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Circular Carbon Economy Index
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Discussion Paper

Southeast Asia and the Circular Carbon Economy

A Rapidly Developing Region

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About KAPSARC

KAPSARC is an advisory think tank within global energy economics and sustainability providing advisory services to entities and authorities in the Saudi energy sector to advance Saudi Arabia's energy sector and inform global policies through evidence-based advice and applied research.

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Executive Summary and Key Points

Paris-aligned energy transitions are a rising priority on the policy agendas of Southeast Asian (SEA) nations, despite multiple competing priorities. The potential of these countries to realize their medium- and long-term decarbonization ambitions and the progress they are making reflect their circumstances as rapidly developing economies and globally connected trade participants. As these countries proceed with their energy transitions toward net-zero greenhouse gas (GHG) emissions, their energy stakeholders are balancing competing priorities: affordability, security, and sustainability. Population growth will increase the demand for energy services. The role of energy will become even more critical as these countries continue to develop domestic industries and sustain workforces. Yet, at the same time, existing climate ambitions and policy roadmaps are already shaping the trajectory of the energy systems, with the potential for further progress in deploying clean technologies, implementing robust mitigation policies, and securing sustainable financing.

This KAPSARC Discussion Paper examines the progress and potential of six major SEA economies, Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Viet Nam, on the road to net-zero emissions, or carbon circularity. It approaches this through the lens of the Circular Carbon Economy (CCE) Index, which builds on the technology-neutral approach of the CCE framework. The CCE Index was developed in 2021 by KAPSARC researchers to operationalize the CCE concept for use in net-zero policymaking and planning. The Index, now in its third annual edition, uses 38 metrics from up-to-date, high-quality global datasets to create scores for how 64 countries, comprising 90% of global emissions, are currently deploying CCE technologies (CCE Performance) and approaches, as well as how well-enabled they are by supporting factors and frameworks to achieve the transitions (CCE Enablers).

This paper investigates three overarching questions:

- How do the national circumstances of SEA countries shape their performance across the CCE Index's identified areas?
- What enabling factors are in place, as indicated by the CCE Index?
- What commonalities and differences among the six SEA countries can be identified using the Index?

Analyzing the 2023 CCE Index, the paper shows how the SEA region scores slightly higher overall than the global average, and much higher than the middle-income average on combined CCE Performance and Enablers scores. Singapore, the only high-income country in the group, consistently scores well across dimensions. SEA

countries rank in the middle third of countries, with none occupying top or bottom positions.

In **CCE Performance**, SEA countries surpass the global average in energy efficiency, renewable energy, and electrification. They have been expanding energy access, particularly electricity access, while increasing economic activity, with renewable energy playing an increasingly significant role. More specifically, the region's gross domestic product (GDP) growth has outpaced that of its population and energy demand, resulting in a 21% improvement in its energy intensity performance over the past two decades. This has happened partly on the back of services-driven economic growth. Electrification has also contributed to slowing energy demand growth. Over the past decades, the SEA region has made remarkable progress in electrifying end-use consumption and in improving electricity access. Even though Indonesia and the Philippines together comprise more than 20,000 islands, they have achieved electricity access rates of 97%, while the rest of the region stands at 100%. SEA countries also perform comparatively well on renewable energy. The Philippines, owing to its geothermal energy resources, produced 17% of its total primary energy consumption from renewables (excluding traditional bioenergy).

In switching from using the highest carbon dioxide (CO_2)-intensive fossil fuels such as coal and oil in its power sectors, the SEA region is showing a concerning trend, with the share of CO_2-intensive fuels in its power mix rising by up to 8 percentage points between 2016 and 2021. Most countries have been either stagnating or moving in the opposite direction. While the share of renewable energy in electricity generation has been increasing in most countries, coal and oil-fueled electricity still constitute almost half of the SEA's power consumption, with the exception of Thailand, where the electricity mix is dominated by natural gas.

The region generally scores low on the more costly or less accessible CCE technologies, namely carbon capture, utilization and storage (CCUS), clean hydrogen and nuclear energy. Indonesia is the main contributor to the SEA's high average CCUS score, with eight major projects in the pipeline, mostly in early development. Similarly, SEA countries are in the initial stages of developing clean hydrogen. As of now, there are no nuclear power plants in the SEA region, resulting in a zero score for the nuclear indicator. However, they are being considered by at least three out of the six countries. Finally, despite its tropical climate and extensive forested areas, the SEA scores lower in the area of natural sinks than its peer groups (by income and region). While land use and forestry emissions have been on a declining trajectory in Indonesia due to improved land management since 2016, in Malaysia the trend has been the opposite.

On **CCE Enablers**, the SEA scores around the global average but lower than the East Asia and Pacific region and high-income country groups, on average. Year-over-year improvement is found for all countries in the SEA, primarily driven by policy and regulatory improvements. While the SEA has shown improvement in this area, its average score remains below the global average. Opportunities persist for policymakers to enact laws supporting net-zero ambitions and release long-term frameworks. Access to technology and financing also emerge as critical enabling factors for the SEA. Domestic clean energy technology creation lags relative to other regions, necessitating a reliance on imported technologies and knowledge. Initiatives like the Just Energy Transition Partnership (JETP) are common across several SEA countries and have the potential to facilitate sustainable financing avenues.

More specifically, in the CCE Enabler dimension on policies and regulations, the SEA's scores align with the global averages on energy efficiency and renewable energy, emissions reporting, and climate change policy, while it scores lower than the global average on CCUS policy and natural sinks protection. However, all the SEA's peer groups also show lower scores on CCUS policy compared to the other indicators, reflecting the nascent state of the industry. Several countries in the SEA region still possess the potential to formalize their net-zero ambitions through legislation and put in place more robust policy instruments and regulations.

The CCE Enablers technology, knowledge and innovation dimension indicates good performance on indicators measuring technology transfer and utilization of international technology – namely, international high-technology interaction, medium-, and high-tech industry value-added, as well as university and industry technology collaboration.

In the finance and investment CCE Enablers dimension, despite some major intraregional differences in SEA countries' ability to leverage CCE investments and sustainable finance, the region as a whole displays robust levels of financial development and integration into global markets, benefiting also from the existence of a global financial hub in the region. These advantages are crucial capacities that can be leveraged to increase access to global sustainability funds, which can

significantly contribute to addressing the transition investment needs of the SEA region.

The paper finds that the CCE Index captures the technological performance of SEA countries and identifies elements for further inspection through energy balance statistics and market data. In the area of enablers for net-zero transitions, a common refrain is the need for increased access to sustainable finance, technology, and knowledge to supplement the lack of domestic creation through universities, the private sector, and research and development (R&D) activities. Singapore stands out in many indicators. It is an SEA outlier in terms of its population and economic structure. However, the other five countries have shown rapidly developing economies and an impressive expansion of modern energy services to their populations, all while beginning to chart their journeys toward CCEs and net-zero.

1. Introduction

Paris-aligned energy transitions are a rising priority on the policy agendas of Southeast Asian nations, despite multiple competing priorities. Over the last few years, Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Viet Nam have revised their medium-term Paris Agreement nationally determined contributions (NDCs) and prepared long-term low greenhouse gas (GHG) emission development strategies (LT-LEDS). Additionally, they have created or revised sector-specific policy roadmaps to articulate their long-term decarbonization ambitions and establish implementation frameworks. Four of the six countries – Malaysia, Singapore, Thailand, and Viet Nam – have also set mid-century net-zero emission targets (ECIU 2024).

The potential of Southeast Asian countries to realize their medium- and long-term decarbonization ambitions and the progress they are making reflect their circumstances as rapidly developing economies and globally connected trade participants. Excluding the high-income entrepot Singapore, the region's other countries are classified as middle-income economies by the World Bank.[1] Southeast Asia is rich in energy resources, and demand for energy is expected to continue increasing in the coming decades.

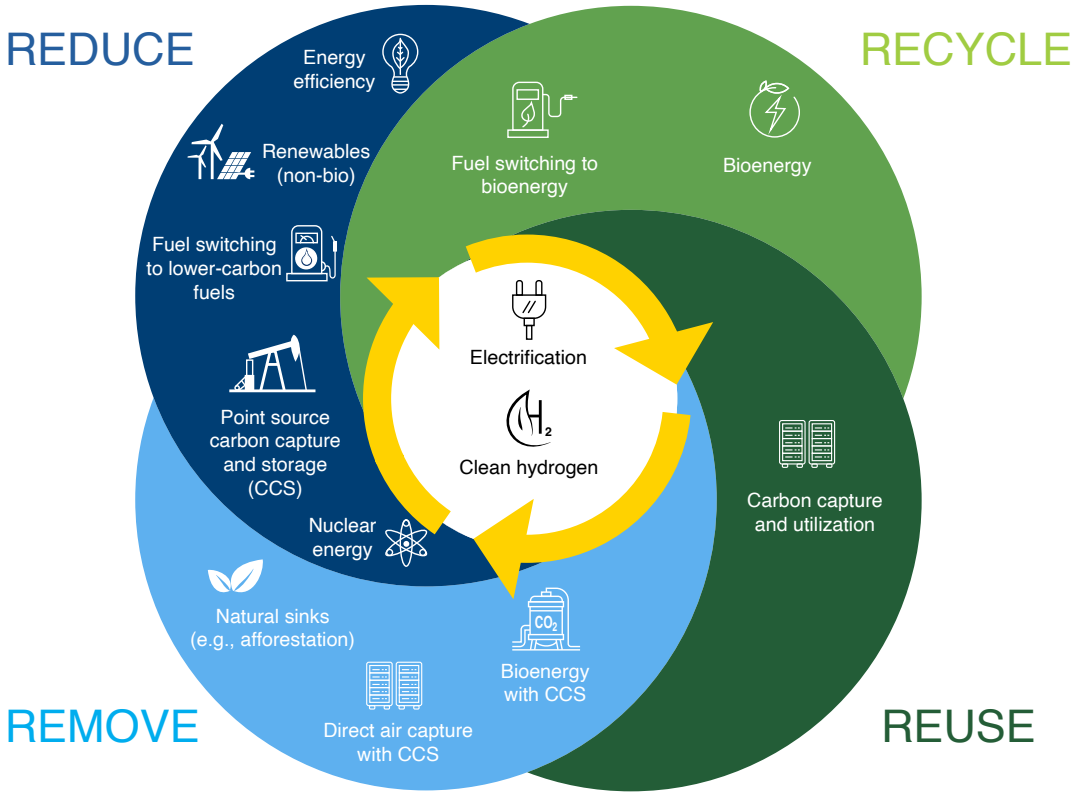
As these countries proceed with their energy transitions toward net-zero emissions, their energy stakeholders are balancing competing priorities: affordability, security, and sustainability. Population growth across the six countries examined in this paper will increase demand for energy services. The role of energy will become even more critical as these countries continue to develop domestic industries and sustain workforces. At the same time, existing climate ambitions and policy roadmaps are already shaping the trajectory of their energy systems, with the potential for further progress in deploying clean technologies, implementing robust mitigation policies, and securing sustainable financing, as discussed in this study.

The circular carbon economy (CCE) is a concept that offers a holistic and technology-agnostic framework for assessing climate change mitigation options and pathways globally, nationally, and organizationally (Figure 1). It builds on the familiar three "Rs" – reduce, reuse, recycle – while incorporating a fourth element for "remove." Unlike the circular economy, the concept of CCE draws attention to emission and energy flows specifically, with the ultimate goal of achieving full carbon emission circularity, or net-zero emissions. The CCE framework embraces all available mitigation technologies and options, including renewable electricity generation, natural sinks, and emerging technologies like clean hydrogen and carbon capture, utilization and storage (CCUS).

Utilizing the CCE concept can enable stakeholders to increase their mitigation ambitions by diversifying their portfolio of options. It facilitates comparisons among countries and regions using common metrics to evaluate progress, assess technology options, and identify best practices. Moreover, beyond the technology portfolio, the CCE concept serves as a robust framework for comprehending the policy, business, and economic conditions conducive to enhancing mitigation performance.

The CCE Index, developed at KAPSARC, is a country comparison index that benchmarks countries on their

Figure 1. The circular carbon economy.



Source: CCE Index web portal 2024 (Alaa Alarfaj).

carbon circularity journey. Its 2023 edition comprises 38 indicators, divided across two sub-indices. The first, CCE Performance, measures countries' current engagement with eight major climate change mitigation technologies and approaches (energy efficiency, renewable and nuclear energy, fuel switching, electrification, natural sinks, clean hydrogen and CCUS). The second, CCE Enablers, gauges how countries are positioned to make progress toward carbon circularity and net-zero emissions via metrics in five areas: policies and regulation; technology, knowledge and innovation; finance and investment; business environment; and system resilience. Figure A.1 in Appendix 1 displays the 2023 CCE Index indicator framework and aggregation logic, which is based on a simple averaging of the components. The full CCE Index methodology is available in Luomi, Yilmaz, and Alshehri (2021), and the full index results and data can be accessed at https://cceindex.kapsarc.org/.

The 2023 CCE Index covers 64 countries, with six classified as Southeast Asia (SEA): Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Viet Nam (Luomi, Yilmaz, and Alshehri [2024]). While these SEA countries share commonalities, diverse national circumstances shape their performance and potential. The CCE Index identifies these commonalities and differences, offering a snapshot of countries' progress in their energy transitions and their potential to realize further ambitions.

This KAPSARC Discussion Paper assesses the status and the medium- and long-term mitigation strategies of the six SEA countries on the road to net-zero emissions through the lens of the CCE Index. It acknowledges that each country will chart a unique energy transition pathway reflecting its national circumstances. By employing the CCE concept, the paper aims to highlight shared opportunities and challenges to foster the development of CCEs.

This paper investigates three overarching questions:

- How do the unique circumstances of SEA countries shape their performance across the CCE Index's identified areas?
- What enabling factors are in place, as indicated by the CCE Index?
- What commonalities and differences among the six SEA countries can be identified by the Index?

