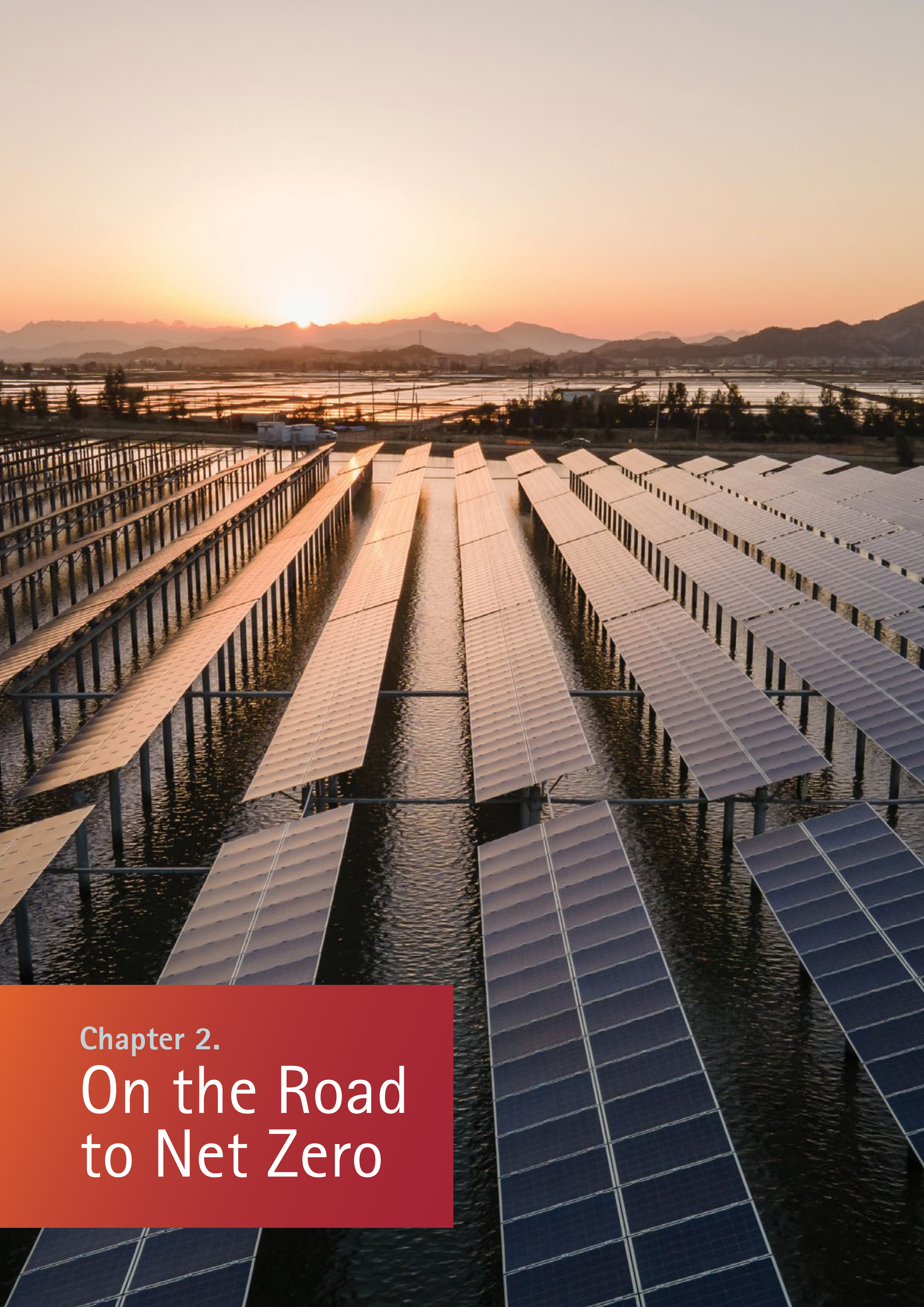


Chapter 2.

On the Road to Net Zero

Highlights

- Climate change mitigation—avoiding and curtailing greenhouse gas emissions to prevent global warming—is among the most critical issues to confront policymakers around the world. The global commitment under the Paris Agreement of 2015 to reduce the Earth's temperature increase to well below 2 degrees Celsius carries significant long-term growth consequences for the ASEAN+3 region, which itself is home to some of the world's largest emitters of greenhouse gases.

- The transition to net zero—where the amount of carbon dioxide (the main greenhouse gas) produced is balanced by the amount removed from the atmosphere—by the 2050 goal set by the Paris Agreement implies a complete transformation of how the ASEAN+3 region produces, consumes, and allocates existing resources. Shifting from fossil fuel use will demand an unprecedented public and private investment and impact economies' macroeconomic fundamentals.

- The key to climate change mitigation is to put an appropriate price on carbon emissions. However, with ASEAN+3 economies relying mainly on fossil fuels for energy, doing so would see sustained pressure on medium- to long-term inflation if alternative energy supplies are not available at affordable prices. Yet, not doing so could reduce the region's competitiveness if major trading partners with more stringent carbon pricing policies impose border adjustments to equalize the price of carbon embedded in their domestic products and imports. Deep and rapid adjustments away from use of fossil fuels also mean that some economies in the region face substantial risks to financial stability if policy actions to promote the net zero transition spark a sudden and disorderly adjustment in market expectations.

- The sooner that scalable, reliable, and affordable low-carbon alternatives become available for ASEAN+3, the less painful and costly the shift from fossil fuels will be. Indeed, the road to net zero is rich in opportunity. Abundant renewable energy resources, carbon storage potential, and critical minerals provide ASEAN+3 economies an enormous advantage in meeting growing global demand for clean energy, low-emission products, carbon-removal technologies, and carbon offsets, among others. Many of region's economies are already well-placed to leverage their comparative advantage in technology, manufacturing, natural resources, and financial services to reap economic benefits from the transition.

- Mobilizing private capital will be key for the ASEAN+3 region to realize the economic gains from the transition to net zero while minimizing its negative impact on growth. Financial markets are increasingly adopting new instruments and practices to accelerate green and transition finance activity, but the region remains confronted by a huge funding gap. Development of comparable standards, frameworks, and taxonomies across the region for sustainable finance instruments will be crucial in accessing much-needed financing.

- The region must employ well-designed fiscal, financial, and monetary policy tools to bring about an orderly transition while managing climate-related risks effectively. More important, regionally coordinated action will achieve a greater impact than economies acting alone. Enhanced cooperation and exchange among the ASEAN+3 economies—especially in cross-border energy trade, innovation and new technology, and green financial networks—would expedite and smoothen the region's journey toward net zero.

I. Introduction

Climate change has emerged as one of the foremost macro-critical issues for policymakers around the world in the coming years and decades. Climate scientists attribute the increase in global temperature over the past few decades to the greenhouse gases (GHGs) that humans have been adding to the atmosphere since the Industrial Revolution of the 1700s. Continued warming has potential to cause significant physical damage and economic harm by disrupting oceanic patterns and accelerating glacial melting, causing radical changes to weather systems, extreme heat and humidity, more wildfires, more destructive storms, rising sea levels and flooding, ocean acidification—and the list goes on.

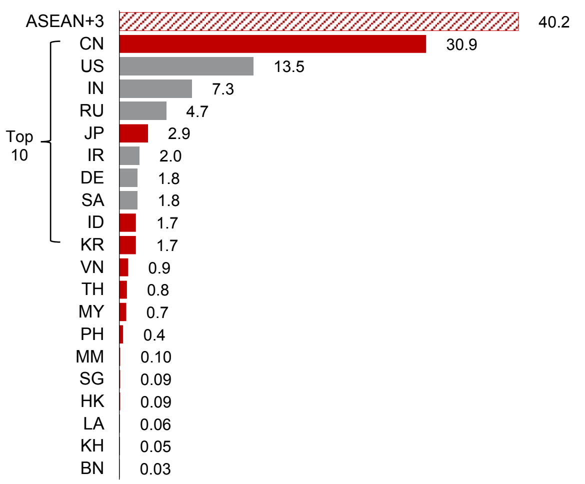
The ASEAN+3 region is home to three of the 10 largest GHG emitters in the world (China, Indonesia, and Japan) and accounts for over one-third of global GHG emissions. On a per-capita basis, the region's annual GHG emissions are above the world average, although there is substantial variance across economies (Figure 2.1 and Figure 2.2). The most important GHG from the standpoint of climate change is carbon dioxide. That is because carbon dioxide remains longer in the atmosphere than other GHGs and is a major part of emissions from human activities (mainly the burning of carbon-rich fossil fuels like coal and oil). Other important GHGs are methane (the main part of natural gas), nitrous oxide (from the use of nitrogen-based fertilizers), and halocarbons (chemicals used in solvents, fire-fighting agents, refrigerants, and the like).

All ASEAN+3 economies have committed to contributing to climate action under the Paris Agreement of 2015 (Box 2.1). The central goal of the 2015 Paris Agreement is to limit global warming to well below 2 degrees Celsius—preferably to 1.5 degrees—by 2050, compared to pre-industrial global average temperatures. To achieve this long-term temperature goal, countries would need to reach global peaking of GHG emissions as soon as possible (before 2030) to realize a climate-neutral world by the Agreement's 2050 goal. Approaches for dealing with climate change fall into two complementary categories: (1) mitigation—curtailing the emissions of GHGs and/or taking GHGs out of the atmosphere; and (2) adaptation—learning to live with the consequences of climate change.[1]

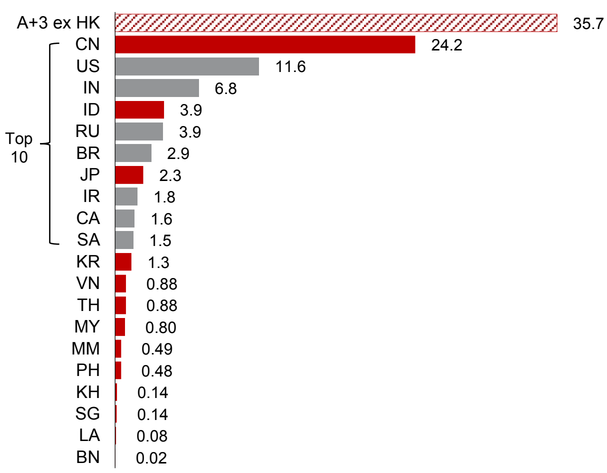
Almost all ASEAN+3 economies have set or are considering a target of reducing GHG emissions to net zero around mid-century (Figure 2.3). Net zero means cutting GHG emissions to as close to zero as possible, with any remaining emissions reabsorbed from the atmosphere by oceans and forests, for instance. Carbon neutrality refers to net zero carbon dioxide emissions. Since carbon dioxide is the main GHG causing climate change, the terms "net zero" and "carbon neutrality" are often used interchangeably. Transitioning to a net zero emissions world will require a complete transformation of how the region produces, consumes, and moves about. Transition policies will impact economies' fiscal positions, trade flows, and asset prices, among other aspects. While the transmission mechanisms and expected impacts will differ across individual economies, there will be implications for the long-term macroeconomic and financial development of the ASEAN+3 region as a whole.

Figure 2.1. ASEAN+3 and Selected Economies: Greenhouse Gas and Carbon Dioxide Emissions

Greenhouse Gas Emissions, 2019
(Percent of world total)



Carbon Dioxide Emissions, 2021
(Percent of world total)



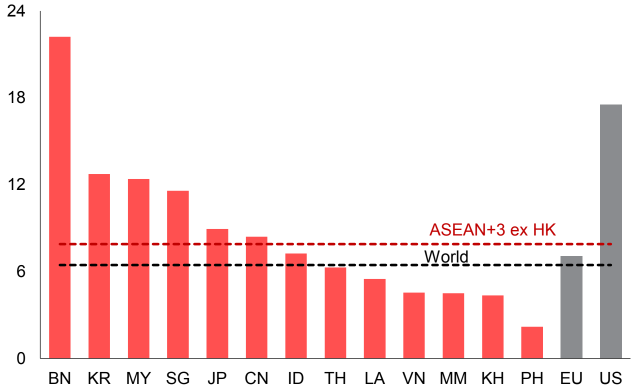
Source: Ritchie, Roser, and Rosado (2020); AMRO staff estimates.
Note: Total greenhouse gas emissions are the sum of emissions of various gases: carbon dioxide, methane, nitrous oxide, and smaller trace gases such as hydrofluorocarbons and sulfur hexafluoride; emissions from land use change (which can be positive or negative) are taken into account. Carbon dioxide emissions include all emissions from energy production (from coal, oil, gas, and flaring) plus direct industrial emissions from cement and steel production; and exclude emissions from land use change. A+3 ex HK = ASEAN+3 excluding Hong Kong. BN = Brunei; BR = Brazil; CA = Canada; CN = China; DE = Germany; HK = Hong Kong; ID = Indonesia; IN = India; IR = Iran; JP = Japan; KH = Cambodia; KR = Korea; LA = Lao PDR; MM = Myanmar; MY = Malaysia; PH = Philippines; RU = Russia; SA = Saudi Arabia; SG = Singapore; TH = Thailand; US = United States; VN = Vietnam.

This chapter was written by Marthe M. Hinojales and Ling Hui Tan (co-anchors), with contributions from Andriansyah, Diana del Rosario, Thanh Thi Do, Aziz Durrani, Suan Yong Foo, Seung Hyun (Luke) Hong, Vanne Khut, Jade Vichyanond, and Fan Zhai.

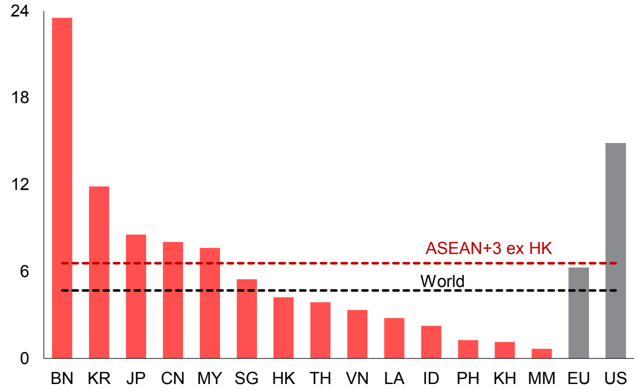
[1] A third approach seeks to actively counter GHG-induced warming. Solar radiation modification/management—sometimes referred to as geoengineering—aims to bring down temperatures by managing the net amount of solar radiation absorbed by the Earth (IPCC 2021). However, this approach is controversial (Rohling 2022).

Figure 2.2. ASEAN+3 and Selected Economies: Greenhouse Gas and Carbon Dioxide Emissions per Capita

Greenhouse Gas Emissions per Capita, 2019
(Tons of carbon dioxide equivalent)



Carbon Dioxide Emissions per Capita, 2021
(Tons)



Source: Ritchie, Roser, and Rosado (2020); AMRO staff estimates.
Note: Total greenhouse gas emissions are the sum of emissions of various gases: carbon dioxide, methane, nitrous oxide, and smaller trace gases such as hydrofluorocarbons and sulfur hexafluoride; emissions from land use change (which can be positive or negative) are taken into account. Carbon dioxide emissions include all emissions from energy production (from coal, oil, gas, and flaring) plus direct industrial emissions from cement and steel production; and exclude emissions from land use change. BN = Brunei; CN = China; EU = European Union; HK = Hong Kong; ID = Indonesia; JP = Japan; KH = Cambodia; KR = Korea; LA = Lao PDR; MM = Myanmar; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; US = United States; VN = Vietnam.

Figure 2.3. ASEAN+3: Net Zero Targets

No net zero target	*By 2040*	*By 2050 or sooner*	*By 2060 or sooner*
Philippines	Myanmar: Net zero emissions from forestry and other land use by 2040	Brunei: Net zero by 2050	China: Carbon neutrality before 2060
		Cambodia: Carbon-neutral economy by 2050	Indonesia: Net zero emissions in 2060 or sooner
		Hong Kong: Carbon neutrality before 2050	
		Japan: Net zero by 2050	
		Korea: National carbon neutrality by 2050	
		Lao PDR: Net zero GHG emissions by 2050	
		Malaysia: Net zero emissions by 2050 at the earliest	
		Singapore: Net zero emissions by 2050	
		Thailand: Carbon neutrality by 2050, net zero emissions by 2065	
		Vietnam: Carbon neutrality by 2050	

In policy document | In law | Declaration/ pledge | Aspirational target

Source: Lang and others (2022); AMRO staff compilation.

Past issues of the ASEAN+3 Regional Economic Outlook (AREO) have consistently identified climate change as a "perennial risk" to the region's macroeconomic outlook.

- AMRO (2018) highlighted the impact of natural disasters in the ASEAN+3 region, including on economic growth and fiscal positions, and stressed the importance of building sufficient economic buffers in anticipation of these shocks.

- AMRO (2020) noted that the risk of climate change and natural disasters could spill over to the financial system, magnifying its impact on the real economy. With more frequent, intense, and widespread disasters, the balance sheets of insurers and reinsurers would become increasingly exposed, and banks would face rising credit defaults as collateral values are eroded. In addition to physical risks, ASEAN+3 financial sectors would also need to prepare against transition risks, including stranded assets (i.e., assets that have suffered from unanticipated or premature write-downs, devaluation, or conversion to liabilities) and rebalancing of their lending operations away from carbon-emitting projects toward clean and green investments.

- AMRO (2022a) pointed to a number of medium- and long-term regional- and country-specific actions and policies in the ASEAN region to adapt to climate change. However, many initiatives to mitigate the risks from climate change remain conceptual—yet to be translated into policies and action plans.

This thematic chapter focuses on the transition to net zero in the context of structural transformation and growth in ASEAN+3 economies. It discusses three broad questions from the perspective of long-term growth in ASEAN+3 economies:

- What are the macro-financial implications of transitioning out of a high-carbon economy?

- What are the opportunities for transitioning into a carbon-neutral economy?

- (How) Can finance facilitate the transition?

Box 2.1:

ASEAN+3 Mitigation Targets under the Paris Agreement

All ASEAN+3 economies have signed on to the Paris Agreement of 2015, the framework governing international efforts to reduce carbon emissions. The Paris Agreement recognizes two objectives: (1) keeping temperature increases to well below 2 degrees Celsius; and (2) enhancing adaptive capacity, strengthening resilience, and reducing vulnerability to climate change.

At the heart of the agreement are the Nationally Determined Contributions (NDCs) under which all economies contribute targets for emissions in 5 or 10 years (Table 2.1.1). These are unilateral and voluntary, as is the metric on which they are based: some economies make pledges in terms of absolute emissions, some in terms of reductions, some for emissions relative to GDP, and so on. Some developing economies have both conditional and unconditional pledges, with the more ambitious targets being conditioned on receiving needed climate funding from advanced economies. Economies are expected to raise their ambitions by submitting revised NDCs every five years. The NDCs are also aligned with national adaptation plans, which set out how economies intend to improve their climate resilience.

Table 2.1.1. ASEAN+3: Nationally Determined Contributions

Economy	Latest Submission	Target(s) for 2030
Brunei	31 December 2020	Reduce greenhouse gas (GHG) emissions by 20 percent relative to projected business-as-usual level in 2030.
Cambodia	31 December 2020	Reduce GHG emissions by 41.7 percent relative to projected business-as-usual level in 2030 (target is mostly conditional on international support).
China	28 October 2021	Reduce carbon intensity (carbon dioxide emissions per unit of GDP) by over 65 percent from 2005 level and achieve peak carbon dioxide emissions before 2030.
Hong Kong	28 October 2021 (Annex I in China's NDC submission)	Reduce carbon intensity by 65 percent to 70 percent from its 2005 level (equivalent to an absolute carbon emission reduction of 26 percent to 36 percent).
Indonesia	23 September 2022	Reduce GHG emissions by 32 percent relative to projected business-as-usual level in 2030 (additional reduction of up to 11 percent conditional on international support).
Japan	22 October 2021	Reduce GHG emissions by 46 percent from level in FY2013 (ending 31 March 2014) to 760 $MtCO_2e$.
Korea	23 December 2021	Reduce GHG emissions by 40 percent from 2018 level to 727.6 $MtCO_2e$.
Lao PDR	11 May 2021	Reduce GHG emissions by 60 percent relative to projected baseline level in 2030 (additional reductions conditional on increased financial support from advanced economies).
Malaysia	30 July 2021	Reduce GHG emissions per unit of GDP (emission intensity) by 45 percent from 2005 level.
Myanmar	3 August 2021	Reduce/avoid carbon dioxide emissions totaling 244.5 $MtCO_2e$ over 2021–30 (total reduction of 414.8 $MtCO_2e$ conditional on international financial and technical support).
Philippines	15 April 2021	Reduce cumulative GHG emissions by 2.7 percent compared to projected cumulative business-as-usual emissions over 2020–30 (additional reduction of 72.3 percent conditional on support or the means of implementation under the Paris Agreement).
Singapore	4 November 2022	Reduce GHG emissions to about 60 $MtCO_2e$ in 2030 after peaking emissions earlier.
Thailand	2 November 2022	Reduce GHG emissions by 30 percent compared to projected business-as-usual level in 2030 (additional reduction of 10 percent conditional on adequate and enhanced access to technology development and transfer, financial resources, and capacity-building support).
Vietnam	8 November 2022	Reduce GHG emissions by 16 percent relative to projected business-as-usual level in 2030 (additional reduction of 27 percent conditional on international support).

Source: United Nations Framework Convention on Climate Change (UNFCCC) Nationally Determined Contributions Registry.
Note: Greenhouse gases targeted in countries' Nationally Determined Contributions vary. They may include, in addition to carbon dioxide, hydrofluorocarbons, methane, nitrogen trifluoride, nitrous oxide, perfluorocarbons, and sulfur hexafluoride. FY = fiscal year; $MtCO_2e$ = million tons of carbon dioxide equivalent.

This box was written by Marthe M. Hinojales and Ling Hui Tan.

II. Out with the Old: Macroeconomic Implications of Moving Away from Fossil Fuels

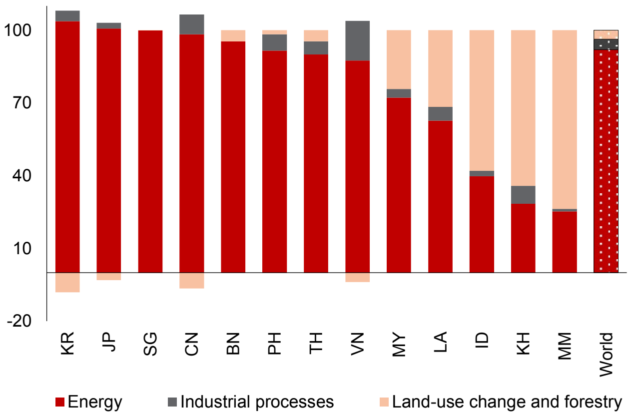
The key to climate change mitigation—limiting global warming—is a substantial reduction in fossil fuel use. According to the Intergovernmental Panel on Climate Change (IPCC), carbon dioxide emissions are the dominant cause of global warming (IPCC 2021). Over 90 percent of global carbon dioxide emissions come from the energy sector (Figure 2.4), and electricity and heat generation is its largest emitting subsector. Transportation and manufacturing follow as emitters (Figure 2.5). Fossil fuels—coal, oil, and natural gas—supply over 80 percent of the world's energy (Figure 2.6). Coal—the "dirtiest" fossil fuel—puts out the most carbon dioxide per unit of energy and is the single largest source of the global temperature rise. Oil is next, followed by natural gas, which is considered the cleanest-burning fossil fuel of the three.

ASEAN+3 economies rely mainly on fossil fuels for energy—though to varying degrees, given their diverse economic and geographic size and structure. The energy sector is the main source of carbon emissions for most ASEAN+3 economies except Cambodia, Indonesia, and Myanmar where forestry and land-use dominate (Figure 2.4). The carbon intensity of the energy mix (measured by carbon dioxide emissions per unit of primary energy) also varies, with China, Lao PDR, and Vietnam at the high end of the scale and well above the world average, and Brunei, Cambodia, Myanmar, and Singapore at the low end and well below the world average (Figure 2.7). This diversity is correlated with the share of fossil fuels, particularly coal, in energy consumption (Figure 2.6).

Like the rest of the world, ASEAN+3 economies have committed to reducing their reliance on fossil fuels to achieve their emission targets.[2] Almost all the economies of the region have set targets or pledged to reduce the use of coal power (Table 2.1). Brunei, Indonesia, Korea, the Philippines, Singapore, and Vietnam were among the 44 countries that fully or partially endorsed the Global Coal to Clean Power Transition Statement at the 26th United Nations Climate Change Conference of the Parties (COP26) in November 2021.

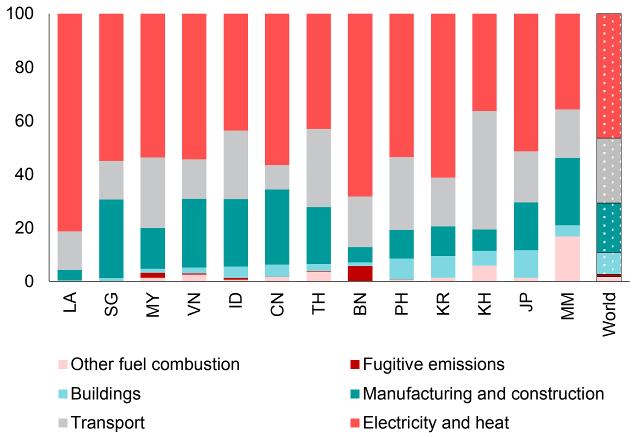
What are the implications of reducing fossil fuel use for medium- and long-term growth and stability in ASEAN+3 economies? The following subsections discuss four key questions: (1) What will happen to prices and inflation as fossil fuels are phased out? (2) Will the region's export growth be affected by asymmetric regional and global carbon pricing policies? (3) Will stranded assets cause huge financial losses and financial instability? And most importantly: (4) Will economic development and growth be stunted due to insufficient reliable energy supply?

Figure 2.4. ASEAN+3 and World: Carbon Dioxide Emissions, by Sector, 2019
(Percent of total carbon dioxide emissions)



Source: Climate Watch (2022); AMRO staff calculations.
Note: Energy sector refers to emissions generated from the use of energy and includes electricity and heat generation, buildings, transportation, manufacturing, fugitive emissions, and other fuel combustion processes. BN = Brunei; CN = China; ID = Indonesia; JP = Japan; KH = Cambodia; KR = Korea; LA = Lao PDR; MM = Myanmar; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; VN = Vietnam.

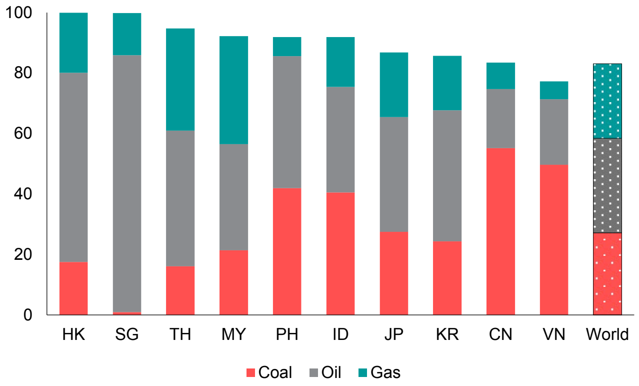
Figure 2.5. ASEAN+3 and World: Carbon Dioxide Emissions, by Energy Subsector, 2019
(Percent of total energy sector carbon dioxide emissions)



Source: Climate Watch (2022); AMRO staff calculations.
Note: Fugitive emissions are GHG emissions that are not produced intentionally by a stack or vent, e.g., leaks from industrial plants and pipelines. BN = Brunei; CN = China; ID = Indonesia; JP = Japan; KH = Cambodia; KR = Korea; LA = Lao PDR; MM = Myanmar; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; VN = Vietnam.

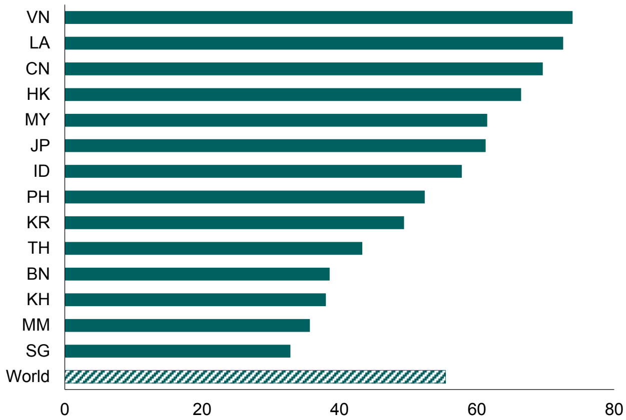
[2] The 2021–25 ASEAN Plan of Action for Energy Cooperation did not include a fossil fuel phaseout—instead, it envisaged "growing capacity additions from coal in the coming years"—but did aspire for renewable energy to reach 23 percent of the bloc's total primary energy supply and 35 percent of its installed power capacity by 2025 (ASEAN Centre for Energy 2020).

Figure 2.6. Selected ASEAN+3 and World: Share of Fossil Fuels in Primary Energy Consumption, 2021
(Percent of total primary energy consumption)



Source: BP Statistical Review of World Energy (2022); AMRO staff calculations.
Note: Primary energy consumption is measured in exajoules and includes international marine and aviation fuel consumption. CN = China; HK = Hong Kong; ID = Indonesia; JP = Japan; KR = Korea; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; VN = Vietnam. Data not available for Brunei, Cambodia, Lao PDR, and Myanmar.

Figure 2.7. ASEAN+3 and World: Carbon Intensity of Energy Mix, 2021
(Tons of carbon dioxide per terajoule)



Source: International Energy Agency (2022f); AMRO staff calculations.
Note: Carbon intensity of energy mix is defined as carbon dioxide emissions from fuel combustion per unit of total energy supply (including fossil and nonfuel forms of energy, biofuels, as well as heat and electricity). Total energy supply is calculated as: production + imports - exports - international marine bunkers - international aviation bunkers ± stock changes. BN = Brunei; CN = China; HK = Hong Kong; ID = Indonesia; JP = Japan; KH = Cambodia; KR = Korea; LA = Lao PDR; MM = Myanmar; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; VN = Vietnam.

Table 2.1. ASEAN+3: Commitments to Reduce Reliance on Coal

Economy	Commitment(s)
Brunei	• Transition from unabated coal power generation in the 2040s (or as soon as possible thereafter). Stop issuing new permits for new unabated coal-fired power generation projects, stop new construction of unabated coal-fired power generation projects, and end new direct government support for unabated international coal-fired power generation.
Cambodia	• No new coal generation capacity beyond already committed projects as of 2019.
China	• Accelerate the pace of coal reduction during the 14th Five-Year Plan period (2021–25). Promote clean end-use energy by replacing coal with natural gas, electricity, and renewable energy. Stop building new coal-fired power projects abroad.
Hong Kong	• Phase out coal as a power generation source by 2035.
Indonesia	• Transition from unabated coal power generation in the 2040s (or as soon as possible thereafter). Reduce the share of coal in the power generation mix to 38 percent by 2050 (from 59 percent in 2019).
Japan	• Reduce the share of coal in the power supply to 19 percent by 2030. End government support for unabated coal power projects overseas.
Korea	• Transition from unabated coal power generation by 2050. Stop issuing permits for new unabated coal-fired power generation projects. Lower reliance on fossil fuel imports to under 70 percent by 2030.
Lao PDR	• No stated targets or pledges.
Malaysia	• Stop building new coal power plants. Gradually retire existing plants with about 7 GW of coal-fired generation capacity by 2033 at the end of their respective 25-year power purchase agreements.
Myanmar	• Decrease the share of coal in the electricity generation mix to 20 percent by 2030 (11 percent conditional on international support).
Philippines	• Transition from unabated coal power generation in the 2040s (or as soon as possible thereafter). Moratorium on new coal-fired power plants in October 2020.
Singapore	• Phase out unabated coal power generation. Stop issuing permits for new unabated coal power stations by 2040.
Thailand	• No stated targets or pledges.
Vietnam	• Transition from unabated coal power generation in the 2040s (or as soon as possible thereafter). Stop issuing new permits for new unabated coal-fired power generation projects; stop new construction of unabated coal-fired power generation projects; and end new direct government support for unabated international coal-fired power generation. Restrict the development of coal-fired power plants and reduce the share of coal power to 13 percent by 2045.

Source: AMRO staff compilation.

Will Inflation Go Up?

"... [F]ossilflation, and its broader repercussions on other input and output prices, is likely to remain an important contributor to headline and underlying inflation in the foreseeable future."

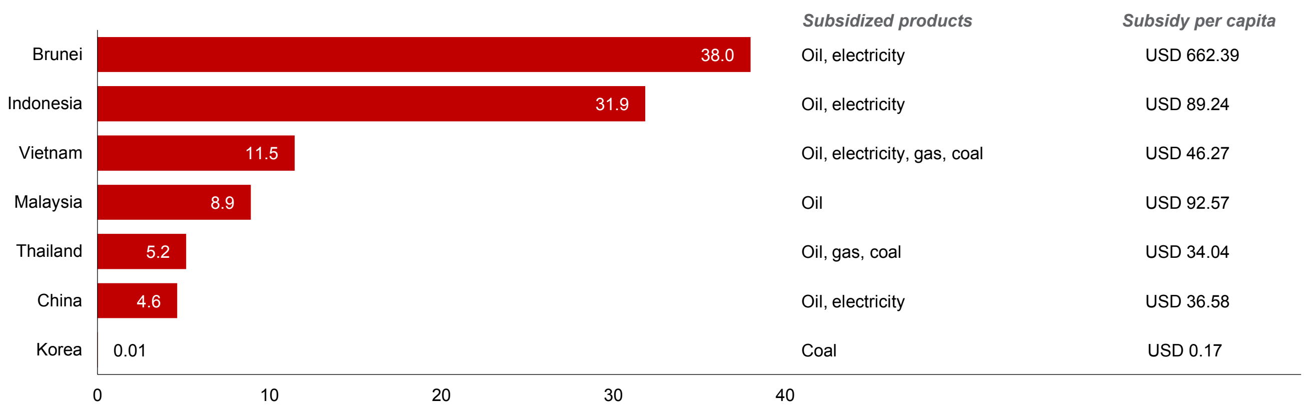
Isabel Schnabel
European Central Bank Executive Board Member
March 2022

The key to reducing fossil fuel use is carbon pricing—making those responsible for carbon emissions pay a price that reflects their external ("social") cost. When producers and consumers have to pay for each ton of carbon dioxide they directly or indirectly emit, they would have an explicit price incentive to shift away from fossil fuels. Thus, policies to disincentivize the use of fossil fuels usually involve raising energy and energy-related prices to reflect the damage done by emissions. According to the International Monetary Fund (IMF), increasing fuel prices to their "socially efficient" levels will reduce projected global carbon dioxide emissions by 36 percent below baseline levels in 2025 and put the world on track to contain global warming to the Paris Agreement goal of 1.5–2 degrees Celsius (Parry, Black, and Vernon 2021).

Fossil fuel subsidies can be considered negative carbon pricing, and ASEAN+3 economies will need to phase them out. The International Energy Agency (IEA) identifies seven ASEAN+3 economies that subsidize at least one fossil fuel (Figure 2.8). In Brunei, China, Indonesia, Malaysia, and Thailand, certain types of oil are sold at below-market retail prices. Coal prices remain subsidized in Korea and Vietnam. The average subsidization rate is highest in Brunei and Indonesia, at over 30 percent. These seven ASEAN+3 economies are among economies worldwide that adopted the 2021 Glasgow Climate Pact, calling for "accelerating efforts toward the … phase-out of inefficient fossil fuel subsidies" (UNFCCC 2021).

Phasing out fossil fuel subsidies will raise domestic (fossil fuel) energy prices but need not raise inflation. The direct impact of fuel subsidy reform is an increase in energy prices for households and firms—particularly low-income households and state-owned electricity companies, which tend to be the main beneficiaries of the subsidies. Indeed, some countries have had difficulty reforming fuel subsidies because the resulting price rises led to widespread public protests. The indirect impact of fuel subsidy reform is an increase in prices of other goods if firms pass on higher energy costs to consumers. But the effect on inflation should be temporary as long as appropriate macroeconomic policies are in place to forestall expectations of further increases in prices and wages.[3] Global experience suggests that a phased approach helps reduce the impact of subsidy reform on inflation as it gives households and enterprises time to adjust and gives the government time to establish supporting social safety nets and improve the efficiency of state-owned energy producers (Clements and others 2013).

Figure 2.8. Selected ASEAN+3: Fossil Fuel Subsidies, 2021
(Percent, average subsidization rate)



Source: IEA (2022i).
Note: The IEA uses the price-gap approach to estimate subsidies to fossil fuels that are consumed directly by end-users or consumed as inputs to electricity generation. This approach compares the average end-user price paid by consumers with a reference price that corresponds to the full cost of supply: Subsidy = (Reference price - End-user price) × Units consumed.

3/ The extent to which higher energy costs result in a persistently higher inflation will depend on the strength of second-round effects on wages and the prices of other inputs. This may especially be a concern for economies that have difficulty anchoring inflation expectations.

ASEAN+3 economies are presently at different stages of considering and implementing carbon pricing. Carbon pricing goes beyond eliminating fuel subsidies to positively taxing the carbon content of fossil fuels or their carbon dioxide emissions. The two main approaches to carbon pricing are a carbon tax and a cap-and-trade program or emissions trading scheme/system (ETS). A carbon tax works by directly setting a price for emissions.[4] An ETS works by restricting the volume of emissions and letting the market determine their price.[5] Table 2.2 summarizes the current state of carbon pricing in ASEAN+3 economies. Only Japan and Singapore have implemented a carbon tax (Box 2.2), and only China, Japan, and Korea have ETSs (Box 2.3). Carbon pricing can also be achieved implicitly, e.g., through regulatory limits on emissions. In this case, the implicit carbon price is based on how much a company spends to reduce emissions to comply with government regulations.

Table 2.2. Selected ASEAN+3: Status of Carbon Pricing Policies

Economy	Carbon Pricing Policy		Status
	Carbon tax	ETS	
Brunei	Under consideration	Under consideration	The National Carbon Climate Policy states that Brunei will introduce carbon pricing (either an ETS or a carbon tax) applicable to all industrial facilities and power utilities by 2025.
China		Regional ETSs implemented in 2013, 2014, and 2016. National ETS implemented in 2021	
Indonesia	Under development	Under development	Indonesia will has pledged to implement a carbon tax by 2025. Law No. 7/2021, passed in October 2021, introduced a so-called cap-and-trade-and-tax scheme (combining an ETS with a carbon tax) to be initially imposed on coal-fired power generation plants. The Indonesia Stock Exchange is setting up a carbon credit trading platform for domestic carbon trading.
Japan	Implemented in 2012	Regional ETSs implemented in 2010 and 2011. National ETS under consideration	
Korea		Implemented in 2015	
Lao PDR	Under consideration	Under consideration	As mandated by the National Green Growth Strategy, Lao PDR will utilize carbon pricing (either an ETS or a carbon tax) to stimulate efficient and economical energy usage.
Malaysia	Under consideration	Under development	As indicated in the Budget 2023 speech, the government intends to introduce a carbon tax regime and is studying the feasibility of a carbon pricing mechanism. Malaysia introduced voluntary carbon trading at the domestic level in December 2022 as a first step before transitioning to a domestic ETS.
Philippines	Under consideration	Under consideration	As mandated by the Low Carbon Economy Act, the Philippines will establish a cap-and-trade system for the industrial and commercial sectors. The Department of Finance is reportedly studying the viability of a carbon tax.
Singapore	Implemented in 2019		
Thailand	Under consideration	Under development	The Excise Department is studying a carbon tax for industrial sectors. Following a pilot voluntary ETS in 2015–20, Thailand is developing an ETS in the Eastern Economic Corridor region and drafting the ETS legal framework.
Vietnam		Under development	Decree No. 06/2022/ND-CP issued in January 2022 provides details for the establishment and development of a carbon market under the 2020 Law on Environmental Protection. A pilot system will start by 2025 and be fully implemented by 2028.

Source: Andriansyah and Hong (2022); World Bank (2022a); AMRO staff compilation.

