IRENA
International Renewable Energy Agency

Socio-economic footprint of the energy transition

SOUTHEAST ASIA

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Abbreviations

°C	degree Celsius
ACE	ASEAN Centre for Energy
ACGF	ASEAN Green Catalytic Green Finance Facility
ADB	Asian Development Bank
APAEC	ASEAN Plan of Action for Energy Cooperation
APG	ASEAN power grid
ASEAN	Association of Southeast Asian Nations
ASEAN-5	Indonesia, Malaysia, the Philippines, Singapore and Thailand
CAGR	compound annual growth rate
CCTs	clean coal technologies
CLMV	Cambodia, Lao People's Democratic Republic, Myanmar and Viet Nam
CO_2	carbon dioxide
CO_2eq	carbon dioxide equivalent
DMC	domestic material consumption
ETM	Energy Transition Mechanism
EJ	exajoule
EPT	environmental protection tax
EU	European Union
EU-27	Economies of the European Union
EV	electric vehicle
FDI	foreign direct investment
FIT	feed-in tariff
GHG	greenhouse gas
GDP	gross domestic product
$GtCO_2$	gigatonne of carbon dioxide
GW	gigawatt
IRENA	International Renewable Energy Agency
kWh	kilowatt hour
LCR	local content requirement
LTMS-PIP	Lao-Thailand-Malaysia-Singapore Power Integration Project
LULUCF	land use, land-use change and forestry
Mt	megatonne
MW	megawatt
NDC	Nationally Determined Contribution
OECD	Organisation for Economic Co-operation and Development
PDP	power development plan
PES	Planned Energy Scenario
PJ	petajoule
PPP	purchasing power parity
PV	photovoltaic
RCEP	Regional Comprehensive Economic Partnership
R&D	research and development
tCO_2	tonnes of carbon dioxide
TFEC	total final energy consumption
TPES	total primary energy supply
TVET	technical and vocational education and training
USD	United States dollar

Executive summary

The Association of Southeast Asian Nations (ASEAN)[1] has enjoyed impressive economic growth over the past couple of decades. Southeast Asia's gross domestic product (GDP) in purchasing power parity (PPP) has grown at a compound annual growth rate (CAGR) of 4.7% over the past three decades (*i.e.* 1991-2021) (World Bank, n.d.), maintaining robust and steady growth despite headwinds such as the Asian financial crisis of 1997 and the global financial crisis of 2008-2009. However, there are substantial differences across countries that relate to economic development and structure, as well as population size. The ASEAN-5 (Indonesia, Malaysia, the Philippines, Singapore and Thailand) account for the largest share of regional GDP (around 83% in 2021) and took early steps in the region towards industrial development (World Bank, n.d.). The CLMV countries (Cambodia, Lao People's Democratic Republic [Lao PDR], Myanmar and Viet Nam), on the other hand, have experienced the region's fastest growth recently in terms of GDP and PPP. The region has seen consistent growth based on raw material, service and light manufactured goods exports (IRENA, 2018a).

Aside from some individual economic characteristics, the sectoral move from agriculture to more manufacturing and services has been one of the many common structural drivers of growth in the larger economies (World Bank, n.d.). Southeast Asia has seen the emergence of a larger middle class, increasing consumer expenditure. Foreign direct investment (FDI) has been a key driver of manufacturing expansion in the region. As a result, the region has become a major manufacturing and trading hub (IRENA, 2018a). The European Union, Japan and the United States have generally been the largest sources of FDI. Since 2015, however, investment from other Asian economies (*e.g.* China, Singapore, South Korea) has increased significantly as manufacturers have searched out new low-cost locations and pushed to access ASEAN markets more thoroughly. Innovative financing schemes are gaining traction to address the continuously growing need throughout the region. These include SDG Indonesia One and PT Penjaminan Infrastruktur in Indonesia, the ASEAN Green Catalytic Green Finance Facility (ACGF) or the Energy Transition Mechanism (ETM) at the regional level, and a new partnership with the Philippines and Indonesia launched by the Asian Development Bank (ADB).

[1] *The Member States of the Association of Southeast Asian Nations (ASEAN): Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam. The terms "ASEAN" and "Southeast Asia" are used interchangeably to refer to this set of countries unless otherwise mentioned.*

Economic and population growth, and rising living standards, have also led to a rapid rise in energy demand. The energy supply in the region grew at an average rate of 3.0% annually between 2000 and 2020. Much of this increase was met by fossil fuels, which accounted for around 77% of total primary energy supply (TPES) in 2020 (IEA, n.d.). While the total renewable energy supply has increased from 5 100 petajoules (PJ) in 2000 to 6 600 PJ in 2020, its share in the total TPES fell from 32% in 2000 to 23% in 2020, owing to reduced consumption of traditional biomass. Since 2005, the number of people living in cities in Southeast Asia has followed a similar trend to regional population growth (a CAGR of 1.2%) (UN, 2022), though slightly higher, in the range of 1.1% to 1.6% (ACE, 2022a), contributing to the large reduction in traditional biomass use. The share of other renewables (including modern bioenergy, geothermal, hydro, solar and wind) has increased from 13.1% to 17.5% over the same period (*i.e.* 2000-2020). Modern bioenergy, geothermal energy and hydropower make up over 98% of Southeast Asia's renewable energy, despite tremendous growth in solar photovoltaic (PV) and wind. Total final energy consumption (TFEC) increased by 75% between 2000 and 2020, led by increased electricity consumption in buildings. Buildings have been the source of the greatest growth in power usage of any sector, owing to an increase in the use of air conditioners and appliances (IEA, n.d.).

The need for energy in the region has risen quickly, as have greenhouse gas (GHG) emissions and environmental issues

ASEAN countries' dependence on fossil fuels – coupled with their growing energy needs – means the region is already on the pathway to becoming one of the largest GHG emitters in the world. Carbon dioxide (CO_2) emissions in the region have increased at one of the fastest rates in the world over the last few years, a result of the combined toll of fossil fuel consumption and systematic, large-scale land conversion and forest loss. Good progress has nonetheless been made in reducing deforestation in the region. Indonesia's primary forest loss has declined since 2015, although the region as a whole lost 1.4 million hectares (ha) (equivalent to half the area of Belgium) and Indonesia lost more than 0.9 million ha (equivalent to the area of Cyprus or one-third that of Belgium) in 2016 following a year of major fires in 2015 (Global Forest Watch, n.d.). As part of the Paris Agreement, furthermore, Indonesia plans to reduce yearly deforestation to 325 000 ha between 2020 and 2030 (EU REDD, n.d.). Still, substantial GHG emissions will continue to be produced in the coming decades if they are not stopped by forward-looking policy (IRENA, 2018a). The ASEAN region's total GHG emissions in 2019 were almost 25% greater than the total GHG emissions of the EU-27[2] and accounted for 7.8% of world GHG emissions (WRI, 2022). The land use, land-use change and forestry (LULUCF) sector in ASEAN is the greatest emitter, reaching around 1.2 gigatonne of carbon dioxide equivalent emissions in 2019. This represents more than half of the global emissions from LULUCF (WRI, 2022). Indonesia is by far the largest emitter of GHGs in the region and the world's fifth-largest emitter of GHGs, driven by forest and carbon-rich peatland conversions (Crippa *et al.*, 2021; WRI, 2022).

[2] *The EU-27 refers to the economies of the European Union (EU), which consists of 27 countries (Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden), as of 1 February 2020.*

ASEAN countries are highly vulnerable to climate change. Stretched across archipelagos, river basins and forests, the region faces the potentially disastrous impacts of rising sea levels and temperatures and extreme weather conditions. Cambodia and Myanmar, for example, have some of the highest vulnerabilities to climate change in the world, paired with low readiness to improve resilience (ADB, 2023). Changes in weather alone resulted in human displacement of 65.2 million people in the region (IDMC and ADB, 2022). Moreover, a lack of access to sustainable energy greatly affects the region's ability to adapt to climate change, with around 45 million people lacking access to electricity and 250 million to clean cooking fuels (IRENA, 2021).

Southeast Asia faces many economic challenges. The Asian Development Bank recently revised down the growth forecast for 2023 from 5.0% to 4.7% (ADB, 2023). Global trade has suffered because of the COVID-19 pandemic, affecting trade-dependent economies like the Southeast Asia region. In several countries, government expenditure to address domestic distributional concerns and align deficit spending with transition objectives has been negatively impacted due to increased fossil fuel subsidies and energy import costs.

Beyond pure economics, the region also could improve on several human well-being indicators. These indicators include employment, education and health. The pandemic has had a disproportionate impact on the livelihoods of those in informal employment: informal workers in Southeast Asia have been the first to lose their jobs (Khana *et al.*, 2021). Most ASEAN countries (with the exception of Brunei Darussalam) have lower shares of education spending in GDP than the average of middle-income countries (around 4.1% of GDP) (World Bank, n.d.). In terms of health expenditure, Singapore has constantly increased domestic general government health expenditure per capita over the last two decades, and Brunei Darussalam has more public spending per capita on health than the average of upper-middle income countries (World Bank, n.d.). These two exceptions aside, overall social spending per capita in Southeast Asia is more than 10% less than the average of the upper-middle income countries (CE, n.d.).

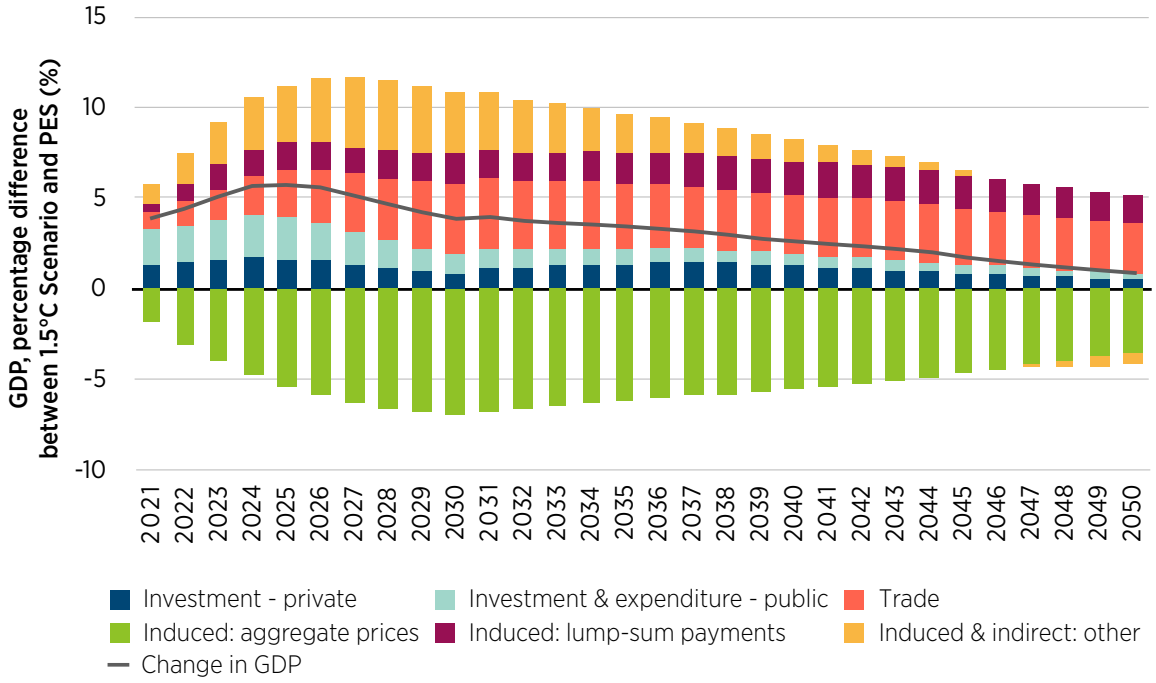
Rising air pollution has been a long-term problem across the region. Outdoor air pollution is extraordinarily high in cities, while indoor air pollution is significant in many rural areas that lack access to clean cooking. Worryingly, this issue will only be exacerbated if the region continues to invest in coal-fired power stations and private motorised transport (UNESCAP, 2017). In 2016, Lao PDR and the Philippines saw the highest mortality rates (per 100 000 population) attributed to household and ambient air pollution in 2016 in the region (World Bank, n.d.). The amount of health costs linked to energy system-related air pollution in Southeast Asia in 2019 was significantly lower (four to six times lower) than the average for the Middle East, China or even the EU-27 plus the United Kingdom (CE, n.d.). Without proper measures to curb reliance on fossil fuels and use of traditional methods, however, these relatively low health costs can increase at an alarming rate in the future.

The region has introduced ambitious goals and targets to address these issues, but challenges remain in policy design and implementation. Nine of the ten ASEAN countries have pledged to achieve net-zero targets as listed in the various long-term strategy documents submitted to the United Nations Framework Convention on Climate Change, or UNFCCC. Several countries have announced plans to reduce reliance on coal, and some have expressed their commitment to phasing down coal but require further regulatory frameworks and roadmaps that allow an accelerated transition because the region is home to the youngest coal-fired plants in the world. Indonesia, for example, has signed up to stop all new coal-fired power plants after the completion of currently planned plants. Overall, the region aspires to have 23% of renewables in the TPES by 2025, along with a 35% share of renewable energy in installed capacity (up from today's 31% share) (IRENA and ACE, 2022). In the national context, several countries have plans for renewables, such as Brunei Darussalam, which has a target of 35% renewables in its power mix by 2035, and Indonesia, with a target of 23% by 2025.

The clean energy transition can drive economic growth in the region

The energy transition, through its systematic shift to renewable energy and energy efficiency, can deliver large socio-economic benefits in Southeast Asia. IRENA's analysis presented in this report shows that Southeast Asia could experience an annual average of 3.4% higher GDP growth under IRENA's 1.5˚C Scenario, compared with the Planned Energy Scenario (PES), over the period 2021 to 2050. In cumulative terms, the region would add around USD 13.1 trillion (in 2019 dollars) to the GDP already anticipated in the PES. Following the initial impact of front-loaded investments, GDP gains would not be as high over time, but in 2050, GDP would still be 1% higher in the 1.5˚C Scenario than in the PES (Figure S1). The main macroeconomic drivers that have key impacts on GDP difference are trade, investment, and indirect and induced effects depending on the considered period in the transition. In the first half of the first decade of the transition (*i.e.* 2021-2025), the investment driver plays the most important role in the difference in GDP, while trade becomes the main driver from the second half of the first decade (*i.e.* 2025-2030). Nevertheless, induced and indirect effects also have an impact in driving differences in GDP from the second half of the first decade in the transition, but to a lesser extent in comparison to the trade driver.

Figure S1 ASEAN's GDP, percentage difference between 1.5˚C Scenario and PES by driver, 2021-2050



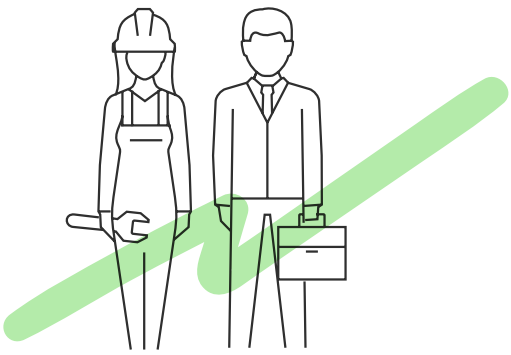
Trade plays an increasingly positive role throughout 2021-2050 in the 1.5˚C Scenario, to the point of being the strongest influencing factor in the last decade of the transition in Southeast Asia (Figure S1). Under the 1.5˚C Scenario, increased renewable energy reliance reduces Southeast Asian countries' import balance for fuels over the period up to 2050, which leads to a notable improvement in the net trade balance and in turn drives up GDP difference significantly by 2050 (equivalent to USD 412 billion[3] in 2050). This improvement in the net trade balance in fuels is a major driver of the GDP impact in the medium term and the main driver in the long term. This is mostly attributable to lower demand for oil and gas imports in Indonesia and for all fuel imports in the rest of the ASEAN countries.

[3] *In 2019 USD.*

The investment driver is the second most influential factor in GDP differences across the transition period. The impact of private investment is positive, although its contribution is quite modest over the entire transition period due to the negative impacts of stranded assets in the fossil fuels sector, which lower the overall net impact. Private transition-related investments (energy efficiency and other end uses, grids and energy flexibility, and renewables) play an important role in overtaking the negative effect of fossil fuel investment in the power sector, crowding out investment in other sectors and the loss of fossil fuel supply investment. Public investment and expenditure boost regional GDP differences during the transition. Due to the energy transition's front-loaded investment needs, most public investment would occur in the first decade of the transition, before decreasing in the following decades. In the 1.5°C Scenario, government social spending rises to USD 26.8 billion[4] (Indonesia accounts for 26%) more than the PES in 2050. It boosts government-provided non-defence services like public administration, healthcare and education, boosting public and personal services. Consumer expenditure also plays a positive role throughout the first two decades in the Southeast Asia region under the 1.5˚C Scenario within the indirect and induced driver. Its impacts are higher until 2030 compared to the latter years of the transition period, when the impacts start diminishing. Household consumption benefits from a diversified economy, investment stimulus and international climate co-operation flows that support low-income households.

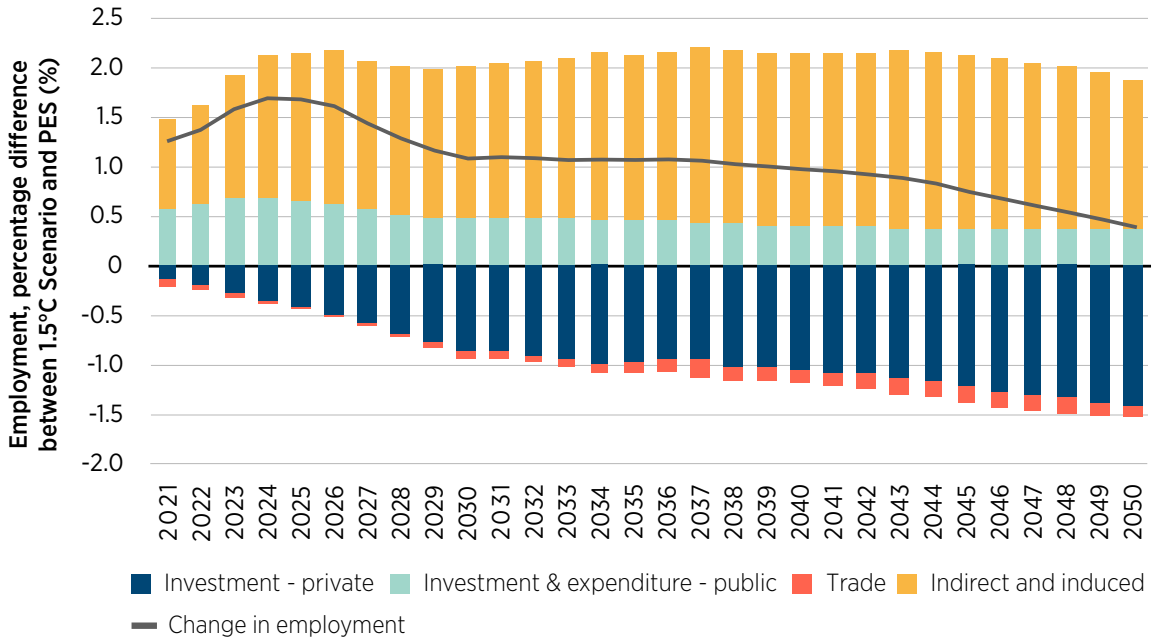
The energy transition drives job creation in Southeast Asia

Under the 1.5˚C Scenario, employment would be higher than in the PES by an average of 1.0% over the 2021-2050 period (Figure S2). The employment gain would reach its peak in the first decade (around 1.7% increase between the 1.5˚C Scenario and the PES, which would be around 6 million additional jobs), then would decline to an estimated 1.2 million additional jobs in 2050 (representing more than 0.3% more jobs than in the PES). This trend is underpinned by drivers mainly related to indirect and induced effects, and investment, while trade has a minor impact. Indirect and induced effects, through increased wages and consumer expenditure, are the main drivers of job creation throughout the transition period. In the 1.5°C Scenario, this driver adds 5.4 million jobs to the PES in 2050. Public investment and expenditure also lead to more jobs. The consequences would be greater in the years to 2030, due to greater government investments in transition-related expenditures (energy efficiency and end uses, electrification, renewables, *etc.*) in the short term. Service-oriented sectors receive greater public funding for building redesign, energy management system upgrades, and retrofits. Compared to the PES, social spending increases during the transition, leading to substantially more new jobs in the region, which benefits from the international climate co-operation flows. By 2050, there are 1.7 million jobs lost due to the loss of fossil fuel supply investment, and 4.4 million jobs lost due to declines in fuel extraction activities. Policy intervention is required to retrain workers for other jobs and avoid major disruptions to living standards. These occupations are typically concentrated in specific countries and have a regional impact, emphasising the need to consider the diverse geographic effects to develop focused policy interventions.



[4] *In 2019 USD.*

Figure S2 Employment in Southeast Asia, percentage difference between the 1.5˚C Scenario and the PES by driver, 2021-2050

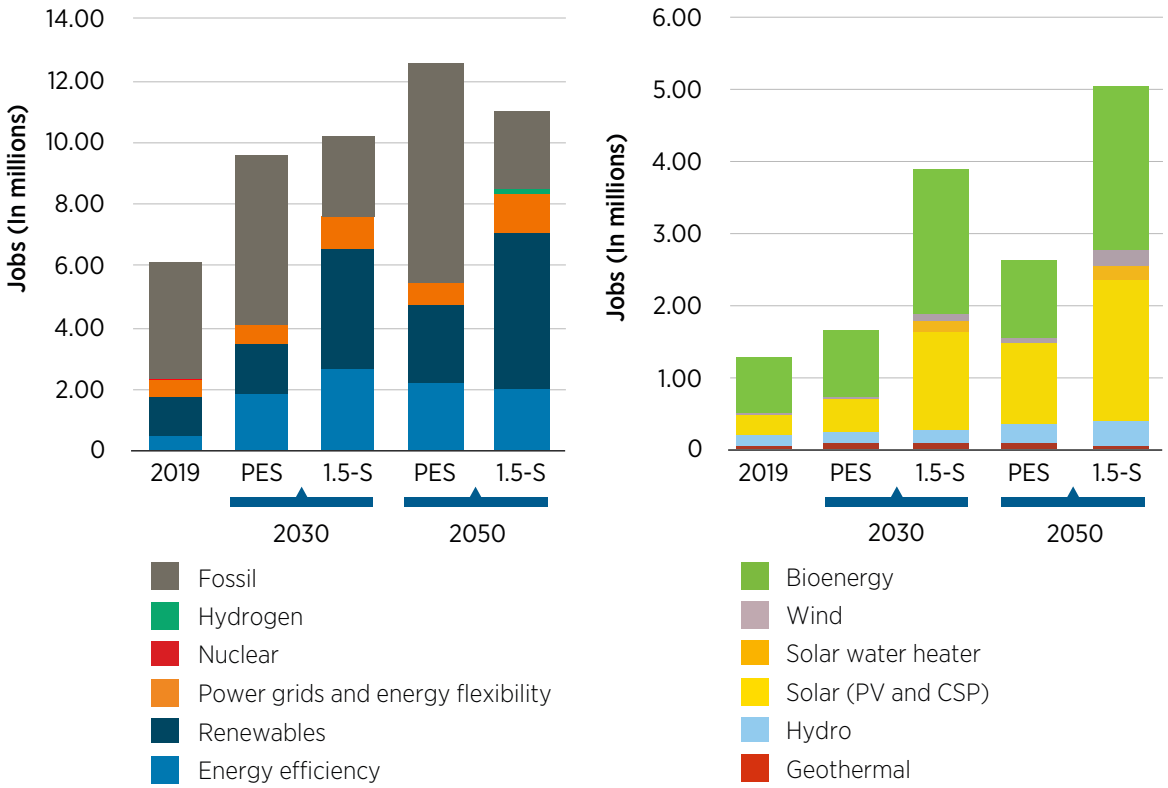


The ASEAN region would also see a higher number of energy sector jobs under the 1.5˚C Scenario than in the PES in the period up to 2030 (left panel of Figure S3). In 2030, total jobs in the energy sector would reach 10.3 million under the 1.5˚C Scenario, compared to 9.7 million in the PES. By 2050, the energy sector under the 1.5˚C Scenario would employ 11 million people, compared to 12.6 million in the PES. This difference in employment between the 1.5˚C Scenario and the PES in 2050 is due to the loss of jobs in the fossil fuel sector, which would be largely but not entirely offset by jobs created by the front-loaded construction of new renewable plants and infrastructure (including investments in energy efficiency).

