerns which the former has brought upon. Globally, decarbonization has been actively pursued, especially among the developed nations. However, it is worthwhile to comprehend the progress that ASEAN has made in this regard. Hence, this paper shall bring forth the latest updates on the efforts of decarbonization undertaken by the ASEAN member states (AMS). The respective goals and targets for decarbonization being set by each AMS will be consolidated. Focus will be placed on relevant policies formulated by the respective government and major projects which are either completed or in the pipeline to accomplish the goal of decarbonization in ASEAN. Existing engineering solutions to catalyse decarbonization which have been deployed in the region will then be highlighted. Finally, the challenges and opportunities which lie ahead of ASEAN's journey towards decarbonization will be identified.**

Keywords*—Decarbonization, Carbon emission reduction, ASEAN, Renewable energy, Sustainable development.

I. INTRODUCTION

ASEAN, or Association of Southeast Asian Nations, is a regional grouping of 10 member countries that statistically ranks as one of the fastest growing economic regions in the world. According to projections, ASEAN could become the fourth-largest economy in the world by 2030 [1], and the region is witnessing rapid industrialization and urbanization. This economic growth has contributed to sharp rises in energy use and carbon emissions, posing serious environmental challenges.

Decarbonization, which is achievable by increasing low-carbon energy, improving energy efficiency, and applying leading-edge carbon capture technologies, is vital for sustainable development. Working to solve these environmental issues is crucial for ensuring the health and well-being of ASEAN's people and for minimising the effects of climate change worldwide.

This paper discusses the decarbonization initiatives in ASEAN at large. It covers what each individual member state is aiming to achieve, government policies that should be put in place to help, and what major low or no carbon emission projects are being proposed. It also points out the engineering solutions being applied to stimulate those efforts, and calls attention to the important challenges and opportunities ahead for ASEAN on the pathway to a low-carbon future. Through studying these issues, the paper intends to highlight the need for a coordinated and integrated decarbonisation effort, as well as to contribute towards global efforts to combat climate change. All the efforts can be further categorized into energy, transportation and the buildings sector, which allows a more granular view of the activities undertaken to decarbonize.

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II. CURRENT STATUS OF DECARBONIZATION IN ASEAN

A. Economic Growth and Industrialization

From 2015 to 2021, ASEAN's economy expanded at an impressive average rate of about 7.5% per year [2]. That surge in growth spurred a boom in industry and the spread of cities, which in turn drove up energy needs. Across the region, energy consumption has climbed by roughly 4% annually, with coal, oil, and natural gas meeting most of that demand [3], making ASEAN one of the world's fastest-growing sources of carbon emissions.

By 2020, Indonesia, Malaysia, Thailand, Vietnam, and the Philippines together released approximately 1.65 gigatons of CO_2—about 4.75% of global emissions [4]. The International Energy Agency reports that since 2000, ASEAN's CO_2 output has jumped nearly 70%, surpassing 1.3 billion tons in 2020 [5]. This dramatic rise is largely a consequence of the region's rapid industrialization and urban expansion.

B. Environmental Concerns

ASEAN's rapid expansion has come with a heavy environmental price, as soaring carbon emissions are fuelling global climate change. The region now confronts serious ecological threats—smog-choked cities, rampant deforestation, and declining biodiversity. In Indonesia and Malaysia, vast swaths of forest are cleared to make way for palm oil plantations, placing them among the world's leading drivers of deforestation [6]. Urban centers such as Bangkok, Jakarta, and Manila routinely record air quality levels that exceed WHO recommendations, putting millions at risk of respiratory and cardiovascular problems. In Indonesia alone, land-use changes like forest clearing emit roughly 2.6 billion tons of CO_2 each year, ranking it as one of the largest contributors to emissions from deforestation worldwide [7].

C. Comparative Analysis

ASEAN's member states have begun to tackle their carbon footprints, but they still trail behind developed regions in decarbonization. Note that the decarbonization rate (DCR) can be calculated to assess the annual rate of emission reduction relative to economic growth as given by Eq. (1):

$$DCR = \left(1 - \frac{CI_{x,t}}{CI_{x,t-1}}\right) \times 100 \quad (1)$$

, where $CI_{x,t}$ = Carbon intensity in year and $CI_{x,t-1}$ = Carbon intensity in previous year.