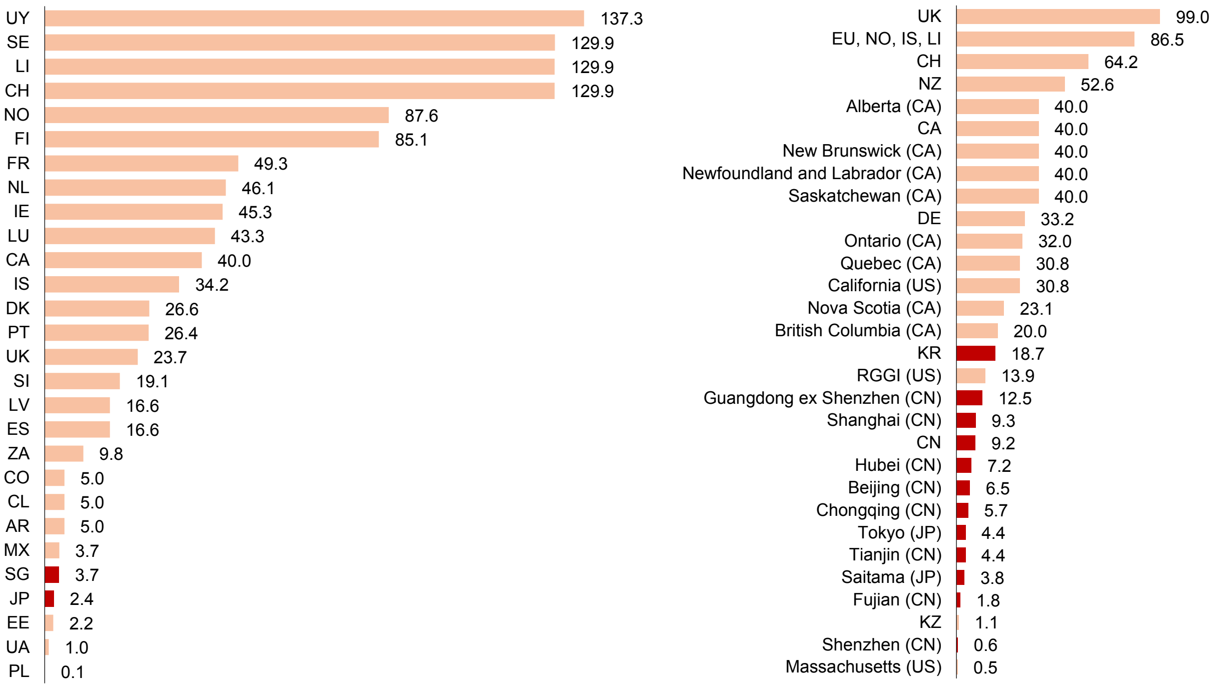
4/ In addition to direct carbon taxes, which are based on carbon emissions, indirect carbon taxes include fuel excise taxes, which are levied on the source of GHG emissions rather than directly on the emissions.

5/ Under an ETS, the government places a limit on total emissions and allocates rights (allowances) to emit GHGs to regulated entities (firms), either free of charge or via auction. Firms must hold allowances sufficient to cover their emissions. To comply with their emission quotas, firms can either implement internal abatement measures or acquire allowances in the carbon market. By creating supply and demand for allowances, an ETS establishes a market price for (excess) GHG emissions.

Current (explicit) carbon prices in the ASEAN+3 region—where they exist—are lower than in other parts of the world and too low to be effective for mitigating climate change (Figure 2.9). The effectiveness of carbon pricing in reducing emissions depends to a large extent on the price of emissions (i.e., the carbon tax rate or the ETS market-clearing price). This must be high enough to incentivize firms to shift away from fossil fuels. According to the IMF, carbon prices need to rise from the current global average of USD 6 per ton of carbon dioxide (tCO_2) to USD 75 per tCO_2 by 2030 in order to limit global warming (Black, Parry, and Zhunussova 2022). Other models, however, suggest that a much higher carbon price—closer to USD 200 per ton of carbon dioxide equivalent (tCO_2e) in 2030—would be needed to incentivize a transition toward net zero by 2050 (NGFS 2022).[6]

Figure 2.9. Selected Economies: Carbon Prices, 2022
(US dollars per ton of carbon dioxide equivalent)

Carbon Tax | **ETS**



Source: World Bank (2022a).
Note: Subnational carbon tax rates are not shown. Nominal prices on 1 April 2022. Prices are not necessarily comparable between carbon pricing initiatives because of differences in the number of sectors covered and allocation methods applied, specific exemptions, and different compensation methods. AR = Argentina; CA = Canada; CH = Switzerland; CL = Chile; CN = China; CO = Colombia; DE = Germany; DK = Denmark; EE = Estonia; ES = Spain; FI = Finland; FR = France; IE = Ireland; IS = Iceland; JP = Japan; KR = Korea; KZ = Kazakhstan; MX = Mexico; LI = Lichtenstein; LU = Luxembourg; LV = Latvia; NL = the Netherlands; NO = Norway; NZ = New Zealand; PL = Poland; PT = Portugal; RGGI = Regional Greenhouse Gas Initiative; SE = Sweden; SG = Singapore; SI = Slovenia; UA = Ukraine; UK = United Kingdom; US = United States; UY = Uruguay; ZA = South Africa.

Large hikes in the price of carbon could increase inflation, especially if sudden or "disorderly." A large hike in carbon prices would increase costs, particularly in the energy sector which, as noted, still relies heavily on fossil fuels. Thus, it can be considered an adverse supply shock. The impact of a carbon price increase on energy price inflation would depend on the transition period of the policy (i.e., the time given for industries to adapt to carbon pricing and make the switch out of fossil fuels) and the availability of green technology and alternative fuel sources for industries to switch into. If power generation companies—which normally are the first to face a higher carbon price—are unable to adapt quickly by adopting decarbonization or new lower-emission technologies, they will pass on some of the burden through increased electricity tariffs. If low-emission power generation alternatives (such as solar, wind, or nuclear energy) are not yet widely available, energy prices could be significantly higher in the medium term until resources are reallocated and the transition to clean energy is complete.[7]

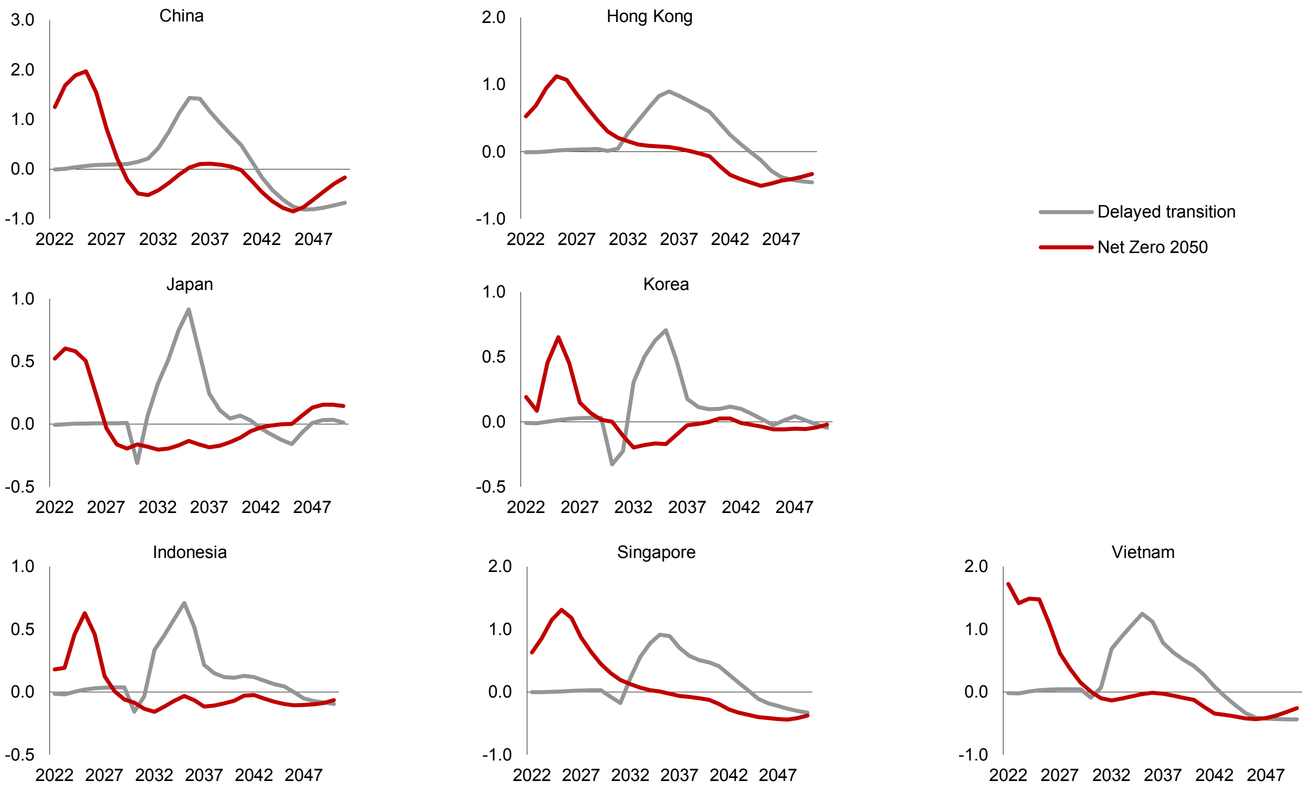
6/ NGFS (2022) estimates the carbon price as the marginal abatement cost necessary to reach a specific temperature increase. The estimated price reflects the stringency of policy as well as how technology costs will evolve—for example, it tends to be lower in economies where there are a greater number of low-cost abatement options available.

7/ Empirical studies of the historical effects of carbon pricing on inflation mainly focus on Europe, where these policies were first implemented. Känzig (2022) finds that restrictive carbon policy shocks in the EU ETS (2005–18) led to persistent increases in euro area headline inflation. McKibbin, Konradt, and Weder di Mauro (2021) find that carbon taxes implemented in the euro area (1985–2020) had positive effects on headline inflation especially in the first two years, but the effects were contained after three years. The effects on the producer price index were larger, suggesting that producers absorbed most of the carbon tax rather than passing it on to consumers. Konradt and Weder di Mauro (2022) find that the response of headline inflation seemed especially muted in economies with revenue recycling schemes and monetary policy regimes that could accommodate the carbon tax (i.e., those outside the euro area). Results for Canada (2000–19) even point to slightly deflationary responses associated with putting a price on carbon. Moessner (2022) finds that ETS allowance prices in 35 OECD economies (1995–2020) had a small positive effect on headline inflation but carbon taxes had no significant effects on headline, core, or energy inflation.

The same applies to implicit carbon pricing through regulations such as restrictions on coal use for power generation, energy intensity limits, and compulsory standards and technological performance requirements. In China, for example, where the regulatory approach is often used to target emission reductions at the sectoral and regional level, limitations on energy use contributed to power crunches in several regions that curbed production and drove up the producer price index in the fall of 2021 (AMRO 2022a). Indeed, a key consideration for China's carbon neutrality roadmap is how to allocate the carbon budget to smooth the adjustment costs frontier across the transitional period (Zhai and Foo 2022).

Achieving an "orderly" transition requires governments to communicate a clear and predictable path for future tightening of carbon emission policies and to accelerate structural changes toward affordable clean energy options. Early simulations by the Network for the Greening of the Financial System (NGFS) suggest that the implementation of carbon prices to achieve net zero targets will cause inflation to increase only mildly before returning to prior trends (Figure 2.10).[8] However, the global energy crisis triggered by the Ukraine crisis has provided an example of what could happen to inflation under a more disorderly transition than one modeled by the NGFS (Schnabel 2022; Kho and Zhao 2022). At the same time, the crisis could also provide added impetus for policies to drive an increase in clean energy investments in the region (Section III).

Figure 2.10. Selected ASEAN+3: Inflation Projections under Transition Scenarios
(Percent change from baseline)



Source: International Institute for Applied Systems Analysis (IIASA) NGFS Climate Scenarios Database (October 2022 vintage).
Note: The baseline is a hypothetical scenario with no physical or transition risks. The (orderly) "Net Zero 2050" transition scenario assumes that optimal carbon prices in line with economies' long-term targets are implemented immediately after 2020 and global net zero carbon dioxide emissions is achieved in 2050. The (disorderly) "delayed transition" scenario assumes that annual emissions do not decrease until 2030, and strong policies are then needed to keep global warming below 2 degrees Celsius in 2100.

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[8] Energy price shocks are generally seen as reflecting shifts in relative prices within a basket of goods, rather than a sustained rise in inflation that requires monetary policy action. But when shocks feed through only slowly—for instance, as the carbon price is raised—inflation expectations may change, forcing central banks to react.

Box 2.2:

Carbon Taxes in Japan and Singapore

Japan

Japan was the first ASEAN+3 economy to introduce a carbon tax in October 2012. The so-called special tax for climate change mitigation is applied to crude oil and petroleum products, natural gas, and coal, on top of existing taxes on these products (Figure 2.2.1). The tax rate was increased gradually over three and a half years to reach JPY 289 (USD 2.60) per ton of carbon dioxide equivalent (tCO_2e). Revenue from the tax is used to support renewable energy projects and energy-saving measures, yielding a "budget effect" in the form of lower emissions.

The carbon tax was calibrated to avoid putting an excessive burden on households and businesses. The estimated price increases due to the tax range from JPY 0.76–0.78 per liter for gasoline, kerosene, and liquefied petroleum gas to JPY 0.11 per kilowatt-hour for electricity, although substantial regional variation exists in the extent of pass-through to electricity prices (Ding 2022). There are also several exemptions and refund measures for specific products used in certain industries, such as imported coal, light oil used for agriculture, forestry and fishing, and heavy and light oil used for domestic cargo and passenger ships and railways (Japan Ministry of the Environment 2012).

The tax alone was expected to achieve only modest emission reductions. At the time of introduction, its "price effect" was estimated to achieve a 0.2 percent emission reduction and the "budget effect" a 4.2 percent emission reduction between 2013 and 2030 (Japan Ministry of the Environment 2013).

Singapore

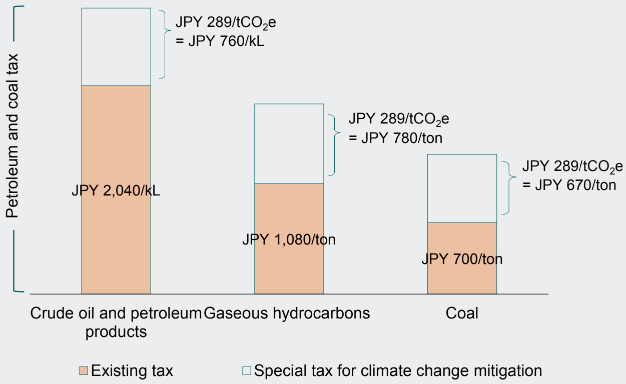
Singapore introduced a carbon tax in January 2019. It is applied on facilities that directly emit at least 25,000 tCO_2e of greenhouse gas (GHG) emissions annually—in all, about 50 facilities in the manufacturing, power, waste, and water sectors, accounting for 80 percent of the economy's total GHG emissions. The tax is set at a low initial rate of SGD 5 (USD 3.55) per tCO_2e until 2023 to provide an adjustment period for emitters.

The carbon tax will be raised over the next few years to reach SGD 50–80 per tCO_2e by 2030 (Singapore NCCS 2022) (Figure 2.2.2). The pre-announced carbon tax trajectory is meant to give businesses certainty and impetus to plan their transition, e.g., by investing in low-carbon technologies and carbon markets. The tax increase will be revenue-neutral in the sense that the revenue will be used to support decarbonization efforts and to cushion the impact on businesses and households. Companies will be allowed to offset up to 5 percent of their taxable emissions with high-quality international carbon credits starting in 2024. Companies in emission-intensive trade-exposed sectors will be given transitory allowances for part of their emissions based on internationally recognized efficiency benchmarks, where available, or on the facilities' decarbonization plans.

The tax is not expected to have a big impact on household utility bills (and consequently on consumer behavior) in the near term. The SGD 5 per tCO_2e tax is estimated to result in a 1 percent increase in total electricity and gas expenses for households, which is offset by rebates for eligible households (Tan and Toh 2018). The SGD 25 per tCO_2e tax in 2024–25 is estimated to lead to an increase of about SGD 4 per month in utility bills for an average household living in a four-room Housing and Development Board flat, but additional rebates will be provided to eligible households to cushion the impact (Tan 2022).

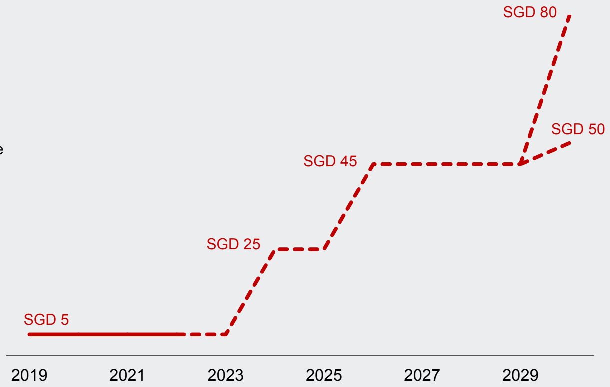
This box was written by Andriansyah.

Figure 2.2.1. Japan: Carbon Tax



Source: Japan Ministry of the Environment (2012).
Note: kL = kiloliter.

Figure 2.2.2. Singapore: Carbon Tax
(Singapore dollars per ton of carbon dioxide equivalent)



Source: Singapore NCCS (2022).

Box 2.3:

Emissions Trading Schemes in the Plus-3

Japan

Japan has two subnational emissions trading systems (ETSs): the Tokyo Cap-and-Trade Program (since 2010) and the Saitama Target Setting ETS (since 2011). Both ETSs cover energy use-related carbon dioxide emissions from the industry, power, and buildings sectors, for a combined total coverage of 21 million tons of carbon dioxide emissions. The Tokyo ETS covers about 1,200 facilities and the Saitama ETS about 600 facilities with an annual energy usage equivalent to 1,500 kiloliters or more of crude oil.

The ETSs are so-called baseline-and-credit systems that set mandatory emission-reduction targets for large buildings and factories. Each regulated ("covered") facility has its own cap, which serves as the baseline from which it must achieve its reduction target. The absolute emission baseline for each facility is determined by the historical emissions associated with their total energy consumption and an emission-reduction target ("compliance factor") based on the type of facility and factors such as expected energy efficiency gains and the extent to which they consume energy supplied by other facilities. Covered facilities that achieve emissions below their baseline earn "excess emission reduction credits." These can be sold to other covered facilities or be banked for future compliance (i.e., to pay for future emissions that exceed the baseline). Covered facilities can also use eligible offsets to meet their compliance obligations. Eligible offsets include credits generated from domestic renewable energy projects and emission reductions in certain noncovered facilities in or outside the two jurisdictions. The two ETSs are linked, meaning that Tokyo and Saitama credits are officially eligible for trade between the two jurisdictions.

Prices for excess emission reduction credits in the Tokyo ETS have been decreasing since 2011 (Figure 2.3.1). There has been little active trading in the market. According to Abe and Arimura (2022), some 85 to 90 percent of regulated facilities achieved their emission-reduction targets through internal abatement efforts without making use of emissions trading. This suggests that emission caps were not low enough to generate demand for emission credits or to bring about a significant reduction in energy-use in regulated facilities.

Korea

Korea was the first ASEAN+3 economy to launch a nationwide mandatory ETS in January 2015. Korea's ETS covers direct emissions of six greenhouse gases (GHGs) as well as indirect emissions from electricity consumption from 684 large emitters in the waste, domestic aviation, buildings, industry, and power sectors, accounting for 591 million tons of carbon dioxide equivalent ($MtCO_2e$) of GHG emissions.

The Korea ETS is a cap-and-trade system whereby a cap is set on the total amount of GHG emissions and regulated entities are issued emission allowances, each representing 1 ton of carbon dioxide equivalent (tCO_2e). Regulated entities must measure their annual emissions and surrender allowances to cover their responsibility; those that emit less than their allocation can sell their excess allowances, while those that do not have enough allowances to cover their annual emissions need to buy them. Annual GHG emission caps ranged from 540 $MtCO_2e$ to 593 $MtCO_2e$ in the first two phases of implementation (2015–20). For the third implementation phase, the caps are 589 $MtCO_2e$ for 2021–23 and 567 $MtCO_2e$ for 2024–25. Regulated entities can use carbon offset credits from eligible domestic and international projects to meet up to 5 percent of their compliance obligations.

Most sectors receive free allowances based on their historical average GHG emissions. Auctioning was introduced in the second implementation phase for 3 percent of the allocation to 26 subsectors such as electricity, domestic aviation, wooden products, and metal foundry; the auction share was increased to 10 percent and the number of subsectors increased to 41 in the third phase. The auction volume for 2022 was 22.8 $MtCO_2e$ (allowances). Auctions take place on the Korea Exchange, which also manages the platform for spot secondary market transactions in allowances and offset credits.

This box was written by Andriansyah.

The allowance price evolved as the market developed. The price started at about KRW 8,500 (about USD 6.5) per tCO_2e and rose more or less steadily for five years, reaching KRW 40,900 per tCO_2e at the end of 2019 (Figure 2.3.2). Price changes have been driven by revised climate targets and ETS rules, as well as demand from market participants and speculators. Allowance prices dipped in 2020 as COVID-19 reduced economic activity. Prices rose in the middle of 2021 when the government proposed a tightening of the country's 2030 emission target and at the end of 2021 when 20 financial institutions were allowed into the market to bolster liquidity (World Bank 2022b). Market stabilization measures are in place to deal with persistent supply-demand imbalances, including auctioning of allowances from the reserve, imposing banking limitations, changing the borrowing limits, changing the offset restrictions, and temporarily setting a price floor or ceiling.

China

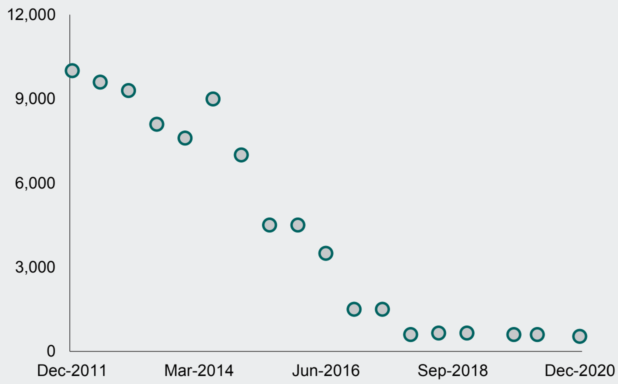
China implemented a national ETS in July 2021. Before that, eight subnational ETSs were piloted: in Beijing, Guangdong, Shanghai, Shenzhen, and Tianjin in 2013; Chongqing and Hubei in 2014; and Fujian in 2016. Sectoral coverage of the subnational ETSs varies but mainly comprises transport, buildings, industry, and domestic aviation. Emission coverage ranges from 13 $MtCO_2e$ (Shenzhen) to 259 $MtCO_2e$ (Guangdong). The national ETS currently covers only the power sector, but it is already the world's largest in terms of covered emissions—4,500 $MtCO_2$ from more than 2,100 regulated entities. Entities regulated under the national system do not face compliance obligations under the subnational ETSs.

Unlike ETSs elsewhere with a fixed cap on emissions that would decline over time, the cap on China's national ETS can go up or down from year to year. Each regulated entity receives a "verified allowance" equal to the amount of carbon dioxide it is allowed to emit, which is based on its historical output and the corresponding intensity benchmark. The flexible cap is the sum of verified allowances for all regulated sites. In the pilot subnational ETSs, the total emission allowance is determined through a top-down approach (e.g., in Beijing), a bottom-up approach based on reported emissions data (e.g., in Fujian), or a combination of both. All regulated entities in the national ETS and most existing entities in the subnational ETSs are given their allowances for free; a small portion of allowances are auctioned in some subnational ETSs (e.g., Beijing, Guangdong, and Shanghai). Regulated entities can then buy or sell permits (each permit representing 1 tCO_2e of emissions) as needed to meet their compliance obligations. They are also allowed to use eligible domestic project-based offsets to meet a portion of their compliance obligations: up to 5 percent in the national ETS, and ranging from 1 percent (Shanghai) to 10 percent (Guangdong, Hubei, Shenzhen, and Tianjin) in the subnational ETSs (Section III goes into more detail on carbon offsets).

Prices for emission allowances in the national and subnational ETSs vary widely. Trading on the national ETS has been limited so far—a total of 194 $MtCO_2e$ of allowances changed hands during the first 12 months of operation, and the emission allowances closed at CNY 58.24 per tCO_2e on 15 July 2022, compared to CNY 51.23 per tCO_2e on its first trading day a year earlier (Xue 2022). Allowance prices in the pilot subnational ETSs ranged from about CNY 30 per tCO_2e in Chongqing, Fujian, and Tianjin to about CNY 120 per tCO_2e in Beijing by the end of 2022 (Figure 2.3.3). The ETSs have contingency measures in place to ensure market stabilization, including market suspension, additional allowance auctions and buy-back options (although no market stabilization actions have reported to date).

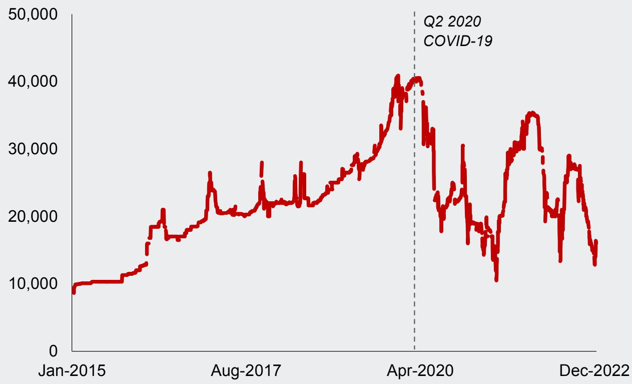
The subnational ETSs will gradually be integrated into the national ETS. Sectoral coverage of the national ETS will expand to include six additional industries: iron and steel, aluminum, cement, chemicals, papermaking, and civil aviation.

Figure 2.3.1. Japan: Tokyo ETS Excess Emission-Reduction Credit Prices
(Yen per ton of carbon dioxide equivalent)



Source: Fujitsu Research Institute (2020).

Figure 2.3.2. Korea: ETS Allowance Prices
(Won per ton of carbon dioxide equivalent)



Source: International Carbon Action Partnership (2022).

Figure 2.3.3. China: Daily Emission Allowance Prices
(Yuan per ton of carbon dioxide equivalent, 30-day moving average)

Source: International Carbon Action Partnership (2022).

Will Exports Suffer?

"There is no doubt that climate concerns will lead to restrictions on trade. The question is how and when."

Henrique Schneider
Chief Economist of the Swiss Federation of Small and Medium-sized Enterprises
November 2022

Carbon pricing could also have implications for export competitiveness. As noted, carbon pricing can increase production costs, directly (by requiring firms to pay a carbon tax or purchase emission allowances) and indirectly (by increasing the explicit or implicit cost of inputs such as fuels and electricity). By increasing production costs, carbon pricing can substantially reduce the relative competitiveness of an economy. Such concerns are particularly acute for so-called energy-intensive, trade-exposed sectors (EITEs)— aluminum, cement, chemicals, iron, and steel, plastics, and refined petroleum, to name a few—and in economies where these sectors contribute substantially to economic activity and employment (Parry and others 2021). Furthermore, exporters in high-carbon sectors could see their market shares shrink if a lower carbon price for foreign producers allows them to export at a lower cost—a problem referred to as "carbon leakage."[9] Changes in cross-country trade and capital flows arising from differentiated carbon prices could result in losses in export earnings, employment, and FDI for some economies, with implications for productivity and innovation in the longer term (Venmans, Ellis, and Nachtigall 2020).

The empirical literature finds very small or negligible effects of carbon pricing policies on competitiveness and carbon leakage. There could be various reasons for this, including still-low levels of carbon prices, a limited number of carbon pricing schemes that have been examined (given that most of them are still in the early stages of implementation), protection for at-risk sectors such as large (over-) allocations of emission allowances, or the ability of firms to pass on the additional cost to consumers (World Bank 2016; Dechezleprêtre and Sato 2017; Joltreau and Sommerfeld 2019). In addition, carbon pricing policies may not yet be as critical as other determinants of production and investment decisions, like the availability of skilled labor, infrastructure, quality of institutions, and market size (AMRO 2021). Studies of carbon leakage are also faced with methodological constraints.

Nonetheless, there has been increasing interest in the idea of border carbon adjustments (BCAs) to counter potential losses in competitiveness and carbon leakage due to asymmetric carbon prices. Conceptually, BCAs would accompany domestic carbon pricing policies and be imposed on the "embodied carbon" in an economy's imports—these imports would be subject to fees and other charges on their emissions content as if they were produced domestically, thus leveling the playing field between local and foreign producers.[10] A variation of a BCA can also be implemented on the export side, in the form of rebates for exporters for all or part of the domestic carbon price paid on their exports. Accordingly, BCAs would address the problem of competitiveness loss and carbon leakage by imposing a cost on imports from foreign producers facing no (or lower) carbon prices and/or providing offsetting payments (e.g., rebates) for exports of domestic producers that pay higher carbon prices.

In practice, BCAs are complex to design and implement. Details to be sorted out include the scope of application (e.g., which sectors and products to be included); the methodology for calculating embedded emissions; the rate of (import) charges or (export) rebates to set; assessing "equivalency" among existing carbon pricing systems, or between pricing and non-pricing systems; and alignment with international trade laws and agreements (Sawyer and Gignac 2022). No national or supranational jurisdiction has implemented a BCA yet. The most advanced is the European Union's Carbon Border Adjustment Mechanism (CBAM), which enters its preliminary stage in October 2023 (Box 2.4). BCAs are also being explored in Canada and the United Kingdom, where explicit carbon prices are relatively high, as well as in Japan and the United States, where explicit carbon prices are relatively low (Figure 2.9).

Widespread use of BCAs globally would have significant implications for ASEAN+3 trade and production. Based on the latest available data in 2018, ASEAN+3 accounts for nearly 38 percent of carbon emissions embedded in global trade, more than half of which is accounted for by China (Figure 2.11, left panel). Of the top 20 economies in the world with the highest carbon emissions embedded in trade, seven are from ASEAN+3 (Figure 2.11, right panel). Moreover, as noted, explicit carbon prices in the region are generally non-existent or much lower than in some of its major trading partners (Figure 2.12). BCAs on embodied

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9/ Carbon leakage refers to the shift in production from a jurisdiction with stringent carbon policies to a jurisdiction with less stringent policies. While the former reports reduced emissions as a consequence of its high carbon price, the increase in carbon-intensive activity in the latter offsets this reduction, leading to increased global emissions overall, i.e., "leakage."

10/ If accompanying a domestic carbon tax, a BCA would function as a value-added tax imposed at the border. If accompanying an ETS, a BCA would mirror the requirements for purchases for emission allowances by domestic producers (Cosbey 2021).

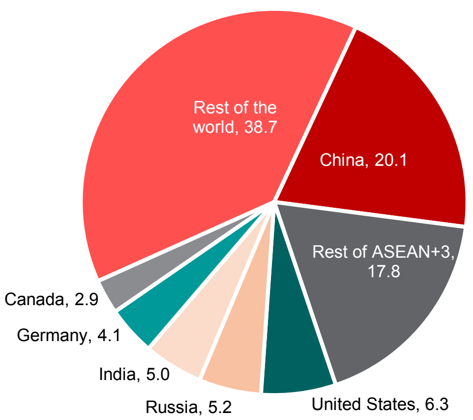
carbon will make the region's exports more expensive, which could reduce external demand and trade flows for the affected goods. For the CBAM, for example, this would be the case for producers with higher carbon footprints than their EU counterparts whereas those with lower emission intensities than EU producers might enjoy a cost advantage (Cosbey 2021). In the ASEAN+3 region, only Singapore appears to have a lower emission intensity than the European Union, although Japan is not far behind (Figure 2.13).

Minimizing the negative consequences of BCAs on ASEAN+3 exports will entail strong policy and regulatory adjustments at the domestic level. ASEAN+3 economies with no carbon pricing would need to adopt some form of it—either a carbon tax or an ETS—in order to reduce extra charges levied on their exports by BCAs.

A carbon tax would help to generate revenue that could be directed toward domestic "green" projects or other climate-related purposes, instead of being channeled to the BCA-implementing trading partner (Parry and others 2021). Adopting a carbon pricing policy would also provide a strong signal on policy direction, even if the carbon price is initially low (Venmans, Ellis, and Nachtigall 2020). Other targeted policies, especially for EITEs, could also help to lessen the impact of BCAs and alleviate business concerns about competitiveness, particularly policies that incentivize or assist domestic exporters to shift to or accelerate the use of low-carbon and more efficient products and technologies (Section IV). The degree of adjustment for each ASEAN+3 economy will depend on its reliance on carbon-intensive products, the carbon intensity of its trade, and its access to resources and means (i.e., technology and financing) to reduce carbon use.

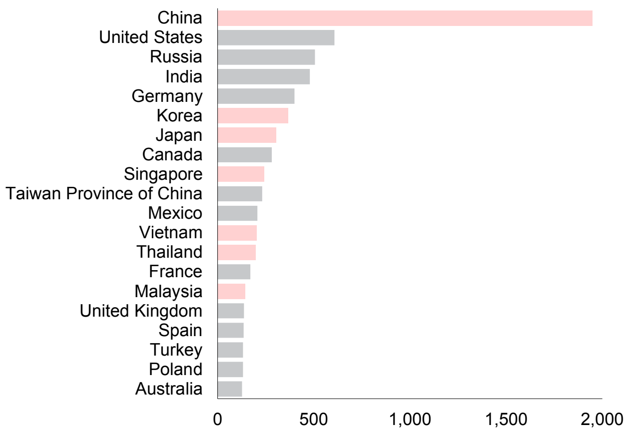
Figure 2.11. ASEAN+3 and Selected Economies: Carbon Dioxide Emissions Embodied in International Trade, 2018

(Percent of world total)



Source: OECD.Stat; AMRO staff calculations.

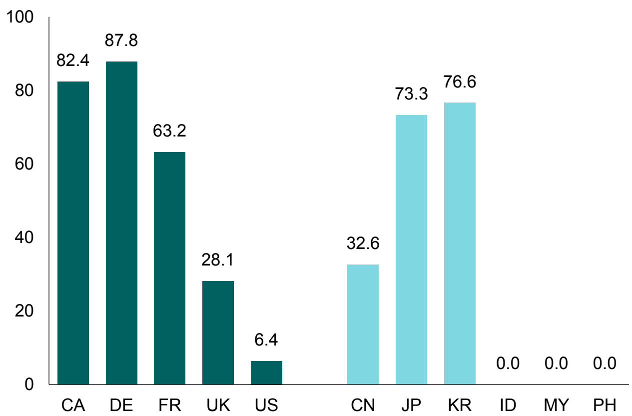
(Million tons of carbon dioxide, top 20 economies)



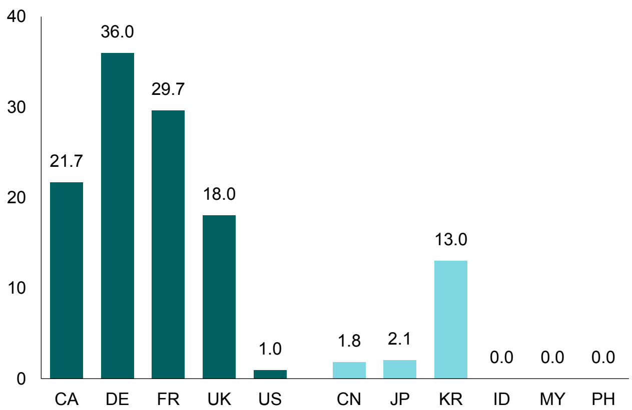
Source: OECD.Stat; AMRO staff calculations.

Figure 2.12. Selected Economies: Carbon Pricing, 2021

Share of GHGs Subject to Explicit Carbon Price
(Percent)

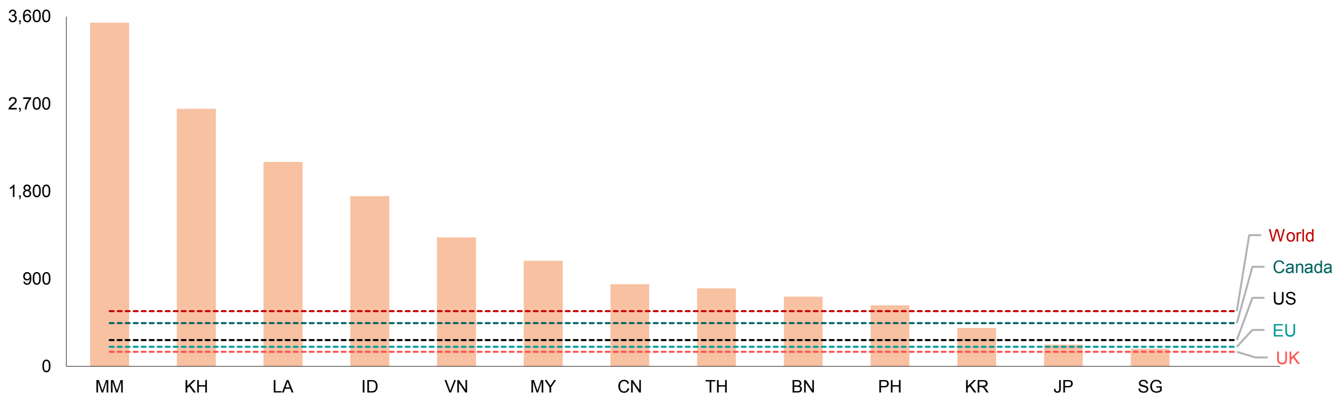


Average Explicit Carbon Price
(Real 2021 euros per ton of carbon dioxide equivalent)



Source: OECD (2022).
Note: Explicit carbon price consists of emissions trading system (ETS) permit prices and carbon taxes. CA = Canada; CN = China; DE = Germany; FR = France; ID = Indonesia; JP = Japan; KR = Korea; MY = Malaysia; PH = Philippines; UK = United Kingdom; US = United States.

Figure 2.13. ASEAN+3 and Selected Economies: Emission Intensity, 2019
(Tons of carbon dioxide equivalent per million dollars of GDP)



Source: Climate Watch (2022).
Note: Data not available for Hong Kong. BN = Brunei; CN = China; ID = Indonesia; KH = Cambodia; EU = European Union; JP = Japan; KR = Korea; LA = Lao PDR; MM = Myanmar; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; UK = United Kingdom; US = United States; VN = Vietnam.

Box 2.4:

What Will the European Union's Carbon Border Adjustment Mechanism Mean for ASEAN+3 Exports?

In July 2021, the European Union proposed a carbon border adjustment mechanism (CBAM) for imports from non-EU economies. The stated aim of the CBAM is to limit carbon leakage by equalizing the carbon price between EU and non-EU products and encouraging trading partners to adopt carbon pricing. The CBAM, which is not yet finalized, will initially cover five industrial sectors—aluminum, cement, electricity generation, fertilizers, and iron and steel—plus hydrogen, indirect emissions (under certain conditions), and certain precursors and downstream products of the targeted sectors. Under the CBAM, EU importers would be required to declare the total emissions associated with their annual imports of these products and purchase carbon certificates corresponding to the carbon price that would have been paid to produce the goods in the European Union—i.e., the average trading price of emission allowances on the EU Emissions Trading System (EU ETS). During the transition period starting from October 2023, only emission reporting will be required; no carbon charges will be levied. The CBAM will be phased in as early as 2027 and be fully operational after five to nine years. A determination will be made before the end of the transition period about whether to extend the CBAM's scope to other goods, including organic chemicals and polymers. The goal is to include all goods covered by the EU ETS by 2030 (European Parliament 2022).

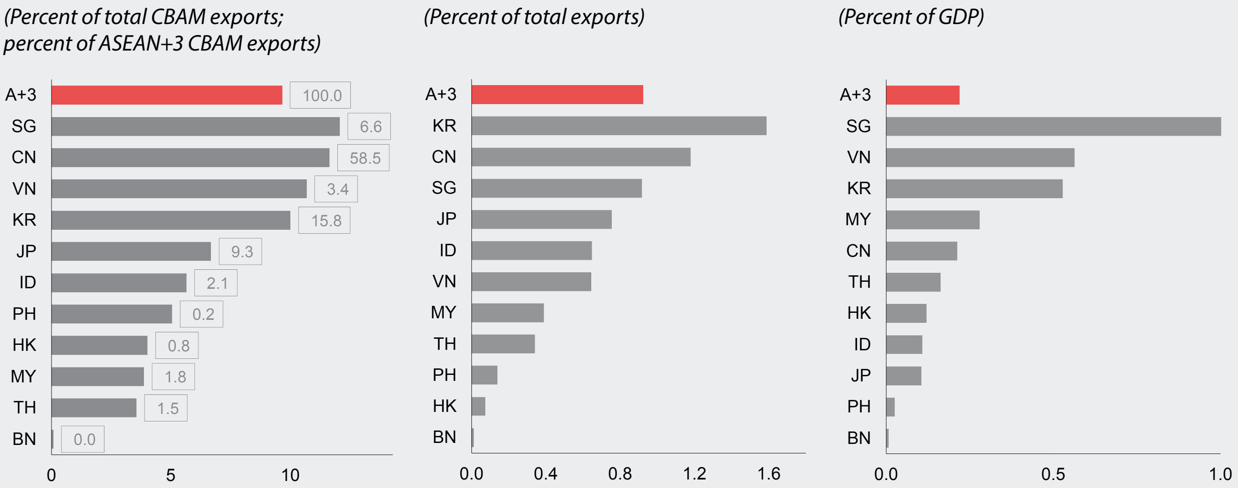
The CBAM—under its initial scope—is expected to have limited impact on ASEAN+3 exports. The European Union is ASEAN+3's second-largest export market of the CBAM-covered product categories, after the United States. China is the region's biggest exporter of CBAM products to the European Union, followed by Korea and Japan (Figure 2.4.1, left panel). However, given that the share of CBAM exports in ASEAN+3's total exports and GDP is relatively small—at 0.9 percent in 2019 and 0.22 percent in 2021—the trade impact of the CBAM under its current scope might not be severe (Figure 2.4.1, center and right panels). Simulations by AMRO staff using a global computable general equilibrium model, following He, Zhai, and Ma (2022), suggest that exports to the European Union could decline by about 0.1 percent for China, 0.2 percent for Japan, and 0.12 percent for ASEAN economies in 2030 relative to the counterfactual baseline (absent the CBAM). Within the region, Vietnam and Indonesia are likely to feel the greatest impact (Figure 2.4.2, top panel).