Renewable energy sector jobs account for around 45.8% of total energy sector jobs, *i.e.* around 5.1 million jobs by 2050 under the 1.5°C Scenario (left panel of Figure S3). This is followed by jobs in fossil fuels accounting for 23.1% (*i.e.* 2.5 million jobs) and in energy efficiency with a share of 18.3% (*i.e.* 2 million jobs). Power grids and flexibility create 1.3 million jobs, representing around 11.5% of total energy sector jobs. Nuclear, vehicle charging infrastructure and hydrogen each contribute less than 1%.

Bioenergy dominates job creation in the ASEAN renewables sector (right panel of Figure S3). Under the 1.5˚C Scenario, bioenergy accounts for 52.4% (*i.e.* over 2 million jobs) of renewable energy jobs by 2030, and 45.4% (*i.e.* around 2.3 million jobs) by 2050. This is followed by solar PV technologies, with 33.8% (*i.e.* 1.3 million) and 38.9% (*i.e.* 2 million jobs) shares in 2030 and 2050, respectively. Hydropower jobs account for 6.3% in 2050 under the 1.5˚C Scenario. Solar water heating and wind energy account for 4% and 4.5%, respectively, in 2050 under the 1.5˚C Scenario.

Figure S3 Energy sector (left) and renewable energy sector (right) jobs in the PES and the 1.5˚C Scenario, 2019, 2030 and 2050



Note: CSP = concentrating solar power; PV = photovoltaic; 1.5-S = 1.5°C Scenario; PES = Planned Energy Scenario.

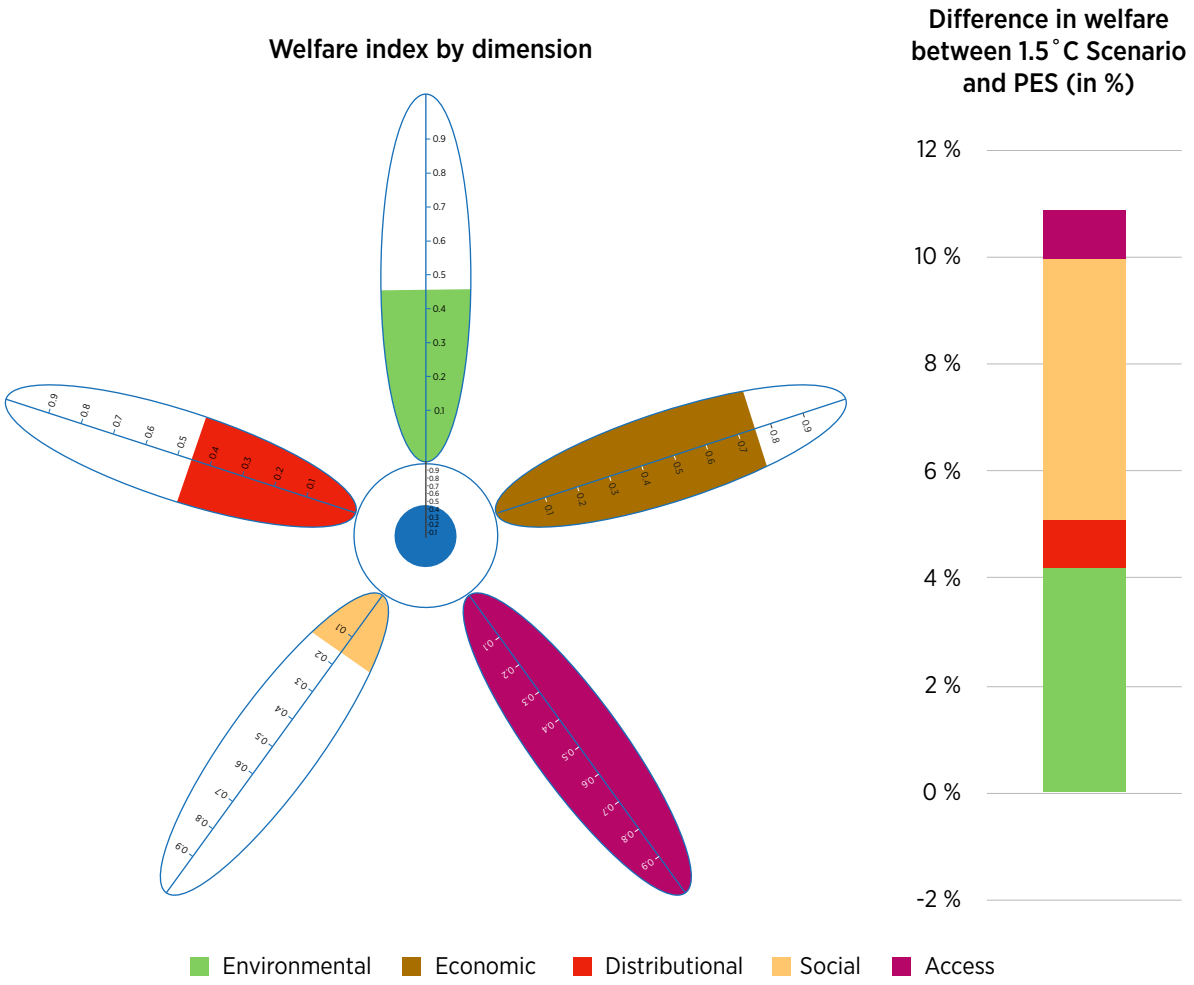
The energy transition has great potential for improving welfare in Southeast Asia

In addition to the specific economic and employment benefits discussed above, a key potential of the energy transition lies in its ability to improve Southeast Asia's overall welfare. Driven by social and environmental dimensions, the improvement in welfare in Southeast Asia under the 1.5°C Scenario, relative to the PES, improves by 10.9% by 2050 (right panel of Figure S4). The energy transition particularly improves public health through significantly reduced indoor and outdoor air pollution. The energy transition would also improve ASEAN's energy access dimension. Southeast Asia achieves universal energy access under the 1.5°C Scenario pathway from 2030. Under both the PES and 1.5°C Scenario, ASEAN's energy consumption reaches the sufficiency level, assumed at 20 kilowatt hours (kWh)/capita/day in line with the literature (Millward-Hopkins *et al.*, 2020),[5] in the first half of the first decade (*i.e.* 2021-2025). This implies that the energy accessed is not only basic, but sufficient. The economic dimension experiences marginal improvement under the 1.5˚C Scenario, mainly due to the slight improvement in the non-employment indicator.[6] The distributional dimension sees small improvements under the 1.5˚C Scenario compared with the PES in Southeast Asia. The small extent of these improvements is due to the limited available flexibility for governments in their spending choices (fiscal space).

[5] *Sufficiency level estimated between 11.6-30.4 kWh/capita/day across all 119 countries depending on the scenarios considered.*

[6] *The state of not having paid work, excluding young people (aged 15 to 24 years) getting an education. Non-employment is hence calculated as the share of the working-age population (aged 15 to 64 years) that is neither employed nor young (aged 15-24) and getting an education. Non-employment is used instead of unemployment or employment metrics because of its more comprehensive gauging of the social implications of paid work, which is the main goal of a welfare index. Indeed, while unemployment and employment are evaluated as shares of the labour force, non-employment is defined on the basis of the entire working-age population (not only the part of it belonging to the labour force), and hence beyond a short-term lack of paid work it also captures a long-term lack of paid work (which is excluded from the labour force).*

Figure S4 Welfare Index by dimension for 1.5˚C Scenario (left) and difference in welfare between the 1.5˚C Scenario and the PES (right), 2050



Note: Left panel: The five petals are on a scale from 0 to 1 and represent the absolute values of the five dimensions of the welfare Index. The number in the centre is also on a scale from 0 to 1 and represent the absolute value of the overall welfare Index.

The analysis suggests that additional policy actions would be needed to further improve welfare indicators in Southeast Asia (left panel of Figure S4). The social dimension offers the highest potential for further improvements via additional policy development, with a focus on the implementation of policies addressing increases in social spending. The environmental and distributional dimensions also offer significant potential for improvement via additional policies. Policies addressing the reduction in the consumption of materials would produce improvements in the environmental dimension. To further strengthen the economic and distributional dimensions, more attention should be paid to policies that increase wealth distribution and create greater fiscal space, which in turn enables improvements in income distribution.

A comprehensive policy framework is needed

For these benefits to be realised, ASEAN countries will require a comprehensive policy framework that not only drives forward the transition of energy systems, but also protects people, livelihoods and jobs. IRENA's climate policy baskets - which underlie the macro-econometric model and the results of which are presented in this report - contain a range of tools (*e.g.* investments in public infrastructure, increased social spending, cross-sector carbon pricing and subsidies, *etc.*) to support a just and inclusive transition, in addition to policies that enable, deploy, integrate and promote energy transition technologies.[7] Addressing justice and fairness is required to ensure support and buy-in by all (including national stakeholders, regional-level actors and citizens) to deliver benefits equitably, to ensure no one is left behind, to ensure costs do not fall disproportionately on disadvantaged groups, and to ensure the energy transition supports rather than counteracts social welfare and equality. The region's energy transition policy framework should be holistic to provide clean and sufficient energy to all and enable a just transition from fossil-based to renewables-based economies. This clean energy transition is a gradual process, with benefits realised over time. Southeast Asia has the potential to benefit immensely from the opportunities created by the clean energy transition if appropriate policies and frameworks are put in place.

[7] *See Chapter 3 and Box 6 for more details.*

01 Introduction

Southeast Asia[8] has witnessed impressive economic growth. Its gross domestic product (GDP) in terms of purchasing power parity (PPP) has expanded at a compound annual growth rate (CAGR) of 4.7% in the past three decades (*i.e.* 1991-2021) despite economic headwinds such as the Asian financial crisis of 1997 and the global financial crisis of 2008-2009.

Economic and population growth, and rising living standards, have resulted in a rapid rise in energy demand. The energy supply in the region has been growing at an average rate of 3% annually for the past 20 years (IEA, n.d.). Much of this increase has been met by fossil fuels, which accounted for 78% of total primary energy supply (TPES) in 2020 (IEA, n.d.). The region's energy demand is expected to continue to grow rapidly over the coming decades; If past years' trends continue, the region is projected to see a CAGR of 4.8% increase in energy demand until 2050 (ACE, 2022a)

Meanwhile, the region's large renewable energy potential remains largely untapped. While total consumption of renewables has increased since the 2000s, their share in the TPES has fallen from 32% in 2000 to 23% in 2020, owing to reduced consumption of traditional biomass. Modern bioenergy, geothermal energy and hydropower make up over 98% of Southeast Asia's renewable energy, despite tremendous growth in solar photovoltaic (PV) and wind (IRENA, n.d.; ACE, 2022a).

Continued reliance on fossil fuel means Southeast Asia is on the path to becoming one of the largest regional greenhouse gas (GHG) emitters in the world. Carbon dioxide (CO_2) emissions in the region have increased at a faster rate than anywhere else in the world over the last few decades, owing to the combined impact of fossil fuel consumption, as well as systematic large-scale land conversion and forest loss. Both trends will continue to produce substantial GHG emissions in the coming decades if they are not stopped by forward-looking policy (IRENA, 2018a).

Increased emissions can be detrimental to Southeast Asian countries that are highly vulnerable to climate change. Stretched across archipelagos, river basins and forests, the region faces the potentially disastrous impacts of rising sea levels and temperatures and extreme weather conditions (IPCC, 2022). The Asian Development Bank (ADB) estimates climate change might reduce the region's GDP by 11% by the end of the century under the business-as-usual case – a higher loss than most of the other regions in the world – because of its impact on agriculture, tourism and fisheries, as well as human health and productivity (ADB, 2015). As home to more than half of the world's population living in coastal and river delta areas, Southeast Asia faces the very real menace that global heating poses to its economies and people (ADB, 2015). This is in addition to the adverse effects of air pollution, and are expected to significantly increase in the coming decades under current policies (WEF, 2019).

Aware of the potential negative impacts of climate change and air pollution, many of the region's governments intend to address these challenges. This includes significant progress in some renewable energy projects and the development of national plans and targets, including in ASEAN countries' Nationally Determined Contributions (NDCs), for a net-zero future. These plans stand in the context of Southeast Asia's many parallel socio-economic challenges, including the need to protect living standards and jobs; expand access to affordable, safe energy; and address numerous environmental challenges and, in recent years, the additional effects of the COVID-19 pandemic. Reconciling all these different priorities is no small feat in a region whose young populations hope to live better lives now and in the coming decades.

[8] *The Member States of the Association of Southeast Asian Nations (ASEAN) are Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam. The terms "ASEAN" and "Southeast Asia" are used interchangeably to refer to this set of countries unless otherwise mentioned.*

Understanding the socio-economic consequences of the transition pathways (at different levels of ambition) is thus a fundamental aspect of proper planning and policy making. Policy makers need to be aware of how such choices will affect people's well-being and overall welfare and of the potential gaps and hurdles that could affect progress. Exploring these complex issues in a series of studies since 2016 (IRENA, 2016, 2018b, 2020a, 2020b, 2021a), the International Renewable Energy Agency (IRENA) has analysed key drivers and impacts, providing insights to support energy transition planning and implementation at global, regional, and national levels. In these studies, IRENA has emphasised that a holistic global policy framework is needed for the energy transition to be successful and broadly beneficial. Different policy elements complement and reinforce one another, covering a broad spectrum of technical, social and economic issues to accelerate the transition and ensure that its benefits are broadly shared and its burdens minimised.

The socio-economic analysis is carried out using a macro-econometric model (E3ME)[9] that links the energy system and the world's economies within a single quantitative framework. It analyses the impact of the energy transition on variables such as GDP, employment and welfare to inform energy system planning and policy making to support a just and inclusive energy transition at the global, regional and national level.

At the global level, IRENA explored these issues in its flagship report, the *World energy transitions outlook: 1.5°C Scenario pathway* (IRENA, 2021a, 2022a) (see Box 1). Two energy roadmaps are analysed: 1) a scenario based on previously announced plans, the Planned Energy Scenario (PES)[10]; and 2) an ambitious energy transition scenario (1.5°C Scenario)[11] that aims to achieve the 1.5˚C goal consistent with the Paris Agreement. The timeframe of the analysis is from 2021 to 2050. It finds that transforming the energy sector can yield widespread benefits: GDP growth averaging an additional 0.5% over the PES through 2030, and energy sector employment reaching 139 million, which is 33 million more than in the PES. Of those 139 million jobs, 38 million would be in renewable energy. Global welfare would be around 20% higher than in the PES. However, these global impacts will be unevenly distributed across countries and regions, depending on local socio-economic structures, the degree of reliance on fossil fuels and other commodities, and the depth of the renewables supply chain, among other factors.

[9] *The E3ME global macroeconometric model (www.e3me.com) is used for the assessment of socio-economic impacts. Energy mixes and related investment, based on the World Energy Transitions Outlook 2022 (IRENA, 2022a), are used as exogenous inputs for each scenario, as well as climate- and transition-related policies.*

[10] *The PES is the reference case for this study, providing a perspective on energy system developments based on governments' energy plans, as well as other planned targets and policies as of 2019, including NDCs under the Paris Agreement. Policy changes and targets announced since then are not considered in the modelling exercise but are mentioned in the chapters to provide insights on latest developments.*

[11] *The 1.5°C Scenario describes an energy transition pathway by which the increase in global average temperature by the end of the present century is limited to 1.5°C, relative to pre-industrial levels. It prioritises readily available technology solutions including all sources of renewable energy, electrification measures and energy efficiency, which can be scaled up at the necessary pace for the 1.5°C goal.*

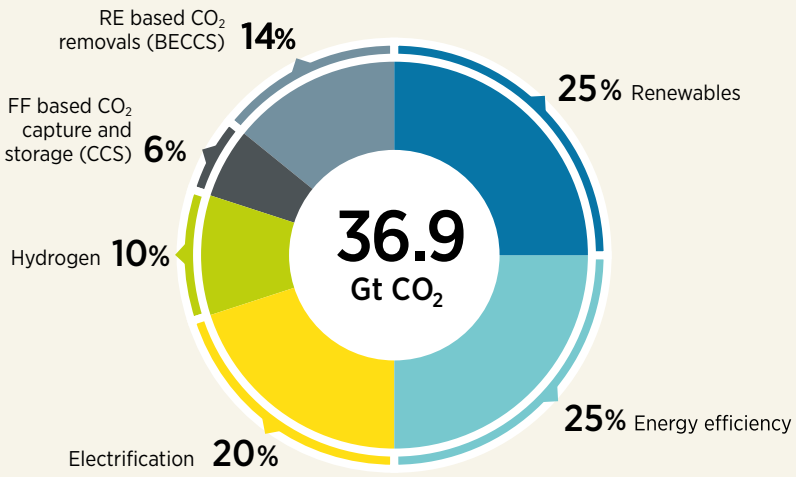
BOX 1 WORLD ENERGY TRANSITION OUTLOOK: 1.5°C PATHWAY

The *World energy transitions outlook* outlines a pathway for the world to achieve the goals of the Paris Agreement and halt the pace of climate change by transforming the global energy landscape. The report presents options to limit global temperature rise to 1.5 degrees Celsius (°C) and to bring CO_2 emissions closer to net zero by mid-century at the global level. It offers high-level insights on technology choices, investment needs, accompanying policy needs and the socio-economic implications to achieve a sustainable, resilient and inclusive energy future.

IRENA's 1.5°C Scenario considers today's proven technologies, as well as innovative technologies that are under development but that could play a significant role by 2050. Figure 1 shows the six main components of the CO_2 emissions abatement based on the most recent edition of the *World energy transitions outlook*. Renewable energy plays a key role in the decarbonisation effort. Over 90% of the solutions in 2050 involve renewable energy through direct supply, electrification, energy efficiency, green hydrogen and bioenergy with carbon capture and storage (Figure 1). Fossil-based carbon capture and storage has a limited role to play, and the contribution of nuclear remains at the same levels as today.

The report presents analysis at a globally aggregated level.

Figure 1 Reducing emissions by 2050 through six technological avenues

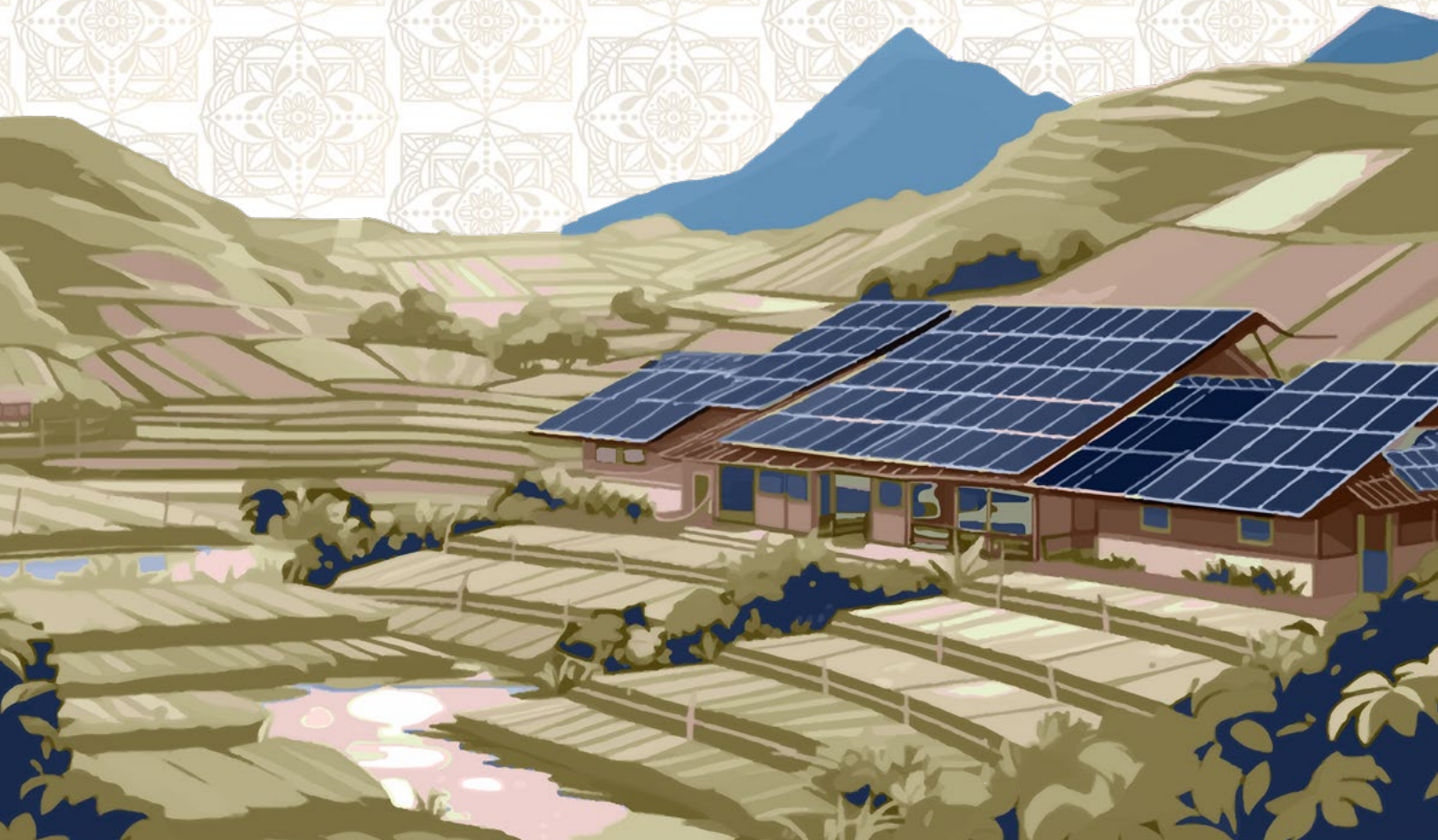


Note: CCS = carbon capture and storage; BECCS = bioenergy with carbon capture and storage; FF = fossil fuels; $GtCO_2$ = gigatonnes of carbon dioxide; RE = renewable energy.