A higher DCR implies a faster decarbonization pace.

While advanced economies have rolled out cutting-edge technologies and strict emissions standards—achieving, for example, a 24 % cut in greenhouse gases from 1990 levels—their ASEAN counterparts continue to see rising emissions as their economies continue to grow [8]. The level of commitment and progress varies widely among member states, pointing to the need for a more cohesive and ambitious regional strategy.

In South Asia, the situation is quite similar. Rapid economic expansion and increasing urbanization are driving up energy consumption and CO_2 emissions. Countries like India and Bangladesh have set aggressive renewable energy goals, but they often struggle with infrastructure challenges and limited financial resources. Even so, progress in solar and wind energy is beginning to show promising results [9].

Africa is still in the early phases of decarbonization. The primary focus for many countries remains expanding access to energy and stimulating economic growth. Despite these foundational challenges, interest in renewable energy is growing steadily - especially geothermal power in Kenya and solar energy in South Africa - fuelled by increasing international investment and support [10].

North America, particularly the U.S. and Canada, has made meaningful progress in cutting emissions. This has been driven by policy changes, technological innovation, and significant investment in renewables. In the U.S., the transition from coal to natural gas and renewable sources has played a big role, while Canada has benefited from its strong reliance on hydroelectric power [11].

In Europe, the European Climate Law now legally obligates EU countries to reduce emissions by at least 55% by 2030. Many member states are enacting new laws to meet the long-term goal of climate neutrality by 2050 [12]. Around 57% of European businesses have already committed to Net Zero targets by mid-century, with over 80% of them publishing detailed plans to get there [13]. External factors - such as Europe's accelerated move away from Russian energy due to the Ukraine war, and the U.S. Inflation Reduction Act - are also reshaping the region's climate policy and diplomacy [14].

South America's green transition is spearheaded by Brazil and Chile, heavily investing in hydroelectric, solar, and wind power. While Brazil's hydropower reliance curbs emissions, Amazon deforestation remains a pressing environmental threat [15].

In Oceania, Australia and New Zealand are leading regional decarbonization efforts. Australia has rapidly expanded its solar and wind capacity, though it remains the second-largest coal exporter in the world [16]. Meanwhile, New Zealand is aiming for 100% renewable electricity by 2030 [17].

Overall, this comparison reveals stark contrasts: developed regions have advanced far down the decarbonization path, whereas developing areas such as ASEAN, South Asia, and Africa face unique structural and financial barriers even as they strive toward low-carbon futures.

III. GOALS AND TARGETS FOR DECARBONIZATION

Table I and Fig. 1 summarizes ASEAN members' decarbonization goals.

Table I. ASEAN's decarbonization goal [18] – [26].

Country	Goal	Key Strategies
Indonesia	Net-zero by 2060	Renewable energy, solar, bioenergy, CCS
Vietnam	Carbon neutrality by 2050	Solar/wind energy, CCS, energy efficiency
Thailand	Carbon neutrality by 2050	Solar PV, bioenergy, energy efficiency
Malaysia	45% reduction by 2030	Solar energy, bioenergy, electric vehicles
Philippines	75% emissions reduction by 2030	Wind, geothermal, hydro energy, green bonds
Singapore	Net-zero by 2050	Energy efficiency, carbon capture, innovation
Laos	Net-zero by 2050	Hydropower, solar/wind energy, international funding
Cambodia	42% reduction by 2030	Biomass energy, energy efficiency
Brunei	Net-zero by 2050	Energy efficiency, natural gas, CCS
Myanmar	30% renewables by 2030	Hydropower, solar/bioenergy

Each ASEAN member state has set specific goals and targets to reduce carbon emissions along with main strategies or measures. Majority of ASEAN member state still has heavy reliance on coal and fossil fuels which hinders their decarbonisation progress.