That noted, the CBAM could have a substantial negative impact on ASEAN+3 exports if its scope is extended to include all products and services and all indirect emissions from upstream value chains. The model simulations suggest that under such an "extreme case" scenario, the CBAM would result in a 11.4 percent decline in China's exports to the European Union and shave 0.12 percent off China's GDP in 2030 compared to the baseline. ASEAN exports to the European Union will be 9.7 percent lower, and GDP will be 0.2 percent lower (Figure 2.4.2, bottom panel). Japan and Korea will not be impacted as severely as the rest of the region, most likely due to their lower carbon intensity, higher energy efficiency (e.g., access to less polluting technologies), and existing domestic carbon prices.

The consequences for ASEAN+3 trade would be exacerbated if other major trading partners implement similar policies. The CBAM could set the tone for future border carbon adjustments (BCAs) in Canada, the United Kingdom, and the United States. ASEAN+3 exporters are likely to lose their cost advantage as their carbon footprints exceed those of these three trading partners (Figure 2.13). These markets account for an additional 12.5 percent of ASEAN+3 exports of CBAM-covered products, or about 1.2 percent of the region's total exports (Figure 2.4.3, left panel). If all other economies follow suit and impose BCAs on the same group of carbon-intensive goods, this will affect nearly 10 percent of the region's total exports, equivalent to about 2.2 percent of its GDP (Figure 2.4.3, right panel). Realistically, the implementation of BCAs is likely to be gradual. Carbon-intensive products tend to have complex value chains and as such, the initial impact is likely to be limited to raw materials and primary products rather than the overall supply chain (Darvell 2022). Gradual implementation would give the region's economies time to introduce or refine their own carbon pricing schemes (Table 2.2) and reduce the risk of a sudden shock to exports and economic activity.

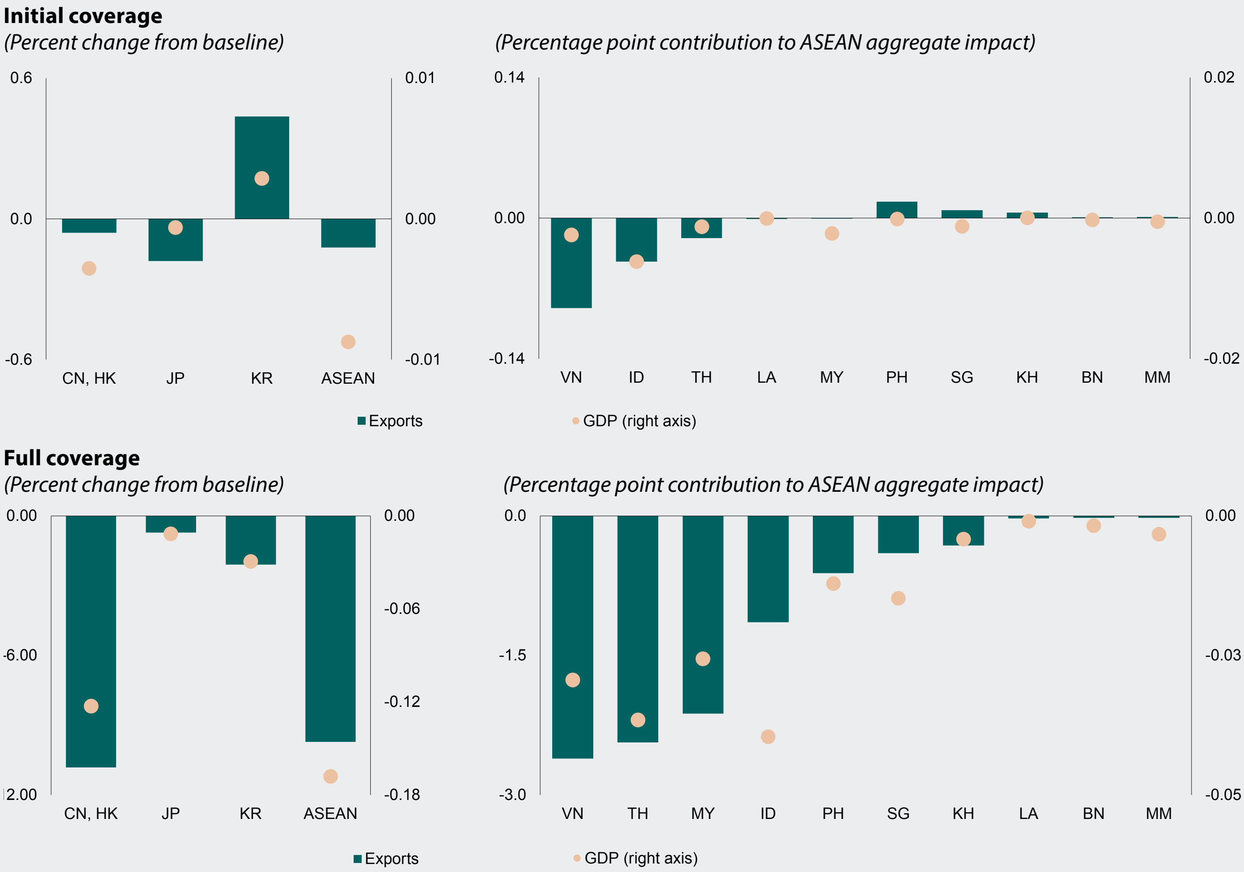
This box was written by Marthe M. Hinojales and Fan Zhai.

Figure 2.4.1 Selected ASEAN+3: Exports of CBAM Products to the European Union, 2019–22 Average



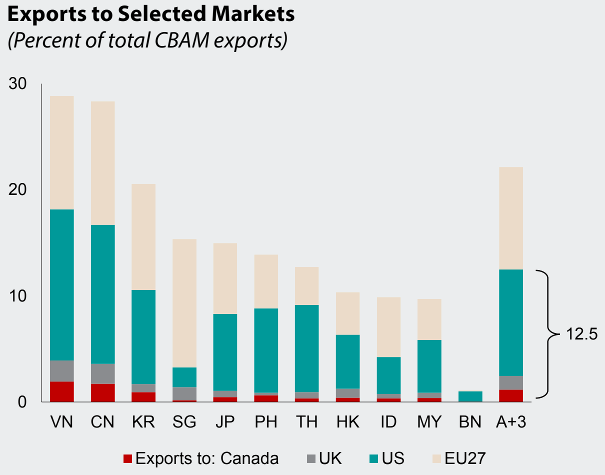
Source: IHS Markit; Haver Analytics; and AMRO staff calculations.
Note: Data for Cambodia, Lao PDR, and Myanmar not available. In the left panel, figures in boxes refer to each economy's share of total ASEAN+3 exports of Carbon Border Adjustment Mechanism (CBAM) products. BN = Brunei; CN = China; HK = Hong Kong; ID = Indonesia; JP = Japan; KR = Korea; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; and VN = Vietnam.

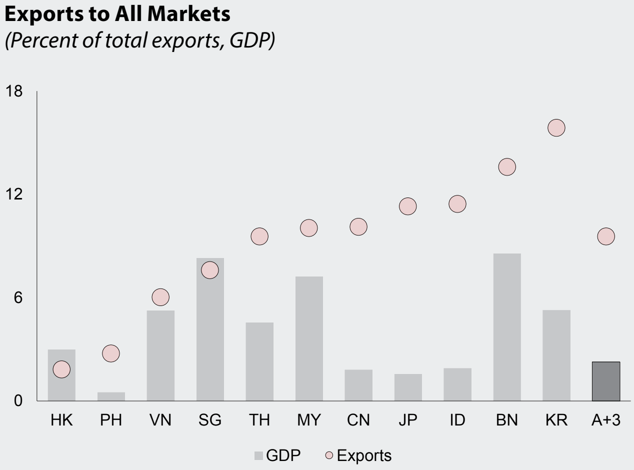
Figure 2.4.2. ASEAN+3: Estimated Impact of CBAM on GDP and Exports to the European Union, 2030



Source: AMRO staff.
Note: The baseline is the case without the Carbon Border Adjustment Mechanism (CBAM). "Initial coverage" refers to direct emissions from the covered sectors (represented in the model by chemicals, electricity, iron and steel, nonferrous metals, and nonmetallic minerals). "Full coverage" refers to all exports and both direct and indirect emissions. Both scenarios assume a carbon price of USD 75 per ton of carbon dioxide equivalent (tCO2e) embodied in imports of the European Union while the carbon price per ton for China is assumed to be USD 9.2; for Indonesia, USD 2.09; for Japan, USD 3.39; for Korea, USD 18.75; for Singapore, USD 3.7; and 0 for the rest of ASEAN. The CBAM, which adjusts for differences between the EU carbon price and carbon price in exporting economies, is assumed to be imposed from 2026. The simulation results show that the CBAM will lead to increases in import costs (measured in tariff-equivalents) of CBAM products from the EU perspective, but the estimated tariff-equivalents will vary across exporting economies. Thus, while most exporting economies are expected to experience a decline in exports, a few, such as Korea in the "initial coverage" scenario could see a small increase because their comparatively lower tariff-equivalents could produce some trade diversion in their favor. BN = Brunei; CN = China; HK = Hong Kong; ID = Indonesia; JP = Japan; KH = Cambodia; KR = Korea; LA = Lao PDR; MM = Myanmar; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; VN = Vietnam.

Figure 2.4.3. ASEAN+3: Exports of CBAM Products, 2019–22





Source: IHS Markit; Haver Analytics; and AMRO staff calculations.
Note: Data for Cambodia, Lao PDR, and Myanmar not available. A+3 = ASEAN+3; BN = Brunei; CN = China; EU27 = 27 members of the European Union; HK = Hong Kong; ID = Indonesia; JP = Japan; KR = Korea; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; UK = United Kingdom; US = United States; VN = Vietnam.

What about Stranded Assets?

"No energy company will be unaffected by clean energy transitions."

Fatih Birol
International Energy Agency Executive Director
January 2020

The transition to a low-carbon economy could result in stranded assets. Hitting the net zero goal by 2050 requires economies around the world to undergo deep and rapid structural adjustments (UNEP 2022). In this context, stranded assets would include natural resources (fossil fuel reserves left in the ground) and investments in infrastructure or properties that would never be fully utilized due to government regulation, technological change, or evolving societal norms and consumer behavior. In macroeconomic terms, when a price—explicit or implicit—is suddenly put on carbon emissions that used to be free, this will trigger an accelerated obsolescence of existing capital stock associated with high emissions, especially in the energy, transportation, manufacturing, and building sectors.[11] For example, oil and coal reserves might have to remain in the ground as "unburnable carbon" (stranded volumes); coal power stations could be prematurely closed due to pressure for fossil fuel divestment (stranded capital); and oil and gas companies—and the banks that finance them—could see their profitability plunge with changing consumer demand (stranded value).[12] Potential output could therefore decline in the short term.

ASEAN+3 economies that rely on export revenues from fossil fuels are likely to face risks from stranded assets. The risk is greatest for economies that currently depend on fossil fuel resources in the ground and/or carbon-intensive built capital, as well as those that are expected to rely on carbon-intensive rents and revenues as a result of large reserves and the young age of their carbon-intensive infrastructure (Peszko and others 2020). Brunei and Vietnam are among the top 10 countries most exposed to stranded-asset risk (Figure 2.14). China, Indonesia, and Malaysia are potentially vulnerable due to the significant contribution of the fuel extractive and/or carbon-intensive sectors to economic growth (Figure 2.15). Cambodia, like Vietnam, is vulnerable mainly because of the large share of young coal power plants in its power generation mix (Figure 2.16). The region's coal resources face the most immediate risk of being stranded, compared to oil and natural gas (Figure 2.17). Economies that rely on coal rents are also at risk of revenue shocks (Figure 2.18).

The creation of stranded assets could also have implications for the region's financial stability.[13] Most of the world's unburnable carbon—the excess of available fossil fuels beyond what can be burned if global warming is limited to below 2 degrees Celsius—is held by companies listed in global financial centers (Allen and Coffin 2022). This means that the fossil fuel assets of these companies are now overvalued. The so-called carbon bubble is estimated to reach between USD 1 trillion and USD 4 trillion by 2050 (IPCC 2022). Policy action to promote the transition toward a low-carbon economy could spark a fundamental reassessment of prospects and burst the carbon bubble. If the bubble bursts suddenly rather than gradually deflating over a span of decades, it could trigger a financial crisis—a climate Minsky moment. Sudden revaluations could trigger fire sales of carbon-intensive assets, which could potentially destabilize financial markets and spark a procyclical crystallization of losses and a persistent tightening of financial conditions (Carney 2015).

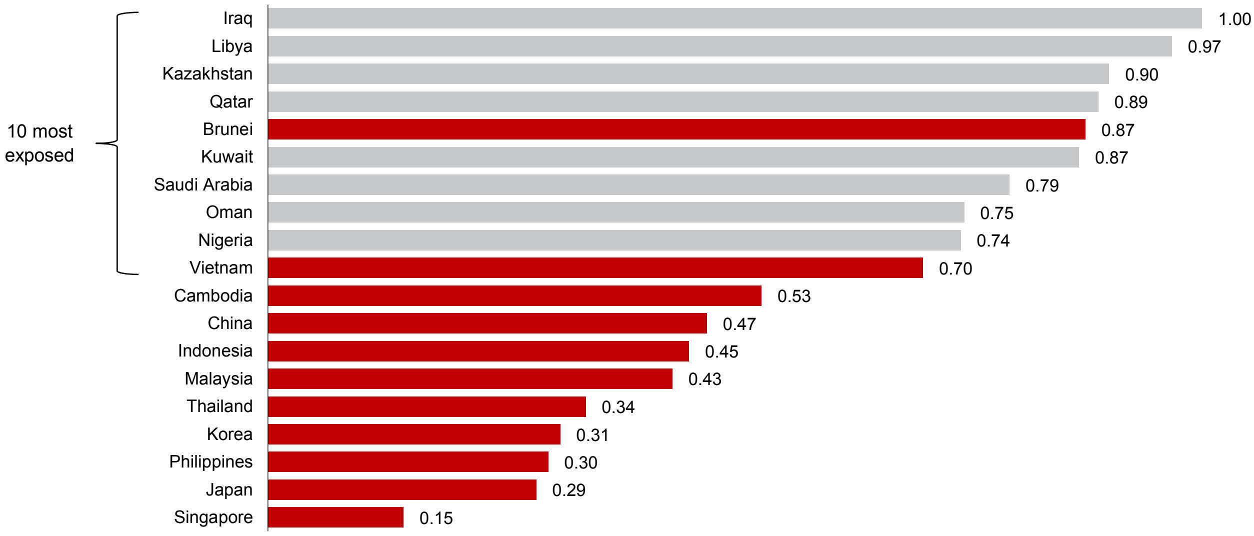
How serious is this transition risk for the region? According to Carbon Tracker, the majority of embedded emissions are listed on the stock exchanges of China (and Hong Kong), the United States, India, Russia, and Saudi Arabia (Figure 2.19). However, in the share of an exchange's market capitalization taken by companies with fossil fuel reserves, China's financial centers (Hong Kong, Shanghai, and Shenzhen) have comparatively low equity exposure to fossil fuel reserves—less than 10 percent—and the same is true for Bangkok, Jakarta, Seoul, and Tokyo (Allen and Coffin 2022). On the other hand, AMRO staff research suggests that a significant share of ASEAN+3 bank loans could be affected by transition risks (Figure 2.20) (Wong, Gabriella, and Durrani 2022). In fact, Chinese and Japanese banks are the largest funders-underwriters of global coal projects, accounting for 61 percent of total funding during 2019–21 (Urgewald 2022).

11/ Obsolescence of capital stock is a recurring and ordinarily seen feature of dynamic economic systems. Assets can become stranded through competition, innovation, and economic development (Bos and Gupta 2019; Semieniuk and others 2022). As old ("sunset") industries are replaced by new ("sunrise") industries as drivers of growth, even premature stranding of old assets is not necessarily detrimental. However, while asset stranding is a common economic phenomenon, the speed at which stranded assets accumulate can have negative repercussions on the real economy.

12/ Welsby and others (2021) estimate that by 2050, nearly 60 percent of oil and fossil methane gas and 90 percent of coal must remain unextracted to allow for a 50 percent probability of limiting global warming to 1.5 degrees Celsius. Furthermore, oil and gas production must decline globally by 3 percent each year until 2050.

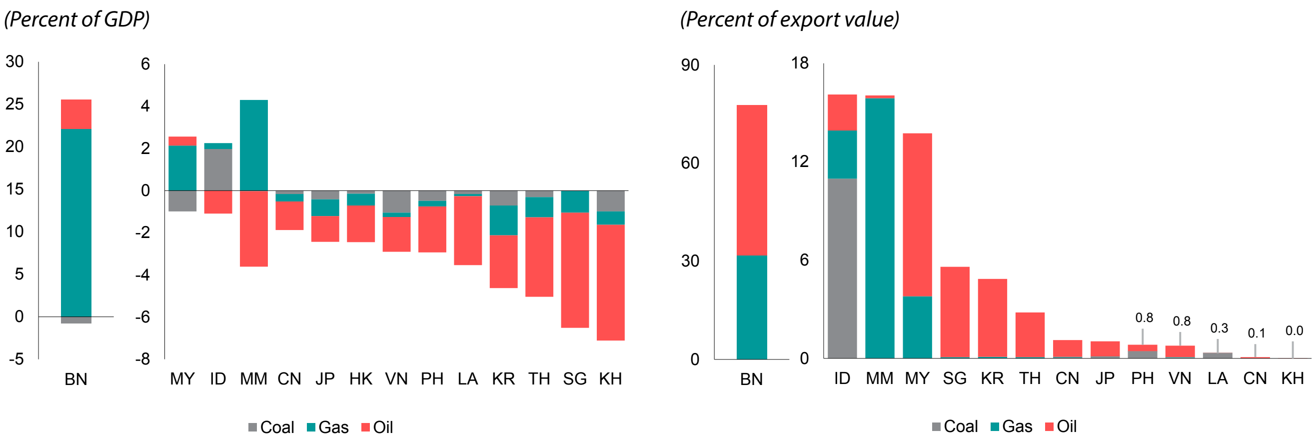
13/ Transition risks are one channel through which climate change can affect financial stability. Other channels include physical risks, i.e., the impact on insurance liabilities and the value of financial assets that arise from climate- and weather-related events, such as floods and storms that damage property or disrupt trade; and liability risks, i.e., the impacts that could arise in the future if parties who have suffered loss or damage from the effects of climate change seek compensation from those they hold responsible, such as carbon extractors and emitters and their insurers (Carney 2015).

Figure 2.14. ASEAN+3 and Selected Economies: Degree of Exposure to Stranded-Asset Risk, 2019
(Index)



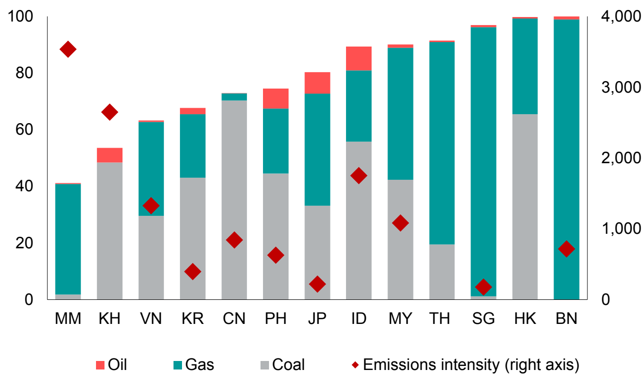
Source: Peszko and others (2020).
Note: The exposure index is based on four indicators: (1) current reliance on fossil fuel–export revenues as a percentage of GDP, an indicator of current dependency on commodity exports; (2) future reliance on expected resource rents from known fossil fuel reserves as a percentage of current gross national income, a forward-looking indicator of dependency on commodity rents; (3) current carbon intensity of manufactured exports, an indicator of current dependency on carbon-intensive manufactured goods and services; and (4) committed (future) emissions from built capital in the power sector divided by current annual power generation, a forward-looking indicator of dependency on carbon-intensive goods and services as a function of the age and emissions intensity of electricity generation. The indicator ranges from 0 to 1, where 0 is the lowest exposure and 1 is the highest exposure.

Figure 2.15. ASEAN+3: Fossil Fuel Exports, 2020–21



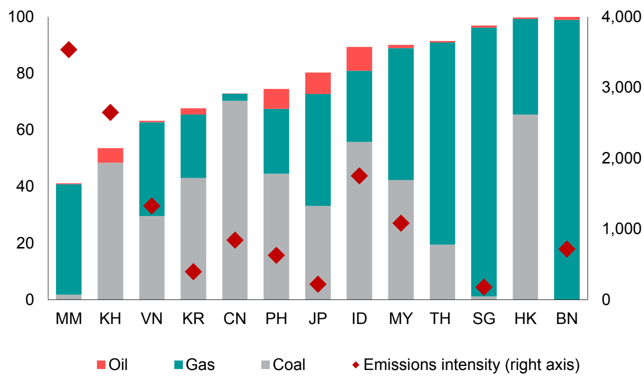
Source: UNComtrade; World Development Indicators, World Bank; AMRO staff calculations.
Note: Data in the left chart refer to net exports. Data in the right chart refer to total exports. BN = Brunei; CN = China; HK = Hong Kong; ID = Indonesia; JP = Japan; KH = Cambodia; KR = Korea; LA = Lao PDR: MM = Myanmar; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; VN = Vietnam.

Figure 2.16. ASEAN+3: Power Generation from Fossil Fuels and Emission Intensity
(Percent of total generation; tCO₂e per dollar of GDP)



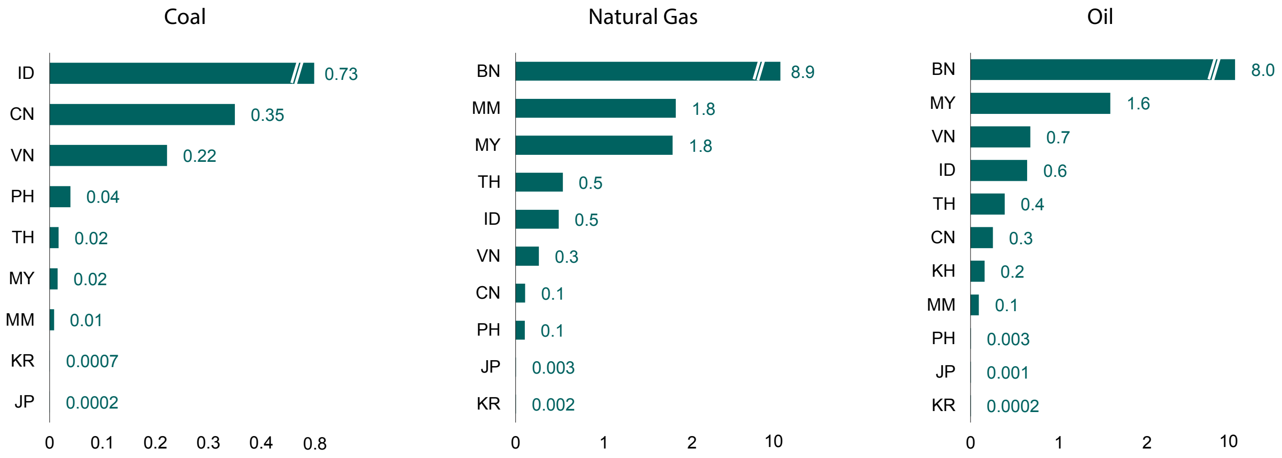
Source: Climate Watch; World Development Indicators, World Bank.
Note: BN = Brunei; CN = China; HK = Hong Kong; ID = Indonesia; JP = Japan; KH = Cambodia; KR = Korea; MM = Myanmar; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; and VN = Vietnam. Electricity generation data as of 2015; data for Lao PDR are not available. Emission intensity data as of 2019; data for Hong Kong are not available.

Figure 2.17. World: Unextractable Fossil Fuel Reserves to Limit Global Warming by 2050
(Percent of total reserves)



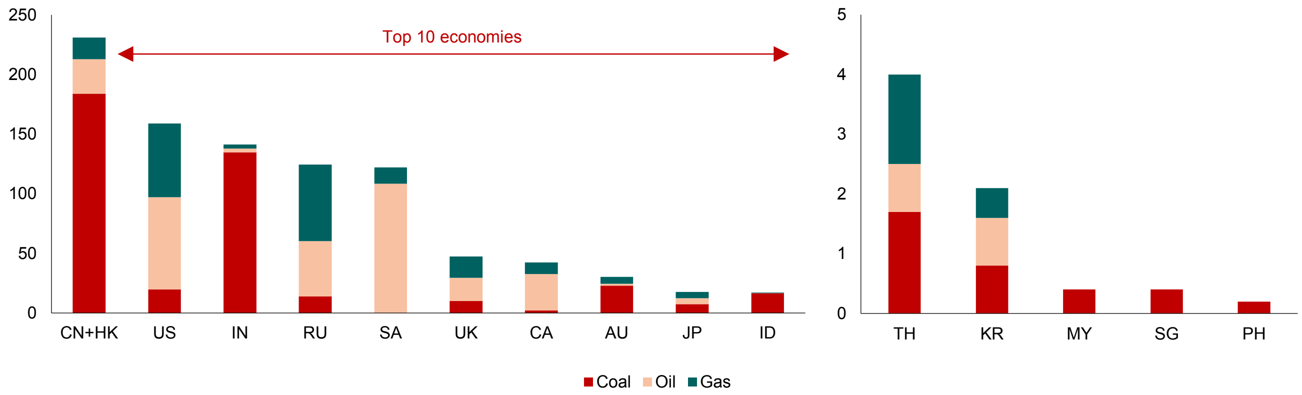
Source: Welsby and others (2021); BP Statistical Review of World Energy (2022); AMRO staff calculations.
Note: Unextractable reserves refers to the amount of fossil fuels that would need to be left in the ground, regionally and globally, to allow for a 50 percent probability of limiting global warming to 1.5 degrees Celsius by 2050.

Figure 2.18. Selected ASEAN+3: Fossil Fuel Rents, by Fuel Type, 2020
(Percent of GDP)



Source: World Development Indicators, World Bank.
Note: BN = Brunei; CN = China; ID = Indonesia; JP = Japan; KH = Cambodia; KR = Korea; MM = Myanmar; MY = Malaysia; PH = Philippines; TH = Thailand; VN = Vietnam.

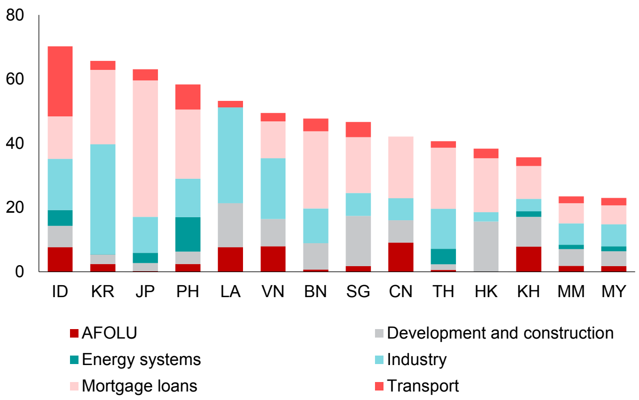
Figure 2.19. Selected Economies: Embedded Emissions in Fossil Fuel Reserves of Listed Companies, 2022
(Gigatons of carbon dioxide)



Source: Carbon Tracker (2022); AMRO staff calculations.
Note: Data are based on primary listing location and include listed and partially listed companies and all share types (restricted and freely tradeable). AU = Australia (Sydney); CA = Canada (Toronto); CN = China (Shanghai and Shenzhen); HK = Hong Kong; ID = Indonesia (Jakarta); IN = India (Mumbai); JP = Japan (Tokyo); KR = Korea (Seoul); MY = Malaysia (Kuala Lumpur); PH = Philippines (Manila); RU = Russia (Moscow); SA = Saudi Arabia (Riyadh); SG = Singapore; TH = Thailand (Bangkok); UK = United Kingdom (London); US = United States (New York).

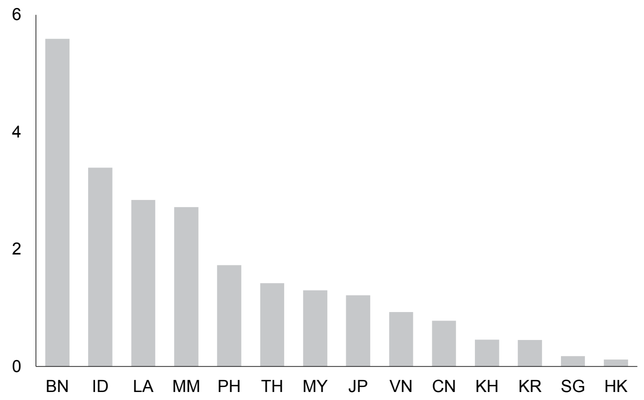
Figure 2.20. ASEAN+3: Bank Exposure to Transition Risks, 2021

Climate Change-Related Loans, by Economy
(Percent of total bank loans)



Source: National authorities via Haver Analytics; AMRO staff calculations.
Note: Myanmar's loans are based on information reported in 2020. AFOLU = agriculture, forestry, and other land use; BN = Brunei; CN = China; HK = Hong Kong; ID = Indonesia; JP = Japan; KH = Cambodia; KR = Korea; LA = Lao PDR; MM = Myanmar; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; VN = Vietnam.

Emissions per Loan, by Economy
(Tons of carbon dioxide per billion US dollars)



Source: National authorities via Haver Analytics; AMRO staff calculations.
Note: The computed shares are weighted, derived using the loan amount in each economy and sector. Emissions are based on information reported in 2020. Myanmar's loans are also dependent on information reported in 2020. BN = Brunei; CN = China; HK = Hong Kong; ID = Indonesia; JP = Japan; KH = Cambodia; KR = Korea; LA = Lao PDR; MM = Myanmar; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; VN = Vietnam.

Pilot stress tests of climate risk conducted by ASEAN+3 central banks suggest that banks would be able to absorb the losses. The People's Bank of China's (PBC's) pilot test in 2021 showed rising default risks in the thermal power, steel, and cement sectors in the absence of a low carbon transformation; nonetheless, banks were able to maintain capital adequacy ratios (CARs) above the regulatory requirement under the different stress scenarios (Reuters 2022a; China Banking News 2022).[14] Results from the Hong Kong Monetary Authority's pilot climate risk stress test likewise showed that while CARs among systemically important banks would fall in a disorderly transition, strong capital buffers would mitigate the overall impact (HKMA 2021). A pilot climate risk scenario analysis by Japan's central bank and financial regulator concluded that the estimated increase in annual credit costs due to climate risks would not exceed the average annual net income of the six major banks and nonlife insurance companies assessed (Bank of Japan and Financial Services Agency 2022). However, none of the climate risk stress tests conducted anywhere in the world to date fully captures risks from an abrupt correction in the prices of assets on bank balance sheets (Financial Stability Board 2022).

Over the long term, several factors may mitigate the risk of stranded assets. Carbon price adjustments, or regulatory equivalents, need not be sudden and unexpected. The more gradual the rise in the price of carbon, the less capital will have to be discarded before it reaches the end of its economic life. Clear and well-communicated policy signals are therefore key. A change in relative prices and a tightening of emission standards should unleash a new wave of technological progress and the cost of decarbonization could fall dramatically once endogenous technological change is considered (Acemoglu and others 2012). New "sunrise" industries are already beginning to come up to replace and reform "sunset" fossil fuel-related industries, generating demand for new resources such as critical minerals and creating value for previously unpriced natural resources such as forests and wildlife that act as carbon sinks (Section III).

Will Economic Growth Be Stunted?

"No country in the world has been able to industrialize using renewable energy..."

Yemi Osinbajo
Vice President of Nigeria
May 2022

The transition to carbon neutrality will likely be challenging for growth, especially in developing economies.[15] The implications of the net zero transition for growth can be understood in terms of the Kaya identity, where carbon emissions are expressed as a product of population, per capita GDP, energy intensity of GDP, and carbon intensity of energy (Kaya 1990):

$$\text{Carbon emissions} = \text{Population} \times \frac{\text{GDP}}{\text{Population}} \times \frac{\text{Energy}}{\text{GDP}} \times \frac{\text{Carbon emissions}}{\text{Energy}}$$

The identity implies that a reduction in carbon emissions can be achieved by a reduction in energy demand (consumption), which is captured by the first three terms on the right-hand side, and/or a reduction in carbon intensity of energy (e.g., through the adoption of cleaner sources of energy). In other words, economies would need to consume less energy and/or change their energy mix in order to meet their emission targets. If a close positive relationship exists between energy demand and GDP, and if a substantial change in the energy mix is slow to materialize, then an economy may have to forfeit some GDP growth to reduce the consumption of primary energy—and thus, emissions.

The relationship between energy demand and GDP (income level) is thought to follow an S-shaped curve. Bogmans and others (2020) find that for low-income economies, the income elasticity of energy demand is low and increasing; for middle-income economies, the elasticity peaks at approximately unity; and for high-income economies, the elasticity is decreasing. This suggests that reducing energy consumption to lower emissions would imply a greater cost to growth for low- and middle-income economies than for high-income economies. Reflecting this, some economies, including China, Hong Kong, and Malaysia among the ASEAN+3, have committed to reduce their emissions intensity (i.e., the ratio of emissions to GDP) rather than their absolute level of emissions, while others, including Brunei, Cambodia, Indonesia, the Philippines, Thailand, and Vietnam, have set goals to reduce emissions off a business-as-usual growth scenario (Box 2.1).

14/ The 2021 pilot test covered 23 major banks. In June 2022, the PBC announced plans to expand its climate stress test to assess the impact of climate risks in additional industries, including aviation, metals, and petrochemicals, on the financial sector.

15/ To be sure, achieving carbon neutrality will benefit everyone with a preserved climate in the long term but the transition to a decarbonized steady state could see declines in real income and the standard of living in some economies under certain scenarios.

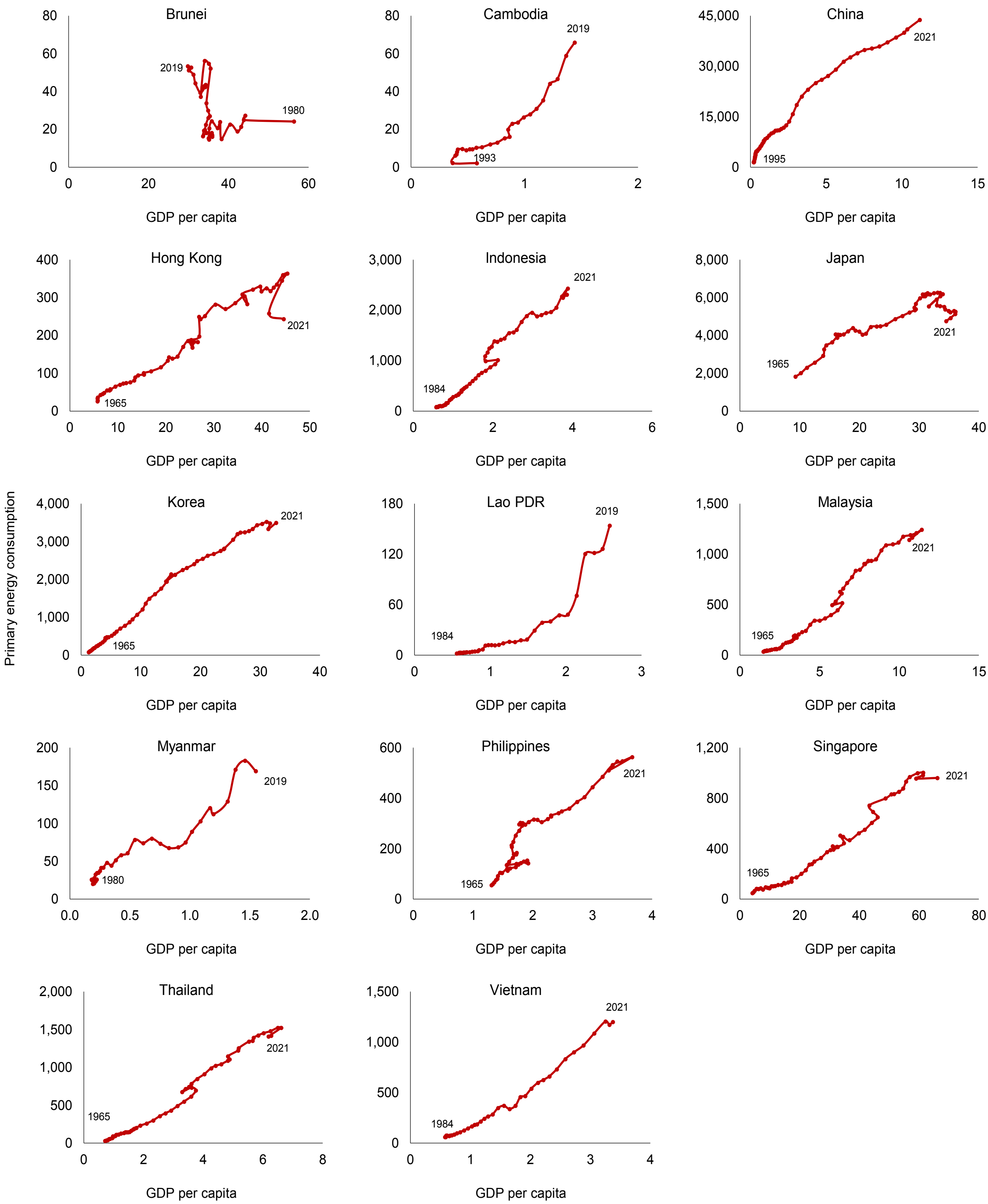
Energy demand in the region is generally expected to remain on an uptrend over the next few decades. The region's economies are in different stages of economic development, but almost all of them have more than doubled the size of their economies since 2000. Economic growth has been accompanied by urbanization and motorization, which have led to greater energy consumption (Figure 2.21). As the region's economies continue to develop, their energy demand will increase in tandem. On the other hand, energy demand is also a function of energy intensity, which can be lowered through more efficient energy consumption—as has been the case over the past two decades across the region (Figure 2.22). For energy demand to decline, future energy efficiency gains—e.g., from more stringent energy performance and fuel-economy standards, building energy codes and industry targets, and technological advances in energy management in the industrial and building sectors—will need to outpace the effect of income growth on energy consumption (Table 2.3). IEA projections indicate that this is not likely to happen in the region, except possibly in Japan (IEA 2022a; IEA 2021b).[16]

The implication of emission reduction for the region's long-term growth and development therefore hinges on changing the energy mix away from fossil fuels. As noted earlier, almost all ASEAN+3 economies have set targets or pledged to increase the share of clean or renewable energy in their energy mix and to reduce the use of coal power (Table 2.1). As ASEAN+3 economies progressively incorporate non-fossil fuel sources into their energy mix, their energy carbon intensity is projected to decline.

According to national authorities' policy roadmaps and IEA assessments, the decline in carbon intensity will likely be sufficient to bring down absolute GHG emissions by 2050 in the Plus-3, but not in ASEAN, where energy demand is expected to remain robust in the decades to come (IEA 2021b; Lee 2021). The key question, therefore, is whether the region's emerging market and developing economies will be able to meet their future energy needs without relying as much on coal and other fossil fuels; it is worth noting that even the world's advanced economies are not expected to switch substantially out of fossil fuels by 2050 (IEA 2022h) (Figure 2.23). The next section discusses the outlook for reducing carbon intensity in the region.