The paper begins, in Section 2, by providing the macroeconomic context of the SEA region to establish

the regional and national circumstances. Section 3 summarizes the 2023 CCE Index and the standing of SEA countries among all 64 countries included in the Index. Section 4 focuses on the CCE Performance sub-index, exploring areas such as energy efficiency, renewable electricity generation, CCUS, and clean hydrogen, utilizing the index scores and supporting energy balance statistics. Section 5 assesses the CCE Enablers sub-index to gauge the potential and preparedness to realize CCEs or reach net-zero. Finally, Section 6 draws conclusions.

2. About the SEA Countries

Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Viet Nam collectively comprise Southeast Asia (SEA) in the CCE Index. With a population exceeding 596 million people, the SEA ranks among the most populous regions globally (APERC 2023a).

The SEA region holds significant importance to the global economy as a major trade and manufacturing hub. Situated at the nexus of the Indian Ocean, South China Sea, and Pacific Ocean, the region plays a vital role in international supply chains. It features several rapidly growing economies, with Indonesia, Thailand, and Viet Nam emerging as major players in the global market. The region's economic growth is fueled by a young and expanding population, rising disposable incomes, and substantial investments in infrastructure and technology, all of which are reflected in an average 159% increase in the six countries' gross domestic product (GDP) since 2000 (with a 4.4% compound annual growth [CAGR]) (Table 1).

Beyond its economic importance, the SEA is a key player in the global energy landscape. Indonesia is a net energy exporter and one of the world's largest thermal coal exporters to markets in China, India, Japan, and Korea. Despite the region possessing large reserves of oil, natural gas, and coal, the other SEA countries are finding themselves becoming net energy importers. Malaysia, a significant liquefied natural gas (LNG) exporter, shifted to net energy importer status in 2019 due to its increasing coal and oil imports. The Philippines, currently experiencing rapid economic growth, also faces energy demand surpassing its domestic production. Thailand has diminishing domestic oil and natural gas reserves, coupled with low-quality lignite coal reserves. Like the Philippines, Viet Nam has become a net energy importer amid its rapid industrialization and service sector growth. While Singapore boasts a burgeoning economy with robust financial, shipbuilding, petroleum, and biotechnology sectors, it is fully urbanized and lacks domestic fossil energy resources.

Nevertheless, the region is diversifying its primary energy sources. Renewable energy deployment has been accelerating due to declining capital costs; short-term power development plans; long-term decarbonization roadmaps; and supportive policy instruments and frameworks such as feed-in tariffs, improved foreign ownership rights, and renewable energy certificates. Additionally, international platforms like the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), Asia Pacific Economic Cooperation (APEC), and Association of Southeast Asian Nations (ASEAN) facilitate knowledge sharing and foster multilateral partnerships to achieve energy efficiency, clean energy, and energy security objectives.

Table 1. Key macroeconomic indicators.

	Indonesia	Malaysia	Philippines	Singapore	Thailand	Viet Nam
Population in 2021 (millions)	274	34	114	5	72	97
Population growth (CAGR 2000-2021)	1.1%	1.7%	1.7%	1.4%	0.6%	1.0%
GDP in 2021 (billions, PPP constant, 2017)	3,247	884	992	588	1,223	1,036
GDP growth (CAGR 2000-2021)	4.6%	4.0%	4.5%	4.5%	3.2%	5.9%
GDP per capita in 2021 ($/person, PPP constant 2017)	11,859	26,333	8,096	107,741	17,087	10,628
GDP per capita growth (CAGR 2000-2021)	3.5%	2.3%	2.8%	3.0%	2.6%	4.9%
Income classification	Middle	Middle	Middle	High	Middle	Middle
Electricity access	97%	100%	97%	100%	100%	100%

Sources: APERC (2023a); World Bank (2019).

Notes: CAGR = compound annual growth rate; PPP = purchasing power parity.

3. High-Level Overview of the CCE Index Scores

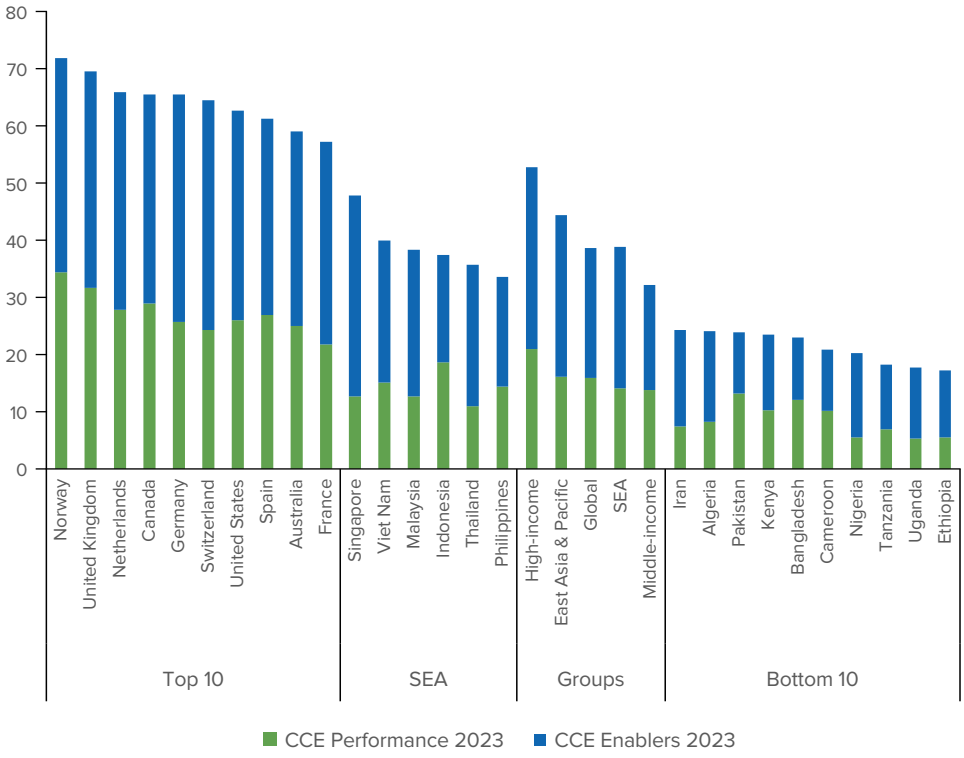
The CCE Index provides a composite score for comparing countries' standings in two sub-indices. The Performance sub-index measures countries' current levels of engagement with major climate change mitigation technologies and approaches, and the Enablers sub-index benchmarks their transition potential by monitoring enabling environments. Figure 2 shows the aggregate 2023 CCE Index scores for the top and bottom 10 countries included in the Index, flanking the six SEA countries and the region's peer group averages (global, SEA, East Asia and Pacific, high-income and middle-income).

In 2023, most SEA countries occupy mid-range positions in the global ranking, with none in the top or bottom 10. Of the SEA countries, Singapore secured the highest position at 15 out of 64, trailing Japan and Italy but leading the United Arab Emirates and China. Viet Nam (22) scores similarly to Saudi Arabia and Qatar, while Malaysia (25) falls between Poland and Egypt. Indonesia (31) and Thailand (32) closely follow. Despite being the lowest ranked country in the SEA, the Philippines (42) still places in the third quartile. Overall, Singapore and Viet Nam score higher than the global average, whereas the remaining SEA countries fall below, with the SEA average slightly exceeding the global average score.

Within the SEA, Singapore leads the rankings and has by far the smallest population size and the highest GDP per capita. Viet Nam, with the highest GDP per capita growth performance over the past two decades, has the second highest score. Indonesia ranks fourth despite having the largest economy in the region. Thailand closely follows Indonesia with a higher GDP per capita than Indonesia but lower than that of Malaysia. The Philippines, ranking the lowest of the six, has the lowest GDP per capita and the highest population increase in the past two decades.

As shown in Figure 2, across the board the SEA countries achieve higher scores in Enablers than in Performance, echoing trends observed in most countries in the 2023 Index. The global average Performance score is 32, with the SEA average slightly lower at 28. Conversely, the global average Enablers score is 45, while the SEA average slightly exceeds it at 49. Further analysis of scores within the SEA region is provided in subsequent sections.

Figure 2. SEA countries' ranking in the 2023 CCE Index, top and bottom countries and peer groups.



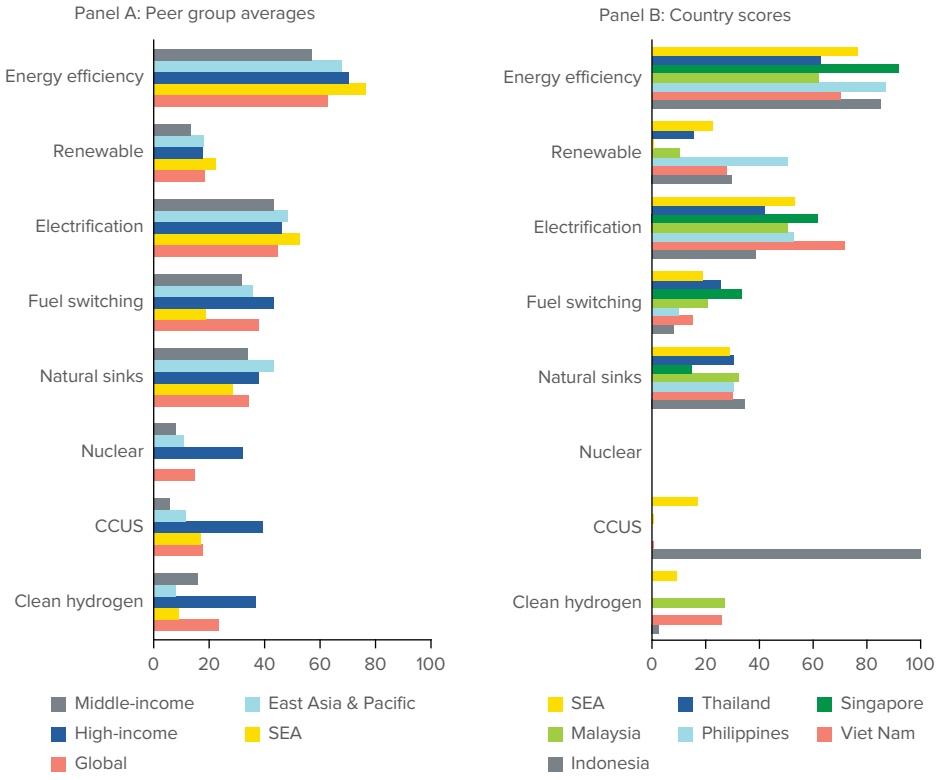
Source: Authors' computation from Luomi, Yilmaz, and Alshehri (2024).

Note: The bars indicate the proportional contributions of the CCE Performance and CCE Enablers sub-indices to the total CCE Index score.

4. CCE Performance

The CCE Performance sub-index measures eight CCE activities and technologies. All eight indicators are equally weighted, meaning that scoring well across more indicators yields a higher score than performing well in a few dimensions. This reflects a key message of the CCE concept, namely that various technologies will need to be deployed in line with country- and context-specific circumstances to reach net-zero in a cost-effective manner. The 2023 CCE Performance scores by peer group and within SEA are illustrated in Figure 3.

Figure 3. SEA countries' 2023 CCE performance scores compared.



Source: Authors' computation from Luomi, Yilmaz, and Alshehri (2024).

In the 2023 CCE Index, in comparison to their peer groups, SEA countries exceed the 2023 CCE Index global average in energy efficiency, renewable energy, and electrification. However, they lag in fuel switching and currently lack installed nuclear energy capacity. CCUS and clean hydrogen technologies are emerging into the picture, and hence the region's overall average scores for these technologies still remain below the global average.

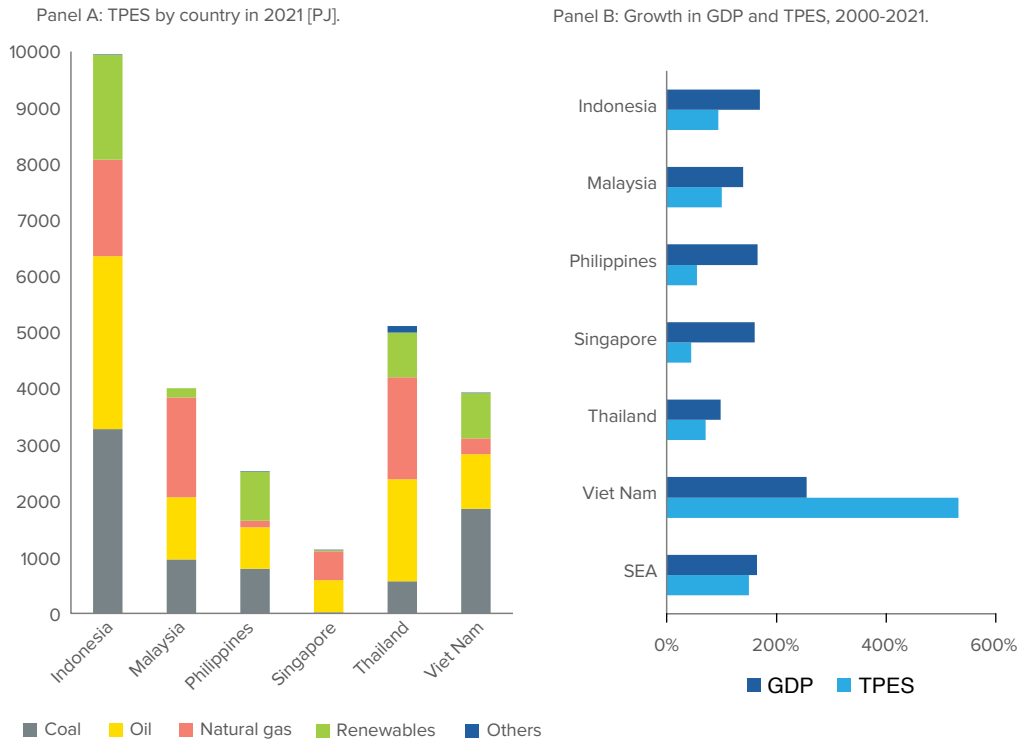
Among SEA countries, Indonesia has commercial-scale CCUS projects in early development stages, while Malaysia and Viet Nam have announced sizable clean hydrogen projects, mainly based on renewable energy. Additionally, Indonesia has also announced two moderately sized clean hydrogen projects, with more under consideration.