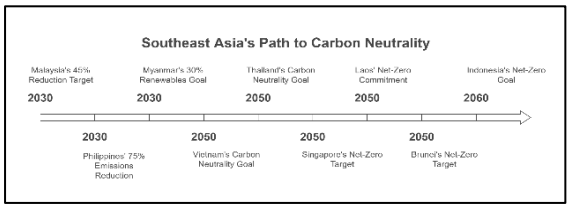

Fig. 1. Southeast Asia's Path to Carbon Neutrality.

ASEAN has set collective targets to strengthen sustainability and cut carbon emissions, including boosting renewables in its energy mix to 23% by 2025 and improving energy efficiency by 20% over the same period [24]. Through the ASEAN Plan of Action for Energy Cooperation (APAEC) 2016–2025, member states collaborate and leverage advanced technologies to achieve these goals [24]. Figure 2 illustrates ASEAN's key performance indicators: reducing carbon intensity, increasing renewable energy capacity, enhancing energy efficiency, and both curbing deforestation and promoting reforestation. Note that carbon intensity can typically be evaluated as per Eq. (2):

$$CI_x = \frac{E_{CO_2}}{GDP} \quad (2)$$

, where

CI_x = Carbon Intensity (tCO_2 per million USD)

E_{CO_2} = Annual CO_2 emissions ($MtCO_2$)

GDP = Gross Domestic Product (in million USD, purchasing power parity (PPP)-adjusted)

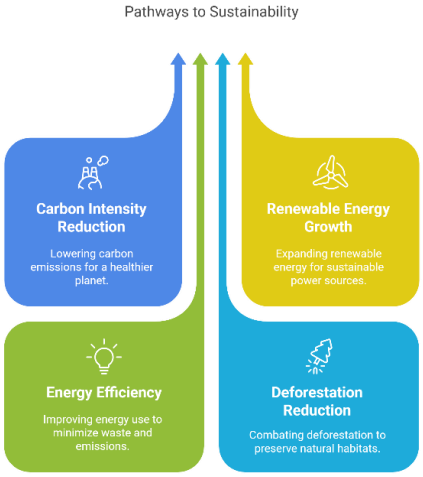

Fig. 2. Key performance indicators.

IV. GOVERNMENT POLICIES AND MAJOR PROJECTS

Brunei Darussalam has made notable strides in embracing renewable energy, centering its efforts on solar power. Its flagship Tenaga Suria Brunei (TSB) Solar Power Plant, presently rated at 1.2 MWp, has already delivered significant energy savings and reduced CO_2 emissions. Ambitious expansion plans aim to scale up capacity to 27 MWp by 2035—enough to save about 8.553 million MMBtu of natural gas and avoid roughly 530,887 tonnes of CO_2 emissions. To complement large-scale installations, Brunei is also piloting a residential rooftop solar program. A 2023 study estimates that widespread rooftop panels could unlock up to 763 MW of capacity while saving BND 10.3 billion compared to conventional solar farms [27].

Cambodia, keen to diversify away from fossil fuels, is exploring innovative biomass solutions—most notably, converting rice straw into power. A feasibility analysis for a 10 MW rice-straw biomass plant identified Prey Veng, Takeo, and Battambang as ideal sites. Such a facility could generate around 1,251 GWh per year and cut CO_2 emissions by approximately 1.06 million tonnes versus a coal-fired plant. Financial models suggest the project would break even within six to ten years, underscoring its promise as a sustainable energy option [28].

Indonesia has pledged to source 23 % of its energy from renewables by 2025 and 31 % by 2050. Solar PV is poised to lead the charge, growing from just 17.22 MW in 2020 to an ambitious 6.5 GW by 2025 and 45 GW by mid-century. Biomass is another cornerstone, with targets set at 32,654 MW of biomass-generated electricity by 2050. Yet, progress hinges on overcoming hurdles like grid bottlenecks and upfront costs—challenges that demand stronger policy support and investment incentives [29].