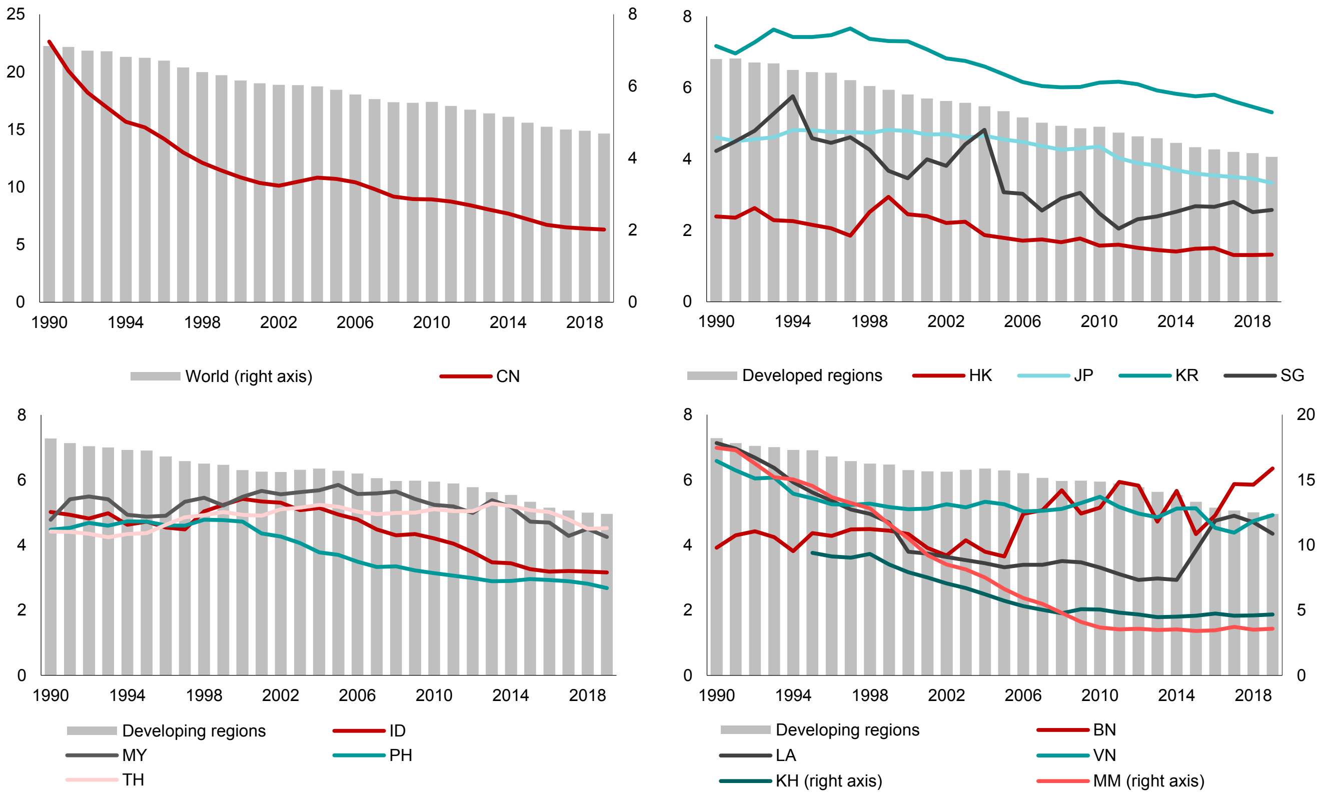
16/ Based on countries' stated policies, IEA (2022h) forecasts that energy demand in advanced economies will decline by about 0.5 percent a year whereas energy demand in emerging market and developing economies will increase by over 1.4 percent a year over the rest of this decade.

Figure 2.21. ASEAN+3: Primary Energy Consumption versus GDP Per Capita
(Terawatt-hours; Thousands of US dollars in constant 2015 prices)



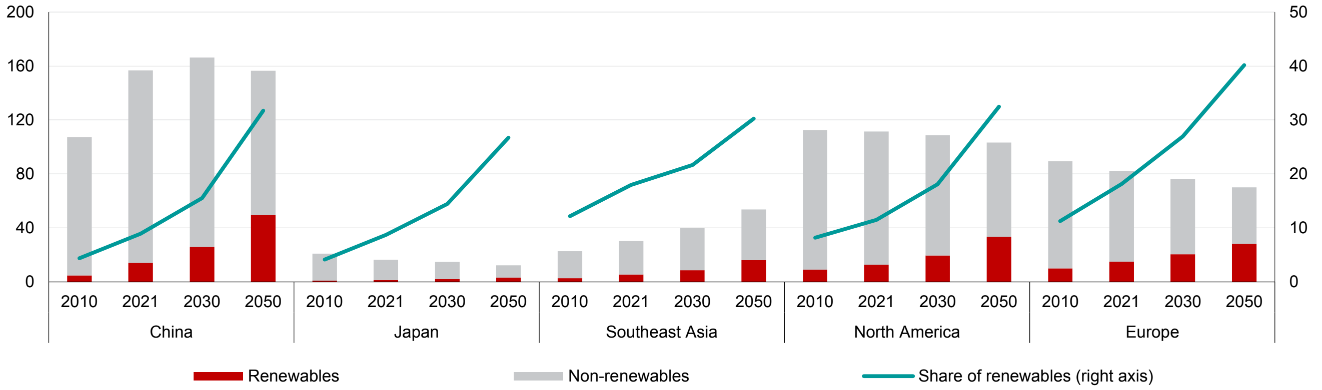
Source: Our World in Data (2022a); World Development Indicators, World Bank.
Note: Primary energy consumption refers to the total energy demand of an economy, including for the use of electricity, heating, and transport. Data includes only commercially traded fuels (coal, oil, and gas) as well as nuclear and modern renewables except traditional biomass.

Figure 2.22. ASEAN+3: Energy Intensity of GDP
(Megajoules per constant 2017 international dollars using purchasing power parity rates)



Source: International Energy Agency (IEA).
Note: BN = Brunei; CN = China; HK = Hong Kong; ID = Indonesia; JP = Japan; KH = Cambodia; KR = Korea; LA = Lao PDR; MM = Myanmar; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; VN = Vietnam.

Figure 2.23. Selected Economies: Projected Energy Supply and Energy Mix
(Petajoules; percent)



Source: International Energy Agency (2022h); AMRO staff calculations.
Note: Projections are based on the IEA's "stated policies scenario," which accounts for policies and implementing measures affecting energy markets adopted as of the end of September 2022, together with relevant policy proposals even if specific measures needed to put them into effect have yet to be fully developed.

Table 2.3. ASEAN: Energy Access and Energy Efficiency Targets

Economy	Energy Access Policies and Targets	Energy Efficiency Policies and Targets
Brunei		• Reduce total energy consumption by 63 percent from business-as-usual (BAU) levels by 2035. • In June 2021, the Ministry of Energy announced new minimum energy performance standards for air conditioning systems and other electrical appliances. This plan is expected to reduce energy intensity by 45 percent from 2005 levels by 2035.
Cambodia	• Achieve near-universal electrification by 2030.	• Cut energy consumption by 20 percent relative to BAU by 2035.
Indonesia	• Achieve 100 percent electrification by the end of 2024.	• Reduce energy intensity by 1 percent a year to 2025.
Lao PDR	• Achieve electrification rate of 98 percent by 2025.	• Reduce final energy consumption by 10 percent from the BAU level by 2040.
Malaysia	• Achieve (rural) electrification rate of 99 percent by 2025.	• Promote energy efficiency in the industry and buildings sectors and reduce overall energy intensity by 2040 through mandatory minimum efficiency performance standards.
Myanmar	• Achieve electrification rate of 100 percent by 2030.	• Reduce primary energy demand by 8 percent from the BAU level by 2030.
Philippines	• Achieve 100 percent electrification by 2028.	• Reduce energy intensity by 40 percent by 2030 from 2010 level. Decrease energy consumption by 1.6 percent a year by 2030 from baseline forecasts. Reduce energy intensity and total energy consumption by 24 percent relative to the BAU level by 2040
Singapore		• Improve energy intensity by 35 percent from the 2005 level by 2030.
Thailand		• Reduce energy intensity by 30 percent from the 2010 level by 2036.
Vietnam		• In June 2019, the government officially approved the Vietnam Scaling Up Energy Efficiency Project to promote energy efficiency in the industrial sector. The project received funding from the World Bank in March 2021.

Source: International Energy Agency (IEA); AMRO staff compilation.

III. In with the New: Growth Opportunities of Moving Toward Carbon Neutrality

The transition to net zero is rich in opportunities, holding out the prospect of expanding markets for renewable energy, low-emission products, carbon-removal technologies, and carbon offsets, among others. There are many ways to reduce the buildup of carbon dioxide and other GHGs in the atmosphere. High-emitting fuels like coal, oil, and gas can be replaced with nearly carbon-free alternatives, such as solar power, wind power, or nuclear power. Carbon dioxide can be captured from fossil fuel power and manufacturing plants and stored underground. Carbon dioxide can also be removed from the atmosphere by reforestation and farming practices that store more carbon in the soil. This section takes stock of what has been achieved in ASEAN+3 in this area so far, highlights the most promising transition opportunities for its economies given their natural, human, and technological resources, and explores what they can do to make the best use of these opportunities.

Clean Energy

"Ensure access to affordable, reliable, sustainable, and modern energy for all."

United Nations Sustainable Development Goal 7

Clean energy comes from zero-emission sources that do not pollute the atmosphere. This includes renewable energy, derived from sources that can constantly replenish, as well as alternatives like nuclear energy and hydrogen. Clean energy is considered "green" if it is generated from renewable sources like the sun, wind, and water. Hydrogen, for example, is considered a clean fuel in that it produces no emissions—only water—when consumed in a fuel cell, but hydrogen is considered "green" only if it is produced using renewable energy sources. Nuclear energy is not renewable by most definitions, but nuclear energy production does not release GHGs, so it is a clean fuel.[17]

[17] Nuclear energy is produced when atoms are split apart during nuclear fission. The most common fuel used for nuclear fission in nuclear power plants is uranium, which is a non-renewable resource.

Renewable energy

The ASEAN+3 region has an abundance of renewable energy resources. Sunlight, wind, and water are plentiful—at least in theory. In practice, an economy's renewable energy potential depends not just on resource potential, but also on technical potential (i.e., the amount of energy that can be generated given topographic, environmental, and land-use constraints, among others) and economic and market potential, which is the amount of energy that can be produced viably, taking into account market factors (Brown and others 2016). For example, even as solar energy is abundant, its widespread deployment may not be feasible for economies like Singapore, with its limited land area and rooftop space.[18] And while Japan is endowed with ample geothermal resources, lack of social acceptance limits their use for energy generation (GRSJ 2020). Yet even after adjusting for such factors, the region still has significant renewable energy potential to be tapped—according to ADB (2021), for example, most ASEAN economies have utilized less than 2 percent of their solar potential.

All ASEAN+3 economies include renewable energy targets among their climate change or sustainable growth strategies; many have also made commitments for specific types of renewable energy (Table 2.4). If these targets are met, the share of renewable energy in total electricity generation and consumption will increase substantially over the next decade and a half—driven mainly by solar, hydro, and wind energy.

Policymakers in the region are employing various measures to promote renewable energy. Key policies include: renewable energy auctions whereby the government issues a call for tenders to install a certain capacity of renewable energy-based electricity; feed-in tariffs that pay renewable energy producers to transfer excess electricity to the grid;[19] net metering, an electricity billing system that offers a credit to residential and commercial customers for sending excess electricity from their renewable energy sources (e.g., solar panel systems) to the grid; as well as government regulations mandating biofuel blending and renewable transport fuels (Table 2.5).[20] Outright fiscal support along with various tax reductions are also used to incentivize suppliers and help keep end-user prices low.

Table 2.4. ASEAN+3: Commitments on Renewable Energy

Economy	Commitment(s)
Brunei	• Meet 30 percent of overall power generation mix with renewable energy by 2035, using mainly solar photovoltaic.
Cambodia	• Increase the share of renewable energy in the power generation mix to 25 percent by 2030 (of which 12 percent will come from solar photovoltaic) and 35 percent by 2050.
China	• Meet more than 50 percent of additional electricity consumption over 2021–25 with renewable power generation. Increase the share of renewable energy in final electricity consumption (by 15 percent for hydro and 18 percent for non-hydro renewables) by 2025. Supply 33 percent of national power consumption with renewables by 2025.
Hong Kong	• Increase the share of renewable energy in the fuel mix for electricity generation to 7.5–10 percent by 2035 and to 15 percent before 2050.
Indonesia	• Increase the share of renewables in the power generation mix to 43 percent by 2050. Increase the installed capacity of renewables (by 10.4 GW of hydropower, 4.7 GW of solar photovoltaic, 3.4 GW of geothermal, 1.3 GW of other new renewables, 0.6 GW of bioenergy and 0.6 GW of onshore wind) in 2021–30.
Japan	• Increase the share of renewables in the energy mix to 36–38 percent (of which 14–16 percent solar, 11 percent hydropower, 5 percent wind, 5 percent biomass, and 1 percent geothermal) by 2030.
Korea	• Install 70 GW renewable energy out of a total of 198 GW capacity by 2030.
Lao PDR	• Increase the share of nonlarge hydropower renewables in the power mix to 30 percent by 2025.
Malaysia	• Increase renewable energy generation to 18 GW (40 percent of the country's energy supply) by 2035.
Myanmar	• Increase the share of renewable energy (hydro, solar and wind) in the total energy mix to 39 percent by 2030 (48 percent conditional on international support).
Philippines	• Increase the share of renewable energy in the power generation mix to 35 percent by 2030 and 50 percent by 2040.
Singapore	• Increase solar panel deployment to at least 2 GW-peak by 2030. Import up to 4 GW of low-carbon electricity, about 30 percent of electricity supply, by 2035.
Thailand	• Increase the share of renewable energy in the fuel mix used to produce electricity to 50 percent by 2040. Increase the share of biomass, biogas, solar, and wind to achieve the renewable energy target.
Vietnam	• Increase the share of renewables (excluding hydropower) in the power generation mix to 52 percent in 2045. Increase generation of wind power to 23.1 GW by 2030 and 122.4 GW by 2045; large-scale solar power to 11.2 GW by 2030 and 76.0 GW by 2045; biomass and other renewables to 1.2 GW by 2030 and 5.2 GW by 2045; and pumped hydroelectricity and storage to 2.5 GW by 2030 and 29.0 GW by 2045.

Source: AMRO staff compilation from various government announcements.
Note: GW = gigawatt.

18/ Singapore alone among the ASEAN+3 is as an "alternative energy-disadvantaged" economy due to its urban density, low wind speeds, limited and relatively flat land area, and lack of geothermal resources (Singapore Ministry of Sustainability and the Environment 2019).

19/ Feed-in tariffs and premiums typically involve long-term contracts and cost-based compensation. Renewable energy producers receive a fixed, above-market electricity price from the service provider or grid operator for each unit of energy they produce and deliver to the grid as part of this performance-based incentive program.

20/ A biofuel blending mandate sets a requirement on fuel suppliers to blend a certain percentage of fuels derived from biomass (e.g., ethanol or palm oil) with a petroleum-based fuel (e.g., diesel).

Table 2.5. ASEAN+3: Renewable Energy Policies

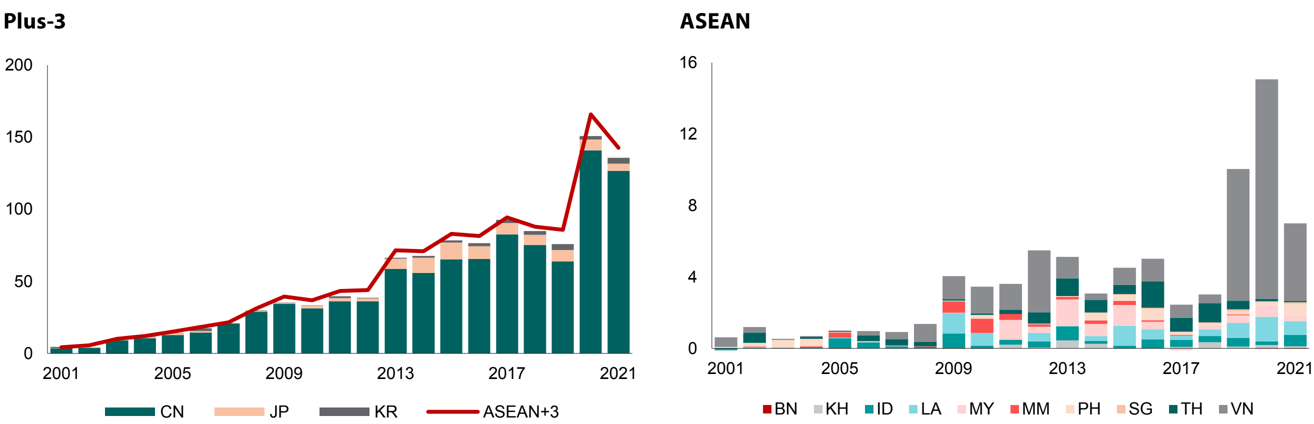
	Economy	BN	CN	ID	JP	KH	KR	LA	MM	MY	PH	SG	TH	VN
Regulatory	Feed-in tariff/premium payment		●	●	●					●	●		●	●
	Electric utility quota obligation/ Renewable portfolio standards		●	●			●			●	●			●
	Net metering/billing						●			●	●	●	●	●
	Biofuel blend, renewable transport obligation/mandate		●	●			●			●	●		●	●
	Renewable heat obligation or mandate, heat feed-in tariff, fossil fuel ban for heating		●				●							
	Tradable renewable energy certificates				●		●					●		●
	Tendering		●	●	●	●			●	●	●	●		●
Fiscal	Tax reductions		●	●	●		●		●	●	●		●	●
	Investment or production tax credits		●	●			●			●	●			●
	Energy production payment		●		●		●				●		●	●
	Public investment, loans, grants, capital subsidies or rebates		●	●	●		●			●	●	●	●	●

Source: REN21 (2022); AMRO staff compilation.
Note: BN = Brunei; CN = China; HK = Hong Kong; ID = Indonesia; JP = Japan; KH = Cambodia; KR = Korea; LA = Lao PDR; MM = Myanmar; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; VN = Vietnam.

These policies, together with declining renewable energy-generation costs, have led to a robust rollout of renewables capacity in recent years (Figure 2.24). According to the International Renewable Energy Agency (IRENA), the global weighted average levelized cost of electricity of newly commissioned utility scale solar photovoltaic projects declined by 88 percent and that of onshore and offshore wind projects by at least 60 between 2010 and 2021 (IRENA 2022) (Figure 2.25). Renewables make up about a quarter of ASEAN+3 power generation on average, with the share ranging from as high as 70 percent in Lao PDR to less than 1 percent in Hong Kong and Brunei (Figure 2.26).[21] China leads the region in installed capacity, followed by Japan, Vietnam, and Korea (Figure 2.27) (Box 2.5). Hydropower, (onshore) wind, and solar photovoltaics are dominant sources, collectively accounting for more than 90 percent of the region's current renewable energy capacity and mix (Figure 2.28). These three sources of renewable energy are considered truly "zero" emissions, compared to other renewables such as geothermal energy (low emissions) and biomass (neutral emissions). They provide an especially advantageous pathway for the region to reduce its dependence on fossil fuels.

More can be done in the region to hit national targets on time (Figure 2.29). The uptake of renewable energy remains constrained by massive investment needs, administrative bottlenecks (e.g., licensing, lengthy contract negotiations) and tepid public support. Parallel efforts to upgrade and modernize national grids, improve the ease of doing business, improve rural electrification, and resolve land acquisition issues can entice much-needed private sector participation and resources. Regional cooperation will have a role to play, given the substantial investments needed for scaling up renewables.

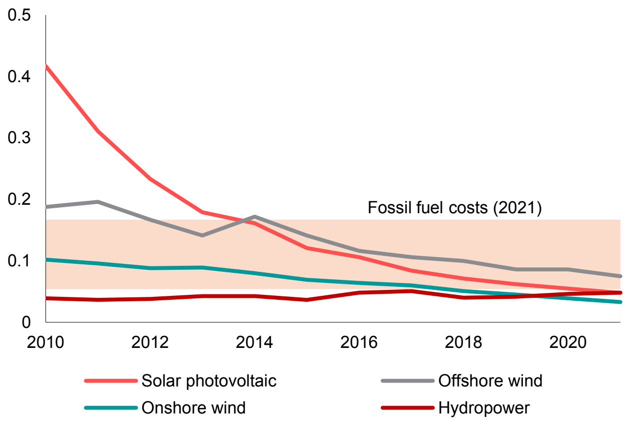
Figure 2.24. ASEAN+3: Renewable Net Capacity Additions
(Gigawatts)



Source: International Renewable Energy Agency (IRENA); AMRO staff calculations.
Note: BN = Brunei; CN = China; ID = Indonesia; JP = Japan; KH = Cambodia; KR = Korea; LA = Lao PDR; MM = Myanmar; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; and VN = Vietnam.

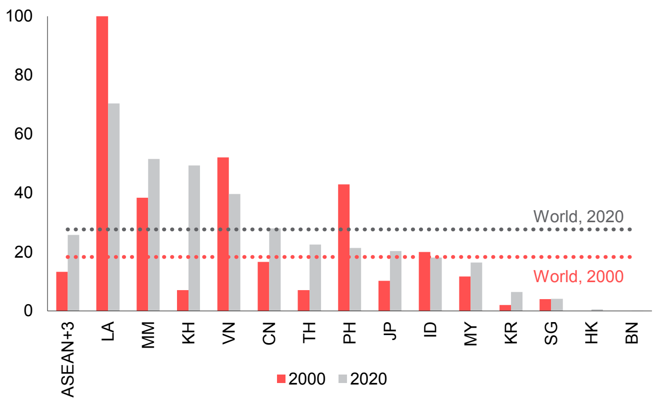
[21] Lao PDR, the Philippines, and Vietnam saw their shares of renewables in electricity generation decline between 2000 and 2020. The three economies increased the use of fossil fuels—mainly coal—for various reasons, e.g., to supplement variable hydropower supply, especially during the dry season (Lao PDR); as a cheaper and more reliable energy source (the Philippines); and to meet surging energy demand driven by rapid economic growth (Vietnam).

Figure 2.25. World: Levelized Costs of Electricity, by Selected Technology
(2021 US dollars per kilowatt-hour)



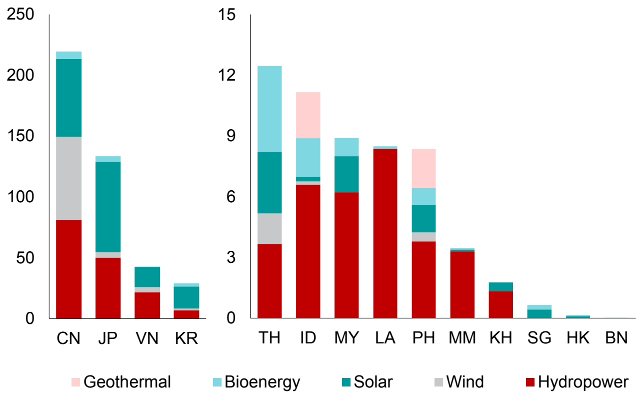
Source: International Renewable Energy Agency (2022).
Note: The levelized cost of electricity or energy calculates the present value of the total cost of building and operating a power plant over an assumed lifetime; as such, it allows for the comparison of projects with different technologies and varying risk-return characteristics.

Figure 2.26. ASEAN+3: Renewable Electricity Generation
(Percent of total generation)



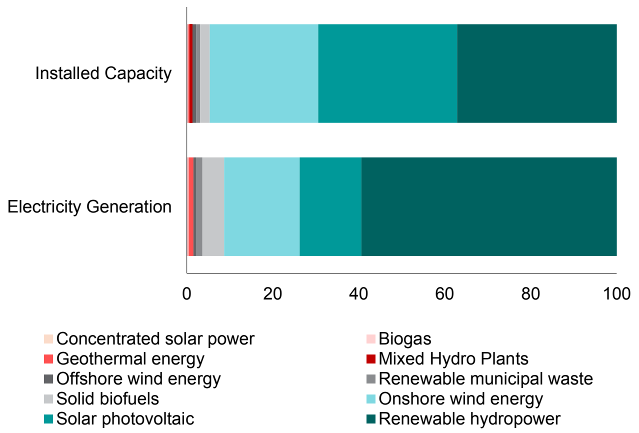
Source: International Renewable Energy Agency (IRENA); AMRO staff calculations.
Note: BN = Brunei; CN = China; HK = Hong Kong; ID = Indonesia; JP = Japan; KH = Cambodia; KR = Korea; LA = Lao PDR; MM = Myanmar; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; VN = Vietnam.

Figure 2.27. ASEAN+3: Renewable Energy Installed Capacity, 2021
(Gigawatts)



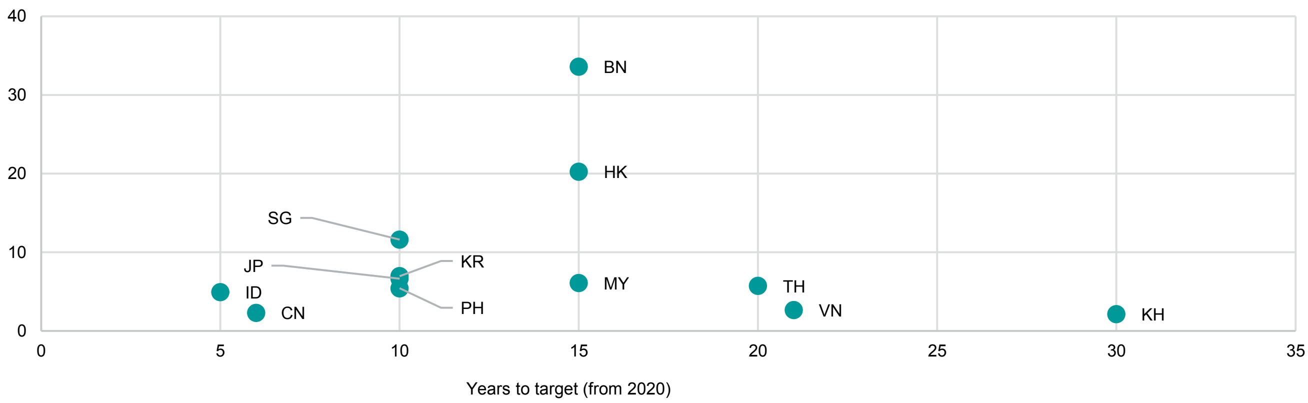
Source: International Renewable Energy Agency (IRENA); AMRO staff calculations.
Note: BN = Brunei; CN = China; HK = Hong Kong; ID = Indonesia; JP = Japan; KH = Cambodia; KR = Korea; LA = Lao PDR; MM = Myanmar; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; VN = Vietnam.

Figure 2.28. ASEAN+3: Renewable Technology Mix
(Percent of total renewables)



Source: International Renewable Energy Agency (IRENA); AMRO staff calculations.
Note: Data for installed capacity as of 2021, while for electricity generation, data are as of 2020.

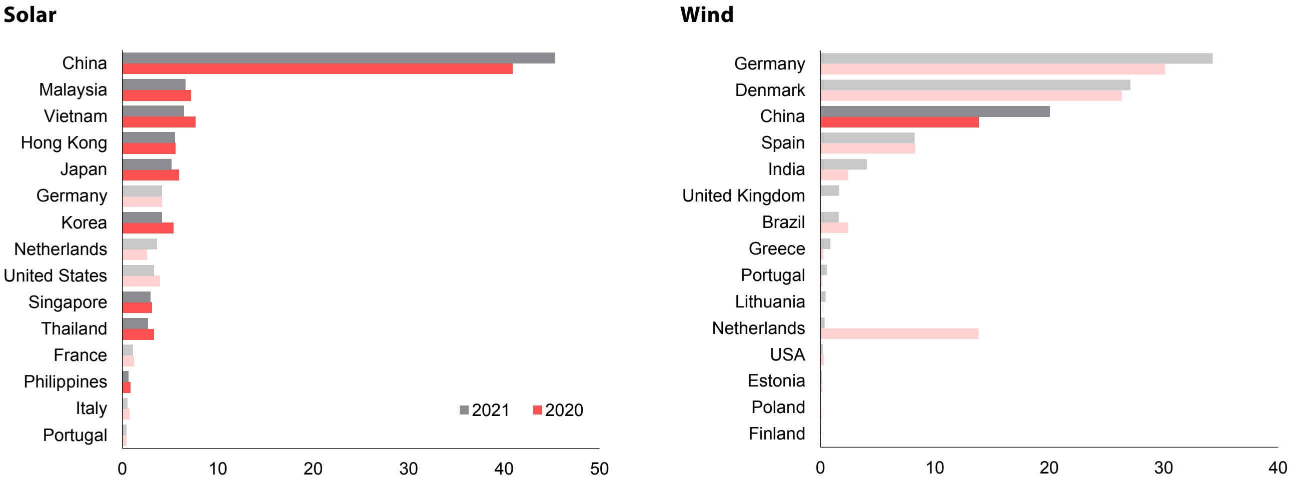
Figure 2.29. ASEAN+3: Implied Compound Annual Growth Rate of Renewables Share to Achieve Announced Target
(Percent)



Source: AMRO staff calculations.
Note: The implied compound annual growth rate for each economy is based on the difference between the actual share of renewable energy (as of 2020) and the target share of renewable energy that has been officially announced. Hence, economies in the upper left quadrant of the chart have to do more in less time in order to reach their announced targets compared to economies in the lower right quadrant of the chart, for example. Lao PDR and Myanmar are omitted due to unavailability of official actual data. Cambodia's data refer to its target for solar energy only. BN = Brunei; CN = China; ID = Indonesia; JP = Japan; KH = Cambodia; KR = Korea; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; VN = Vietnam.

Trade in renewables will benefit the ASEAN+3 region as a whole, while providing an additional stream of revenues for exporters. In June 2022, Singapore started a two-year pilot project to import hydropower from Lao PDR; Thailand, Vietnam, and Cambodia also import hydropower from Lao PDR, which aims to build its reputation as the "battery of Southeast Asia" (PWC 2022) (Box 2.6). Similar agreements could provide revenue for other potential exporters in the region, such as Indonesia, Malaysia, Myanmar, Thailand, and Vietnam, although the export opportunities would be weighed against local needs (Tani 2022). The surge in demand for clean energy technology globally will be another boost for ASEAN+3 exporters of solar panels, wind turbines, and energy storage equipment, given their comparative advantage. ASEAN+3 economies are among the top 15 exporters of solar power products globally; China is also a major exporter of wind power products (Figure 2.30). However, trade restrictions in major trading partners could be obstacles—the United States' long-running restrictions on solar panel imports from China and, by extension, Cambodia, Malaysia, Thailand, and Vietnam, is a cautionary example.[22]

Figure 2.30. World: Top 15 Exporters of Solar and Wind Energy Products, 2020–21
(Percent of world exports in billions of US dollars)



Source: IHS Markit Global Trade Atlas; UN Comtrade; AMRO staff calculations.
Note: Solar energy products refer to HS code 854140. The top 15 exporters accounted for 92.6 percent of all solar energy products sold on international markets during 2021. Wind energy-related goods refer to HS code 850231. The top 15 exporters accounted for 99.7 percent of all solar energy products sold on international markets during 2021.

[22] The solar-panel trade conflict between the United States and China dates to 2012, when the United States began imposing duties on China-made solar panels, arguing that manufacturers in China were unfairly selling their products in the United States at prices below the cost of production. The United States also banned the import of polysilicon and solar power products from Xinjiang, claiming that they were made using forced labor. The tariffs were then expanded to apply to solar panels manufactured in Cambodia, Malaysia, Thailand, and Vietnam over suspicion that they were circumventing the restrictions on Chinese products. In June 2022, the United States announced a two-year tariff exemption for solar products from those four ASEAN economies. But in December 2022, the United States determined that four major Chinese manufacturers had circumvented existing tariffs on China-made solar cells and panels by finishing their products in Cambodia, Malaysia, Thailand, and Vietnam. Those companies will face the same duty rates the United States already assesses on their China-made products once the two-year waiver expires in June 2024. In addition, all solar companies exporting to the United States from Cambodia, Malaysia, Thailand, and Vietnam will be required to certify that a significant proportion of their materials are not from China.

Box 2.5:

Vietnam's Solar Energy Boom

Vietnam has seen unparalleled growth in solar power. Installed solar power capacity shot up from essentially zero in 2017 to over 16 gigawatts in 2021, putting Vietnam with China, Japan, and Korea among the top 10 countries with the highest solar capacity in the world (Figure 2.5.1). Solar power output increased to account for almost 5 percent of Vietnam's total electricity generation in 2021—the second-highest share in ASEAN+3 after Japan (Figure 2.5.2) (Ember 2022).

This growth was initiated by the 2015 Decision of the Prime Minister outlining the renewable energy development strategy and vision through 2050. Decision 2068/QD-TTg of 2015 sets targets for solar power production to increase to 35.4 billion kilowatt-hours (kWh) or 6 percent of total electricity production in 2030 and 210 billion kWh (20 percent of total electricity production) in 2050. The Decision was followed over the next five years by a raft of policies, regulations, initiatives, and programs focused on the development of solar energy in Vietnam.

Specific encouragement for solar power development includes feed-in tariffs (FITs) and preferential tax rates, land-use incentives, and access to finance. The government had early on identified the importance of creating favorable conditions for the private sector to participate in solar power development in Vietnam. In April 2020, Decision 13/2020/QD-TTg committed the country's largest power company, Vietnam Electricity, and its branches to purchase electricity from solar energy generators at fixed FIT rates for 20 years (Figure 2.5.3). The FIT program incentivized investors to move quickly to install rooftop solar power—by its expiry at the end of 2020, there were 104,000 rooftop solar power projects in 63 localities across the country.

A few key issues still need to be resolved for solar power to realize its full contribution to Vietnam's clean energy transition.

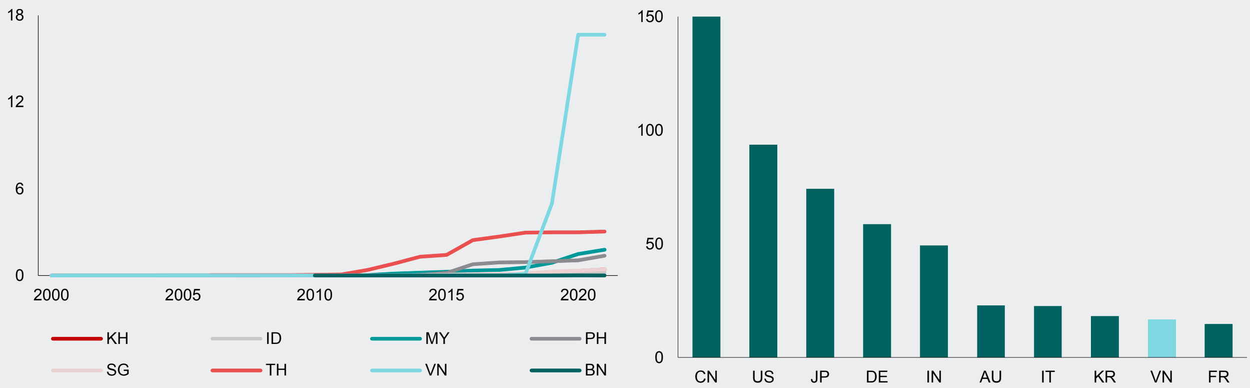
- *Grid congestion*. The national grid system is not able to integrate large amounts of solar power. The FITs proved so popular they caused an overload of supply and Vietnam Electricity stopped receiving requests for connection and signings of power purchase agreements at the end of 2020. Many solar power plants still cannot operate at full capacity, resulting in a waste of resources and electricity not being transmitted from areas with surplus to areas in need. A clear grid investment plan to integrate variable energy should be a priority.

- *Energy storage*. Solar energy production varies with the weather, season, time of day, region of the country, and so on. Therefore, it is necessary to find solutions to store excess solar power generated when the sun is shining for use when (or where) it is not. Better forecasting of variable solar energy production would also help grid management.

- *Regulatory framework*. Many of Vietnam's regulations on the licensing, construction, and operation of solar power plants and the purchase and sale of solar power are still incomplete and unclear. This has brought difficulties for businesses, such as unexpected costs, delays, and disputes with Vietnam Electric. A comprehensive and transparent regulatory and legal framework would help remove bottlenecks in transmission and capacity and improve the landscape for investment.

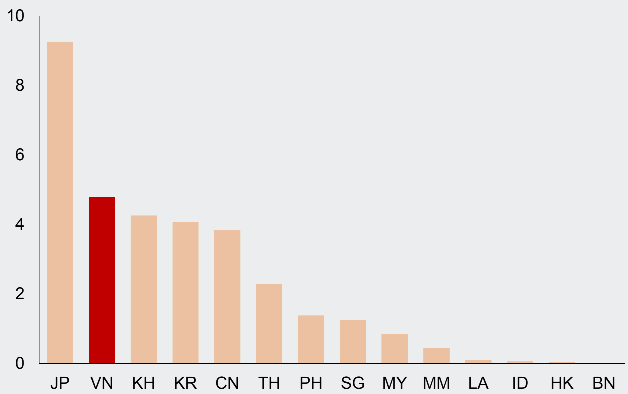
This box was written by Thi Thanh Do.

Figure 2.5.1. Selected Economies: Installed Solar Photovoltaic Capacity
(Gigawatts)



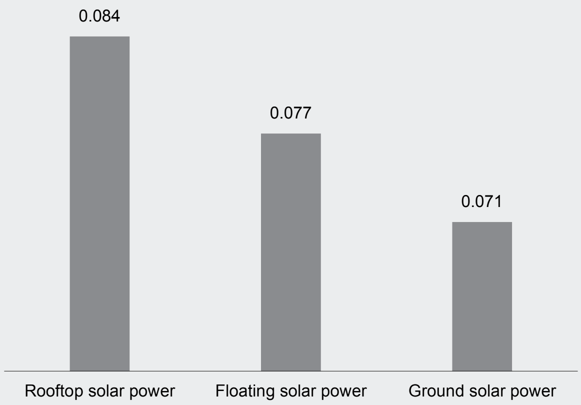
Source: International Renewable Energy Agency; AMRO staff calculations.
Note: AU = Australia; BN = Brunei; CN = China; DE = Germany; FR = France; ID = Indonesia; IN = India; IT = Italy; JP = Japan; KH = Cambodia; KR = Korea; LA = Lao PDR; MM = Myanmar; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; US = United States; VN = Vietnam.

Figure 2.5.2. ASEAN+3: Electricity Production from Solar Photovoltaics, 2021
(Percent of total electricity production)



Source: Our World in Data (2022b).
Note: BN = Brunei; CN = China; HK = Hong Kong; ID = Indonesia; JP = Japan; KH = Cambodia; KR = Korea; LA = Lao PDR; MM = Myanmar; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; VN = Vietnam.

Figure 2.5.3. Vietnam: Feed-in Tariff Rates, 2021
(US dollars per kilowatt-hour)



Source: Vietnam National Steering Committee for Electricity Development.

Box 2.6:

(Hydro)Powering Lao PDR's Energy Trade

Lao PDR has a huge natural advantage in hydropower energy development over its ASEAN peers (Figure 2.27). With a considerable portion of the Mekong River located within its borders, along with favorable terrain, high yearly precipitation, and low population density, it is among the world's top economies in terms of hydropower potential per capita, and the highest among the ASEAN+3 (Hoes and others 2017).

Total installed hydropower capacity in Lao PDR jumped in the last decade, thanks to a massive investment program. Between 2019 and 2021, it added about 2.1 gigawatts (GW) of hydropower capacity, the third-highest globally during the period (Figure 2.6.1). Within the region, it ranked below only China, Japan, and Vietnam in terms of total installed capacity in 2021 (Figure 2.6.2).

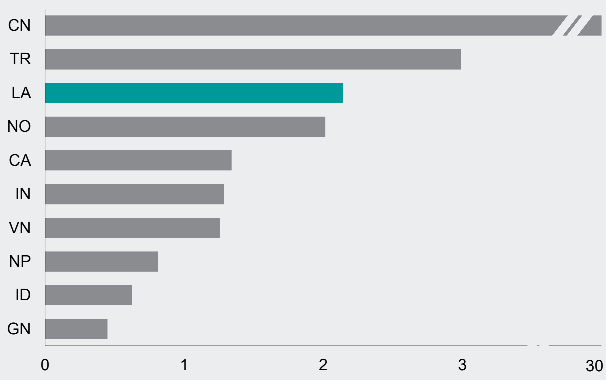
Lao PDR is the top net exporter of electricity in ASEAN (Figure 2.6.3). With installed hydropower capacity at least three times greater than domestic consumption of electricity, it has seized the economic opportunity to export surplus energy to the rest of the region (PWC 2022). Lao PDR exports nearly 80 percent of its total hydropower generation capacity. Electricity exports—mainly hydropower—are key drivers of the economy's trade and economic growth, accounting for about 22 percent of total export earnings during 2017–21, and about 9 percent of its 2021 GDP (Figure 2.6.4). Thailand is its largest export market, followed by Cambodia, Vietnam, and Myanmar. Singapore was added to the list in June 2022, with the signing of the Lao PDR–Thailand–Malaysia–Singapore Power Integration Project, which allows it to import up to 0.1 GW of hydropower through existing interconnections in Thailand and Malaysia for an initial period of two years—the first multilateral cross-border electricity trade involving four ASEAN economies.

Lao PDR's ambition is to become the "Battery of Southeast Asia." Much of the expansion in its electricity sector will be driven by strong external demand and official bilateral agreements: power exports are anticipated to increase sharply from about 4.5 GW currently to more than 25GW by 2030, of which about 10GW is earmarked for Thailand, about 8 GW for Vietnam, and 6 GW for Cambodia (UNESCAP 2022; VNA 2022). To meet the anticipated rise in demand for renewable energy, hydropower development is a top priority in Lao PDR's national energy policy. Besides about 70 operational hydropower dams, about 280 additional hydropower projects are in the pipeline, mostly backed by Thai and Chinese investors and partners from Korea, the United States, and Vietnam (Figure 2.6.5).

