Chapter 3

Transformational Strategies:

Progress Made and New Challenges being Met

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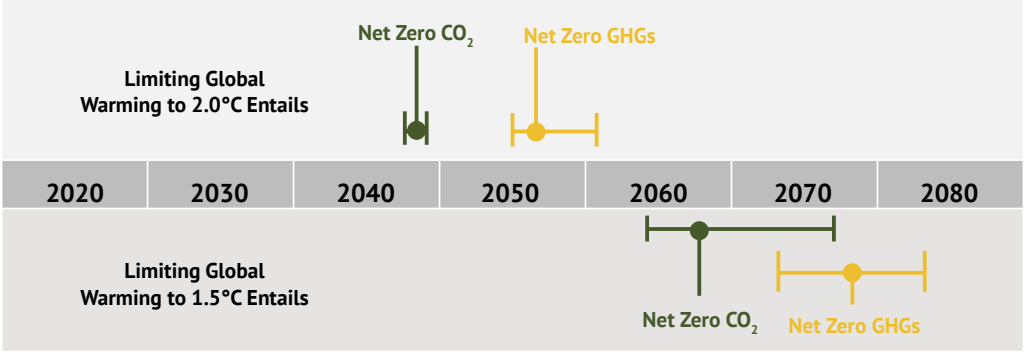
This chapter conducts an empirical examination of similarities and differences in policies and actions across developed and developing Asian countries to promote low-carbon green growth. It seeks to assess whether policies and plans are aligned with low-carbon pathways leading to net zero emissions targets. It reviews the strategies and actions undertaken by the major economies of the Association of Southeast Asian Nations (ASEAN) and East Asia, comparing and contrasting these with initiatives in advanced economies such as Japan, the Republic of Korea (henceforth, Korea), and Singapore. Success stories and initiatives based on experiences across countries, sectors, or specific user groups that can provide lessons to the entire region are also highlighted.

While much has been achieved, and significant efforts are being made across the region, the analyses indicate that current and planned efforts are not sufficient in terms of the scale of action that will be required globally to achieve a net zero future. Figure 3.1 shows that, in order to limit global warming to 1.50C, countries need to achieve net zero carbon dioxide (CO2) emissions by 2050 and net zero emissions of all greenhouse gases (GHGs) by 2070 (given that some non-CO2 gases, such as methane emanating from agriculture, are more difficult to phase out). How quickly the highest emitters reach net zero emissions plays a crucial role in limiting warming to 1.5°C (Levin et al., 2021). Recent commitments by China, Japan, Korea, the United States (US), and the European Union (EU) towards net zero targets are likely to impart greater momentum to the low-carbon energy transition across economies.

While technology is one of the key drivers of transformative low-carbon pathways, the availability of finance and enabling policies are equally important for the rapid diffusion and upscaling of alternative options.

Economies in ASEAN and East Asia have had a number of successes in implementing low-carbon growth strategies. Examples include innovative applications of know-how in industrial units, frameworks or models for examining and changing behaviour and consumption patterns, and the application of targeted policies and initiatives that have enabled efficiency improvements or influenced market dynamics toward alternative technologies. Such successes need to be sustained, replicated, and scaled up.

Figure 3.1 Scenarios Limiting Warming to 1.5°C and 2.0°C



CO_2 = carbon dioxide, GHG = greenhouse gas.

Source: ERIA Study Team.

This chapter has five sections. The first section gives a comparative assessment of the region's performance in low-carbon green growth in recent decades. The second section examines how different policy instruments have been developed and deployed to support the implementation. Potential and opportunities to bring efforts into line with the net zero targets are identified. The third section assesses how the pandemic shock has disrupted the early envisioned low-carbon pathways by developing and emerging economies of ASEAN and East Asia. This assessment focuses on a number of key sectors which are vital to economic livelihoods and significant in terms of emission reduction potential. The fourth section extends the low-carbon green growth discussion to cover the circular economy perspective, to point out how the pandemic response actions so far heighten policy attention to new priorities of the circular economy, including the disposal of toxic medical waste and other conservation efforts. The fifth section presents a preliminary review of countries' response actions to the coronavirus disease (COVID-19) pandemic. The assessments of this chapter provide the basis for closer examination of post-COVID-19 recovery priorities and pathways in the next chapter. The last section highlights key takeaways from this chapter.

1. Comparison of Trends Across Key Low-Carbon Green Growth Indicators

1.1. Energy Consumption and Energy Intensity

Nearly 87% of all human-produced CO2 emissions emanate from the combustion of fossil fuels such as coal, oil, and gas. The remainder results from clearing of forests and other land use changes (9%), as well as industrial processes such as cement manufacturing (4%). Clearly, energy is not only the primary driver of economic growth but also of carbon emissions in most countries.[1] At present, China is the highest energy-consuming country, followed by the US and India. However, the growth (compound annual growth rate) of energy consumption during 2010–2019 was 4% for China, 6% for India, and less than 1% for the US, largely reflective of the stage of development and structure of the economies. Total energy consumption declined only in Japan during this period. Although the energy consumption of all ASEAN Member States (AMS) is low due to the small size of their economies, the growth of energy consumption was high for the Lao People's Democratic Republic (Lao PDR) (20%), Cambodia (13%), Myanmar (12%), and Viet Nam (9%), while the growth rate for other AMS was 3%–6% during this time.

Driven by considerations of energy security, and with continuous improvements in technologies and processes, the efficiency of energy use has been improving across most countries, as indicated by declines in the energy intensity of gross domestic product (GDP). China and Japan exhibited the largest declines in energy intensity during 2010–2018, with a reduction of 4% for China and 3% for Japan. The energy intensity of the US dropped by 2% while that of Korea and India declined by 1% each. Amongst the AMS, the energy intensity increased by 12% in the Lao PDR, 2% in Viet Nam, 3% in Brunei, and 5% in Myanmar and Cambodia. The energy intensity of GDP declined for other AMS, including Singapore, Malaysia, Thailand, and the Philippines.

[1] Non-CO_2 emissions from agriculture, forestry, and other land use are significantly high in a few ASEAN Member States (AMS) such as Indonesia, the Lao People's Democratic Republic (Lao PDR), and Cambodia (Zeleke et al., 2016).

1.2 Per Capita Emissions and Economic Growth

Per capita emissions are an important indicator to measure the performance of low-carbon green development strategies. According to the statistics provided by the US Energy Information Administration (2021), total per capita CO2 emissions declined for major developed countries such as Japan, Australia, and the US during 2010–2018, but continued to increase in other major economies like China, India, and Korea, largely because of energy use.

While the growth of per capita emissions was 5% for India, it was 2% for China and Korea. Average per capita emissions for ASEAN also increased during 2010–2018. Amongst AMS, the per capita energy use and emissions of Brunei and Singapore are significantly higher than in the US and grew by 1.4% during 2010–2018. While the per capita emissions of the Lao PDR increased by more than 20 times, they rose by 12% for Myanmar and Cambodia and 8% for Viet Nam during the same period.

1.3 Energy Poverty and Access to Clean Energy

Table 3.1 presents the key development and environmental indicators for ASEAN and selected major economies across the world. Most of the major economies had achieved 100% village electrification by 2018 and 99.99% household electrification by 2019, although the availability and reliability of power supply remains a major challenge in many rural areas. According to Sachs et al. (2020), about 2.3% of India's population is living below the poverty line (US$1.9 per day), while the poverty situation is much better in China (0.2%).

Table 3.1 Key Development and Environmental Indicators of Major Economies

Indicator	Australia	China	India	Japan	Rep. of Korea	US	ASEAN
Population with access to electricity (%)	100.0	100.0	92.6	100.0	100.0	100.0	94.36
Population with access to clean fuels and technology for cooking (%)	100.0	59.3	41.0	100.0	96.7	100.0	58.1
Per capita CO_2 emissions ($MtCO_2$ per capita)	16.3	7.4	1.8	9.6	16.3	16.2	8.9
Per capita energy consumption (MBtu/person)	243.2	102.4	23.4	151.3	243.3	309.7	145.8
Share of renewable energy in total primary energy supply (%)	6.5	11.2	8.5	10.2	1.9	9.8	12.0
Share of renewable power generation	17.9	27.0	18.3	22.0	4.6	17.8	30.2
Energy intensity of GDP (1,000 Btu per US$1 at 2015 constant PPP)	5.1	6.7	3.6	3.6	5.9	5.2	4.4
Poverty headcount ratio at US$1.90/day (%)	0.5	0.2	2.3	0.5	0.5	0.5	2.2

ASEAN = Association of Southeast Asian Nations, Btu = British thermal unit, CO_2 = carbon dioxide, GDP = gross domestic product, Mt = metric ton, MBtu = million British thermal units, PPP = purchasing power parity, US = United States.

Source: Compiled by the ERIA Study Team based on data from US Energy Information Administration (n.d.) and Country Profile: Sustainable Development Report (2020).

Amongst the AMS (Table 3.2), poverty is highest in the Lao PDR (8.9%), followed by Indonesia (3.7%), the Philippines (3.1%), and Myanmar (2.1%). Myanmar is also far behind in access to clean energy, with only 70% of its population having access to electricity, and only 18% with access to clean cooking fuel. Many other AMS also lack access to clean fuel and technology for cooking – the Lao PDR (6%), Cambodia (18%), and the Philippines (43%).

National development considerations such as providing access to clean energy and infrastructure – or enhancing education, health, and employment opportunities to improve people's well-being – are overriding priorities that influence the energy and emission levels of countries. Alternative development pathways can have a strong influence on countries' emission trajectories.

Despite the relatively high energy and emission intensity of China compared with other major economies under study, its rates of decline of energy intensity and emission intensity were the largest during this period, indicating the success of energy efficiency and decarbonisation efforts, including the closure of many polluting factories in recent years (Nace, 2017). After China, Japan has the second largest rate of decline in energy intensity. The US has the second largest decline in emission intensity during this period, with a rise in the rate of technological progress (Chetwynd and Sargent, 2019).

In the ASEAN and East Asia region, there are two distinct sets of countries in terms of decarbonisation. Figure 3.2 illustrates carbon emissions and economic growth. While countries such as Indonesia, Malaysia, Thailand, and Singapore have improved energy efficiency and carbon intensity, the situation is the opposite in countries like Brunei, Myanmar, Cambodia, the Lao PDR, and Viet Nam, where both energy intensity and emission intensity grew during this period. The Philippines is a special case, where the economy improved in terms of carbon intensity but continued to reflect positive growth. The Lao PDR is a very small country in terms of GDP but exhibited high growth in both energy and emission intensity during this period, indicating that low-carbon green growth featured less in their development plans. Extensive use of fossil fuels and less attention to energy efficiency are primary factors behind such trends (Ayertey Odonkor, 2020).

2. Targets, Policies, and Measures with Implications for Low-Carbon Development

To avoid furthering the climate change crisis, it is critical to contain cumulative emissions within limits. While some nations still lack a clear strategic plan towards any climate commitment, others have proposed targets of net zero emissions by mid-century. Recognising the urgency, some nations such as New Zealand have even declared a climate emergency (Taylor, 2020).

2.1. Targets for Emissions Reduction

All ASEAN and East Asian countries have ratified the Paris Agreement and have submitted their nationally determined contribution (NDC) plans to reduce GHG emissions. The parties have also committed to submitting an update of the NDCs every 5 years to demonstrate progress and enhance their ambitions over the previous target.

Table 3.2 Economic and Environmental Status Comparison Amongst ASEAN Member States

Indicator	Brunei Darussalam	Myanmar	Cambodia	Indonesia	Lao PDR	Malaysia	Philippines	Singapore	Thailand	Viet Nam	ASEAN
Population with access to electricity	100.0	69.8	89.1	98.1	93.6	100.0	93.0	100.0	100.0	100.0	94.36
Population with access to clean fuels and technology for cooking (%)	100.0	18.4	17.7	58.4	5.6	96.3	43.2	100.0	74.4	66.9	58.1
Per capita CO_2 emissions ($MtCO_2$ per capita)	23.9	0.6	0.8	2.0	4.2	7.7	1.2	42.0	4.4	2.6	8.9
Per capita energy consumption (MBtu/person)	425.0	11.4	12.6	29.8	61.0	120.1	18.0	662.3	79.3	38.9	145.8
Share of renewable energy in total primary energy supply (%)	0.0	19.6	23.9	5.8	25.5	6.6	10.7	0.41	6.6	20.8	12.0
Share of renewable power generation	0.1	58.9	60.2	18.2	66.2	17.5	24.0	3.3	17.3	36.4	30.2
Energy intensity of GDP (1,000 Btu per US$1 at 2015 constant PPP)	5.5	1.9	3.2	2.6	8.5	4.4	2.1	7.0	4.5	4.3	4.4
Poverty headcount ratio at US$1.90/day (%)	NA	2.1	0.2	3.7	8.9	0.0	3.1	0.9	0.0	0.6	2.2

ASEAN = Association of Southeast Asian Nations, Btu = British thermal unit, CO_2 = carbon dioxide, GDP = gross domestic product, Mt = metric ton, MBtu = million British thermal units, NA = not applicable, PPP = purchasing power parity, US = United States.

Source: Compiled by the study team based on data provided by US Energy Information Administration (n.d.) and Country Profile: Sustainable Development Report 2020.

Figure 3.2 Patterns of Decoupling of Carbon Emissions from Economic Growth

AUS = Australia, BRN = Brunei, CHN = China, CO_2 = carbon dioxide, GDP = gross domestic product, IDN = Indonesia, IND = India, JPN = Japan, KHM = Cambodia, KOR = Republic of Korea, kt = kiloton, LAO = Lao PDR, MMR = Myanmar, MYS = Malaysia, NZL = New Zealand, PHL = Philippines, SGP = Singapore, THA = Thailand, VNM = Viet Nam.

Source: Compiled by ERIA Study Team.

Further, the parties are invited to submit their long-term strategy or long-term low GHG emissions development strategies by 2021 as part of the 2021 United Nations Climate Change Conference (COP26). The long-term strategy/long-term low GHG emissions development strategies are particularly beneficial in driving and shaping short-term action, and can play a fundamental role in informing the future NDCs (Falduto and Rocha, 2020).

Table 3.3 presents the mitigation targets and updates of ASEAN and East Asia countries. The data indicate that most countries in the ASEAN and East Asia region, except Myanmar and the Lao PDR, have spelt out clear emission reduction targets. In the 2020 NDC update process, while most ASEAN and East Asian countries did not make any changes to their NDC commitments, a few countries proposed a stronger NDC target. Singapore, for instance, targeted an emission intensity reduction of 36% by 2030 in its NDC commitment against the reference year 2005 (UNFCCC (n.d.)). In its first NDC update, the country specified an absolute target of peaking emissions at around 65 million tons of carbon dioxide equivalent (MtCO2e) in 2030 (UNFCCC (n.d.)).

Table 3.3 Mitigation Targets and Updates of ASEAN and East Asian Countries

Country	Summary of pledges and targets	2020 NDC update	LT-LEDS/ Informal long-term climate commitment
Brunei Darussalam	NDC target: Reduce energy consumption 63% by 2030 (reference: BAU)	First NDC: Reduction in GHG emissions by 20% relative to BAU by 2030	
Cambodia	Reduce emissions, conditional 27% by 2030 (reference: BAU) Reduce emissions, conditional 41.7% emission reduction (reference: BAU) of which 59.1% is from FOLU; 25% of renewable energy in the energy mix (solar, wind, hydro, biomass) by 2030	Reduce emissions, conditional 41.7% emission reduction (reference: BAU) of which 59.1% is from FOLU; 25% of renewable energy in the energy mix (solar, wind, hydro, biomass) by 2030	
Indonesia	29% below BAU by 2030, including LULUCF	Mitigation target remained unchanged	With a low-carbon scenario compatible with the Paris Agreement target, Indonesia foresees peaking of national GHGs emissions in 2030 with a net sink in FOLU, further exploring opportunity to rapidly progress towards net zero emissions in 2060 or sooner.
	Conditional – up to 41% below BAU by 2030, including LULUCF	Mitigation target remained unchanged	
Lao PDR	INDC targets: 70% of forest cover by 2020; 30% renewable energy, excluding large hydro, of total energy consumption by 2030; share of biofuels to meet 10% of transport fuels; expansion of large hydro to 5,500 MW by 2020 and 20,000 MW by 2030	NDC target – 2030 unconditional target – 60% GHG emission reductions compared to baseline scenario, or around 62,000 $ktCO_2$ in absolute terms Conditional sectoral targets across the land use change and forestry, agriculture, energy, and waste sectors	

Country	Summary of pledges and targets	2020 NDC update	LT-LEDS/ Informal long-term climate commitment
Myanmar	By 2030, boost hydropower capacity by 9.4 GW to achieve electrification, using at least 30% renewable energy sources; expand forest area 30% by 2030	Reducing its reliance on coal from 33% under a BAU scenario to 20% (3,620 MW) as an unconditional target by 2030, but a conditional target of 11% (2,120 MW); unconditional target for new renewable energy of 11% (2,000 MW) of total energy mix by 2030. Conditionally, increase the renewable energy contribution to 3,070 MW (17% of the total energy mix).	
Malaysia	Reduce emissions intensity of GDP by 35% (reference: 2005)	Unconditional reduction in emissions intensity of GDP by 45% (reference: 2005)	
	45% conditional reduction in		
Thailand	Reduce emissions by 20% (reference: projected BAU)	Mitigation target remains unchanged	
	25% conditional reduction (reference: projected BAU)		
Philippines	Reduce emissions conditional 70% below BAU by 2030		
Singapore	INDC – reduce emission intensity by 36% by 2030 (reference: 2005)	First NDC – peak emission level at 65 MtCO2e around 2030 to achieve a 36% reduction in emission intensity from 2005 levels by 2030	Achieve net zero emissions as early as possible after mid-century
Viet Nam	8% below BAU by 2030, including LULUCF	The base year is revised to 2014 compared with 2010 in the previous NDC; 9% below BAU by 2030, including LULUCF	
	Conditional – 25% below BAU by 2030, including LULUCF	Conditional 27% below BAU by 2030, including LULUCF	
China	Peak CO2 emissions by 2030 at the latest		Achieve net zero emissions by 2060
	Non-fossil share: 20% in 2030		
	Forest stock: +4.5 billion cubic metres by 2030 compared to 2005		
	Carbon intensity: −60% to −65% below 2005 by 2030		

Country	Summary of pledges and targets	2020 NDC update	LT-LEDS/ Informal long-term climate commitment
India	33%–35% below 2005 emissions intensity of GDP by 2030		
	Create additional carbon sink of 2.5–3.0 GtCO2e through additional forest and tree cover by 2030		
	2030 conditional target(s) – non-fossil share of cumulative power generation capacity 40% by 2030		
Republic of Korea	37% below BAU by 2030	Reduce total national GHG emissions by 24.4% in 2017 (709.1 MtCO2e) by 2030	Achieve net zero emissions by 2050
New Zealand	30% below 2005 by 2030	Reduce emissions of biogenic methane to 24%–47% below 2017 levels by 2050, including to 10% below 2017 levels by 2030	Reduce net emissions of GHGs (other than biogenic methane) to zero by 2050
Japan	26% below 2013 by 2030	Mitigation target remained unchanged	Achieve net zero emissions by 2050
Australia	26%–28% below 2005 by 2030	Mitigation target remained unchanged	

ASEAN = Association of Southeast Asian Nations; BAU = business as usual; FOLU = forestry and land use; GDP = gross domestic product; GHG = greenhouse gas; $GtCO_2$ = gigatons of CO_2 equivalent; GW = gigawatt; INDC = Intended Nationally Determined Contribution; $ktCO_2$ = kilotons of CO_2 equivalent; LT-LEDS = long-term low greenhouse gas emissions development strategies; LULUCF = land use, land use change, and forestry; $MtCO_2$= million tons of CO_2 equivalent; MW = megawatt; NDC = nationally determined contribution.

Note: Targets are unconditional unless specified otherwise.

Source: UNFCCC (n.d.), NDC Registry. https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx (accessed 20 August 2021).

Singapore's long-term low-emission development strategy builds on the enhanced NDC target by aspiring to halve its emissions from its peak to 33 MtCO2e by 2050, with a view to achieving net zero emissions as soon as viable in the second half of the century. Similarly, China proposes to peak its emissions by 2030 and achieve net zero emissions by 2060.

A review of emission reduction targets suggests that, on the one hand, there are very limited signs of enhancement of 2030 NDC targets, although many of these countries have progressed in formulating their long-term strategies and announcing informal long-term national climate commitments, mostly in the form of net zero carbon targets for a climate-resilient and low-carbon future. AMS such as Viet Nam, Singapore, and Cambodia have proposed stronger unconditional and conditional emissions reduction targets as part of the Paris Agreement.

While several developing countries have also proposed ambitious non-binding targets, such as the net zero vision, in accordance with the 1.5°C target of the Paris Agreement, none of these targets are backed by formal binding emission reduction targets incorporated in their NDCs. In addition, there are no clear roadmaps laid out that envisage how countries expect to transition towards their proposed targets. Notwithstanding this, if pursued, these visions by China, Korea, Japan, and New Zealand imply the deployment of transformational low-carbon strategies. Regional cooperation in technology transfer, trade and investment, finance, and capacity building will be instrumental in attaining such targets.

2.2. Policies and Measures Driving Low-Carbon Development

An analysis of policies and measures adopted across countries indicates that countries include diverse strategies and measures across sectors and at different levels directed towards achieving the NDC targets. Low-carbon strategies in the energy sector largely include enhancing low-carbon/decarbonised fuels on the supply side (via strategies such as the development of renewable energy portfolio standards) and demand-side strategies that focus on energy efficiency across sectors as well as fuel switching across end-uses. The use of taxes and subsidies to incentivise low-carbon options and the inclusion of carbon pricing are also used widely across countries. Increasingly, countries have focused on integrating local considerations in rolling out measures related to waste and water management, sustainable mobility, and smart cities. Table 3.4 provides an assessment of low-carbon green growth policies and measures practised or proposed in ASEAN and East Asia countries.