Landlocked Laos relies heavily on hydropower thanks to its plentiful waterways. While this has turned Laos into a net exporter of electricity—especially to Thailand and Vietnam—it also leaves the country vulnerable to seasonal shortages. To smooth out supply, a 2022 study advocates deploying floating photovoltaic (FPV) arrays on reservoir surfaces. Covering just 10 % of four major dams with FPV installations could satisfy national power needs by 2030, providing a clever way to buffer dry-season dips [30].

Malaysia has laid out clear targets: 31 % renewable energy capacity by 2025 and 40 % by 2035, backed by hefty solar investments [31]. The potential of harnessing solar energy to fulfil the needs of the chemical and metal manufacturing plants was found to be feasible [32]. The Sarawak Corridor of Renewable Energy and the Small Renewable Energy Program are already reshaping the national grid, while floating solar projects help sidestep land constraints and boost efficiency [33]. On the transport front, the Low Carbon Mobility Blueprint 2021–2030 aims to put 100,000 electric vehicles on the road by 2030, alongside solar-powered charging corridors [34]. Encouragingly, hospitals are also tapping into rooftop PV, cutting both their energy bills and carbon footprints [35, 36].

Myanmar faces the twin challenges of low electrification and rural energy shortages. Although hydropower remains dominant, the government is ramping up solar home systems and mini-grids to bring power to off-grid communities. A 2021 review highlighted Myanmar's vast solar potential, with plans to electrify the nation by 2030. By 2020, renewable projects—mainly hydro and solar—had already reached 3,302 MW of capacity [37].

The Philippines targets a 35 % renewable share by 2030 under its Renewable Portfolio Standards. In Bohol, a mix of solar, wind, biomass, and hydropower could push renewable penetration beyond 50 %, according to recent analysis. This multi-technology approach is crucial if the country hopes to hit its ultimate goal of 100 % renewables across all sectors by 2050, with solar PV and battery storage at the core [38, 39]. Note that renewable energy penetration index can be estimated as per Eq. (3):

$$REPI = \frac{E_{RE}}{E_{Total}} \times 100 \quad (3)$$

, where

E_{RE} = Renewable energy generation (TWh)

E_{Total} = Total energy consumption (TWh)

Land-scarce Singapore is turning to offshore solar—and even floating arrays—to expand capacity without consuming precious real estate [40]. On Pulau Ubin, a micro-grid blends solar PV, bio-diesel generators, and storage into a smart, off-grid energy hub [41]. Meanwhile, the Intelligent Energy System (IES) pilot explores cutting-edge tools to bolster grid resilience, curb waste, and smooth the integration of renewables into the national network [42].

Thailand is rapidly growing its solar, wind, and waste-to-energy portfolio to reach carbon neutrality by 2050. GIS-based studies show that over a third of the country's land is well suited for solar farms, especially in the northeast [43]. While waste-to-energy facilities offer promise, success will depend on securing consistent waste streams and improving collection and sorting systems [44].

Finally, Vietnam's draft Eighth Power Development Plan (PDP8) puts solar PV front and center—shifting from large ground-mounted farms to smaller, distributed systems to navigate land and grid constraints [45]. Offshore wind is also gaining traction through partnerships with international developers. Despite record-setting PV installations since 2019, Vietnam must tackle grid upgrades and regulatory refinement to sustain this rapid growth [46].

V. CHALLENGES AND OPPORTUNITIES

Decarbonization across ASEAN is no easy feat - it comes with complex challenges - but it also presents a valuable opportunity to drive innovation and stimulate economic growth. On the technical front, many nations in the region face difficulties due to the high costs and limited expertise involved in adopting advanced clean-energy technologies [3]. For island nations like Indonesia and the Philippines, the situation is even more complicated. Deploying renewable energy infrastructure across thousands of scattered islands increases logistical hurdles and costs, resulting in slow progress and uneven access to electricity. Modernizing outdated grid systems to handle the unpredictable nature of renewables also requires substantial investments and a skilled workforce - both of which are currently in short supply.