Substantial infrastructure development will be needed to propel this ambition. Grid expansion remains a physical limitation for energy trade within ASEAN (PWC 2022). In Lao PDR, power infrastructure development has been primarily for generation—less than 5 percent of the value of future power projects has been devoted to transmission and distribution (Stimson 2021). Expanding the transmission infrastructure would facilitate more power purchase agreements with regional neighbors and help guarantee the monetization of any excess capacity from projects in the pipeline. Exploring the use of pumped storage will also maximize the operational efficiency of hydropower plants, especially to address demand for energy during the dry season (Vientiane Times 2022). "Soft" infrastructure, i.e., trained and qualified hydropower experts, must also be expanded in parallel, in order to manage and assess upcoming projects for their economic, financial, social, and environmental impacts (ADB 2019). This could be achieved, for example, through joint training and research programs with external partners. Mobilizing financing—especially from development partners and the private sector—will be especially crucial to boost hydropower exports in a sustainable way, without overly increasing financial or fiscal vulnerabilities (AMRO 2022b).

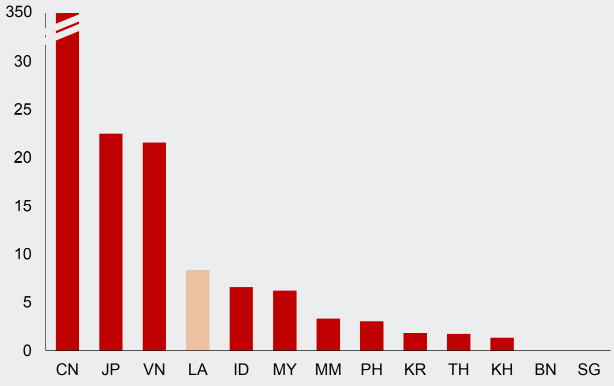
This box was written by Marthe M. Hinojales.

Figure 2.6.1. Top 10 Economies: New Installed Renewable Hydropower Capacity, 2019–21
(Gigawatts)



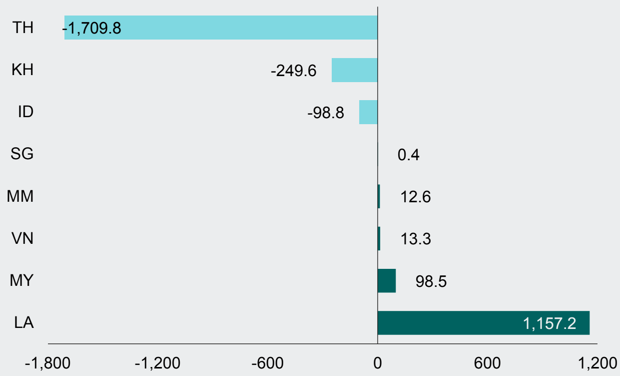
Source: IRENA; AMRO staff calculations.
Note: CA = Canada; CN = China; GN = Guinea; ID = Indonesia; IN = India; LA = Lao PDR; NO = Norway; NP = Nepal; TR = Turkey; VN = Vietnam.

Figure 2.6.2. ASEAN+3: Installed Renewable Hydropower Capacity, 2021
(Gigawatts)



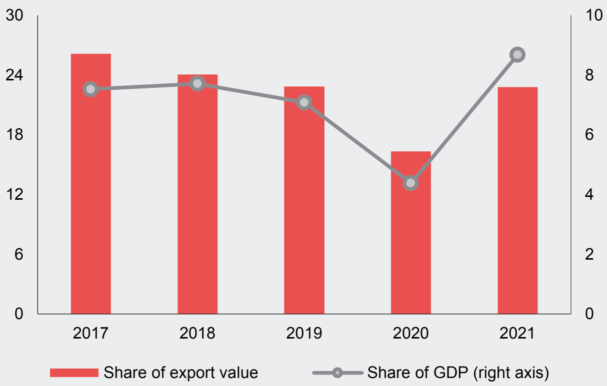
Source: IRENA; AMRO staff calculations.
Note: Data not available for Hong Kong. BN = Brunei; CN = China; ID = Indonesia; JP = Japan; KH = Cambodia; KR = Korea; LA = Lao PDR; MM = Myanmar; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; VN = Vietnam.

Figure 2.6.3. ASEAN: Electricity Trade Balance, 2020–21
(Average value in millions of US dollars)



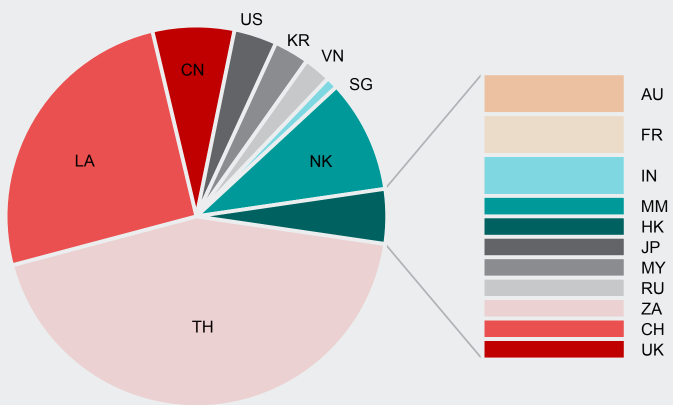
Source: UNComtrade; AMRO staff calculations.
Note: Data not available for Brunei and the Philippines. Data for electricity exports refer to commodities under HS Code 2716. ID = Indonesia; KH = Cambodia; LA = Lao PDR; MM = Myanmar; MY = Malaysia; SG = Singapore; TH = Thailand; VN = Vietnam.

Figure 2.6.4. Lao PDR: Electricity Exports
(Percent of total export value; percent of GDP)



Source: UNComtrade; World Bank, World Development Indicators; AMRO staff calculations.
Note: Data for electricity exports refer to commodities under HS Code 2716.

Figure 2.6.5. Lao PDR: Planned Hydropower Projects, by Economy of Sponsor, 2020
(Share of total number of projects)



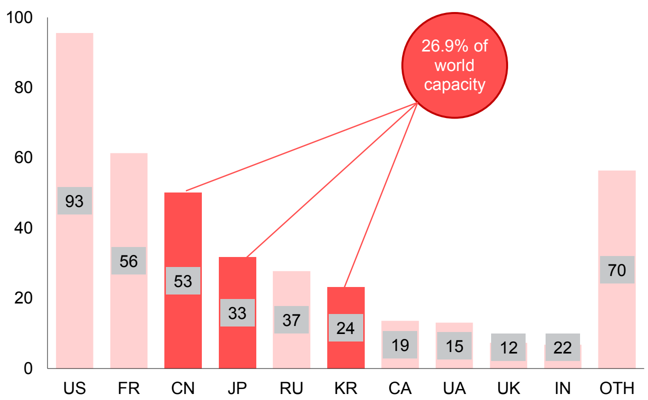
Source: Stimson (2020).
Note: Projects with multiple economy-sponsors are counted under each economy. AU = Australia; CH = Switzerland; CN = China; FR = France; HK = Hong Kong; IN = India; JP = Japan; KR = Korea; LA = Lao PDR; MM = Myanmar; MY = Malaysia; NK = not known; RU = Russia; SG = Singapore; TH = Thailand; UK = United Kingdom; US = United States; VN = Vietnam; ZA = South Africa.

Nuclear energy

After declining in the wake of the 2011 Fukushima accident, the region's interest in nuclear energy is picking up again.[23] The Plus-3 economies account for more than a quarter of the world's nuclear capacity (Figure 2.31); within this group, Korea has the greatest reliance on nuclear energy for power generation (Figure 2.32). According to IEA (2022d), carbon dioxide emissions in Japan and Korea during 1990–2020 would have been appreciably higher if they had not used nuclear energy (Figure 2.33). There is now growing recognition by policymakers that the transition to net zero will be faster if nuclear is part of the energy mix.[24] China leads the global appetite for additional nuclear capacity, with more than 15 new reactors under construction at the end of 2021, and a target to double the share of nuclear energy in power generation by 2035 (Table 2.6). In Japan, public support for a nuclear restart reached above 60 percent in 2022—the highest since 2011 (Lee 2022). Korea reversed its nuclear phaseout policy (which had been in place since 2019) in 2022 (World Nuclear News 2022). Within ASEAN, Indonesia, the Philippines, and Vietnam have declared intentions to pursue or restart nuclear power projects to reduce fossil fuel dependence, and Singapore is also considering it as part of its 2050 energy mix (Ang 2022).

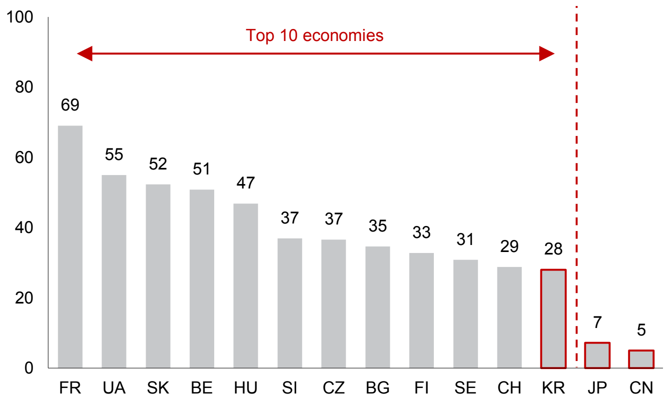
The potential for nuclear energy in an economy depends on factors such as its projected energy demand and decarbonization needs and the availability and quality of infrastructure and capacity (Energy for Growth Hub and Third Way 2022). Based on these criteria, the Plus-3 economies and Vietnam are assessed to be relatively more "nuclear-ready" markets, whereas economies like Singapore and Lao PDR have smaller energy needs that can be met efficiently by other sources (Figure 2.34). Public support is key in making nuclear energy a credible option in ASEAN—a 2018 survey found support to be generally lacking in Indonesia, Malaysia, Singapore, Thailand, and Vietnam (Figure 2.35) (Ho and Chuah 2022). Availability of international financing is also of utmost importance, given that nuclear energy involves substantial upfront costs. An appetite for nuclear energy in ASEAN would be a boon to China, Korea, and Japan, which are all major exporters of reactors (Figure 2.36).

Figure 2.31. World: Operational Nuclear Capacity, 2021
(Gigawatt electric)



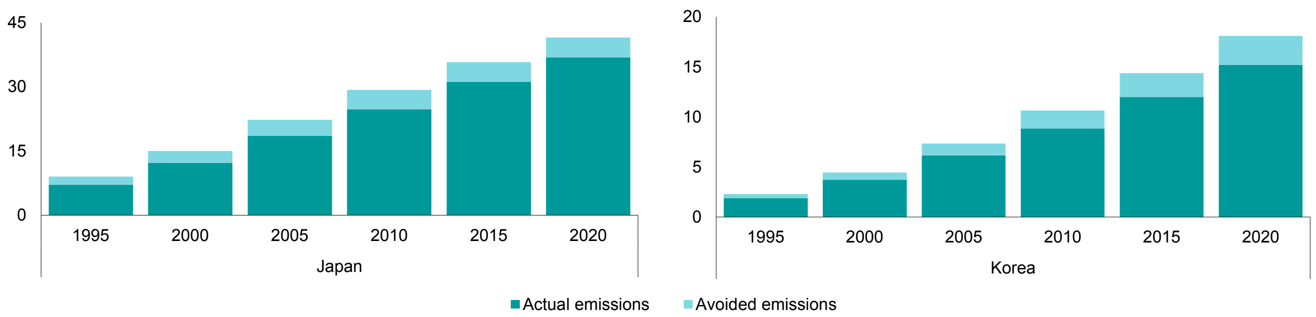
Source: International Atomic Energy Agency (IAEA); AMRO staff calculations.
Note: Figures refer to the number of operational reactors. CA = Canada; CN = China; FR = France; IN = India; JP = Japan; KR = Korea; OTH = Others; RU = Russia; UA = Ukraine; US = United States. Others refer to 22 other economies.

Figure 2.32. Selected Economies: Share of Nuclear Power in Electricity Generation, 2021
(Percent of total electricity supply)



Source: International Atomic Energy Agency (IAEA); AMRO staff calculations.
Note: BE = Belarus; BG = Bulgaria; CH = Switzerland; CN = China; CZ = Czech Republic; FI = Finland; FR = France; HU = Hungary; JP = Japan; KR = Korea; SE = Sweden; SI = Slovenia; SK = Slovakia; UA = Ukraine.

Figure 2.33. Japan and Korea: Cumulative Carbon Emissions Avoided by Nuclear Power Since 1990
(Gigatons)

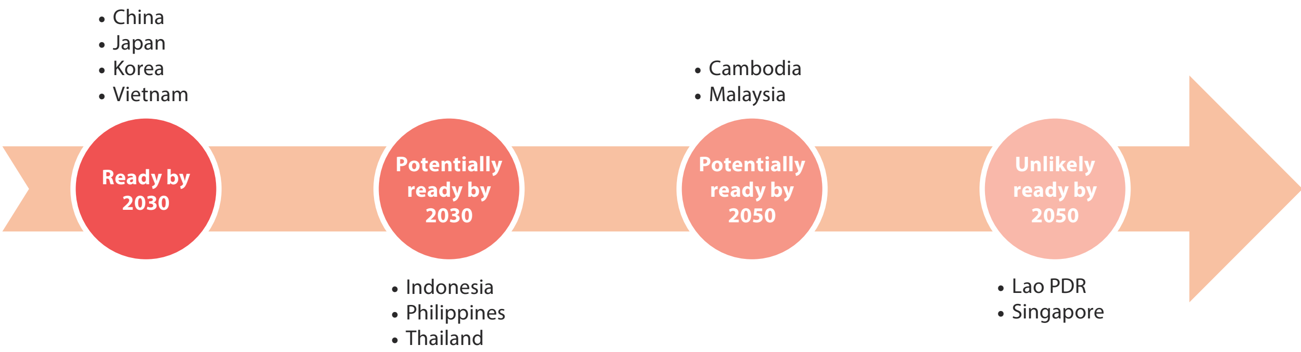


Source: International Energy Agency (IEA); Our World in Data; AMRO staff calculations.

23/ The Fukushima Daiichi Nuclear Power Station disaster in Japan sparked public distrust of the safety of nuclear technology. More than 20 reactors around the world have been decommissioned since then and new projects have been discouraged by lack of supportive policy, very stringent safety requirements, large upfront costs, long gestation periods, as well as unattractive electricity prices.

24/ As reactors can operate at capacity without interruption, they can provide a continuous and reliable supply of energy unlike variable renewable sources (such as solar or wind energy), help meet fluctuations in demand and stabilize power grids, expand the suite of decarbonization tools, and also provide economic savings (IEA 2019a; IEA 2020b). The land footprint of nuclear energy is smaller than other clean energy sources (NEI 2015).

Figure 2.34. Selected ASEAN+3: Readiness for Advanced Nuclear Development, 2022



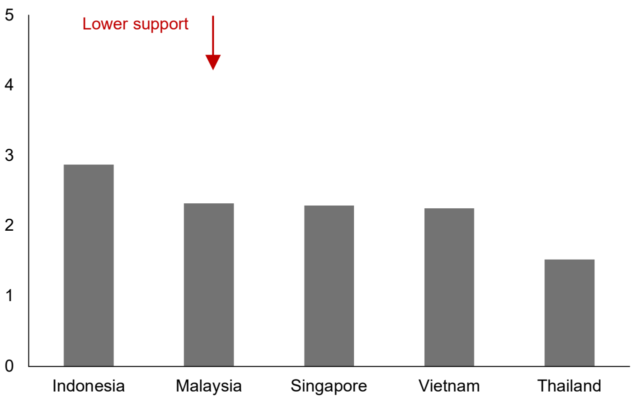
Source: Energy for Growth Hub and Third Way (2022).
Note: Data as of October 2022.

Table 2.6. Selected ASEAN+3: Policy Developments Related to Nuclear Energy, as of December 2022

Economy	Developments
Cambodia	• Expanded the ongoing triangular cooperation in the application of nuclear technology with Lao PDR and Vietnam in October 2022. • Signed a memorandum of understanding with Russia's State Atomic Energy Corporation (ROSATOM) and China National Nuclear Cooperation to boost cooperation on nuclear energy.
China	• Committed to "actively develop nuclear power in a safe and orderly manner" in the 14th Five-Year Plan (2021–25). The Plan targets an increase in nuclear power capacity to 70GW for the share of nuclear energy in the power generation mix to reach 10 percent by 2035. • Issued 26 regulations and standards related to nuclear safety in 2021, in accordance with its 2018 Nuclear Safety Law.
Indonesia	• Submitted draft legislation in June 2022 with a plan to open its first nuclear plant by 2045.
Japan	• Set a target share of 20 percent to 22 percent for nuclear energy in the 2030 power generation mix in its 6th Strategic Energy Plan.
Korea	• Reversed its earlier policy of nuclear phaseout and resumed construction in two plants. Nuclear energy is targeted to have a minimum share of 30 percent in the energy mix by 2030.
Lao PDR	• Expanded the ongoing triangular cooperation in the application of nuclear technology with Cambodia and Vietnam in October 2022. • Signed a memorandum of understanding with Russia's ROSATOM in July 2022 to promote nuclear energy domestically.
Myanmar	• Signed a roadmap agreement with Russia's ROSATOM in September 2022, which included the possible rollout of a small modular reactor.
Philippines	• Issued an executive order in February 2022 to incorporate nuclear power into the energy mix, which opens the possibility of restarting the Bataan Nuclear Power Plant (never operated).
Thailand	• To receive technical assistance to develop and deploy small modular reactors, under the US' Net Zero World Initiative, announced in November 2022.
Vietnam	• Considering the resumption of a suspended plan to build two nuclear power plants—a joint project with Russia's ROSATOM and a consortium led by Japan Atomic Power—following the program's suspension in 2016.

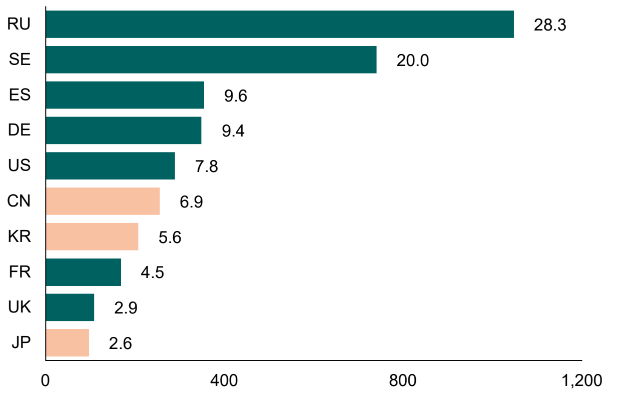
Source: AMRO staff compilation.

Figure 2.35. Selected ASEAN: Public Support for Nuclear Energy Development, 2018
(Mean score; 5 = Highest support)



Source: Ho and Chuah (2022).
Note: Each economy had 1,000 respondents. The survey was conducted in 2018.

Figure 2.36. World: Top 10 Exporters of Nuclear Reactors, 2021
(Millions of US dollars)



Source: UNComtrade; and AMRO staff calculations.
Note: Numbers refer to each economy's share of world exports. Data refer to HS code 8401. CN = China; DE = Germany; ES = Spain; FR = France; KR = Korea; RU = Russia; SE = Sweden; TW = Taiwan Province of China; US = United States.

Clean hydrogen

Clean hydrogen can help decarbonize heavy industry, expand zero-emission transport options and encourage the uptake of renewables. Hydrogen is an energy carrier rather than a primary energy source. This means that it does not exist freely in nature—it occurs naturally only in compound form—and it must be produced (separated) using other sources of energy through a process called electrolysis. Different colors denote the type of energy used in hydrogen production (Figure 2.37). About 99 percent of hydrogen in use globally is gray or black/brown, a color range indicative of a significant contribution to global carbon emissions (IEA 2019b). Demand for hydrogen comes largely from oil refining and industrial processes, particularly ammonia (for fertilizers), and methanol and steel production. Switching these and other hard-to-abate industries to clean (green, yellow, pink, or blue) hydrogen would be the fastest and easiest way to lower emissions. Clean hydrogen can power fuel cell electric vehicles (FCEVs). It can substitute for natural gas in national grids for power and heating. It can also enable the use of renewables by acting as a form of energy storage as well as an energy carrier capable of carrying large amounts of energy over long distances (Phoumin 2021).

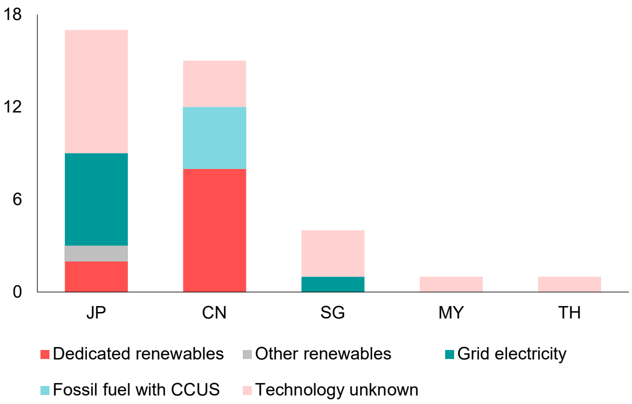
Clean hydrogen is beginning to take off across the ASEAN+3 region. About 38 operational projects in the region have been commissioned to help reduce emissions, decarbonize raw inputs to industrial applications, and explore hydrogen as an energy carrier. Most are in Japan and China, with the rest in Singapore, Malaysia, and Thailand (Figure 2.38). Blue hydrogen projects are mostly in China, which produces about 30 percent of the world's hydrogen, mostly fueled by coal (IEA 2022k). As for upcoming facilities, about 70 are in various stages of development across the region, primarily for industry and transport use (Figure 2.39). ASEAN+3 economies with a rapidly growing renewables sector could be especially well-placed to take advantage of opportunities from clean hydrogen.[25]

Figure 2.37. Hydrogen Energy Technologies

Gray	• Produced from natural gas (methane), with carbon emissions
Black/Brown	• Produced through gasification of bituminous orlignite coal, with carbon emissions
Blue	• Grey or black/brown hydrogen with carbon capture and storage
Green	• Produced through electrolysis powered by renewable energy sources
Yellow	• Produced through electrolysis using solar power
Pink	• Produced through electrolysis powered by nuclear energy
Turquoise	• Produced through methane pyrolysis, with solid carbon byproduct
White	• Found in underground deposits

Source: World Nuclear Association; AMRO staff compilation.
Note: Yellow hydrogen is a form of green hydrogen. Turquoise hydrogen production has yet to be proven at scale, White hydrogen can be obtained through fracking but there are no strategies to exploit it at present.

Figure 2.38. ASEAN+3: Operational Projects for Clean Hydrogen, by Technology Type, as of October 2022
(Units)



Source: International Energy Agency (2022j) (October 2022 database); AMRO staff calculations.
Note: CCUS = carbon capture, utilization, and storage; CN = China; JP = Japan; MY = Malaysia; SG = Singapore; TH = Thailand. The database covers all projects commissioned since 2000 to produce hydrogen for energy or to mitigate climate change. Clean hydrogen refers to hydrogen produced from renewable or nuclear energy or from fossil fuels with CCUS.

Currently, four ASEAN+3 economies have national hydrogen strategies in place.

- Japan issued its Basic Hydrogen Strategy in December 2017 (the world's first national hydrogen strategy) and its Strategic Roadmap for Hydrogen and Fuel Cells in March 2019, which together set out the broad policy framework to: develop an integrated hydrogen supply chain; reduce hydrogen production costs; enhance hydrogen storage and transportation; and expand industrial and consumer use of hydrogen and ammonia. The Green Growth Strategy issued in December 2020 and updated in June 2021 includes hydrogen and ammonia among 14 identified growth sectors for the Japanese economy (Clifford Chance 2022).

- Korea issued its Hydrogen Economy Roadmap in January 2019, focusing on market creation for hydrogen FCEVs and fuel cells for power generation. The Hydrogen Economy Promotion and Hydrogen Safety Management Law, which took effect in 2021, supports hydrogen-focused companies through research and development (R&D) subsidies, loans, and tax exemptions, and is the world's first law aimed at promoting hydrogen vehicles, charging stations, and fuel cells, as well as transparent hydrogen pricing (Nakano 2021; Kim 2021).

[25] The production of green hydrogen could divert renewable energy from other end uses, which prompts debate about whether green hydrogen should only be produced from renewable capacity that would not otherwise be commissioned or used.

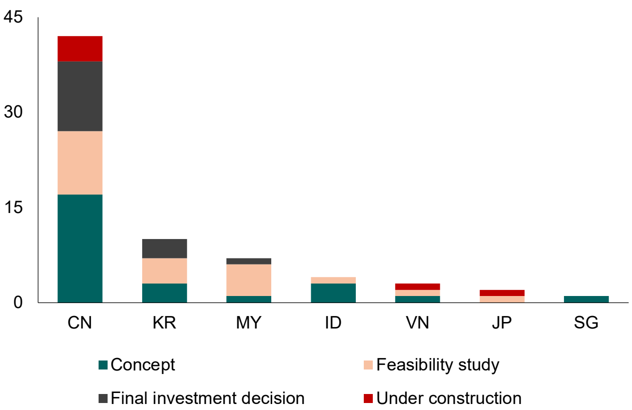
- China released its first National Hydrogen Development Plan in March 2022. It focuses on developing the domestic industry, improving internal expertise, and expanding manufacturing capacity for electrolyzers as the key component for clean hydrogen production (Yin 2022).

- Singapore released its National Hydrogen Strategy in October 2022, which focuses on R&D and experimentation in advanced hydrogen technologies; developing and scaling up supply chains for clean hydrogen; land and infrastructure plans to import, store and transform hydrogen into power; and workforce training for jobs along the hydrogen supply chain (Singapore Ministry of Trade and Industry 2022).

Cost is the key challenge to overcome. The hydrogen value chain is complex and capital-intensive, and evolving—many hydrogen technologies are still under development and a global supply chain has yet to be established. Current estimates suggest that the cost of supplying green hydrogen is about three to five times higher than natural gas, the "cleanest" fossil fuel (Phoumin 2021). Costs need to come down and production needs to ramp up for clean hydrogen to meet its promise in the ASEAN+3 region. This will require action to scale competitive supply, stimulate local demand, develop transportation technology, and facilitate cooperation across value chains and economies (de Pee and others 2022).

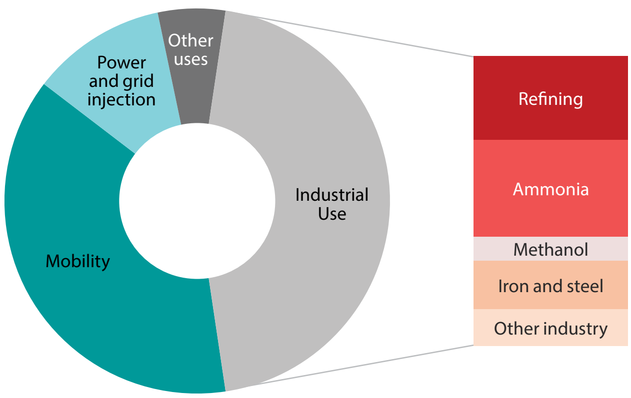
Figure 2.39. ASEAN+3: Upcoming Projects for Clean Hydrogen, as of October 2022

By Development Status
(Units)



Source: International Energy Agency (2022j) (October 2022 database); AMRO staff calculations.
Note: CN = China; KR = Korea; ID = Indonesia; JP = Japan; MY = Malaysia; SG = Singapore; VN = Vietnam.

By End-Use
(Percent of total projects)



Source: International Energy Agency (2022j) (October 2022 database); AMRO staff calculations.

Electric Vehicles

"The future of passenger vehicle powertrains is electric ..."

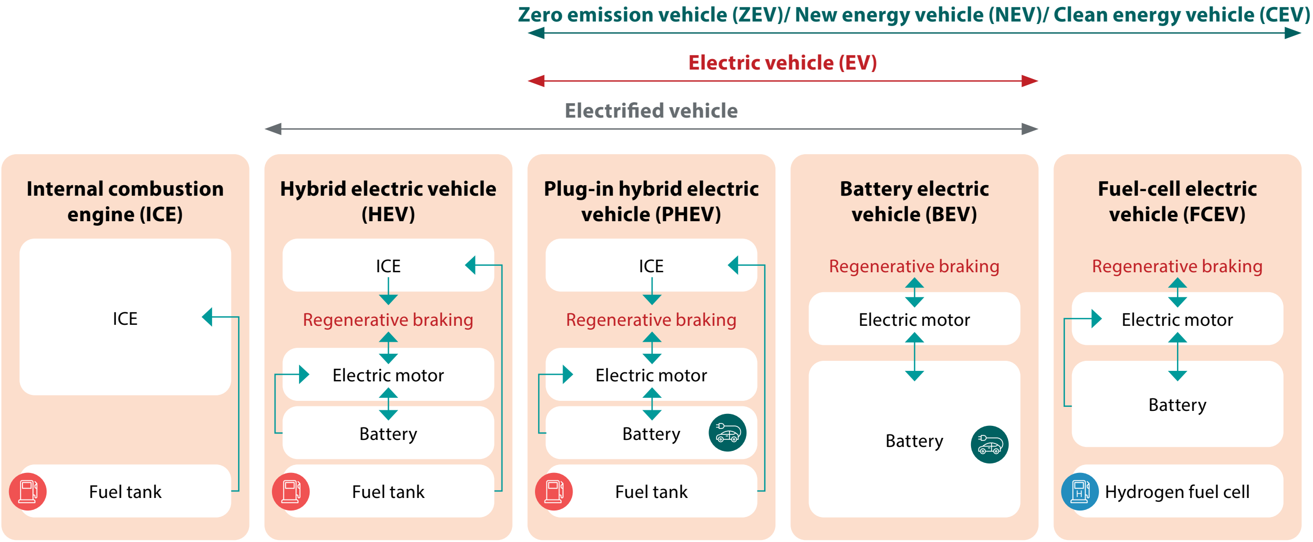
McKinsey & Company
September 2021

Electric vehicles (EVs) are an important part of meeting global goals on climate change. As EVs—and the broader category of zero emission vehicles (ZEVs)—do not run on fossil fuels, it is generally agreed that they create a lower carbon footprint than vehicles with traditional internal combustion engines (Figure 2.40).[26] In ASEAN+3, the share of carbon emissions from transport, while still below the world average, has been trending up over the last few decades in tandem with the increase in the number of motor vehicles—transport accounts for over 15 percent of carbon emissions in Japan, Korea, Malaysia, the Philippines, and Thailand (Figure 2.41 and Figure 2.42).

EV adoption is gaining traction but remains uneven across the ASEAN+3 region. China has the world's largest fleet of electric vehicles—it accounted for over 50 percent of the global EV stock in 2021 (Figure 2.43, left panel). More EVs were sold in China in 2021 than in the entire world in 2020 (Figure 2.43, right panel). In 2021, electric cars made up 16 percent of new car sales in China; by contrast, about 6 percent of Korea's total new car sales were EVs, while in Japan, the share was only about 1 percent (Figure 2.44). Uptake of passenger EVs is at an early stage in ASEAN economies: Singapore has the highest share among total registered vehicles (Figure 2.45), while interest in EVs is highest in Thailand (Figure 2.46).

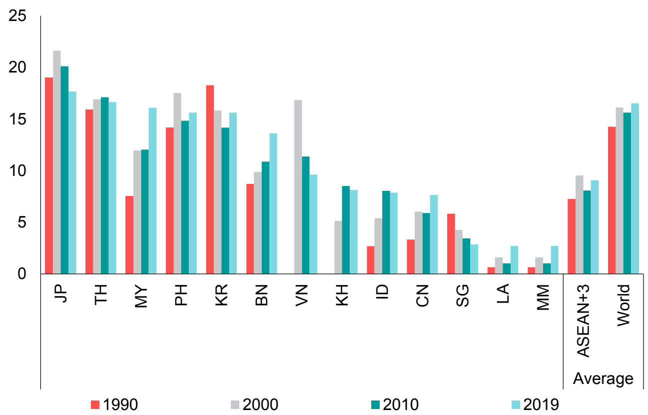
[26] EVs do not directly emit carbon dioxide but the electricity they run on is in large part still produced from fossil fuels in many parts of the world; energy is also used to manufacture EVs and their batteries. Different studies comparing lifetime emissions of EVs and gasoline-powered vehicles find different results due to differences in the specific make of vehicles being compared and different assumptions about the electricity grid mix, electricity emissions (marginal versus average), driving patterns, and so on (Hausfather 2022).

Figure 2.40. Electric Vehicles, Electrified Vehicles, and Zero Emission Vehicles



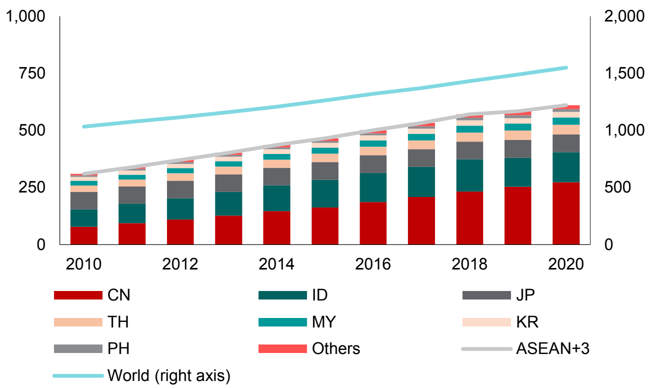
Source: AMRO staff compilation.
Note: EVs are vehicles that use electricity to power an electric motor. Technically, FCEVs are a type of EV since they also use electricity to power an electric motor. However, conventional usage refers to EVs as BEVs and PHEVs only.

Figure 2.41. ASEAN+3: Carbon Emissions from Transport
(Percent of economy's total carbon emissions)



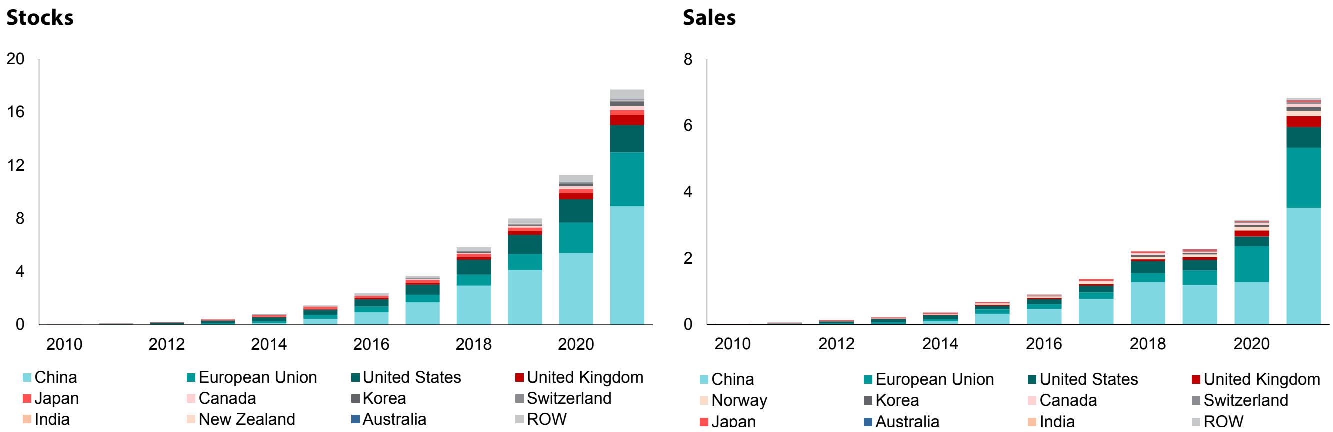
Source: Our World In Data; AMRO staff calculations.
Note: Data for Hong Kong are not available. Transport excludes aviation and shipping. BN = Brunei; CN = China; ID = Indonesia; JP = Japan; KH = Cambodia; KR = Korea; LA = Lao PDR; MM = Myanmar; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; VN = Vietnam.

Figure 2.42. ASEAN+3: Number of Motor Vehicles
(Millions of units)



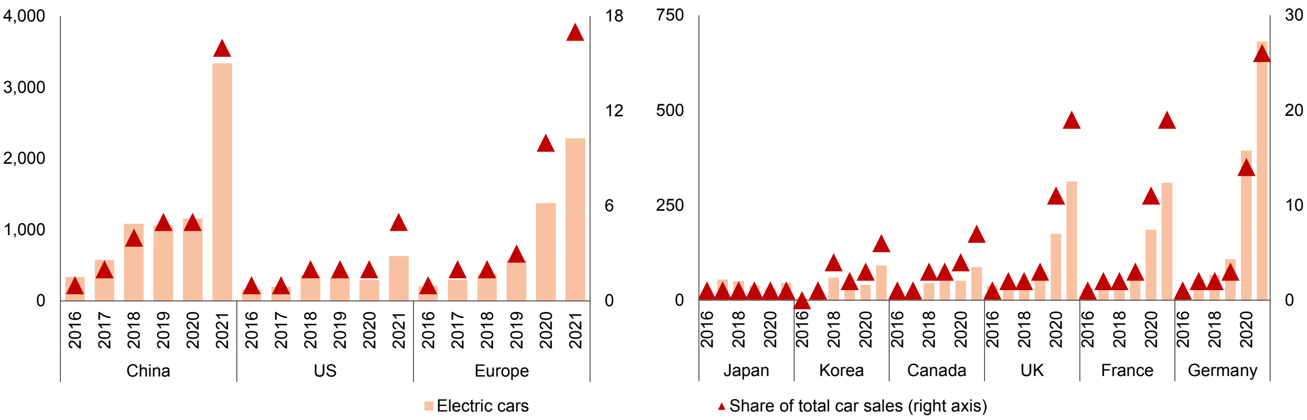
Source: ASEANstats; national authorities; AMRO staff calculations.
Note: Data for Japan, Indonesia, Thailand, Malaysia, and the Philippines refer to motor vehicles in use and registered road motor vehicles, respectively. CN = China; ID = Indonesia; JP = Japan; KH = Cambodia; KR = Korea; MY = Malaysia; Others = Brunei, Lao PDR, Hong Kong, Myanmar, Singapore, and Vietnam; PH = Philippines; TH = Thailand.

Figure 2.43. World: Electric Vehicle Stocks and Sales, by Economy
(Millions of units)



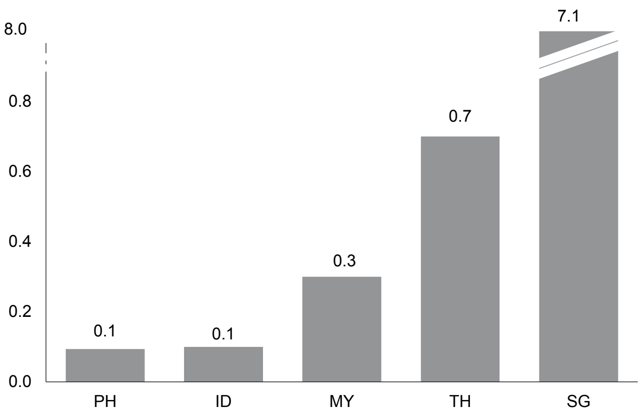
Source: International Energy Agency; AMRO staff calculations.
Note: Electric vehicles comprise battery electric and plug-in hybrid electric buses, cars, trucks, and vans. EU = European Union; ROW = rest of the world; UK = United Kingdom; US = United States.

Figure 2.44. Selected Economies: Electric Car Registrations and Sales
(Thousands of units; percent of total car sales)



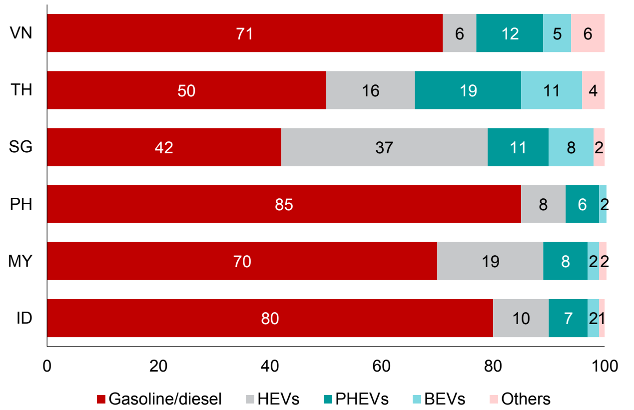
Source: International Energy Agency.
Note: Electric cars include battery electric cars and plug-in hybrid electric cars. UK = United Kingdom; US = United States.

Figure 2.45. Selected ASEAN: Electric Vehicle Adoption Rate, 2021
(Percent of registered vehicles)



Source: ASEANstats; national authorities; various media reports; AMRO staff calculations.
Note: The number of registered vehicles is sourced from ASEANstats whose latest data point is 2020 proxied as the latest data. ID = Indonesia; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand. Data for Thailand are as of 2022, and 2019 for the Philippines.

Figure 2.46. ASEAN-6: Powertrain Preferences, September–October 2022
(Percent of responses by country)



Source: Deloitte (2023).
Note: Responses to survey question "What type of engine would you prefer in your next vehicle?" from Indonesia (ID, 1,001 responses); Malaysia (MY, 1,005 responses); the Philippines (PH, 1,007 responses); Singapore (SG, 1,015 responses); Thailand (TH, 1,004 responses), and Vietnam (VN, 1,017 responses). BEVs = battery electric vehicles; HEVs = hybrid electric vehicles; PHEVs = plug-in hybrid electric vehicles. EVs refer to BEVs and PHEVs.