Table 3.4 Summary of Low-Carbon Policies and Initiatives Practised or Proposed in ASEAN and East Asia Countries

Policy/Measure		BRN	SGP	IDN	THA	VNM	LAO	MYS	PHL	MMR	KHM	CHN	IND	JPN	AUS	NZL	KOR
Energy supply	Efficient fossil generation technologies		X									X	X	X	X	X	X
	Investment excise and other tax credits		X	X								X	X	X			X
	Renewable portfolio standards						X			X		X	X	X	X	X	
Power	Power management	X															
	Increase in share of renewables in electricity generation	X		X	X		X	X	X		X			X		X	
	Advanced fossil generation technologies																
	Retiring old, inefficient plants											X					
Energy demand	Efficiency labels		X	X	X	X	X	X				X	X	X	X	X	X
Industry	Efficiency improvement/shift to low-carbon technologies	X	X								X						
Buildings	Efficient/green buildings		X					X			X			X			
	Control of individual vehicle ownership		X														
	Vehicle emission standards/improvement		X	X	X	X			X			X	X	X	X		X
	Cleaner fuels	X							X					X			X
	Phasing out of conventional ICE vehicles													X			
	Reducing emissions through walk-cycle-ride	X	X								X						
	Crop carbon sequestration			X								X	X	X	X		X
	Reduction of open field burning			X	X						X	X	X	X			
	Promote climate resilience in agriculture						X	X									
Residential	Efficient appliances		X						X								
R&D	Clean and/or energy efficiency programmes		X		X				X			X	X	X	X		X
Carbon sink programmes	Afforestation/reforestation programmes		X	X	X			X				X	X	X			X
	CCS/CCUS		X									X			X	X	X
	Mitigation of HFCs from refrigeration and ACs		X											X			
	Carbon taxes	X	X											X			

Policy/Measure		BRN	SGP	IDN	THA	VNM	LAO	MYS	PHL	MMR	KHM	CHN	IND	JPN	AUS	NZL	KOR
Financing	Climate funds		X	X										X	X	X	X
	Institutional capacity		X									X	X	X	X		X
Local level measures	Demand-side energy management		X	X	X	X						X	X	X	X		X
	Sustainable transport systems		X	X	X			X				X	X	X	X		X
	Sustainable cities		X	X	X	X						X	X	X			X
	Waste management		X		X			X			X						
	Use of market-based instruments											X		X	X		
	Subsidies, grants, rebates		X	X								X	X	X	X	X	X
	Investment excise and other tax credits		X	X								X	X	X			X
	Public investment and loans		X	X	X							X	X	X	X	X	X
	Renewable portfolio standards						X			X		X	X	X	X	X	
	Low-carbon fuels, e.g. hydrogen and biofuels		X				X							X			X
Power	Power management	X															
	Regional power grids		X														
	Increase in share of renewables in electricity generation	X		X	X		X	X	X		X			X		X	
	Switch to cleaner/diversified energy sources		X	X			X				X			X		X	
	Advanced fossil generation technologies																
	Transmission/distribution grid improvements			X	X	X						X	X				
	Retiring old, inefficient plants											X					
	Feed-in tariffs		X	X	X	X		X	X			X	X	X	X	X	X
Energy demand	Retiring old, inefficient plants											X					
	Sales tax, energy tax, VAT reduction		X	X	X	X						X	X		X	X	X
Industry	Efficiency improvement/shift to low-carbon technologies	X	X								X						
	Corporate performance ratings			X													
Buildings	Efficient/green buildings		X					X			X			X			

Policy/Measure		BRN	SGP	IDN	THA	VNM	LAO	MYS	PHL	MMR	KHM	CHN	IND	JPN	AUS	NZL	KOR
Transport	Mass transit goals/increased use of public transport	X	X				X	X	X		X	X	X	X	X		X
	Control of individual vehicle ownership		X														
	Vehicle fuel efficiency goals/efficiency improvement	X	X	X	X	X		X	X		X	X	X	X			
	Vehicle emission standards/improvement		X	X	X	X			X			X	X	X	X		X
	Greater use of biofuels/biofuel standards		X	X	X		X		X			X	X				X
	Cleaner fuels	X							X					X			X
	Electrification	X	X		X				X		X			X			X
	Phasing out of conventional ICE vehicles													X			
	Financing schemes for sustainable transport								X								
	Reducing emissions through walk-cycle-ride	X	X								X						
Agriculture	Fertiliser management			X								X	X	X	X		X
	Crop carbon sequestration			X								X	X	X	X		X
	Methane mitigation			X								X	X	X	X	X	X
	Reduction of open field burning			X	X						X	X	X	X			
	Climate-friendly agribusiness value chain						X										
	Promote climate resilience in agriculture						X	X									
	Promote low-carbon technologies						X				X						
Residential	Efficient appliances		X						X								
	Clean and/or efficient cook stoves										X						
R&D	Clean and/or energy efficiency programmes		X		X				X			X	X	X	X		X
	Carbon sinks		X	X	X							X	X	X	X		X
Carbon sink programmes	Afforestation/reforestation programmes		X	X	X			X				X	X	X			X
	Forest Cover/REDD+	X		X		X	X	X		X	X						X
	CCS/CCUS		X									X			X	X	X
	Climate resilience in forestry						X										
	Mitigation of HFCs from refrigeration and ACs		X											X			

Policy/Measure		BRN	SGP	IDN	THA	VNM	LAO	MYS	PHL	MMR	KHM	CHN	IND	JPN	AUS	NZL	KOR
Carbon pricing	Emission trading systems													X		X	X
	Carbon taxes	X	X											X			
	Subsidies/tax incentives			X													
Financing	Climate funds		X	X										X	X	X	X
Capacity building	Public awareness		X	X	X	X						X	X	X	X		X
	Institutional capacity		X									X	X	X	X		X
	Human resources development		X	X	X	X						X	X	X	X		X
Local level measures	Demand-side energy management		X	X	X	X						X	X	X	X		X
	Net metering				X								X	X	X		
	Sustainable transport systems		X	X	X			X				X	X	X	X		X
	Green transport infrastructure		X														
	Sustainable cities		X	X	X	X						X	X	X			X
	Low-carbon lifestyle		X	X								X	X	X	X		X
	Waste management		X		X			X			X						
	Shift of energy intensive industries		X	X								X	X	X	X		X
	Use of market-based instruments											X		X	X		
	Water management		X				X	X									

AC = air conditioner; ASEAN = Association of Southeast Asian Nations; AUS = Australia; BRN = Brunei; CCS = carbon capture and storage; CCUS = carbon capture, utilisation, and storage; CHN = China; HFC = hydrofluorocarbon; ICE = internal combustion engine; IDN = Indonesia; IND = India; JPN = Japan; KHM = Cambodia; KOR = Republic of Korea; LAO = Lao PDR; MMR = Myanmar; MYS = Malaysia; NZL = New Zealand; PHL = Philippines; R&D = research and development; REDD+ = Reducing Emissions from Deforestation and forest Degradation, plus the sustainable management of forests, and the conservation and enhancement of forest carbon stocks; SGP = Singapore; THA = Thailand, VAT = value-added tax; VNM = Viet Nam.

Sources: ADB and ADBI (2013), Low-Carbon Green Growth in Asia: Policies and Practices. Tokyo: Asian Development Bank Institute; and UNFCCC (n.d.), NDC Registry. https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx (accessed 26 July 2021).

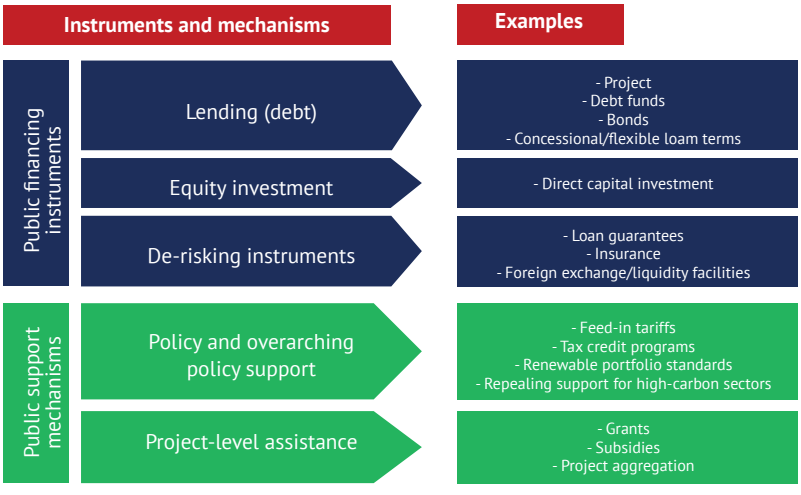
There are several policy approaches to the implementation of NDCs or other climate commitments. The plans and pledges regarding climate action are backed by policies and measures at the national, subnational, and sectoral levels. Figure 3.3 indicates the key policy instruments and financing mechanisms being adopted in ASEAN and East Asia.

Such public support mechanisms and public financing instruments are important elements in the implementation of effective and efficient climate actions.

We note that at the national level, climate action is often integrated into the country's development agenda. Low-carbon policies and measures are introduced in several countries, not with emission reductions as their primary goal, but with the objective of improving energy security, enhancing livelihood creation, reducing air pollution, or improving access to modern and clean energy forms. The Government of Indonesia, for instance, launched the Low-Carbon Development Initiative in 2017, focused on identifying development policies that would help the country promote multiple (social, economic, and environmental) goals simultaneously, while preserving and improving the country's natural resources (Kementerian PPNN/Bappenas, 2019). Realising a more prosperous and sustainable vision for Indonesia includes action on various fronts (Kementerian PPNN/Bappenas, 2019), including increasing renewable energy's share of energy use; reducing energy intensity; and fully enforcing moratoriums on forests, palm oil, mining, and peat land development.

Malaysia's Green Technology Master Plan (2017–2030) outlines multisectoral efforts to reduce GHG emission intensity and support economic growth through the adoption of green technology.

Figure 3.3 Category of Policy Instruments and Financing Mechanism Being Practised in Developing Countries of ASEAN and East Asia to Reduce Carbon Emissions



Source: Anbumozhi and Kimura (2018).

Other examples of climate mitigation strategies include the Lao PDR and India. The Lao PDR's climate strategy, The National Climate Change Strategy, sets out mitigation and adaptation measures in seven sectors: agriculture and food security, forestry and land use change, water resources, energy and transport, industry, urban development, and public health (ADB, WREA, and World Bank, 2010). India's National Action Plan on Climate Change (2008) contained eight sub-missions: the National Solar Mission, National Mission for Enhanced Energy Efficiency, National Mission on Sustainable Habitat, National Water Mission, National Mission for Sustaining Himalayan Ecosystem, Green India Mission, National Mission for Sustainable Agriculture, and National Mission on Strategic Knowledge for Climate Change (Pandve, 2009). This has been followed by several policies and measures in each of these areas to enhance efforts and progress in line with India's NDC, which seeks to achieve an emission intensity reduction of 33%–35% by 2030 compared with 2005 levels, 40% non-fossil fuel-based generation capacity, and enhancing the carbon sink to 2.5–3.0 gigatons of carbon dioxide ($GtCO_2$).

Increasing the share of renewables in the energy mix is, along with energy efficiency, one of the key strategies to achieving emission reduction targets. This strategy offers the dual benefit of enhancing energy security by reducing import dependence on fossil fuels. Initiatives to increase renewables in the ASEAN and East Asia countries include the 10-year Alternative Energy Development Plan (2012–2021) in Thailand, which aims to promote alternative energy usage to 25% of energy consumption and reduce dependence on energy imports. The Renewable Energy Development Strategy, launched in 2015, sets renewable energy targets for Viet Nam. The Energy Five-Year Plan (FYP) is the framework legislation defining energy development in China. In parallel to the main Energy FYP, China has 14 other supporting FYPs, such as the Renewable Energy 13th FYP, Wind FYP, and Electricity FYP. The 13th Renewable Energy Development FYP (2016–2020) was adopted by the National Energy Administration in 2016, establishing targets for renewable energy deployment until 2020. Countries are increasingly including climate-oriented plans and policies in their national development plans and energy sector plans at different levels.

Sectoral approaches are also common in emission mitigation strategies, especially where particular sectors are high energy users and carbon emitters, such as transport and industry.

For instance, Singapore has a long-standing reputation for innovative transport policies and effective land use and transport planning to achieve a sustainable transport system. Discouraging private motorised mobility, promoting public and shared mobility, and adopting an integrated approach to land use and transport planning are the three main pillars of Singapore's approach to sustainable transport (Diao, 2019). Malaysia's National Land Public Transport Master Plan (SPAD, 2012) aims to reach a 40% overall public transport modal share by 2030, almost doubling the current modal share of about 20%. This objective is to be met by implementing measures to enhance connectivity, service levels, safety, and convenience; reduce journey times; and ensure the sustainability of the public transport system. Another example of a sectoral

approach to low-carbon growth is India's industry sector. Industry – a major contributing sector to India's GHG emissions – is governed by the Perform, Achieve, and Trade scheme, which is a cap-and-trade market-based approach and has been used to incentivise more efficient technologies within the identified industries (Oak and Bansal, 2019).

Low-carbon green growth initiatives are also taking place at subnational and local levels. Some initiatives, such as carbon pricing, are initially tested at a city/municipality level before being implemented at the sectoral or national level. Other initiatives, such as the development of eco-friendly, carbon-efficient cities, waste, and water management, not only assist in emission reduction but also help in the development of more habitable and sustainable cities.

Fiscal and regulatory measures are prevalent in most ASEAN and East Asia countries, primarily to promote growth in renewable energy use. Feed-in tariffs (FiTs) are used in most countries except Brunei, the Lao PDR, Myanmar, and Cambodia. The use of FiTs has demonstrated huge success in enhancing renewable energy installations, the most recent and classic example being that of Viet Nam. The country has shown rapid growth in solar installations since the introduction of FiTs in 2017, with solar installations increasing more than 50 times from 86 megawatts in 2018 to 4,450 megawatts by June 2019 (Do et al., 2020).

Carbon pricing is also emerging strongly in the region as a tool to curb carbon emissions. Emission trading is prevalent in countries like Japan and Korea as the mechanism to generate a carbon price, while others like Brunei and Singapore impose a carbon tax directly. The Singapore tax scheme under the Carbon Pricing Act, 2018 stipulates that any industrial facility which emits direct GHG emissions equal to or above 2,000 tons of carbon dioxide equivalent (tCO2e) annually has to register as a reportable facility and pay a carbon tax from 1 January 2019 at a rate of US$5 per tCO2e from 2019 to 2023. The country plans to review the carbon tax rate by 2023, with plans to raise it by US$5–US$10 per tCO2e by 2030.

Japan has a well-established history of using a carbon price as a signal to reduce carbon emissions. The first carbon emissions trading system (ETS) implemented in Japan was the Voluntary Emission Trading Scheme, launched in 2005, which covered CO2 emissions from industrial processes (production and energy consumption); offices (energy consumption); and waste management (waste incineration, waste combustion, and waste recycling) (IGES, EDF, and IETA, 2016). In 2012, the scheme was discontinued and replaced with a new subsidy-based voluntary cap-and-trade scheme called Advanced technologies promotion Subsidy Scheme with Emission Reduction Targets (ASSET). Under this programme, entities establish a reduction target based on past emissions and suggest new technologies to use to reach these targets. Japan has also implemented the Joint Crediting Mechanism, a bilateral offset crediting mechanism (Japan with developing countries) to incentivise low-carbon technologies in 17 partner countries (ICAP, 2021). Currently, Japan has three carbon pricing initiatives: the Tokyo ETS (first city-level cap-and-trade system on emissions started in 2010); the Saitama

ETS (initiated in 2011); and the Global Warming Countermeasure Tax, which is a national carbon tax (started in 2012) (Kojima and Asakawa, 2020).

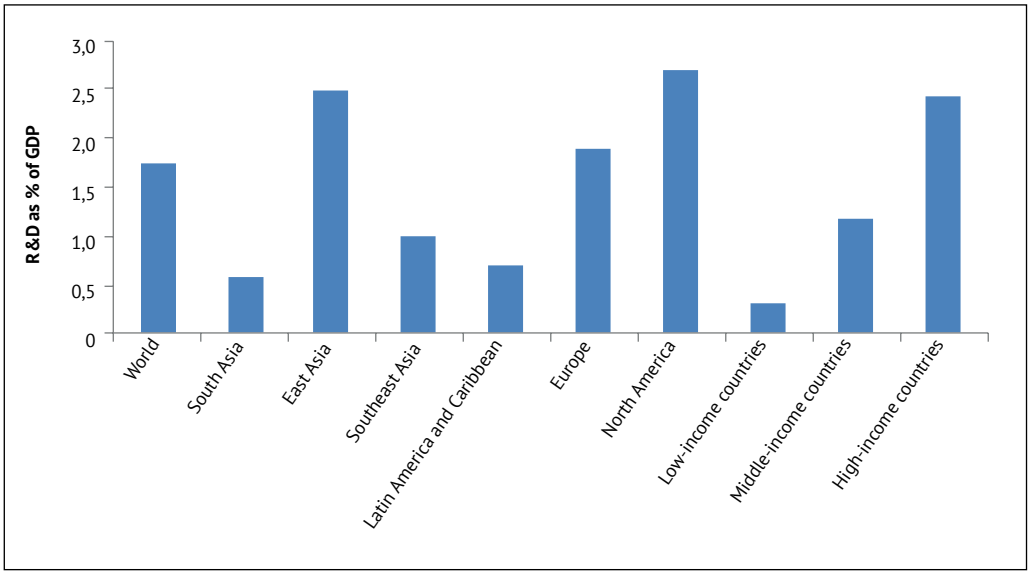
Financing is critical to support low-carbon green growth, as it plays a crucial role in mobilising the funding needed for the transition. However, financing is often one of the key barriers to the penetration of innovative low-carbon technologies, particularly in developing countries. The Swiss Sustainable Finance (2020) report on financing the low-carbon economy suggested that overcoming this barrier necessitates the development of a supportive political framework, which requires close cooperation between all stakeholders – financial players, regulators, and real-economy representatives.

Low-carbon green growth undoubtedly requires more technological progress in low-carbon production and supply, and consequently much higher investments in research and development (R&D) across countries. There are large variations in the levels of investment in R&D amongst countries. According to the United Nations Educational, Scientific and Cultural Organization Institute for Statistics (UNESCO, n.d.), the US leads China in R&D expenditure, followed by Japan, Korea, Germany, India, France, and the United Kingdom (UK). As evident from Table 3.5, R&D expenditure as a share of GDP is high in the more developed countries of the region, although China has also emerged as a country with high R&D expenditure. In countries such as the US, Japan, Korea, and other European countries, R&D investment is largely in the private sector, while government investment contributes to about 55% of India's total R&D expenditure. Compared with other major economies, India's per capita R&D expenditure is quite low – about 13% of the per capita R&D expenditure of China and only 3% of that of the US. As a region, the total R&D expenditure of ASEAN is relatively low, at around 70% of India's total R&D expenditure. However, the per capita R&D expenditure of ASEAN is comparable with that of China due to the huge variation amongst individual countries in the region, and Singapore having an even higher per capita R&D expenditure than the US. On the other hand, the share of R&D expenditure in the regional GDP of ASEAN is less than 1%.

The Asian Development Outlook 2020 (ADB, 2020) examined the variation in R&D expenditure as a share of GDP between regions in terms of the innovation gap. This indicates that the gap between developing Asia and advanced economies is narrowing (Figure 3.4) but, within developing Asia, the innovation gap is widening (ADB, 2020). The analysis also indicates that firms which are larger, older, and/or engaged in information and communication technology or high-tech manufacturing or exporting, are likely to innovate more. Moreover, other than R&D, human capital (both education and training) as well as infrastructure (e.g. institutional conditions such as property rights and the rule of law) are important determinants of innovation.

The mere availability of technologies is not enough, however. Innovation-based growth and development strategies that seek to promote long-term sustainability and focus on livelihood creation can effectively help economies successfully transition not only to low-carbon pathways but also to higher income levels and greater inclusiveness, compared with

Figure 3.4 R&D Expenditure as a Share of GDP Across Regions, 2017 (%)



GDP = gross domestic product, R&D = research and development.

Source: UNESCO (n.d.).

incremental innovations in products and/or processes. However, innovation is a multidimensional and complex process. Table 3.6 illustrates the stages of technology development and key policy challenges lying ahead if markets are to adopt new technologies. Investment in early R&D is necessary but not sufficient by itself for successful market penetration. The demonstration and commercialisation of emerging technologies are also vital for ensuring successful business models that enable rapid upscaling and adoption of the technologies.

R&D, knowledge sharing, and capacity building are equally important aspects of low-carbon transitions, particularly in a regional context, where countries can assist each other in case of lack of finance, rigid labour markets, lack of energy alternatives or energy-related lock-ins, resource constraints, and governance barriers. Most of these issues concern developing nations. The role of developed economies is to work together with their developing counterparts to assist them in scaling up and spreading low-carbon transformation in the region.

Current global commitments fall far short of the levels required to limit global warming to 1.5°C as desired under Article 2 of the Paris Agreement, and an analysis by the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) has indicated that the emission targets set by AMS are not in line with global goals (UNESCAP, UNEP, and Greenwerk, 2020).