Financing is another major hurdle. Large-scale green energy initiatives often struggle to get off the ground because the investment landscape remains shallow [47]. Without consistent access to capital, governments face difficulty implementing solar power installations, wind energy projects, and energy-efficient upgrades. Bridging this funding gap will require tapping into international climate finance sources, such as green bonds, concessional lending, and other supportive financial tools [48]. Complicating matters further, inconsistent regulations and enforcement mechanisms across ASEAN countries make regional collaboration difficult. In some cases, short-term political or economic interests take precedence over long-term environmental planning.

Despite these setbacks, the region has promising pathways forward. By offering targeted incentives - such as tax breaks, subsidies, or credit guarantees - governments can attract more private sector investment into renewable energy and energy efficiency. Instruments like the ASEAN Green Bond Standards provide a reliable structure for channelling

private funds into sustainable development efforts [49]. Strengthening partnerships in research and development can help generate homegrown solutions, while regional collaboration enables faster sharing of knowledge and successful strategies. Businesses that prioritize sustainability are also likely to gain a competitive advantage, appealing to environmentally conscious consumers and investors.

Looking to the future, advancements in energy storage, grid optimization, and next-generation renewable technologies offer real potential to lower costs and boost reliability. Improved battery systems will help balance the intermittent nature of solar and wind power, making them more suitable for integration into national grids [50]. To make the most of these innovations, ASEAN countries must revise outdated policies, streamline approval processes, and gradually eliminate subsidies for fossil fuels The realisation of ASEAN Power Grid which involves Laos-Thailand-Malaysia-Singapore should come sooner than 2045 to enhance regional energy security as well as tapping into the vast potential of hydropower from Laos. Deployment of more floating solar system could also be further explored due to its proven feasibility in Singapore. Educating the public and supporting grassroots clean energy projects will also be key to building widespread community support.

In essence, while ASEAN faces a range of technical, financial, and policy-related challenges, the long-term benefits are significant: a more stable and sustainable energy network, growth in future-oriented industries, and a stronger role on the global climate stage. With coordinated action, strategic policymaking, and access to international funding, the region can transform its current challenges into a powerful clean energy success story.

VI. CONCLUSION

ASEAN's path toward decarbonization has been marked by both significant progress and persistent challenges. The region's ambitious climate goals, along with a range of national policies and on-the-ground initiatives, reflect a strong commitment to lowering emissions. Central to these efforts are engineering-driven solutions like solar and wind power, energy-efficient infrastructure, and modernized electricity grids which are essential for meeting sustainability targets. However, to truly speed up the transition, the region must close remaining technical gaps, secure more robust financing, and simplify regulatory processes. By fostering innovation, attracting greater investment, and strengthening regional collaboration, ASEAN has the potential not only to shape a greener future for itself but also to make a meaningful contribution to the global climate effort. The ASEAN Summit 2025 in Kuala Lumpur, Malaysia should serve as the catalytic platform to advance this agenda of decarbonization.

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REFERENCES

[1] I. Overland *et al.,* "The ASEAN Climate and Energy Paradox," *Ener. and Clim. Change*, vol. 2, pp. 100019, 2021.

[2] H. Holifah, L. T. Laut and Rr. R. Sugiharti, "Analisis Potensi Konvergensi Ekonomi Negara Anggota Asean-10 Tahun 2015-2021 Dan Faktor-Faktor Yang Mempengaruhinya," *Jurnal Jendela Inovasi Daerah*, vol. 7, no. 1, pp. 123–135, 2024.

[3] R. Safrina and N. A. Utama, "ASEAN Energy Transition Pathway Toward The 2030 Agenda," *Environ. Prog. Sustain. Ener.*, vol. 42, no. 4, e14101, 2023.

[4] H. C. Lau and X. Lin, "Pathways to Achieve Rapid Decarbonization of ASEAN," in *Offshore Technol. Conf.*, Texas, USA, no. OTC-32016-MS, 2022.

[5] E. T. Hariani, R. F. Widyawati and A. L. Ginting, "Determinants of Carbon Emissions in 10 ASEAN Countries," *Econom. Develop. Anal. J.*, vol. 11, no. 3, pp. 313–320, 2022.