4.1 Energy Efficiency

The CCE Performance sub-index identifies the energy efficiency indicator as one of the areas where SEA countries (average score 76) outperform peer groups, including high-income countries (Figure 3, Panel A). The energy efficiency indicator measures countries' total primary energy consumption per unit of economic output (TPEC/GDP),[1] also referred to as "energy intensity." Using publicly available regional data from the APEC Expert Group on Energy Data and Analysis (EGEDA) for total primary energy supply (TPES) allows for an investigation into relative increases in domestic energy needs and GDP, and provides context for the region's high performance in this metric.

Figure 4, Panel A shows the TPES by energy carrier for each country and the SEA average. The TPES varies greatly across the countries: Indonesia has by far the largest total supply, nearly double that of Thailand, while Singapore has roughly one-tenth the amount of Indonesia. Malaysia and Viet Nam are close to the SEA average. Coal is present in each country except for Singapore. Natural gas supply varies by country, with Malaysia, Singapore, and Thailand having a large share, and the Philippines and Viet Nam having a smaller share. Renewable energy supply is also uneven, with Thailand and Viet Nam close to the SEA average, while Malaysia and Singapore only have small shares.

Figure 4. Primary energy supply and GDP of the SEA region.



Source: Authors' computation from EGEDA (2023).

From 2000 through 2021, TPES doubled for SEA as an aggregate, nearly matching the population increase over this period (100%) (Figure 4). However, GDP growth outpaced both population and TPES (159%), resulting in a 21% improvement in TPES/GDP (1.1% CAGR), as shown in Figure 4, Panel B. This translates into an enhancement in the SEA's energy intensity over the last two decades, consistent with the CCE Index energy efficiency score. Viet Nam stands out as having the highest growth in GDP and TPES over the period. In 2000, Viet Nam's TPES was smaller than Singapore's. Expanding energy access, industrial activity uptake, and economic growth have supported the strong increase in TPES.

As the sole high-income country in the SEA region, Singapore has the region's highest energy efficiency score owing to its less resource-intensive and more service-based economy. Following decades of industrialization, Singapore's key sectors, such as value-added manufacturing (e.g., electronics) and services (e.g., information technology), generate economic value with lower energy consumption than heavy industries such as manufacturing (World Bank 2019). Sectors like refining and petrochemicals, which require energy feedstocks, rely on imported resources and export the finished energy products. In 2021, over 90% of Singapore's crude oil imports were utilized for refining processes, with almost all refined products being exported, resulting in a minimal net impact on total primary energy supply and contributing significantly to economic value (EGEDA 2023). Although Singapore boasts a high energy efficiency score in the Index (ranked sixth globally), its TPES and population represent a small fraction (less than 1.0%) of the SEA region.

The Philippines scores the second highest in energy efficiency (score 87). Since 2000, the Philippines has experienced the slowest growth in TPES among all SEA countries (1.7% CAGR), yet its GDP has grown at the second-fastest rate (4.5% CAGR). Like Singapore, the Philippines' economy is driven by services, contributing around 60% to its GDP. Overseas remittances, constituting approximately 3% of GDP in 2021, play a crucial role in the country's economy (Republic of the Philippines Statistics Authority 2023). The reliance on services like business process outsourcing (such as call centers) has enabled the Philippines to achieve rapid economic growth without a proportional increase in energy consumption (World Bank 2023e).

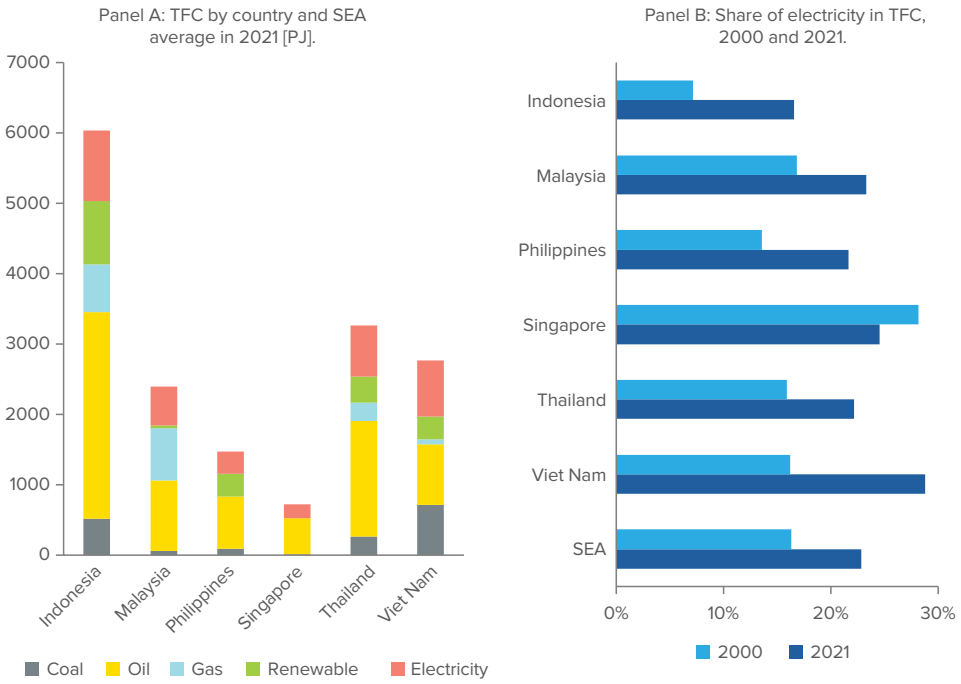
Indonesia's average energy efficiency performance is slightly above the SEA average, but it has maintained a consistent trajectory over time. However, the country's population and industrialization pathway present an interesting contrast to Singapore. With a population of 274 million, Indonesia's population is 50 times larger than that of Singapore. Between 2000 and 2021, Indonesia transitioned from a manufacturing-focused economy, representing approximately 30% of its economy, to one reliant on resource extraction (Aswicahyono, Hill, and Narjoko 2011; Deutsche Bank 2024). In 2021, the top three exports by value were mineral products, biomass products like palm oil, and metals, whereas in 2000, mineral products and machinery dominated its export market (OEC 2023). Consequently, Indonesia's TPES nearly doubled (a 95% increase), while GDP expanded by 170% – surpassing Singapore's growth of 45% and 161% for TPES and GDP, respectively.

4.2 Electrification

The second highest scoring indicator is electrification. It is tracked in the CCE Index with the share of electricity in total final consumption (TFC), which measures the energy carriers consumed in end-use sectors, including for non-energy processes.[1] As electrification increases, TFC decreases, all else being equal, due to the inherent efficiency gains from converting electrical energy to mechanical or thermal energy rather than from chemical energy. The composition of TFC and the share of electricity in TFC in 2000 and 2021 in SEA countries are illustrated in Figure 5, panels A and B.

In 2021 – the data year for the 2023 CCE Index score – the SEA region's average electrification indicator score was 23%: higher than the global average. The region has made remarkable progress in electrifying end-use consumption. According to EGEDA, in 2000, the share of electricity in TFC was only 16% (EGEDA 2023). This advancement reflects the economic development of the six countries and the modernization of their energy systems. In several SEA countries, expanding electricity access has been a high priority policy. Viet Nam leads in this regard with the highest share of electricity access at 29%. Policy support for rural electrification has facilitated the connection of millions of Vietnamese homes to the national electricity grid (ADB 2011).

Figure 5. TFC and share of electricity.



Source: Authors' computation from EGEDA (2023).

The Philippines and Indonesia face unique challenges in increasing electricity access and electrification due to geographical barriers. Together, these countries comprise over 20,000 islands. While electricity grids connect major cities and surrounding rural areas on larger islands, many remote inhabited islands lack connection to the main electricity networks. These communities often rely on microgrids or diesel generators for electricity generation. Both countries have implemented policies to enhance electrification. For instance, the Rural Electrification Program has played a vital role in alleviating poverty and providing access to modern energy services for communities in the Philippines (United States International Trade Administration 2022a). In 2000, electricity access in Indonesia and the Philippines stood at 86% and 99.2%, respectively, rising to 97.5% and 99.2% in 2021 (World Bank 2023a, 2023b).

Notably, Singapore's electrification share declined between 2000 and 2021. Commercial services play a crucial role in Singapore's economy and are one of the largest consumers of electricity. However, industrial and non-energy activities constitute the largest overall end-use energy demands. The growth in energy demand for these activities has lowered Singapore's electrification share. For instance, the chemicals industrial sub-sector accounts for nearly a quarter of Singapore's TFC. Additionally, non-energy activities, such as feedstocks for the production of fertilizers and plastics, contribute to over half of Singapore's TFC. The significance of industrial activities is partly attributable to Singapore's strategic location at the mouth of the Malacca Strait, a key trade route for goods, including energy carriers, from the Indian Ocean to the South China Sea for markets in Asia.

4.3 Renewable Energy

The CCE Index's renewable energy indicator measures the share of renewable energy sources in total primary consumption, excluding traditional biomass, such as firewood, and waste. The SEA region's performance on this indicator (average score 22.4, Figure 4, Panel A) surpasses that of its peers, including the global average (score 19). Norway is the top performing country in renewable energy among the 64 countries covered in the Index, boasting substantial hydro resources for electricity generation. Figure 4, Panel A depicts the different energy

carriers in TPES in play in the SEA region, based on data from EGEDA. It is important to note that the EGEDA energy statistics, unlike those of the CCE Index, include traditional biomass in the scope of renewables.

The Philippines has the highest score in renewable energy within the SEA region (score 50, Figure 3, Panel B) and the fourth highest score globally, obtaining around 17% of its TPEC (excluding traditional biomass) from renewable sources. This score is due in large part to geothermal energy. The Philippines has substantial geothermal potential because it is situated in a tectonically active area on the "ring of fire" and is the third-largest producer of geothermal energy behind the United States and Indonesia (Fronda et al. 2020).

Viet Nam scores second highest on the renewable energy indicator (score 28). Electricity production from hydropower and solar resources is the largest component of the country's renewable energy consumption. Between 2000 and 2021, Viet Nam's renewable energy consumption increased from around 8% to just under 10%, paralleling the increase in the country's electricity consumption (as shown by Viet Nam's high score on electrification) – a laudable achievement. Thailand (4%), Malaysia (3%), and Singapore (0%) register the lowest levels on the renewable energy indicator. In Thailand, solid biomass is still consumed alongside fossil fuels in large quantities in the industrial and residential sectors. Fossil fuels maintain a prominent role in primary energy consumption in Malaysia and Singapore.

4.4 Fuel Switching

In the 2023 CCE Index, the fuel switching indicator measures reductions in electricity generation using oil, coal, and derived gas[1] over a five-year period (2016 to 2021) and their total share in a country's electricity mix in 2021, rewarding countries for both reductions and lower levels of these fuels. Along with electrification, the composition of the fuel mix for power generation greatly influences CO_2 emissions. As electricity consumption increases, decarbonizing electricity production becomes even more important.

As shown in Figure 3, Panel A, the SEA region scores lower than its peer groups in fuel switching. Over the period 2016-2021, Malaysia made modest progress (a change of 1.7 percentage points), whereas the other countries either stagnated (Singapore and Thailand) or increased (Indonesia, the Philippines and Viet Nam) their share of higher carbon intensity fossil fuels in electricity generation. For the latter group, this increase was 4.0-7.9 percentage points.

On average, the share of oil and coal in the power consumption of the SEA region is around 47%, which reflects the significant role of these two fossil fuels in the region's economies, especially in Indonesia, Malaysia, and Viet Nam. Coal is utilized for electricity generation in much greater quantities than oil. Over the five-year period, the share of oil declined for all six countries. However, Indonesia, the Philippines, and Viet Nam saw a substantial increase in the share of coal-fired electricity generation, resulting in these countries scoring lower compared to the SEA average. Thailand's share of oil and coal-fired generation was negligible relative to its peers, as over half of the country's electricity supply comes from natural gas. (On the central role of coal in SEA countries' economies, see Section 5.3.)

The share of renewable electricity generation (not encompassed by the fuel switching indicator) increased in all countries except the Philippines, where renewable electricity generation declined over the same five-year period. This was due to renewable electricity generation remaining constant while other sources such as coal increased (EGEDA 2023).

When accounting for natural gas, the share of electricity generation from fossil fuels in the SEA region increases to 82% in 2016, highlighting the key role natural gas plays in the region's power sector mix (EGEDA 2023). Through 2021, fossil fuel electricity generation decreased by 6%. Much of this reduction was due to natural gas electricity generation being replaced by renewables, with only Singapore increasing gas-fired generation.

4.5 CCUS, Clean Hydrogen, and Nuclear Energy

Due to the early deployment stage of CCUS and clean hydrogen for low-carbon energy applications, these indicators in the CCE Index count the total capture capacity of projects in the pipeline. For CCUS, this

includes projects that are operational, in construction, advanced development, and early development. For clean hydrogen, the indicator includes blue and green hydrogen projects that are commissioned, financed, under construction, or undergoing feasibility studies.