COVID-19 has temporarily pushed down the level of emissions due to reduced economic activity. However, while this dip is likely to be short-lived, the current phase provides an opportunity to keep emissions down. This opportunity increases the need for regional cooperation, strengthening of regional institutions, improving regional infrastructure and connectivity, advancing trade policy,

Table 3.5 Key Fiscal, Innovation, and Public Investment Indicators in Asia's Major Economies

Country	GDP (current US$)	Public debt (% of GDP)		Population ('000)	GDP per capita (US$)	CO_2 emissions/ population (metric ton)	Government expenditure on education (% of GDP)	Current health expenditure (% of GDP)	R&D (% of GDP)	Military expenditure (% of GDP)	Gross debt position (% of GDP)	Tax revenue (% of GDP)
		Central government debt	General government debt									
Year	2019	2019	2019	2019	2019	2018–2019	1999–2019	2018	2002–2018	2019	2020	2016–2019
Australia	1,396,567.01	34.82	46.28	25,364.31	55,060.30	15.32	5.10	9.28	1.87	1.90	60.41	23.30
Bangladesh	302,571.25	35.82	no data	163,046.16	1,855.70	0.51	1.30	2.34	0.14	1.30	39.62	8.80
Brunei Darussalam	13,469.42	2.58	28.64	433.29	31,086.80	16.65	4.40	2.41	0.28	3.30	no data	-
Cambodia	27,089.39	no data	28.61	16,486.54	1,643.10	0.65	2.20	6.03	0.12	2.30	31.47	19.70
China	14,342,903.01	no data	56.29	1,397,715.00	10,261.70	6.84	1.90	5.35	2.19	1.90	61.70	9.10
India	2,868,929.42	46.16	72.34	1,366,417.75	2,099.60	1.71	3.80	3.54	0.65	2.40	89.33	12.00
Indonesia	1,119,190.78	30.18	30.49	270,625.57	4,135.60	2.03	3.60	2.87	0.23	0.70	38.48	10.20
Japan	5,081,769.54	201.39	237.95	126,264.93	40,246.90	8.45	3.20	10.95	3.26	0.90	266.18	11.90
Lao PDR	18,173.84	62.64	no data	7,169.45	2,534.90	2.53	2.90	2.25	0.04	0.20	70.94	
Malaysia	364,681.37	52.49	57.24	31,949.78	11,414.20	7.23	4.20	3.76	1.44	1.00	67.58	12.00
Mongolia	13,996.72	59.97	81.62	3,225.17	4,339.80	6.67	4.10	3.79	0.10	0.70	no data	16.80
Myanmar	76,085.85	38.84	no data	54,045.42	1,407.80	0.59	1.90	4.79	0.03	1.40	42.37	5.80
New Zealand	206,928.77	31.54	no data	4,917.00	42,084.40	6.49	6.30	9.21	1.37	1.50	48.02	29.00
Pakistan	278,221.91	85.56	no data	216,565.32	1,284.70	0.92	2.90	3.20	0.24	4.00	87.20	-
Philippines	376,795.51	no data	36.97	108,116.62	3,485.10	1.24	2.50	4.40	0.16	1.00	48.86	14.00
Republic of Korea	1,646,739.22	36.42	41.92	51,709.10	31,846.20	11.31	4.30	7.56	4.81	2.70	48.41	15.50
Singapore	372,062.53	129.29	no data	5,703.57	65,233.30	8.40	2.90	4.46	1.94	3.20	131.19	13.30
Sri Lanka	84,008.78	86.78	no data	21,803.00	3,853.10	0.95	2.10	3.76	0.11	1.90	98.25	11.60
Thailand	543,548.97	34.02	34.07	69,625.58	7,806.70	3.47	4.10	3.79	1.00	1.30	50.45	14.90
Viet Nam	261,921.24	44.25	43.37	96,462.11	2,715.30	2.37	4.20	5.92	0.53	2.00	46.62	-

Sources: World Bank (2019), World Development Indicators. https://data.worldbank.org (accessed 16 February 2021); and IMF (2018), Global Debt Database. https://www.imf.org/external/datamapper/datasets/GDD (accessed 16 February 2021).

Table 3.6 Public Policy Mechanisms for Supporting Low-Carbon Innovations

Stage of technology development	Early research	Demonstration and commercialisation	Market update
Key policy challenges	Increase the volume of early-stage research Improve the flow of funding to promising research Transfer academic research into commercial environment Do not write off promising technologies too early	Identify scalable, lab-proven technologies Provide soft credit where it is required to achieve target returns Establish clear performance standards Do not try to pick winners, but cull losers aggressively Develop a replicable blueprint for large-volume roll-out Provide support to close the cost gap with mature technologies Ensure the availability of credit despite market and policy risks Ensure the economic system can absorb new technologies and remain stable Support/create lead customers	Ensure energy diversity, providing, if necessary, long-term support for higher-cost technologies Protect public budgets Avoid locking in uncompetitive market structures Shift emphasis to 'polluter pays' rather than maintaining subsidies indefinitely
Enabling policies			
Regulation		National/state/local procurement targets Feed-in tariffs Reverse auctions/requests for contract Renewable portfolio standards/ green certificates/PAT Renewable fuel standards	Top-runner requirements Utility regulation
Finance mechanisms for innovation	Incubators National laboratories Prizes National/state-funded venture capital National/state-run venture capital R&D grants	Project grants	Technology transfer funds National/state/local infrastructure funds
Credit mechanisms		Venture loan guarantees Green bonds Loan guarantees Debt funds	Export trade credit Microfinance Sovereign/policy risk insurance National/state/local energy service companies funds
Tax-based policies	Capital gains tax waivers R&D tax credits	Innovation clusters Accelerated depreciation Investment tax credits Production tax credits	Carbon tax
Carbon market mechanisms	0.5	Monitoring, reporting, and verification	Domestic carbon cap and trade Project-based carbon credits National and multilateral carbon funds

PAT = Perform, Achieve, and Trade; R&D = research and development.

Source: Compiled by the ERIA Study Team.

and developing cross-border solutions to common problems (World Bank, 2020).

Given that several countries in the region face similar challenges and have similar needs, apart from learning from each other's best practices, ways to work towards aggregating demand and finding scalable solutions through regional cooperation can play a key role in moving towards a sustainable carbon-constrained future.

3. Critical Evaluation of Changes in Emission Trajectories During the COVID-19 Pandemic

The unprecedented onset of the COVID-19 pandemic presented both opportunities and threats to the low-carbon transition. Although lockdown restrictions to contain the spread of the pandemic resulted in a decline in emissions and an improvement in air and water quality, there is a high possibility of these positive environmental developments being short-lived. Research on the recovery from the 2008 financial crisis suggested similar trends (Peters et al., 2012).

The pandemic has caused several detrimental impacts on the environment, apart from the possibility of a rebound effect on emissions in the post-pandemic phase. It has caused a surge in the generation of medical waste; haphazard use and disposal of disinfectants, masks, and gloves; and the burden of untreated waste (Rume and Islam, 2020). In the energy sector, climate action has also been negatively affected by delays in and disruptions to renewable energy investments, construction, and supply chains; and the risk of potential investors losing tax incentives, tariffs, or other revenue sources (Königreich, 2020).

3.1. Impact of the Pandemic on the Energy Sector and Emissions

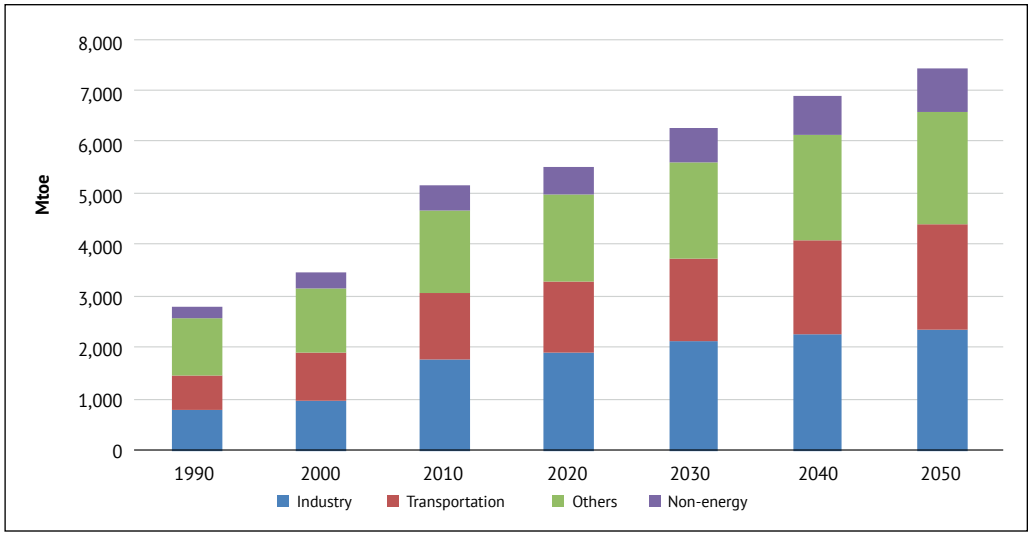
ASEAN achieved an energy intensity reduction of 24.4% from 2005 to 2017 (Putra, Munardy, and Gurning, 2020). The region also achieved a renewable energy share of 14.3% in the total primary energy supply by 2017. The current regional targets, set by the ASEAN Plan of Action on Energy Cooperation (2016–2025), are a 30% energy intensity reduction and a 23% renewable energy share in total energy supply by 2025. Based on the Economic Research Institute for ASEAN and East Asia (ERIA) outlook for final energy consumption (Kimura and Han, 2021), under business-as-usual scenarios, there will be a significant increase in the use of renewable energy by the industry and transport sectors at least until 2050 (Figure 3.5).

Transportation energy demand is projected to grow moderately by about 1.4% per year, and its energy consumption share is projected to be 27.7% by 2050. Industry's annual growth rate in 2017–2050 is projected at about 0.9% per year, but its energy consumption share is projected to be the largest at about 31.7% by 2050. This implies dependence on imports of oil and natural gas. Figure 3.6 shows that the primary energy supply in ASEAN and East Asian countries is expected to grow at an average annual rate of 3.6% between 2020 and 2050.

Oil is currently the dominant energy source, followed by coal and natural gas. However, coal's share is projected to be the largest soon and may reach up to 53% by 2040 – a significant increase from 32.9% in 1990.

The prospect of switching out internal combustion engines that are dependent on oil and gas for hybrid

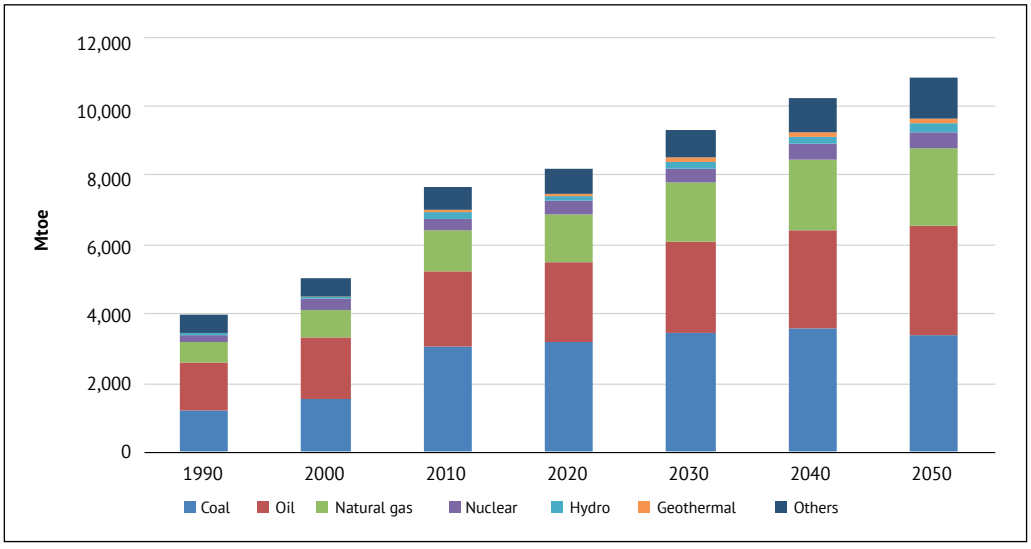
Figure 3.5 Final Energy Consumption by Sector in ASEAN and East Asian Countries, Business as Usual, 1990–2050



ASEAN = Association of Southeast Asian Nations, Mtoe = million tons of oil equivalent.

Source: Kimura and Han (2021).

Figure 3.6 Final Energy Supply by Fuel in ASEAN and East Asia, Business as Usual, 1990–2050



ASEAN = Association of Southeast Asian Nations, Mtoe = million tons of oil equivalent.

Source: Kimura and Han (2021).

or electric vehicles is promising and is clearly on ASEAN's agenda. Yet coal use in the ASEAN region is projected to increase rapidly to meet the region's growing electricity demand, with primary energy supply being dominated by coal, oil, and natural gas. Both ASEAN and developing countries face challenges in matching energy demand with low-carbon supply as they transition to a low-carbon economy. There is a heightened need to accelerate the development of greener energy sources, including renewables, hydrogen, and clean technologies. If governments allow massive fossil fuel use in industries during their recovery from the pandemic-induced recession, this will discourage such a development.

The COVID-19 pandemic disrupted the demand and supply of electricity throughout the first and second quarters of 2020. A sharp decline in oil demand resulted from the massive travel and commerce restrictions, and reduced operations in many industries (Campion, 2020). Many power projects were halted due to the disruption. Most oil companies witnessed revenue loss and some of them have cut their national refinery activities as a response to the drop in demand from the transportation sector. For oil producer countries, such as Brunei Darussalam and Malaysia, the revenue from this sector fell sharply.

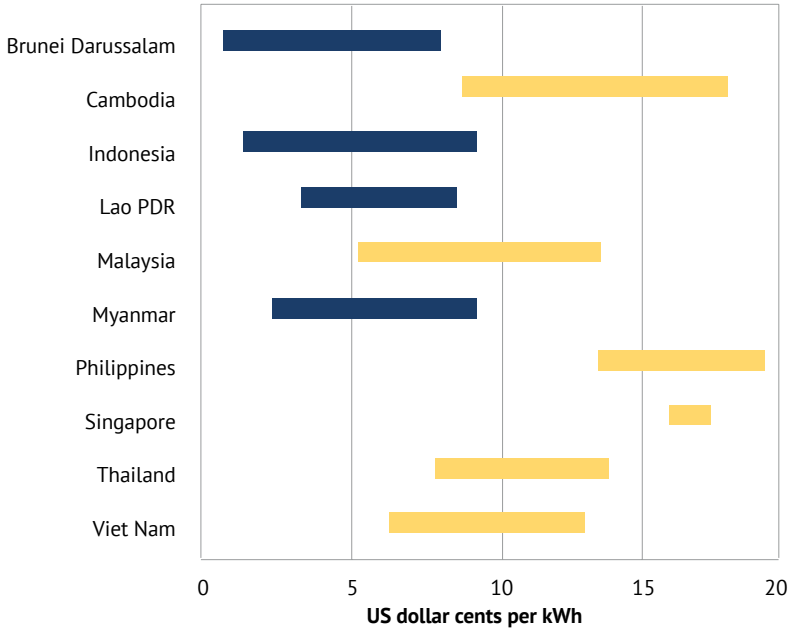
Before the pandemic, the vulnerabilities of the power sector were (i) increasing severity and frequency of natural disasters, (ii) weak power sector financial health, (iii) a fuel mix that relied on fossil fuels, (iv) growing energy demand, and (v) poor air quality and pollution (Lowder, Lee, and Leisch, 2020). Lockdown measures have decreased overall electricity demand, lowering commercial and industrial use while increasing residential consumption, thus changing the shape of load curves. IEA (2020) estimated that global electricity demand decreased by 2.5% in the first quarter of 2020 and observed a 5% contraction by the end of the year. In March and April 2020, the International Financial Corporation (IFC) observed a 15% drop in demand, on average, in many countries (IFC, 2021). Overall electricity demand has decreased, with some countries reporting up to a 20% drop in consumption during periods of full lockdown (from March to October 2020) (ACE, 2020).

Prior to the pandemic, countries had customised their electricity tariffs according to consumption range and use type. The range of electricity tariffs for households is shown in Figure 3.7.

Differences in electricity tariffs across the region are based on the average production cost, which varies depending on the fuel types, tariff components, and subsidy regimes.

The unforeseen impact of the pandemic led countries to extend flexible support to electricity consumers, with discounts and tax rebates. Some countries are offering support to the most affected communities and low-income households in the form of full payment help or deferred electricity bill payments. The various types and duration of relief offered, and the customers targeted in Southeast Asian countries, are summarised in Table 3.7. The targeted consumers include hospitals, residential consumers, commercial facilities, and agriculture.

Figure 3.7 Pre-COVID-19 Electricity Tariffs for Households in ASEAN Member States



ASEAN = Association of Southeast Asian Nations, COVID-19 = coronavirus disease, kWh = kilowatt-hour, US = United States.

Source: ACE (2020).

Table 3.7 Types of Targeted Support to Electricity Consumers in ASEAN Member States

Electricity tariff relief		Brunei Darussalam	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam
Type of relief	Tariff exemption for targeted customers			●			●			●	●
	Tariff reduction for targeted customers	●		●	●	●		●		●	●
	Tariff adjustment for targeted customers		●						●		
	Payment extension									●	
	Refund									●	
Targetted customers	Residential first lowest tier			●	●	●	●	●	●	●	●
	Residential second lowest tier			●		●	●	●	●	●	●
	Residential third lowest tier					●	●		●	●	●
	Industrial		●			●				●	
	Commercial	●	●			●				●	●
	Others (agriculture, health, infrastructure, etc.)	●			●						●
	Availability period	1 April–30 September 2020	April–July 2020	April–September, extended to 10 December 2020	No specific deadline	1 April–31 December 2020	April–June 2020	April–June 2020	"SUC: July or August 2020 U-Save: April 2020–January 2021"	April–June 2020	May–July 2020

SUC = Solidarity Utility Credit, u-Save = Utilities Save.

Source: ERIA Study Team based on ACE (2020).

This has affected renewable energy uptake and energy efficiency improvements related to uptake.

Enormous renewable energy potential can be developed, with potential solar photovoltaic (PV) capacity exceeding 41 terawatts and potential wind capacity exceeding 1.8 terawatts for a range of reasonable levelised costs of energy. The COVID-19 pandemic has affected the renewable energy sector in ASEAN in the following ways:

- Renewable energy project development: Revenues from existing wind and solar projects have been largely resilient to COVID-19 impacts, but projects in the pipeline have experienced slowdowns due to changes in energy markets, regulatory delays, and workers' safety and workforce issues, as illustrated by the hydropower dam projects along the Mekong River. Many of these projects will be delayed but will eventually come online and are expected to rebound in late 2021.

- Supply chain disruption: As for renewable energy construction projects, many of the world's largest solar panel, battery, and wind turbine manufacturers – as well as many raw materials (e.g. steel for turbines and rare earth materials for batteries) – are located in China, and the country's COVID-19 related lockdowns and travel restrictions are likely to have disrupted supply chains. Renewable energy project developers that were completing their projects during this pandemic may have incurred additional costs and delays that could affect their anticipated returns or project milestones.

- Fossil fuel prices and renewables competitiveness: With a global economic slowdown, and the resulting fall in transportation and electricity demand, oil and natural gas prices have plunged. These low prices translate to reductions in the levelised cost of energy from existing oil and gas power generation plants. Currently, the levelised cost of energy from solar PV is competitive with combined-cycle natural gas turbines in several Southeast Asian markets and is anticipated to drop further over the next decade. If the temporary reduction in fossil fuel prices is prolonged, investment in gas-based projects could hamper renewables deployment.

3.2 Impact on the Trajectory of GHG Emissions

Daily global GHG emissions dropped by 17% in the first quarter of 2020 compared with 2019 levels. Falling industrial production, fewer cars on the road, and less power generation contributed to temporary improvements in air quality and reductions in emissions and pollutants. While this is positive in mitigating climate change, the drop is due to the COVID-19 pandemic and measures to stop its spread, such as nationwide lockdowns and travel restrictions. For Japan, emissions in 2020 decreased due to the fall in fossil fuel imports (crude oil 11.5%, liquid natural gas 5.7%, and coal 1.0%) in January–June 2020 compared with the same period the previous year.

3.3. Impact on digital technology transformation

In 2016, countries in the region recognised the importance of digital and emerging technology in energy development, including automation, high-efficiency energy systems, and new technologies such as batteries

and hydrogen technology. Digital technologies are set to make energy systems more interconnected, intelligent, efficient, and sustainable (The ASEAN Post, 2018). Advances in areas such as data analytics, artificial intelligence, and blockchain technology have reached the shores of the energy sector. Digitalised energy systems will be key to ensuring that energy demands are met in a cost-efficient and reliable manner. This system will help to address many challenges related to power generation. Countries like the Philippines, Myanmar, and Cambodia often face power outage issues and skyrocketing utility bills due to the inefficient power systems in place. Machine learning, blockchain, and cloud computing can be used to design a power system to enhance demand response. A digital energy system will also help with balancing system reserves and tapping into power from self-generators such as owners of rooftop solar systems. As Southeast Asia marches towards a digital future, there will be added pressure on utilities providers to modernise their systems. These necessary changes will not only benefit utility companies but will also generate additional revenue for technology providers. Consumers will enjoy savings in the long run as well.

3.4. Impact of Pandemic on Agriculture Emissions and Natural Capital

Agriculture and forests account for about 20% of total emissions and make up a significant share of the economy in ASEAN – Cambodia (%20), the Lao PDR (15%), Viet Nam (14%), Indonesia (12.7%), Malaysia (7.3%), the Philippines (8.8%), and Thailand (8%) (Anbumozhi, Kalirajan, and Kimura, 2018). As the majority of the population is heavily reliant on the agriculture sector, forestry, and fisheries, the disruption caused by the COVID-19 pandemic and lockdowns poses the risk of unemployment, which will eventually result in a widespread reduction in living standards due to limited capacity and access to basic necessities (Boss et al., 2020). Across the region, forests cover about 45% of the land area, but contracted at an annual rate of 1.5% from 1990 to 2018. Deforestation releases higher quantities of carbon emissions because of peatland degradation. In 2017, carbon emissions from peatland drainage contributed the equivalent of 1.3%–3.1% of fossil fuel emissions in Southeast Asia. Land use is responsible for about 20%–25% of regional GHG emissions.

Some examples of policy approaches to GHG emissions reduction in agriculture and forestry sectors are listed in Box 3.1.