[6] F. K. S. Lim, L. R. Carrasco, D. P. Edwards and J. McHardy, "Land-use Change from Market Responses to Oil Palm Intensification in Indonesia," *Conser. Biol.*, vol. 38, no. 1, pp. e14149, 2024.

[7] I. Basuki *et al.,* "Reforestation Opportunities in Indonesia: Mitigating Climate Change and Achieving Sustainable Development Goals," *Forests*, vol. 13, no. 3, pp. 447, 2022.

[8] R. I. Mogoș, I. Petrescu, R. A. Chiotan, R. C. Crețu, V. A. Troacă and P. L. Mogoș, "Greenhouse Gas Emissions and Green Deal in The European Union," *Front. Environ. Sci*., vol. 11, pp. 1141473, 2023.

[9] S. Jolly, "Application of Solar Energy in South Asia: Promoting Intergenerational Equity in Climate Law and Policy," *Int. J. Priv. Law*, vol. 7, no. 1, pp. 20-39, 2014.

[10] K. E. Altieri, H. Trollip, T. Caetano, A. Hughes, B. Merven and H. Winkler, "Achieving Development and Mitigation Objectives Through A Decarbonization Development Pathway in South Africa," *Clim. Polic.*, vol. 16, no. sup1, pp. S78–S91, 2016.

[11] D. Rasbash, K. J. Dillman, J. Heinonen and E. I. Ásgeirsson, "A National and Regional Greenhouse Gas Breakeven Assessment of EVs Across North America," *Sustainability*, vol. 15, no. 3, pp. 2181, 2023.

[12] "Fit for 55 - The EU's Plan for A Green Transition – Consilium," [Available online on 6 Sep. 2024] https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55/.

[13] "Net Zero Pledges in Europe," [Available online on 6 Sep. 2024] https://insights.issgovernance.com/posts/net-zero-pledges-in-europe/.

[14] "Decarbonisation Nations: How EU Climate Diplomacy Can Save The World | ECFR," [Available online on 6 Sep. 2024] https://ecfr.eu/publication/decarbonisation-nations-how-eu-climate-diplomacy-can-save-the-world/.

[15] P. Alarcón, "Old and New Challenges of The Energy Transition: Insights from South America," *South African J. Int. Affairs*, vol. 30, no. 2, pp. 263–278, 2023.

[16] D. Christian. "A Renewable Power in Waiting? Australia's Changing Energy Geopolitics." *Handbook on the Geopolitics of the Energy Transition*, Edward Elgar Publishing, pp. 468-482,2023.

[17] D. Stephen, B. Carey, P. Doorman, K. Luketina, B. White and S. J. Zarrouk. "2015-2020 New Zealand Country Update," in *Proc. World Geotherm. Congr.*, vol. 2020, 2020.

[18] B. S. Bataeva, "Implementation of Measures to Decarbonize the Indonesian Economy for Sustainable Development," *J. Law and Admin.,* vol. 19, no. 3, pp. 64–76, 2023.

[19] A. Gladyr, O. Bialobrzheskyi and V. Nozhenko, "Laboratory Equipment for the Solar Power Plants Studying," in *2023 IEEE 4th KhPI Week on Adv. Technol.*, Kharkiv, Ukraine, pp. 1–4, 2023.

[20] S. Rajbhandari, P. Winyuchakrit, B. B. Pradhan, A. Chaichaloempreecha, P. Pita and B. Limmeechokchai,

"Thailand's Net-zero Emissions by 2050: Analysis of Economy-wide Impacts," *Sustain. Sci.*, vol. 19, no. 1, pp. 189–202, 2024.

[21] "Malaysia Aims To Be Well-Positioned To Reduce Emissions, Ready For Low-Carbon Economy - PM ANWAR," [Available online on 7 Sep. 2024] https://www.pmo.gov.my/2023/06/malaysia-aims-to-be-well-positioned-to-reduce-emissions-ready-for-low-carbon-economy-pm-anwar/.