Indonesia is the main contributor to the SEA region's high average CCUS score, with eight major projects in the pipeline, mostly in early development. These projects, scheduled for commissioning between 2025 and 2030, aim to capture over 300 million tons[1] of CO_2 per year, a substantial portion of Indonesia's 2021 energy-related CO_2 emissions of 578 million tons (EGEDA 2023). Several of the projects involve Japanese companies, reflecting the growing cooperation between the two countries on carbon management technologies. The largest project is a CCS hub jointly developed by Indonesia's national oil company Pertimina and ExxonMobil. Compared to its 2022 score on this indicator, Indonesia increased its capture capacity substantially due to the inclusion of this project in its pipeline. According to Bloomberg New Energy Finance, from which this data is derived, other countries in the region lack commercial-scale CCUS projects.

Similarly, SEA countries are in the initial stages of developing clean hydrogen, with most projects in early development. Over 1 million tons per year of clean hydrogen production capacity are planned in the SEA region, with commissioning dates between 2023 and 2030. Malaysia has the highest SEA score (score 27), with its nameplate hydrogen capacity increasing over 34 times from 2021. Notable projects in the SEA region include the *Enterprize Energy Thang Long Wind 2 Hydrogen Production Electrolysis Project* in Viet Nam, followed by the *Pupuk Indonesia Bontang Hydrogen Production Electrolysis Project,* and the *Samsung Engineering H2biscus Hydrogen Production Electrolysis Project* in Indonesia. Although Singapore scored zero in the 2023 Index, the country has announced ambitions to become a regional and global player in hydrogen markets. Accordingly, the country's Index score is expected to rise as projects are officially announced in the coming years.

CCUS and clean hydrogen are important components of the CCE framework, as these technologies can help ensure flexible and technology-agnostic decarbonization solutions for hard-to-abate sectors. According to data in the Index, the momentum of CCUS projects is building both globally and in the SEA region, with major growth in project portfolios in the past three years (Luomi, Yilmaz and Alshehri 2024). Considering the sizable share of hard-to-abate sectors in the economies of all six countries in the region, clean hydrogen in particular plays a crucial role in their long-term plans, with Malaysia envisioning becoming a regional CCUS hub (see Section 6).

As of now, there are no nuclear power plants in the SEA region, resulting in a zero score for the nuclear indicator. However, energy planners in Indonesia and the Philippines are considering nuclear generation as part of a future low-carbon electricity generation portfolio (World Nuclear Association 2022). Singapore is exploring the feasibility of new reactor designs suitable for its dense urban environment and limited land.

4.6 Natural Sinks

The natural sinks indicator encompasses two aspects: (1) forest area as a proportion of total land area (%) – indicating natural sink capacity; and (2) changes in ecosystem services (i.e., losses in tree cover, grasslands, and wetlands) – reflecting how well countries are preserving their forests and other natural ecosystems that capture and sequester CO_2. Despite its tropical climate and extensive forested areas, the SEA region's score (average 29) is lower than its peers, including the global average (score 34.4). The average share of forested areas in the SEA region is 40%, with Malaysia (58%), Indonesia (49%), Viet Nam (47%), and Thailand (39%) having some of the largest proportional forest areas among the countries included in the CCE Index. The Philippines and Singapore have lower proportions of forested areas, at 24% and 22% respectively. What drags the SEA countries' indicator score down are their low scores for ecosystem conservation, with all but the Philippines (score 27) scoring 15 or less on this metric. According to Climate Watch (2024), between 2011 and 2020, the SEA region was the source of approximately 550-1,000 million tons of CO_2 ($MtCO_2$) from land use change and forestry (LUCF) emissions. This accounted for 19%-32% of the region's total GHG emissions (including LUCF). Differences among SEA countries, however, are significant, with Viet Nam's forests estimated to have acted as a net carbon sink (12-23 $MtCO_2$ per year in 2011-2020), Singapore, the Philippines, and Thailand having relatively small net forestry emissions, and Malaysia's forests converting from a sink to a source of emissions since 2016. In the balance, Indonesia's LUCF emissions are accountable for most of

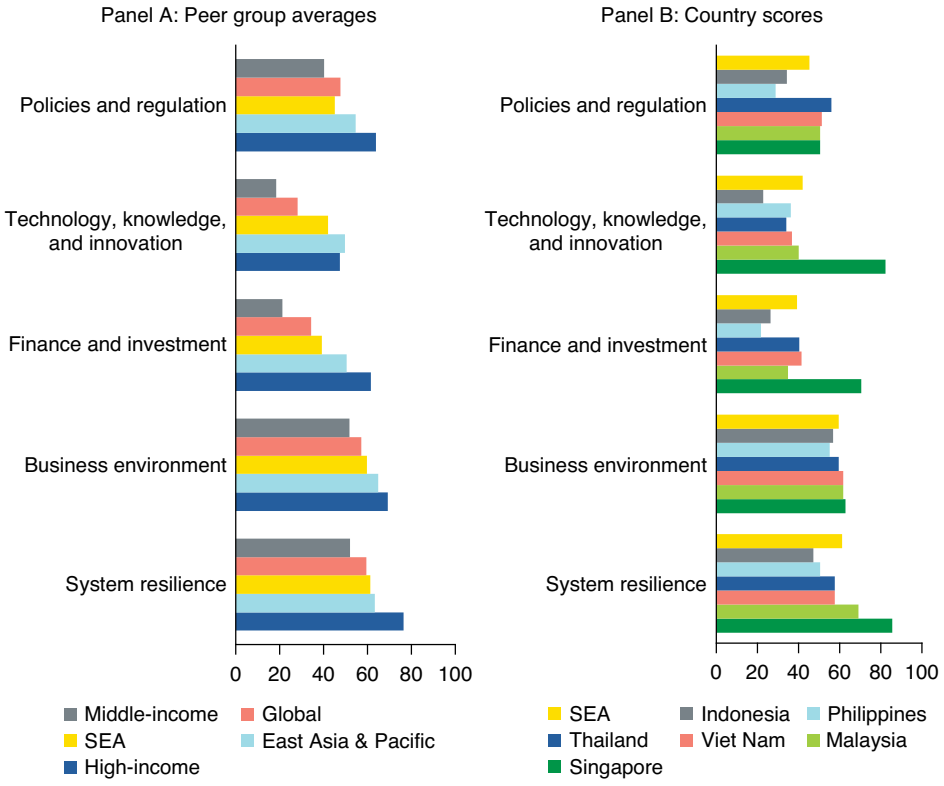
the SEA region's LUCF emissions, ranging between an estimated 481-1,149 $MtCO_2$ per year in 2011-2020, and accounting for one-third to two-thirds (34%-57%) of the country's total GHG emissions (including LUCF) over this period. Indonesia's forestry emissions also make it the world's sixth-largest emitter. LUCF emissions have also comprised a relatively high share of Malaysia's total GHG emissions (including LUCF), accounting for 18%-20% in 2016-2020 (Climate Watch 2024).

Both Indonesia and Malaysia are significant producers of biofuels, some sourced from deforested areas. In Indonesia, LUCF emissions have been on a declining trajectory due to improved management since 2016 (with a drastic reduction between 2015 and 2016 from 1,147 to 514 $MtCO_2$ per year). In Malaysia the trend has been the opposite, as the country managed to temporarily reverse net deforestation in 2011–2015 but has seen net LUCF emissions of 63-72 $MtCO_2$ per year since 2016 (Climate Watch 2024). Improved forestry management and balanced biofuels production could lead to higher natural sinks scores for these two countries. Natural sinks also play a vital role in the NDCs of each SEA country (see Appendix 2).

5. CCE Enablers

The CCE Enablers sub-index measures how countries currently stand on various critical enabling factors for net-zero transitions and benchmarks their potential to accelerate these transitions. It encompasses five dimensions: policies and regulation; technology, knowledge, and innovation; finance and investment; business environment; and system resilience (Figure 6). The SEA region's total average CCE Enablers score (50) is higher than the global (45) and middle-income group (37) averages but lags behind those of high-income countries and the East Asia and Pacific region. In the Index, the latter includes three other high-income countries (Australia, Japan, and the Republic of Korea), and China. The delta between SEA countries and high-income countries and the East Asia and Pacific region highlights the potential for progress in the region as it develops enabling frameworks.

Figure 6. SEA countries' 2023 CCE Enablers scores compared.



Source: Authors' computation from Luomi, Yilmaz, and Alshehri (2024).

When examining the five enabling dimensions separately, on average the SEA region performs slightly above the global average, with the exception of policies and regulation, where the SEA region's average score (45) is below the global average (48). In technology, knowledge and innovation, the SEA region's score is well above the global average. Among the SEA countries, Singapore stands at the top of the CCE Enablers index score distribution. Removing Singapore from the SEA average, however, does not change the regional ranking. Singapore scores higher than its peer groups in all dimensions except policies and regulations.

Even though enabling environments generally take time to transform, due to their complexity and multi-dimensional nature, it is worth examining year-on-year changes. Figure 7 shows the drivers of changes in SEA countries' CCE Enablers dimension scores from 2022 to 2023, based on the 2023 CCE Index edition results. It reveals that year-over-year, all SEA countries have improved their net Enablers scores, primarily driven by gains in the policies and regulations dimension. This is largely attributable to long-term emission targets and improved CCS policy frameworks in some SEA countries. Conversely, system resilience scores consistently lower, even if only marginally, across all countries, driven by lower energy security and equity scores.

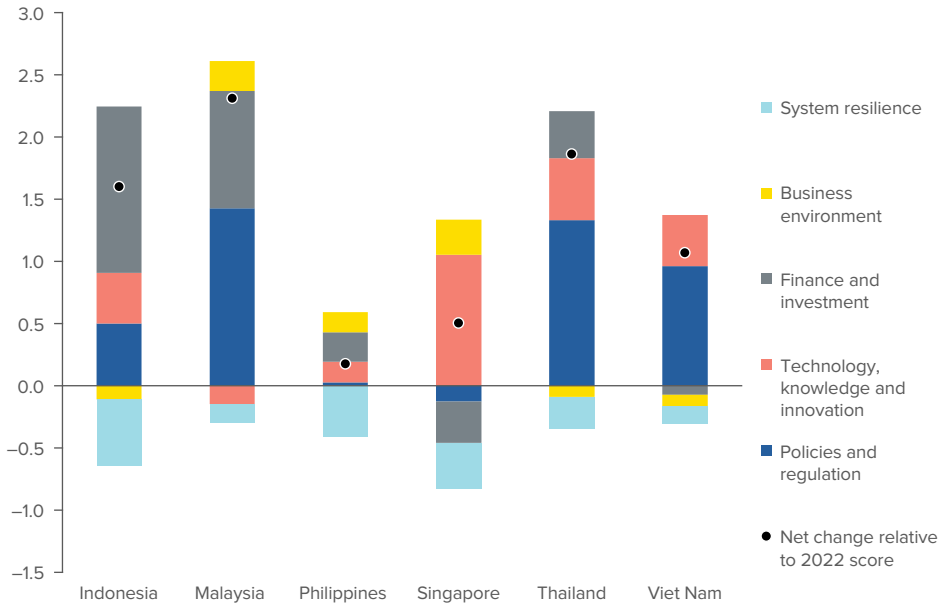
The high-level comparison of SEA countries on CCE Enablers reveals that the region's middle-income countries in particular indicate various areas for improvement to accelerate their CCE transitions. The following subsections unpack the Enablers sub-index to provide a more detailed discussion of the five enabling dimensions.

5.1 Policies and Regulation

This dimension contains indicators that assess government support for CCE and net-zero transitions through policy and regulatory frameworks. It includes three indicators that capture technology and activity-specific policies (energy efficiency and renewable energy, CCUS, and natural sinks). The remaining two indicators quantify the fulfillment of emissions reporting obligations under the United Nations Framework Convention on Climate Change (UNFCCC) and the level of commitment to net-zero pathways from national and sub-national governments. Figure 8 compares the peer group averages and individual SEA countries' scores on the five indicators.

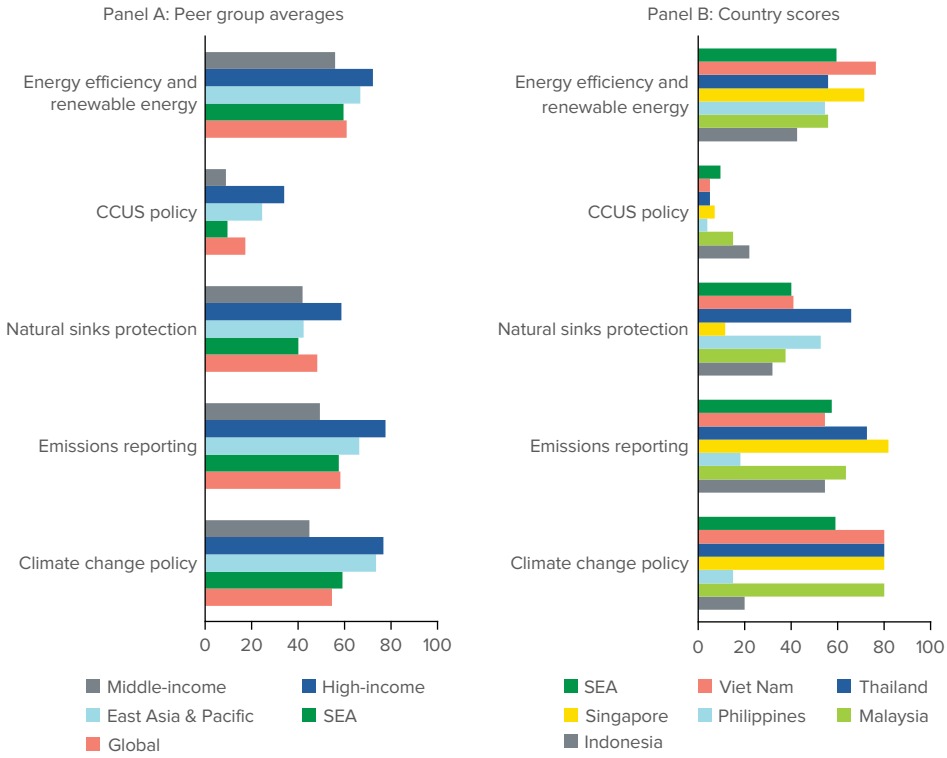
Over the last several years, the SEA countries have published and revised their NDCs. NDCs set targets at

Figure 7. Changes in SEA CCE Enablers scores 2022-2023.