There are many barriers to implementing carbon emission reduction practices in agrarian economies, which have been reinforced during the pandemic. These include the accessibility of finance, rural poverty, access to digital technologies, technology transfer, and diffusion problems. For rice farming, COVID-19 has affected access to credit, capital inputs, remittance income, and the safety of food and water. During emergencies such as the 2019 drought and the COVID-19 pandemic, farmers need assistance and support, either from the government or the private sector (Fox, Promkhambut, and Yokying, 2020). For Viet Nam, the output of the agriculture, forestry, and fishery sectors in the first 9 months of 2020 was hit by the compound impact of the COVID-19 epidemic, African swine fever, and climate change. Table 3.8 shows the estimated impacts of

Box 3.1 Economic Policy Approaches Adopted by Major Asian Countries for Climate Change Mitigation in the Agriculture and Forestry Sector

Governments are experimenting with a range of policy instruments to reduce carbon emissions from the agriculture and forestry sectors and meet other public policy objectives:

- Green standards and regulations: Standards and rules for agricultural land and forest management; and controls on deforestation and peatland degradation
- Support measures: For carbon sequestration, and flood and drought control, increasing investments in technologies, targeted outcomes, and production practices
- Economic instruments: Payment of ecosystem services, putting a price on forestation through REDD+ mechanisms or trading schemes
- Trade measures: Lower tariff and non-tariff barriers on climate-smart technologies and products
- R&D: Increase in public R&D of climate-smart agriculture, private R&D, and capacity building
- Information, education, training, and advice: Increasing public awareness for more sustainable patterns of agricultural production and consumption through eco-labelling, training, education, and advice

R&D = research and development; REDD+ = Reducing Emissions from Deforestation and Forest Degradation in Developing Countries.
Source: Compiled by the ERIA Study Team.

Table 3.8 Estimated Impacts of the Pandemic on Agricultural Production in ASEAN

Item	Impact
Baseline in 2018	
Volume of agricultural production in 2018 (million tons)	548.33
Labour productivity in 2018 (tons/worker)	5.272
With COVID-19 scenario in 2020	
Estimated agricultural labour force due to COVID-19 (million)	100.77
Estimated volume of agricultural production (million tons)	531.295
Change in volume of agricultural production due to decrease in agricultural labour force (%)	3.11
Reduction in volume of agricultural production (million tons)	–17.034
Estimated GDP in 2020 (US$ billion)	264.6
Difference in GDP compared with 2000 (US$ billion)	–3.758
Change in GDP (%)	–1.40
Total population in ASEAN (million)	655.28
Increase in poverty ratio due to agricultural labour force reduction (%)	2.24
Estimated increase in the number of people living below US$1.90 a day (million)	14.68

ASEAN = Association of Southeast Asian Nations, COVID-19 = coronavirus disease, GDP = gross domestic product.

Source: Gregorio and Ancog (2020).

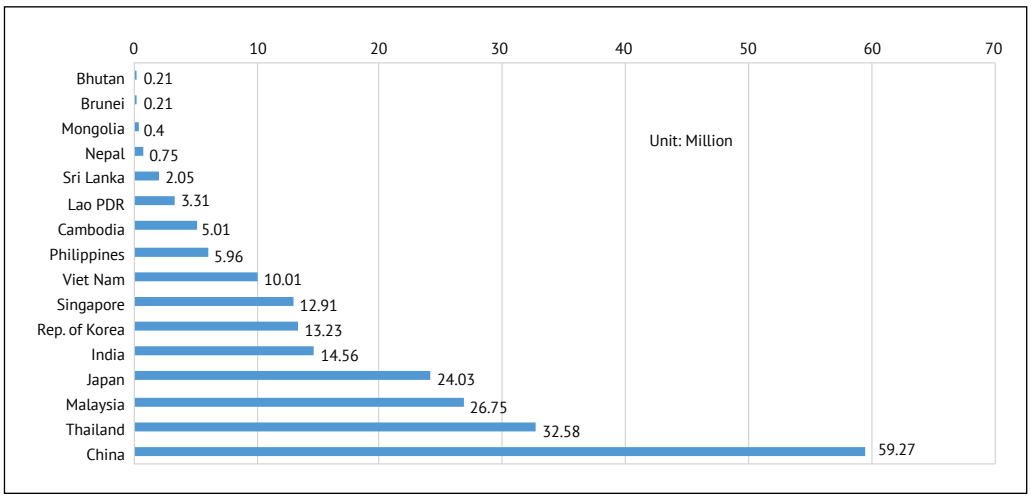
the pandemic on regional agricultural production.

In addition, COVID-19 is changing markets in a fundamental way by altering the shopping behaviour of producers and consumers. Many innovations, such as e-extension, e-trading, and mobile payments, are being implemented. Further, demand is likely to increase for innovations in delivery. Responding to this changing ecosystem requires public–private partnership. Many ASEAN governments are already looking for ways to address COVID-19 disruptions and engage with the changing systems (Boss et al., 2020). Aligning agricultural and forestry policies with low-carbon and digitalisation goals would reduce the costs of implementing these green growth options.

3.5 Impact of the Pandemic on the Tourism Sector

The Asia-Pacific region accounts for 30% of the world's international tourism receipts. Figure 3.8 shows the tourist profile of Asia in 2018.

Figure 3.8 Tourists Visiting Asia in 2018



Source: The Phnom Penh Post (2018).

For 14 countries with data available in the ASEAN and East Asia region, the International Labour Organization estimated that the jobs and livelihoods of at least 15.3 million workers or 5.9% of workers – 6.4 million women and 8.9 million men – in the tourism sector are at risk because of the pandemic (ILO, 2020). Staff of airlines, hotels, travel agencies, and transport companies across the region are being asked to take paid or unpaid leave, accept reduced wages or, worse, are simply let go. Cambodia, Thailand, and Viet Nam have the highest share of employment in tourism, at 6.7%, 9.0%, and 6.9%, respectively.

Tourism is a particularly important sector for Southeast Asia in the transformation to a low-carbon economy. Transport-related CO_2 emissions from the tourism sector have fallen substantially during the pandemic, but are likely to bounce back in 2021 (ACE, 2020). Transport-related CO_2 emissions of the tourism sector remain a major

challenge, and the sector needs to work closely with the transport sector to support its commitment to accelerate decarbonisation and implement a high-ambition scenario. There is no specific targeted policy progress other than international discussions on a tax on air passengers and company offset programmes. Nevertheless, Asia's tourism sector can no longer be solely dependent on the decarbonisation strategies of related sectors such as green hotel buildings, and must determine its own high-ambition scenario beyond transport – a scenario where tourism would significantly decouple growth from emissions. Transforming tourism for climate action requires embracing a low-carbon pathway through the measurement and disclosure of emissions related to tourism activities, the setting of evidence-based targets, and the adoption of instruments and strategies to scale up mitigation and adaptation, with all stakeholders having to play a role. In this regard, developing a set of actionable policy recommendations in consultation with the United Nations World Tourism Organization member states will be the next step.

3.6 Impact of the Pandemic on Supply Chains and Opportunity in the Race to Net Zero

In the first half of 2020, Asia-Pacific exports suffered a severe slump due to shockwaves from the global COVID-19 pandemic and widespread lockdowns that disrupted supply chains, industrial production, and consumer spending. As lockdowns eased in several countries, Asia-Pacific exports rebounded in the last quarter of 2020, helped by improving export orders from China, the EU, and the US, as the automotive, pharmaceutical, and electronics sectors, amongst others, showed strong growth in output during the third quarter of 2020. The rebound in China's economy has helped the recovery in exports from many other Asian economies. China's export sector increased by 11.4% year on year in March 2021, after an increase of 9.9% year on year in March 2020. Korea's exports rose by 7.6% year on year in September 2020. In Malaysia, exports rose by 13.6% year on year in September 2020, with exports of manufactured products up by 16.3% year on year. Singapore's non-oil domestic exports rose by 5.9% year on year in September 2020, with electronics exports surging higher by 21.4% year on year (Biswas, 2021).

Eight supply chains – food, construction, consumer goods, electronics, automotive, professional services, fashion, and freight – account for more than half of global GHG emissions. The ASEAN and East Asia region is a significant participant in all eight global supply chains. Analysis from the ERIA showed that China, the EU, and the US together account for almost three-quarters of ASEAN's global carbon exporters (Anbumozhi, Ramanathan, and Wyes, 2020). The evidence reveals that mature and nurturing markets are increasingly outsourcing their carbon burden to production networks in ASEAN. About 40% of all emissions in these supply chains could be abated at a cost of US$10 per ton of CO_2 equivalent using mechanisms such as the increased use of recycled materials, energy efficiency improvements, and increased adoption of renewable energy. Interventions listed in Box 3.2 are estimated to reduce supply chain emissions with only a 1%–4% increase in end-consumer prices in the medium term.

Box 3.2 Supply Chain Opportunity in the Transition Towards a Low-Carbon Economy

Major actions taken by companies to support the transition to a low-carbon economy include:

- building a comprehensive carbon emissions baseline, gradually filled with actual supplier data;
- setting ambitious and holistic carbon emission reduction targets and publicly reporting progress;
- revisiting product design choices for a low-carbon economy;
- designing a circular value chain and geographic sourcing strategy;
- setting and tracking ambitious green procurement standards;
- working jointly with small and medium-sized enterprise suppliers through technical assistance programmes to address their emissions; and
- developing internal governance mechanisms to align regulatory incentives with emission targets.

Source: ERIA Study Team

While regulatory and market-based policy instruments could make such interventions broadly accessible, decarbonising the entire supply chain remains a challenge. Even pioneering companies struggle to find and act upon appropriate data on energy use and embedded carbon emissions, particularly in fragmented supply chain landscapes. That can be a challenge in certain sectors such as micro, small, and medium-sized enterprises in electronics and small-holder agribusiness. However, firms working with suppliers across the region with new integrated technology, finance, and business models will be a vital part of the transition to low carbon in the post-COVID-19 era.

4. New Challenges in Resource Use and Planning for a Circular Low-Carbon Economy

Resource efficiency contributes directly to mitigating climate change and achieving NDC targets in most cases, without necessarily having any adverse economic effect. In the midst of the pandemic and climate crises, G20 energy ministers in 2020 agreed on a communiqué that endorsed the circular carbon economy (CCE) platform as a tool to manage emissions and foster access to energy. They acknowledged the CCE approach as a holistic, integrated, inclusive, and pragmatic approach that supports and enables sustainable development; and that encourages countries to take advantage of all technologies, forms of energy, and mitigation opportunities, according to resource availability, economics, and national circumstances. The circular economy is a holistic

approach to resources management that can guide international efforts towards a more inclusive, resilient, sustainable, and low-carbon energy system (ASEAN, 2021). The CCE in the context of hydrocarbon-rich countries is often used to denote 'reduce, reuse, recycle' activities, as in the production, circulation, and consumption of energy and other resources (Mansouri et al., 2020).

4.1. Motivation and Drivers of the CCE

The CCE in the ASEAN context is often used to denote the 4Rs – reduce, reuse, recycle, and remove – in the process of production, circulation, and consumption of energy and other resources. 'Reduce' refers to using less raw materials and energy input to achieve the established purpose of production or consumption. 'Reuse' refers to converting carbon emissions into value-added materials for industry by utilising and advancing approaches such as carbon capture and utilisation (CCU). 'Recycle' means relying on natural resources, including the use of energy carriers like hydrogen, methanol, and ammonia. 'Remove' refers to implementing nature-based solutions such as direct carbon emission capture from industry and the atmosphere (Mansouri et al., 2020). The technologies that could contribute to the CCE are listed in Table 3.9.

Table 3.9 4R Technologies in Managing Carbon Circularity

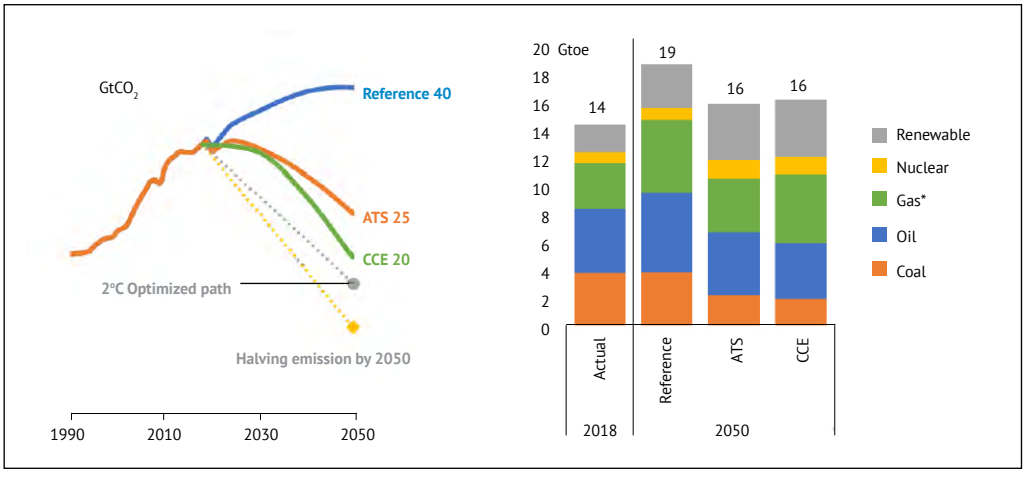
Reduce	Reuse	Recycle	Remove
Reducing the amount of carbon entering the system	Reusing carbon without chemical conversion	Recycling carbon with chemical conversion	Removing carbon from the system
- Energy and materials efficiency - Renewable energy, including hybrid use with fossil fuel - Nuclear energy, including hybrid use with fossil fuel - Advanced ultra-super-critical technologies for coal power plants - Hydrogen (blue/green) fuel cells for long-distance heavy-duty vehicles - Ammonia produced from zero carbon hydrogen (blue/green) for power generation and ships - Direct reduction in steel making by using CO2 free hydrogen (blue/green)	- CCU - Use CO_2 at carbon utilisation facilities, such as at greenhouses for enhancing crops - Bio-jet fuels with reed beds - Algal synthesis	- CCU - Artificial photosynthesis - Bioenergy recycling in the pulp and paper industry - Bioenergy with carbon capture and storage - Carbamide (urea production using CO_2 as feedstock) - Coal ash concrete curing with absorbing CO_2 - Electrochemical reduction of CO_2 - Fine chemicals with innovative manufacturing processes and carbon recycling - Fischer-Tropsch exothermic of carbon dioxide with hydrogen syngas - Hydrogenation to formic acid - Oil sludge pyrolysis - Sabatier synthesis (CO_2 methanation: exothermic of carbon dioxide with blue/green hydrogen) - Thermal pyrolysis	- CCS - DAC - Carbon dioxide removal - Fossil fuels-based blue hydrogen

4R =reduce, reuse, recycle, remove; CCU = carbon capture and utilisation; CO2 = carbon dioxide; DAC = direct air capture.

Source: Masnouri et al. (2020).

The CCE offers a way forward for countries with hydrocarbon resources to make meaningful contributions towards climate change. Figure 3.9 shows scenarios for the CCE and the use of alternative technologies. Estimations at the global level show that carbon emissions could be reduced through the application of the 'circular carbon model' in the energy sector. By transforming waste into energy and material streams, with the application of 4R technologies, the power and transport sectors have high potential for emission reductions. CCE technologies that 'reduce' include hydrogen power generation, 'reuse' technologies include algae biodiesel production; 'recycle' technologies include carbon-absorbing concrete, and 'remove' technologies include CCU. By intensively adopting these technologies, global carbon emissions could be reduced by a maximum of 40% by decarbonising the fossil fuel sector, compared with the reference scenario and alternative renewable energy technology scenarios, as illustrated in Figure 3.9.

Figure 3.9 Emission Reduction Potential of CCE Technologies



ATS = advanced technologies scenario, CCE = circular carbon economy, GtCO2 = gigaton of carbon dioxide, Gtoe = gigaton of oil equivalent.

Source: Kobayashi (2020).

National guidelines on the establishment and improvement of a low-carbon and circular economic system were issued in China in 2020. The country aims to meet NDC targets to achieve peak CO2 emissions by 2030 and carbon neutrality by 2060. The guidelines suggested that, by 2025, China's industry, energy, and transportation systems will see a noticeable improvement, with manufacturing, circulation, and consumption systems featuring low-carbon and circular development taking shape. To ensure that the country's future is based on efficient use of resources, strict ecological environmental protection, and effective control of GHG emissions, the guidelines propose undertaking key tasks in six systems (Table 3.10). They also called for efforts to develop an agriculture waste management system; strengthen farmland protection and promote water saving; and build a waste recycling system for renewable resources such as paper, plastics, tyres, metals, and glass.

Table 3.10 Six Systems to Low-Carbon and Circular Economy Development in China

System component	Main contents
Production system	– promote green industrial upgrading – accelerate green development of agriculture – improve the green development of the service sector – strengthen green and environmental protection industries – make industrial parks and clusters more circular – build green supply chains
Consumption system	– promote the consumption of green products – advocate a green and low-carbon lifestyle – resolutely stop food and beverage waste – promote the sorting, reduction, and recycling of household waste in accordance with local conditions – promote the prevention and treatment of plastic pollution throughout the chain
Circulation system	– actively adjust the transport structure – strengthen the organisation and management of logistics and transport – promote low-carbon means of transport – strengthen the recycling and utilisation of renewable resources – establish a green trade system
Green infrastructure upgrading	– promote green and low-carbon transformation of the energy system – improve the control of and the intensity – upgrade urban environmental infrastructure – upgrade green transport infrastructure – improve the living environment in both urban and rural areas
Green technology innovation system	– encourage research and development of green and low-carbon technologies – accelerate the application of scientific and technological achievements
Legal and regulatory system	– strengthen legal and regulatory support – improve the green pricing mechanism – increase fiscal and taxation support – vigorously develop green finance – improve green standards, green certification systems, and statistical and monitoring systems – foster a green trading market mechanism

Source: State Council of China, Guofa (2021).

The objectives, scope, and comprehensiveness of CCE strategies vary widely across countries. In 2000, Japan enacted the Basic Act for Establishing a Sound Material-Cycle Society, which is very similar to the EU Circular Economy Action Plan. A Sound Material-Cycle Society is a society in which natural resources are conserved, and the environmental load is reduced to the greatest extent possible, by preventing or reducing the generation of waste from products by promoting their cyclical use. Ten years before this act in 1991, the Act on the Promotion of Effective Utilization of Resources – an initiative of the Ministry of Economy, Trade and Industry – required industries to undertake recycling initiatives. China enacted a Circular Economy Promotion Law in 2008.

In ASEAN, the CCE concept has been reflected mostly by the ASEAN Socio Cultural Community and within the ASEAN Economic Community, while some notions related to the circular economy may have been discussed or

considered in specific policy areas, such as sustainable consumption under the work on consumer protection. In 2020, Viet Nam started discussing a legal framework for the circular economy, with a focus on resource efficiency. Indonesia is preparing a circular economy ecosystem in which resources and waste are managed sustainably, targeting full implementation by 2024. Thailand is formulating effective zero-waste and waste-to-energy measures with local governments to create a circular economy and meet the Sustainable Development Goals. Malaysia issued version 3.0 of its Guidelines on Green Procurement in October 2020, which guide government ministries and agencies on procuring products, services, and work in the public sector in a way that considers environmental criteria to conserve resources and minimises the negative impacts of human activities.

Reducing GHG emissions has frequently been cited as an important objective of the circular economy in several ASEAN and East Asian countries. This may be due to a combination of the growing importance of the low-carbon green growth agenda and the high GHG reduction potential of recycling. In several AMS, this transition to a circular economy could also be seen as an important opportunity to create new industries and jobs under the ASEAN Comprehensive Economic Recovery Framework (ACRF) broad strategy 5: advancing towards a more sustainable and resilient future.

4.2 Circular Economy and Waste Management Before the Pandemic

Solid waste management, including the disposal of municipal solid waste, is a major challenge facing most of the region. The amount of waste generation and the generation of municipal solid waste in AMS are presented in Table 3.11.

Table 3.11 Waste Generation in ASEAN Member States

Country	Per capita MSW generation (kg/capita/day)	Annual MSW generation (ton)	Annual hazardous waste generation (million tons)	Annual e-waste generation (metric kiloton)
Brunei Darussalam	1.40	210,480		
Cambodia	0.55	1,089,429		
Indonesia	0.70	64,000,000		
Lao PDR	0.69	77,380		8.00
Malaysia	1.17	12,840,000	1,517,434.06	
Myanmar	0.53	841,508		
Philippines	0.69	14,660,000	1,693,856.72	39,000
Singapore	3.76	7,514,500	411,180	110
Thailand	1.05	26,770,000	3,300,000	368.31
Viet Nam	0.84	22,020,000		1,609.78

kg = kilogram, MSW = municipal solid waste, MT = million tons.

Source: UNEP (2017).

The municipal solid waste generated in emerging economies is composed mainly of organic waste, plastic, paper, glass, and metal. Most countries have already established national strategies and reduce, reuse, recycle (3R) policies that cut across green growth, sustainable development, and climate change policy strategies. As illustrated in Table 3.12, countries such as Cambodia, Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Viet Nam have specific laws on waste management. From an institutional perspective, waste management policymaking at the national level is under the jurisdiction of the respective Ministry of Environment, while many other ministries also have roles in regulating specific waste streams.

Table 3.12 Waste Management and Recycling Policies of ASEAN Member States

Country	Policy details
Cambodia	• Law on Environmental Protection and Natural Resource Management (1996) • Sub-decree on Solid Waste Management (1999)
Indonesia	• Environmental Protection and Management Act No. 32 (EPMA 32/2009) • Law No. 18/2008 on Municipal Solid Waste Management: 3R as the Principal Approach for Waste Management; Law No. 33/3009 on Hazardous Waste • Government Regulation No. 81/2012 on 3Rs and Extend Producer Responsibility President Regulation No. 97/2017 on Policy and National Strategy of MSW • GP No.101/204 Packaging Under Law No. 18/2008; Government Regulation (e-waste) under Law No. 39/2009
Malaysia	• Solid Waste and Public Cleansing Management Act (2007): Aims to improve the collection, recycling, and disposal of solid waste; prescribed recycling and separation of recyclables • National Strategic Plan for Solid Waste Management (2005): Comprehensive efforts to promote the reduction, reuse, and collection of solid waste. There are eight regulations on 3R in the solid waste act. • Environmental Quality Act (1974)
Philippines	• National 3R policies: Set the goal of achieving a waste conversion rate of at least 25% (2000) • Ecological Solid Waste Management Act (2000): Mandates management for 'zero waste' as a national policy. Requires local governments to recycle 25% of waste collected. • PD No. 1152: Philippine Environment Code (1977); Republic Act No. 8749: Philippine Clean Air Act (1999); Republic Act No. 9275: Philippine Clean Water Act (2004)
Singapore	• Green Plan (2012): Has a 'zero landfill' objective. Includes a national recycling programme for households launched in 2001, with the target of 60% recycling by 2012. The recycling rate rose from 57% in 2009 to 70% by 2030, with the goal of becoming a zero-waste nation. • Environmental Public Health (general waste collection) Regulations; Environmental Public Health (toxic industrial waste regulations)
Thailand	• Enhancement and Conservation of National Environmental Quality Act (1992), Factory Act (1992), and Public Health Act (1992); Maintenance of Public Sanitary Order Act (1992) • Regulation on National Waste Management System (2007); Draft Waste Electrical and Electronic Equipment Management Act, Draft Waste Management Act, Draft Promotion of 3Rs and Utilisation of Waste • National Solid Waste Management Master Plan; Action Plan 'Thailand Zero Waste', 2016
Viet Nam	• National 3R Strategy: Sets 3R targets for 2020 • Environmental Protection Law (2005): Includes 14 provisions to promote 3R and related activities • Law on Environmental Protection (2014, as amended) • National Solid Waste Management Master Plan to 2025, Vision to 2050

3R = reduce, reuse, recycle; ASEAN = Association of Southeast Asian Nations; MSW = municipal solid waste.