Source: IRENA (2023).

This report on socio-economic impact analysis focuses on Southeast Asian countries and provides insights into how a comprehensive energy transition could affect their economies and people. This report is organised as follows: Chapter 2 provides the macroeconomic overview and trends in the region and discusses some of the key trends and the status of the energy sector and related policies. Chapter 3 presents the main results of the macro-econometric modelling to evaluate the socio-economic impacts of the energy transition in Southeast Asia through to 2050 and shows the extent to which the transformation would affect economic growth (GDP), employment and welfare. Chapter 4 summarises the findings and provides policy recommendations for achieving the energy transition in a just and inclusive manner.

02 Energy and macroeconomic trends

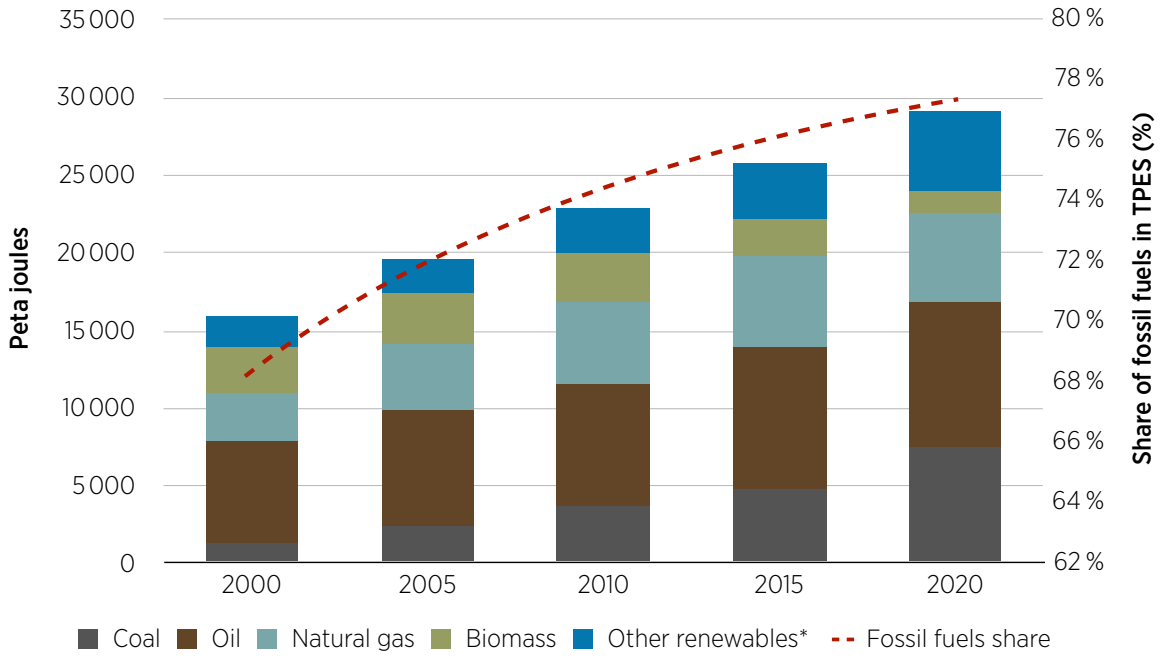


Southeast Asia is a rapidly emerging regional economy with a population that grew almost 11.7% over the decade spanning 2011-2021, reaching approximately 674 million inhabitants in 2021 (UN, 2022). The regional economy grew at a CAGR of 4.1% between 2011 and 2021, reducing poverty and giving rise to an emerging middle class (World Bank, n.d.). In line with this development, regional energy demand has risen rapidly, along with GHG emissions and environmental problems. This chapter provides a background and summarises current trends.

2.1 THE CURRENT ENERGY MIX

Southeast Asia's energy demand and supply have increased rapidly in recent decades. Total primary energy supply (TPES) has expanded at an annual average of around 3% for the past 20 years, reaching 29 100 petajoules (PJ) in 2020 (Figure 2) (IEA, n.d.). Fossil fuels accounted for 77% of TPES in 2020, or 22 500 PJ. Oil is the biggest source of energy. While total renewable energy supply has increased from 5 100 PJ in 2000 to 6 600 PJ in 2020, its share in the TPES has declined from 32% in 2000 to 23% in 2020, owing to reduced reliance on traditional biomass while other energy sources were increasing. The share of other renewables (including modern bioenergy, geothermal, hydro, solar and wind) has increased from 13.1% to 17.5% over the same period. Modern bioenergy, geothermal energy and hydropower make up over 98% of Southeast Asia's renewable energy, despite tremendous growth in solar photovoltaic (PV) and wind. Indonesia and the Philippines have the most geothermal resources, whereas Cambodia, Lao People's Democratic Republic (Lao PDR) and Myanmar have developed hydroelectric resources using their steep terrains and heavy precipitation (IRENA, n.d.; ACE, 2022a).

Figure 2 ASEAN's TPES, by source, 2000-2020



Source: IEA (n.d.).

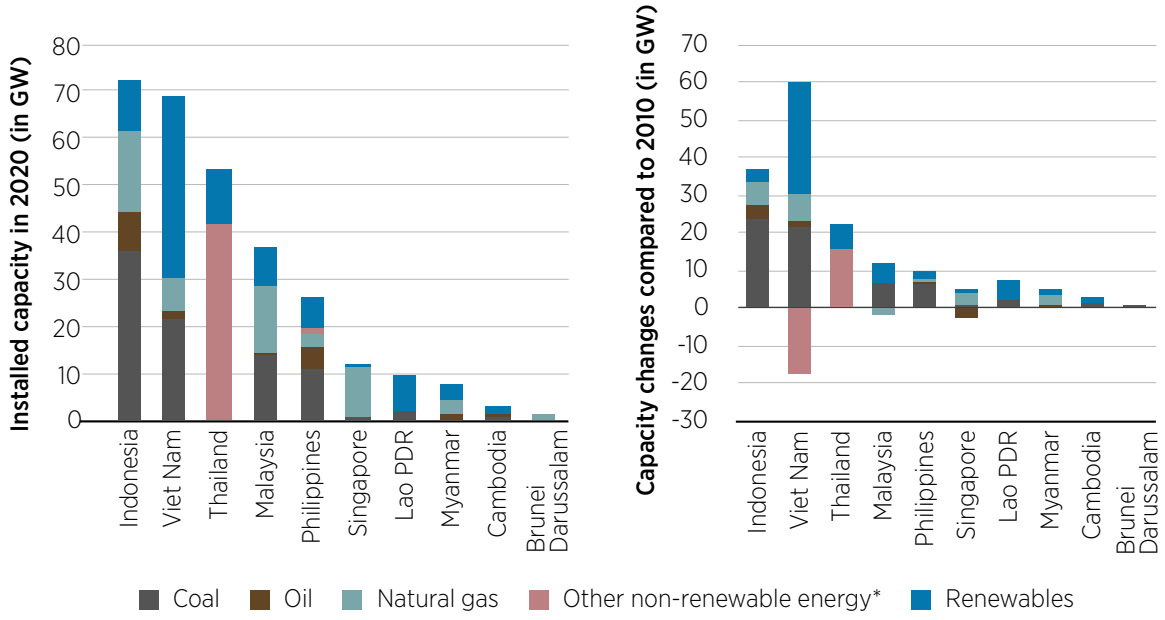
Note: *"Other renewables" includes modern bioenergy, geothermal, hydro, solar and wind.

Total final energy consumption (TFEC) rose by 75% between 2000 and 2020. Industries, including manufacturing sectors, and transportation account for most of this increase. In the transportation sector, oil demand surged 80% between 2000 and 2020, reflecting a significant increase in the number of automobiles and trucks. Since 2005, the number of people living in cities in Southeast Asia has followed a similar trend to the regional population growth, though slightly higher, in the range of 1.1% to 1.6% (ACE, 2022a), contributing to the large reduction in traditional biomass use. Buildings have witnessed the greatest growth in power usage of any sector, owing to an increase in the use of air conditioners and appliances (IEA, n.d.).

Although the region has been a net importer of oil since 2005, six out the ten countries are still net energy exporters (Liu *et al.*, 2019). While the region remains a major exporter of coal and gas, it is expected to become a net importer of natural gas by 2025 and coal by 2039 (ACE, 2022a). This prospect is of significant concern. Countries must carefully monitor their energy import bills, trade balance and supply security as well as diversify their energy sources to meet rising demand and mitigate stress on government spending that is already strained due to an increased debt-to-GDP ratio during the pandemic (ADB, 2022b).

In the power sector, Southeast Asia had a total installed capacity (on-grid and off-grid) of over 292 gigawatts (GW) in 2020 (IRENA, n.d.) (Figure 3). Fossil fuels represented 69% of capacity, led by coal (37%) and followed by natural gas (25%). Renewables provided 31% (89.7 GW), with large intra-regional differences. The highest share of renewable energy was accounted for by hydropower (18% of the total installed capacity); solar energy accounted for around 8% of total installed capacity. Between 2000 and 2020, renewables capacity increased with a CAGR of 5.1% in the first decade, while the speed of deployment was higher in the second one, reaching a CAGR of over 10.5% (Figure 4).

Figure 3 ASEAN's total power installed capacity in 2020 (left) and capacity changes compared to 2010 (right)

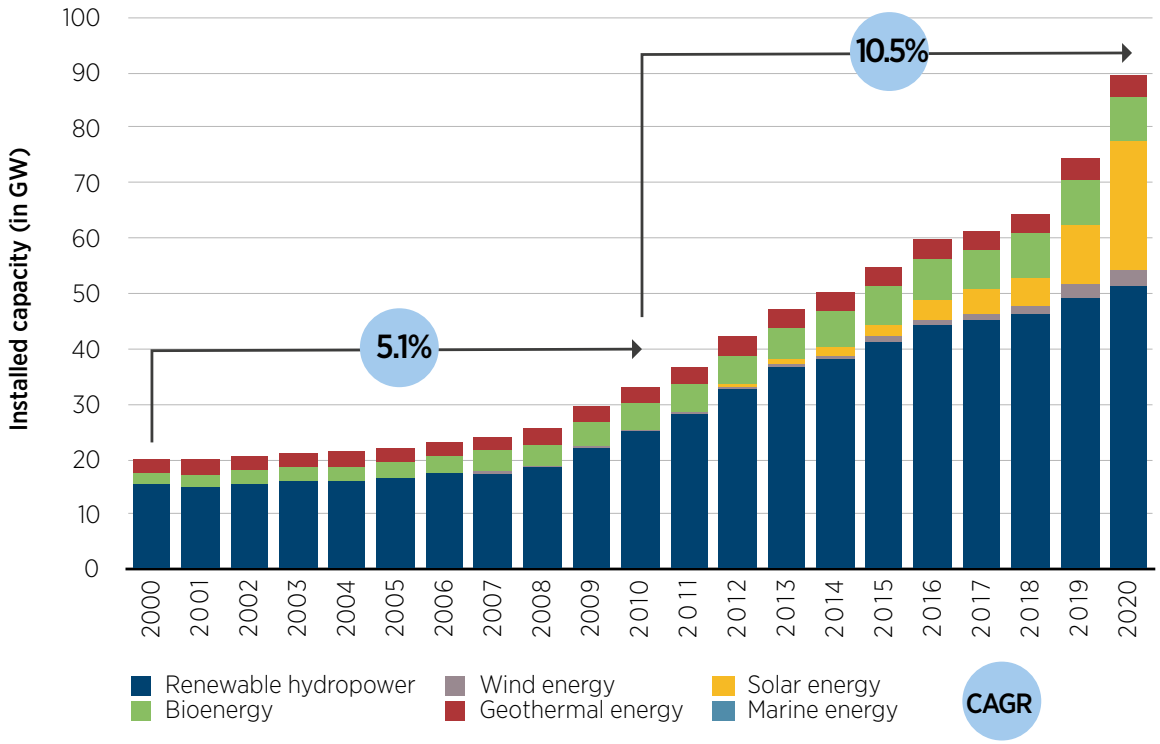


Note: Other non-renewable energy* includes pumped storage, co-products from chemical industries, *etc.*

Source: IRENA (n.d.).

Lao PDR, Cambodia and Viet Nam were among the ASEAN countries with the highest shares of renewables in 2020 in their power capacity mix, with 80%, 56% and 56%, respectively, largely due to hydropower, which accounted for 85% or more of their renewable production (IRENA, n.d.). However, their total capacity in the Southeast Asian power mix represents less than 20%. Larger economies such as Indonesia, Thailand, the Philippines and Malaysia rely largely on fossil fuels, with a share of renewables at around 14.4%, 22.1%, 26.5% and 23.2%, respectively. Viet Nam has seen the largest growth in capacity as well as the largest growth in renewables (led by solar PV) in the past decade (right graph of Figure 3). The country is the second-largest manufacturer of solar PV modules worldwide (Wood Mackenzie, 2022), and nearly 24.2% of its power capacity mix was solar-based in 2020 (IRENA, n.d.). A strong public appetite for clean energy and the government's commitment to it have been major motivators in Viet Nam. In addition, a favourable investment climate and generous feed-in tariffs (FITs) have encouraged business. Malaysia is the fourth-largest manufacturer, while Thailand and Singapore are seventh and ninth globally, highlighting the ASEAN region as an important PV manufacturing centre.

Figure 4 ASEAN's renewable energy installed capacity (GW), 2000-2020



Note: Renewable hydropower is hydropower (excl. pumped storage).

Source: IRENA (n.d.).

The development of renewables in the Southeast Asian region has been driven by industrial policies, in addition to the strategic role of Chinese investments that made Viet Nam and Malaysia solar PV manufacturing hubs. It is also driven by supportive policies, including 1) fiscal policies, together with financial incentives; 2) policies in the power sector; and 3) policies for direct end use (Box 2).

BOX 2 DEPLOYMENT POLICIES IN SOUTHEAST ASIA

Fiscal policies, together with financial incentives

Fiscal incentives, such as various types of tax incentives, are becoming a crucial policy to build up the renewable energy market as an attractive instrument. These incentives have been implemented across the region to encourage more renewable energy investors to enter and participate in the market. They include tax incentives such as tax holidays, tax allowances and value-added tax exemptions, as currently implemented by Cambodia, Indonesia, Malaysia, Philippines, Thailand and Viet Nam.

Cambodia has enacted an income tax exemption of three to nine years from the time of first earned income, and subsequently, a sliding scale of tax breaks on income tax beginning at 25% of the tax due for the first two years, 50% for the next two years and 75% for the final two years, thanks to a newly enacted Law on Investment (Kai, 2022). Malaysia is reported to have extended its Green Investment Tax Allowance and Green Income Tax Exemption until 2023. The schemes offer investors a 2% per annum interest rate subsidy for the first seven years, while financial institutions receive a 60% government guarantee of the cost of green components (Malaysia Sustainable Energy Development Authority, n.d.).

In Thailand, the government has provided financial incentives for factories and animal farms of small and medium size, supporting construction costs of biogas production facilities from waste and wastewater. Biogas is to be used for power, heat and/or biomethane through the Thailand Alternative Energy Development Plan 2018-2037 (Thailand Ministry of Energy, 2020). Viet Nam's investment law defines clean energy as a preferential investment sector and therefore grants eligibility for fiscal incentives. This includes a preferential corporate income tax rate, exemption from import tax for eligible components and exemption from land lease charges in certain localities (Nhat, 2021). However, there is a marked absence of any fiscal or financial incentives in Brunei Darussalam, Lao PDR, Myanmar and Singapore. The development of such measures would be a catalyst to improve renewable energy deployment in their respective markets.

Policies in the power sector

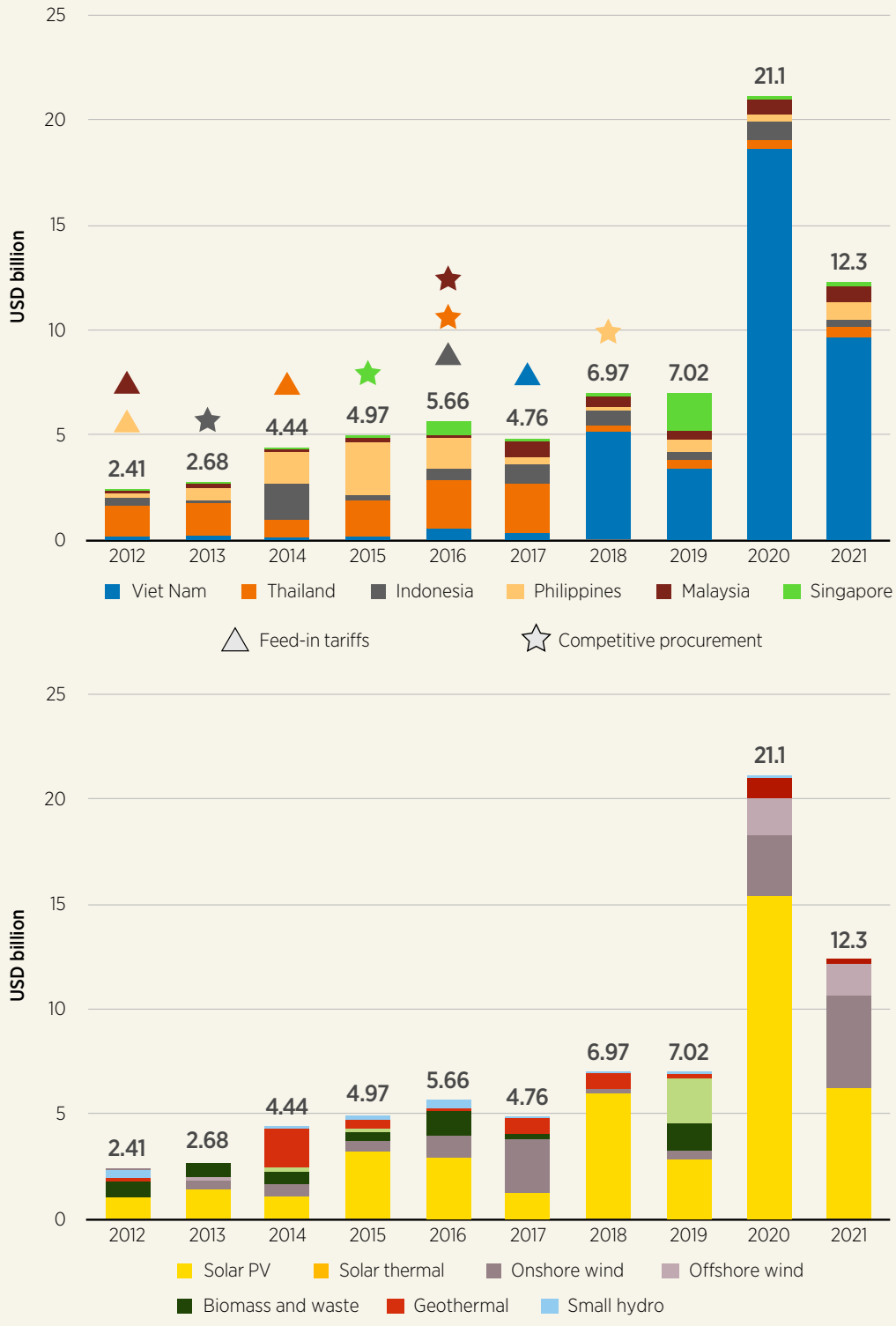
Half of the ASEAN Member States – Indonesia, Malaysia, the Philippines, Thailand and Viet Nam – have implemented FIT schemes (ACE and China Renewable Energy Engineering Institute, 2018). FITs are considered popular entry-level renewable energy schemes because they can encourage the construction of new renewable energy projects by granting long-term purchase agreements for the sale of renewable energy power.

Renewable energy auctions are another effective renewable energy scheme. Renewable energy auctions enable policy makers to scale renewable energy at competitive costs by facilitating price discovery and lowering windfall profits for power companies. Renewable energy auctions can also support objectives beyond price (*e.g.* system integration and development of local industries) and provide speedier project implementation, greater transparency in the selection process and a swift response to changing market values. Among the Member States, the use of renewable energy auctions is seen as an attractive policy to boost renewable energy in the region, with almost all countries already employing this scheme (USAID, n.d.).[12] IRENA has analysed auctions in Southeast Asia in a separate brief on the topic (IRENA, 2022b). Implementing policies such as FITs and auctions boosted renewable energy investments in Southeast Asia (see Figure 5).

[12] *Only Brunei Darussalam has not implemented renewable energy auctions to-date.*

Net-metering has also served as an attractive scheme. The mechanism allows owners of distributed energy generation systems to be compensated if their unused electricity is exported to the utility grid (US NREL, n.d.). Among the Member States, only Cambodia and Lao PDR have not introduced this scheme. Brunei Darussalam was the latest country to implement it.

Figure 5 Renewable energy investments in Southeast Asia by country (top graph) and technology (bottom graph), 2012-2022



Policies for heating/cooling and transport

Beyond the power sector, the deployment of renewables for the transportation sector (including the blending of liquid biofuels and electric mobility) has also developed in the last two decades. However, the sector still heavily relies on fossil fuels, causing air pollution and other adverse impacts. Because of the rapid urbanisation process and economic development in the region, transport demand and energy consumption will likely keep rising in the following decades. As reported in the *7th ASEAN Energy Outlook* report (ACE, 2022a), with an increasing reliance on fossil fuel imports, the ASEAN region could face serious energy security challenges as the availability of energy sources at an affordable price could be jeopardised.

The region has been deploying liquid biofuels for almost two decades. Indonesia, Lao PDR, Malaysia, Philippines, Thailand, and Viet Nam are among the leading countries that have implemented biofuel mandates. For example, Indonesia and Malaysia announced their biodiesel blending policies in the mid-2000s as part of national strategies to promote palm oil-based biofuel production and use. In February 2022, the Indonesian government launched a road test for an increased blending ratio from 30% to 40% biodiesel. The government hopes to reach 100% pure biodiesel in the future to break its dependence on fossil fuel diesel (Indonesia Window, 2022). In 2020, renewable energy investments in biofuels only accounted for USD 0.08 billion (US dollars) out of USD 21.1 billion (0.38%) (see Figure 5). Ambitious biofuel mandates such as Indonesia's will increase renewable energy investments in biofuels.