Source: Authors' computation from Luomi, Yilmaz, and Alshehri (2024).

Figure 8. SEA countries' 2023 CCE Enablers scores compared: policies and regulation.



Source: Authors' computation from Luomi, Yilmaz, and Alshehri (2024).

economy-wide, sectoral and technology levels and describe measures that are ongoing and planned to help reach these targets. NDCs can be mapped onto the CCE framework to compare strategies across the region (see Table 2 in the appendix). Details of the NDCs are drawn directly from submissions to the UNFCCC. LT-LEDS and similar frameworks supplement the NDCs and are included in Table 2. These have been sourced via the UNFCCC's Long-term Strategies Portal and government websites.

The SEA region's score closely aligns with the global averages for energy efficiency and renewable energy, emissions reporting, and climate change policy, while it scores lower than the global average on CCUS policy and natural sinks protection. However, all the SEA region's peer groups also show lower scores on CCUS policy compared to the other indicators, reflecting the nascent state of the industry. Across this dimension, the SEA region scores much lower than high-income countries, but generally higher than the medium-income group, with the exception of natural sinks protection.

The SEA region's climate change policy indicator scores are on average higher than the global and middle-income country averages. This indicator measures net-zero commitment by national and sub-national governments. It is based on levels of commitment and government, as reported by The Net Zero Tracker (ECIU 2024). All six countries have long-term development plans guiding energy and climate policies. The Philippines and Indonesia score the lowest on this indicator. The Philippines' low score is attributed to the fact that it only registers net-zero commitment at the city level (Cebu), while Indonesia's net-zero target remains under discussion. The SEA's long-term emission reduction frameworks are summarized in Appendix 2.

On the emissions reporting indicator, which measures countries' compliance with UNFCCC reporting obligations, SEA countries have a mixed record: Singapore has submitted nine out of 11 required reports and the Philippines only two. The Philippines' latest UNFCCC emissions inventory is for the year 2000, albeit the Republic of the Philippines Department of Environment and Natural Resources (2024) has made available an emissions inventory for 2018 on its website. Up-to-date emissions data is a key prerequisite for data-driven policymaking.

The SEA region outperforms its peer groups on policy and regulatory support for energy efficiency and renewable energy, as measured by the Regulatory Indicators for Sustainable Energy (RISE) (World Bank 2022b). One reason for this is the plethora of renewable energy policies enacted in the region to increase its share of renewable energy. This Enablers indicator shows that the SEA region is approximately on par with the global average, with Viet Nam and Singapore scoring higher than the SEA average.

In Viet Nam, a set of strategy documents – the *Industrial Development Strategy through 2025, a Vision toward 2035* and *Development Strategy of Renewable Energy* – pave the way for investment and development opportunities in renewable energy projects. Solar photovoltaic capacity has steadily grown due to a combination of stable support via a feed-in tariff and rules for power purchasers to offtake generation (U.S. International Trade Administration 2022b). As highlighted by the CCE Index electrification indicator, Viet Nam's policies on increasing electricity access have been remarkably successful.

In Singapore, solar photovoltaics are considered by the government to be the most viable renewable energy resource. Policymakers have recently made efforts to enhance the regulatory framework and streamline compliance requirements to facilitate an expansion of solar electricity generation. One novel innovation is the creation of a program called SolarNova to aggregate demand for solar deployment on public buildings and spaces (Singapore National Climate Change Secretariat 2020). Public buildings in Singapore include government facilities and government-owned residential housing. The potential for public buildings to generate demand under this program is substantial given that approximately 77% of all Singaporean residents live in government-owned housing (Singapore Housing and Development Board 2022).

In Thailand, the *Power Development Plan 2018* aligns government planners and the power industry on the expected growth in electricity demand and technology portfolios to maintain a reliable and cost-effective source of electricity (Kingdom of Thailand Ministry of Energy 2020b). A revised *Power Development Plan* is under development and is expected to include more detailed projections on renewable energy, CCUS, and clean hydrogen for power generation (Kingdom of Thailand Ministry of Natural Resources and Environment 2021a)..

In the Philippines, the *Renewable Energy Act of 2008* introduced programs to promote the development and commercialization of renewable energy resources (Republic of the Philippines Department of Energy 2023b). These include a feed-in tariff scheme, net metering, and renewable portfolio standards. Additionally, the Philippines opened investment opportunities in geothermal projects to foreign companies, which helped support the deployment of geothermal power assets.

All SEA countries have low scores for CCUS policy. This indicator uses the CCS Policy Indicator from the Global CCS Institute and focuses on critical policy frameworks for the domestic regulation of CCS operations. As discussed in the Performance section, Malaysia has ambitious plans to utilize CCUS to reduce emissions, especially in hard-to-abate industries. Lacking a regulatory framework and facing high costs, Malaysia has not developed any CCUS projects. Similar to its clean hydrogen ambitions, Malaysia envisions being a regional CCUS hub, aiming to establish three to six individual CCUS hubs by 2050 with a total capacity of 40 to 80 $MtCO_2$ per year. Storing CO_2 outside Malaysia is a possibility, but the country has not developed a domestic CO_2 storage policy to date.

The SEA region lags all peer groups in natural sinks protection. Singapore has a land area of only approximately 730 km^2 and protected areas cover on average only 12% of the country's key biodiversity areas (KBAs). Removing it from the SEA group average calculation brings the remaining five countries' average (41%) closer to the global average (43%). Thailand scores the highest, with 59% of its KBAs formally protected. Indonesia, which has the highest land and forest sector emissions, protects 30% of its KBAs. A more direct way to gauge forest carbon is to examine the share of a country's total land area comprising terrestrial protected areas. For Indonesia, this share is 12%, which is slightly below the global average of 18% (World Bank 2024). As can be seen, in either case, the policy indicator does not fully reflect the current extent of deforestation, even if, as mentioned previously, it has been decreasing in recent years.

5.2 Technology, Knowledge, and Innovation

This dimension comprises six indicators that measure countries' progress on the creation, diffusion, and absorption of knowledge. Access to technology and knowledge transfer is a common need articulated by all six SEA countries in their NDCs and LT-LEDS. The SEA region scores well on indicators measuring technology transfer and utilization of international technology (international

high-technology interaction) (score 77); medium- and high-tech industry value added (score 62); and university and industry technology collaboration (score 53) (Figure 9). In the international high-technology interaction indicator, the SEA region scores higher than all its peer groups, with five out of the six countries demonstrating robust performance in this area; Indonesia is the exception. This indicator is based on the Global Innovation Index and shows that SEA countries score at or above expectations for their level of development (WIPO 2022).

The SEA region scores lower on domestic knowledge creation-related indicators, namely academic research intensity, clean energy technology patents, and research and development (R&D) expenditure. These scores paint a picture of a region that requires access to technology to progress on the creation of CCEs.

Singapore has the highest technology dimension score of all 64 CCE Index countries, achieving maximum scores on academic research intensity and the contribution of medium- and high-tech industries to the economy (in per capita terms), and high scores on the other indicators. The second-highest scoring country for the technology indicator is the Republic of Korea, which achieves maximum scores for R&D expenditure and clean energy patents, but lower scores for the remaining indicators.

Within the SEA region, Singapore scores the highest in five of the six indicators with a clear leading position in domestic knowledge creation activities like academic research, clean energy technology patent creation, and R&D expenditures. Removing Singapore from the SEA average lowers the regional average scores slightly in these indicators and confirms the observation that the largest gaps across the SEA countries under this dimension exist in knowledge creation-related activities.

The region's strong performance in technology absorption capacities is due to its well-established manufacturing capacities and proximity to knowledge creation hubs, such as Japan, the Republic of Korea, and China. In

Figure 9. SEA countries' 2023 CCE Enablers scores compared: technology, knowledge, and innovation.

Source: Authors' computation from Luomi, Yilmaz, and Alshehri (2024).

particular, country scores for indicators aiming to capture intra-national technology cooperation – i.e., university-industry cooperation and medium- and high-tech manufacturing value added to the economy – are higher than the global average or around the regional average (Figure 9, Panel B). Similarly, all SEA countries, with the exception of Indonesia, score significantly higher than the global average in international high-technology interactions.

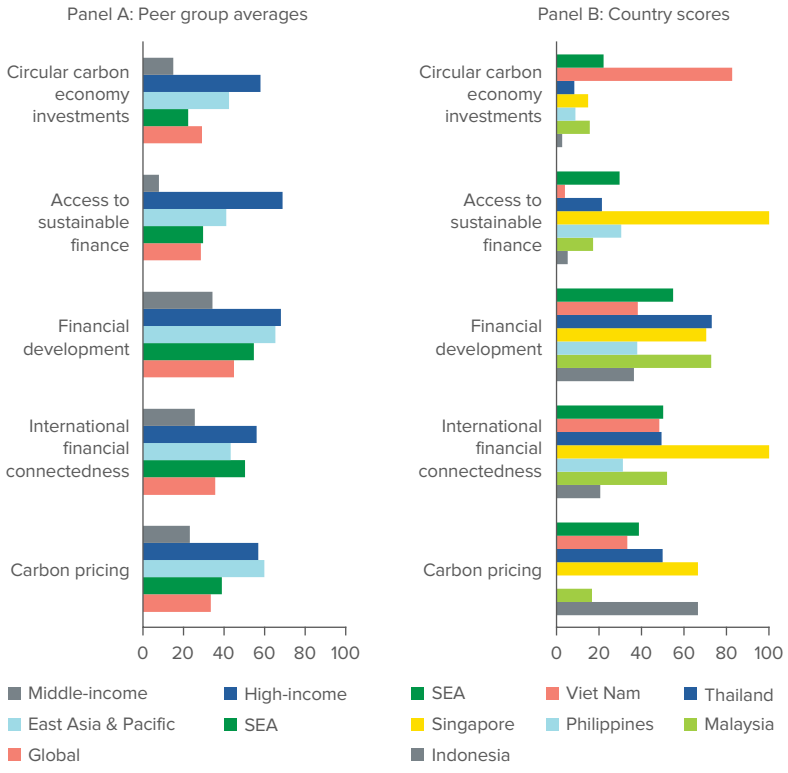
While raising a country's technology creation capacity may require both time and resources, the SEA region's high performance in intra- and cross-country technology collaboration is promising and can give a significant boost to its efforts to accelerate its decarbonization efforts.

5.3 Finance and Investment

The finance and investment sub-dimension consists of five indicators. Two general measures under this dimension account for financial development (measured via the International Monetary Fund's [IMF's] Financial Development Index, which measures access to, and the efficiency and depth of, financial markets and banking systems) and international financial connectedness (measured via global capital flows relative to national GDP). In addition, there are three CCE-specific indicators, namely CCE transition investments, access to sustainable finance, and carbon pricing mechanisms. The two first of these indicators aim to capture countries' CCE-related sustainable investment performance (by measuring investments in the main climate change mitigation technologies) and their capacity to access much-needed sustainable finance (measured via the issuance of sustainable debt per country of domicile). The third one captures the existence of different types of carbon pricing mechanisms (emissions trading schemes [ETS], carbon taxes and/or crediting mechanisms).

The SEA region generally performs well on most of the indicators, with average scores above the global and middle-income group averages (Figure 10, Panel A). The region's

Figure 10. SEA countries' 2023 CCE Enablers scores compared: finance and investment.



Source: Authors' computation from Luomi, Yilmaz, and Alshehri (2024).

financial development and connectedness are significantly higher than those of its peers, while its performance on the two sustainable finance and investment indicators is around the global average or slightly below. Intuitively perhaps, the region lags significantly behind those with more developed countries (including the East Asia and Pacific region) in development and connectedness.

There are notable intra-regional differences in most indicators: Malaysia, Thailand, and Singapore, for example, display higher financial development than the other SEA countries. Singapore, as a regional financial hub, has the highest score in international financial connectedness in the region. On this indicator, Malaysia, Thailand, and Viet Nam stand around the SEA regional average, while the Philippines and Indonesia rank below it (Figure 10, Panel B). For CCE investments, scaled to economy size, Viet Nam leads the region with a globally competitive score (83), ranking eighth out of the 64 countries in this indicator despite its lower penetration of sustainable finance (Figure 10, Panel B). State enterprises, such as the Bank for Investment and Development of Vietnam, certainly play a critical role in CCE investments, which mostly utilize public resources. Viet Nam's score on CCE investments is noteworthy given the investment environment in Indonesia, which boasts a larger capacity CCUS project pipeline, and Malaysia's aspiration to be a regional CCUS hub.

Access to sustainable finance is a common enabler identified by SEA countries in their NDCs and long-term decarbonization frameworks. Four countries – Indonesia, the Philippines, Thailand, and Viet Nam – include additional reductions, conditional on access to technology, finance, and knowledge transfer. The Philippines NDC's conditional GHG reductions increase from under 3% to over 70% provided that the country can enhance access to climate finance, technology development and transfer, and capacity building (Republic of the Philippines 2021). In the 2023 CCE Index, Indonesia, and Viet Nam have the lowest SEA scores in this indicator. However, the two countries display different CCE investment performance. Viet Nam's investment performance stands strong, due in part to banking reforms that require institutions to incorporate ESG risks in their lending practices and introduce market mechanisms for lending to green projects (IFC 2019). Meanwhile, Indonesia lacks much-needed investment, which is reflected in it having the lowest scores among SEA countries for CCE investments (score 3) and access to sustainable finance (score 5).