Source: ERIA Study Team.

In developing CCE policies that are based on resource efficiency principles, governments have included provisions for measuring baselines, quantifying problems, setting targets, and monitoring progress towards achieving them through benchmarking. Recent reviews of waste management and resource efficiency in the fast-growing economies of Asia have shown that setting national quantitative targets is important to show ambition, create commitment, and send clear policy signals for a circular economy. For example, Anbumozhi and Kim (2016) found that quantitative targets for improving energy efficiency could help avoid disjointed actions and provide a long-lasting context for energy efficiency policies. Resource efficiency targets must be sufficiently clear for key stakeholders – such as specific government agencies, industry, and consumers – to understand them and act on them.

ASEAN has initiatives to measure recycling efficiency. Table 3.13 presents the national targets for achieving material, energy, and water efficiency in selected countries. Some countries have set ambitious resource productivity, recycling, and waste reduction targets in the water and energy sectors. The targets undergo yearly performance measurements and are supervised. Japan, China, and Singapore are countries that have set targets in all three key areas of resource efficiency and recycling, which include material efficiency. Overall, targets for recycling are more commonly used than material or water efficiency targets.

Table 3.13 Material, Energy, and Waster Efficiency Targets in ASEAN Member States

Country	Material efficiency	Energy efficiency	Water efficiency
Philippines	Achieve a waste conversion rate of at least 25% by 2025	Reach average annual energy savings of 23 million barrels of fuel oil equivalent	
Singapore	Reach 60% of household waste recycling by 2025 Achieve a recycling rate of 70% by 2030	Improve energy efficiency by 35% from 2005 levels by 2030	Reduce domestic water consumption to 140 litres per person per day by 2030
Thailand		Reduce energy consumption by 13% in 2010 and 20% in 2020	Reduce water use by 10% between 2020 and 2030
Viet Nam		Reduce total energy consumption by 3%–5% (2010–2015) and then by 5%–8% (2015–2020)	

ASEAN = Association of Southeast Asian Nations.

Source: Compiled by the ERIA Study Team from various documents.

Sometimes, disharmony and lack of coordination amongst the implementing institutions and stakeholders cause waste mismanagement. At the local level, provincial governments and municipalities are directly responsible for handling waste management services. In addition to local governments, non-governmental agents such as private sector companies, non-governmental organisations, and community bodies have also been involved in public–private partnerships in the waste sector.

According to a Greenpeace Southeast Asia report released in June 2019, between 2016 and 2018, plastic waste imports in the ASEAN region grew by a staggering 171%, from 836,529 tons to 2,265,962 tons – equivalent to around 423,544 20-foot shipping containers (Greenpeace, 2019). A large amount of waste entering the sea has seriously polluted the marine environment and threatened the fishery, tourism, and other related industries in the region.

The problem of marine waste management has attracted the attention of ASEAN. At the 34th ASEAN Summit in June 2019, AMS leaders unanimously adopted the Bangkok Declaration on marine waste management and pledged to take joint action on the management of marine waste, strengthen the enforcement of relevant laws, maintain regular policy dialogue and information sharing, and explore innovative solutions. While the Bangkok Declaration is a first step, much more needs to be done, such as bans, taxes, comprehensive waste management reform, and significant investment in waste management infrastructure.

4.3 Impact of COVID-19 on Medical Waste Generation Recycling

During the pandemic, many types of medical and hazardous waste are being generated. According to the Ministry of Ecology and Environment of China (2020), 196 large and medium-sized cities produced 843,000 tons of medical waste, and the amount increased due to the impact of COVID-19 in 2020. From 20 January to 2 June 2020, the cumulative amount of medical waste treated increased by 25.7% compared with before the epidemic.

During the pandemic, a weak waste management system in cities in Southeast Asia left local administrations with an additional 1,000 tons of medical waste per day (Alcoseba Fernandez, 2020). In March 2020, the volume of medical waste increased by 27% in Malaysia and 30% in Jakarta (Kojima et al., 2020). A survey by the Asian Development Bank showed that Manila and Jakarta are the cities that generated the most COVID-19 related medical waste in ASEAN (ADB, 2020). The total amount of medical waste generated in India is projected to rise to almost 775.5 tons per day by 2022 from 550.0 tons per day in 2018 (Varmani, 2020).

Some governments have existing legislation and regulations in place for the disposal of infectious medical waste from hospitals and households. They should continue to follow these and consider if additional capacity and resources are needed to maintain compliance. Specific initiatives undertaken by the governments include:

- Japan: In 2020, the Ministry of the Environment issued a series of documents (e.g. Countermeasures for

Novel Coronavirus Waste Disposal) and established the Department of Novel Coronavirus Infection Countermeasures to deal with the epidemic.

- Korea: In January 2020, Korea developed the Novel Coronavirus Special Countermeasure for Medical Waste Management (First and Second Edition), which complements specific measures for strengthening the safety management of waste.

- China: In February 2020, China issued the Comprehensive Treatment of Medical Institutions Waste Work Plan to strengthen the construction of medical waste centralised disposal facilities by the end of 2020. The aim was for each city at or above the prefectural level to build at least one medical waste centralised disposal facility at the city level. On 1 September 2020, the Law on the Prevention and Control of Environmental Pollution by Solid Waste came into force. The law increases the regulatory requirements for medical waste, and mentions the disposal of hazardous solid waste caused by emergencies such as major infectious diseases.

- India: The Central Pollution Control Board published the COVID-19 Standard Operating Procedures that deal with the handling, treatment, and safe disposal of medical waste (Ministry of Health and Family Welfare, India, 2020). The board guidelines provide a series of steps for safe disposal of waste generated in isolation wards with COVID-19 patients, sample collection centres and laboratories for COVID-19 suspected patients, and quarantine camps/home-care facilities. The guidelines also outline the duties of common biomedical waste treatment facilities, state pollution control boards, and urban local bodies. Participating states in India have also prepared state-wide guidelines on the management of COVID-19 waste in line with the Biomedical Waste Management Rules (2016), which were formulated on the basis of an initial baseline survey carried out under the project. The procurement of personal protective equipment for medical waste handlers in Karnataka and Maharashtra is also underway.

- Indonesia: On 24 March 2020, Indonesia issued the Circular Letter on Infectious Waste and Household Waste Management during the COVID-19 pandemic, to strengthen the management of the following waste: infectious waste from medical institutions, infectious waste from people during home isolation, and daily household waste from masks or other personal protective equipment. The waste must be labelled as hazardous waste, handed over to a licensed disposal service provider, and burned in a sealed container (performed at least once every 2 days). Local governments have been instructed to provide special containers for mask waste disposal in public places (Aqil and Dipa, 2020).

- Viet Nam: Robust enforcement measures – such as separation at source and more frequent collection (at least twice a day) using sealed bags – allowed Viet Nam to limit the number of infected cases. The collected waste must be treated within a day, referring to several technical standards. Meanwhile, liquid waste must be disinfected and then delivered to concentrated wastewater plants for further treatment.

4.4.Opportunities and Country Strategies for Handling Solid Waste and Promoting the CEE

4.4.1. Ban on non-recyclable solid waste imports

The main characteristics of the CCE and the number of technical, economic, or social enabling policy factors required are illustrated in Table 3.14. The attributes differ according to the type of economic system and institutional arrangement. While the list of enabling policy factors is not exhaustive, it demonstrates the wide range of changes that will be needed to trigger or advance the circular economy transition. Central to achieving the necessary systemic changes, however, will be finding synergetic economic and social incentives, e.g. through financial mechanisms that encourage consumers and producers to hire rather than buy a product, while stimulating the eco-design of the products (Anbumozhi, Ramanathan, and Wyes, 2020).

Table 3.14 Characteristics and Enabling Factors of the Circular Carbon Economy

Key characteristics of a circular carbon economy	Enabling policy factors
Less input and use of natural resources • minimised and optimised exploitation of raw materials, while delivering more value from fewer materials • reduced import dependence on natural resources • efficient use of all natural resources and blue hydrogen • minimised overall energy and water use **Increased share of renewable and recyclable resources and energy** • non-renewable resources replaced with renewable ones within sustainable levels of supply • increased share of recyclable and recycled materials that can replace the use of virgin materials • closure of material loops • sustainably sourced raw materials **Reduced emissions** • reduced emissions throughout the full material cycle through the use of less raw material and sustainable sourcing • less pollution through clean material cycles **Fewer material losses/residuals** • build-up of waste minimised • incineration and landfill limited to a minimum • dissipative losses of valuable resources minimised **Keeping the value of products, components, and materials in the economy** • extended product lifetime, keeping the value of products in use • reuse of components • value of materials preserved in the economy through high quality recycling	**Eco-design and innovation** • products designed for a longer life, enabling upgrading, reuse, refurbishment, and remanufacture • product design based on the sustainable and minimal use of resources and enabling high-quality recycling of materials at the end of a product's life • substitution of hazardous substances in products and processes, enabling cleaner material cycles **Repair, refurbishment, and remanufacture** • repair, refurbishment and remanufacture given priority, enabling reuse of products and components **Recycling** • high-quality recycling of as much waste as possible, avoiding down-cycling (converting waste materials or products into new materials or products of lesser quality) • use of recycled materials as secondary raw materials • well-functioning markets for secondary raw materials • avoidance of mixing and contaminating materials • cascading use of materials where high-quality recycling is not possible **Business models** • focus on offering product–service systems rather than product ownership • collaborative consumption • collaboration and transparency along the value chain • industrial symbiosis (collaboration between companies whereby the waste or by-products of one become a resource for another) **Eco-innovation** • technological innovation • social innovation • data, monitoring, and indicators

Source: Anbumozhi and Kim (2016).

4.4.2. Enabling policy factors of the CCE

On 10 May 2019, 187 countries took a major step forward by adding plastic to the Basel Convention, a treaty that controls the flow of hazardous waste from one country to another. The Basel Convention Plastic Waste Amendments requires exporting countries to obtain the consent of receiving countries before shipping contaminated, mixed, or non-recyclable plastic waste. This revision provides an important tool to stop dumping unwanted plastic waste.

As of November 2020, China had imported 7.18 million tons of solid waste, 41% less than the previous year's total. On 19 January 2020, China issued The Policy Options on Further Strengthening Plastic Pollution Control, indicating that it would strengthen the treatment of plastic pollution in accordance with the idea of banning one batch, replacing one batch with recycling, and regulating one batch. In addition to restricting the use of plastic, there will be a total ban on the import of waste plastic. On 1 September 2020, the revised Solid Waste Law came into effect, which clearly stipulates that the country will gradually realise zero imports of solid waste. The main objective is to continue to strengthen the clean-up and rectification of solid waste distribution centres and 'scattered and polluted' enterprises, strengthen the supervision of solid waste use and recycling, and investigate and punish illegal environmental behaviour in the solid waste use and processing industries. As a result of the progressive target setting, the amount of solid waste to be recycled in China increased to 350 million metric tons in 2020 from 246 million tons in 2015.

Faced with public opposition and rising pollution, Asian countries are stepping up efforts to ban foreign waste and implement emergency policies. In 2019, Malaysia's Ministry of Environment and Water shut down 139 recycling plants, 109 of which were illegal. The ministry has also banned the import of plastic waste during the epidemic, and the ban will be fully implemented by December 2021. Viet Nam has taken similar steps, such as banning import licences for plastics. Thailand has been implementing a ban on all imports of plastic scrap and waste since January 2021. Indonesia has legislated to stop the import of certain types of plastic waste from Western countries. These policies have closed the gate of waste imports to some extent.

4.4.3. Zero-waste circular cities

With socio-economic development and improved waste management, the establishment of waste-free cities has become the planning goal of more countries and cities. A zero-waste city refers to an advanced urban development and management model that aims to promote green lifestyles, minimise the amount of waste produced, strengthen recycling programmes, and ensure that waste released into the environment is harmless. In 2014, the EU released 'Towards a Circular Economy: A Zero Waste Programme for Europe' and the 'Circular Economy Package'. European countries have established a Waste Free Europe Network, while Japan has established the Waste Free Research Institute. In 2015, the US Conference of Mayors issued a resolution 'Supporting the Principle of Waste Free Cities'; and in 2018, 23 cities around the world jointly issued a declaration on 'Building Waste Free Cities'. In 2000, Japan published the

Basic Law for Promoting the Formation of a Recycling Society; and in 2019 it issued 'The 4th Fundamental Plan for a Establishing a Sound Material-Cycle Society' to achieve a cumulative 25% reduction in single-use plastics by 2030, a 60% rate of recycling for containers and packaging by 2030, and 100% effective utilisation of used plastics by 2035, including circular economy measures. The international community established the Zero Waste International Alliance in 2002 to guide the development of zero waste in the world. On 28 August 2018, leaders from 23 cities and regions signed the C40 Cities' Advancing Towards Zero Waste Declaration to reduce the amount of waste generated by each citizen by 15%, reduce the amount of waste sent to landfills and incineration by 50%, and increase the diversion rate to 70% by 2030. Asian policymakers now incorporate zero waste concepts in their strategies. Singapore has taken the lead in experimenting and reforming the waste management ecosystem (Box 3.3).

Box 3.3 Sustainable Waste Management Ecosystem in Singapore

Singapore disposes of much of its waste through waste-to-energy initiatives – of the 7.23 million tons of solid waste generated in 2019, more than 40% was incinerated. According to the National Environment Agency, incineration reduces waste by up to 90%, saving landfill space, and the heat recovered produces steam that is used to generate electricity. Despite awareness-raising campaigns to encourage a 3R (reduce, reuse, recycle) mindset, and designating 2019 as a 'Year Towards Zero Waste', Singapore's domestic recycling rate dropped from 22% in 2018 to 17% in 2019. To increase the recycling rate, Singapore has launched initiatives such as the Zero Waste Masterplan and the Resource Sustainability Act, 2019 – aiming to establish itself as a sustainable, resource-efficient, and climate-resilient nation, and a regional Circular Economy Centre of Excellence, driving green investment efforts around the region and the world. The Resource Sustainability Act sets out regulatory measures targeting the following three waste streams, which generally have high generation and low recycling rates: electrical and electronic waste, food waste, and packaging waste. Singapore will realise this vision by introducing Southeast Asia's first extended producer responsibility law, holding firms accountable for the responsible disposal of post-consumer waste. Measures include mandatory reporting for companies that produce or use packaging; and extended producer responsibility for e-waste by 2021, food waste by 2024, and packaging by 2025. The Zero Waste Masterplan, launched by Singapore's Ministry of Environment and Water Resources in 2019, aims to reduce the incinerated rubbish sent to Semakau Landfill each day by 30% by 2030, since Singapore's Semakau Landfill is projected to hit capacity by 2035. The plan also targets increasing the overall recycling rate to 70% by 2030, from 60% in 2018, by adopting a circular economy approach to waste and resource management practices and shifting towards more sustainable production and consumption. The plan sets targets for food waste, electronic waste, packaging waste, and research and development. Singapore also plans to improve its circular economy capabilities by investing S$45 million in research on circular solutions and S$25 million in research on waste-to-energy solutions.

Source: Minh (2021).

4.5. Enabling policy factors of circular economy

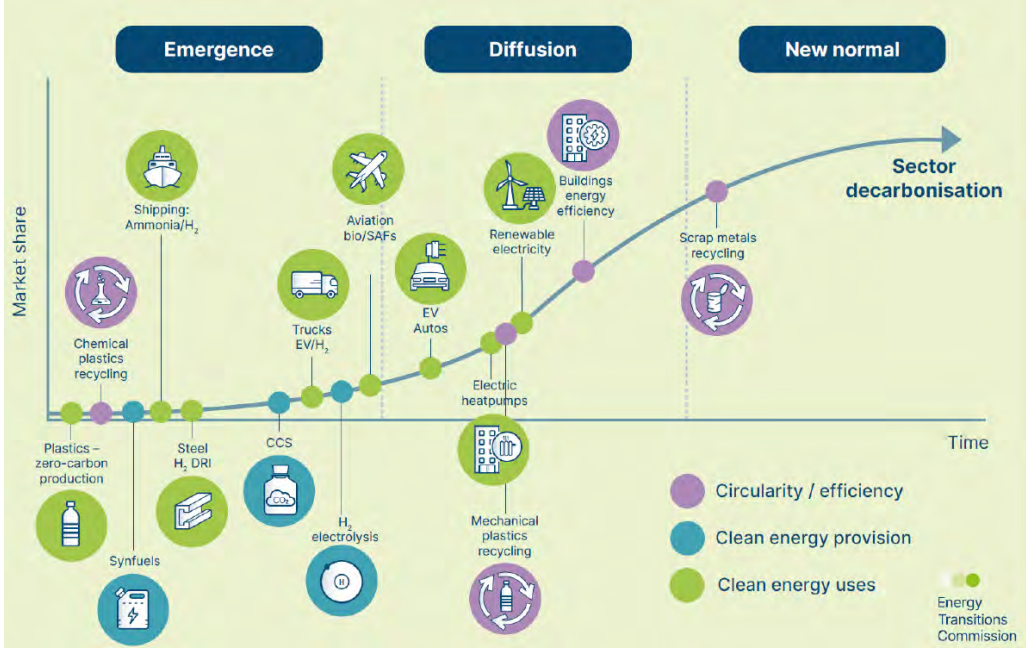
Creating a CCE requires fundamental changes throughout the value chain, from product design and technology to new business models, new ways of preserving natural capital (extending product lifetimes) and turning waste into a resource (recycling), new modes of consumer behaviour, new norms and practices, and education and finance. Integration between policy levels and policy domains, as well as within and across value chains, is also essential. Action will be needed at all levels, from the regional to the local, and by all stakeholders, including governments and businesses.

5.Trajectories of Investments and Rethinking Financing to Deliver Transformative Low-Carbon Actions

There is an urgent need to scale up investment significantly in low-carbon circular and more resource-efficient alternatives and to shift investment away from carbon-intensive processes and products. The low-carbon transition requires utilising all sources of finance – public, private, and international, including institutional investors.

Figure 3.10 shows a route map involving the adoption of several sector decarbonisation strategies and decisions on niche low-carbon technologies that are potentially costly, difficult to diffuse under current policy conditions, and politically unpopular.

Figure 3.10 Circular and Clean Energy Technology and Investment Road Map for Net Zero Future



CCS = carbon capture and storage, CO2 = carbon dioxide, DRI = direct reduced iron, EV = electric vehicle, GHG = greenhouse gas, H2 = hydrogen, SAF = sustainable aviation fuel.

Source: Energy Transitions Commission (2020).

The IEA estimated that the total annual energy investment will surge to US$15 trillion by 2050 (IEA, 2021). This unparalleled increase in investment is estimated to add 0.4% a year to annual global GDP growth as the world emerges from the COVID-19 crisis.

5.1 Low-Carbon Investment Challenges During the COVID-19 Pandemic

Although the economic crisis caused by the COVID-19 pandemic is different from other previous crises, experience in designing previous economic recovery packages has shown that 'green new deals' often have advantages over traditional fiscal stimuli, both in the short and long term. For example, green recovery packages focusing on investment in renewable energy will have positive impacts in the short and long term while ensuring the implementation of national emissions reduction commitments. In the short term, investments in renewable energy create more direct jobs in production and distribution, construction, and installation in the context of high unemployment. Such investments promote jobs in the supporting supply chain, helping to increase GDP in the short run (GGGI, 2020).

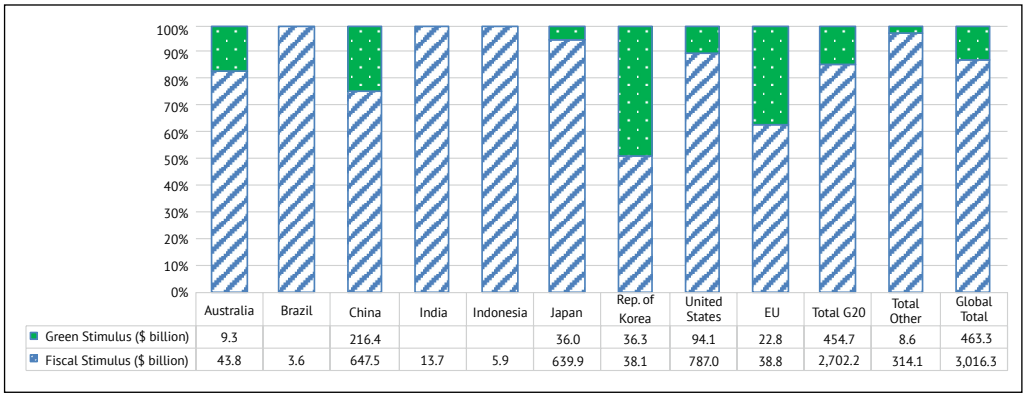
Following the 2007–2009 financial crisis, governments announced about US$520 billion for green measures such as railways, energy efficiency, grid modernisation, renewable energy, and water and waste management (Figure 3.11). Based on the analysis of 10 major economies, the amount announced for green stimulus spending in response to the COVID-19 recession is at a similar level, although the leading countries are different (Jaeger, 2020).