While palm oil is the main feedstock for liquid biofuel production in this region, it is important to recognise that it has received heavy criticism. Potential concerns include the further pressure on biodiversity, potential risks associated with oil plantations (*i.e.* degradation, increased forest fire hazard and social conflicts between palm oil companies and local communities), as well as issues related to land tenure and benefits distribution for rural people. The future growth of palm oil-based biodiesel should carefully address these concerns to enable sustainable growth (IRENA, 2022b). In terms of bioethanol, the Philippines and Thailand are considered leading countries in this region with measures for a 10% blending ratio in each country. Despite the feedstock issue, the blending ratio for both countries is expected to increase in the future as they aim for more renewables in their portfolios (Lim, 2020; Bloyd, 2009).

Reducing the reliance on fossil fuel imports in the transport sector is not limited to the implementation of biofuel mandates but can also be approached through the promotion of electric mobility in the region. The ASEAN region has expressed strong interest in electric vehicles (EVs) and established precise deployment objectives. Several Southeast Asian countries, including Indonesia, Malaysia and Thailand, have published plans for EV deployment. Singapore has for example set a goal of eliminating the use of all vehicles powered by fossil fuels by the year 2040 in its long-term land transport strategy. Even though the region is still in the early stages of EV deployment, enablers such as charging infrastructure, skilled labour for the operation and maintenance of EVs and associated infrastructure, fiscal and non-fiscal incentives, and public promotion would popularise the uptake of EV transport throughout the region (Kresnawan *et al.*, 2022). Among the ASEAN Member States, Cambodia, Lao PDR, Myanmar and Viet Nam have not set any EV targets or dedicated EV policies (Schröder and Iwasaki, 2021; ACE, 2022b). Nevertheless, in the case of Viet Nam, private companies such as VinFast have attempted to promote EVs. It is certainly only a matter of time before there is another clean energy solutions boom in Viet Nam if the lessons learnt from the solar success can be applied to the promotion of EVs. The pursuit of electric mobility and the development of solar energy could establish a symbiotic relationship (Kresnawan and Yurnaidi, 2021).

2.2 ECONOMIC GROWTH AS MEASURED BY GDP

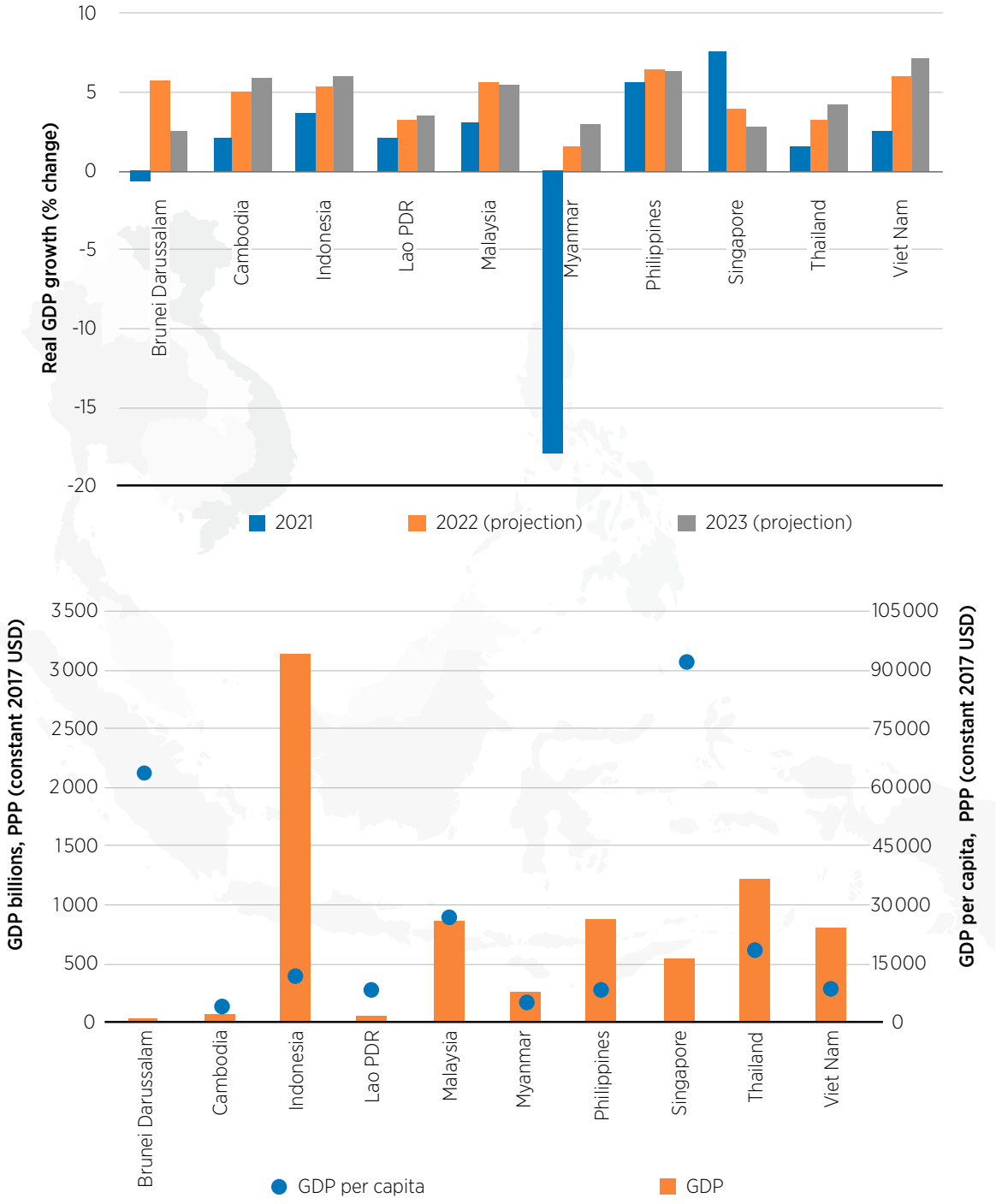
For decades, Southeast Asia has seen economic growth at rates surpassing global averages. Disrupted by the 1997 Asian financial crisis, growth resumed in the 2000s, led by a surging demand for commodities and by the formation of regional production networks and hubs (ERIA, 2014). The COVID-19 crisis affected ASEAN countries significantly in 2020 (Rhee, 2020), although the region rebounded in 2021. All Southeast Asian economies, except Brunei Darussalam and notably Myanmar, observed economic growth. The entire region's GDP was expected to grow by 5% in 2022 and 4.6% in 2023, though at a rate below pre-pandemic trends (IMF, n.d.). As Figure 6 shows, there are substantial differences across countries that relate to economic development and structure, as well as population size.

The ASEAN-5 (Indonesia, Malaysia, the Philippines, Singapore and Thailand) account for the largest share of regional GDP (around 83% in 2021) and took steps in the region towards industrial development (World Bank, n.d.). The CLMV countries (Cambodia, Lao PDR, Myanmar and Viet Nam), on the other hand, have experienced the region's fastest growth recently (IRENA, 2018a; World Bank, n.d.). Indonesia alone accounts for around 40% of population and a similar share (around 40%) of ASEAN GDP. The country is a major exporter of raw materials, and its economy is therefore vulnerable to market price fluctuations (IFC and World Bank, 2019; IRENA, 2021a). Cambodia, Lao PDR and Myanmar have seen higher GDP growth rates than Brunei Darussalam, Malaysia, Singapore, and Thailand on the back of exports of raw materials and light manufactured goods (IRENA, 2018a).

Brunei Darussalam and Singapore, by contrast, are small states with populations of less than a few million people, with very different economic development trajectories; Brunei Darussalam's economy is based on the export of oil and natural gas, whereas Singapore also exports services. Both have high per capita GDPs owing to the structure of their economies and their small populations (IRENA, 2018a). Singapore's per capita GDP (around USD 93 400 in 2020[13]) is more than eight times higher than Indonesia's and more than 22 times higher than Cambodia's.

[13] *In 2017 USD.*

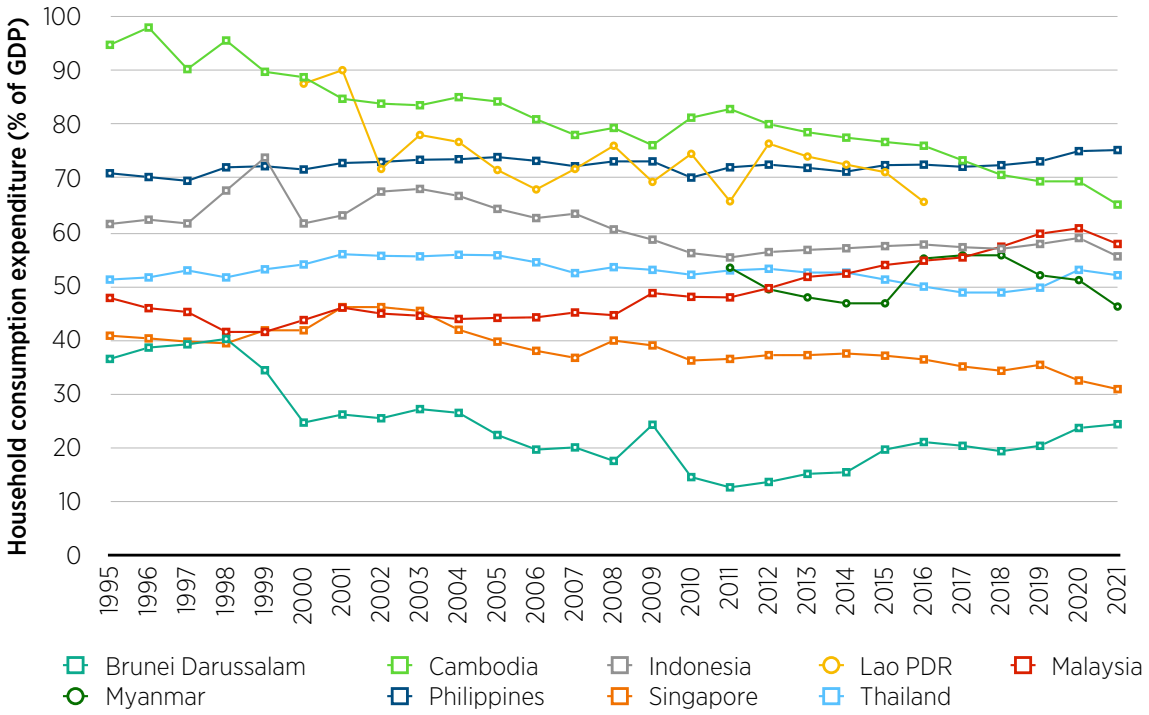
Figure 6 Real GDP growth in Southeast Asia, 2021-2023 (top), and GDP and GDP per capita in 2020 (bottom)



Source: Gulde-Wolf *et al.* (2022); IMF (n.d.); World Bank (n.d.).

Besides some individual economic characteristics, there are several common structural drivers of the development among the countries of the region. One of common characteristics has been the sectoral move away from agriculture in the ASEAN region's larger economies (World Bank, n.d.). Since 2000, the average share of agriculture in GDP has fallen from 21.5% to 11% in 2021, in favour of other sectors (ADB, n.d.). The result has been growing household consumption owing to higher incomes and the emergence of a larger middle class (Figure 7) (IRENA, 2018a).

Figure 7 Evolution of household consumption expenditure in Southeast Asia, 1995-2021



Source: World Bank (n.d.).

Note: Data for Viet Nam are not available.

The region has also become a major manufacturing and trading hub (IRENA, 2018a). Over the past two decades, manufacturing value added has on average been around 18% of the GDP. Particularly in the case of CMLV countries, the share of manufacturing value added grew from 9% in 2000 to 17% in 2020. Several subsectors within the manufacturing sector are supported by local content policies, including renewables, other efficiency, and transportation sectors.[14] Indonesia, for example, has been aiming to become a regional hub for EVs by 2030 and has created several incentivising industrial policies to encourage investment in this sector. The country has implemented local content requirements (LCRs) for EV batteries: by 2021, electric four-wheelers produced in Indonesia were supposed to reach at least 35% local content, rising to at least 40% by 2023, at least 60% by 2029 and at least 80% by 2030. This local content requirement not only capitalises on the fact that Indonesia is a leading producer of nickel (a critical raw mineral needed to produce lithium-ion batteries) but also aims to increase value added to domestically sourced raw materials (Box 3). Other examples include Indonesia's target on local content in solar PV and Malaysia's Large-Scale Solar programme requirement to have local companies with 51% Malaysian equity as bidders.

[14] *Local content policies ensure that the energy transition at the industrial level includes local markets and workforces. At the base level, policies could require a percentage of a project's costs to utilise locally produced components and services (e.g. engineering, consultancy fees, equipment and more), but more robust policies go further to require using local employment, promoting knowledge sharing, facilitating local innovation and connecting local suppliers into larger supply chains (IRENA, 2020).*

BOX 3 LEVERAGING EXISTING RESOURCES TO MOVE UP THE SUPPLY CHAINS FOR GREATER VALUE ADDED

Southeast Asia is rich in mineral markets to support the energy transition. Indonesia in particular has taken an all-in approach to upgrading its global domination of nickel production to become the EV hub of Southeast Asia. This is an example of a country leveraging its resources to creating greater value-added and moving up the supply chain.

The ASEAN market overall is one of the largest mineral markets in the world, and the development of this sector is key to the socio-economic development of this region (ASEAN Secretariat, n.d.). In October 2021, the 8th ASEAN Ministerial Meeting on Minerals approved Phase 2 of the ASEAN Minerals Cooperation Plan for 2021-2025. Phase 2 efforts include increasing investments in all parts of the minerals value chain, adopting sustainable development principles and expanding stakeholder engagement, building all-around capacity around minerals governance, and developing improved and efficient data collection and processing tools for an information system for the region (Viet Nam Plus, 2021).

The expansion of the manufacturing and industrial sectors in the region has also been bolstered by foreign direct investment (FDI). For example, the Philippines and Viet Nam had 8% and 23% of gross capital formation, respectively, in 2019 via FDI (ADB, n.d.). The United States, the European Union, and Japan have generally been the largest sources of FDI. Since 2015, however, investment from Asian economies (*e.g.* Chinese investments in solar PV) has increased significantly as manufacturers have searched out new low-cost locations and pushed to access ASEAN markets more thoroughly.

Innovative financing schemes are gaining traction to address the continuously growing need throughout the region. Indonesia has the largest economy in Southeast Asia, and that has impacts on the type of financing support it can attract. To mobilise the private sector to help fund the gap in its national development objectives, the Indonesian government has supported the deployment of several initiatives in the past five years that attract private investment, such as SDG Indonesia One and PT Penjaminan Infrastruktur. SDG Indonesia One, Indonesia's national infrastructure finance institution, is a unique integrated funding platform with a USD 4 billion target split into four pillars of support based on donor and investment interests: development, de-risking, financing and equity facilities. As of March 2022, the total commitment from 35 partners had reached USD 3.27 billion. Among other outcomes, a 13.48 megawatt (MW) capacity for renewable energy power plants provides potential for emission reduction of about 5 867 tonnes of carbon dioxide equivalent per year (tCO_2eq/yr) and access to clean water for about 2 000 families (Pranawa, 2022). The PT Penjaminan Infrastruktur is an infrastructure guarantee fund that the government has set up within the ministry of finance, a vital piece of its blended finance for development (Merchant, 2020).

The region has other energy sector-specific initiatives to bring in further access to finance. At the regional level, the ASEAN Green Catalytic Green Finance Facility (ACGF) is an example of an innovative approach based on the co-operation of ASEAN Member States and partnership with an international development finance institution, ADB. The ACGF pairs technical assistance (*i.e.* helping ASEAN Member State governments to identify and prepare bankable projects) with ACGF loans (from the ASEAN Infrastructure Fund and co-financing partners that covered upfront capital investment costs) to de-risk projects. This in turn mobilises commercial investment into green projects. Since its launch in 2019, the ACGF has attracted USD 2 billion in co-financing pledges and has supported projects ranging across renewable energy, energy efficiency, sustainable urban transport, water and waste management, and climate-resistant agriculture (ADB, 2022a; ADB, n.d.). The facility also has received support from

the European Union and other international agencies (ADB, 2021). ADB has also been supporting its members through different instruments and advisory services (ADB, 2022c, 2022d).

In November 2021, the ADB launched a new partnership with the Philippines and Indonesia called the Energy Transition Mechanism (ETM), the first of its kind in the Asia Pacific region. The first seed financing for the ETM was USD 25 million from Japan's ministry of finance. This blended finance approach has the goal of retiring coal-fired power plants on an accelerated schedule. Through the mechanism, a 246 MW coal plant in the Philippines has already reduced its expected life of 50 years by half (ACEN, 2022). Similarly, the retirement of Cirebon-1, a 660 MW coal plant in West Java (Indonesia) is also under advanced discussion (ADB, 2022c). ADB will work with government stakeholders to determine the optimal business model for each country. In addition, the ETM consists of two multimillion-dollar funds: one is entirely focused on retiring or repurposing existing coal-fired power plants and the other is dedicated to new clean energy investments in energy generation, storage and grid upgrades (Hickey, 2021).

One of the biggest challenges for ASEAN Member States will be deciding how and where to allocate scarce public funds as they work to recover the economy, given that public funds currently finance 75% of green projects (Climate Bonds Initiative, 2019). In the bid to diversify their energy mix and to increase renewable share, all countries in the region have reconsidered their investments in fossil fuels, especially in coal-fired power plants in the power sector. Major ASEAN coal users signed the Global Coal to Clean Power Transition Statement at COP26. These include Brunei Darussalam, Indonesia, Philippines, Singapore and Viet Nam, which together account for more than 60 GW of coal installed capacity.

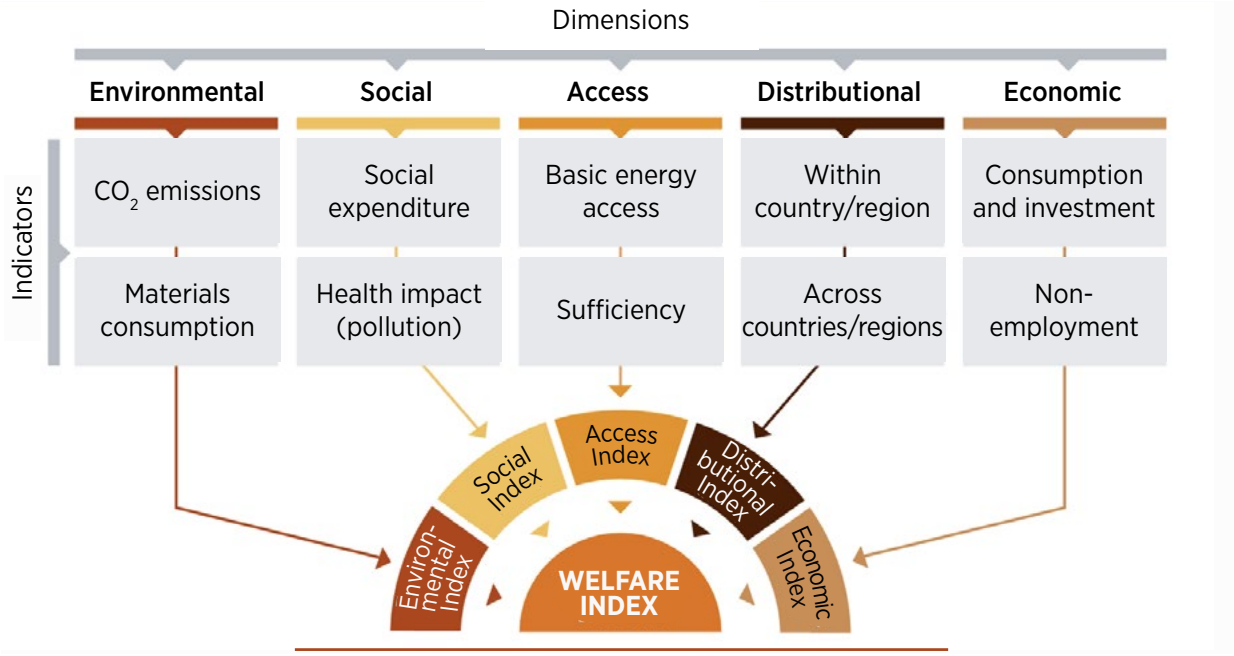
The average share of government expenditure in GDP in most Southeast Asian countries has historically been lower than the average of middle- and high-income countries (World Bank, n.d.), and general government spending varies greatly across the ASEAN region as well. Brunei Darussalam – which spent 22.4% of its GDP in 2021 – has the highest share of general government expenditure in GDP in ASEAN region (World Bank, n.d.). In contrast, Cambodia's government spending in 2020 accounted for only 7.6% of its GDP, the lowest share in the region (World Bank, n.d.). Despite the perceived scarcity of public funds, substantial funds could be unlocked and redirected from fossil fuel subsidies to support the clean energy transition. Fossil fuel subsidies in Southeast Asia during 2010-2020 were on average USD 32 billion per year and were set to increase in line with crude oil prices due to major subsidy contribution to oil consumption (IEA, 2022). Subsidising fossil fuels with limited public funds can have a negative impact on ASEAN's ability to expand its use of renewable energy and other low-carbon alternatives (IISD, 2014).

The ASEAN region includes both developing and developed countries, some of which are leaders in the research and development (R&D) of energy transition technologies, while others receive support from international development finance institutions, foreign governments or ASEAN counterparts. Singapore is among the frontrunners in promoting R&D, having awarded over USD 100 million in grants to more than 60 companies and 20 research institutes. Malaysia is also well supported in R&D, thanks to government funding and a collaborative stakeholder environment. However, the region could still improve support for renewable energy R&D to facilitate its energy transition. One way to achieve this is through increased public spending on education and R&D.

2.3 THE DIMENSIONS OF IRENA'S WELFARE INDICATOR

GDP is the standard measure of economic output. The concerns of citizens, however, go beyond GDP, because it does not include or value factors that are not priced into the market, such as human health, fulfilling jobs and environmental quality. And while climate change will likely have negative impacts on future GDP, it also will have significant impacts on societies, nature and economies that no measure of GDP captures. Conventional indicators such as GDP are thus incomplete, as they do not consider future constraints of natural resources and climate. To incorporate some of the aspects of social well-being, IRENA has developed and upgraded a Welfare Index (IRENA, 2016, 2019, 2020a, 2020b, 2021a, 2022a) for use in its benefits analyses. The indicator has five dimensions relating to the energy transition: economic, social, environmental, distributional and access. Each dimension is composed of two indicators (Figure 8).