Malaysia, the Philippines, and Thailand appear to display a balance between their access to sustainable finance and CCE investment levels, despite the fact all three countries' performances in these indicators are lower than the global averages.

On carbon pricing, the region performs above the middle-income countries' and global averages (Figure 10). On this indicator, a total of 30 countries out of 64 score zero. In the SEA group, the Philippines was the only country not implementing or developing carbon pricing mechanisms as of March 2023 (World Bank 2023d). Singapore and Indonesia achieve the highest scores (67 each), with Singapore having a nationwide carbon tax in place (established in 2019) and Indonesia having launched an ETS for its power sector in 2023 as part of its Economic Value of Carbon scheme. Thailand's (score 50) baseline-and-credit mechanism, the Voluntary Emission Reduction Program, has been operational since 2014, and it has been considering setting up compliance mechanisms for several years. Viet Nam (score 33) is developing an ETS and Malaysia (score 17) has been considering one.

Overall, Singapore stands out in the SEA region as being well positioned to mobilize international capital for investments in clean energy businesses and technologies due to its status as a major financial center. The country's scores on two indicators – international financial connectedness and access to sustainable finance – are substantially higher than those of other SEA countries. Globally, Singapore ranks eighth on the former and second on the latter.

Singapore has a stated goal of becoming a leading center for sustainable financing in Asia. In 2017, to expand access to sustainable finance, Singapore launched the Green Bond Grant Scheme, tasked with issuing green bonds and supporting the development of the ASEAN Green Bond Standards. To date, over U.S. $6.5 billion in green bonds have been issued by Singaporean financial institutions. Additionally, Singapore launched the Green Investments Programme capitalized with U.S. $2 billion to support domestic and regional investments (Singapore National Climate Change Secretariat 2020).

In addition, international financing structured around minilateral financing partnerships can be a powerful way to direct financial flows to *just* CCE transitions. Just Transition Energy Partnerships are emerging as an important tool to leverage the necessary external financial resources for the SEA region's net-zero transitions. Two SEA countries have been spearheading these initiatives, which have received significant global attention. The JETP

initiative in Indonesia is regarded as central to its decarbonization ambitions. The Indonesian JETP is a multi-billion agreement from 2022 to decarbonize the country's economy with the support of the International Partners Group (IPG), which includes the Group of Seven (G7) countries (JETP Indonesia 2023b). It is modeled on a similar partnership with South Africa in 2021, which has since been replicated in Senegal, Indonesia, and Viet Nam. Indonesia's *JETP Comprehensive Investment and Policy Plan (CIPP)* outlines key measures for its power sector and identifies policy and financing enablers (JETP Indonesia 2023a). In the first phase of the Indonesian JETP, U.S. $20 billion has been committed from international public and private institutions (U.S. Embassy & Consulates in Indonesia 2023). The full investment cost is estimated to be around U.S. $100 billion.

One of the key transition challenges for Indonesia is the prevalence of coal in the country's power sector. Under the *CIPP*, existing on-grid coal-fired power plants will undergo a managed phase-out, while the moratorium on new coal-fired power plants will be maintained. The crux of the challenge for Indonesia is balancing its industrial growth and economic development while mitigating GHG emissions. In the supporting modeling for the *CIPP*, after 2040, fossil fuel plants, including coal and natural gas, will either be retired or retrofitted to run completely on bioenergy or hydrogen-based energy carriers like ammonia. Early coal retirements, estimated to begin in 2035, will be enabled by international financial support. In addition to financing, capacity building and technical assistance are key enablers to up-skilling the country's domestic workforce.[1]

The implementation of a feed-in tariff scheme in Viet Nam has led to a large expansion in solar photovoltaic capacity, especially in the early 2020s (U.S. International Trade Administration 2022b). In conjunction with the renewable energy performance indicator, a favorable policy environment is leading to investment in solar photovoltaic capacity and the production of renewable electricity.

Viet Nam has also launched a JETP initiative between Viet Nam and the IPG called the Resource Mobilisation Program (RMP) (European Commission 2023). The RMP is a living document intended to support the delivery of Viet Nam's 2030 targets and 2050 net-zero goals. Specific targets are accelerating peak economy-wide GHG emissions from 2035 to 2030, reaching peak power sector emissions by 2030 (170 million tons of CO_2 equivalent [CO_2-e]), capping coal-fired generation capacity at 30.2 gigawatts (GW), and generating 47% electricity from renewables by 2030. The RMP identifies areas for investment, policy development, and regulatory reforms. Currently, U.S. $15.8 billion of financing has been committed.

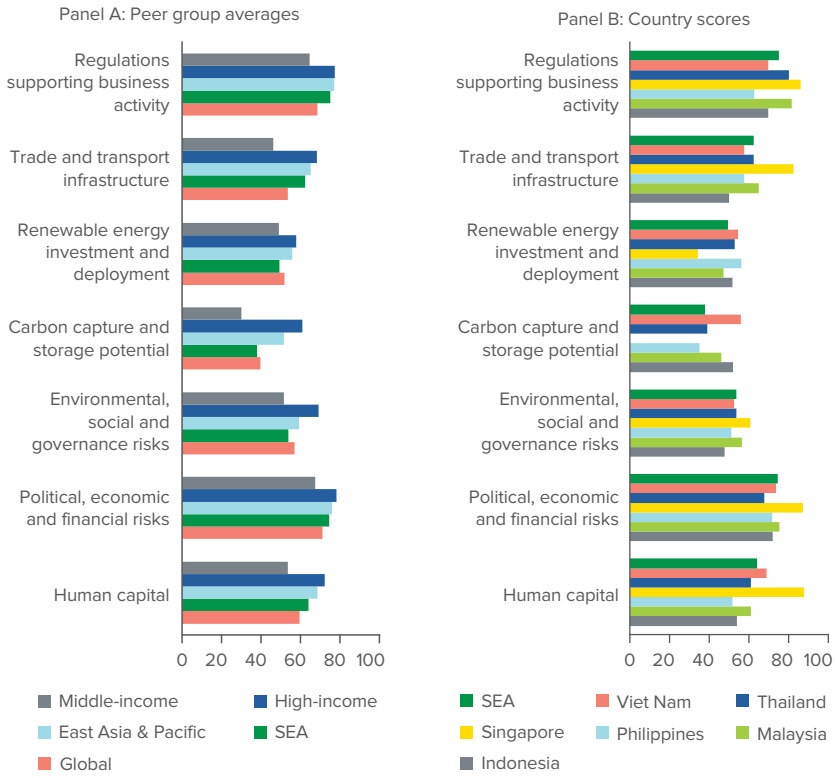
Overall, based on the CCE Index results, the SEA region displays robust levels of financial development and integration into global markets. The region is also home to a global financial hub. These advantages are crucial capacities that can be leveraged to increase access to global sustainability funds, which can contribute significantly to addressing the SEA region's transition investment needs.

5.4 Business Environment

As captured in the SEA CCE Performance scores, enabling business environments are already leading to demonstrable progress in renewable energy, clean hydrogen, and CCUS projects. The business environment dimension of the CCE Index uses seven indicators to track the strength of related enablers: regulations supporting business activity; trade and transport infrastructure; renewable energy investment and deployment opportunities; and political, economic, and financial risks. The SEA region's scores are generally in line with the global average and above the middle-income group for most indicators (Figure 11). Unlike several other dimensions, the SEA region scores lower than high-income peers across all indicators, suggesting room for continued progress.

Despite having a slightly lower score than the global average for renewable energy investment and deployment opportunities, the region is still active in this area. An important effort in the SEA region is the development of renewable energy certificates (RECs) to provide a market mechanism to accelerate the deployment of renewable energy technologies. Since 2015, the six SEA countries have introduced RECs to increase demand for renewable electricity among commercial users. In 2021, nearly 13 GW of renewable energy capacity registered for eligibility, of which three-quarters were from hydro and solar generators (APERC 2023b). If these voluntary markets are successful, the SEA

Figure 11. SEA countries' 2023 CCE Enablers scores compared: business environment.



Source: Authors' computation from Luomi, Yilmaz, and Alshehri (2024).

region's Performance indicator scores for renewable energy and fuel switching could improve. Additional measures like mandatory renewable portfolio standards could complement the voluntary markets.

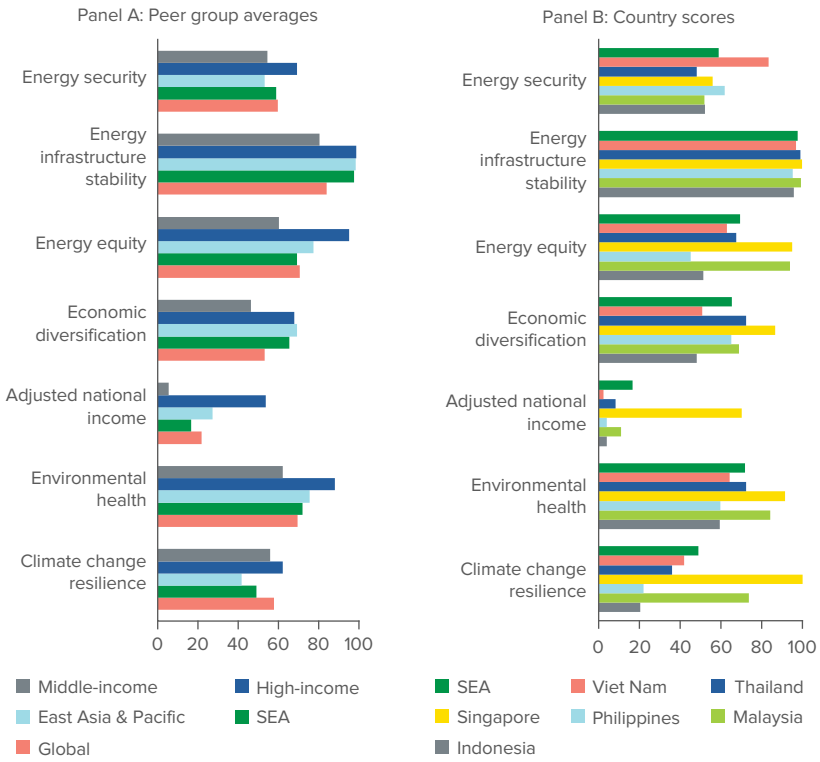
Singapore scores well in nearly all indicators under this dimension, including the environmental, social, and governance (ESG) risks indicator. As shown in the finance and investment sub-dimension, Singapore is the SEA region's most developed financial player. In addition to accelerating sustainable finance, Singapore has introduced measures in its banking system to consider ESG risks in lending practices. Several financial institutions in Singapore have signed the United Nations (UN) Principles for Sustainable Investment and have developed a set of principles called the Singapore Stewardship Principles for Responsible Investors to integrate ESG considerations into the sector.

In the Philippines, foreign ownership of geothermal projects facilitates foreign direct investment as a vehicle for increasing the share of renewable electricity generation in the country's energy mix. In its clean hydrogen sector, the Philippines has signed memorandums of understanding with Hydrogen Technology Inc. (HTI) in Japan and Star Scientific Ltd. in Australia. As discussed in Section 5.3, Viet Nam has also enacted banking regulations to incorporate ESG risks in lending practices.

5.5 System Resilience

The system resilience dimension includes seven measures of energy system resilience and broader socio-economic system and environmental health and resilience (Figure 12). The SEA region's scores across the indicators are in line with the global average. Similar to its other peer groups, excluding high-income countries, the SEA region receives a low score for adjusted national income, which measures countries' savings that can

Figure 12. SEA countries' 2023 CCE Enablers scores compared: system resilience.



Source: Authors' computation from Luomi, Yilmaz, and Alshehri (2024).

support financing their CCE transitions. Singapore, as a high-income developed economy, outperforms its SEA peers across many indicators.

The system resilience dimension contains three energy system-related indicators: energy security, energy infrastructure stability, and energy equity. As with any region, energy security is an important consideration for the SEA countries. The energy security indicator measures the share of total fuel imports out of total imports of goods and services, as per the World Bank (2023c). The rationale for this formulation is that energy security in many countries can be reflected as fiscal security. The higher the share of fuel imports, the lower the energy security score. The SEA region's average for energy security is in line with the global average (Figure 12, Panel A). While many SEA countries are large resource producers and exporters, the region imports a substantial amount of energy products in physical and monetary terms. Viet Nam boasts the highest score in this indicator due to its share of total fuel imports out of goods and services being one-third that of the other SEA countries.

The concept of using fuel imports to quantify energy security requires a closer look for Singapore (score 56). It is a major refinery hub and imports refined products, and crude oil and liquids for processing into refined products, many of which are exported. Further, due to its geostrategic location, a substantial portion of refined products are used for international marine bunkers. Despite appearing to have poor energy security due to its high energy imports, these imports are a significant contributor to Singapore's economy rather than just a cost.

In terms of energy infrastructure stability, which is measured via the system average interruption duration index (SAIDI) and system average interruption frequency index (SAIFI), compiled by the World Bank (World Bank 2022a), SEA countries display robust performance. The group average score of 98 is well above the global average (84) and on par with the high-income (99) and East Asia and Pacific (98) averages. Populations in urban centers tend to have access to more reliable energy services, while rural areas are prone to less reliable services. Large urban centers in the SEA countries, even

excluding Singapore, are one possible reason for the high scores.

The energy equity indicator comes from the energy equity score of the World Energy Council's Trilemma Index (WEC 2023), which measures energy access and affordability (namely electricity access, and electricity and gasoline and diesel prices). On this indicator, Singapore and Malaysia score high, whereas the other four countries perform below the global average of 71. The high scores for Singapore and Malaysia are attributable to high rates of electricity access and favorable residential electricity tariffs relative to similar cities in Europe.