Experience from past crisis responses has also shown that investments in infrastructure, health services, water, and sanitation have positive effects on creating jobs when the needed skill sets already exist (GGGI, 2020). Some examples of stimulus packages to recover from the 2008 financial crisis include the following, categorised by country:

- US: The green recovery package in response to the 2008 financial crisis, worth US$21 billion, created economic value equal to 1.2–2.1 times the economic value during 2009–2011.
- EU: Green investments in the European Economic Recovery Plan accounted for 13.2% of the total stimulus, worth 200 billion, or about 1.5% of the EU's GDP. One-third of the stimulus was invested in energy efficiency and other green initiatives. The economic impacts of the green investment ranged from 0.6% to 1.1% of GDP at the national level and up to 1.5% of GDP at the European level.
- China: The green component of the Stimulus Package of China in 2008–2009 was about US$221 billion, accounting for one-third of the total stimulus package, which was about 12.5% of GDP. Around 5.25% was invested in energy savings, pollution control, and ecological improvement. There was about a 0.68% increase in total employment for every 1% increase in the share of solar PV generation.
- Korea: The Green New Deal, 2009–2012 plan, worth US$38.1 billion, represented about 4% of GDP. Some 80% was allocated to green measures such as renewable energies (US$1.80 billion), energy-

efficient buildings (US$6.19 billion), low-carbon vehicles (US$1.80 billion), railways (US$7.01 billion), and water and waste management (US$13.89 billion). It was intended to create 950,000 jobs, although this was not achieved. Many green stimulus plans are not properly evaluated ex post.

Figure 3.11 Global Stimulus Packages and Green Investments During 2008 Crisis (as of 1 July 2009)



	Australia	Brazil	China	India	Indonesia	Japan	Rep. of Korea	United States	EU	Total G20	Total Other	Global Total
Green Stimulus ($ billion)	9.3		216.4			36.0	36.3	94.1	22.8	454.7	8.6	463.3
Fiscal Stimulus ($ billion)	43.8	3.6	647.5	13.7	5.9	639.9	38.1	787.0	38.8	2,702.2	314.1	3,016.3

EU = European Union.

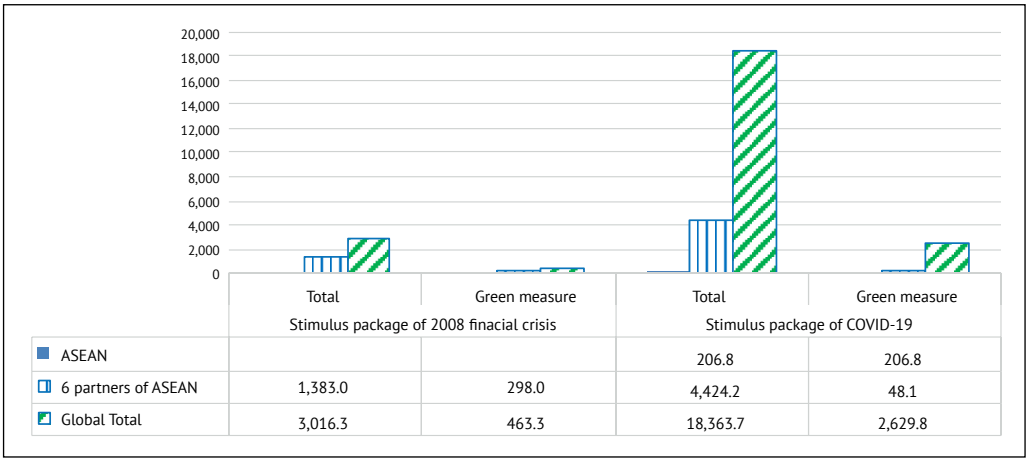
Source: ERIA Study Team analysis based on Barbier (2010).

Prioritising the use of economic recovery packages to invest in and support low-carbon circular areas demonstrates the important role of the government in implementing the Paris Agreement commitments. However, in the stimulus package to recover from the COVID-19 pandemic, the share of the green recovery is much less than the green stimulus for recovery from the financial crisis in 2008, which was estimated to be US$10 trillion at the G20 level.

The total value of the global stimulus package for economic recovery from the COVID-19 pandemic (up to April 2021) was US$18,360.1 billion, out of global GDP of about US$84,537.7 billion (21.72% of GDP) in 2020 (IMF, 2021b); the green stimulus comprised US$2,629.8 billion (14.32% of the total stimulus package). The stimulus package in 2008 was US$3,016.3 billion, of which US$463.3 billion comprised the green stimulus (15.36% of the total stimulus package). The total value of the stimulus package for recovering from the COVID-19 pandemic was US$206.8 billion (6.71% of GDP) amongst AMS and up to US$4,424.2 billion (17.23% of GDP) in the six ASEAN Partner countries, compared with US$1,383.0 billion in 2008 (Figure 3.12).

Global efforts to implement national fiscal measures to cope with the COVID-19 pandemic are estimated at US$18,363.7 billion, of which developed economies accounted for 86.45%, emerging markets economies 13.27%, and low-income and developing countries 0.28% (Figure 3.13).

Figure 3.12 Stimulus Packages After the 2008 Financial Crisis and After the Onset of COVID-19 (US$ billion)

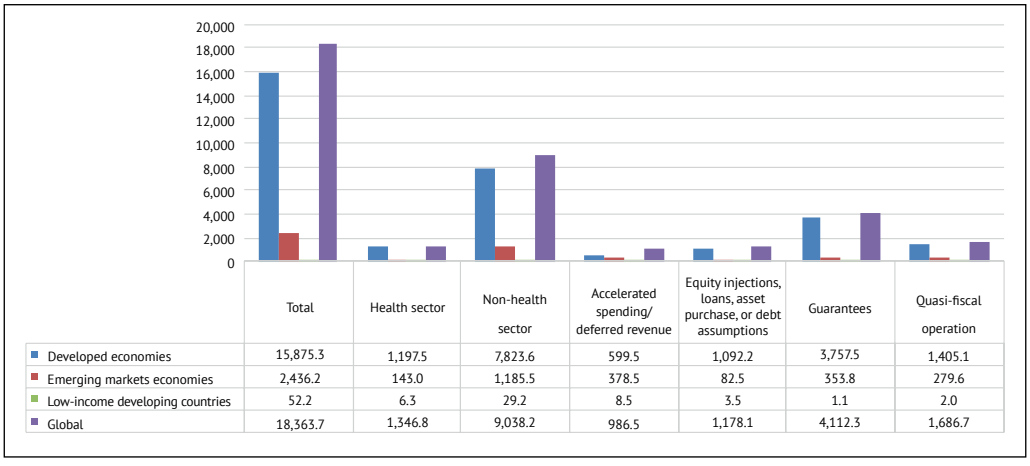


	Total	Green measure	Total	Green measure
	Stimulus package of 2008 finacial crisis		Stimulus package of COVID-19	
ASEAN			206.8	206.8
6 partners of ASEAN	1,383.0	298.0	4,424.2	48.1
Global Total	3,016.3	463.3	18,363.7	2,629.8

ASEAN = Association of Southeast Asian Nations, COVID-19 = coronavirus disease.

Source: ERIA Study Team, calculated from Barbier (2010); IMF (2021a); Vivid Economics (2021); Sharma (2020); European Commission (2021); Carbon Brief (2021); and Clarke (2020).

Figure 3.13 Country Fiscal Measures in Response to the COVID-19 Pandemic (US$ billion)



	Total	Health sector	Non-health sector	Accelerated spending/ deferred revenue	Equity injections, loans, asset purchase, or debt assumptions	Guarantees	Quasi-fiscal operation
Developed economies	15,875.3	1,197.5	7,823.6	599.5	1,092.2	3,757.5	1,405.1
Emerging markets economies	2,436.2	143.0	1,185.5	378.5	82.5	353.8	279.6
Low-income developing countries	52.2	6.3	29.2	8.5	3.5	1.1	2.0
Global	18,363.7	1,346.8	9,038.2	986.5	1,178.1	4,112.3	1,686.7

COVID-19 = coronavirus disease.

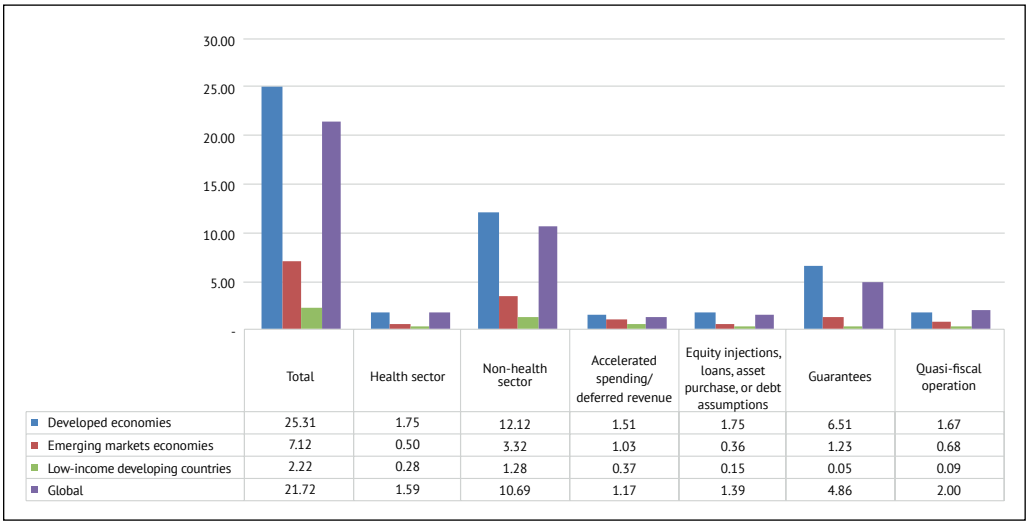
Source: ERIA Study Team calculations based on IMF (2021a).

Support packages increase with the level of development of an economy – not only in absolute value but also in the level of support as a share of GDP. The world's total average support package accounts for 21.72% of GDP – 25.31% of GDP in developed economies, 7.12% in emerging economies, and 2.22% in low-income and developing countries (Figure 3.14).

The expenditure structure of support packages varies greatly between developed and developing countries. Non-health sector spending occupies the largest share of the support packages of all countries – about 49.3% in developed economies, 48.7% in emerging markets, and 55.8% in developing countries. Although all countries focus significantly on non-

health sector spending, differences emerge in other areas. Developed economies spend up to 23.7% on credit guarantees to businesses, while direct spending on the health sector is 7.5%, compared with 2.0% on the guarantee and 12.0% on the health sector in low-income developing countries (Figure 3.15).

Figure 3.14 Country Fiscal Measures in Response to the COVID-19 Pandemic
(share of GDP, %)

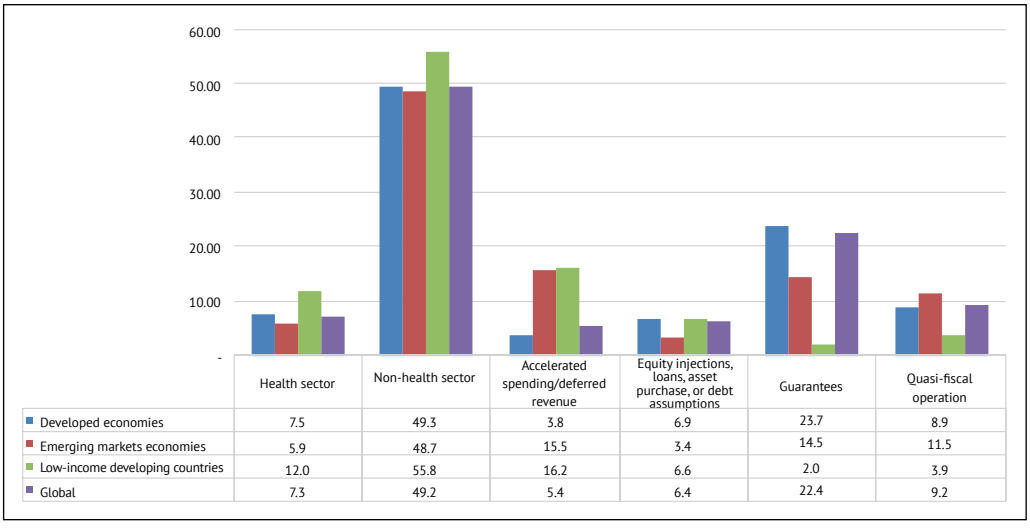


	Total	Health sector	Non-health sector	Accelerated spending/ deferred revenue	Equity injections, loans, asset purchase, or debt assumptions	Guarantees	Quasi-fiscal operation
Developed economies	25.31	1.75	12.12	1.51	1.75	6.51	1.67
Emerging markets economies	7.12	0.50	3.32	1.03	0.36	1.23	0.68
Low-income developing countries	2.22	0.28	1.28	0.37	0.15	0.05	0.09
Global	21.72	1.59	10.69	1.17	1.39	4.86	2.00

COVID-19 = coronavirus disease, GDP = gross domestic product.

Source: ERIA Study Team calculations based on IMF (2021a, 2021b).

Figure 3.15 Share of Fiscal Measures in Response to the COVID-19 Pandemic
(%)



	Health sector	Non-health sector	Accelerated spending/deferred revenue	Equity injections, loans, asset purchase, or debt assumptions	Guarantees	Quasi-fiscal operation
Developed economies	7.5	49.3	3.8	6.9	23.7	8.9
Emerging markets economies	5.9	48.7	15.5	3.4	14.5	11.5
Low-income developing countries	12.0	55.8	16.2	6.6	2.0	3.9
Global	7.3	49.2	5.4	6.4	22.4	9.2

COVID-19 = coronavirus disease.

Source: ERIA Study Team calculations based on IMF (2021a).

The support packages of the AMS totalled US$206.8 billion (5.58% of GDP), while those of the six ASEAN Partner countries totalled US$4,631.7 billion (16.10% of GDP). Table 3.15 shows the efforts of the AMS – introducing stimulus packages to avoid supply disruptions and create demand – although many of them are not high on the Greenness Index (Vivid Economics, 2021). As with other countries in the world, the stimulus package of the ASEAN+6 focused on the non-health sector, at 41.07%, compared with 49.22% globally.

However, the AMS and the six ASEAN Partners have different priorities. The focus on the non-health sector is higher in the AMS, at 53.90% of the stimulus package, compared with 40.49% in the six ASEAN Partners. Support for the health sector was 10.49% in the AMS and 3.24% in the six ASEAN Partners. The AMS prioritised implementing guarantees (15.29%) and equity injections, loans, asset purchase, or debt assumptions (9.88%), while the six ASEAN Partners prioritised quasi-fiscal operations (34.70%) and accelerated spending/deferred revenue (12.06%) (Table 3.15).

Table 3.15 Fiscal Measures in Response to the COVID-19 Pandemic of the ASEAN+6

Country	Amount (US$ billion)							Share of GDP (%)
	Total	Health sector	Non-health sector	Accelerated spending/ deferred revenue	Equity injections, loans, asset purchase or debt assumptions	Guarantees	Quasi-fiscal operations	
Global	**18,363.7**	**1,346.8**	**9,038.2**	**986.5**	**1,178.1**	**4,112.3**	**1,686.7**	**21.72**
ASEAN+6	**4,631.0**	**165.2**	**1,902.0**	**541.2**	**41.4**	**431.4**	**1,545.1**	**16.10**
Of which								
ASEAN	**206.8**	**21.7**	**110.8**	**7.8**	**20.4**	**31.6**	**9.8**	**5.58**
Singapore	70.4	0.6	53.9		15.9			20.72
Indonesia	57.3	18.9	29.1		2.4	6.9		5.41
Malaysia	27.0	0.4	14.7			12.0		7.99
Thailand	21.3					10.4	8.0	4.23
Viet Nam	14.2	0.0	4.8	7.8	0.4		1.2	4.17
Philippines	13.1	1.5	8.3		0.9	2.4		3.62
Cambodia	1.7	0.1					0.6	6.38
Myanmar	1.634	0.189			0.8			2.01
Brunei	0.1							1.21
Lao PDR	0.003	0.003						0.02
6 ASEAN Partners	**4,424.2**	**143.5**	**1,791.1**	**533.5**	**21.0**	**399.8**	**1,535.3**	**17.23**
Japan	2,473.4	89.9	710.8	243.5		147.0	1,282.1	48.99
China	1,135.2	21.3	689.3	231.9		58.0	134.8	7.71
Rep. of Korea	279.1	8.5	65.0	39.6		60.1	105.9	17.11
India	246.8	9.8	80.3	18.5	8.9	116.9	12.4	9.11
Australia	243.4	11.5	207.8		10.4	13.8		17.91
New Zealand	46.2	2.5	37.8		1.8	4.1		22.06

ASEAN = Association of Southeast Asian Nations, COVID-19 = coronavirus disease, GDP = gross domestic product.
Note: ASEAN+6 refers to the 10 ASEAN Member States plus Australia, China, Japan, India, New Zealand, and the Republic of Korea.
Source: ERIA Study Team calculations based on IMF (2021a, 2021b).

5.2 Closing the Low-Carbon Financing Gaps Through Stimulus Packages

Many countries are struggling to mobilise long-term finance to meet low-carbon infrastructure needs. Annual investment in transmission and distribution grid expansion currently requires US$260 billion, rising to US$820 billion in 2030 (IEA, 2021) at the global level. The number of public charging points for electric vehicles needs to rise from around 1 million in 2021 to 40 million in 2030, requiring an annual investment of almost US$90 billion until 2030. The required roll-out of hydrogen and carbon capture, utilisation, and storage (CCUS) after 2030 means laying the groundwork now: annual investment in CO_2 pipelines and hydrogen-enabling infrastructure needs to increase from the current US$1 billion to around US$40 billion in 2030.

The integration of low-carbon investments in economic recovery stimulus packages is one way to generate finance. The intensity of green components is observed mainly in developed countries. The US has seen a significant change in its approach to climate change since January 2021, with the highest allocation for green measures in the world, at US$1,465.17 billion, accounting for 25.02% of the post-COVID-19 recovery stimulus packages. Developing and least developed countries' packages mainly provide direct support to healthcare, pandemic containment activities, vulnerable businesses, and people. Table 3.16 shows the profile of stimulus packages in AMS and ASEAN Partner countries. The recovery packages of most AMS did not support the achievement of environmental objectives. However, no green allocation does not mean that developing and least developed countries have stopped implementing the Paris Agreement commitments on GHG emissions reduction. Whether they hindered the achievement of NDCs requires further analysis, as the implementation of several low-carbon measures is affected by the decline in state budget revenues due to lockdowns during the pandemic.

Most spending and committed green recovery funds have been in developed economies. In June 2020, the United Nations Conference on Trade and Development warned that developing countries would need an additional US$2.5 trillion to support the overall economy to overcome the unprecedented COVID-19 crisis. The support packages of selected countries and regions around the world are summarised below.

- EU: The Next Generation EU recovery fund and the Just Transition Fund (climate action fund) total 750 billion (US$847 billion). The Next Generation EU will provide 500 billion in non-refundable aid and 250 billion in loans to member countries, of which 25% will be for climate actions, including 30 billion to promote the Just Transition Fund for coal-dependent countries.
- Germany: The recovery programme of 80 billion (US$90.4 billion) focuses on innovation, sustainability, and support for cities. It aims to digitise clean energy infrastructure and support a green recovery in cities in areas such as public transport and circular economies.

Table 3.16 Stimulus Packages of COVID-19 and Green Measures by Country

Region	Country	Total stimulus package		Green measures	
		Total (US$ billion)	Share of GDP (%)	Total (US$ billion)	Share of stimulus (%)
Global total		**18,363.7**	**21.72**	**2,629.8**	**14.32**
ASEAN		**206.8**	**5.58**	**-**	**-**
Six ASEAN Partners		**4,424.2**	**20.48**	**48.1**	**1.09**
ASEAN	**Singapore**	**70.4**	**20.72**	**-**	**-**
	Indonesia	57.3	5.41	-	-
	Malaysia	27.0	7.99	-	-
	Thailand	21.3	4.23	-	-
	Viet Nam	14.2	4.17	-	-
	Philippines	13.1	3.62	-	-
	Cambodia	1.7	6.38	-	-
	Myanmar	1.6	2.01	-	-
	Brunei	0.1	1.21	-	-
	Lao PDR	0.003	0.02	-	-
6 ASEAN Partners	Japan	2,473.4	48.99	19.3	0.78
	China	1,135.2	7.71	1.5	0.14
	Rep. of Korea	279.1	17.11	11.2	4.02
	India	246.8	9.11	0.8	0.32
	Australia	243.4	17.91	13.6	5.60
	New Zealand	46.2	22.06	1.6	3.42
Others	US	5,856.0	27.98	1,465.2	25.02
	EU	1,460.0	10.61	847.0	58.01

ASEAN = Association of Southeast Asian Nations, COVID-19 = coronavirus disease, EU = European Union, GDP = gross domestic product, UK = United Kingdom, US = United States.

* The total green recovery packages are calculated based on the projects that have information about the amount, updated to April 2021.

Source: ERIA Study Team calculations from IMF (2021a, 2021b); Vivid Economics (2021); Sharma (2020); Carbon Brief (2021); and Clarke (2020).