Almost all ASEAN+3 economies have targets for EV adoption (Table 2.7). In recent years, many of them have introduced policy measures to promote EV adoption, such as import duty reductions/exemptions for EVs and/or charging stations (Cambodia, Malaysia, the Philippines), tax and registration fee exemptions or rebates (Malaysia, the Philippines, Singapore, Thailand, Vietnam), and subsidies for EV purchases (China, Japan, Thailand) or installation of EV charging infrastructure (Hong Kong, Japan, Lao PDR). In September 2022, Indonesia mandated the use of EVs for government officials across the country in an effort to expedite its transition to battery-powered transportation (Thomas 2022).

Accelerated EV adoption in ASEAN+3 will help spur investment and bring about a needed transformation in the region's automobile industry. Many ASEAN+3 economies have also set targets or ambitions and supporting policies to develop their domestic EV industries (Table 2.7). China's domestic EV industry is already relatively mature and is now expanding its footprint overseas (Box 2.7). Korea's Hyundai Motor Group plans to invest USD 16.5 billion over the next eight years to expand its production of EVs in its home market and capture 12 percent of the global EV market by decade's end (Jennings 2022). Japan's automobile industry, having long enjoyed a competitive advantage in gasoline-powered and hybrid electric vehicles, has been relatively slower to ramp up EV production capacity and is racing to make up lost ground. Among ASEAN economies:

- Indonesia offers several incentives to encourage investment in EV manufacturing, including tax allowances and holidays, as well as tariff cuts for imported machinery and materials used in EV production. The country's huge nickel and copper reserves make it a competitive investment destination for EV manufacturers.

- Thailand—known for years as the "Detroit of Asia" for its track record in manufacturing automobiles—aims to become a global hub for EV and parts production. In

February 2022, the government approved measures to promote domestic manufacturing of EVs, including the exemption of import duty on significant electrical parts in 2021–25 (Theparat and Apisitniran 2022).

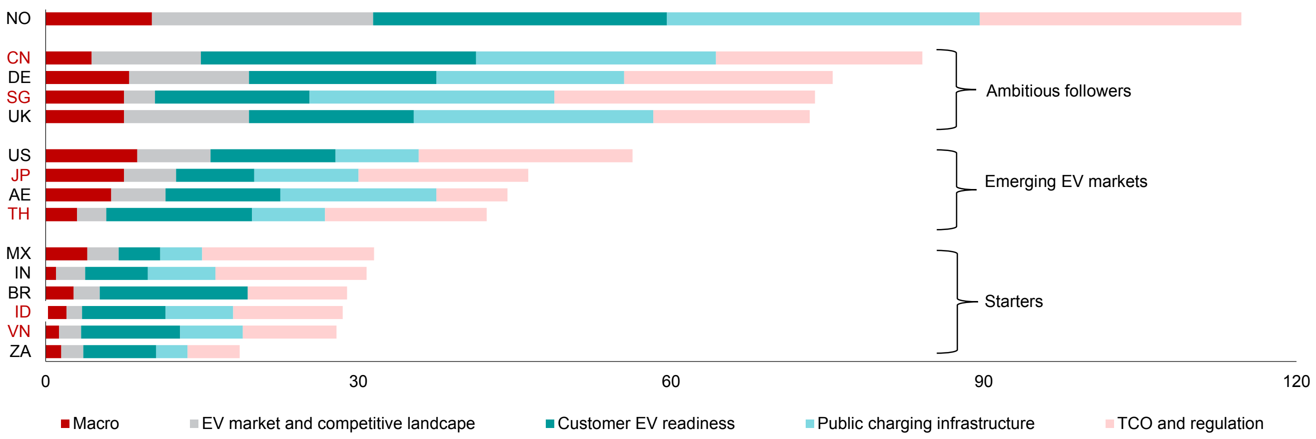
- Malaysia provides full import and excise duty exemptions and a sales and service tax waiver until the end of 2025 for locally assembled ("complete knocked down") EVs. Volvo Car Malaysia rolled out the first locally assembled EV in March 2022. Malaysia is focusing on producing EV components rather than competing with neighboring Indonesia and Thailand in EV production.

- Vietnam's VinFast, established in 2017, is the largest manufacturer of electric two-wheelers and the only domestic manufacturer of electric cars in the country. While demand for electric cars in Vietnam is embryonic, Vinfast has set its sights on the global market—in November 2022, it shipped its first batch of 999 electric cars to the United States and is building an EV plant there (Nguyen 2022).

For the region's EV industry to achieve its market potential, challenges to EV adoption need to be overcome. Developing economies such as Cambodia, Lao PDR, and Myanmar have relatively weak infrastructure and low technological capacity, which can affect their readiness for EV adoption. Even larger emerging-market economies such as Indonesia and Vietnam are rated by business consultancy Arthur D. Little as "starters" in electric mobility readiness, reflecting "major challenges in costs and infrastructure" (Schlosser and others 2022) (Figure 2.47). A recent survey by Deloitte (2023) indicates that lack of public charging infrastructure and battery safety and performance concerns are among the impediments to EV adoption in the ASEAN-6 (Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam).

Competition from EV producers elsewhere and protectionist policies in large markets could challenge the region's EV export ambitions. US EV pioneer Tesla remains the dominant player in the luxury EV market, owning and operating the largest fast-charging network in the world. Traditional brands like General Motors and Volkswagen are also ramping up their EV lines, not only with luxury EVs but also with different vehicle body types and price points (Figure 2.48). Plus-3 EV makers are rising to meet the competition, but ASEAN EV makers might find the global field more daunting unless they can carve out their own niche. Moreover, policies in major trading partners that favor domestically produced EVs could short-circuit the region's promising EV export growth. The US Inflation Reduction Act, passed in August 2022, is a prime example.[27]

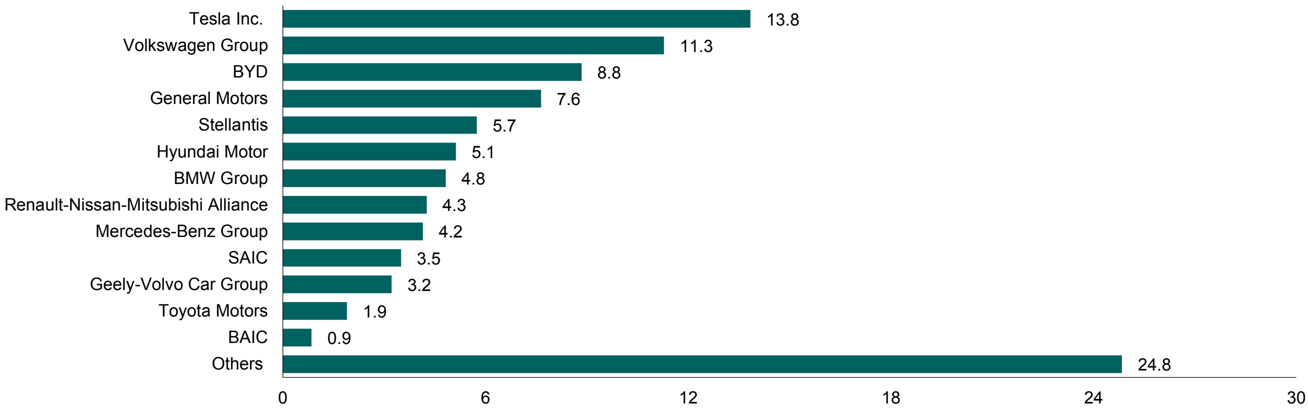
Figure 2.47. Selected Economies: Electric Mobility Readiness, 2022



Source: Schlosser and others (2022).
Note: "Macro" factors include GDP per capita and quality of electricity infrastructure; "EV market and competitive landscape" factors include the number of battery electric vehicles (BEVs) offered in the market and EV market share expectations for 2021–26; "Customer EV readiness" factors include home ownership rate and customers' likelihood of purchasing an EV as their next vehicle; "Public charging infrastructure" factors include third-party highway high-performance charging network density and compound annual growth rate of public/destination charging points; "TCO and regulation" factors include tax and tariff benefits and direct financial subsidies for BEVs. AE = United Arab Emirates; BR = Brazil; CN = China; DE = Germany; EV = electric vehicle; ID = Indonesia; IN = India; JP = Japan; MX = Mexico; NO = Norway; ZA = South Africa; SG = Singapore; TCO = total cost of ownership; TH = Thailand; UK = United Kingdom; US = United States; VN = Vietnam.

[27] The 2022 US Inflation Reduction Act includes a tax credit of up to USD 7,500 per EV purchased domestically, but only for EVs with final assembly in North America. In addition, as of January 2024, at least 40 percent of the critical minerals used in the production of the EV must come from the United States or its free trade agreement partners, while the battery must have at least 50 percent of North American content. These minimum thresholds rise to 80 percent by 2027 for critical minerals and 100 percent from 2029 for batteries (Feingold 2022).

Figure 2.48. Global Electric Vehicle Market Share, by Main Producer, 2021
(Percent)



Source: Statista.
Note: Includes battery electric vehicles and plug-in hybrid electric vehicles.

Table 2.7. Selected ASEAN+3: Targets for Electric Vehicle Adoption and Production

Economy	Type of Targets for Electric Vehicle (EV) Adoption	Target(s) for EV Production
Brunei	• EV share in annual vehicle sales	
Cambodia	• EV share of all cars, motorcycles, and urban buses	
China	• NEV share in annual vehicle sales; BEV share in NEVs • NEV share in public fleet stock (e.g., buses, taxis, delivery vehicles) FCEV sales and stock • Charging infrastructure	• 1.2 million NEV annual production capacity by 2025 (Shanghai).
Hong Kong	• Phase-out of fuel-propelled private cars including hybrid vehicles • Reduction in vehicular emissions	
Indonesia	• EV and electric motorcycle stock • EV share in car and two-wheeler sales • Charging stations and battery swap stations • Phaseout of fossil fuel-powered cars	• Production of 2 million electric motorcycles by 2024. • Production of 600,000 EVs and 2.45 million electric two-wheelers by 2030.
Japan	• EV, FCEV, and HEV share in passenger car sales • FCEV urban bus stock • EV charging points and hydrogen refueling stations	
Korea	• Passenger BEV and FCEV stock • EV share in new vehicle sales • Total cost of ownership-parity with internal combustion engines for EVs and FCEVs. • FCEV taxi, urban bus, and truck stock • Charging stations	• Production of 430,000 passenger EVs and FCEVs by 2022, 4.5 million by 2030.
Lao PDR	• EV share of all automobiles	
Malaysia	• EV market share • Charging stations	
Philippines	• EVs (two-, three-, or four-wheeled) in use	
Singapore	• Phase-out of internal combustion engine passenger vehicles • Charging stations	
Thailand	• ZEV share in new car sales • Charging stations and battery swapping stations for electric motorcycles	• Production of 250,000 EVs, 3,000 electric buses, and 53,000 motorcycles by 2025. • 50 percent of total auto production to be EVs by 2030. • 35 percent share of ZEVs in domestic bus production by 2025, 50 percent by 2030 and 85 percent by 2035. • 30 percent share of ZEVs in domestic car and van production by 2030, 50 percent by 2035.
Vietnam	• ZEV share of all vehicles	• Production capacity of 3.5 million EVs by 2040, 4.5 million by 2050.

Source: National authorities; International Energy Agency (2022c); AMRO staff compilation from various media reports.
Note: BEV = battery electric vehicles; EV = electric vehicle, which can be BEV or hybrid plug-in electric vehicle (HPEV); CEV = clean energy vehicle, which can be EV or fuel cell electric vehicle (FCEV); HEV = hybrid electric vehicle; NEV = new energy vehicle (same as CEV); ZEV = zero emissions vehicle (same as CEV). Targets include official targets and unofficial targets (ambitions).

Box 2.7:

China's Electric Vehicle Leapfrog

Mass production of electric vehicles (EVs) has long been a key element of China's industrialization strategy. The government began thinking about ways to build a domestic EV industry in the 1990s, recognizing that China could not match advanced economies in internal combustion engine innovation and aiming to address environmental issues such as air pollution in big cities. In the early 2000s, the 863 EV Project was rolled out as part of China's 10th and 11th Five-Year Plans, with the government investing CNY 2 billion (about USD 290 million) in EV research and development (R&D) during the decade. In 2004, 16 state-owned companies formed an EV industry association to integrate technological standards and work cooperatively to develop a top-of-the-line EV. In 2009, the government released a three-year Auto Industry Restructuring and Revitalization Plan, which included a goal to increase production capacity and sales of so-called new energy vehicles (NEVs) (Figure 2.39). The subsequent Energy-Saving and New-Energy Auto Industry Plan (2012–20) set ambitious targets to have half a million NEVs on the road by 2015 and 5 million by 2020, with the help of government support for pilot programs, purchase incentives, R&D programs, charging facilities, and battery recycling. Foreign ownership limits on NEVs were scrapped in 2018, paving the way for Tesla to set up a wholly owned Chinese subsidiary that began to build EVs in 2019, and for Volkswagen to raise its stake in an EV joint venture to 75 percent in 2020.

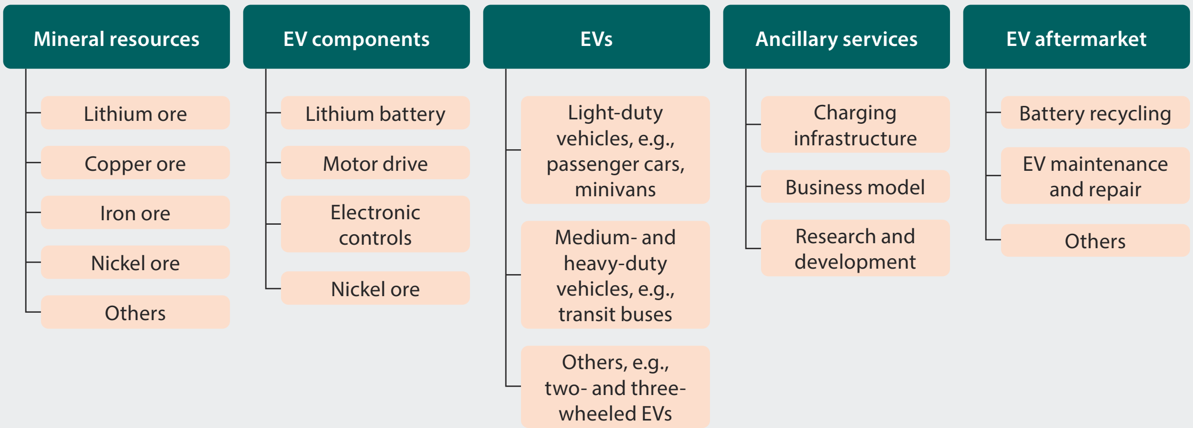
Ramping up domestic adoption has been an important—though costly—part of the EV development plan. As early as 2009, the government started to provide generous incentives to encourage EV purchases. EV manufacturers were granted subsidies for EVs sold, with the size of the subsidy largely determined by the vehicle's battery capacity—the larger the capacity, the larger the subsidy. The subsidies—together with preferential tax policies such as purchase tax waivers for NEVs (introduced in 2014) and local government incentives, e.g., bonuses for switching to NEVs and free EV license plates (introduced in 2012 in Shanghai) — helped to shrink the price difference between EVs and conventional vehicles and so increase their popularity. By 2017, the government began to wind down the subsidies in stages. The intention was to move from direct financial aid to a market-based approach by the end of 2021, although the subsidies were extended through 2022 to support the automobile sector during the downturn caused by the COVID-19 pandemic. In total, the government has spent about CNY 100 billion on EV subsidies. The purchase tax waiver for NEVs had been due to expire at the end of 2022 but was extended (for the third time) through 2023, at an estimated cost of CNY 100 billion in foregone revenue (Interesse 2022).

Progress in EV development and deployment has been rapid. Production has increased massively—by 2021, China accounted for about 60 percent of global EV production. EV production costs in China are about 50 percent lower than elsewhere in the world, thanks to important parts of the value chain being available inside the country (Figure 2.7.1) (Kawakami, Muramatsu, and Shirai 2022). EV charging points continue to be built—reaching even rural villages—at a speed faster than in any other country (Figure 2.7.2). Domestic consumption patterns are changing rapidly—by 2021, one out of every two EVs sold in the world was in China, and it will remain by far the top single country for EV sales for decades to come (Maguire 2022) (Figure 2.7.3). Exports have grown exponentially—mainly Tesla and European EV brands made in China to date, although cost-competitive Chinese auto manufacturers such as BYD, Nio, and SAIC are now making inroads in European markets and countries across Southeast Asia (Figure 2.7.4).

Still, more can be done. On the demand side, EV infrastructure availability, EV pricing, and climate change concerns will be key determinants of consumers' buying patterns, requiring continued efforts by the authorities. On the supply side, disruptions that affected China's EV production and exports in the past two years have highlighted how important it is for the industry to build resilience, including by strengthening links with ASEAN economies for technology sharing and development as well as production along the entire EV value chain.

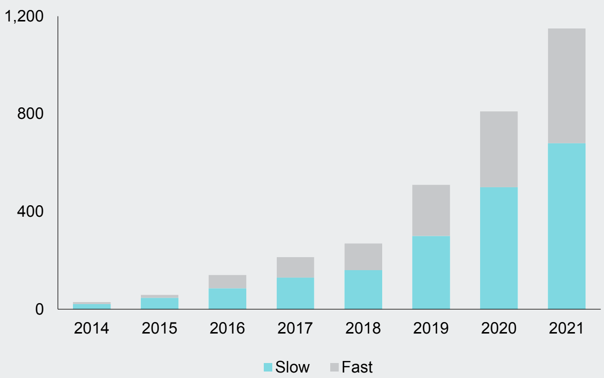
This box was written by Suan Yong Foo.

Figure 2.7.1. China: Electric Vehicle Industrial Ecosystem



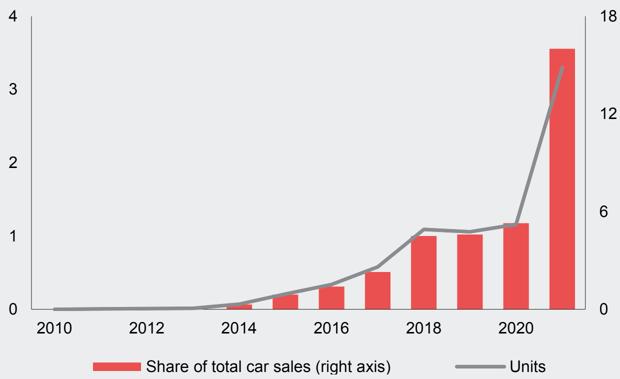
Source: Daxue Consulting (2022); AMRO staff.

Figure 2.7.2. China: Publicly Available Electric Vehicle Charging Points
(Thousand units)



Source: International Energy Agency.

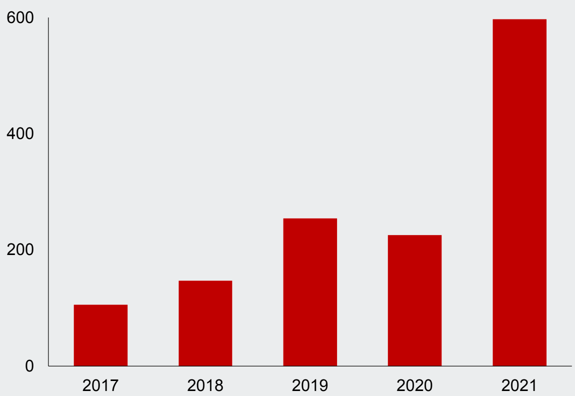
Figure 2.7.3. China: Electric Car Sales
(Million units; percent of total car sales)



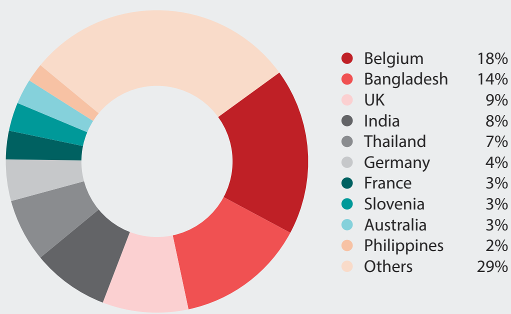
Source: International Energy Agency.

Figure 2.7.4. China: Electric Vehicle Exports

Volume
(Thousand units)



Destination market
(Percent of exports)



Source: China General Administration of Customs; Statista.
Note: UK = United Kingdom. EV exports to Bangladesh are mainly two- and three-wheeled vehicles.

Energy Storage

"This is the energy storage decade."

Yayoi Sekine
BloombergNEF Head of Decentralized Energy
November 2021

Energy storage is crucial for the green transition. Batteries and fuel cells will have a central place in road transportation systems that run mainly on electricity and/or hydrogen. Energy storage will also be crucial in future electricity systems reliant on variable renewable energy (VRE) sources like wind and sunlight. Storage technologies differ in duration (i.e., the length of time over which the storage facility can deliver maximum power when starting from a full charge), energy density (i.e., the maximum amount of energy that can be stored per unit volume), and other attributes such as scale economies. For example, most currently deployed energy storage uses electrochemical technology in the form of lithium-ion batteries, which have high energy density and short storage durations, making them particularly well-suited for EVs and mobile electronics. Mechanical technology, like pumped-storage hydropower, is widely used for grid-scale storage, while chemical technologies, like hydrogen, have potential for large-scale storage of VRE (Figure 2.49).

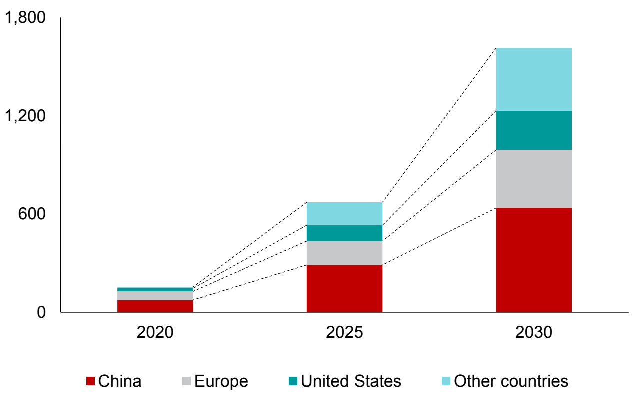
A rapid scaling-up of demand for energy storage is expected over the next few decades as EVs supplant internal combustion engines and as the share of electricity generation from wind and solar photovoltaics increases. According to the IEA (2020a), global annual lithium-ion battery production would need to reach about 1,500 gigawatt-hours (GWh) per year by 2030 to meet government EV targets around the world—and twice that amount to meet long-term sustainability goals (Figure 2.50).[28] As for grid-scale battery storage, total installed capacity would need to expand from about 16 gigawatts (GW) in 2021 to 680 GW in 2030 for the world to meet its ambition to reach net zero by 2050 (Figure 2.51) (IEA 2022g).

Figure 2.49. Energy Storage Technologies

Electrochemical	Chemical	Mechanical	Thermal
Lithium-ion batteries	Hydrogen	Pumped storage hydropower	Molten salt storage
Lithium-ion batteries are widely used in EVs and shortduration electricity system storage applications	Very large amounts of hydrogen can be stored in constructed underground salt caverns	Pumped storage hydropower accounts for over 90 percent of global functional grid-scale energy storage capacity	Molten salt is used as a heat transfer fluid and thermal energy storage in solar power plants

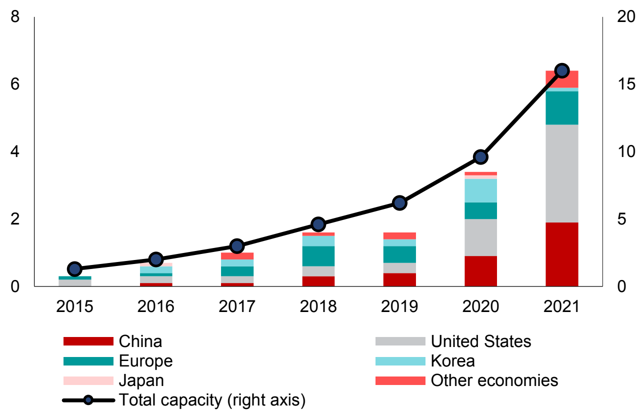
Source: AMRO staff compilation.

Figure 2.50. World: Projected Annual Electric Vehicle Battery Demand
(Gigawatt-hours)



Source: International Energy Agency (2021a).
Note: Only considers lithium-ion batteries. 2025 and 2030 projections based on current and announced policies.

Figure 2.51. World: Grid-Scale Battery Storage Capacity Additions
(Gigawatts)

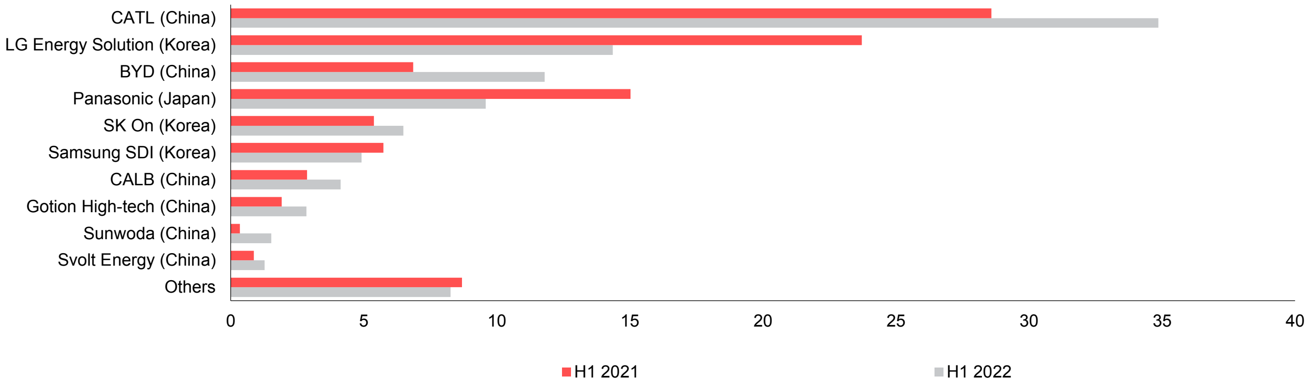


Source: International Energy Agency (2022g).

[28] Battery production for an output of 1,000 GWh per year would require the equivalent of 50 plants, each on the scale of a Tesla Gigafactory. Building a large-scale battery factory can take anywhere from two to five years, depending on the location.

Today's EV battery value chains are concentrated in the Plus-3, particularly China. China produces three-quarters of the world's lithium-ion batteries; Korea accounts for 5 percent and Japan 4 percent of global production capacity. These three economies are home to the world's top 10 EV battery producers, with a combined market share of more than 90 percent (Figure 2.52). Over half of the world's lithium, cobalt, and graphite processing and refining capacity, and 70 percent to 85 percent of production capacity for cathodes and anodes (key battery components) are in China. Korea and Japan have considerable shares of the value chain downstream of raw material processing, particularly in the production of cathode and anode material and other battery components such as separators (IEA 2022e).

Figure 2.52. World: Top 10 Electric Vehicle Battery Producers
(Percent of global sales)



Source: SNE Research (2022).
Note: H1 = first half of the year.

China's dominance in EV battery production is likely to be maintained in the medium term, although competition among the Plus-3 is heating up. Of the EV battery production capacity announced worldwide for the period to 2030, about 70 percent is in China. But Korea and Japan, which may be better positioned to penetrate the US and European EV markets, have started initiatives to boost the competitiveness of their own battery industries. In July 2021, the Korean government announced plans to invest USD 35 billion in its EV battery industry by the end of the decade—with key players LG Energy Solution, SK Innovation, and Samsung SDI driving investment in R&D and battery production—to secure the country's spot as a major global force in the sector (Park and Lee 2021). The Japanese government earmarked the equivalent of about USD 877 million in the fiscal 2021 supplementary budget for setting up domestic battery storage production, and subsequently indicated that a further USD 24 billion in public and private investment would be needed to develop a competitive manufacturing base for batteries (Jiji Press 2021; Reuters 2022b).[29]

ASEAN new entrants are poised to join the EV battery value chain by leveraging their proximity to the Plus-3 technology leaders as well as their upstream mineral and metal resources. Indonesia and Thailand, in particular, are attracting foreign investment from major battery and EV manufacturers.

- Indonesia aims to produce 140 GWh of EV battery capacity per year (of which 50 GWh will be for export) by 2030—from zero EV battery production today (IEA 2022a).[30] In March 2021, a holding company, Indonesia Battery Corporation (IBC), was created from four state-owned companies in the mining and energy sector with some USD 17 billion to invest in developing an EV battery ecosystem in the country. Construction has begun on Indonesia's first EV battery plant—a joint venture between IBC and a Korean consortium led by LG Energy, with production capacity of 10 GWh for Hyundai EVs—which is expected be operational in 2024 (Holman 2021). IBC has secured investments worth USD 15 billion from China's CBL and Korea's LG Energy Solution and is pursuing agreements with major global EV battery manufacturers such as CATL, Foxconn, and Tesla.

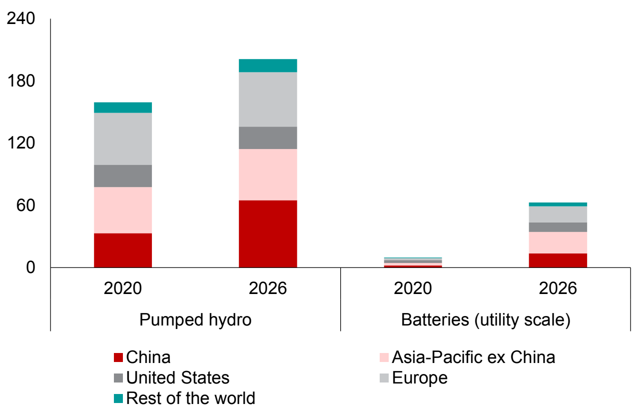
[29] In August 2022, Toyota announced that it would invest up to USD 5.6 billion to ramp up production of EV batteries in the United States and Japan, and Honda announced plans to jointly establish a USD 4.4 billion EV battery plant in the United States with LG Energy Solution (Herh 2022).
[30] For context, 140 GWh is equivalent to about 4–6 percent of global EV battery capacity demand in 2030, as forecasted in IEA (2022b).

- Thailand is developing a local EV battery industry clustered in the Eastern Economic Corridor (EEC) to help achieve its aim of becoming a regional EV production hub by 2035. The first lithium-ion battery factory in Southeast Asia was opened in the EEC in December 2021 by a domestic renewable energy company (Muramatsu 2021);[31] the utility arm of Thailand's state-owned oil and gas conglomerate is building an EV battery plant and developing EV battery technology; and a government-funded pilot plant is developing an alternative to lithium-ion batteries that will make use of the country's abundant zinc resources (Phoonphongphiphat 2022). Foreign companies, such as China's SAIC Motors and Great Wall Motors, also plan to build EV battery production plants in Thailand. In June 2022, the government approved enhanced benefits for investment in EV battery production: projects using advanced technology will enjoy a 90 percent reduction of import duty on raw and essential materials for five years if the output is sold domestically (Sullivan 2022).

- Vietnam's potential for nickel mining makes it a prime location for EV battery production (as featured in the next subsection). In December 2021, Vietnam's domestic car manufacturer, Vinfast, began construction of a facility to produce batteries for its own EVs. The localization of supply chains will expand Vietnam's capacity as a manufacturing hub and make the country an attractive target for investment.

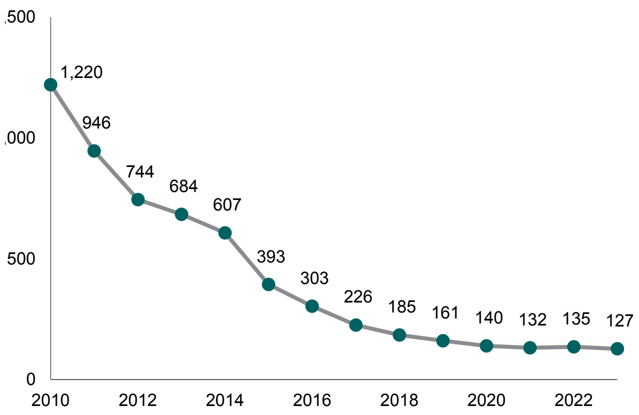
Batteries are a technology opportunity for the energy sector beyond just EVs—and the Plus-3, particularly China, are major global players. According to IEA (2021c), while pumped storage hydropower will remain the largest source of installed energy storage system capacity worldwide, utility-scale batteries are expected to account for most of the storage growth over the next few years as the price of lithium-ion technology has declined substantially with its widespread commercial use (Figure 2.53 and Figure 2.54). Lithium-ion battery storage contributed 95 percent of new utility-scale capacity globally in 2021 (Colthorpe 2022a).[32] China's 14th Five-Year Plan for New Energy Storage Technology Development sets out an ambitious target to install over 30 GW of energy storage (excluding pumped hydro) by 2025 and 100 GW by 2030—a nearly 3,000 percent increase on its installed capacity in 2020 (Reuters 2021a). The government encourages, and most provinces now require, renewable energy developers to bundle 10 percent to 30 percent of energy storage capacity with their projects. As noted earlier, China accounts for almost three-quarters of global manufacturing capacity of lithium-ion batteries; outside China, the largest manufacturers of lithium-ion batteries are in Korea, Japan, and the United States.

Figure 2.53. World: Actual and Projected Installed Energy Storage Capacity
(Gigawatts)



Source: International Energy Agency (2021c).

Figure 2.54. Lithium-ion Battery Price
(2021 USD per kilowatt-hour)



Source: BloombergNEF.
Note: Forecast prices (2022 and 2023) are in nominal terms.

31/ The plant has an initial production capacity of 1 GWh per year. The company plans to expand production capacity to 4 GWh at a later stage, and possibly to 50 GWh (Muramatsu 2021).

32/ Other types of batteries could emerge as breakthrough technology: for example, in July 2022, China commissioned the world's largest vanadium redox flow battery, with a capacity of 100 MW and a storage volume of 400 MWh (Colthorpe 2022b).

ASEAN has untapped markets for energy storage system applications. ASEAN has collectively set an aspirational target for renewable energy to make up 23 percent of its energy mix by 2025, and most members have plans for wind and/or solar power to be part of their renewable-energy implementation framework—hence, the development and deployment of energy storage technologies will be critical (Table 2.4). At present, however, unlike the Plus-3, few ASEAN economies count among the world's main markets for large-scale energy storage systems, and fewer still have specific policies to encourage energy storage adoption in the power sector.

- Thailand is realizing its plans to become a global production base for energy storage technology, with full support from the government and private firms. The Power Development Plan (2018–2037) released in 2019, mandated the state-owned Electricity Generating Authority of Thailand (EGAT) to develop energy storage systems to support the take-up of renewable energy. Thailand was the first ASEAN country to develop a wind-hydrogen hybrid power plant in 2018;[33] EGAT is also promoting solar-hydro battery energy storage.[34] Meanwhile, the private sector is also pursuing opportunities to develop projects with battery energy storage system technologies, including with foreign firms.[35]

- The Philippines has rapidly become one of the most active energy storage markets in ASEAN, with major power generation companies investing in portfolios of battery storage. Among its efforts to modernize its electricity sector, the government in 2019 issued guidelines to clarify who could own, operate, and ultimately benefit from the deployment of energy storage systems in the electric power industry. The country's first-ever co-located solar and storage plant went online in early 2022, and a proposal has been announced to build a massive solar-plus-storage facility that would be one of the biggest in the world (Colthorpe 2022c).

- Indonesia is attracting substantial investments in solar-plus-storage projects—for exporting electricity to the Singapore market. A Singapore-German joint venture is building a large-scale solar-plus-storage plant in the Riau Islands that will send electricity to Singapore through an undersea cable; and similar deals are being negotiated across the province (Murtaugh 2022).

Critical Minerals

"Wherever you are in the world, please mine more nickel ..."

Elon Musk
Founder and Chief Executive Officer of Tesla
July 2020

The shift to clean energy and EVs will drive a huge increase in requirements for critical minerals. Production of a typical electric car requires over 200 kilograms of minerals—graphite, copper, nickel, manganese, cobalt, lithium, and rare earth elements (REEs)—compared to about 35 kilograms of copper and manganese for a conventional car.[36] An onshore wind plant requires nine times more mineral resources (copper, zinc, manganese, chromium, nickel, and molybdenum) than a gas-fired plant (copper and chromium). The types of minerals used vary by technology. Vast quantities of copper and aluminium are required for electricity networks. Lithium, nickel, cobalt, manganese, and graphite are vital for battery performance, longevity, and energy density while permanent magnets used in turbines and EV motors rely crucially on REEs. According to the IEA, global mineral demand for clean energy technologies will rise by at least four times by 2040 to meet climate goals, with particularly high growth for EV-related minerals (Figure 2.55) (IEA 2022l).

China, Indonesia, Myanmar, and the Philippines are among the world's top producers of critical minerals. China is the world's largest producer of graphite, molybdenum, and REEs and the third-largest producer of lithium; it also mines more than 5 percent of the world's manganese, copper, and nickel. Indonesia and the Philippines are the world's top producers of nickel. Myanmar is the third-largest global producer of REEs (Figure 2.56).[37]

33/ In a wind-hydrogen hybrid system, excess electrical energy generated by wind turbines is used to decompose water in an electrolyzer to produce and store that energy as hydrogen. EGAT has applied this system to 12 wind turbines across the country.

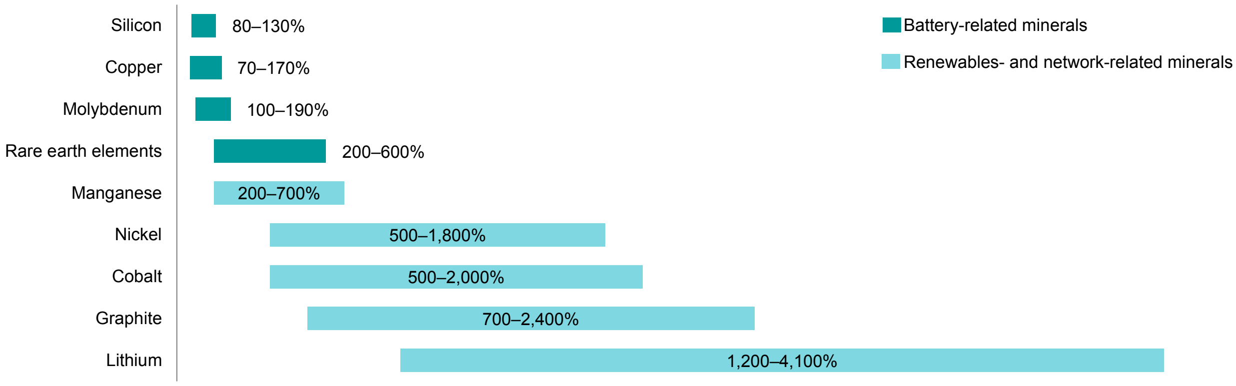
34/ After completing the world's largest hydro-floating solar power plant in 2021, EGAT is building a second one, which will be equipped with a battery energy storage system (The Nation 2022).

35/ Thai renewable energy company BCPG has obtained financing of more than USD 14 million (including from the Asian Development Bank) for a project integrating utility-scale wind power generation with a battery energy storage system (ADB 2020). Another Thai renewable energy company, Super Energy, is building Southeast Asia's largest battery energy storage system in partnership with a Chinese inverter manufacturer (Colthorpe 2021).

36/ REEs are a family of 17 elements. REEs are not rare, but minable concentrations are less common than most other minerals.

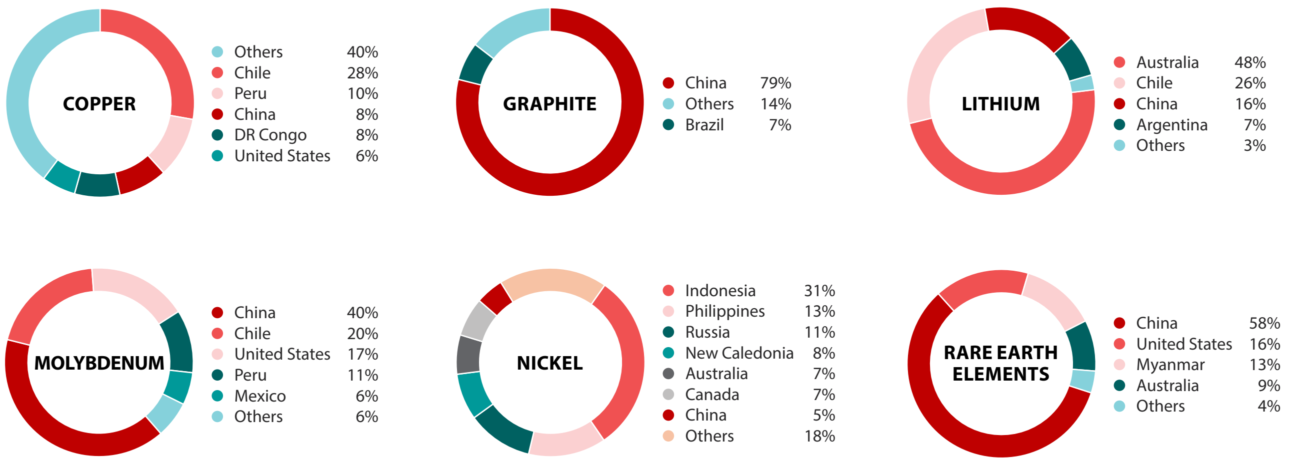
37/ About 55 percent of the world's REE reserves are in China and Vietnam (USGS 2022).