Figure 8 Structure of IRENA's Energy Transition Welfare Index



Source: IRENA (2022a).
Note: CO_2 = carbon dioxide.

The economic dimension is composed of an indicator that measures consumption and investment per capita and another that measures non-employment as the ratio of the share of the working-age population (age group from 15 to 64 years) that is neither employed nor under education while belonging to the 14-24 age group. In Southeast Asia, rising incomes, combined with growing populations and urbanisation, are raising household consumption, but consumption is still considerably lower than in high-income countries.

Similarly, while investment shares of GDP in the region are high when compared to the rest of the world, most Southeast Asian countries need substantial infrastructure investments – particularly in their transport, communication, energy, water supply and sewerage sectors. This will not only improve their economic competitiveness, but perhaps more importantly, liveability, human capital and health in the region (UNESCAP, 2017).

In 2019, consumption and investment per capita in Southeast Asia was USD 3 690, significantly lower than the global average of USD 8 707 (CE, n.d.).[15] Unemployment in Southeast Asia is on average around 3% (see Chapter 2, Section 4 for more information), which is low in comparison to the average unemployment in lower-middle-, upper-middle- and high-income countries at around 5.9%, 6.8% and 5.7%, respectively (World Bank, n.d.). Non-employment is also low: around 12.6% of the Southeast Asian population in 2019 (*e.g.* the Middle East region is around 41.4%, while the EU-27[16] plus the United Kingdom is at 18.1%) (CE, n.d.).

The two indicators of the social dimension are social expenditure per capita on education and health costs per person linked to energy system-related air pollution. Economic development has improved health and education, resulting in a better quality of life for Southeast Asian citizens (ERIA, 2014; World Bank, 2019). Nevertheless, the region's average indicators on education and health are lower than expected for its income levels, jeopardising the potential for future development and prosperity. Unequal access to healthcare and education widens income inequalities (World Bank, 2019) (see the distributional dimension), and the prospect of higher mortality owing to increased air pollution in Southeast Asia is a very real threat.

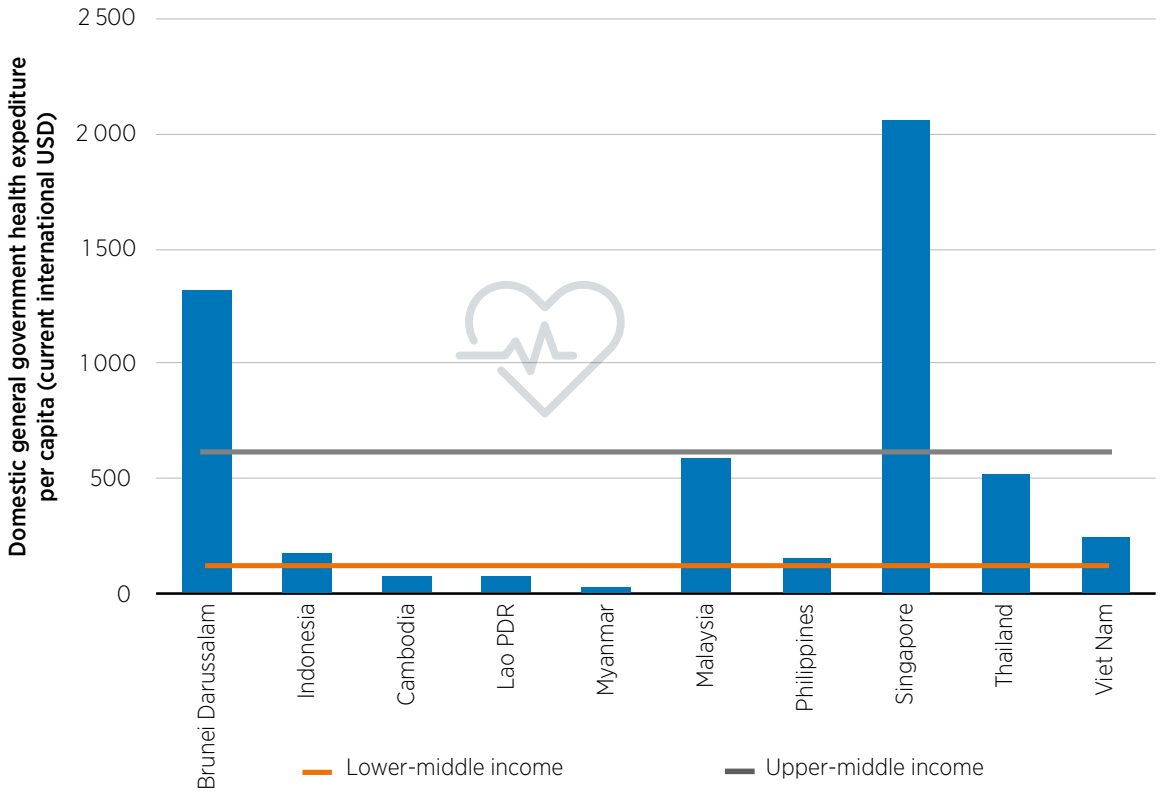
Most ASEAN countries have lower shares of education spending in GDP than the average of middle- and high-income countries (around 3.8% and 4.8% of GDP, respectively) with the exception of Brunei Darussalam, Malaysia, Viet Nam and the Philippines, which are greater than 3.5% of GDP (World Bank, n.d.). Only Singapore – which has constantly increased domestic general government health expenditure per capita over the last two decades – and Brunei Darussalam have more public spending per capita on health[17] than the average of upper-middle income countries (Figure 9) (World Bank, n.d.). Overall, social spending per capita in Southeast Asia is over 10% less than the average of the upper-middle income countries (CE, n.d.).

[15] *Amounts of consumption and investment per capita are in 2019 USD.*

[16] *The EU-27 refers to the Economies of the European Union (EU), which consists of 27 countries (Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and Sweden), as of 1 February 2020.*

[17] *In PPP.*

Figure 9 Public health expenditure per capita in Southeast Asia, 2019



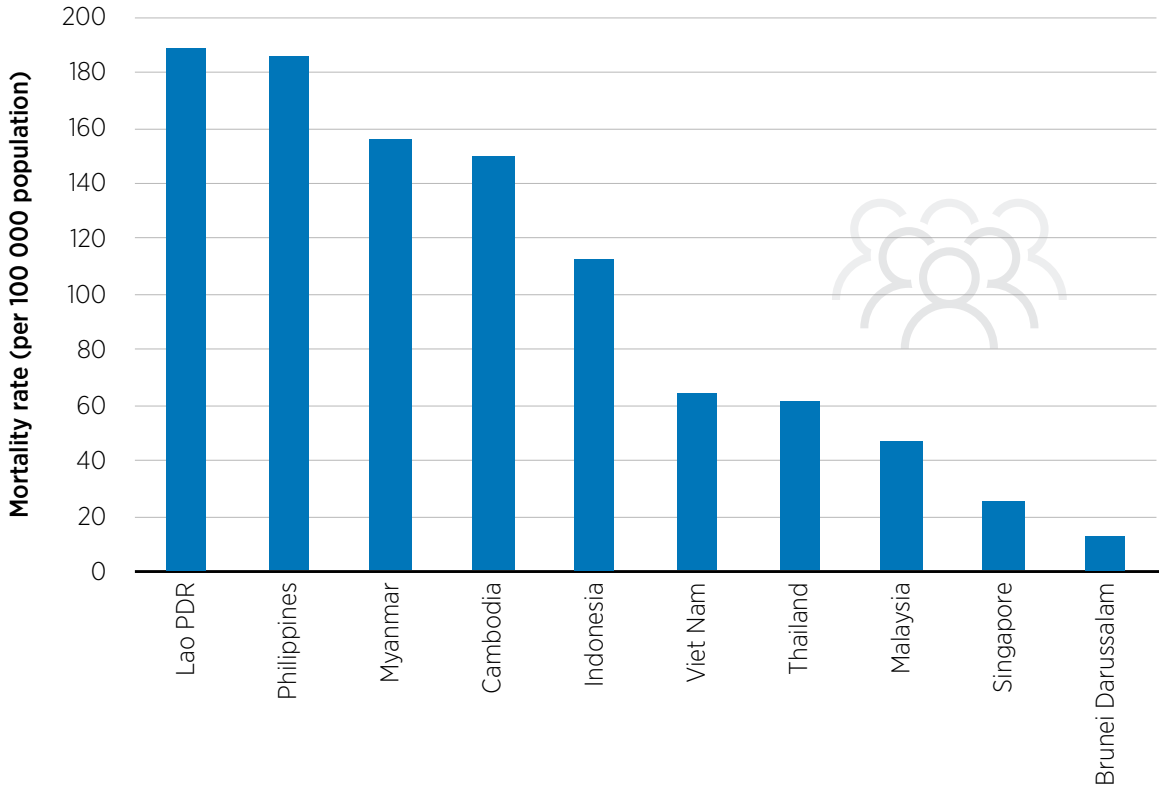
Source: World Bank (n.d.).

Air pollution is a significant health issue in Southeast Asia. Outdoor air pollution is extraordinarily high in cities, while indoor air pollution is significant in many rural areas that lack access to clean cooking. Worryingly, this issue will be exacerbated if the region continues to invest in coal-fired power stations and private motorised transport, in addition to deforestation[18] (UNESCAP, 2017). In 2016, Lao PDR and the Philippines saw the highest mortality rates in the region due to air pollution (Figure 10). High indoor temperatures may also cause heat stroke, stress and further mortality (Bhattacharya *et al.*, 2021). Good progress has been made in reducing deforestation in the region. Indonesia's primary forest loss has declined since 2015, although the region lost 1.4 million hectares (ha) (equivalent to half the area of Belgium) and Indonesia lost more than 0.9 million ha (equivalent to the area of Cyprus or one-third that of Belgium) in 2016 following a year of major fires in 2015 (Global Forest Watch, n.d.). As part of the Paris Agreement, Indonesia plans to reduce yearly deforestation to 325 000 ha between 2020 and 2030 (EU REDD, n.d.). Health costs amounted to USD 192 per person in Southeast Asia in 2019 – significantly below the Middle East average of USD 1168, China's average of USD 1011 or even the EU-27 plus the United Kingdom average of USD 723 (CE, n.d.).[19] Without proper measures to address fossil fuel operation and development, however, these relatively low health costs may increase at an alarming rate in the future.

[18] *Increased deforestation leads to reduced humidity, which in turn leads to more rapid spread of forest fires, which in turn increases air pollution through GHG emissions.*

[19] *Health costs are in 2019 USD.*

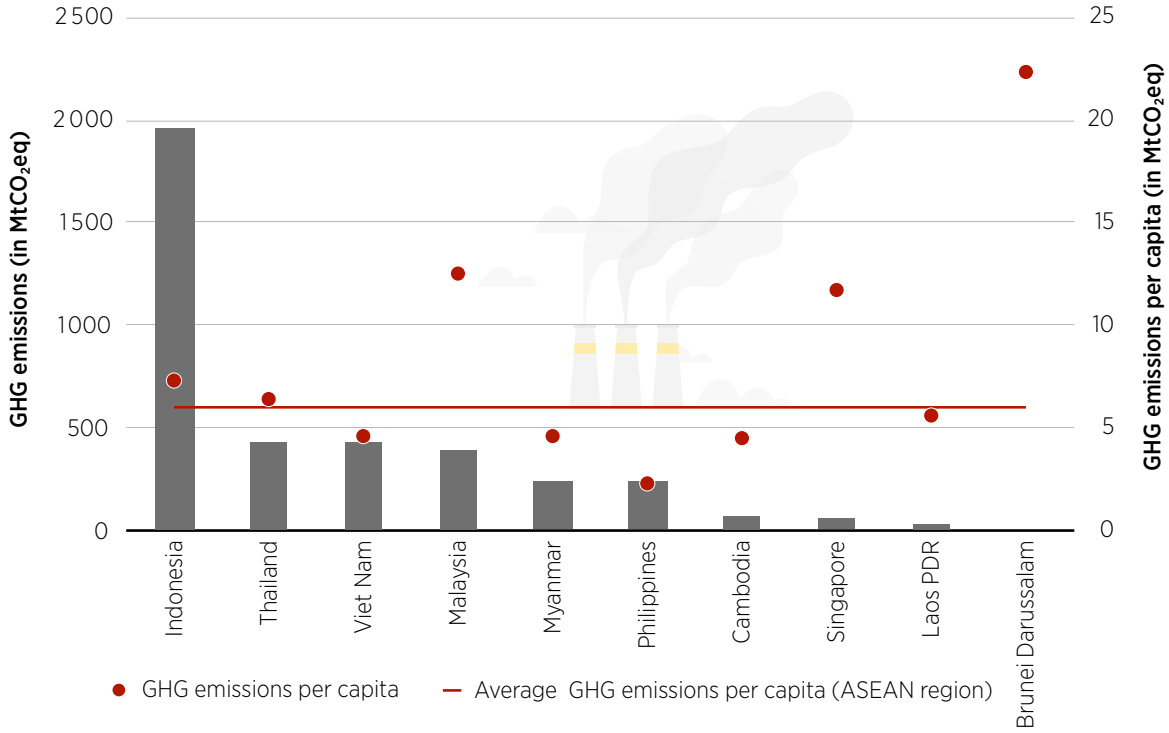
Figure 10 Mortality rate attributed to household and ambient air pollution, age-standardised (per 100 000 population) in Southeast Asia, 2016



Source: World Bank (n.d.).

The environmental dimension of welfare in Southeast Asia is extremely important. The region is highly vulnerable to climate change and the large health impact of air pollution, which is already affecting the region. The actual effect of this dimension of IRENA's Welfare Index reaches far beyond the index's own measure; climate change will have a vast effect on Southeast Asia's economies, beyond what is measurable by current econometrics. ASEAN countries' CO_2 emissions have been rising rapidly due to the region's heavy reliance on fossil fuels for power generation, as well as large-scale deforestation and land conversion (IRENA, 2018a). The ASEAN region's total GHG emissions in 2019 were almost 25% greater than the total GHG emissions of the EU-27 and account for 7.8% of global GHG emissions (WRI, 2022). Indonesia is by far the largest emitter of GHG emissions in the region (Figure 11), and the world's fifth largest emitter, driven by forests and carbon-rich peatlands conversion (Crippa *et al.*, 2021; WRI, 2022). The land-use change and forestry (LULUCF) sector is the greatest emitter, reaching around 1 gigatonne of carbon dioxide ($GtCO_2$) equivalent emissions in 2019. This represents more than half of the global emissions from LULUCF (WRI, 2022). Focusing on CO_2 emissions only, Indonesia was still the world's tenth-largest emitter from fuel combustion (IRENA, 2021a). Cities are much more polluted than rural areas, highlighting the challenge of rapid urbanisation, but also the potential for efficiency improvements and decoupling (UNESCAP, 2017).

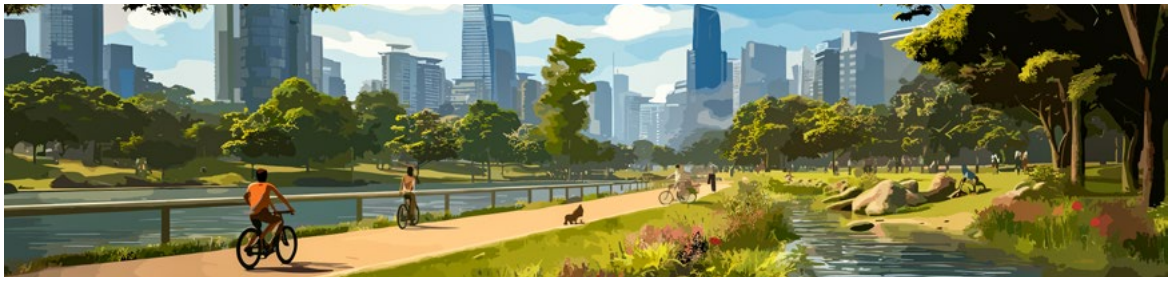
Figure 11 Total and per capita GHG emissions in Southeast Asia, 2019



Source: Emissions Database for Global Atmospheric Research (EDGAR) in Crippa *et al.* (2021); Climate Analysis Indicator Tool (CAIT) Database in WRI (2022).

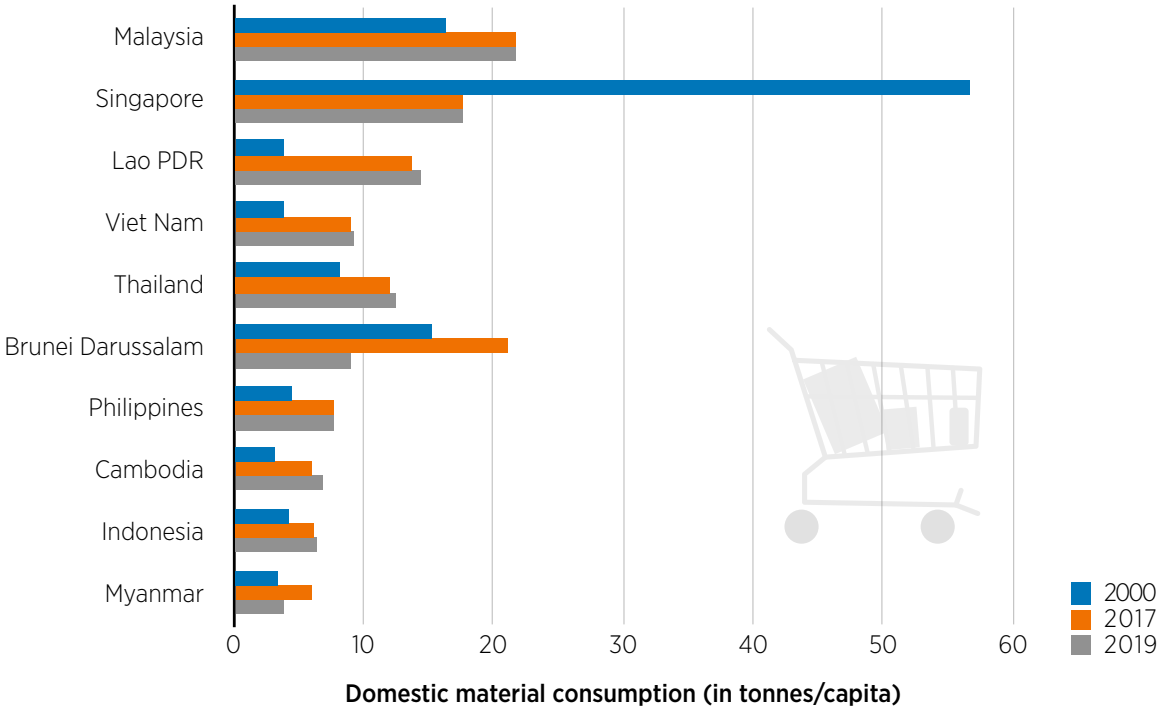
Domestic material consumption (DMC),[20] the other measure included under the environmental dimension of welfare in IRENA's Welfare Index, has risen dramatically in Southeast Asia. With the exception of Singapore and Brunei Darussalam, DMC has increased everywhere in Southeast Asia over the past 20 years, with particularly large increases in Cambodia, Indonesia, Lao PDR, Malaysia, Thailand, the Philippines and Viet Nam (Figure 12). Material consumption has increased only slightly in recent years, owing to the construction of new infrastructure and the outsourcing of the material- and energy-intensive stages of production from high-income countries to less resource-efficient countries. The shift in production from the former to the latter means that more natural resources are needed to produce the same output (UN, 2019).

In per capita terms, Cambodia, Lao PDR and Viet Nam more than doubled their DMC from 2000 to 2019 (OECD, n.d.). DMC per capita decreased by at least threefold in Singapore between 2000 and 2019, reaching 17.6 tonnes per capita (t/capita), due to a decline in material resources imports (mainly construction minerals) since 2000 (Schulz, 2007; OECD, n.d., 2022). Nevertheless, Singapore's DMC per capita is still higher than that of other countries (except Malaysia) and almost five times higher than Myanmar's (Figure 12).



[20] *DMC measures the total amount of materials directly used by an economy and is defined as the annual quantity of basic materials extracted from domestic territory plus all physical imports minus all physical exports.*

Figure 12 DMC per capita in Southeast Asia



Source: OECD (n.d.).

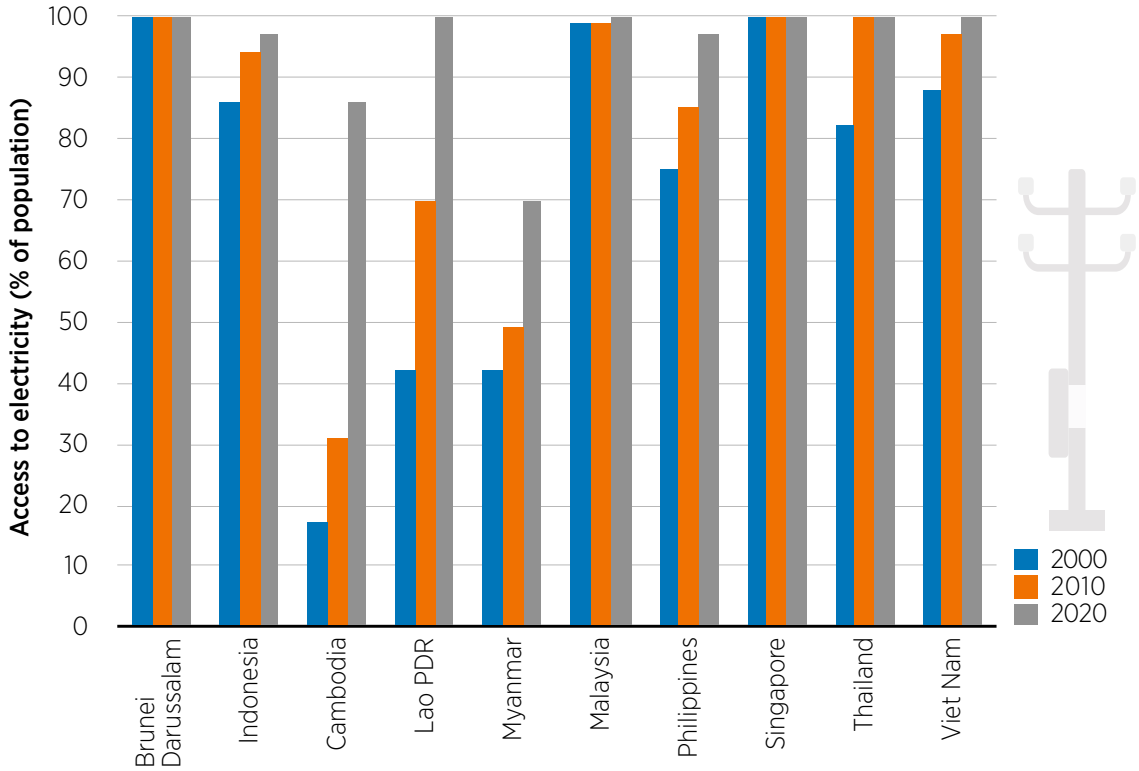
As Figure 12 shows, many countries in the region have still low DMC values (compared to OECD's average of 17.5 t/capita in 2019, for example), despite the increase over the past decades. Material consumption focused on metal ores, non-metallic minerals, and biomass for food and feed in Southeast Asia (3.5 t/capita in 2019) was lower than the global average value (5.3 t/capita) (CE, n.d.). Compared to another region in the world, ASEAN's material consumption is significantly less than the EU-27 plus the United Kingdom figure, which is 12.1 t/capita, but higher than the five African regions (which vary between 0.7 and 2.5 t/capita) (CE, n.d.). Looking ahead, resource productivity and decoupling economic activity from environmental pressure should be prominent policy objectives in Southeast Asia to align economic development with environmental and social objectives (UNESCAP, 2017).