[22] "Net Zero Readiness Index: Malaysia - KPMG Global," [Available online on 7 Sep. 2024]: https://kpmg.com/xx/en/home/insights/2021/09/nzri-malaysia.html.

[23] A. Vidinopoulos, J. Whale and U. Fuentes Hutfilter, "Assessing The Technical Potential of ASEAN Countries to Achieve 100% Renewable Energy Supply," *Sustain. Ener. Technol. and Assess.*, vol. 42, pp. 100878, 2020.

[24] K. Fahim, L. De Silva, F. Hussain, Sk. Shezan and H. Yassin, "An Evaluation of ASEAN Renewable Energy Path to Carbon Neutrality," *Sustainability*, vol. 15, no. 8, pp. 6961, 2023.

[25] P. Kyophilavong, "Decarbonization Pathways in Laos: The Challenges and Solutions," *Asian Econ. Papers*, vol. 22, no. 3, pp. 46–63, 2023.

[26] M. Triani, H. B. Tambunan, K. Dewi and A. S. Ediansjah, "Review on Greenhouse Gases Emission in the Association of Southeast Asian Nations (ASEAN) Countries," *Energies*, vol. 16, no. 9, pp. 3920, 2023.

[27] N. Hamdani, N. A. Muhamad and R. Petra, "Rooftop PV Energy Potential Based on Housing Design in Brunei National Housing Planning," *Eng. Proc. 2023*, vol. 53, pp. 21, 2023.

[28] S. Sokrethya, Z. Aminov, N. Van Quan and T. D. Xuan, "Feasibility of 10 MW Biomass-Fired Power Plant Used Rice Straw in Cambodia," *Energies*, vol. 16, no. 2, pp. 651, 2023.

[29] Y. Yudiartono, J. Windarta and A. Adiarso, "Sustainable Long-Term Energy Supply and Demand: The Gradual Transition to a New and Renewable Energy System in Indonesia by 2050," *Int. J. Renew. Ener. Develop.*, vol. 12, no. 2, pp. 419–429, 2023.

[30] Y. Nhiavue, H. S. Lee, S. W. Chisale and J. S. Cabrera, "Prioritization of Renewable Energy for Sustainable Electricity Generation and An Assessment of Floating Photovoltaic Potential in Lao PDR," *Energies*, vol. 15, no. 21, pp. 8243, 2022.

[31] M. Ziyai, M. Mehrpooya, M. Aghbashlo, M. Omid, A. S. Alsagri and M. Tabatabaei, "Techno-Economic Comparison of Three Biodiesel Production Scenarios Enhanced by Glycerol Supercritical Water Reforming Process," *Int. J. Hydr. Ener.*, vol. 44, no. 33, pp. 17845-17862, 2019.

[32] A. Y. Kian and S. C. Lim, "On the Potential of Solar Energy for Chemical and Metal Manufacturing Plants in Malaysia," *Int. J. Adv. Sci., Eng. and Inform. Technol.*, vol. 13, no. 5, pp. 1898-1900, 2023.

[33] S. C. Lim, M. M. F. Dawoud, K. Y. Hoe and W. W. Yin, "Recent Progress in Floating Solar Photovoltaic Systems: A Review from Malaysia's Perspective," *J. Eng. Technol. and Appl. Phys.*, vol. 6, no. 1, pp. 1-3, 2024.

[34] A. Chindamanee and S. C. Lim, "Feasibility Study of Solar-Powered Electric Vehicle Charging Infrastructure at Selected Petrol Stations in Malaysia," *J. – The Institution of Engineers, Malaysia*, vol. 85, no. 1, pp. 25-28, 2024.

[35] C. L. Siow, H. Y. Leao and A. Panneerselvam, "Techno-economic Study of Solar Energy Implementation in Hospitals in Malaysia," *Int. J. Ener. Econ. and Polic.*, vol. 15, no. 2, pp. 583-586, 2025.