Figure 2.55. World: Projected Growth in Demand for Critical Minerals, 2020–40



Source: International Energy Agency (2022l).
Note: Projected demand growth between 2020 and 2040 for each mineral is presented as a range based on different underlying scenarios used in the IEA's simulations.

Figure 2.56. World: Major Producers of Critical Minerals, 2020
(Percent of total global production)



Source: USGS (2022).

Mineral-rich ASEAN economies are pursuing policies to capitalize on the rising global demand for these resources.

- Indonesia—the world's largest nickel producer and home to the largest reserves of the metal—aims to capture more of the value chain by developing a domestic nickel-based EV industry, from nickel mining to producing battery components and assembling EVs. Consistent with Indonesia's strategy of developing downstream industries for natural resources, and following its earlier success in developing an integrated steel supply chain, the government reimposed a ban on exports of unprocessed nickel ore in 2020 and is considering an export tax on nickel products with less than 70 percent nickel content as well as limiting the construction of nickel smelters producing nickel pig iron (ferronickel) with a view to shifting use from steelmaking toward battery production.[38] So far, the strategy appears to be

[38] Historically, Indonesia's nickel strategy focused on the supply chain for steel production. Its first export ban on nickel ore was imposed in 2014 to force mining companies to process the ore domestically into Class 2 nickel (e.g., ferronickel/nickel pig iron). The strategy succeeded in attracting investments in nickel processing from China, which were critical in developing a fully integrated steel supply chain. The export ban was relaxed in early 2017 with plans to fully reimpose it after a few years. Steel- and battery-related nickel products are not the same, however—Indonesia's processing industry is dominated by low nickel-content products like ferronickel/nickel pig iron with nickel content of 30–40 percent, whereas battery cathode production usually requires Class 1 products that contain a minimum of 99.8 percent nickel (Huber 2021).

working to attract downstream investments focused on nickel refining and processing—spending on nickel investment projects in one of its biggest industrial parks reached USD 18 billion in 2022, triple the figure in 2019 before the export ban was imposed (Listiyorini 2022).

- The Philippines—with the world's fifth-largest reserves of nickel and rich deposits of copper and gold—is also looking to ride the rising global demand for critical minerals. Unlike Indonesia, however, its recent efforts have focused more on the upstream segment. In 2021, the government lifted a nine-year moratorium on new mining agreements and a four-year ban on open-pit mining for copper, gold, silver, and complex ores. This opened the door for new investments and for pending projects to proceed to their development and commercial extraction stages.[39] The government aims to triple the size of the country's mining sector by 2027. It is estimated that as many as 190 new mining projects could get under way in the next four years, with nickel accounting for one-third of the new mines and the bulk of new open-pit mining (Mitchell 2022).

- Vietnam—with the world's second-largest reserves of REEs and abundant nickel deposits—also has potential for mineral exploitation, though it is at a much earlier stage than the Philippines and Indonesia. In 2018, the government approved a USD 400 million investment plan for mineral exploration, extraction, and processing over 2025–35, and announced a ban on all natural ore or mineral exports until the end of that period.[40] An Australian exploration and mining company is developing three projects in northern Vietnam with the aim of producing nickel-cobalt-manganese precursor products for Asia's growing lithium-ion battery industry.[41]

The policies are not without challenges. Indonesia's export ban on nickel ore has already been challenged by the European Commission at the World Trade Organization. Moreover, nickel mining in Indonesia is particularly carbon-intensive due to heavy reliance on coal, and it has been associated with deforestation, water pollution, and conflicts with indigenous people over land use. To meet the needs of EV companies and their environment-conscious consumers, the government will have to establish and enforce strict environmental standards for the mining and processing of nickel for EV batteries. The same applies to Vietnam. Mining is also contentious in the Philippines after past cases of environmental mismanagement fueled a strong lobby against the industry.

Carbon Capture, Utilization, and Storage

"Unless we develop carbon dioxide removals rapidly and on large scale ... it will be impossible to limit global warming to 1.5 degrees Celsius."

Adair Turner
Chair of the Energy Transitions Commission
March 2022

Carbon capture, utilization, and storage (CCUS) refers to the process of capturing carbon dioxide before it enters the atmosphere and reusing or storing it. Carbon dioxide can be captured from fossil fuel combustion or industrial processes (or directly from the air) using separation technologies. It can then be transported by ship or pipeline to be used in a range of applications or stored permanently in underground geological formations like saline aquifers. Technologies for CCUS are not new: for many years the oil and gas industry has been using captured carbon for "enhanced oil recovery" (EOR), where it is injected into fields with declining output rates to extract more oil and gas. Almost three-quarters of carbon dioxide captured over the past five decades was used for EOR and then stored underground (Robertson and Mousavian 2022). The process of capturing and storing carbon dioxide without reusing it is known as carbon capture and storage (CCS).

CCUS can be valuable as a tool for decarbonization and emission reduction for ASEAN+3. The region has the youngest existing coal power plants among major regions in the world (Figure 2.57). Meeting the 1.5 degrees Celsius commitment under the Paris Agreement would mean most of these coal power plants would have to be retired at least 20 years early (IPCC 2022). Retrofitting these assets with CCUS technology would allow them to be used for longer, which could help minimize the negative impact on growth from asset stranding and economic dislocation (Section II). CCUS also is critical for the decarbonization of hard-to-abate but essential industries like cement, iron and steel, and chemicals manufacturing (Global CCS Institute 2022).

39/ More than a third of the Philippines' total land area has been identified as having high mineral potential and less than 5 percent of the Philippines' mineral reserves is estimated to have been extracted so far (Reuters and Dela Cruz 2021).

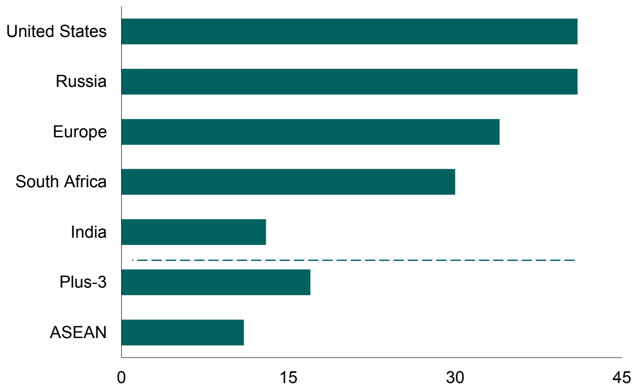
40/ The 11-year investment plan aims to produce more than 146,400 thousand tons of gold ore; 216,000 tons of copper ore; and 103,000 tons of nickel ore (Minh 2018).

41/ Northern Vietnam is already well equipped with infrastructure and established electronic supply chain networks of major EV battery manufacturers.

CCUS can also present new economic opportunities. Economies with large extractive sectors, e.g., Brunei, Indonesia, and Malaysia, could deploy CCUS to reduce emissions along their extractive supply chain, increasing the viability of fields that otherwise would remain undeveloped. Economies whose industrial sectors have strong carbon capture prospects, e.g., the Philippines and Singapore, could use CCUS for carbon recycling (IEA 2019) (Figure 2.58). Economies with domestic storage potential, e.g., Malaysia, Thailand, and Vietnam, could fill the demand for offshore storage of captured carbon.

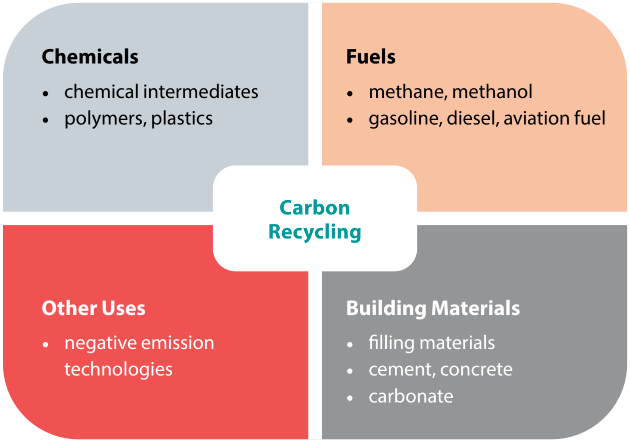
Available estimates of actual and potential carbon dioxide storage resources in the region total over 3,000 gigatons in the Plus-3 and almost 200 gigatons in ASEAN, although only a fraction will ever be economically and technically viable (Figure 2.59).[42] The development of large-scale shared carbon storage that industrial users can tap anywhere in ASEAN+3 would also foster a captured carbon value chain, which would increase opportunities for the region's shipping and logistics sectors—Japan is already active on this front.[43]

Figure 2.57. ASEAN+3 and Selected Economies: Average Age of Existing Coal Plants, 2020
(Years)



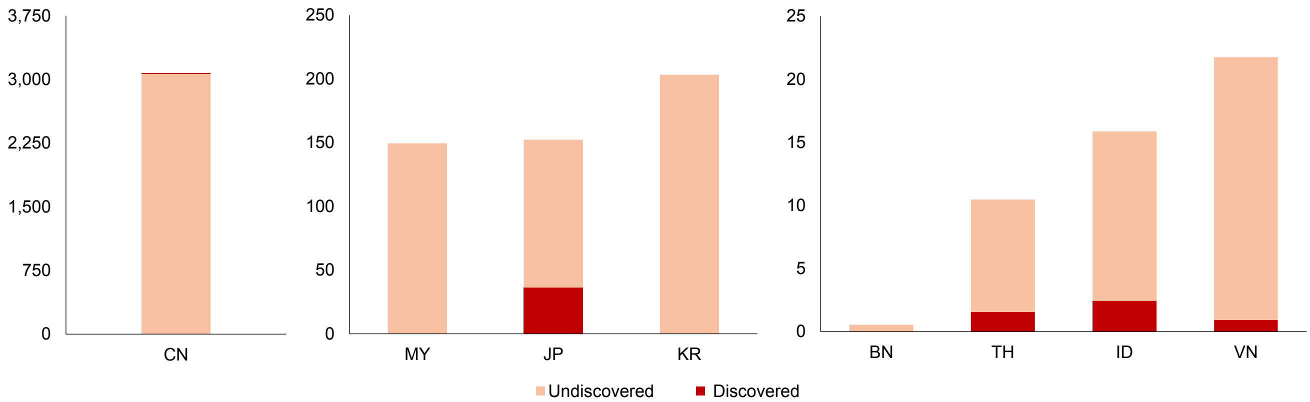
Source: International Energy Agency.

Figure 2.58. Carbon Recycling: Potential Applications



Source: International Energy Agency; AMRO staff compilation.
Note: This only refers to applications that require conversion. Direct (unconverted) uses of carbon dioxide also exist—e.g., to enhance the yield of biological processes, for solvents and heat transfer, and for food and beverage and medical uses.

Figure 2.59. Selected ASEAN+3: Estimated Carbon Storage Resources
(Gigatons of carbon dioxide)



Source: OGCI (2022).
Note: Discovered resources refer to the estimated quantity of storage resources in which the potential for storage has been ascertained within an assessed geologic formation. Undiscovered resources refer to the estimated quantity of resources in which the suitability for storage has not been ascertained within the target geologic formation. Undiscovered resources include: (1) prospective resources, i.e., storage resources estimated to be potentially accessible within undiscovered geologic formations or uncharacterized parts of discovered geologic formations by application of future exploration/development projects; and (2) inaccessible resources, i.e., resources that cannot be used by future storage development projects. Chart shows only ASEAN+3 economies with available data. BN = Brunei; CN = China; ID = Indonesia; JP = Japan; KR = Korea; MY = Malaysia; TH = Thailand; VN = Vietnam.

[42] Most of the storage in Southeast Asia is expected to be in saline aquifers, but depleted oil and gas fields can also provide important storage opportunities. The storage potential in the region is likely to exceed needs by a large amount, even in a scenario compatible with net zero (IEA 2021d).

[43] Mitsubishi Shipbuilding is building a demonstration test ship to transport liquefied carbon dioxide, the world's first such carrier intended specifically for CCUS (Mitsubishi Heavy Industries 2022).

CCUS activity and deployment in the ASEAN+3 is led by a handful of economies. Ten large-scale CCUS projects are in various stages of development in China, Indonesia, Korea, Malaysia, and Thailand (Table 2.8). China and Japan are the most CCUS-ready economies in the region, followed by Korea, Indonesia, and Malaysia (Figure 2.60) (Global CCS Institute 2022). CCUS momentum in China is driven by its energy production and use, as well as its abundant storage potential (Figure 2.59). Japan also has storage potential, as well as transport infrastructure and a supportive legal environment. Indonesia and Malaysia are CCUS frontrunners given their well-established extractive sectors, with both aiming to become key offshore storage hubs (Battersby 2022; Nair 2022). Brunei and Singapore have also indicated interest in CCUS (Table 2.9).

There is room for growth. According to the IEA, to be in line with the temperature objectives set out in the Paris Agreement, carbon capture in Southeast Asia will have to reach at least 35 million tons a year in 2030 and exceed 200 million tons a year by 2050, with CCUS deployed at scale across the fuel transformation, industry, and power generation sectors (IEA 2021d).

The main barriers to CCUS in the region are the lack of data on geological storage resources, legal and regulatory frameworks, and policy incentives. Early, accurate, and trustworthy "bankable" onshore and offshore storage data are critical for attracting capital and facilitating the development and uptake of CCUS in the region.[44] CCUS needs to be identified and integrated or (explicitly) mentioned in national climate policies and strategies for the requisite legal and regulatory frameworks to materialize soon enough to attract the necessary investments and public support (Table 2.9). Incentives for investment and financing—particularly blended finance—are critical as most governments are unable to fully fund CCUS projects, while carbon utilization projects can be technically and financially risky for investors (IEA 2021d; Robertson and Mousavian 2022). Regional cooperation can also identify opportunities to support wider and faster use of technology across the ASEAN+3, through collaboration in technology, knowledge, and infrastructure development.

Table 2.8. ASEAN+3: Carbon Capture, Utilization, and Storage Facilities and Projects, as of November 2022

Project Name	Status	Facility Industry	Capacity (Mtpa CO_2)	Purpose
China				
Karamay Dunhua Oil Technology CCUS EOR	Operational	Methanol production	0.1	EOR
CNPC Jilin Oil Field CO2 EOR	Operational	Natural gas processing	0.6	EOR
SINOPEC Qilu-Shengli CCUS	Operational	Chemical production	1.0	EOR
CNOOC South China Sea Offshore CCS	Operational	Natural gas processing	0.3	Storage
Guodian Taizhou Power Station Carbon Capture	In construction	Power generation	0.5	EOR
Huaneng Longdong Energy Base CCS	Advanced development	Power generation	1.5	Storage
SINOPEC Shengli Power Plant CCS	Early Development	Power generation	1.0	EOR
Indonesia				
Repsol Sakakemang Carbon Capture and Injection	Early Development	Natural gas processing	2.0	Storage
Sukowati CCUS	Early Development	Oil refining	1.4	EOR
PAU Central Sulawesi Clean Fuel Ammonia Production with CCUS	Early Development	Fertilizer production	2.0	Under evaluation
Korea				
Korea-CCS 1 and 2	Early Development	Power generation	1.0	Storage
Malaysia				
Petronas Kasawari Gas Field Development Project	Early Development	Natural gas processing	3.3	EOR
Thailand				
PTTEP Arthit CCS	Advanced development	Natural gas processing	1.0	Storage

● Operational ● In construction ● Early Development ● Advanced development

Source: Global CCS Institute (2022); AMRO staff compilation from various media reports.
Note: CCS = carbon capture and storage; CCUS = carbon capture, utilization, and storage; EOR = enhanced oil recovery; Mtpa CO2 = million tons of carbon dioxide a year.

[44] Long lead times are associated with developing carbon storage resources; some studies show this process alone can take up to 10 years.

Figure 2.60. ASEAN+3 and Selected Economies: CCS Readiness Index, 2021
(0 to 100; 100 = Highest assessment)

Economy	CCS Readiness *(overall)*	Interest	Storage	Policy	Legal
United States	72	82	96	49	73
Canada	71	48	98	41	75
Leader average	*72*	*65*	*97*	*45*	*74*
China	53	86	87	40	32
Japan	50	39	71	39	41
Korea	36	38	45	20	43
Malaysia	31	40	46	9	39
Indonesia	30	56	52	4	34
Vietnam	29	48	56	3	28
Philippines	22	24	35	2	29
Thailand	22	41	39	4	24
Memo items:					
Brunei	–	1	24	10	–
Hong Kong	–	–	–	–	–
Cambodia	–	–	–	3	–
Lao PDR	–	–	18	–	–
Myanmar	–	8	13	1	–
Singapore	–	15	0	12	–

Source: Global CCS Institute (2022); AMRO staff calculations.
Note: Carbon capture and storage (CCS) readiness is assessed on the basis of four factors: (1) interest—the intensity of fossil fuel production and/or consumption; (2) storage—factors that affect various aspects of carbon dioxide injection and storage, including site viability; (3) legal—presence of national frameworks conducive to CCS regulation; and (4) policy—presence of available explicit and implicit support for CCS. Each indicator is given different weights by the Global CCS Institute to come up with the overall score.

Table 2.9. ASEAN+3: Key Carbon Capture, Utilization, and Storage Policies and Initiatives

Economy	Policies and Initiatives
Brunei	• Brunei is exploring the potential of carbon capture, utilization, and storage (CCUS) to mitigate emissions from the oil and gas sector. • In January 2022, local start-up Perdana Solutions signed an agreement with consultancy Asia Pacific Energy Solutions on the first carbon capture and storage (CCS) partnership in Brunei. Shell is evaluating the technical and commercial feasibility of transporting carbon from Singapore to store in Brunei.
China	• CCUS has been included in China's carbon mitigation strategies since the 12th Five-Year Plan (2011–15). In 2019, the Ministry of Science and Technology and the Administrative Center for China's Agenda 21 jointly issued an updated Roadmap for Development of CCUS Technology in China, which set goals for reducing the cost and energy consumption of carbon capture by 10 percent to 15 percent in 2030 and by 40 percent to 50 percent by 2040. The 14th Five-Year Plan (2021–25) highlighted the role of CCUS in low-carbon development and called for implementing near-zero emissions CCUS demonstration projects.
Indonesia	• Indonesia's 2011 National Action Plan on Climate Change recognized that CCUS could contribute up to 40 percent of the energy sector's target emission reductions. The government is preparing draft regulations to accelerate implementation of CCS and CCUS projects in the oil and gas area. • In 2017, the Ministry of Energy and Mineral Resources opened the National Center of Excellence for CCS and CCUS, which acts as a knowledge hub and funding facilitator.
Japan	• In 2021, the Ministry of Economy, Trade, and Industry (METI) launched the Asia CCUS Network, an international industry-academia-government platform aimed at knowledge sharing and improvement of the business environment for utilization of CCUS in Asia. METI has drafted a long-term CCS roadmap to store 120–240 million tons of carbon dioxide a year by 2050. It plans to create a legal framework for CCS to enable companies to store carbon dioxide underground or under the seabed by 2030. • Japanese oil refiner Eneos Holdings and utility J-Power plan to launch the country's first permanent CCS operation by the end of this decade.
Korea	• The National CCS Comprehensive Plan was established in July 2011 and subsequently updated as Korea CCS 2020 to promote the development and use of CCS technology. The Ministry of Science and ICT launched the Korean CO2 Storage Environmental Management Research Center in April 2011. • Six Korean energy companies have signed an agreement with Malaysia's Petronas for a cross-border project to transport carbon captured in Korea to Malaysia for storage.
Malaysia	• Malaysia's state-owned oil and gas company, Petronas, is leading efforts to implement CCUS.
Singapore	• Singapore's Long-Term Low Emissions Development Strategy 2020 cites the need to adopt advanced low-carbon technologies like CCUS to facilitate its transition. The government is exploring partnerships with companies and other countries with suitable geological formations to enable carbon dioxide storage opportunities and carbon recycling pathways. • In 2020, the government established the Low-Carbon Energy Research Funding Initiative to support research, development, and demonstration projects in low-carbon energy technologies such as CCUS. Singapore is aiming to realize at least 2 million tons of carbon capture potential by 2030 as part of a plan to make its Jurong Island oil refinery hub more sustainable.
Thailand	• Thailand's state-owned oil and gas group PTT is leading efforts to implement CCUS. In 2022, PTT Group, together with national educational, government, and private sector partners, established the Thailand CCUS Technology Development Consortium to develop effective technology prototypes.

Source: AMRO staff compilation from various media reports.

Carbon Offsets

"Explore carbon sinks. Net zero is not gross zero."

Ricardo Hausmann
Harvard Kennedy School Professor
December 2022

Carbon offsetting refers to reductions in GHG emissions that compensate for GHGs generated elsewhere. A carbon offset typically represents one ton of carbon dioxide or its GHG-equivalent reduced through a project that avoids activities contributing to GHG emissions (e.g., deforestation and land use conversion) or a project that removes GHGs from the atmosphere (e.g., through afforestation/reforestation or carbon sequestration). It is a way to "undo" emissions that are considered to be not abatable given the current capabilities of technology. Carbon offsets can be bought and sold by generating carbon credits—tradeable instruments that represent ownership of (or the right to emit) a unit of emissions that typically is one ton of carbon dioxide equivalent. The emission reduction of a carbon-offset credit must be verified by an independent third party; the Gold Standard and Verra, for example, are two internationally recognized standard-setters.

Trade in carbon-offset credits takes place in three main types of markets, as well as under bilateral and multilateral results-based agreements.

- *Domestic compliance markets*—where companies trade domestic carbon-offset credits to meet part of their legal obligations under a cap-and-trade emissions system—are operational in most ETSs, including those in China, Japan, and Korea (Box 2.3).[45]

- *International compliance markets*—where governments or companies trade carbon-offset credits internationally to meet commitments to emission reduction—are still in the early stages. Demand in these markets stems mainly from the airline industry's compliance requirements under the carbon offsetting and reduction mechanism of the International Civil Aviation Organization (ICAO).[46] Another source of demand may arise from national governments trading emission credits to satisfy their Nationally Determined Contributions to climate change mitigation under Article 6 of the Paris Agreement. Japan has been cooperating with several countries, including Cambodia, Indonesia, Lao PDR, Myanmar, the Philippines, Thailand, and Vietnam, to develop carbon offset projects under the Joint Crediting Mechanism, which can pave the way for authorization as "internationally transferred mitigation outcomes" under the United Nations Framework Convention on Climate Change (UNFCCC) (Box 2.8).[47]

- *Voluntary carbon markets*—where companies and individuals purchase carbon offsets to comply with their own voluntary commitments—are a fast-growing segment of the global carbon offset market. Although the value of these markets is still small, demand is rising as more companies voluntarily adopt internal climate change goals as part of their corporate social responsibility or public relations strategy (Section IV).

- *Results-based climate finance*—which generally refers to payments made by international funders to developing countries for achieving climate-related results such as reductions in emissions—is a financing modality that can be used for the purpose of carbon offsetting. One of the more widely known results-based carbon offsetting programs is the UNFCCC's Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD+) mechanism, which allows international development partners or private companies to make payments to—i.e., purchase carbon-offset credits from—developing countries after the latter's completion of actions to conserve and enhance carbon sinks and reservoirs in the forestry sector. Given that 15 percent of the world's tropical forests are in Southeast Asia, which has the highest rate of deforestation in the world, ASEAN countries could stand to benefit from participating in REDD+ (Box 2.9).

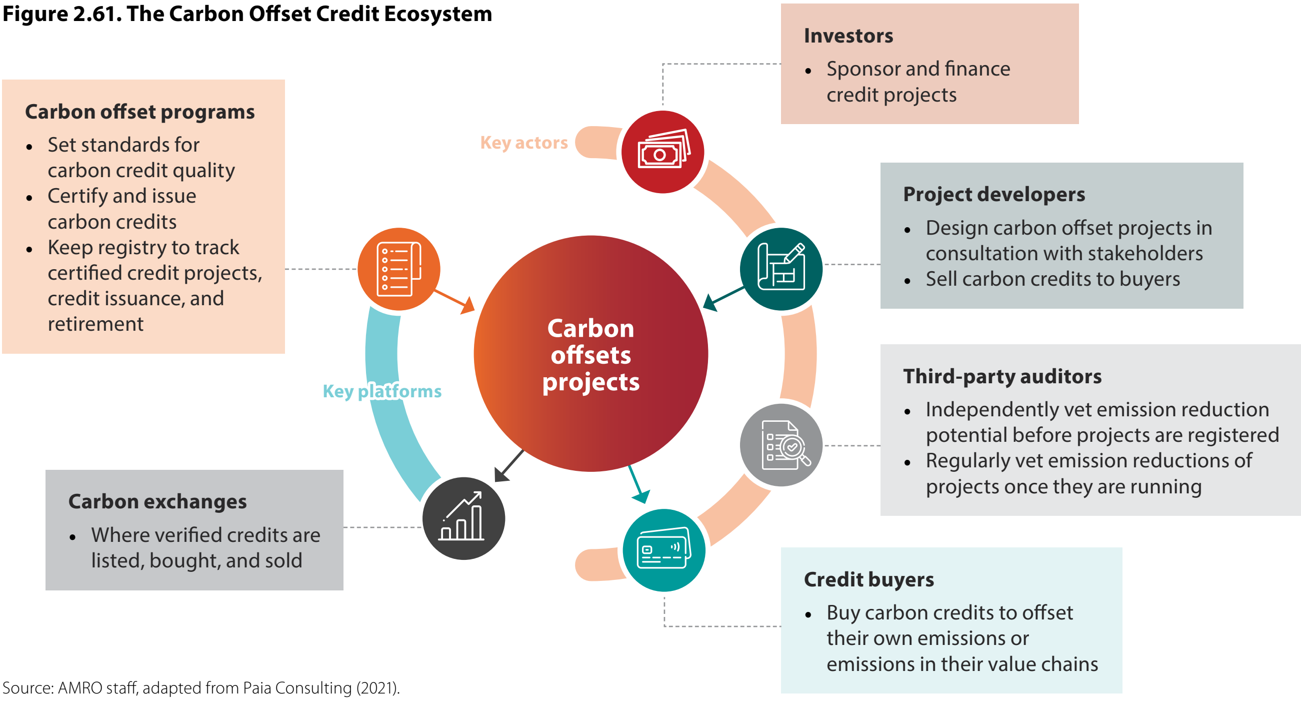
45/ Offsets in a cap-and-trade system are intended to increase flexibility for—and so reduce the overall cost of—compliance. However, one concern is that allowing capped entities to use offsets instead of requiring all reductions to come from their own facilities can shift or divert effort from capped sectors. Hence, the use of offset credits is restricted in most ETSs. For example, regulated entities can only use offsets for up to 5 percent of their compliance obligations in the national ETSs in China and Korea (Box 2.3).

46/ The ICAO's Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) relies on use of emission units from the carbon market to offset carbon dioxide emissions that cannot be reduced through technological and operational improvements and sustainable aviation fuels. CORSIA is being implemented in three phases: a pilot phase (2021–23), a first phase (2024–26), and a second phase (2027–35). More than 100 economies will participate in the pilot phase, including ASEAN+3 economies: Cambodia, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, and Thailand.

47/ The Joint Crediting Mechanism is a project-based bilateral offset crediting mechanism launched by Japan in 2013 to facilitate the mitigation of GHG emissions through the diffusion of low-carbon technologies, products, systems, services, and infrastructure.

Carbon markets, particularly the voluntary segment, hold significant promise for the ASEAN+3 region. Bain & Company estimates that carbon offsets in Southeast Asia could generate up to USD 10 billion a year in financial opportunities by 2030 (Hardcastle, Kulkarni, and Lichtenau 2021). These benefits accrue to a variety of participants, ranging from project developers and financers to auditors and brokers (Figure 2.61). For the host economy, proceeds from the sale of carbon offsets can be used to foster investment in low-carbon projects and promote innovation in green technology. Growing carbon markets also encourage job creation in finance and other professional service sectors, such as auditing, consulting, and legal advisory. Moreover, as carbon offsets become more widespread, so does their role in creating financial instruments (e.g., derivatives structured around carbon-offset credits), contributing to financial market development at large.

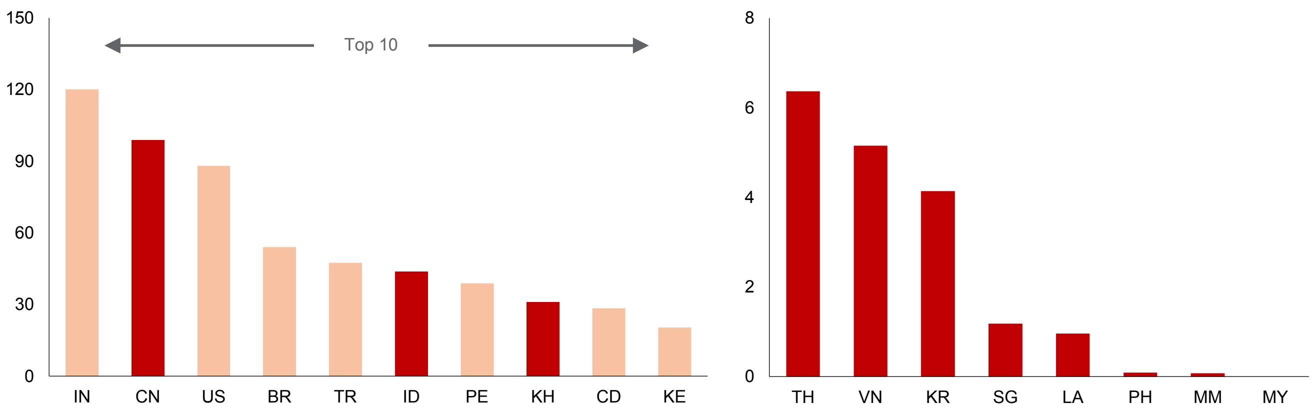
Figure 2.61. The Carbon Offset Credit Ecosystem



Source: AMRO staff, adapted from Paia Consulting (2021).

The ASEAN+3 region has significant potential to generate carbon offset projects. According to international advisory company Climate Focus, China is the world's second-largest supplier of voluntary carbon offsets, mostly as renewable energy (particularly wind power) projects. Indonesia is the world's fifth-largest supplier and Cambodia the eighth—largely on account of both having projects that avoid deforestation and land-use conversion (Climate Focus 2022) (Figure 2.62). Singapore is embarking on a five-year research effort, Carbon Integrity SG, to identify nature-based projects in Southeast Asia that can be developed as potential sources of carbon credits (Wong 2022). Malaysia's newly opened voluntary carbon market exchange aims to support the development of domestic carbon credit projects that can be purchased by domestic companies to offset their emissions.

Figure 2.62. ASEAN+3 and Selected Economies: Nonretired Voluntary Carbon Offset Credits, by Host Economy, March 2023
(Megatons of carbon dioxide equivalent)



Source: Climate Focus (2022); and AMRO staff calculations.
Note: Excludes nonretired voluntary offset credits from international projects that are not assigned to any country in particular. BR = Brazil; CD = Democratic Republic of Congo; CN = China; ID = Indonesia; IN = India; KE = Kenya; KH = Cambodia; KR = Korea; LA = Lao PDR; MM = Myanmar; MY = Malaysia; PE = Peru; PH = Philippines; SG = Singapore; TH = Thailand; TR = Turkey; US = United States; VN = Vietnam.

The region is also becoming a substantial source of demand for voluntary carbon offsets as more companies adopt carbon-reduction targets. Out of some 3,400 companies that have signed up to the Science-Based Targets Initiative—a multilateral partnership that helps companies meet emission-reduction targets—about 500 are in ASEAN+3. Moreover, the region's demand is poised to expand as more multinationals require their Asia-based supply chains to follow stricter environmental standards.[48] Thailand's state-owned electricity generator, together with 10 of the country's largest energy-sector companies, set up a voluntary emission offset program in 2021 where members could trade carbon credits (Thanthong-Knight 2021).

Singapore and Hong Kong, as key international financial centers, are well placed to become regional and global trading hubs for voluntary carbon offsets.

- Singapore has two international exchanges trading voluntary carbon credits. The first, AirCarbon Exchange (ACX), was established in 2019 with government support. ACX began by offering trading opportunities focused on airlines, and has grown to more than 160 clients including financial institutions, project developers, and other key industry players. The second, Climate Impact X (CIX), was borne out of a private-public partnership in 2021. CIX's initial focus is on carbon credits generated from projects related to the protection, management, and restoration of natural ecosystems and biodiversity. By early 2023, the exchange expects to see carbon credits traded on a larger scale under standardized contracts among multinational companies, institutional investors, and financial firms (Nomura 2022).
- In October 2022, Hong Kong's stock exchange launched a new platform, Core Climate, an international carbon marketplace for trading carbon credits and other instruments to support the global transition to net zero. Participants will be able to use the platform to source, hold, trade, settle, and retire voluntary carbon credits from internationally certified carbon projects around the world.

A few challenges need to be resolved for the region to benefit more fully from carbon-offset trading. First, carbon offset credits sold in voluntary carbon markets today can be verified by any independent certification body with minimal (onsite) monitoring by third parties. As such, substantial variation in the quality of available carbon credits has led to low trust among buyers and investors.[49] Second, most offset transactions in the region are done through brokers or directly with developers, with wide variance in margins and little correlation with quality. Carbon credit trading exchanges can tackle this problem by standardizing margins, increasing market efficiencies, improving access to high-quality offset credits, and establishing a derivatives market to improve liquidity. Lastly, key regional challenges include inconsistent government support and policies and unresolved issues around Article 6 of the Paris Agreement and the international legitimacy of offsets (Box 2.8). Overcoming these challenges will benefit economies in the region that have potential for developing carbon offset projects (e.g., Cambodia and Indonesia) and economies with potential to become regional or global carbon trading hubs (e.g., Hong Kong and Singapore).

48/ For example, in 2020, Tesla required Korea's LG Chem to submit carbon emissions data from its battery production (Lee 2020).

49/ In general, high quality carbon offset credits must be associated with GHG reductions or removals that are: additional; not overestimated; permanent; not claimed by another entity; and not associated with significant social or environmental harms (Broekhoff and others 2019).

Box 2.8:

Carbon Offsets: From Kyoto to Paris

The 1997 Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) established a cap-and-trade system that imposed national caps on the greenhouse gas (GHG) emissions of advanced economies. Countries could meet their targets by reducing their own emissions, trading emission allowances, or purchasing carbon offset credits. To generate offset credits, the Clean Development Mechanism (CDM) was established for offset projects in countries without binding emission commitments under the Kyoto Protocol. Credits earned by CDM offset projects—called "certified emission reductions" (CERs)—could be used to cover part of the purchasing countries' emission-reduction obligations. In all, more than 8,000 projects in 111 countries (including Cambodia, China, Indonesia, Korea, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam) were registered to sell CERs from various ventures such as wind power development, bus rapid transit schemes, and the distribution of more efficient cookstoves.

The Paris Agreement, which replaced the Kyoto Protocol in 2015, requires all countries to set emission-reduction pledges, with Article 6 providing principles for "voluntary cooperation" to reach their climate targets. Articles 6.2 and 6.4 define the framework for the international compliance carbon market agreed at the 26th United Nations Climate Change Conference of the Parties (COP26) in Glasgow in 2021.

- Article 6.2 allows countries to trade emission reductions and removals with one another through bilateral or multilateral agreements. These traded credits are called "internationally transferred mitigation outcomes" (ITMOs). They can be measured in carbon dioxide equivalent or other metrics, such as kilowatt-hours of renewable energy.

- Article 6.4 will create a global carbon market overseen by a COP-designated supervisory body. Project developers will request to register their projects with the supervisory body. A project must be approved by both the country where it is implemented and the supervisory body before it can start issuing UN-recognized credits. These credits, known as "Article 6, paragraph 4, emission reductions" (A6.4ERs), can be bought by countries, companies, or even individuals.

ITMOs can already be traded between countries, in theory. Countries such as Japan and Switzerland have concrete projects in place to buy such credits and count them toward their Nationally Determined Contributions. However, it is typically a lengthy process for countries to conclude these agreements, so it may still be some time before ITMOs are widely traded.

It will likely take a few years before A6.4ERs can be issued and traded. Detailed rules still need to be worked out, such as rules to govern how projects will be assessed before being registered and how emission reductions will be measured, among others. Meanwhile, the CDM will continue for a transitional period while its underlying infrastructure and remaining funds will largely be repurposed for the future Article 6.4 mechanism.

This box was written by Ling Hui Tan.

Box 2.9:

Monetizing ASEAN's Forests

The Reducing Emissions from Deforestation and Forest Degradation (REDD+) scheme is a mechanism that creates financial value for the carbon stored in forests by offering results-based payments to developing economies for actions to reduce or remove forest carbon emissions. Support for REDD+ implementation comes from donor countries, including the European Union, Japan, and Norway, and multilateral initiatives including the Green Climate Fund and the World Bank's Forest Carbon Partnership Facility (FCPF).

Developing economies need to meet a host of requirements to qualify for results-based payments for REDD+ activities. These include: having a national strategy or action plan addressing the drivers of deforestation and forest degradation, land tenure issues, forest governance issues, gender considerations, and so on; a safeguards information system to support the rights of indigenous peoples and local communities; a national forest monitoring system providing reliable data on forest areas and their changes; and a system for measuring, reporting, and verifying results-based actions. Meeting these requirements takes many years—up to a decade in many cases.

Seven ASEAN countries are participating in REDD+.

- Vietnam was the first Asian country to reach eligibility for REDD+ results-based payments in 2018, but it will be some time before payments materialize. In October 2020, Vietnam signed an agreement with the World Bank's FCPF, unlocking up to USD 51.5 million in exchange for reducing 10.3 million tons of carbon dioxide equivalent (MtCO2e) of emissions from six North Central Region provinces through 2025 (World Bank 2020a).

- Indonesia received its first results-based payment of USD 103.8 million in August 2020 from the Green Climate Fund, in recognition of having avoided 20.3 MtCO2e of emissions in 2014–16. Further payments of up to USD 110 million could be forthcoming from a November 2020 program with the FCPF to reduce 22 MtCO2e of emissions in East Kalimantan through 2025 (World Bank 2020b). But Indonesia's REDD+ partnerships have not all been smooth. In September 2021, it terminated a longstanding agreement with Norway—under which it stood to receive USD 1 billion for slowing emissions from deforestation—after transfer of the first payment was stalled for more than two years (Reuters 2021b).

- Lao PDR completed its REDD+ readiness preparations and signed an agreement with the FCPF in December 2020 for its first jurisdictional program. Under the agreement, which runs to 2025, Lao PDR will receive up to USD 42 million for verified reductions of up to 8.4 MtCO2e of emissions in the north of the country (World Bank 2021).

- Cambodia has embarked on five REDD+ projects to date and has earned more than USD 12 million selling carbon credits from these projects to major international companies (Khmer Times 2022). However, it has not accessed REDD+ results-based finance at the national scale. Cambodia has announced its intention to pursue multiple financing opportunities for REDD+ implementation at different scales—the government has increased the size of protected areas to 41 percent of the country's total area, including 72 separate national parks, wildlife sanctuaries, multiuse areas, natural heritage sites, and biodiversity corridors (Kimmarita 2022).

- Malaysia, Myanmar, and Thailand are in the process of qualifying for REDD+ results-based payments.

This box was written by Jade Vichyanond.

IV. (How) Can Finance Pave the Way?

The transition to net zero GHG emissions requires significant changes by governments, businesses, and households—and an unprecedented amount of investment. While estimates vary, most suggest that over a trillion dollars in additional investment annually for decades will be needed to support the green transition in emerging market and developing economies. According to the IMF, the world would need about USD 3.3 trillion in energy-related investments a year until 2030 to achieve net zero by 2050 (Georgieva 2022).

Private capital will have to contribute the lion's share of needed investments. In theory, private capital should be attracted into green industries when it is more profitable to invest in clean energy and green technologies than in fossil fuels and the technologies that rely on them—and therefore market forces should drive the green transition on their own. In practice, however, this may not happen because the risk-adjusted private return on investment of "brown" (high emissions) projects is still relatively high while that of green (low or zero emissions) projects is still low; and investors, businesses, and consumers have insufficient information to make the decisions that would facilitate the green transition.

Financial markets are increasingly adopting products, tools, and practices to facilitate the green transition by improving information flow, price discovery, market efficiency, and liquidity. This is giving investors data to switch from market portfolios with significant exposure to fossil fuels into lower-carbon investments and/or companies that implement carbon neutrality. Sustainable finance is the practice of integrating environmental, social, and governance (ESG) criteria into financial services to bring about sustainable development outcomes (MAS 2022). ESG factors cover a broad range of issues, including climate change and the low-carbon transition under the "environmental" pillar. ESG investing considers these nonfinancial factors alongside traditional financial factors in the investment decision-making process.

ESG issues are fast becoming a key factor in investment portfolio allocation and management.

- Total assets invested in ESG funds (comprising mutual funds and exchange-traded funds) globally more than doubled in a span of two years to reach nearly USD 10 trillion in 2021, based on data compiled by Bloomberg.[50] Europe and the United States are major investment destinations, while ESG funds dedicated to ASEAN+3 economies, either individually or regionally (e.g., Greater China or ASEAN), account for 3 percent of total assets, predominantly going to China and Japan.