- Korea: Fiscal investment of W114.1 trillion is planned by 2025 to help create new markets and promote the private sector. The goal of the Korean New Deal is to transform the economy from a fast follower to a leader, from a carbon-dependent economy to a green economy, with the society becoming more inclusive. It will also invest fiscal resources and improve regulations to promote innovation and investment by the private sector (ADB and ACGF, 2020).
- 50.54 million), will promote economic recovery with resilience and greenness. The transport sector stimulus package of £283 million (US$357.57 million) aims to help restore bus and tram services and improve safety during the pandemic.
- US: In December 2020, Congress passed a US$900 billion bipartisan stimulus package to stabilise the US economy. Direct aid, unemployment benefits, healthcare measures such as vaccine procurement, and business loans dominated the package, alongside US$17 billion of

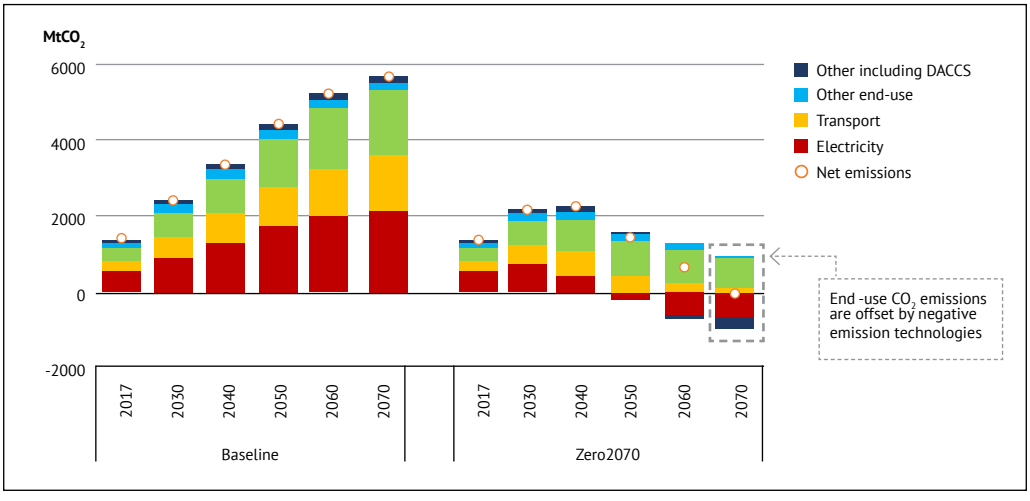
support for the aviation industry. This stimulus also included a US$35 billion commitment to clean energy, diversified across a range of quantified policies (Vivid Economics, 2021). A new target for the US is to achieve a 50%–52% reduction from 2005 levels in economy-wide net GHG pollution in 2030 (White House, 2021).

5.3 Reframing Investment Signals and Incentives in Support of Low-Carbon Green Infrastructure

There are major opportunities to achieve a net zero emission future by improving energy efficiency in certain sectors. Figure 3.16 shows that energy and transport are the largest GHG emission sectors, accounting for 66.3% of total GHG emissions from burning fossil fuels. High-income and upper middle-income countries are assumed to reach zero emissions by 2050 in the scenario represented in the figure. It will take another 20 years beyond 2050 for low-income countries and least developed countries to achieve net zero energy-related CO2 emissions, by 2060 and 2070, respectively.

A wide range of technologies, including renewables, nuclear, CCS, and import of hydrogen and ammonia, are necessary for deep emission reduction by 2070. The share of these technologies collectively reaches 79% of primary energy supply in 2070 in the ASEAN carbon neutrality scenario (Figure 3.16).

Figure 3.16 ASEAN Carbon Neutrality Scenario in 2050 and Beyond



ASEAN = Association of Southeast Asian Nations, CO_2 = carbon dioxide, DACCS = direct air capture for carbon storage, $MtCO_2$ = million tons of carbon dioxide.

Source: IEEJ-ERIA (2020); and IEA (2021), CO2 Emissions from Fuel Combustion. https://www.iea.org/subscribe-to-data-services/co2-emissions-statistics (accessed 4 September 2021).

Massive investment challenges remain to be addressed. A summary of the recovery packages of 20 countries[2] and the EU (Carbon Brief, 2021)[3]showed that they accorded the highest priority for support to the transport, energy, and buildings sectors (Table 3.17). The sectoral distribution of the green recovery packages of the 20 countries and the EU that collected data is as follows:

- Transport sector: The total spending is US$602.64 billion, with 77 projects, accounting for 33.20% of the total amount and 38.12% of the total number of projects. The highest amount is in the US (US$486.17 billion), followed by Italy (US$39.36 billion), France (US$27.99 billion), Germany (US$22.11 billion), and Spain (US$16.68 billion).

- Energy sector: The total spending is US$562.93 billion, with 39 projects, accounting for 31.01% of the total amount and 19.31% of the total number of projects. The highest amount is in the US, at US$500.00 billion, followed by Germany (US$25.34 billion), Italy (US$15.55 billion), and Spain (US$5.66 billion).

- Building sector: The total spending is US$456.65 billion, with 31 projects, accounting for 25.15% of the total amount and 15.35% of the total number of projects. The highest amount is the US (US$398.00 billion), followed by Italy (US$18.11 billion), Spain (US$8.01 billion), and France (US$7.66 billion).

- Industry sector: The total spending is US$76.93 billion, with 14 projects, accounting for 4.24% of the total amount and 6.93% of the total number of projects. The highest amount is in the US (US$46.00 billion), followed by the EU (US$11.78 billion) and Sweden (US$6.29 billion).

- R&D sector: The total spending is US$44.95 billion, with 22 projects, accounting for 2.48% of the total amount and 10.89% of the total number of projects. The highest amount is in the US (US$35.00 billion), followed by Spain (US$4.01 billion), Italy (US$2.95 billion), and France (US$2.71 billion).

- Employment sector: The total spending is US$22.04 billion, with three projects, accounting for 1.21% of the total amount and 1.49% of the total number of projects. Only the EU (US$34.17 billion) and New Zealand (US$0.77 billion) spend in this sector.

- Agriculture sector: The total spending is US$34.94 billion, with four projects, accounting for 1.92% of the total amount and 1.98% of the total number of projects. Only the EU (US$17.68 billion), Italy (US$3.74 billion), France (US$0.47 billion), and Chile (US$0.15 billion) spend in this sector.

- Nature sector: The total amount is US$14.36 billion, with 12 projects, accounting for 0.79% of the total amount and 5.94% of the total number of projects. Most countries in Europe spend in this sector, including Italy (US$11.99 billion), Germany (US$0.82 billion), and Sweden (US$0.55 billion), as well as India in Asia (US$0.80 billion).

[2] Canada, Chile, China, Colombia, Denmark, Finland, France, Germany, India, Ireland, Italy, New Zealand, Nigeria, Norway, Poland, Korea, Spain, Sweden, the UK, the US, and the EU.

[3] The green recovery packages are calculated based on the projects that have information about the amount, updated to April 2021.

Table 3.17 Post-COVID-19 Green Recovery Package Projects by Sector of 20 Countries and the EU

No.	Sector/Subsector	Total	Share	Americas				Europe												Asia				Africa
				US	Canada	Colombia	Chile	EU	Germany	Italy	France	Spain	UK	Sweden	Denmark	Poland	Finland	Norway	Ireland	New Zealand	Rep. of Korea	China	India	Nigeria
A	**Total amount (US$ billion)**	**1,815.44**	**100.0**	**1,465.17**	**4.80**	**4.18**	**3.05**	**63.63**	**54.05**	**94.17**	**41.29**	**38.84**	**12.97**	**8.59**	**5.46**	**2.36**	**1.04**	**0.41**	**0.29**	**1.58**	**11.22**	**1.54**	**0.80**	
I	**Energy (US$ billion)**	**562.93**	**31.01**	**500.00**	**2.00**	**4.18**			**25.34**	**15.55**	**2.36**	**5.66**	**1.47**		**0.38**	**1.00**	**0.04**	**0.24**	**0.01**		**4.70**			
1.1	Electricity bills	12.96	2.30						12.96															
1.2	Renewable electricity	17.13	3.04		2.00	4.18				6.95		3.77	0.22						0.01					
1.3	Hydrogen	20.73	3.68						12.38	3.76	2.36	1.89	0.33					0.01						
1.4	Renewable electricity/	4.70	0.83																		4.70			
1.5	Carbon capture and storage	0.66	0.12										0.28		0.38									
1.6	Energy efficiency	0.02	0.00														0.02							
1.7	Nuclear	0.43	0.08										0.43											
1.8	No information	506.30	89.94	500.00						4.84			0.21			1.00	0.02	0.23						
II	**Transport (US$ billion)**	**602.64**	**33.20**	**486.17**	**1.20**				**22.11**	**39.36**	**27.99**	**16.68**	**5.33**	**0.91**		**0.24**	**0.17**	**0.04**	**0.13**	**0.77**		**1.54**		
2.1	Public transport	257.13	42.67	197.17	1.20				10.43	29.19	5.54	8.01	4.19	0.40		0.09	0.12		0.02	0.77				
2.2	Electric vehicles	184.64	30.64	174.00					6.96		0.75		1.12	0.12		0.15						1.54		
2.3	Car tax																							
2.4	Automotive	12.57	2.09						2.36		10.20		0.01											
2.5	Aviation	11.20	1.86						1.18		10.02													
2.6	Shipping	1.21	0.20						1.18									0.03						
2.7	Oil and gas																							
2.8	Cycling and walking	1.69	0.28							0.06	1.48						0.05		0.10					
2.9	Adaptation	0.01	0.00																0.01					
2.10	R&D	0.49	0.08									0.49												
2.11	Green jobs	0.01	0.00									0.01												
2.12	Hydrogen	0.01	0.00										0.01											
2.13	No information	133.68	22.18	115.00						10.11		8.17		0.39				0.01						

No.	Sector/Subsector	Total	Share	Americas				Europe											Asia				Africa
				US	Canada	Colombia	Chile	EU	Germany	Italy	France	Spain	UK	Sweden	Denmark	Poland	Finland	Norway	Ireland	New Zealand	Rep. of Korea	China	India	Nigeria
III	**Industry (US$ billion)**	**76.93**	**4.24**	**46.00**				**11.78**		**2.47**	**2.81**	**4.48**	**0.32**	**6.29**	**0.33**	**0.26**	**0.70**	**0.01**			**1.48**			
3.1	Energy efficiency	0.14	0.18												0.14								
3.2	Circular economy	3.46	4.50							2.47	0.59			0.03	0.01		0.35	0.01					
3.3	Steel	0.04	0.05										0.04										
3.4	Electric vehicles	0.81	1.05								0.81												
3.5	No information	72.48	94.22	46.00				11.78			1.41	4.48	0.28	6.26	0.18	0.26	0.35			1.48			
IV	**Buildings (US$ billion)**	**456.65**	**25.15**	**398.00**	**1.60**		**2.90**		**3.07**	**18.11**	**7.66**	**8.01**	**5.63**	**0.84**	**4.75**	**0.83**	**0.05**		**0.12**	**0.04**	**5.04**			
4.1	Energy efficiency	379.42	83.09	338.00	1.60				2.95	17.87	7.66		5.59	0.84	4.75				0.12	0.04				
4.2	Adaptation	53.02	11.61	50.00			2.90		0.12														
4.3	Heating	0.13	0.03													0.08	0.05						
4.4	Construction																						
4.5	No information	24.08	5.27	10.00						0.24		8.01	0.04			0.75					5.04		
V	**Agriculture (US$ billion)**	**22.04**	**1.21**				**0.15**	17.68		**3.74**	**0.47**												
5.1	Trees	0.15	0.68				0.15																
5.2	No information	21.89	99.32					17.68		3.74	0.47												
VI	**Employment (US$ billion)**	**34.94**	**1.92**					34.17												0.77			
6.1	Green jobs	34.94	100.0					34.17												0.77			
6.2	No information																						
VII	**R&D (US$ billion)**	**44.95**	**2.48**	35.00					2.71	2.95		4.01	0.15					0.12	0.01				
7.1	Negative emissions	0.14	0.31										0.14										
7.2	Renewable electricity																						
7.3	No information	44.81	99.69	35.00					2.71	2.95		4.01	0.01					0.12	0.01				
VIII	**Nature (US$ billion)**	**14.36**	**0.79**						0.82	11.99			0.07	0.55		0.03	0.08		0.02				**0.80**	
8.1	Trees	1.70	11.84						0.82								0.08						0.80	
8.2	No information	12.66	88.16							11.99			0.07	0.55		0.03			0.02					
B	**Total number of projects**	**202**	**100.0**	**15**	**3**	**2**	**4**	**9**	**23**	**19**	**19**	**13**	**24**	**10**	**6**	**14**	**10**	**10**	**8**	**3**	**3**	**2**	**2**	**3**

No.	Sector/Subsector	Total	Share	Americas				Europe												Asia				Africa
				US	Canada	Colombia	Chile	EU	Germany	Italy	France	Spain	UK	Sweden	Denmark	Poland	Finland	Norway	Ireland	New Zealand	Rep. of Korea	China	India	Nigeria
I	**Energy** (number of projects)	**39**	**19.31**	2	1	**1**		2	5	3	1	2	6		2	5	2	4	1		1			**1**
1.1	Electricity bills	1	2.56						1															
1.2	Renewable electricity	10	25.64		1	1		1	1	1		1	1					1	1					1
1.3	Hydrogen	9	23.08					1	3	1	1	1	1					1						
1.4	Renewable electricity/ Hydrogen	2	5.13												1						1			
1.5	Carbon capture and storage	2	5.13										1		1									
1.6	Energy efficiency	1	2.56														1							
1.7	Nuclear	1	2.56										1											
1.8	No information	13	33.33	2						1			2			5	1	2						
II	**Transport** (number of projects)	**77**	**38.12**	6	1		1	1	12	6	13	8	6	4		4	3	3	4	1		**2**	**1**	**1**
2.1	Public transport	24	31.17	4	1				4	2	1	2	2	2		1	2		2	1				
2.2	Electric vehicles	18	23.38	1				1	4	2	2		2	1		3						2		
2.3	Car tax	1	1.30						1															
2.4	Automotive	8	10.39						1		6		1											
2.5	Aviation	3	3.90						1		2													
2.6	Shipping	3	3.90						1									2						
2.7	Oil and gas	2	2.60																				1	1
2.8	Cycling and walking	5	6.49							1	2						1		1					
2.9	Adaptation	1	1.30																1					
2.10	R&D	1	1.30									1												
2.11	Green jobs	1	1.30									1												
2.12	Hydrogen	1	1.30										1											
2.13	No information	9	11.69	1			1			1		4		1				1						
III	**Industry** (number of projects)	**22**	**10.89**	1				1		1	3	1	3	4	3	1	2	1			1			
3.1	Energy efficiency	1	4.55												1									
3.2	Circular economy	6	27.27							1	1			1	1		1	1						
3.3	Steel	1	4.55										1											
3.4	Electric vehicles	1	4.55								1													
3.5	No information	13	59.09	1				1			1	1	2	3	1	1	1				1			

No.	Sector/Subsector	Total	Share	Americas				Europe												Asia				Africa
				US	Canada	Colombia	Chile	EU	Germany	Italy	France	Spain	UK	Sweden	Denmark	Poland	Finland	Norway	Ireland	New Zealand	Rep. of Korea	China	India	Nigeria
IV	**Buildings** (number of projects)	**31**	**15.35**	5	1		2	1	2	4	1	1	5	1	1	2	2		1	1	1			
4.1	Energy efficiency	19	61.29	3	1		1	1	1	3	1		4	1	1				1	1				
4.2	Adaptation	3	9.68	1			1		1															
4.3	Heating	2	6.45													1	1							
4.4	Construction	1	3.23														1							
4.5	No information	6	19.35	1						1		1	1			1					1			
V	**Agriculture** (number of projects)	**4**	**1.98**				1	1		1	1													
5.1	Trees	1	25.00				1																	
5.2	No information	3	75.00					1		1	1													
VI	**Employment** (number of projects)	**3**	**1.49**					2												1				
6.1	Green jobs	3	100.0					2												1				
6.2	No information																							
VII	**R&D** (number of projects)	**14**	**6.93**	1				1	3	2		1	2					2	1					1
7.1	Negative emissions	1	7.14										1											
7.2	Renewable electricity	1	7.14																					1
7.3	No information	12	85.71	1				1	3	2		1	1					2	1					
VIII	**Nature** (number of projects)	**12**	**5.94**			1			1	2			2	1		2	1		1				1	
8.1	Trees	4	33.33			1			1								1						1	
8.2	No information	8	66.67							2			2	1		2			1					

COVID-19 = coronavirus disease, EU = European Union, R&D = research and development, UK = United Kingdom, US = United States.

Note: The green recovery packages are calculated based on the projects that have information about the amount, updated to April 2021.

Source: ERIA Study Team based on Carbon Brief (2021).

Table 3.18 presents the share of green policy solutions applied by a selection of countries within and outside ASEAN as follows: green infrastructure investments (41.4%), subsidies or tax reductions for green products (15.6%), green R&D subsidies (14.8%), bailouts with green strings attached (10.5%), nature-based solutions (5.7%), and conservation and wildlife protection programmes (4.4%) (Vivid Economics, 2021).

Table 3.19 details the policy solutions used in support packages that have a substantial impact on the environment (brown policy). About 18.3% of countries (19.1% of selected non-ASEAN+6 countries[4] and 17.5% of selected ASEAN+6 countries) apply policies related to subsidies or tax reductions for environmentally harmful products. Some 17.5% of countries (10.0% of selected non-ASEAN+6 countries and 25.0% of selected ASEAN+6 countries)[5]apply subsidy policies related to environmentally harmful activities. Some 15.8% of countries (19.1% of selected non-ASEAN+6 countries and 12.5% of selected ASEAN+6 countries) apply subsidy policies related to an environmentally related bailout without green strings. Some 14.4% of countries (16.4% of selected non-ASEAN+6 countries and 12.5% of selected ASEAN+6 countries) apply subsidy policies related to the deregulation of environmental standards. Some 9.4% of countries (6.4% of selected non-ASEAN+6 countries and 12.5% of selected ASEAN+6 countries) apply subsidy policies related to environmentally harmful infrastructure investments.

5.4 Overcoming Barriers in Shifting Investments Towards Low-Carbon Green Infrastructure

As countries struggle to restart their economies, low-carbon investments are most effective in economies that integrate energy, climate, and investment policies in a coordinated way. Boxes 3.4 and 3.5 exemplify such an approach in Viet Nam and Korea, respectively, during the pandemic crisis.

Nevertheless, policy obstacles are also associated with embedded financial systems and regulations that hinder the allocation of long-term finance to long-term low-carbon infrastructure investments. Such barriers include the way that long-term investments are regulated, climate risks are valued, private financing outcomes are reported, and public finance is allocated and delivered (Table 3.20).

[4]Argentina, Brazil, Canada, Colombia, Denmark, the EU, Finland, France, Germany, Iceland, Italy, Mexico, Norway, Russia, Saudi Arabia, South Africa, Spain, Sweden, Switzerland, Turkey, the UK, the US.

[5]Australia, China, India, Indonesia, Japan, the Philippines, Singapore, and Korea.

Table 3.18 Share of Environmental Policy Measures in the Recovery Packages of Selected Countries (%)

Policy		Selected ASEAN+6 countries*					Selected non-ASEAN+6 countries**					Average
		Agriculture	Energy	Industry	Transport	Waste	Agriculture	Energy	Industry	Transport	Waste	
Green policy	Bailouts with green strings attached						9.1	13.6	27.3	40.9	13.6	10.5
	Green infrastructure investments	12.5	75.0	37.5	62.5	12.5	31.8	77.3	45.5	54.5	4.5	41.4
	Green R&D subsidies		37.5	12.5	12.5	12.5		22.7	27.3	22.7		14.8
	Subsidies or tax reductions for green products		37.5	12.5	37.5			36.4	4.5	27.3		15.6
	Nature-based solutions	25.0					31.8					5.7
	Conservation and wildlife protection programmes	12.5					31.8					4.4
Brown policy	Subsidies for environmentally harmful activities	(25.0)	(25.0)	(37.5)	(37.5)		(4.5)	(18.2)	(18.2)	(9.1)		(17.5)
	Environmentally harmful infrastructure investments		(37.5)	(25.0)				(22.7)		(9.1)		(9.4)
	Deregulation of environmental standards	(12.5)	(25.0)	(25.0)			(13.6)	(22.7)	(27.3)	(13.6)	(4.5)	(14.4)
	Environmentally related bailout without green strings			(12.5)	(50.0)		(9.1)	(13.6)	(18.2)	(54.5)		(15.8)
	Subsidies or tax reductions for environmentally harmful products		(12.5)	(25.0)	(50.0)		(4.5)	(36.4)	(31.8)	(18.2)	(4.5)	(18.3)
Balance between green and brown policy		12.5	50.0	(62.5)	(25.0)	25.0	72.7	36.4	9.1	40.9	9.1	16.8

( ) = measures having negative impacts, ASEAN = Association of Southeast Asian Nations, R&D = research and development. ASEAN = Association of Southeast Asian Nations, R&D = research and development.

* Australia, China, India, Indonesia, Japan, the Philippines, Singapore, and the Republic of Korea.

** Argentina, Brazil, Canada, Colombia, Denmark, the European Union, Finland, France, Germany, Iceland, Italy, Mexico, Norway, Russia, Saudi Arabia, South Africa, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.

Source: ERIA Study Team calculations based on Vivid Economics (2021).