[36] S. C. Lim, L. H. Yew and A. Panneerselvam, "On the Potential of Solar Energy for Hospitals in Malaysia," in *2024 IEEE Int. Conf. Power and Ener.*, Kuala Lumpur, Malaysia, pp. 70-75, 2024.

[37] K. K. Tin, N. Agrahari and A. Kumar, "Review on Renewable Energy Potential and Installation in Myanmar," *WEENTECH Proc. in Ener.*, pp. 1–10, 2021.

[38] D. J. Pojadas and M. L. S. Abundo, "Spatio-temporal Assessment and Economic Analysis of A Grid-Connected Island Province Toward A 35% or Greater Domestic Renewable Energy Portfolio: A Case in Bohol, Philippines," *Int. J. Ener. and Environ. Eng.*, vol. 12, no. 2, pp. 251–280, 2021.

[39] A. Gulagi, M. Alcanzare, D. Bogdanov, E. Esparcia, J. Ocon and C. Breyer, "Transition Pathway Towards 100% Renewable Energy Across The Sectors of Power, Heat, Transport, and Desalination for the Philippines," *Renew. and Sustain. Ener. Rev.*, vol. 144, pp. 110934, 2021.

[40] B. Sun, "The Current State of Solar Energy and Prospects of Offshore Solar Energy in Singapore," *Appl. and Computat. Eng.*, vol. 7, no. 1, pp. 94–98, 2023.

[41] Y. Fan, V. Rimali, M. Tang and C. Nayar, "Design and Implementation of Stand-Alone Smart Grid Employing Renewable Energy Resources on Pulau Ubin Island of Singapore," in *2012 Asia-Pacific Symp. Electromagnet. Compatibil.*, Singapore, pp. 441–444, 2012.

[42] L. H. Koh, Y. K. Tan, P. Wang and K. J. Tseng, "Renewable Energy Integration into Smart Grids: Problems and Solutions - Singapore Experience," in *2012 IEEE Power and Ener. Soc. General Meeting*, San Diego, USA, pp. 1–7, 2012.

[43] K. Phumeesut, T. Suriwong, N. Ketjoy and W. Chamsa-ard, "GIS-based Analysis of Solar Power Plant Suitability in Thailand: Minimizing Natural Disaster Risks," in *2023 8th Int. Conf. Busin. and Industr. Res.*, Bangkok, Thailand, pp. 1182–1187, 2023.

[44] N. Jaisue, N. Ketjoy, M. Kaewpanha and P. Thanarak, "The Barriers Analysis for Waste-to-Energy Project Development in Thailand: Using an Interpretive Structural Modeling Approach," *Energies*, vol. 16, no. 4, pp. 1941, 2023.

[45] S. Shimada and W. Takeuchi, "Revealing A Shift in Solar Photovoltaic Planning Sites in Vietnam from 2019 to 2022," *Remote Sens.*, vol. 15, no. 11, pp. 2756, 2023.

[46] M. Joshi, J. A. Ranola, J. Novacheck, H. Sky and N. Grue, "Development of Renewable Energy Data for Facilitating the Clean Energy Transition in Vietnam," *Golden, CO: Nat. Renew. Ener. Lab., 2021.*

[47] D. Purkayastha and R. Sarkar, "Getting Financial Markets to Work for Climate Finance," *The J. Struct. Finance*, vol. 27, no. 2, pp. 27–41, 2021.

[48] R. Vakulchuk, I. Overland and B. Suryadi, "ASEAN's Energy Transition: How to Attract More Investment in Renewable Energy," *Ener. Ecol. Environ.*, vol. 8, no. 1, pp. 1–16, 2023.

[49] P. Sreelakshmi and R. J. Greeshma, "Green Bonds: A Propitious Financial Instrument of Climate Finance," *Vision: The J. Busin. Perspect.*, pp. 097226292211386, 2023.

[50] S. Sawant, C. Yarramsetty, T. Moger and D. Jena, "Role of Battery Energy Storage in Enhancing the Reliability of Wind-Integrated Power Systems," in *2023 IEEE IAS Glob. Conf. Emer. Technol.*, London, United Kingdom, pp. 1–6, 2023.