- The market for so-called labeled bonds—bonds that have specific ESG or sustainability objectives—has also boomed. ESG-labeled bonds include project-based bonds such as green bonds, sustainability bonds, social bonds, and transition bonds, as well as sustainability-linked bonds that are not associated with a project but instead target firmwide key performance indicators (Figure 2.63). Europe is the main source of labeled bonds, followed by ASEAN+3 and North America (Figure 2.64). Among ASEAN+3 economies, China accounted for half of annual labeled bond volumes in 2021–22, followed by Korea and Japan, which together accounted for nearly 40 percent (Figure 2.65).

The rest of this section focuses on aspects of sustainable finance that pertain to climate change mitigation in the region.

Figure 2.63. ESG-Labeled Bonds

Sustainability bonds
- Proceeds are used for projects or activities with environmental and social benefits. Includes Sustainable Development Goals bonds.

Green bonds
- Proceeds are used for projects and activities with dedicated environmental benefits.

Social bonds
- Proceeds are used for projects and activities with dedicated social benefits. Includes COVID-19-response bonds, affordable housing bonds.

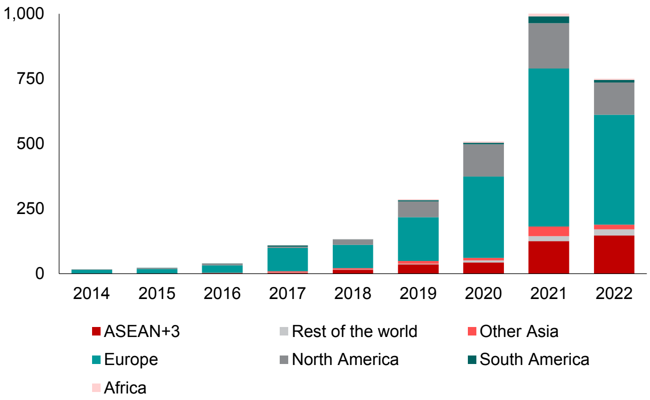
Sustainability-linked bonds
- Proceeds are used for general purposes and not tied to specific projects. Coupon linked to entity-level sustainability performance indicators.

Transition bonds
- Proceeds are used to fund green transition at the activity or entity level.

Source: Climate Bonds Initiative; AMRO staff.

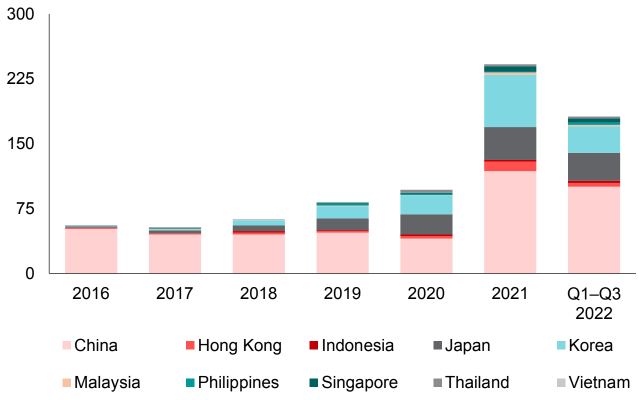
50/ Funds are classified by Bloomberg to be ESG funds if their prospectus indicates that they invest in one or more ESG activities.

Figure 2.64. World: Annual Issuance of Labeled Bonds, by Region
(Billions of US dollars)



Source: Bloomberg L.P.; AMRO staff calculations.
Note: Data include issuances of green bonds, social bonds, sustainability bonds, sustainability-linked bonds, and transition bonds. Available data up to 27 December 2022.

Figure 2.65. ASEAN+3: Annual Issuance of Labeled Bonds, by Jurisdiction
(Billions of US dollars)



Source: AsianBondsOnline, Asian Development Bank; AMRO staff calculations.
Note: Data include green bonds, social bonds, sustainabilty bonds, sustainability-linked bonds, and transition bonds.

Green Finance

"We need an energy transformation on the scale of the industrial revolution at the speed of the digital transformation. And therefore, we need a revolution in finance."

Mark Carney
United Nations Special Envoy on Climate Action and Finance
July 2022

Green finance products are debt and equity instruments issued by public or private actors that direct their investment capital toward mitigating or adapting to climate change. The first green finance product was a climate-awareness bond issued by the European Investment Bank in 2007. Since then, the global market has grown rapidly. Green bonds represent the largest segment of the sustainable finance market: global issuance of green bonds exceeded USD 600 billion in 2021, sales having doubled in one year, and the market has grown at a compound annual rate of about 60 percent in the past five years (Chandhok and others 2022).

At present, there is no common regional or global definition of "green." Two globally recognized principles and standards for green bonds are the Green Bond Principles developed by the International Capital Market Association (ICMA) and the Climate Bonds Standard by the Climate Bonds Initiative (CBI). In the region, the ASEAN Green Bond Standards, developed together with the ICMA and based on its Green Bond Principles, provide more specific guidance on how the principles are to be applied across ASEAN in order for bonds to be labeled as ASEAN Green Bonds (ACMF 2018). Issuers of green financial products in ASEAN+3 typically develop their own frameworks based on such principles and standards (Table 2.10).

China has the second-largest green bond market in the world after the United States. China was the world's most prolific issuer of green bonds—by volume, issuance, and number of issuers—in the first half of 2022 (Chen and Zhang 2022). By the end of the year, 2,178 green bonds had been issued, with a total balance of CNY 1.5 trillion (USD 215 billion). The country's central, provincial, and local governments, financial regulators, and stock exchanges have played key roles in deepening and supporting the growth of the green finance market. The government launched its Green Credit Policy in 2007, encouraging banks to lend more to climate-friendly projects and less to highly polluting ones. By 2011, two of China's major banks, China Development Bank and Industrial and Commercial Bank of China, had built a combined green credit loan portfolio of nearly USD 200 billion in areas like waste treatment, renewable energy, and pollution control (IFC 2012). In 2016, the People's Bank of China (PBC) became the first central bank to issue guidelines for establishing a green financial system. This was followed by guidelines for supporting green bond development by the China Securities Regulatory Commission in 2017, green investment guidelines by the Asset Management Association of China in 2018, green finance disclosure standards by the PBC in 2021, and new principles for green bond issuance by the China Green Bond Standard Committee in July 2022.[51]

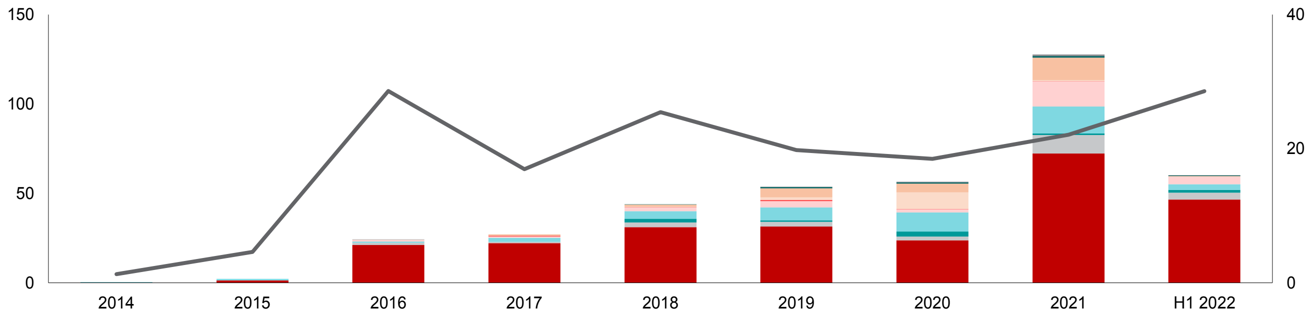
[51] China's domestic green taxonomy, the Green Bond Endorsed Projects Catalogue (2021 Edition) from the PBC, sets the criteria for eligible green projects.

Other ASEAN+3 governments, central banks, and regulatory authorities have also developed green bond markets. According to the CBI, ASEAN+3 economies have collectively issued more than USD 350 billion in green bonds in the past five and a half years, accounting for over 20 percent of green bonds issued globally (Figure 2.66). Some firms in the region have issued green debt (e.g., financial institutions, power companies, and real estate companies), while Hong Kong, Indonesia, Korea, and Singapore have sold green sovereign bonds (Table 2.10).

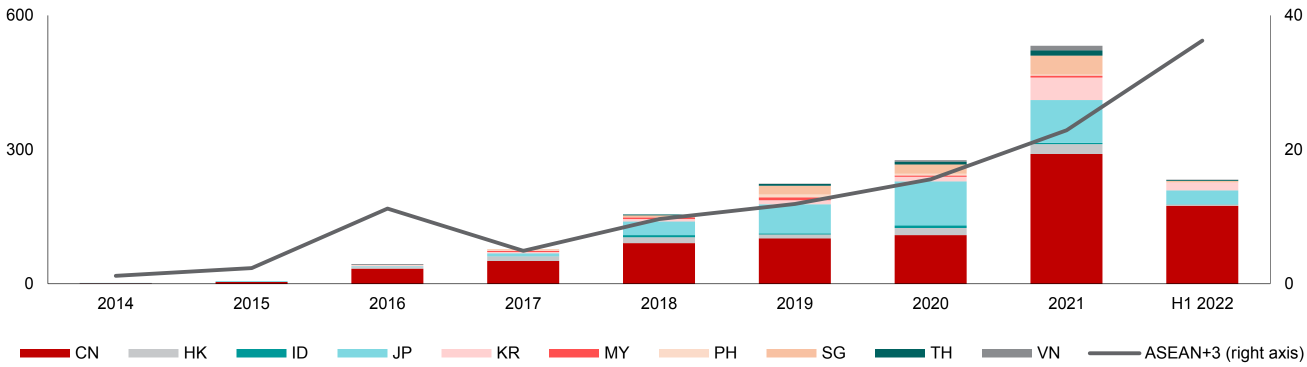
Nevertheless, the financing gap is still huge. ASEAN+3 finance ministries and central banks have a key role to play in continuing to build and develop the green finance market to ensure that sufficient financing can be raised to expedite the transition to a low-carbon economy. Notable policy measures in the region include offering low-cost funding for green projects, both directly (e.g., China's National Green Development Fund and Japan's Green Innovation Fund) and indirectly (e.g., the PBC's Carbon Emission Reduction Facility and Bank Negara Malaysia's Low Carbon Transition Facility), as well as subsidies or grants to cover review and verification costs for issuing green bonds—e.g., Hong Kong, Japan, Malaysia, and Singapore (Table 2.11).

Figure 2.66. ASEAN+3: Green Bond Issuance

Amount Issued
(Billions of US dollars; percent of global amount issued)



Number of Deals
(Count; percent of global deals)



Source: Climate Bonds Initiative Green Bond Database.
Note: Climate Bonds Initiative screens self-labeled debt instruments to identify bonds and similar debt instruments as "green bonds" based on eligible sectors and eligible use of proceeds. The database includes only bonds that are expected to allocate all net proceeds to aligned green assets, projects, or activities. CN = China; HK = Hong Kong; ID = Indonesia; JP = Japan; KR = Korea; MY = Malaysia; PH = Philippines; SG = Singapore; TH = Thailand; VN = Vietnam.

Table 2.10. ASEAN+3: Green Bond Developments

Economy	Green Finance Initiative
Cambodia	• In October 2022, the government agreed in principle to the listing of the first green bond on the Cambodia Securities Exchange. The green bond, issued by a real estate company, has been certified as compliant with ASEAN standards.
China	• China's first green bond was reportedly issued by a wind energy firm in July 2015. • Major banks including Bank of China and China Construction Bank issued green bonds in 2022 under the Common Ground Taxonomy-Climate Change Mitigation, a list of green and sustainable economic activities recognized by China and the European Union first published in November 2021 and updated in June 2022.
Hong Kong	• The inaugural offering of the Government Green Bond Program was made in May 2019, followed by three offerings in 2021 including the first offering of offshore renminbi green bonds. The program raises financing for projects that will improve the environment and facilitate the transition to a low-carbon economy, per the government's Green Bond Framework. • A few financial institutions and corporations in Hong Kong have also issued green bonds. For instance, the MTR Corporation that runs Hong Kong's mass transit railway issued its first green bond in 2016 and a new green bond in 2020.
Indonesia	• The first sovereign green sukuk was issued in March 2018, with proceeds going to selected eligible green projects based on the Green Bond and Green Sukuk Framework. The fifth global green sukuk issued in 2022 was the largest ever green sukuk tranche globally and the first since Indonesia published its Sustainable Development Goals Government Securities Framework in August 2021.
Japan	• The first green bond was issued by the Development Bank of Japan in 2014. In 2017, the Ministry of the Environment published Green Bond Guidelines with the objective of spurring issuances of and investments in green bonds in Japan. The Ministry updated its Green Bond Guidelines in 2020 and 2022, expanding their scope to cover green loans and sustainability-linked loans/bonds, provide guidance on the criteria for "green" eligibility, and develop a list of eligible green projects. • The Japan Bank for International Cooperation (JBIC) launched its first green bond in January 2022. Proceeds from JBIC green bonds, which are guaranteed by the government, are used to fund existing or future eligible projects in accordance with the JBIC Green Bond Framework published in October 2021.
Korea	• The first green bond was issued by the Export-Import Bank of Korea in 2013 for renewable energy development. The first corporate climate bond was issued by Hyundai Capital Services in 2016 to finance leases on hybrid and electric vehicles. The Finance Ministry sold its first "green and sustainability note" in 2019. The Ministry of Environment and the Financial Services Commission published the Korean Green Bond Guideline in December 2020 and supplemented it a year later with the K-Taxonomy Guideline, which provides principles and standards on the types of economic activities that are considered green. • In October 2021, Korea raised EUR 700 million in its first green bond issuance in the London Stock Exchange. • In April 2022, Shinhan Bank issued Korea's first green bond certified by the Climate Bonds Initiative (CBI).
Malaysia	• Malaysia's Tadau Energy issued the world's first green sukuk in July 2017 to finance large-scale solar photovoltaic power plants in Sabah. The green sukuk was issued under the Sustainable and Responsible Investment (SRI) Sukuk Framework developed in 2014 and according to the Guidelines on SRI Funds issued in 2017.
Philippines	• The government raised its first US-dollar denominated green bond in March 2022, followed by a green samurai (yen-denominated) bond issuance in April. The proceeds are earmarked for green assets and projects under the country's Sustainable Finance Framework. • A Philippine geothermal company issued the first CBI-certified climate bond in Asia-Pacific in 2016. Since then, other Philippine companies have tapped the green bond market. The Securities and Exchange Commission approved the ASEAN Green Bonds Standards Guidelines on the Issuance of Green Bonds in August 2018, effectively adopting procedures for issuance set out in the ASEAN guidelines.
Singapore	• The first green bond by a Singapore company was issued by real estate company City Developments Limited in April 2017. In September 2021, the National Environment Agency became the first statutory board to issue a green bond, in accordance with its own green bond framework. The Housing and Development Board and the Public Utilities Board have also issued green bonds and published green bond frameworks. • Singapore launched its inaugural sovereign green bond in August 2022, following the publication of the Singapore Green Bond Framework two months earlier. The so-called Green Singapore Government Securities (Infrastructure) will be used to finance major long-term green infrastructure projects that qualify under the Framework.
Thailand	• The government issued its first "sustainability bond" in August 2020. The first and third tranches of the bond financed clean infrastructure projects such as construction of the Bangkok Mass Rapid Transit Orange Line. • A few financial institutions and corporations in Thailand have also issued green bonds. For instance, B.Grimm Power issued the first CBI-certified climate bond in Thailand in December 2018. The state-owned Export–Import Bank of Thailand issued its first green bond in accordance with the ASEAN Green Bond Standards in September 2022.
Vietnam	• In December 2018, the government introduced a legal framework for corporate green bonds under Decree 163/2018/ND-CP. The first certified green loan in Vietnam was issued in October 2020 by Phu Yen Joint Stock Company to develop and operate a solar power plant in Hoa Hoi.

Source: Climate Bonds Initiative; AMRO staff compilation from various media reports.

Table 2.11. ASEAN+3: Green Finance Incentives and Policy Measures

Economy	Initiative
China	• The CNY 88 billion National Green Development Fund invests in green projects, mainly in national strategic programs. The fund was launched in July 2020 by the Ministry of Finance, Ministry of Ecology and Environment, and Shanghai city government. It has begun making its first batch of investments, which include financing efforts to decarbonize the steel sector and to clean up Erhai Lake. • The People's Bank of China's Carbon Emission Reduction Facility provides low-cost funding to financial institutions to back loans issued to finance companies' emission reduction efforts. The first batch of low-cost loans was issued to financial institutions in December 2021. • Some local governments offer incentives for green finance. For example, Huzhou and Shenzhen offer a subsidy of up to CNY 0.5 million to local enterprises that issue green bonds.
Hong Kong	• The Hong Kong Monetary Authority's Green and Sustainable Finance Grant Scheme provides a subsidy for eligible borrowers to cover their expenses on bond issuance and external review services. The scheme began in May 2021 and runs for three years.
Japan	• The Ministry of the Environment's Financial Support Program for Green Bond Issuance provides subsidies to cover expenses for external reviews or consultation on establishing a green bond framework. • The Ministry of Economy, Trade and Industry's Green Innovation Fund provides 10 years of support to business-led decarbonization initiatives. The JPY 2 trillion fund, established in March 2021, targets priority areas for which action plans have been formulated in the government's Green Growth Strategy for 2050. The fund's first project, a hydrogen-related project developing technologies for transportation, storage, and power generation, started in August 2021. • The Bank of Japan has so-called Funds-Supplying Operations to Support Financing for Climate Change Responses.
Lao PDR	• In September 2022, Lao PDR signed a memorandum of understanding with the International Finance Corporation (IFC) to create a green finance market. The partnership will start with a market readiness assessment to review the current framework for green finance and identify market opportunities for potential green financing products.
Malaysia	• The Sustainable and Responsible Investment (SRI) Sukuk and Bond Scheme helps to offset the external review cost incurred by green sukuk issuers. The MYR 6 million scheme, introduced in 2018 as the Green Sukuk SRI Grant Scheme, has benefited more than 15 issuers involved in renewable energy, green building, and sustainable projects to date. Grant recipients enjoy income tax exemptions up to 2025. • The government's Green Technology Financing Scheme provides government guarantees for working capital, term loan financing facilities, and green bond/sukuk issuances. The MYR 2 billion scheme was open for applications until the end of 2022. • Bank Negara Malaysia's Low Carbon Transition Facility funds capital expenditure or working capital for small and medium enterprises to initiate or facilitate the transition to low-carbon and sustainable operation. The MYR 1 billion facility was launched in January 2022.
Singapore	• The Monetary Authority of Singapore's (MAS') Sustainable Bond Grant Scheme offsets additional expenses for external reviews of eligible green, social, sustainability and sustainability-linked bonds and promotes the adoption of internationally accepted standards. The grant is valid through May 2023. • MAS' Green and Sustainability-Linked Loan Grant Scheme helps firms to obtain green and sustainable financing by defraying the expenses of engaging independent service providers to validate the green and sustainability credentials of a loan and encouraging banks to develop green and sustainability-linked loan frameworks to make such financing more accessible to small and medium enterprises. The grant is valid through December 2023.
Thailand	• The Bank of Thailand has issued guidelines for banks to take account of environmental factors in the financial products and services they offer including for small- and medium-sized enterprises. It is also planning to launch Thailand's "green taxonomy" in the first half of 2023.
Vietnam	• In April 2021, the State Securities Commission, in collaboration with the IFC, introduced a handbook for corporate issuers and other market players in Vietnam on how to issue green bonds, social bonds and sustainability bonds, with guidance in applying the global and ASEAN standards as well as national regulations.

Source: Climate Bonds Initiative; AMRO staff compilation from various media reports.

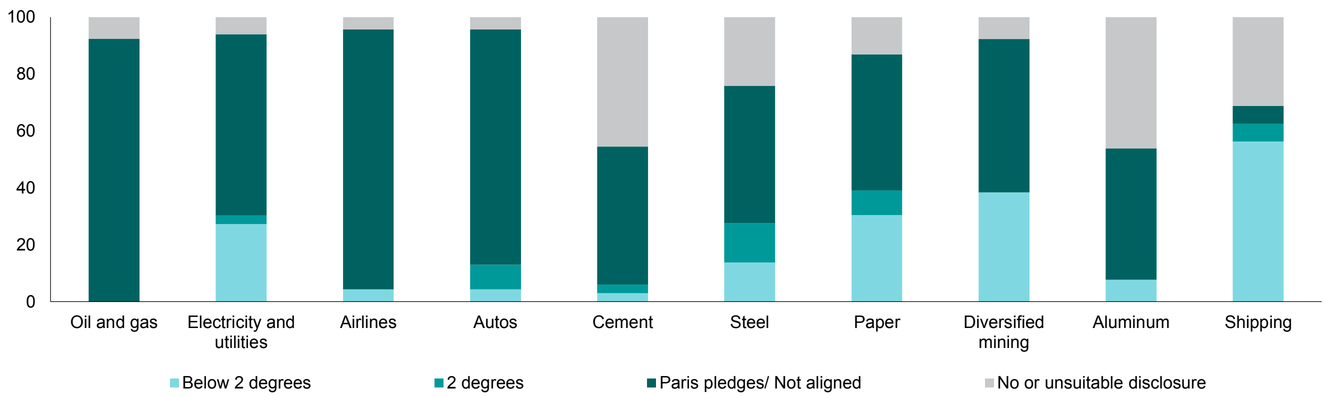
Transition Finance

"To reach net zero, greening the economy is more important than growing the green economy."

Ravi Menon
Monetary Authority of Singapore Managing Director
August 2022

Transition finance is geared toward helping high-carbon industries implement long-term changes to lower their carbon emissions. The transition out of fossil fuels is not straightforward for hard-to-abate or high-carbon sectors, because the technology is still lacking or its cost remains prohibitive (Figure 2.67). These sectors—aviation, oil and gas, mining, and heavy industries such as steel and cement, to name a few—would need to undertake complex transformations to reduce their carbon emissions, e.g., by investing in carbon capture and storage, or by completely redesigning assets and processes to become more energy-efficient. While green finance focuses largely on supporting green activities that generate low or no carbon emissions, a much larger amount of financing is required for non-green high-carbon activities—which make up the bulk of most economies—to reduce their carbon footprint. The role of transition finance is therefore "to provide the funding support for companies that are not so green, to become greener" (Menon 2022)—these include businesses that would not qualify for green finance under the current definitions, and those that are at risk of losing their funding sources because investor preferences change.

Figure 2.67. Carbon Performance Alignment with Paris Agreement Benchmarks in 2030, by Sector
(Percent of companies per sector)

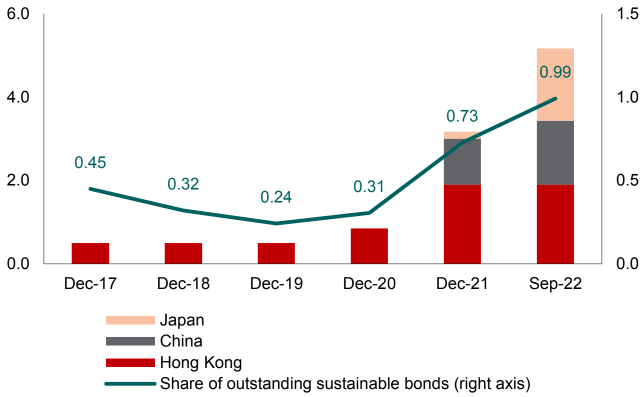


Source: Dietz and others (2021).
Note: The carbon performance assessment covers 292 companies across 10 sectors. Companies are classified according to whether their emissions intensities are aligned with a pathway to limit global warming to 2 degrees Celsius, or with a more ambitious pathway to limit global warming to below 2 degrees Celsius. Companies assessed as meeting benchmarks set by countries' first Nationally Determined Contributions (from 2015) or international commitments (for aviation and shipping) are considered "not aligned" here, as both benchmarks are insufficient to limit global warming to 2 degrees Celsius or below. Of the 292 companies assessed, 16 percent provided insufficient disclosure to calculate their carbon performance.

In the region, China, Hong Kong, and Japan have taken the lead in issuing transition bonds. The Castle Peak Power Company, which owns Hong Kong's largest coal-fired power station, issued the region's first energy transition bond in 2017 (HKEX 2020). Chinese and Japanese companies—mostly from the energy, heavy industry, and transport sectors—entered the market in 2020–21, urged by domestic policymakers to utilize this instrument. Since then, outstanding transition bonds in the region have tripled in volume from USD 850 million at the end of 2020 to USD 5.2 billion by the third quarter of 2022 (Figure 2.68 and Figure 2.69). Still, transition bonds accounted for only about 1 percent of outstanding sustainable bonds in the region.[52] More growth may be to come: China recently rolled out low-carbon transition bonds to help fund decarbonization efforts in eight carbon-intensive industries and the PBC has indicated it will explore more transition finance instruments (Reuters 2022c; Jiang 2022), and Japan aims to issue about JPY 20 trillion worth of sovereign transition bonds over the next 10 years (Reuters 2022d).

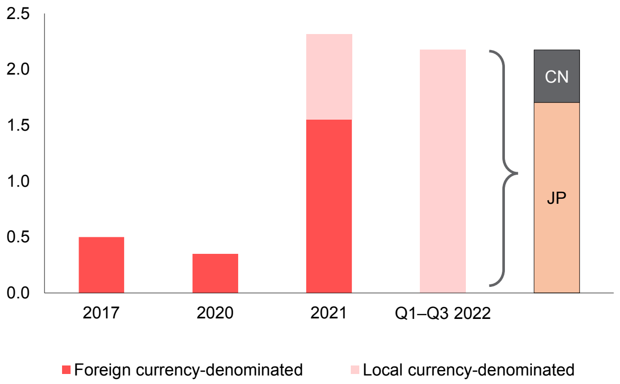
[52] By comparison, green bonds comprise about 70 percent of the total of sustainable bonds outstanding in the region (ADB 2022).

Figure 2.68. ASEAN+3: Outstanding Transition Bonds
(Billions of US dollars, end of period; share of outstanding sustainable bonds)



Source: AsianBondsOnline, Asian Development Bank; AMRO staff calculations.

Figure 2.69. ASEAN+3: New Issuances of Transition Bonds
(Billions of US dollars)



Source: AsianBondsOnline, Asian Development Bank; AMRO staff calculations.
Note: CN = China; H1 = first half; JP = Japan.

Other ASEAN+3 economies are now beginning to issue guidelines and explore instruments for transition finance. Most of the guidelines and frameworks have a broader policy objective to encourage and support the development of sustainable finance-related instruments, including—but not limited to—transition financing. A 2022 survey of ASEAN+3 developments in transition finance—led by the People's Bank of China with support from AMRO—indicates that some economies are exploring the use of government securities for transition finance, and other channels like private equity and venture capital to cater to different types of projects and needs and to provide investors with more options for ESG-related assets. Some banks in the region—notably, Singapore's DBS Bank and UOB Bank—now offer transition financing in the form of loans.

However, many challenges need to be overcome. At the forefront is the lack of market consensus, standards, and overall clarity on what constitutes credible transition finance and how to classify its operations. Transition bonds do not require the issuer or the project to be labeled as green. The ICMA currently does not require separate bond principles for transition bonds as it did for green bonds, sustainable bonds, and sustainability-linked bonds—in part due to the challenge of defining hard-to-abate sectors in a way that can be standardized globally (Furness 2022).[53] As a result, transition financing may suffer from inadequate disclosure which could encourage false transition activities and lead to investor fears of "greenwashing" or "transition-washing"—a situation where high-carbon borrowers overstate their emission-reduction achievements. Other barriers to transition finance include potential reputational risks for lenders supporting companies that are big emitters and the lack of available technology to achieve decarbonization in hard-to-abate sectors (Murdoch 2022; Ma and Terada-Hagiwara 2022).

Transition taxonomy will be "the next milestone for sustainable finance" for the region (CBI 2022). The ongoing development of sustainable finance frameworks and taxonomies across the region—especially for sustainability-linked bonds—should help provide some guidance to address gray areas associated with transition finance, e.g., by delineating specific transition activities with descriptions of technical pathways and emission-reduction targets. Currently, China and Japan have guidelines specifically focused on transition finance.[54] In September 2022, the Asia Transition Finance Study Group, a private initiative of 19 Asian and global commercial banks, published a compilation of voluntary process guidelines for financing low-carbon technologies and energy transition projects in Asia. The Monetary Authority of Singapore is developing a multitier ASEAN taxonomy. Ultimately, interoperability across national taxonomies—as they are developed—would help facilitate intraregional transition financing flows in the ASEAN+3 (Menon 2022), particularly as high-emitting sectors—such as iron and steel, cement, and chemicals—are key players in intra-regional trade.

53/ The ICMA defines sustainability-linked bonds as "bond instrument[s] for which the financial and/or structural characteristics can vary depending on whether the issuer achieves predefined Sustainability/ ESG objectives." (ICMA 2021). It argues, and some commentators agree, that transition bonds are a form of sustainability-linked bonds, and a separate "bond label" would cause unnecessary confusion in the market (Michaelsen 2020; Wright 2021).

54/ Japan's Financial Services Agency, Ministry of Economy, Trade, and Industry, and Ministry of the Environment published Basic Guidelines on Climate Transition Finance in May 2021. China has developed a transition finance taxonomy in some pilot regions (Ma and Terada-Hagiwara 2022; CBI 2022).

V. Summary and Policy Implications

Climate change mitigation, long envisioned as a gradual process of reducing GHG emissions in the world's most carbon-intensive economies, has now become an urgent global imperative. For the ASEAN+3 region, as for the rest of the world, the accelerated transition to a carbon-neutral economy will have major macroeconomic implications in the medium term. Because of the size and breadth of the policy efforts involved—subsidies, incentives, government expenditures, taxes, and regulations—and the pace of the transformation implied, the macroeconomic consequences of the transition are hard to pin down, let alone quantify. While putting a price—explicit or implicit—on carbon (emissions) should help to address the negative externalities created by fossil fuel use, it will also drive up the price of fossil fuel energy and could potentially affect export competitiveness, trigger an accelerated obsolescence of existing capital stock, and even cripple economic growth. On the other hand, the pricing of carbon should stimulate research expenditures, the development of new industries and technologies, new infrastructure spending, and the creation of new financial assets.

The economic costs of moving away from fossil fuels are significant if good alternatives are not readily at hand. Much will thus depend on the speed of development, dissemination, and adoption of new technology, e.g., clean energy options, low-carbon industrial processes and transportation, and carbon capture and sequestration technologies. The sooner scalable, reliable, and affordable low-carbon alternatives become available, the less painful and costly the transition from fossil fuels would be.

ASEAN+3 economies are in a good position to meet the transition challenge and take advantage of emerging opportunities. China—the region's largest economy in geographic and economic size—is the leader on almost every front. Others are well placed to leverage their existing comparative advantage in technology (e.g., Japan and Korea), manufacturing (e.g., Malaysia and Thailand), natural resources (e.g., Indonesia, Lao PDR, and Vietnam), and financial services (e.g., Hong Kong and Singapore) to propel decarbonization efforts and reap economic benefits on the road to net zero. Most of the region's economies will find fresh sources of comparative advantage in their natural endowments of sunlight, wind, water, minerals, flora, and fauna that will enable them to join or create new value chains in renewable energy, hydrogen, EVs, batteries, and carbon offset credits. Those with surplus renewable energy generation capacity and/or massive carbon storage resources, as well as first-movers in clean energy technologies such as hydrogen, will find new markets and sources of growth as global demand for these goods and services is poised to substantially increase. Macroeconomic and financial policies—such as economy-wide carbon pricing, providing public guarantees for mitigation-related loans, speeding up private–public partnerships for emerging technology projects, and promoting climate finance through green credit policies—can contribute to the transition by creating the right conditions and incentives to realize these new drivers of exports and growth.

Fiscal and economic policymakers can play a role through climate-informed public expenditure and utilizing climate fiscal tools such as carbon taxes and ETSs to bring about an orderly transition. As the region emerges from the COVID-19 pandemic, a strong "green public investment" push can lay the foundation for both a sustainable recovery and the transformation needed for a low-carbon economy. On the other hand, rebuilding fiscal buffers drawn down during the pandemic is a top priority in most economies, while other spending priorities—such as for education and health—also compete for public financing. And introducing or ramping up carbon pricing—particularly at rates needed for meaningful climate mitigation—is a challenge when inflation (particularly energy price inflation) is elevated. ASEAN+3 finance ministries will need to find ways to navigate these challenges and mobilize private and public funding for climate change mitigation. Cross-government agency cooperation will be crucial to ensure that public finances and fiscal policy feed into a credible long-term transition strategy for the economy.[55]

Monetary and financial regulatory authorities can play a role by enhancing the ability of the financial system to mobilize funds for green and low-carbon investments while managing climate-related risks. Theoretically, green finance should achieve scale over time as long as the risk-adjusted return from green assets is sufficiently positive. In practice, however, financial supervisory and regulatory authorities need to maintain the integrity of the green finance market by ensuring transparency and information

[55] These and related issues are the focus of the Coalition of Finance Ministers for Climate Action, a group of fiscal and economic policymakers from over 75 countries including 6 ASEAN+3 economies—Indonesia (co-chair), Japan, Korea, Malaysia, the Philippines, and Singapore. The Coalition's work program focuses on: (1) how to align policies and practices with Paris Agreement commitments; (2) sharing experiences and expertise on policies and practices for climate action; (3) carbon pricing measures; (4) mainstreaming climate change in economic policies; (5) mobilizing private sources of climate finance; and (6) how to engage in domestic preparation and implementation of Nationally Determined Contributions to the Paris Agreement goals.

disclosure and setting and enforcing standards to prevent greenwashing. Central banks may go beyond this role by subsidizing "green" firms and/or penalizing "brown" firms, depending on the specific circumstances in each economy.[56] As noted, some ASEAN+3 central banks are already developing green bond markets and guiding credit to climate-mitigation loans. But as more industries switch to low-emission technologies, "greenflation" will become an issue. The imbalance between rising demand for clean energy and technologies and constrained supply of mineral and other inputs for these technologies can be expected to exert sustained upward pressure on the prices of a broad range of products during the transition.[57] The dilemma for monetary policy would be either accepting a higher inflation rate for a prolonged period or responding to these price pressures with higher interest rates and risking slowing down the green transition and economic growth at large.[58]

Regionally coordinated action will achieve a greater impact than economies acting alone. The net zero transition is a race against time; to "win" this race, ASEAN+3 needs to strengthen regional cooperation based on a shared vision for carbon neutrality. Carbon-neutral declarations by China, Japan, and Korea have helped to produce a visible shift in the decarbonization momentum in the region. Various initiatives are under way in ASEAN but a collective long-term vision and mitigation strategy has yet to be formed (Table 2.12). Enhanced cooperation among the ASEAN+3 economies would support the region's journey to net zero through sharing knowledge and technologies and facilitating partnership programs. Potential areas of cooperation include cross-border electricity transmission, innovation and new technology, and green financial networks. Each is summarized in turn.

- *Energy*. Cross-border power grid connections would improve power supply efficiency and help secure a more sustainable energy supply across the region by locating large-scale hydro, wind, and solar power plants in the most ideal places for energy-generation and energy-sharing with other economies. The Lao PDR-Thailand-Malaysia-Singapore Power Integration Project, which started in June 2022, marked a milestone as the first cross-border electricity trade among four ASEAN countries and a step toward realizing the broader ASEAN Power Grid vision of expanding regional multilateral electricity trading. Further efforts could be directed to accelerate ASEAN power grid integration and ensure that it supports future developments in regional renewable energy deployment.

- *Technology*. Technological innovation is important for realizing green growth, but it is expensive. Regionally targeted government efforts in research could help to nurture innovative technologies by creating an expanded market that would justify the initial high start-up costs. As highlighted in Section III, promising new areas include clean hydrogen, energy storage, and CCUS. Clean hydrogen deployment at scale will require supply chain development at the regional level. Energy storage technology is crucial for this, as well as to enable the rollout and transport (trade) of renewable energy. CCUS technology can dramatically cut carbon emissions from conventional fossil fuel use and could create new business fields in green technology across ASEAN+3. In this regard, the region could draw inspiration from EU initiatives to develop and promote new technology, such as the European Clean Hydrogen Alliance, the European Battery Alliance, and European CCS Project Network (Sekine 2021).[59]

- *Finance*. Green financial networks are beginning to have increased influence on the direction of energy development in the ASEAN+3 region. With the number of investors seeking green or sustainable investments growing in the region, it is increasingly important for ASEAN+3 policymakers, state-owned enterprises, and the finance community to discuss regional green project developments, including public-private partnership frameworks and project risk management. Early-stage coordination with the financial community could help in mobilizing funding, especially for innovative (risky) projects.

56/ For example, the European Central Bank and the Bank of England are tasked first with price stability and only then with supporting the government's wider economic strategy—which includes a transition to net zero. The US Federal Reserve, on the other hand, is mandated to focus on price stability and employment and considers it "inappropriate … to use [its] monetary policy or supervisory tools to promote a greener economy or to achieve other climate-based goals" (Newburger 2023).

57/ This is in addition to "fossilflation" caused by the rising price of fossil fuel energy—e.g., as the carbon price is raised (Section II) (Schnabel 2022).

58/ These and related issues are the focus of the NGFS, a group of central banks and financial supervisors from over 85 economies, including 10 ASEAN+3 economies—Cambodia, China, Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore (chair), and Thailand. The NGFS' work program focuses on: (1) how to incorporate climate-related and environmental risks in supervisory frameworks and practices; (2) climate scenario analysis; (3) developing a framework for how central banks should assess, and respond to, diverse climate-related developments; (4) issues and approaches relating to net zero in central banks' own operations; (5) mainstreaming the consideration of nature-related risks; and (6) capacity building and training.

59/ The European Clean Hydrogen Alliance, which was set up in 2020, brings together industry, public authorities, civil society, and other stakeholders to discuss the large-scale deployment of clean hydrogen technologies and what this requires. Six thematic working groups meet throughout the year and focus on the hydrogen value chain parts. The European Battery Alliance was launched in 2017 to bring together EU national authorities, regions, industry research institutes, and other stakeholders in the battery value chain to build up the EU's battery technology and production capacity. The European CCUS Projects Network, which builds on the 2009–18 European CCS Demonstration Project Network, represents and supports major industrial CCS and CCUS projects under way across Europe. Among its notable initiatives is the Northern Lights project, the first ever cross-border, open-source carbon dioxide transport and storage infrastructure network. When it starts operations in 2024, it will offer companies across Europe the opportunity to store carbon emissions permanently deep under the seabed in Norway.

Table 2.12. ASEAN+3: Key Regional Cooperation Initiatives on Climate Change Mitigation

Initiative	Program Areas
ASEAN Plan of Action for Energy Cooperation (APAEC) 2016–25	• Expand regional multilateral electricity trading under the ASEAN Power Grid, strengthen grid resilience and modernization, and promote clean and renewable energy integration. • Pursue the development of a common gas market for ASEAN and enhance gas and liquefied natural gas connectivity and accessibility through the trans-ASEAN gas pipeline. • Optimize the role of clean coal technology in facilitating the transition toward sustainable and lower emission development. • Reduce energy intensity by 32 percent in 2025 (from 2005 levels) and encourage further energy efficiency and conservation efforts, especially in the transport and industry sectors. • Increase the share of renewable energy in the ASEAN energy mix to 23 percent by 2025, and its share in installed power capacity to 35 percent by 2025, among others. • Advance energy policy and planning through regional cooperation to accelerate the region's energy transition and resilience. • Build human resource capabilities on nuclear science and technology for power generation.
ASEAN Catalytic Green Finance Facility	• Provide ASEAN members with technical assistance to identify and prepare commercially viable green infrastructure projects. • Facilitate access to over USD 1 billion in loans from co-financing partners to cover upfront capital investment costs.
ASEAN-Japan Climate Action Agenda 2.0	• Assist in members' long-term strategy and policymaking, including scenario formulation and policy dialogue on mitigation-related issues. • Prioritize decarbonization of selected industries by using fluorocarbons, renewable energy, waste-recycling, water-air, and green logistics (shipping, ports, airports, transport). • Disseminate decarbonization technologies through the Joint Crediting Mechanism and related schemes and expand "zero-carbon" cities.
ASEAN-ROK Carbon Dialogue	• Share policies and know-how regarding carbon pricing (work-plan development is ongoing). • Facilitate cooperation projects to reduce greenhouse gas emissions, including through existing mechanisms such as the Partnership for ASEAN-ROK Methane Action, the ASEAN-ROK Cooperation Centre for Carbon Neutrality and Green Transition; and the ASEAN Green Deal.
ASEAN-China Environmental Cooperation Strategy and Action Plan 2021–25	• Facilitate high-level environmental policy dialogue and exchange, including on environmental data and information management. • Develop sustainable cities, reduce marine plastics, and improve air quality through policy dialogue, joint research, capacity building, and community activities. • Promote biodiversity conservation and ecosystem management through joint projects, capacity building, and research.

Source: ASEAN (2021); AMRO staff compilation.
Note: ROK refers to Korea.

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