The distributional dimension measures income and wealth inequalities within and across regions and countries. There is a lack of granular data on wealth, household income and wages, which hinders full understanding of the social structure in ASEAN countries and the needed policies to provide equitable opportunities (UNESCAP, 2017). The indicator used is the quintile[21] ratio, which is the ratio of the highest quintile of income/wealth distributions to the lowest quintile of income/wealth distributions. Based on quintile ratios, income inequality in Southeast Asia has improved since 1995 (WID, n.d.). The income quintile ratio decreased from 71.6 in 1995 to 41.0 in 2021 in Southeast Asia, which is still double the income quintile ratio in the European Union (*i.e.* 20.5 in 2021). Nevertheless, wealth inequalities remained constant and significant in Southeast Asia in the same period, at the same level as the European Union with a wealth quintile ratio of around 85 in 2021 (WID, n.d.).

[21] *A quintile refers to any of five equal groups into which a population can be divided according to the distribution of values of a particular variable. Thus, the lowest-income quintile refers to the poorest 20% of a given population, the second quintile encompasses the next 20% moving up the income ladder, and so on.*

The access dimension tracks access to basic energy services and the sufficiency of energy consumption. Many Southeast Asian countries have attained 100% access to electricity. The most notable development has been in Cambodia and Lao PDR, where the electricity access rates increased from 16.6% to 86.4%, and from 42% to 100%, respectively, between 2000 and 2020 (World Bank, n.d.) (Figure 13). Steady advancements were also made in Myanmar and the Philippines (UNESCAP, 2020). The progress in electrification in the region is mostly attributable to the expansion of services to rural areas, but a significant gap still exists between urban and rural populations. Today, Cambodia and Myanmar account for the majority of ASEAN's population without access to electricity, but significant progress suggests the region overall is largely on track to achieve universal access to electricity by 2030 (UNESCAP, 2020).

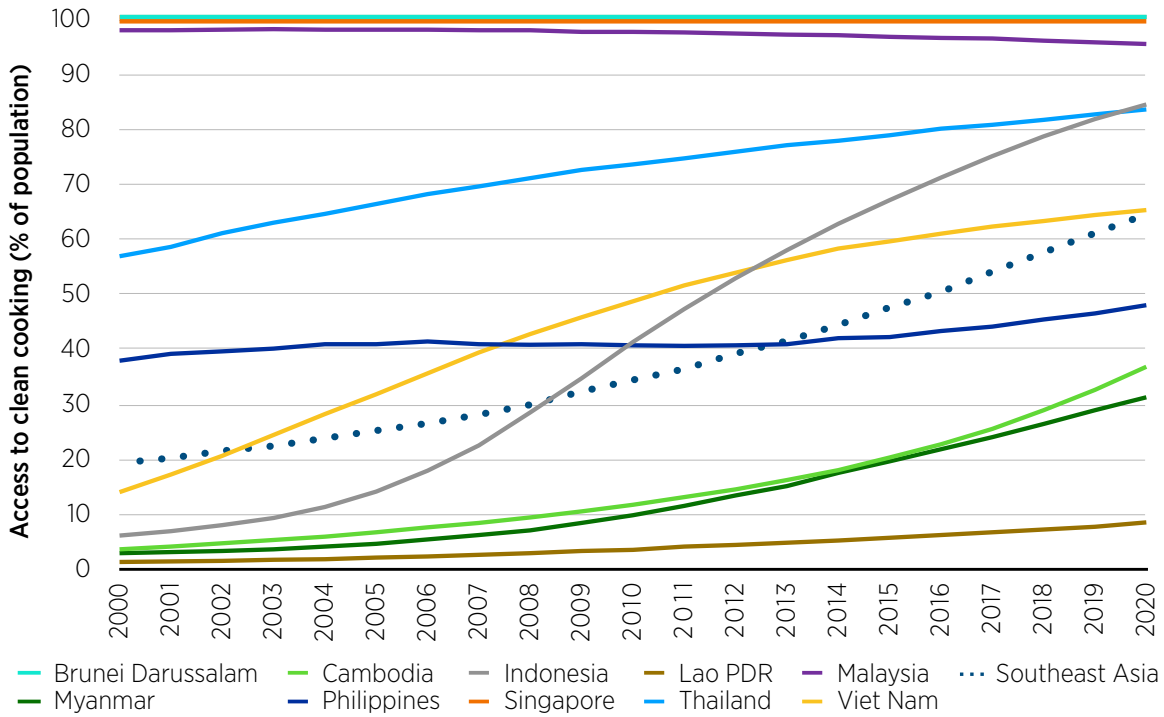
Figure 13 Access to electricity in Southeast Asia



Source: World Bank (n.d.).

Access to clean cooking that refers to non-reliance on traditional fuels (such as biomass), on the other hand, remains far less universal. Some 219 million people in Southeast Asia still rely on solid biofuels like wood and charcoal for all household uses, driving indoor air pollution and adding to deforestation. The region has observed improvements since 2000 (Figure 14), notably in Indonesia and Myanmar. However, access to clean cooking remains below 50% in Cambodia, Myanmar and the Philippines, and falls as low as 9% in Lao PDR (UNESCAP, 2020; IRENA *et al.*, 2022) (Figure 14). A major effort is needed to provide universal access to clean cooking in Southeast Asia (UNESCAP, 2020).

Figure 14 Percentage of population with access to clean cooking, 2000-2020

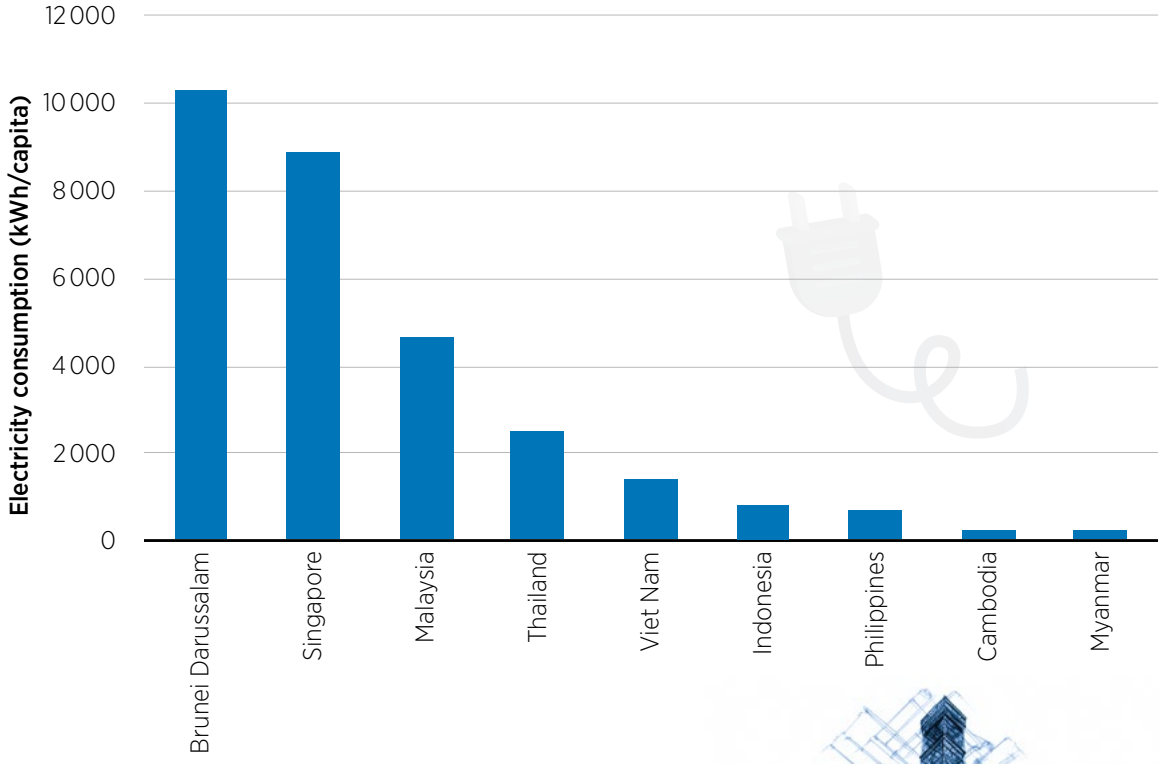


Source: WHO (n.d.).

Taking electricity and clean cooking together, the population share without basic energy access in Southeast Asia was 35.4% in 2019 – slightly higher than the global value of 32.7%, and largely below sub-Saharan regions, which are between 59.6% and 92.5% (CE, n.d.). Improving the quality of life and increasing economic development in the region requires greater accessibility to energy throughout the region, including in rural and remote areas.

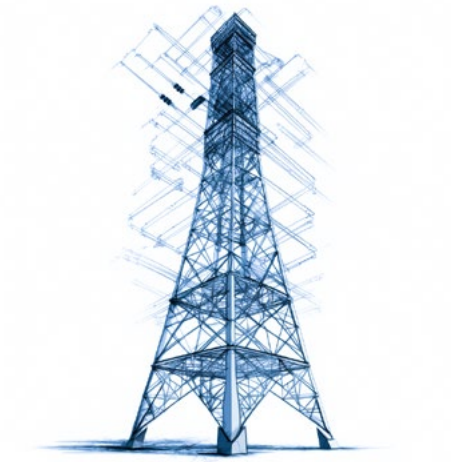
Southeast Asia is one of the world's fastest-growing regions, and its economic growth continuously surpasses global growth rates. With this growth has come markedly increased energy consumption. On a per capita basis, however, Southeast Asia's energy consumption is still substantially below that of most of other regions of the world. The rise in per capita energy demand has been reliant on carbon-intensive sources (UNESCAP, 2020). TFEC per capita has risen since the start of the millennium (from 2.2 exajoules [EJ] in 2000 to 3 EJ in 2016) (Liu and Noor, 2020), and electricity consumption has risen with real income since 2009 (Bhattacharya *et al.*, 2021). However, the rates in most countries suggest much scope for better quality access and more electrification of end uses, moving households away from traditional biomass. Brunei Darussalam has the region's highest annual electricity consumption per capita (Figure 15). In 2019, Southeast Asia's energy consumption was 19.9 kilowatt hours (kWh)/capita/day), almost half of the global value of 37.2 kWh/capita/per day, or less than a third of the EU-27 plus the United Kingdom value at 67.5 kWh/day (CE, n.d.), and slightly below the sufficiency level[22] of 20 kWh/capita/day in line with the literature (Millward-Hopkins *et al.*, 2020).[23]

Figure 15 Electricity consumption/capita in Southeast Asia, 2014



Source: World Bank (n.d.).

Note: Data for Lao PDR are not available.



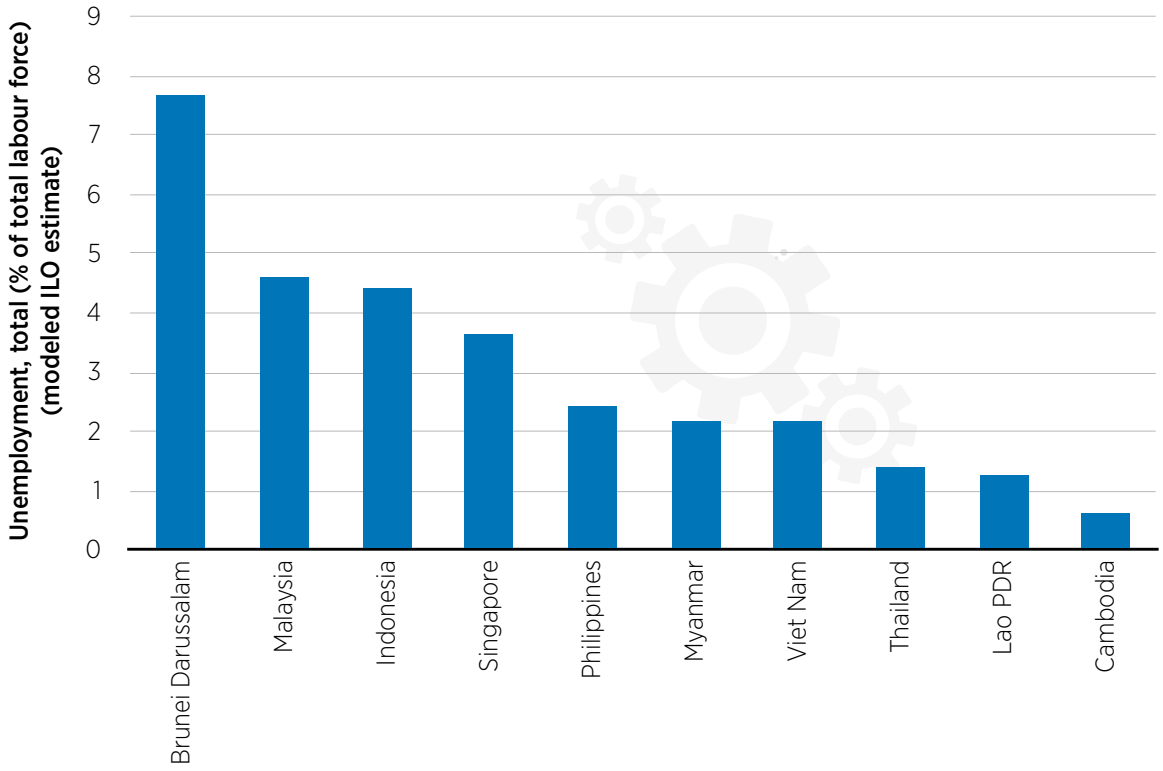
[22] *This indicator has been defined as the required level of energy consumption for decent living, but no more.*

[23] *The authors estimated the sufficiency level between 11.6 and 30.4 kWh/capita/day according to the scenarios across all 119 countries of the Global Trade Analysis Project depending on the scenarios considered.*

2.4 EMPLOYMENT

Southeast Asian countries account for about 8.5% of the world's population, and Indonesia is the fourth most populous country in the world. With young populations, ASEAN countries face considerable pressure to create and maintain jobs, and thus livelihoods (PRB, 2017; IRENA, 2018a). Overall, unemployment in the region is low: Brunei Darussalam's rate of 7.6% by far the highest, and Cambodia's rate of less than 1% is by far the lowest (Figure 16). Still, the region faces challenges including a mismatch among jobseekers' expectations, employment opportunities and skill requirements.

Figure 16 Unemployment in Southeast Asia, 2021



Source: World Bank (n.d.).

Employment opportunities have evolved in tandem with economic structural transformations, which have moved ASEAN's economies away from once heavy reliance on agriculture toward extractive industries and manufacturing as well as services. The share of the service sector, in particular, has grown in ASEAN-5 countries since 2000. By 2017, for example, it represented more than half of the group's GDP. The share of industry, in turn, has declined to around one-third. In contrast, in the CLMV countries, the share of industry has risen, while services have remained stable. Except for Cambodia, Lao PDR, Myanmar and Viet Nam, agriculture accounts for a relatively small share of GDP in the region, despite production of main agricultural products doubling after 1995 (ASEAN Secretariat, 2017).

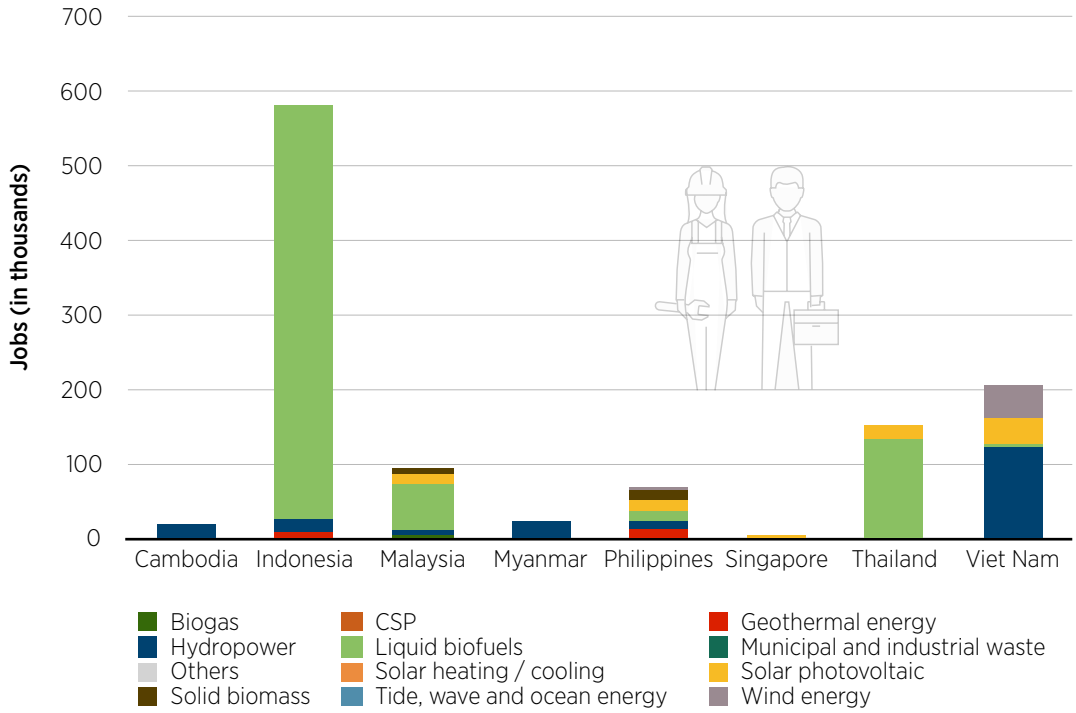
Extractive and manufacturing industries remain important in Southeast Asia (World Bank, n.d.). Almost all Southeast Asian employment (75.2%) in the agriculture sector is informal (ILO, 2018). In industry, the informal employment share (68.8%) is higher than in services (54.1%) (ILO, 2018). In general, informal employment is low in sectors with a large government presence – among others, education and health –and high in sectors such as construction and wholesale and retail trade (ASEAN Secretariat, 2019).

The emergence of the region as a hub for manufacturing and a wide variety of services has brought new employment opportunities. Indonesia, Malaysia, Thailand and Viet Nam have lower wage biofuels than

China in manufacturing and other labour-intensive sectors (Broadman, 2016; Lloyd, 2017). Cambodia and Viet Nam have also seen rapid growth in labour-intensive manufacturing for export (ERIA, 2014). In the Philippines, 80% of the new jobs created between 2010 and 2016 were created in the service sector. Most of them were created in business process outsourcing, followed by tourism and retail trade. The tourism sector in 2015 accounted for close to 13% of national employment, or 5 million workers (ADB, 2016; IRENA, 2018a).

In the context of the energy sector, the diversification of the economy can create employment opportunities in sectors other than oil and gas, while upgrading skills (ILO, 2022). Labour-intensive feedstock supply lines have also created large employment opportunities in Southeast Asia in the biofuel sector. In 2019, the region accounted for 34% of all biofuels jobs worldwide (IRENA, 2020c). Indonesia is by far the region's largest biofuels producer and employer (Figure 17).

Figure 17 Renewable energy jobs in Southeast Asia, 2020



Source: IRENA (2022c).

Note: Data for Lao PDR and Brunei Darussalam are not available. CSP = concentrating solar power.

About 556 000 people worked in Indonesia's biodiesel industry in 2021, an increase of almost 80 000 over the previous year. A rise in the country's biodiesel blending mandate in 2019 from 20% to 30%, coupled with an increase in domestic demand (as restrictions relaxed), led to the increase in both production and jobs.

Viet Nam has established itself as a prominent manufacturer, installer and exporter of PV modules (IRENA, 2021b). Because it pushed to finish projects before transitioning from FITs to auctions, Viet Nam was able to do better than many other nations (Ha, 2021). IRENA estimated there were 35 300 jobs in Viet Nam's solar PV industry in 2021.

Thailand's biofuels development strategy is aimed at boosting farm incomes through increasing molasses, cassava and palm oil feedstock demand. for the government continued to reduce price subsidies between 2020 and 2022 (USDA-FAS, 2022) for ethanol and biodiesel will be extended for another two years, until 24 September 2024, to promote the use of greener fuel mixes and support farmers (Bangprapa, 2022).

With production having increased by less than 2%, IRENA estimated there were 133 900 biofuel jobs in Thailand in 2021, a slight drop of around 5 000 jobs from 2021 estimates (IRENA, 2021c, 2022).

In Malaysia, IRENA estimated there were approximately 61 400 jobs in the biodiesel industry in 2021, a decrease from 106 200 in 2019 (IRENA, 2021c, 2022). Malaysia is an important manufacturer in the solar PV industry, with a module production capacity of roughly 8.9 GW as of 2019 and 16 150 direct PV jobs. This amount could double if indirect employment were considered.

Estimates for renewable energy jobs in the Philippines in 2021 run to about 189 000 (REMB DOE, 2022), including about 69 423 in hydropower (of which almost 60% were in large facilities), 61 926 in solar PV, 26 718 in wind power, about 14 047 in biomass and 11 628 in geothermal power. With the exception of the geothermal sector, these numbers include direct jobs only. In the agricultural supply chain for liquid biofuels (not included in the above total), IRENA estimates there were about 34 300 jobs (IRENA, 2022c).

The region continues to rely on fossil fuels, particularly coal, which creates employment throughout the region, particularly in the Philippines and Viet Nam. The success of ASEAN's just and inclusive energy transition will depend on how the local workforces are empowered and prepared to actively participate in the decarbonisation of the economy. Some of the existing initiatives are presented in Box 4.

BOX 4 SKILLS AND EDUCATIONAL INITIATIVES FOR ENERGY TRANSITION

Across the region, the potential for green employment is greatest in two sectors: power generation, and the agricultural, forestry and fishery sector. These are also the two sectors that are responsible for most of the region's GHG emissions. As efforts are made to decarbonise and sustainably transition these sectors, these sectors also offer the greatest potential for green job creation and will subsequently require the most support for educating, training and reskilling the workforce. Some of the on-going efforts include:

Technical and vocational education and training (TVET)

There is a diverse range of employment by sector and skills levels among the ASEAN Member States, which means there are various priorities for TVET for each Member State. Each of the ten Member States have TVET initiatives. Member States with a higher percentage of their respective workforces participating in the agricultural and industrial sectors (Cambodia, Lao PDR, Myanmar and Viet Nam) generally have strong support for TVET opportunities.