Table 3.19 Environmental Policy Measures in Recovery Packages by Country

Country	Sector	Green policy						Brown policy				
		Bailouts with green strings attached	Green infrastructure investments	Green R&D subsidies	Subsidies or tax reductions for green products	Nature-based solutions	Conservation and wildlife protection programmes	Subsidies for environmentally harmful activities	Environmentally harmful infrastructure investments	Deregulation of environmental standards	Environment-related bailout without green strings	Subsidies or tax reductions for environmentally harmful products
I. Selected ASEAN+6 countries												
Australia	Agriculture				x				x			
	Energy	x	x				x	x				
	Industry	x					x					
	Transport	x								x		
	Waste											
China	Agriculture		x				x					
	Energy		x						x	x		
	Industry		x							x		
	Transport		x		x						x	x
	Waste											
India	Agriculture					x						
	Energy		x		x			x	x	x		x
	Industry				x			x	x	x		
	Transport		x		x							
	Waste											
Indonesia	Agriculture											
	Energy		x	x	x							
	Industry											
	Transport		x									
	Waste											
Japan	Agriculture											
	Energy		x									
	Industry											
	Transport											x
	Waste											
Philippines	Agriculture							x				
	Energy				x							
	Industry								x			x
	Transport							x				
	Waste											
Republic of Korea	Agriculture											
	Energy		x	x								
	Industry		x	x							x	
	Transport		x	x	x			x			x	x
	Waste		x	x								

Country	Sector	Green policy						Brown policy				
		Bailouts with green strings attached	Green infrastructure investments	Green R&D subsidies	Subsidies or tax reductions for green products	Nature-based solutions	Conservation and wildlife protection programmes	Subsidies for environmentally harmful activities	Environmentally harmful infrastructure investments	Deregulation of environmental standards	Environment-related bailout without green strings	Subsidies or tax reductions for environmentally harmful products
Singapore	Agriculture							x				
	Energy											
	Industry							x				x
	Transport							x			x	x
	Waste											
II. Selected non-ASEAN+6 countries												
Argentina	Agriculture		x									
	Energy											x
	Industry									x		x
	Transport											
	Waste											
Brazil	Agriculture									x		
	Energy		x		x					x		
	Industry		x							x		
	Transport										x	
	Waste											
United States	Agriculture						x			x		
	Energy			x	x			x	x	x		x
	Industry									x		
	Transport	x	x							x	x	
	Waste									x		
Canada	Agriculture	x				x					x	
	Energy	x	x					x	x	x	x	
	Industry	x						x				
	Transport	x	x					x	x			
	Waste	x										
EU	Agriculture	x				x						
	Energy	x	x	x								
	Industry	x										
	Transport	x	x		x							
	Waste	x										
France	Agriculture		x									
	Energy		x		x							
	Industry	x	x					x		x		
	Transport	x	x	x	x							
	Waste	x	x									
Germany	Agriculture		x			x						
	Energy		x	x	x							
	Industry		x	x	x							
	Transport										x	
	Waste											

Country	Sector	Green policy						Brown policy				
		Bailouts with green strings attached	Green infrastructure investments	Green R&D subsidies	Subsidies or tax reductions for green products	Nature-based solutions	Conservation and wildlife protection programmes	Subsidies for environmentally harmful activities	Environmentally harmful infrastructure investments	Deregulation of environmental standards	Environment-related bailout without green strings	Subsidies or tax reductions for environmentally harmful products
Italy	Agriculture											
	Energy		x		x							x
	Industry											
	Transport		x		x						x	x
	Waste											
Mexico	Agriculture											
	Energy								x			
	Industry											
	Transport								x			
	Waste											
Russia	Agriculture											
	Energy							x				x
	Industry							x				x
	Transport							x			x	x
	Waste											
Saudi Arabia	Agriculture											
	Energy							x				x
	Industry											
	Transport											
	Waste											
South Africa	Agriculture											
	Energy		x						x	x	x	x
	Industry									x	x	
	Transport											
	Waste											
Spain	Agriculture		x									
	Energy		x									
	Industry		x									
	Transport		x		x						x	
	Waste											
Colombia	Agriculture					x	x					x
	Energy		x									
	Industry											x
	Transport		x									
	Waste											
Turkey	Agriculture											
	Energy		x		x					x	x	x
	Industry											
	Transport									x	x	
	Waste											

Country	Sector	Green policy						Brown policy				
		Bailouts with green strings attached	Green infrastructure investments	Green R&D subsidies	Subsidies or tax reductions for green products	Nature-based solutions	Conservation and wildlife protection programmes	Subsidies for environmentally harmful activities	Environmentally harmful infrastructure investments	Deregulation of environmental standards	Environment-related bailout without green strings	Subsidies or tax reductions for environmentally harmful products
Denmark	Agriculture					x	x					
	Energy		x									
	Industry	x	x	x							x	
	Transport	x	x								x	
	Waste											
Finland	Agriculture					x	x					
	Energy	x	x	x								
	Industry	x	x	x						x		x
	Transport	x		x						x		x
	Waste											
Iceland	Agriculture											
	Energy		x									
	Industry		x	x				x				x
	Transport				x						x	
	Waste											
Norway	Agriculture		x									
	Energy		x	x					x			x
	Industry		x	x							x	x
	Transport		x	x	x						x	x
	Waste											
Sweden	Agriculture		x			x	x	x			x	
	Energy		x		x							
	Industry		x									x
	Transport	x	x	x							x	
	Waste											
Switzerland	Agriculture		x				x					
	Energy		x									
	Industry										x	
	Transport	x	x									
	Waste											
UK	Agriculture						x			x		
	Energy		x		x							
	Industry	x	x	x								
	Transport	x	x	x							x	
	Waste											x

ASEAN = Association of Southeast Asian Nations, EU = European Union, R&D = research and development, UK = United Kingdom.

Source: ERIA Study Team calculations from Vivid Economics (2021).

Box 3.4 Viet Nam's Pandemic Adaptation Policies Towards Green Growth

In the face of negative impacts on the economy from social distancing policies, the Government of Viet Nam issued pandemic adaptation policies towards green growth.

1. Policies adapted to COVID-19 and green growth

These policies ensure to promote the application of information technology in production, business, health, education, and public service provision, etc., in response to COVID-19 and towards green and sustainable growth.

- The remote medical examination and treatment policy aims to implement social distancing policies and promote green growth by limiting people's movement and using resources effectively. According to Directive No. 16/CT-TTg, an important preventive measure against the COVID-19 pandemic is restricting people's access to medical facilities for essential services. Accordingly, the Prime Minister instructed the Ministry of Information and Communications to coordinate with the Ministry of Health in implementing the remote medical examination and treatment model for households, villages, communes, wards, and districts. On 18 April 2020, the Ministry of Health organised the first pilot project at Hanoi Medical University Hospital. Many live television stations have been deployed for medical examination and treatment, especially in meeting serious diseases, including patients with COVID-19.

- Policies in education and training: Official Letter No. 1061/BGD T-GDTrH dated 25 March 2020 of the Ministry of Education and Training on the instruction for teaching on the internet and/or on television for general education institutions when students are absent from school because of COVID-19 during the 2019/20 school year to support students' study and help them complete the general education programme.

- Policy on online public service provision: To adapt to the social distancing policy, the Government of Viet Nam issued Decree No. 45/2020/ND-CP dated 8 April 2020, on the implementation of administrative procedures in the electronic environment. To encourage society to use online public services, on 7 February 2020, the Computerization Department of the Ministry of Information and Communications issued Official Letter 100/THH-TTDVCTT on propagating and encouraging people to increase the use of online public services to limit exposure to crowds.

- The Prime Minister signed and approved a project to plant 1 billion trees from 2021 to 2025 (Decision No. 524/QD-TTg dated 1 April 2021). The project includes 690 million trees in urban and rural areas; and 310 million trees in protection forests, special-use forests, and new production forests in order to contribute to protecting the ecological environment, improving the landscape and responding to climate change, developing the socio-economic situation, improving people's quality of life, and contributing to the sustainable development of the country. Funding for implementation of the project involves mobilising all social resources and diversifying capital sources for planting

and protecting trees from the state budget (expenditure for development investment and recurrent expenditure); and other sources of funding, aid, and legally mobilised sources from organisations, households, individuals, and communities (domestic and foreign).

2. Policies in support of inclusive growth during the COVID-19 pandemic

Implementing Resolution No. 42/NQ-CP to directly support people, workers, businesses and households facing difficulties due to COVID-19, with a total budget of about D62,000 billion. The Prime Minister issued Decision No. 15/2020/QD-TTg dated 24 April 2020 on the implementation of policies to support people facing difficulties caused by the COVID-19 pandemic, applied from 1 April 2020.

Several policies could still lead to an increase in GHG emissions and contravene the government's emission reduction policy, such as policies on electricity price reductions and electricity bill reductions for electricity consumers affected by the COVID-19 pandemic (Official Letter No. 2698/BCT-DTDL dated 16 April 2020 of the Ministry of Industry and Trade), or the 30% reduction in environmental protection taxes on flying fuel (Resolution 979/2020/UBTVQH14, effective 1 August 2020). Although these policies are temporary, they are not likely to change behaviour in electricity and fossil fuel consumption. The results of the monthly carbon dioxide equivalent emission calculations showed that the 10% electricity price support and the 30% reduction in the environmental protection tax on flying fuel for airlines helped to reduce difficulties for people and businesses. However, these solutions did not increase electricity demand because they did not last long enough to affect energy consumption behaviour. Nevertheless, these forms of support are contrary to efforts to raise awareness and fulfil Viet Nam's commitment to reduce GHG emissions (Hoa et al., 2020).

COVID-19 = coronavirus disease, GHG = greenhouse gas.

Source: ERIA study team

Box 3.5 The Republic of Korea's Pandemic Adaptation Policies Towards Green Growth

The COVID-19 pandemic has brought changes to ways of thinking and living, accelerating a move to a digital and eco-friendly economy. As quarantine has become a part of everyday life, demand for remote services surge and remote working is considered usual. The Republic of Korea will invest W76 trillion (US$61.9 billion) by 2025 to strengthen digitisation, eco-friendly growth, and social safety nets, in a sweeping move to reinvigorate the economy hit by the COVID-19 pandemic.

Goal: Transform the economy from a fast follower to a leader, from a carbon-dependent economy to a green economy, creating a more inclusive society

2+1 policies: Digital New Deal and Green New Deal (2) + stronger safety nets (1), which will be implemented with strong fiscal support and improved regulations to promote the private sector

Projects: 10 major projects out of a total of 28 projects (12 for the Digital New Deal, 8 for the Green New Deal, and 8 for social safety nets)

Investment plans

- W6.3 trillion was planned to be invested during 2020 through the third supplementary budget; W67.7 trillion (cumulative) will be invested by 2022; and W160.0 trillion (cumulative) will be invested by 2025 (W114.1 trillion of fiscal investment), with 1.901 million jobs created during the period
- Investment plans by projects:
  - Digital New Deal: W58.2 trillion (W44.8 trillion from fiscal investment), 903,000 jobs created
  - Green New Deal: W73.4 trillion (W42.7 trillion from fiscal investment), 659,000 jobs created
  - Stronger safety nets: W28.4 trillion (W26.6 trillion from fiscal investment), 339,000 jobs created

Expected outcomes

1. Smart country

- Smart industries: W43 trillion of data markets are expected to be created, 18 smart hospitals will be in service, and up to 40% of work will be done remotely
- Smart government: 80% of public services will become digital, and the government will use cloud computing 100%
- Smart cities: High-precision road maps will be available for almost all roads across the country, and 108 smart city management platforms will be set up

2. Green country

- Clean environment: Up to 225,000 public rental houses will be remodelled to be energy-efficient and eco-friendly, 25 cities will be transformed to be smart and eco-friendly, and 723 hectares of urban forests will be planted to reduce fine dust
- Use of low-carbon green energy: 1,130,000 electric cars and 200,000 hydrogen fuel cell cars will be in use across the country, renewable energy production capacity will reach 42.7 gigawatts, and 5 million households will get electricity through smart grids
- Green industries: Up to 1,750 factories will be transformed into clean factories, fine dust reduction systems will be installed in 13,182 small manufacturers, and 10 smart energy platforms will be built

3. Safe country

- Income guarantee: Up to 21 million workers will be covered by employment insurance programs, and 1.13 million households will be made eligible for social security benefits
- Human resources: 100,000 high-tech workers will be available for the artificial intelligence and Smart Works sectors, and 20,000 high-tech workers will be in place for green industrial convergence
- Digital inclusion: Internet access will be made available to all rural areas of the country, and 70% of older persons (aged 70 or older) will be able to enjoy mobile internet access

COVID-19 = coronavirus disease.

Source: Ministry of Economy and Finance, Korea (2020); Lee (2020).

Table 3.20 Examples of Policy Misalignments that Undermine Low-Carbon Investments in Developing Countries of ASEAN and East Asia

Investment environment	Energy policies	- Lack of open and competitive electricity markets - Regulatorwy barriers to international investment in low-carbon energy projects, such as limits on foreign direct investment and restricted access to assets - Market design and energy pricing mechanisms that favour carbon-intensive fossil fuel investments
	Climate policies	- Lack of ambitious targets, beyond nationally determined contributions and binding sectoral objectives - Lack of stability in climate policy and retroactive changes, and divergence with sectoral emission reduction objectives
	Trade policies	- Tariff and non-tariff barriers for low-carbon goods and services - Lack of embedded standards in multilateral free trade agreements and bilateral trade negotiations
	Competition policies	- Lack of transparency, investor protection, and intellectual property rights in low-carbon technologies; and weak enforcement of targets - Unequal treatment in the power sector and subsidy regimes for fossil fuel-producing state-owned enterprises and independent producers of low-carbon energy
	Governance policies	- Lack of long-term scenarios for low-carbon investment planning and procurement of technology and finance - Lack of stakeholder consultation in progressive target setting and policy design
Financial support mechanism	Fiscal policies	- Insufficient carbon pricing and market incentives for low-carbon technology diffusion
	Financial market	- Financial incentives favouring short-termism in performance appraisal of equity and credit markets - Unintended consequences of financial regulations focusing on long-term fiscal stability - Lack of taxonomy in the deployment of innovative financial instruments for new types of investors, such as bond markets and institutional investors
	Banking sector conduct	- Corporate reporting that does not reflect the climate risk - Lack of clarity in fiduciary duty and stewardship with respect to environmental, social, and governance issues - Lack of guidelines and responsible investment codes
	Public financing policies	- Ongoing support to carbon-intensive investments - Continued subsidy support to fossil fuel use - Lack of capacity to assess the risks associated with stranded assets

ASEAN = Association of Southeast Asian Nations.

Source: ERIA Study Team.

Removing these barriers will require key architectural reforms to financial regulations, corporate governance, and public spending in the post-COVID-19 era. While investment decisions are motivated by concerns other than climate change, some of the potential challenges confronting private investments can be transformed into opportunities for regional cooperation. Developing countries in ASEAN, as well as China and India, have strengths in their abundant human capital and enjoy the latecomer advantage of having a large window of opportunity to leapfrog to low-carbon and green investments – frameworks and regional cooperation mechanisms that have been tried and tested in advanced countries.

6. Conclusions

This chapter has discussed the existing similarities, emerging convergence, and differences in economic and emission trajectories and policy actions across countries to promote low-carbon green growth. The interesting question is whether current policies and plans in developing Asia are aligned with the objective of net zero emissions adopted by major economies. To answer this question, the chapter has reviewed strategies and actions undertaken amidst the COVID-19 pandemic. The main conclusions of the analysis on current trajectories are presented below.

Developing and emerging economies of the region are acting on the transition towards a low-carbon economy in a progressive way.

Close examination of carbon emission profiles and policy actions helps to illustrate how, despite having very low per capita GHG emissions, many developing and emerging economies of ASEAN and East Asia are making efforts towards substantial reductions in carbon emissions, resource use, and energy consumption. From a climate change mitigation perspective, countries are keenly aware of the opportunities associated with low-carbon green growth and the risks of being locked into high-carbon infrastructure. Decoupling economic growth from carbon emissions is increasingly a policy goal being prioritised for national benefit rather than as a result of international pressures or concerns. Perhaps more importantly from the perspective of many low- and middle-income AMS, the assessment shows that low-carbon green development can support a range of other policy goals, including local environmental protection, poverty alleviation, energy security, economic competitiveness, the development of new industries and jobs, investment in knowledge and innovation, and local environmental protection. This combination helps to explain the strong interest from many developing countries in low-carbon growth trajectories.

Stronger transformative policy actions are required to achieve a net zero future.

Although the current NDC targets, incremental actions, and trajectory of each country are ambitious when considered against the respective country's baseline, none would lead to the realisation of a low-carbon development pathway consistent with 1.5°C climate stabilisation targets and a net zero future by 2050. GHG emissions are still growing, reflecting rapid increases in GDP and per capita income growth, and the associated demand for energy, transport, and natural resources consumption. Furthermore, the lack of substantial decoupling of emissions in the energy and transport sectors, combined with a lack of effective sectoral technology road maps, means that the global emission budget will continue to be used up by the region at an alarming rate. For countries in the region to adopt even more ambitious abatement targets, new approaches – such as embracing the concept of the CCE; supporting the development of new technologies (e.g. hydrogen, CCUS, and electric vehicles); and reducing the costs of existing clean energy and energy efficiency technologies – will be needed. All countries will need to explore more radical approaches to economic development, including more holistic waste management, conservation of forests, stricter codes for new buildings,

more aggressive targets for the tourism sector, large-scale low-carbon resilient interventions along supply chains, and the pricing of the environmental externalities of fossil fuel production and consumption.

Low-carbon green growth planning needs to be mainstreamed into national development plans.

The country assessments of policies and practices have demonstrated that it is possible to integrate low-carbon green growth objectives into sectoral plans and across sectors – rather than treating low-carbon green growth as an add-on to be solved through stand-alone climate policies and clean energy investment projects. Precisely because both climate change and the COVID-19 pandemic are economy-wide challenges, greening the economic recovery packages towards sustainable development can help to build bridges between different branches of government, and integrate the long-term low-carbon perspective to challenge the status quo. Making low-carbon green growth a government-wide issue to be tackled by national development plans, rather than the preserve of any particular line ministry, was a key lesson before the pandemic, and one that could have lasting consequences in terms of government coordination on climate change, energy, economic, and fiscal policy at the national level. Central to this was the strong priority given to intergovernmental and stakeholder engagement in setting the new targets for NDCs, greening the stimulus packages, and ensuring immediate implementation. This is important in building consensus around hard decisions on carbon pricing and the introduction of other market-based instruments.

Potential to accelerate the low-carbon transition as part of the pandemic recovery is high.

In the ASEAN and East Asian countries studied, there is potential for large-scale reductions in GHG emissions. A significant percentage of the emission savings could come at a negative cost, meaning they will contribute to economic recovery and job creation. This includes measures such as increasing co-generation, improving vehicle efficiency, and reducing electricity system losses. However, even win–win investments frequently face hurdles that require a concerted policy response. The economic recovery and stimulus packages being implemented since the onset of the COVID-19 pandemic offer an opportunity. There is a leadership role to be played by central governments and the private sector through strong technological and innovation policies that could help ensure the required investments in low-carbon solutions in the near future. Transitioning to a net zero carbon future at the regional – ASEAN and East Asia – level is a process. Targets and political commitments can change quickly, but successful delivery requires strong institutional mechanisms to analyse policy options and make hard implementation decisions as part of the ACRF. Implementing the relatively low-cost emission abatement options identified as part of the ACRF will send a signal to investors and help to build the capacity needed for more ambitious action towards a net zero future. This emphasises the need to see low-carbon green growth planning as a continuous process that will respond over time to the interaction between domestic policy objectives and the ACRF's five broader strategies.

Financing new infrastructure investments must be transformative, prioritising a net zero future.

The overall response of most countries during the economic recovery from the pandemic demonstrates that less priority has been given to low-carbon infrastructure planning. There has not been a very strong willingness to act now. However, where low-carbon resilient planning has been successfully mainstreamed into development policymaking or economic recovery packages, more successful long-term outcomes can be expected. Although there are many low or negative cost opportunities to reduce or avoid GHG emissions, there is still a net cost to adopting a low-carbon pathway, even if this is relatively small in comparison to the economic growth that can be expected over the same period with the introduction of new low-carbon technologies. The scale of funding required necessitates the use of a wide range of financing mechanisms, including incentives where appropriate to direct investment into low-carbon technology development, early-stage start-ups, R&D supporting innovation, and stimulating private sector investment.

International climate finance will also be important but, recognising its limitations in the face of such high demands, prioritisation will be required. To ensure funding for low-carbon projects (economy-wide and sector-specific circular zero emission planning), transformative policy changes such as carbon pricing and market-based mechanisms are proposed as high priorities as they are likely to achieve the greatest return. Finally, as national level scenario modelling is unable to take account of external developments, such as the actions of other countries, and is largely based on existing and known technologies, it is likely to be conservative about the potential for emission reductions, particularly in the future. An international paradigm shift towards a global low-carbon economy could have major implications for the economic assumptions underpinning each country's development plan – e.g. by reducing the cost of key technologies, improving the incentives for energy efficiency, or creating markets for new products and services.

A new generation planning toolbox for low-carbon green growth is needed.

Not all countries in the region have good-quality data and scenario modelling capacity to visualise different policy pathways towards a net zero future and the net costs and benefits. To be effective in this context, scenario modelling tools at the regional level need to be open access so that the assumptions can be scrutinised and a degree of customisation made possible. In many cases, appropriate tools do not exist, leading policymakers to make several suboptimal decisions. It seems likely that, in a world where substantial action on low-carbon technology transfer and investments is partially funded through international financial mechanisms linked to the United Nations Framework Convention on Climate Change process, transparency in terms of data acquisition will also be crucial for the monitoring, reporting, and verification of actions undertaken at the country level. Academia, officials, and the corporate sector involved in low-carbon/zero emission planning activities can help to continue this effort by improving the tools that are available; enhancing the capacity of countries to collect,

verify, and incorporate useful data; and ensuring that best practice is shared. Finally, there is increasing interest in integrating resilience considerations in future work. Many energy, transport, and agricultural systems are sensitive to external shocks such as financial crises, pandemics, and climate impacts. As many of the low-carbon infrastructure investments are long-term in nature, there are potential synergies in considering development pathways that deliver low-carbon, circular economy, and resilience benefits.

Shift the emphasis from planning to implementation, including through regional cooperation.

Geopolitically, interest in low-carbon development and a net zero future has grown substantially since 2016 because of the Paris Agreement, rapid technological progress, and the increasing cost and price volatility of fossil fuels. Many countries now have, or are considering, carbon emission reduction targets at the national level, or are putting together new collective targets for the region at the United Nations Framework Convention on Climate Change and the United Nations Climate Change conference (COP26). However, concepts such as the G20's CCE, Japan's Cool Earth plan, and Korea's Green New Deal are only a means to an end, and are best seen as part of a modular and continuous progressive process of policy development and investment at the country level. There is a risk that international processes could overemphasise the economy-wide planning stage at the expense of near-term investment planning and detailed policy development for sectoral actions and implementation. Such programmes – when designed to be flexible to local needs and in conformity with regional cooperation architecture arrangements such as the ACRF, the ASEAN Economic Community Blueprint, and the Regional Comprehensive Economic Partnership – could lead to a very different and more cost-efficient outcome in terms of international technology transfer, mobilisation of private finance, and capacity building for decision-making. One way of viewing new NDC targets and emerging concepts such as the CCE is to see them as investment plans that outline a country's objectives for the sector in question, the regional cooperation policies needed to implement them, and the individual investments needed to deliver them – broken down into those that will be government-funded, those that require private sector investment, and those where international financing is required. New low-carbon planning, undertaken at the regional level but with multisectoral coordination, would inevitably be central to a net zero future.