6. Conclusion

For the SEA countries, transitioning to net-zero and CCEs by mid-century requires a substantial reconfiguration of their existing energy systems. The energy transition in the SEA region is unfolding amid rapid regional development, with governments still prioritizing increased access to quality energy services and affordability above environmental sustainability. The region is rich in energy resources, and many of the SEA countries are important trade partners in energy and other products within the Asia-Pacific and surrounding regions. Consequently, the SEA region's energy systems are heavily fossil fuel-based for both domestic consumption and exports. The national low-carbon development pathways are cultivated with these circumstances in mind. In this way, the SEA region is representative of middle-income economies that expect continued demographic expansion, economic activity, and energy demand. Singapore, the only high-income SEA country, offers insights into the region's potential given its distinctive geography, economic structure, and policy frameworks.

As is shown throughout this study, the unique circumstances of the SEA countries shape their performance across the 2023 CCE Index. In several CCE Performance indicators, the region's scores show how fossil fuels like coal have been instrumental in expanding access to modern energy services and remain vital inputs for industries. The existing energy systems function as a source of both domestic employment and goods for international trade. The common challenge going forward for SEA countries is balancing the imperative for continued economic growth and expanding access to modern energy services while mitigating CO_2 and GHG emissions. Specifically, the major policy tasks for the region as it pursues net-zero and CCE transitions are increasing electrification, expanding renewable energy generation, accelerating fuel switching, and developing clean hydrogen and CCUS value chains and capacities.

The CCE Performance scores indicate that the SEA region is using energy more efficiently on a GDP basis over time while having expanded electricity access to nearly 600 million people. Fuel switching from coal and oil to renewables is occurring, with the potential for more improvements. The Index accurately captures the technological performance of the SEA countries and identifies elements for further inspection through energy balance statistics and market data.

Given the SEA countries' reliance on fossil fuels across end-use cases and the power sector, technologies to decarbonize fossil fuels such as clean hydrogen and carbon management via CCUS are identified by many SEA countries. These countries see themselves as well-positioned to be regional hubs for clean hydrogen and CCUS this decade and beyond. As discussed in this study, these challenges are reflected in the SEA countries' medium- and long-term decarbonization ambitions (see also Appendix 2). These enabling mechanisms – access to finance, technology, and knowledge transfer – are common building blocks for success identified by the six countries.

The CCE Enablers sub-index shows that the SEA region is positioned in the middle of its peer groups in terms of transition potential, near the global average and higher than the middle-income group, but lower than the East

Asia and Pacific region and high-income country groups. This appears logical given that five of the six SEA countries are middle-income, with Singapore increasing the SEA region's average. An exception to this trend is observed in the policies and regulations Enablers dimension, where the SEA region's average score in this category is below the global average. Year-over-year improvement is found for all SEA countries, primarily driven by gains in the policies and regulations sub-dimension. Robust policy frameworks supporting defining long-term emissions targets and supporting policies for CCS underpin these improvements. Additionally, as indicated by the CCE Enablers sub-index results, several SEA countries still possess the potential to formalize their net-zero ambitions through legislation and enabling policy instruments and regulations.

On average, a common refrain is the need for increased access to sustainable finance, technology, and knowledge to supplement the lack of domestic creation through universities, the private sector, and R&D activities.

Singapore stands out in many indicators. It is an SEA outlier in terms of its population and economic structure. However, the other five countries have shown a rapid development of their economies and an impressive expansion of their modern energy services to the population. Singapore is in a unique position to leverage its financial sector and unlock investment in circular carbon economy technologies in the other SEA countries, potentially closing gaps in financing and technology access.

The SEA countries share several common themes in their long-term climate change strategies. All countries aim to reach carbon neutrality or net-zero economies by mid-century. Given the need for financing and protecting domestic industries, realizing these ambitions will be conditional on knowledge transfer and foreign capital. Innovative concepts like the JETP are one such avenue captured by the Index that can strike a balance between economic development and mitigation, identify financing needs, marshal resources, and provide an implementation framework.

Endnotes

[1] This paper focuses on six Southeast Asian countries that were included in the 2023 CCE Index. There are two high-income countries in the region – Singapore and Brunei Darussalam – but only the former is included in the Index. Following a common practice in country comparison composite indicators, the Index excludes countries with a population of less than 1 million.

[2] TPEC and TPES are used interchangeably and refer to the sum of production, net imports, stock changes, and bunkers. TPEC and TPEC are used based on data availability.

[3] Non-energy processes are those that use energy as a feedstock but do not directly provide an energy service.

[4] Derived gas is produced from other energy sources such as coal gasification, biogas, or refinery gas. It is not natural gas or LNG.

[5] A ton, or metric ton, is equal to 1,000 kilograms (kgs).

[6] Additional areas for investment are developing the transmission network, expanding dispatchable renewable energy infrastructure, and fostering domestic supply chains to enable industries to maintain their competitiveness in the energy transition.

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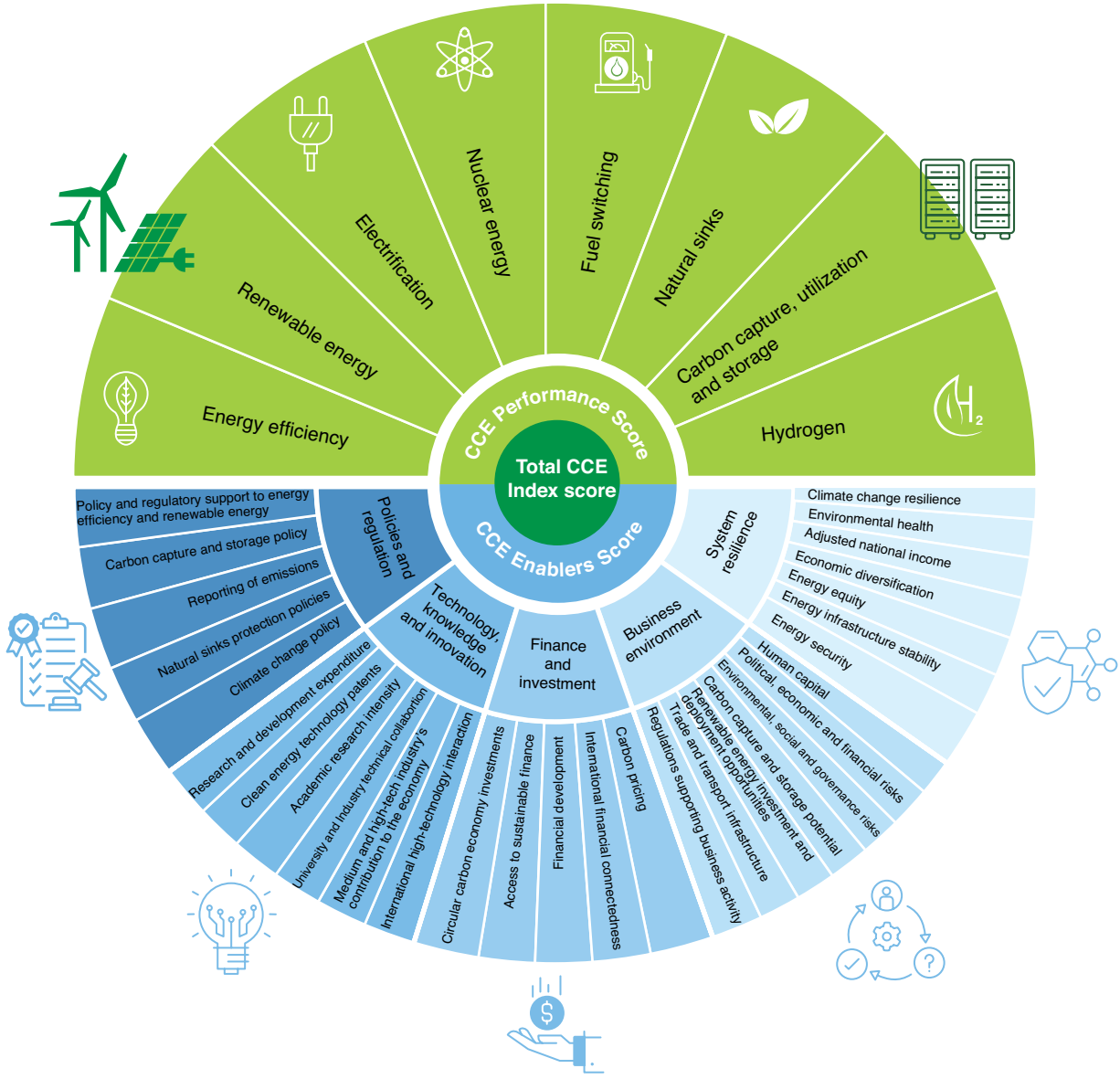
Appendix I

Figure A.1. The 2023 CCE Index indicator framework.



Source: KAPSARC (2024).

Appendix 2
SEA NDCs and LT-LEDS, as of 2023

Table 2. Activities, technologies, and targets from NDCs and LT-LEDS in SEA countries mapped onto the CCE framework.

	Indonesia	Malaysia	Philippines	Singapore	Thailand	Viet Nam
GHG emissions targets 2030/2035	31.89% (unconditional) and 43.20% (conditional) by 2030 compared to business-as-usual. Peak CO_2-e emissions in 2030.	Reduce GHG intensity (against GDP) 45% relative to 2005.	2.71% (unconditional) and 72.29% (conditional) GHG reduction relative to business-as-usual.	60 million tons CO_2-e (economy-wide), with peak emissions at 65 million tons.	30% reduction relative to 2030 baseline (~555 million tons CO_2-e).	15.8% reduction (unconditional) relative to BAU in 2030; 43.5% reduction (conditional).
GHG emissions targets 2050/2060	Net-zero by 2060.	Under development.	Under development.	Halve emissions from peak to 33 million tons by 2050. Net-zero in latter half of the century, when feasible.	Carbon neutral (2050) and net-zero by (2065).	Net-zero (2050) with peak in 2035.
Energy efficiency	1% per year energy intensity improvement. Implement minimum energy performance standards (MEPS).	Reduce energy consumption by 21% (2040) and 22% (2050) relative to business-as-usual.	MEPS. Identifying energy-intensive industries.	Super Low Energy (SLE) Building Programme. MEPS.	Energy intensity reduction of 30% relative to 2010. Reduce peak power demand.	Reduce total final energy consumption by 8% (2019-2030).
Renewable energy	At least 23% (2025) and 31% (2050). Green refineries to produce various drop-in green fuels from bio-resources for blending. 100% B40 blending by 2030.	Increase the share of renewable electricity generation capacity to 40% (2040) then to 70% (2050).	35% renewable electricity generation (2030), 50% (2040).	Scaling up solar photovoltaics via the "Four Switches" strategy and importing renewable electricity from neighboring countries. Gigawatt peak (GWp)[7] by 2030.	Increase share of renewable electricity to 44% (2050). Increase liquid biofuels consumption to 34% (2050).	15%-20% of total primary energy supply (2030) and 80%-85% (2050). Increase share of renewable electricity generation up to 39.2% (2030) and 71.5% (2050).

Table 2. Activities, technologies, and targets from NDCs and LT-LEDS in SEA countries mapped onto the CCE framework. (**continued**)

	Indonesia	Malaysia	Philippines	Singapore	Thailand	Viet Nam
Electrification	Accelerate the Battery. Electric Vehicle Program for Road Transportation.	Increase electrification of transport sector.	100% electricity access (2023–2040).	Electrifying the transport sector.	Increase electricity consumption in the transport sector.	Electrify road, rail, and marine transport sub-sectors.
Nuclear energy	Nuclear is considered "new and renewable energy."	N/A.	Exploring the feasibility.	Conventional technologies are not feasible. Monitoring progress of new designs such as small modular reactors (SMRs).	N/A.	N/A.
Fuel switching	Decrease oil consumption to less than 25% (2025) and 20% (2050) of TPES. Coal share of TPES to less than 30% (2025) and 25% (2050). Natural gas should be minimum 22% in 2025 and minimum 24% in 2050.	Achieve a near-complete phase-out of coal-fired power generation by 2045. Natural gas as a transition fuel.	Moratorium on new coal-fired power plants.	Utilize natural gas as a transition fuel.	Decrease coal use (including lignite) for power generation.	Decommission coal plants older than 40 years; convert some plants to LNG; phase-out coal for power generation by 2050 or co-fire with biomass/ ammonia.

(*continued*)

[1] *Gigawatt peak is the rated power output during ideal conditions, not the nameplate capacity.*

Table 2. Activities, technologies, and targets from NDCs and LT-LEDS in SEA countries mapped onto the CCE framework. (**continued**)

	Indonesia	Malaysia	Philippines	Singapore	Thailand	Viet Nam
Natural sinks	Peat lands restoration of 2 million hectares (ha) and rehabilitation of degraded land of 12 million ha (2030). Forestry and Other Land-Use Net Sink 2030 target to remove 140 million tons of CO_2.	Forest management.	Pursue forest protection and restoration.	GHG removals from land use will be included.	Increase forest cover to 55% (2037).	CO_2-e removals from forestry of 95 million tons (2035) and 185 million tons (2050).
CCUS	Deploy clean coal technology.	Three carbon capture hubs by 2050 of 40 to 80 million tons per year capacity.	N/A.	Investing in R&D. Carbon markets and storage are necessary.	CCUS for natural gas and coal power plants; bio-energy with CCS (BECCS).	N/A.
Low-carbon hydrogen	Hydrogen and hydrogen-based fuel consumption in the power sector.	Consumption in industry, transport, and power sectors. Establish three low carbon hydrogen hubs by 2050.	Under consideration for consumption in industry, transport, and power sectors.	Investing in R&D and building collaboration.	Identified as a technology option.	Produce 100-200 thousand tons (2030); 10-20 million tons (2050).

Sources: See Appendix 2.

The following sections describe the SEA countries' NDCs and LT-LEDS, which are strategies and pathways to achieve countries' longer-term climate ambitions.