- Some of Cambodia's National Technical Vocational Education and Training Policy 2017-2025 priorities, for example include improving TVET to meet market demand, increasing equitable access to TVET and sustainably developing the TVET system with public-private partnerships and stakeholders (ASEAN Secretariat and ILO, 2021).
- Lao PDR's Ninth Five-Year National Socio-economic Development Plan released in 2021 includes a strong focus on developing a skilled workforce. The successful creation of numerous technical-vocational institutions has enabled Lao PDR to reach its five-year target ahead of schedule. The country has resorted to allowances and incentives to encourage general education students to enter vocational training (Lao PDR, 2021).
- Myanmar's 2021 NDCs recognised the crucial need to improve education and TVET. Improving human capital is one of four priorities in the Green Economy Policy Framework (The Republic of the Union of Myanmar, 2021; ASEAN Secretariat and ILO, 2021).

Public-private partnerships for skills delivery

Public-private partnerships are another opportunity for countries to accelerate building the skills and capabilities of their workforces in an efficient and effective manner. For example, Viet Nam has numerous stakeholders involved to support TVET initiatives. In addition to support from several government ministries and agencies and non-governmental organisations, such as that by GIZ (an active partner of Viet Nam's implementation of TVET programmes and facilities), Viet Nam has also relied on the private sector to support vocational training through policies and measures in the Labour Code and Law on Vocational Education. The outcomes of these public-private initiatives mainly result in agreements between vocational-technical schools and the private sector for the placement of trainees into the workforce through internships and labour contracts (ASEAN Secretariat and ILO, 2021).

Thailand's Skill Development Promotion Act is another example of a public-private partnership for improving workforce skills. Companies with more than 100 employees are required to provide skill development programmes for at least 50% of their employees. If they do not provide programmes, they are required to contribute monetarily to a skill development fund. Companies are incentivised to participate in training; in addition to receiving assistance and consultations, the business qualifies for a special tax exemption from the corporate income tax at 100% of the training expenses (Acclime, 2021).

National skill standards

Overall, in the economy, the ASEAN region is dominated by employment opportunities that require low-to-medium skill levels, with general exceptions in the cases of Singapore and Brunei Darussalam. Regional or national-level skill standards and accredited training and certification courses based on the energy sector could help prepare the workforces within the region to adapt to the energy transition (ASEAN Secretariat and ILO, 2021).

There are several national skill standards and accredited training programmes that complement the energy sector. At the regional level, the ASEAN Centre for Energy (ACE) has an Energy Manager Certification, but this is geared towards a smaller subset of the administrative workforce that is already educated with higher skill levels (ACE, 2022c).

- Singapore's Skills Framework for Energy and Power provides individuals, employers and training providers with opportunities to research the sector and learn about career pathways, the required skills and competencies, and the training programmes available (SkillsFuture Singapore, 2021).
- The Indonesian Society of Renewable Energy has contributed to the creation of two job competency standards (for mining and geothermal energy and non-geothermal renewable energy) that are managed by professional certification bodies and are recognised by the government.
- The Philippines Green Jobs Act of 2016 mandates that various government agencies develop green training regulations and qualification frameworks to provide certifications for skilled green professionals (ILO, 2019).

Diversity and inclusion

An inclusive and just energy transition must embrace diversity and inclusion across all demographics, including women, youth, older workers, people with disabilities, migrant workers, indigenous people, unemployed people and vulnerable workers. The ASEAN region is home to a substantial amount of employment vulnerable to climate change; a 2018 ILO report estimated it at more than 47% and even higher in Cambodia, Lao PDR, Myanmar, Thailand and Viet Nam. Men far outnumber women in Southeast Asia's workforce, with women being disproportionately employed in industries or positions with lower pay. Youth unemployment is typically high in ASEAN (ASEAN Secretariat and ILO, 2021). A need remains for concentrated efforts, such as targeted skills and technical training programmes; science, technology, engineering and mathematics education curriculums and apprenticeships; and more opportunities aimed specifically at these disadvantaged populations.

2.5 POLICIES AND INITIATIVES FOR THE ENERGY TRANSITION

Notwithstanding encouraging socio-economic progress in Southeast Asia, the region faces many severe challenges (such as a high reliance on fossil fuels, low health and education spending, *etc.* as discussed in Chapter 2, sections 2 to 4), both in the short-term and in the long-term. The governments of ASEAN countries have plans and targets to address these challenges, including through commitments at the national level for GHG emissions reduction, energy efficiency, and renewable energy targets in their NDCs and national plans.[24] The different policies and initiatives have been grouped into four frameworks: enabling policies, deployment policies, integrating policies and structural policies for a just and inclusive transition.

Enabling policies

Commitments to climate change and renewable energy deployment

All Member States have unified their commitments through the ASEAN Plan of Action for Energy Cooperation (APAEC), and ACE plays a pivotal role in regional co-operation. Although APAEC Phase II: 2021-2025 has raised the energy efficiency target and has a more specific renewable energy target, the plan still highlights clean coal technology (CCTs)[25] as one of the programme areas to optimise as opposed to discontinuing it. Shifting and reducing the role of coal by focusing more on the process to repurpose coal assets or terminate coal usage and introduce a clean energy technology such as renewable gasses (*e.g.* green hydrogen and biogas) and biomass could set a stronger direction and send a more powerful signal for the clean energy pathway in the region.

At the national level, commitments to GHG emissions reduction and renewable energy are indicated in the countries' NDCs and national plans. Most countries in the region indicated the need for international support to achieve more ambitious targets in their NDCs (Annex A). Support and co-operation from the international community in several aspects – such as technical capacity, finance, and policy framework – will help set a more aspiring decarbonisation pathway for the region.

Regarding the renewable energy targets in the national plans, the focus is in the power sector followed by transport and then heating and cooling. Several countries in the region saw opportunities in the clean energy economy and have adjusted their plans to attract private investments. For the transport sector, most countries except Cambodia, Myanmar and Viet Nam have set EV targets, while some countries also have biofuel blending targets. Measures related to EVs have been introduced by all countries as a means to reduce their GHG emissions and achieve better air quality. For heating and cooling, on the other hand, only Singapore and Thailand have set targets, while some countries have mitigation strategies without targets. The ASEAN Member States could consider setting clear renewable energy targets in the heating and cooling and transport sectors. Specific solutions should help unlock renewable energy deployment (such as flexibility technologies, hydrogen and battery storage) to set a direction that drives implementation and replicates success from the power generation industry in drawing investments. In addition, an alignment of the national plans with the NDCs and net-zero pledges is needed for an effective and harmonised implementation.

[24] *The national plans include, but are not limited to energy plans, climate change plans and transportation plans endorsed at the national level.*

[25] *In order to eliminate harmful pollutants such as sulphur dioxide and nitrogen oxide, clean coal technologies have been developed across numerous generations.*

Measures to eliminate distortions and curb investments in fossil fuels

The region has a history of high fossil fuel subsidies, which skyrocketed in 2022 according to the IEA's latest estimates (IEA, 2023). Although the phaseout of fossil fuel subsidies is not imminent, some subsidy reforms for transitioning to cleaner fuel and targeting specific groups (such as cooking fuel from kerosene to liquefied petroleum gas for lower-income people) have been introduced to provide major health benefits, promote energy efficiency, lower GHG emissions and create subsidy savings. Carbon pricing and carbon tax mechanisms have also been introduced in some countries to curb investments in fossil fuels. Viet Nam appears to be a leader in the implementation of an Environmental Protection Tax (EPT), of which the revenue contributes to programmes with environmental benefits but has not yet set up a carbon market. In addition, all ASEAN countries have reconsidered their fossil fuel investments and raised the share of renewable energy in their targets. However, this appears to be a moderate step and still focuses on fossil fuel substitution (*e.g.* coal to gas). Furthermore, Indonesia and the Philippines signed the Global Coal to Clean Power Transition Statement at COP26 but they did not adopt all clauses of the coal pledge (ACE, 2021). As fossil fuel consumption subsidies have been contributed mostly to oil and electricity consumption, policies that urge EV adoption and the transition from coal to renewable energy should come together with subsidy reforms and carbon mechanisms to effectively and holistically scale renewable energy deployment and deeper decarbonisation. In addition, the socio-economic implications of stranded fossil fuel assets need to be addressed via a holistic policy framework. The implementation of carbon-related mechanisms should be carefully considered to target the appropriate groups and reduce negative effects to lower-income populations.

Measures to access financing

To reach ASEAN's renewable energy and energy efficiency 2025 goals, the region will need an estimated USD 300 billion in investments. The gap in raising investments between medium- to large-scale projects and higher risk projects (*i.e.* smaller projects in more rural off-grid areas and R&D projects) is noticeable. Programmes and mechanisms led by international development banks and co-operation with the local public sector have offered examples of how to bridge this gap, such as with the ACGF between the ADB and ASEAN that pairs technical assistance with loans to de-risk projects. The ETM, a partnership between ADB and the Philippines and Indonesia, provides funds for R&D focused on retiring or repurposing existing coal-fired power plants and new clean energy technologies. However, more intervention and co-operation like these examples are needed to reach that required scale of investments (the aforementioned programmes combined are around USD 2.5 billion compared to the USD 300 billion needed). This could be done via promoting the success of these programmes to attract more support, sharing knowledge and replicating models to wider countries in the region. In addition, policies that incentivise investment, innovative financial solutions and new procurement models should create an attractive environment to secure needed financial support.

Measures to increase energy efficiency

Energy efficiency in the power and building sectors, on both the supply and demand sides, plays a critical role for the clean energy transition, especially in countries with high electricity use per capita (Brunei Darussalam, Malaysia and Singapore) and with significant reliance on fossil fuels in their generation mixes. All countries in the region have introduced energy efficiency measures, programmes or standards across the power, transport, and heating and cooling sectors. However, only three countries (Brunei Darussalam, Singapore and Thailand) have set targets across all three sectors. Thailand clearly indicates how its mandatory and promotional-level strategies and measures will contribute to targets. There are regional-level energy efficiency targets and ongoing efforts to harmonise the standard for appliances and an energy management training and certification programme. For the implementation of energy efficiency to be effective, clear targets across sectors, correlated measures and regional collaboration are needed.

Measures to develop needed energy infrastructure

Regional co-operation for multilateral power trading is implemented through the ASEAN power grid (APG) programme, the first commenced multilateral trade agreement between four Member States. A recent study confirmed the economic viability of the programme and emphasised the need for 19 918 MW of renewable energy from cross-border trade for ASEAN to achieve its renewable energy target in 2025. Although there have been bilateral power trades in the region, there is only one multilateral trade (the LTMS-PIP[26] project for 100 MW) that has come to the implementation stage since the introduction of APG in 1999. Policies and regional co-ordination are needed to enable projects like LTMS-PIP that not only provide energy security and support a clean energy transition but also provide a regional venue for greater power system flexibility to integrate larger renewable energy deployment. At the country level, most countries have introduced grid modernisation or smart grids into their Power Development Plans (PDPs). Besides physical infrastructure development, organisational reform is also a great means to enhance renewable energy deployment. Thailand is developing organisational and process reform to streamline permitting and approval processes for a faster and more effective renewable energy rollout. Lao PDR and Myanmar emphasised the need for energy infrastructure to support their rural electrification programmes. Overall, international support and private investments are needed to develop or advance energy infrastructures in the region.

Measures to foster innovation

Innovation across various dimensions – technology, financing, business models, market design, policy, regulation and institutional frameworks – is needed for the region's energy transition. So far, the innovation has been focused on economic and policy research via networks of partnership between research institutes, universities and governments from inside and outside the region. Although technology R&D talent and innovation initiatives like Singapore's EcoLabs Centre of Innovation for Energy exist, gaps remain in terms of bringing technology to market from financing barriers. The private sector has its own R&D functions; however, open innovation and greater collaboration with the public sector will help enhance and bring innovation to fruition. Policies and measures, such as tax incentives, free trade and intellectual property reform, can create a conducive environment for ideas, talents and investments to help bridge the gap between R&D and the industrial sector.

Measures to raise awareness and confidence among consumers and citizens

Citizens play an important role in the clean energy transition. They not only contribute to a significant portion in the energy consumption but also impact the pace of governments and corporations in their decarbonisation. Policies and measures to raise public awareness vary across nations, ranging from leveraging education; communicating the benefits of energy consumption reduction; underscoring the values of biking, walking and public transport over personal and motorised transportation; comparative labelling mandates for cooling appliances; and more.

[26] *Lao-Thailand-Malaysia-Singapore Power Integration Project.*

Deployment policies

The continued rollout of renewable energy and other transition-related technologies will require deployment policies that make it more affordable. Fiscal and financial incentives have been introduced by six governments in the region. As ASEAN moves towards reaching its raised targets, these instruments are expected to leverage and attract more investments. Supportive procurement mechanisms, such as FIT, renewable energy auctions and net-metering, have been introduced in the region. Renewable energy auctions are the most widely adopted instrument to boost renewable investments, followed by net-metering (only Cambodia and Lao PDR have not adopted this mechanism). Lessons from Viet Nam's recent FIT programme, which created a solar boom in the country. While this can be replicated by neighbouring countries that need a fast renewable deployment, careful planning is crucial to ensure that the existing grid infrastructure can support an influx of renewable energy and that there is strong government and regulatory support to work with, not against, the public demand.

For low carbon transport, biofuel mandates and electric mobility have been introduced. However, the sector still relies heavily on fossil fuels, and significant intervention in the transportation sector is needed to curtail GHG emissions and reduce energy security risks as a net-importing oil region. The biofuel mandate is the low-hanging fruit for the region to boost its renewable energy achievement; more than half of the ASEAN nations have already regulated the mandates through its respective blending ratio. Indonesia and Malaysia are leaders in the biodiesel blending policies, while the Philippines and Thailand are leading in bioethanol. Additionally, the region is also increasing its efforts to deploy more EVs to the market, although they remain in the early stages. Most countries have set up their official EV targets and all have introduced regulatory frameworks to attract EV adoption. More robust and innovative EV policies for both the supply and demand sides, such as fiscal, financial and physical incentives, will help accelerate the adoption rate.

Direct use of renewable energy for building heating and cooling and industrial processes is also becoming a priority for the ASEAN region due to this sector's significant contribution to GHG emissions. Unfortunately, most ASEAN countries do not have renewables and energy efficiency targets in heating and cooling. Many industries are heat-intensive, and there are several options for decarbonisation, such as electrified heat pumps, the substitution of renewable gasses and biomass, and harnessing geothermal energy. Energy efficiency measures that raise higher standards for cooling equipment can offer greater decarbonisation opportunities. Renewable heating and cooling technologies are still nascent; therefore, they can incur high upfront investments or prohibitive costs. Hence, a holistic set of policies, such as setting national targets, fiscal and financial incentives, and public-private programmes that allow further collaboration and access to data are needed to mobilise these technologies.

In addition, the development of green hydrogen in the region is not progressing as fast as in other regions. Only a few ASEAN countries have mentioned hydrogen projects in their policies, and they are export oriented. Hydrogen has great potential to provide renewable energy integration by providing flexibility as well as seasonal storage. Like other new technologies, target setting, fiscal and financial incentives, and concrete policy frameworks are needed to attract more investments and trigger adoption.

Integrating policies

The expansion of integrating policies across the ASEAN region and at the national level will expedite the energy transition by dedicating resources to developing and adopting technological advances through supportive policies that support more widespread, efficient and advanced solutions that incorporate more renewable energy into the energy mix. Regionally, the exciting developments surrounding the APG and the continual expansion of grid interconnections across the three planned subsystems are exemplary of the regional level co-ordination and collaboration that ASEAN can achieve and expand upon. These multinational efforts unlock renewable energy resource potential from country to country

and improve the ability to integrate renewable energy into the energy mix at the regional level. At the national level, dedicated policy support for R&D, pilots, and installations or retrofits of advanced technologies like smart meters, smart grids and battery energy storage systems will allow significant improvements to how energy is moved, traded and stored and will enable more automated, efficient energy management and vastly improved grid reliability on a scale that is unable to be met with aging infrastructure. Policies that support integrating advanced technologies and incentivise changes are crucial to reaching and maintaining momentum of the energy transition.

Structural policies for a just and inclusive transition

As the region and Member States are planning and deploying tactics to reach their energy targets and goals, it is vital that they are prioritising policies and practices that ensure an inclusive and just transition for all people, especially the most vulnerable. Labour market policies should put in place protections for people who are most likely to be affected by changes in the job markets as the dominance of fossil fuels wanes and renewable integration scales up, as well as when climate change has devastating physical impacts on employment. Socio-economic protections (such as providing healthcare, unemployment protections, employment guarantees and more) provide stability in times of potential job market shifts.

Policies that are focused on improving the value of the local industries can have positive effects on the socio-economic conditions for entire regions at a time. Local content policies that require the use of local materials and services provide the opportunity for local communities to learn new skills and technologies, participate in the energy transition, and can bring substantial investment into the region. For example, Indonesia's local content requirements on nickel supports its desire to become an EV hub in Southeast Asia. By leveraging its existing resources, Indonesia is poised to become a major player in the EV battery supply chain. Incentives to bring EV-related production to Indonesia are likely to have a range of effects, from increased employment in the extraction and refinement sector to improvements and dedicated education and training for medium- to high-skilled future workers.

Regional trade co-operation, such as the newly enacted Regional Comprehensive Economic Partnership (RCEP), removes barriers that previously kept small and medium-sized enterprises from participating in the global market by eliminating tariffs on 90% of goods for the next decade or more, simplifying customs procedures and governing investments to promote free trade. It is expected that trade agreements such as this will have positive impacts, such as bringing down production costs of renewables and other transition-related technologies that will result in more competitive options against the conventional fossil fuel-focused options.

Promoting substantial resources into R&D will also open opportunities for local solutions to local problems. Singapore's commitment to dedicate 1% of its GDP towards R&D will allow it to focus on sustainable and digital improvements that will transition it from being energy and water constrained into opportunities.

Thoughtful and people-centred policies that offer improved, inclusive access to education, vocational training, and retraining and reskilling opportunities can provide ASEAN region residents with opportunities to move up the socio-economic ladder in reliable, higher skilled jobs that will continue to grow in demand. A strong emphasis on diversity and inclusion is imperative to guarantee that all people – especially women, youths, older people, disabled people, migrants, indigenous people, the unemployed and the vulnerable – are empowered and allowed the opportunities to join the workforce and contribute to and receive the benefits of a growing economy.

Creating national skill standards and accredited certifications can help prepare the national workforces for active participation in the growing clean energy sector, as well as ensure that high-quality, standardised and safe work is performed across the nation. Finding opportunities to create public-private partnerships – such as transitioning students from training into the workforce or requiring skill development programmes for companies of a certain size with incentives for participation – is a way to engage the private sector, which can play an active role in improving opportunities for its local communities.

03 Socio-economic impact of the energy transition

To support transition planning and informed policy making, IRENA analyses the socio-economic footprint of the energy transition using a macroeconometric model to measure impacts on GDP, employment and human welfare. This process provides insights into how some of the policies can lead to attainment of the highest possible benefits.[27]

This chapter presents the key findings of IRENA's socio-economic analysis for ASEAN, outlining potential impacts on economic growth (GDP), employment and welfare, including a discussion of the underlying drivers (Box 5) that lead to the results. These findings delineate the difference between the 1.5°C Scenario and the PES.

BOX 5 DRIVERS OF GDP AND EMPLOYMENT DURING THE TRANSITION*

The analysis presented in this report considers the specific impact of each structural element underlying the energy transition, and the extent to which this impact shifts over time. The structural elements included in the analysis are as follows:

- **Public investment and expenditure** in renewable energy, energy efficiency, power grids and flexibility, green hydrogen, electrification, and other transition-related investments, subsidies, and finance, as well as additional social spending and investment.
- **Private investment** in the energy transition across all technologies and in fossil fuel-related industries (such as exploration and production, refining, logistics, and crowding-out effects in the private sector).
- **Net trade**, primarily through reductions in hydrocarbon imports and exports, although trade differences in other sectors are also included.
- **Induced and indirect effects**, which have different components (aggregate prices, lump sum payments and others). Induced lump sum payments, that is, government recycling of fiscal surpluses in the form of lump sum payments for lower-income groups to improve living standards. Induced aggregated prices, which reflect the effects of the energy transition on the price level. Prices can be higher or lower than under a less ambitious scenario because of the effects of factors such as carbon prices, the evolution of wages and the transition to less expensive fuels. It also includes other impacts of climate change mitigation policies, including fiscal tools, such as carbon prices, energy taxes or reduced fossil fuel subsidies; regulatory tools, such as efficiency standards; and redistribution.

Source: IRENA and AfDB (2022).

Note: *In the case of employment, the "consumer expenditure" driver combines the impacts of taxes, indirect and induced effects, and aggregated consumer price effects, while capturing other labour-related dynamic effects.

[27] *See IRENA (2016, 2020a, 2021a and 2022a) for the methodology analysis.*

3.1 THE PLANNED ENERGY SCENARIO

Under Southeast Asia's plans and policies in the PES, the region is expected to experience significant economic growth, as envisioned in the baseline assumption of the E3ME model.[28] The region's real GDP is expected to increase with a CAGR of 4.9% between 2021 and 2050 (Table 1). Population growth is expected to increase over the 2021-2050 period and during the same period, economy-wide employment increases at CAGR of 0.1%.

Table 1 GDP, labour force and population growth projections under the PES

Variable	2021-2030 (CAGR %)	2031-2040 (CAGR %)	2041-2050 (CAGR %)
Real GDP	5.09	4.92	4.67
Economy-wide employment	0.35	0.11	0.01
Total population	0.67	0.06	0.07

3.2 POLICY INPUTS AND ASSUMPTIONS IN THE 1.5°C SCENARIO

This chapter compares the socio-economic differences between the PES and the 1.5°C Scenario in Southeast Asia using the same inputs and assumptions as the 2022 edition of IRENA's annual flagship publication, *World energy transitions outlook*. IRENA's analysis explores the socio-economic footprint outcomes resulting from different combinations of energy transition roadmaps and climate policy baskets.

IRENA's climate policy baskets encompass several tools aimed at facilitating a just and inclusive energy transition. Carbon pricing, international co-operation, subsidies, progressive fiscal regimes to address distributional issues, investments in public infrastructure and expenditure on social projects are all part of the climate policy baskets. The baskets also include policies that encourage the deployment, integration and promotion of energy transition technologies (Box 6).