Indonesia

Indonesia's first NDC, submitted in 2016, stipulated an unconditional target of 29% and a conditional target of up to 41% relative to a forward-looking business-as-usual growth scenario in 2030. Indonesia's NDC is formulated in the context of poverty reduction and economic development, as enshrined in the Indonesian Constitution: "every person shall have the right to enjoy a good and healthy environment." Indonesia aims to build climate resilience through its mitigation and adaptation measures due to the potential climate vulnerabilities the archipelago nation faces. The NDC has been revised twice, with the latest Enhanced NDC (E-NDC) increasing unconditional emission reductions to 31.89% and conditional reductions to 43.20% (Republic of Indonesia 2022). Additionally, in 2021, the Ministry of Energy and Mineral Resources stipulated a 2060 net-zero emissions target. In this scenario, the energy sector will further utilize natural sinks to remove its remaining gross emissions.

Indonesia's LT-LEDS aims to balance emissions reduction and development goals. Central to achieving Indonesia's decarbonization ambitions is its Just Energy Transition Partnership (JETP) with the international community. The *JETP Comprehensive Investment and Policy Plan (CIPP)* outlines key measures for the power sector and identifies policy and financing enablers (JETP Indonesia 2023a). The focus of the *CIPP* is on the power sector because it accounts for more than half of Indonesia's energy-related GHG emissions. The goal of the *CIPP* is to achieve a net-zero power sector by 2050. An important challenge for Indonesia is decarbonizing its off-grid power generation (i.e., power generation for industrial facilities not connected to the grid). The *CIPP* targets peaking on-grid power sector emissions and increasing renewable energy generation to 44% by 2030.

As discussed in Section 4 (CCE Performance), coal is an important fuel for Indonesia's power sector. Under the *CIPP*, existing on-grid coal-fired power plants will undergo a managed phase-out, while the moratorium on new coal-fired power plants will be maintained. The challenge for Indonesia is balancing the "imperative of industrial growth and economic development" (JETP Indonesia 2023a) while managing GHG emissions. In the supporting modeling for the CIPP, after 2040, fossil fuel plants, including coal and natural gas, will either be retired or retrofitted to run completely on bioenergy or hydrogen-based energy carriers like ammonia. Nuclear power generation is expected to begin in the 2040s, according to the *CIPP*'s modeled results for a "JETP scenario." While not explicitly mentioned in the *CIPP*, the *E-NDC* considers CCUS as a tool to decarbonize coal-fired electricity generation.

As discussed in the *CIPP*, enabling policies and financing are critical to the success of Indonesia's net-zero ambitions. In the first phase of the JETP, U.S. $20 billion has been committed by public and private institutions in the international community (United States Embassy and Consulates in Indonesia 2023). The full investment cost is estimated to be around U.S. $100. For example, early coal retirements estimated to begin in 2035 will be enabled by international financial support. In addition to financing, capacity building and technical assistance are key enablers to up-skilling the domestic workforce.

Malaysia

Malaysia updated its NDC in 2021 with a 2030 target of reducing the GHG intensity of its GDP by 45% relative to 2005. This formulation reflects the desire of policymakers to balance low-carbon development with economic growth. The NDC emphasizes the importance of adaptation for Malaysia, with a focus on the following areas: water management; coastal resources; agriculture and food supply; urban and infrastructure resilience; public health; forestry and biodiversity; and cross-sectoral areas. Seven GHGs are covered: CO_2, methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3).

Malaysia's LT-LEDS consists of policy frameworks from across several governmental units: the *National Energy Policy 2022–2040* and the *Malaysia National Energy Transition Roadmap* (NETR) reports (Economic Planning Unit 2022; Ministry of Economy, Malaysia 2023). The *NETR* focuses on six energy transition levers that align well with the CCE Performance indicators: energy efficiency, renewable energy, hydrogen, bioenergy, green mobility, and CCUS.

Malaysia seeks to capitalize on both its domestic renewable resources and the potential for renewable electricity trade via the ASEAN Power Grid. The domestic target for renewable energy capacity is set at 40% in 2040, increasing to 70% in 2050. Conversely, coal-fired generation is expected to decrease over time as facilities reach the end of their lives; no new coal-fired power plants will be developed. A near complete phase-out of

coal-fired power generation will occur by 2045. Natural gas is expected to act as a transition fuel for Malaysia.

Malaysia views multiple potential supply chain and end-use applications for hydrogen that can help decarbonize industry, transportation, and power generation. As noted in Section 4 (CCE Performance), the nameplate capacity of hydrogen projects has increased 34-fold in Malaysia. Hydrogen is part of the development pathway for the state of Sarawak, amid Malaysia's general hydrogen ambitions. Projects on the island of Sarawak, namely H2ornbill and B2biscus, are collaborations with partners from South Korea and Japan. The country has set targets to completely phase out grey hydrogen as a feedstock by 2050 using blue hydrogen. Complementing Malaysia's renewable electricity plans, green hydrogen production from solar and hydroelectric plants is expected to reach 2.5 million tons per year by 2050. To support the hydrogen supply chain, Malaysia envisions establishing one low-carbon hydrogen hub by 2030, followed by two more by 2050.

Malaysia plans to utilize CCUS to reduce its emissions, especially in hard-to-abate industries. As shown in the CCUS indicator, Malaysia does not have any CCUS projects recorded in the Index. Lacking a regulatory framework and facing high costs, Malaysia has not developed any CCUS projects. Like its hydrogen ambitions, Malaysia envisions being a CCUS hub, establishing between three to six CCUS hubs by 2050 (40 to 80 million tons per year). Storing CO_2 outside Malaysia is a possibility, but the country has not developed a domestic CO_2 storage policy to date.

Financing is highlighted as a key enabler of the targets and ambitions set forth in Malaysia's NDC and NETR and will need to be scaled up over time.

The Philippines

Like Indonesia, the Philippines' NDC highlights the importance of developmental goals for reducing poverty, developing sustainable industrial capacity, ensuring energy security, and building resilience to climate change and climate-related disasters. An unconditional reduction of 2.71% by 2030 (relative to a business-as-usual pathway) is noted, along with a 72.29% conditional reduction. The reduction covers five GHGs: CO_2, CH_4, N_2O, PFCs, and HFCs (Republic of the Philippines 2021).

The Philippines formulated a long-term development pathway for its energy sectors, with a focus on the power sector. The Philippines has a target of having 35% renewable energy in its power generation mix by 2030 and at least 50% by 2040 (Republic of the Philippines Department of Energy 2024). Its *National Renewable Energy Program* identifies enablers, such as easing the foreign ownership limit, as a means of achieving the target. An amendment to the Renewable Energy Act of 2008 allows 100% foreign ownership of solar, wind, biomass, ocean, and tidal energy projects (Republic of the Philippines Department of Energy 2022).

Given the role of coal in the Philippines' electricity generation, the government has implemented a moratorium on new coal-fired power plants. Plans for decommissioning existing coal assets are under consideration. Like Indonesia, access to sustainable financing would enable plants to retire ahead of the end of their operational lives (Republic of the Philippines Department of Energy 2020).

Utilization of clean hydrogen is under consideration. The *National Policy and General Framework, Roadmap, and Guidelines for Hydrogen in the Energy Sector* highlights the role for hydrogen in end-use sectors and power generation. No targets for clean hydrogen utilization are set yet. CCUS is not mentioned in the *Power Development Plan 2020–2040* or related plans.

Like Indonesia, the Philippines is considering nuclear power. Recent legislation allows for the creation of guidelines for the safe utilization of nuclear energy. The Philippines is currently evaluating the feasibility of nuclear energy. The bill also establishes the Philippine Atomic Energy Regulatory Authority, which is responsible for formulating policies and regulations (Republic of the Philippines Department of Energy 2023a). Continued development of policy frameworks and access to foreign capital, technologies, and knowledge are identified by the Philippines as enablers of a potential nuclear energy program.

Singapore

Singapore's NDC reflects its national circumstances as an international trade hub with a small, low-lying land area, high population density, limited land space for deploying technologies, and an export-oriented economy. An absolute reduction target of 60 million tons of CO_2-e by 2030, with a peak earlier, is noted.

Information about Singapore's LT-LEDS is provided by the *Charting Singapore's Low-Carbon and Climate Resilient*

Future report, released in 2022. This long-term development strategy extends the country's climate ambitions beyond 2030, aiming for a 50% reduction of CO_2-e from its peak, with a goal of reaching net-zero in the latter half of the century (Singapore National Climate Change Secretariat 2020). While not explicit targets, Singapore notes its GHG emissions reductions from fuel switching in power generation (oil to natural gas), a vehicle quota system to limit transport sector emissions, unsubsidized electricity tariffs, and its building sector energy efficiency measures.

Due to Singapore's small geographic footprint and high population density, there is limited land available for deploying solar photovoltaics. However, it is pursuing options like floating solar photovoltaics. Electricity imports from the ASEAN Power Grid could support a lower-carbon electricity supply. The long-term development plan identifies "emerging low carbon alternatives" such as CCUS and low-carbon hydrogen as means to decarbonize power generation and hard-to-abate sectors like industry.

Collaboration from international partners is noted as a key enabler for Singapore, including facilitating access to carbon markets, carbon storage, and regional electricity corridors like the ASEAN Power Grid.

In Singapore, in addition to policies to increase the use of natural gas for electricity generation, policies are in place to decarbonize the transport sector through limiting vehicle stocks and encouraging purchases of electric vehicles. Other standards for building energy efficiency are important for moderating electricity consumption, especially given the country's warm and humid climate.

Thailand

Thailand's NDC emphasizes the balance between its economic development and climate change ambitions. Set against a baseline projection of 2030, the NDC targets a 30% reduction in CO_2-e emissions. The ambition could be as high as 40%, conditional on technology transfers, financial resources, and capacity building. Long-term ambitions call for carbon neutrality by 2050 and net-zero GHGs by 2065.

Thailand's energy sector accounts for over two-thirds of its GHG emissions. Thailand's LT-LEDS, the *Mid-century, Long-term Low Greenhouse Gas Emission Development Strategy*, outlines its long-term climate policies and mitigation actions, supporting the first updated NDC in five sectors: energy, industrial processes and product use, waste, agriculture, and forestry. Under this strategy, Thailand foresees utilizing CCUS with natural gas and coal power plants, increasing the share of renewables used in electricity generation to 33%, deploying bioenergy with CCS (BECCS) power plants, and supporting hydrogen technologies (Kingdom of Thailand Ministry of Natural Resources and Environment 2021b). As noted by the Finance and Investment and Technology, Knowledge, and Innovation indicators, the role of technology transfers and financing are crucial to developing and scaling up CCUS and hydrogen technologies in Thailand.

The Energy Efficiency Plan of 2018 targets a reduction in energy intensity of 30% by 2037 through energy efficiency standards and labeling and building code regulations. Energy efficiency measures are expected to reduce peak power demand to 4 GW (Kingdom of Thailand Ministry of Natural Resources and Environment 2021a).

As noted by the natural sinks indicator, forestry is an important mitigation tool for Thailand. The National Forest Policy aims to increase forest cover by up to 55% in the late 2030s.

Viet Nam

Viet Nam updated its NDC in 2022 with a commitment to reduce GHG emissions by 15.8% below 2005 levels by 2030. The reduction target increases to 43.5%, conditional on financial support from international organizations. Several policy roadmaps guide the planning and implementation of Viet Nam's climate strategy.

In terms of long-term development strategies, *The Politburo's Resolution No. 55 on the Orientation of Viet Nam's National Energy Development Strategy* outlines specific objectives. The overall goal is to ensure energy security to sustain economic development. The 10-Year Socio-Economic Development Strategy for 2021–2030 expects the share of renewables used in electricity generation to be between 15%-20% in 2030, increasing to 25%-30% in 2045 (Dezan Shira and Associates 2023b). Viet Nam's energy savings are projected to reach 7% by 2030 and up to 20% by 2045. Its energy-related GHG emissions are in line to decrease by 15% by 2030 and 20% by 2045 against a business-as-usual scenario (Asia Pacific Energy Forum 2020).

The National Energy Master Plan (NEMP) for the 2021–2030 Period, With a Vision to 2050 builds on the objectives of *Resolution No. 55*. The NEMP identifies

developing Viet Nam's hydrogen supply chain to serve growing domestic and international demand. By 2030, the NEMP envisions low-carbon hydrogen production of around 100-200 thousand tons per year, increasing to 10-20 million tons per year in 2050 (Socialist Republic of Viet Nam Department of Foreign Information 2023).

Per the *National Strategy on Climate Change by 2050*, Viet Nam aims to peak emissions in 2035 and become net-zero in 2050. The forestry and land use sectors are expected to reduce their emissions by 90%, with the forestry sector capturing 185 million tons of CO2-e (Socialist Republic of Viet Nam Ministry of Agriculture and Rural Development 2022).

Enablers of Viet Nam's objectives include international collaboration and trade, cooperation in regional energy markets, and deploying JETP measures to gain access to technology, human resource training, and financing.

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About the Project

KAPSARC's Circular Carbon Economy (CCE) Index project seeks to expand and add rigor to the conceptual basis of the CCE concept, as well as its practical operationalization, by developing a robust quantitative framework to measure countries' performances and their progress toward CCEs. The resulting CCE Index is a composite indicator that measures various dimensions of the CCE in a national context, across countries. Its main foci are current performance and enabling factors for future progress.

The first edition of the CCE Index, published in November 2021, covered 30 countries. From the 2022 edition onward, the index covers 64 major economies and oil- and gas-producing countries. The index is disseminated through various research outputs, including KAPSARC discussion papers and commentaries, which present the index results and analyze them in depth, as well as KAPSARC methodology papers, conferences, workshops and other events, and an online platform, located at https://cceindex.kapsarc.org/. The index is updated annually, with the 2023 edition launched in December 2023.

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