[28] *Baseline forecasts are constructed using a comprehensive set of international data sources. The main source for population data is the United Nations (World Population Prospects). For GDP forecasts, the main source is the International Energy Agency (World Energy Outlook). These are supplemented with data from the International Labour Organization, Organisation for Economic Co-operation and Development (STAN), World Bank, Asian Development Bank and European Commission (AMECO, Eurostat, EC Annual Ageing Report, EU Reference Scenario reports). E3ME is a global, macroeconometric model owned and maintained by Cambridge Econometrics: www.e3me.com.*

BOX 6 IRENA'S CLIMATE POLICY BASKETS

IRENA's socio-economic footprint analysis includes in its modelling a very diverse set of policies to enable and support a sustainable energy transition. Holistic planning and synergistic implementation can address the multiple angles of the interactions between the energy, economy and social systems more successfully than an approach that relies on a limited number of interventions.

It should be noted that with a diverse climate policy basket, the final level of carbon pricing needed to bring about an energy transition roadmap depends on the effective implementation of accompanying policies. Since IRENA's analysis includes a diverse policy basket, the transition goals can be achieved with significantly lower carbon prices.

IRENA's socio-economic analysis assesses the following policies:

- International co-operation, supporting enabling social policies in all countries and addressing the international justice and equity dimensions.
- Domestic progressive redistributive policies.
- Carbon pricing, evolving over time with carbon prices differentiated by each country's income level and special treatment of sectors with high direct impacts on people (households and road transport).
- Fossil fuel phaseout mandates in all sectors.
- Phase-out of all fossil fuel subsidies.
- Regulations and mandates to deploy transition-related technologies and strategies, including renewables, EVs, hydrogen and system integration through electrification and power-to-X.
- Mandates and programmes for energy efficiency deployment in all sectors.
- Policies to adapt organisational structures to the needs of renewable-based energy systems (such as in the power sector).
- Subsidies for transition-related technologies, including for households and road transport.
- Direct public investment and spending to support the transition, with participation in all transition-related investments, but with special focus on enabling infrastructure deployment (EV charging stations, hydrogen infrastructure, smart meters, etc.), energy efficiency deployment and policy expenditure.
- Policies to align international co-operation with transition requirements: earmarking of funds to transition-related investments, increasing social spending.
- Public involvement in addressing stranded assets, both domestically and internationally.
- Policies to align government fiscal balances with transition requirements, addressing domestic distributional issues and aligning deficit spending with transition requirements.

Carbon pricing under the 1.5°C Scenario is higher than under the PES. However, because of the regressive implications of carbon pricing, levels have been reduced by half compared to previous reports (IRENA, 2020a, 2021a). Under the 1.5°C Scenario, carbon prices are higher for high-income countries than for less wealthy ones. For example, Southeast Asia's carbon price for 2030 (2019 PPP) is set between USD 105/tCO_2 and USD 150/tCO_2, while this carbon price is USD 30/tCO_2 in low-income countries and USD 150/tCO_2 in EU-27, for example.

The macroeconomic modelling assumes revenue neutrality in governments' fiscal balances. The policies used to implement revenue neutrality depend on the progressiveness of the applied policy basket. Revenue recycling[29] is at the heart of the model's hypothesis. In the PES, when government revenues increase (for instance through carbon prices), income taxes are reduced, while they are increased when government revenues decrease. This approach has regressive implications, however, as the wealthiest households generally pay the lion's share of income taxes and benefit accordingly from the tax cuts. By contrast, in the 1.5˚C Scenario, revenues are assumed to be recycled through lump sum payments that target lower-income households progressively, assuming the adoption of distributional policies to mitigate any regressive effects of the energy transition – not only carbon pricing but also climate change itself. The lump sum payments assume 60% of the payments going to the lowest-income quintile, 30% to the second quintile and 10% to the third quintile.

Another key assumption of the climate policy baskets is the level of international co-operation. Whereas no additional collaboration is assumed in the PES, the 1.5°C Scenario policy basket does include enhanced levels to address the climate change challenge and the structural aspects underpinning an unequal distribution of burdens and responsibilities. Within this framework, all countries contribute to a joint effort according to their respective capability and responsibility in terms of climate equity.[30] International co-operation under the 1.5°C Scenario is modelled as 0.7% of the global GDP between 2021-2050. In contrast and given that current commitments and climate finance pledges have not been met, the PES does not consider international climate co-operation flows.

3.3 ECONOMIC GAINS, AS MEASURED BY GDP, UNDER THE 1.5°C SCENARIO

As discussed earlier, Southeast Asia is expected to experience strong GDP growth at the CAGR of 4.9% in the PES from 2021 to 2050. Under the 1.5˚C Scenario, however, the region's economy is estimated to perform even better: the average GDP gain over the period 2021-2050. In cumulative terms, the region would be adding USD 13.1 trillion[31] to the GDP already anticipated in the PES. Following the initial impact of front-loaded investments, GDP gains would not be as high towards the end of the period, but in 2050, they would still be 1% higher in the 1.5˚C Scenario than in the PES.

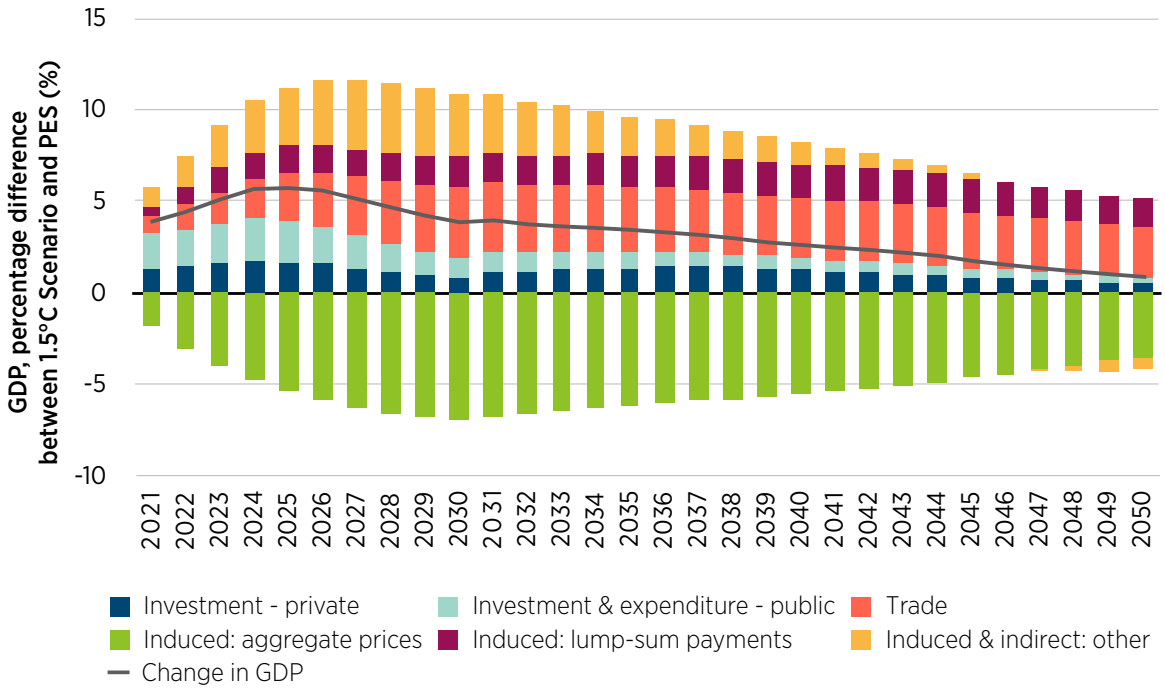
To gain a better understanding of the structural elements underlying the socio-economic footprint, IRENA's macroeconomic analysis disaggregates the outcomes by drivers and sectors. The main macroeconomic drivers that have key impacts on GDP difference are trade, investment, and indirect and induced effects depending on the considered period in the transition. In the first half of the first decade of the transition (*i.e.* 2021-2025), the investment driver plays the most important role in the difference in GDP, while trade becomes the main driver from the second half of this first decade (*i.e.* 2025-2030). Nevertheless, induced and indirect effects also have an impact in driving differences in GDP from the second half of this first decade in the transition, but to a lesser extent in comparison to the trade driver. The different components of the drivers are presented in Figure 18.

[29] *From a modelling perspective, revenue recycling is not only a policy instrument for addressing distributional issues in the context of scenarios; it is also a way to avoid assuming that in the case where large investments must be made to finance the transition, governments would increase borrowing without any quantified impact on the economy and society.*

[30] *Based on the Climate Equity Reference Calculator (https://calculator.climateequityreference.org/).*

[31] *In 2019 USD.*

Figure 18 ASEAN's GDP, percentage difference between the 1.5˚C Scenario and the PES by driver, 2021-2050



Trade plays an increasingly positive role throughout 2021-2050, to the point of being the strongest influencing factor in the last decade of the transition in Southeast Asia. This is because the positive effect of changes in net trade in fuels under 1.5˚C Scenario exceeds the negative effect of net changes in other trade. Most countries in Southeast Asia are currently net energy exporters, but energy use has surpassed or is expected to surpass domestic production by 2030 if recent trends continue, implying net imports of fossil fuels in the next few years. Thus, the lower energy intensity of economic activity in the 1.5˚C Scenario compared to the PES results in lower fuel imports, resulting in higher GDP. After 2030, the consumption of manufactured fuels in road transport and solid fuels and oil for heating is expected to reduce substantially (both in absolute terms and compared to the PES), driven by increased use of biofuels. The improvement in the net trade balance in fuels is several times the positive GDP difference to the PES by 2050 (equivalent to USD 412 billion[32] in 2050), making it a major driver of the GDP impact in the medium term and the main driver in the long term. This is mostly attributable to lower demand for oil and gas imports in Indonesia and all fuel imports in the rest of the ASEAN countries.

Net changes in other trade are moderately negative in ASEAN in the transition. The region gains export revenues for basic non-fuel manufactured products (such as metals, wood and paper, and rubber and plastics) and agricultural products, which have been historically a regional specialisation. However, this is offset by two factors: a reduction in motor vehicles exports (another regional specialisation, historically) due to the switch from fossil-fuel based engines to EVs, which are so far predominantly produced in more mature markets – such as Europe, China, Japan, South Korea and the United States (Statistica, n.d.) – and an increase in demand for advanced manufactured products due to higher demand outstripping domestic supply in the region.

[32] *In 2019 USD.*

The investment driver, which has two components (private investment and public investment and expenditure), is the second-strongest influencing factor on average in the differences in GDP over the whole transition period. The impact of private investment is positive, although its role is quite modest over the entire transition period. Private investment is notably higher throughout most of the 1.5˚C Scenario transition than in the PES, with an additional total cumulative amount of over USD 2 trillion[33] between 2021 to 2050, which corresponds to an average impact of around 1.1% per year in GDP difference between 1.5˚C Scenario and the PES over the same period. Private transition-related investments (energy efficiency and other end-uses, grids and energy flexibility, and renewables) play an important role to overtake the negative effect of fossil fuel investment in the power sector, crowding out investment in other sectors and the loss of fossil fuel supply investment.

The private sector is responsible for 100% of fossil fuel power investment. The ASEAN region, in particular Indonesia and Malaysia (Verbiest, 2014) are large producers and exporters of fossil fuels. Investment in the coal, oil and gas sectors in the region falls in the 1.5˚C Scenario compared to the PES, most rapidly in the years to 2030. This effect is substantial as the sector loses investment by USD 68 billion in 2030 and USD 101 billion[34] in 2050 under the 1.5˚C Scenario compared to the PES, as fossil fuel-based power capacity is almost completely phased out in the 1.5˚C Scenario in 2050.

Additional investments in efficiency and end uses by the private sector equate to 14.6% of the GDP difference in 2024, at the peak of energy efficiency investment, while private investment in grid and energy flexibility, peaking in 2050, accounts for around one-third of the GDP difference at the peak. Renewables private investment in the region is higher than in the PES throughout the transition period, particularly before 2040. These transition-related investments, along with an endogenous response to households' shifting their spending away from fuel costs to other items, together increase demand for basic manufacturing, engineering and transport equipment, business services, and retail sectors.

The public investment and expenditure driver positively impacts the overall regional GDP difference throughout the transition. The driver is strong in the first decade of the transition, before decreasing in the following decades. This is primarily due to the front-loaded investment needs of the energy transition, where most of the public investment occurs in the early years.

Being one of the main beneficiaries of the global transition finance flows, with a relatively small contribution, the ASEAN region sees an increase in government social spending in the 1.5˚C Scenario of USD 26.8 billion[35] (Indonesia accounts for around 26%) compared to the PES in 2050. It leads to increased spending on non-defence services predominantly provided by the government, including public administration, healthcare and education, therefore mainly benefiting public and personal services.

Induced and indirect effects have different components (aggregate prices, lump sum payments and others), whose impact in driving differences in GDP is presented in Figure 18. Induced aggregated prices have a significant negative impact on the GDP difference in the initial years, while the induced and indirect (other) and induced effect lump sum payments have a positive impact on the GDP difference. Thus, these drivers cancel each other out when considering the indirect and induced effects as a whole.

Induced – aggregate prices have the strongest impact on GDP difference. In the ASEAN region, the effects are substantially negative over the transition period, reflecting the domestic response to changes in carbon prices, technology costs, power sector capacity, fossil fuel subsidies, and investment expenditure. Carbon prices and the deployment of high-cost renewable technologies under the 1.5˚C Scenario increase the energy prices.

[33] *In 2019 USD.*

[34] *In 2019 USD.*

[35] *In 2019 USD.*

The increase in price levels is driven largely by higher electricity prices in 1.5˚C Scenario, particularly in Malaysia and Indonesia in the years to 2030. The shares of solid biomass and hydro capacity are higher in the 1.5˚C Scenario than the PES in Indonesia, and the share of geothermal is higher in the rest of the ASEAN countries. These sources each have high levelised costs of generation compared to the PES. Substitution away from coal and natural gas to these technologies increases costs. Although there is no expansion of coal capacity from 2021, and capacity is completely phased out by 2050, coal generation continues to play a substantial role in power generation in the PES – contrary to the 1.5˚C Scenario, where the cost of coal generation in 2030 is two to three times greater due to increased carbon prices. These factors make electricity in the 1.5˚C Scenario comparatively expensive. Nevertheless, the rapid deployment of renewables (mainly solar PV) between 2030 and 2050 in the region, as well as the substantial decrease in the price of solar PV in the 1.5˚C Scenario, lowers electricity costs in 2050 compared to 2030.

The induced and indirect effects (other) play a positive role throughout the first two decades in Southeast Asia region under the 1.5˚C Scenario. These effects are of larger magnitude until 2030 but start diminishing afterwards and become slightly negative from 2045 to 2050, mainly driven by consumer expenditure. Between 2021 and 2030, household consumption benefits from a diversified economy due to investment stimulus and international climate co-operation flows that provide financial support to low-income households. The increase in real incomes leads to an increase of consumer spending. Between 2021 and 2030, the reduction in total household expenditure is much smaller than the reduction in real household disposable income due to income tax increase (see below). That is, average saving rates are lower in the 1.5˚C Scenario during that period. After 2030, income starts to gradually recover due to a decrease in income tax; however, consumption does not. From 2045, the opposite occurs with larger relative reductions in household expenditure than in real disposable income, implying that saving rates increase in the long term in the 1.5˚C Scenario compared to the PES.

Changes in income tax rates, which is a part of the driver, have a slightly negative impact on the GDP difference in the years to 2030. Differences in revenue and spending between 1.5˚C Scenario and the PES throughout the transition period require increases of income taxes in the first decade under the 1.5˚C Scenario. The higher negative impact observed before 2025 is due to low revenues from the carbon tax, which leads to a significant increase in income tax to cover transition-related investments and the loss of value of the oil and gas sector. The latter, which is attributable to both lower global oil prices in the 1.5˚C Scenario and lower extraction volumes, will have a slightly negatively impact on the spending side of the regional fiscal balance. In the same vein, the first decades see an increase of the public transition-related investment and the subsidies to support the transition. Carbon pricing and international co-operation receipts increase revenues in the 1.5˚C Scenario compared to the PES. Thus, as the carbon tax rate increases, income tax decreases and the driver becomes mildly positive. The additional revenues from carbon pricing and the international co-operation flows will play a critical role in the region to enable the investments needed for the transition and to offset the loss of value of the oil and gas sector (particularly in Indonesia) and to support a just transition.

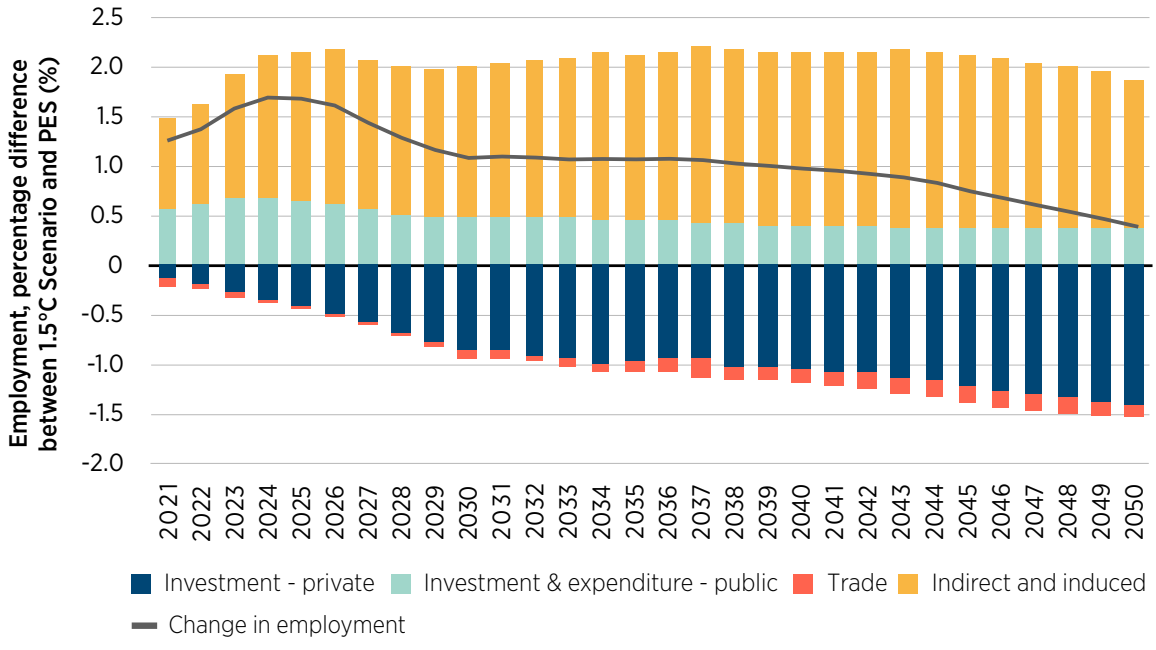
Induced effect – lump sum payments play an increasingly positive role over the first two decades of the transition period (*i.e.* 2021-2041) in driving the overall regional GDP difference, but are modest in comparison to the other two previous drivers (induced – aggregate prices and the induced and indirect effects [other]). Nevertheless, this driver's role is more important in the case of Malaysia. It deals with the domestic distributional issues, *i.e.* providing support to the lower quintile population. The revenue recycling treatment assumes that lump sum payments are paid directly to households in the 1.5˚C Scenario when the government accumulates excess tax revenues after paying for transition-related investment and other policy costs. As previously seen, the evolution of the regional fiscal balances would influence the lump sum payments. These fiscal balances would limit this driver due to equilibrated revenue and spending in the last two decades of the transition period. However, higher carbon taxes in the 1.5˚C Scenario could be a lever to increase the fiscal space for lump sum payments and their socio-economic benefits.

3.4 EMPLOYMENT

Economy-wide employment

Under the 1.5˚C Scenario, employment is higher than in the PES by an average of 1.0% over the 2021-2050 period. The employment difference reaches its peak in the first decade (around 1.7% difference, which is around 6 million additional jobs), then declines progressively to achieve 1.2 million additional jobs (representing more than 0.3% difference) in 2050. This trend is underpinned by drivers related to indirect and induced effects, and investment, while trade has a minor impact. The different components of the drivers are presented in Figure 19.

Figure 19 Employment in Southeast Asia, percentage difference between the 1.5˚C Scenario and the PES by driver, 2021-2050



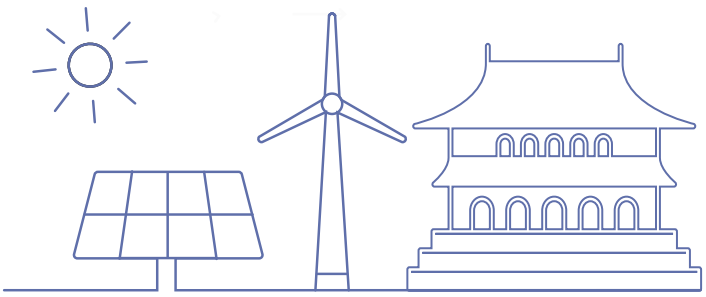
Compared with the PES, the 1.5˚C Scenario results in higher economy-wide employment mainly driven by the indirect and induced effects throughout the transition period. The driver's indirect and induced effects on one hand, and investment as whole on the other hand, considered separately, significantly impact the economy-wide employment difference in the last decade, although they almost cancel each other out. Indirect and induced effects are the main driver throughout the transition period in the

creation of additional jobs (reaching around 5.4 million additional jobs in 2050). Increasing wages has a moderately positive effect on employment in the region. Specifically, the effect is stronger in the years before 2030 because the labour supply is limited, leading to higher wages in response to increased demand. The latter could incentivise employers to potentially increase overall employment levels. From 2035 onwards, the changes due to consumer expenditures become the main driver, mainly as ripple effects from front-loaded transition-related investment in the form of more consumer spending. In 2050, the consumer expenditure driver is responsible for positive employment impacts of around 3.6 million additional jobs in the 1.5˚C Scenario compared to the PES.

The increase in consumption is due to the investment stimulus and the lump sum payments, as discussed in Chapter 3, Section 3, which leads to households consuming more. Also, the shift in the pattern of consumer expenditure under the 1.5˚C Scenario compared to the PES has a notably positive impact on the economy-wide employment difference over the transition period. Consumption shifts from fuels to restaurants and hotels, and miscellaneous goods and services, which include education, personal expenses and financial services. The shift in consumption pattern also leads to a change in sectors servicing consumer expenditure. The sectors that receive an increase in consumer expenditure create more jobs than those lost.

Public investment and expenditure lead to more jobs. The effects are higher in the years to 2030, because of higher government contribution to transition-related investments (energy efficiency and end uses, electrification, renewables, *etc.*) in the short term. More public investment is received by sectors that are more service-oriented and includes redesign of building spaces, energy management system upgrades and retrofits. Also, throughout the transition in comparison with the PES, greater social spending is observed and leads to substantial new employment across the region that benefits significantly from the international climate co-operation flows. The impact of private investment on economy-wide employment is increasingly negative throughout the transition period mainly due to the investment loss in fossil fuels. The value of this fossil fuel supply investment is notably negative given the region's high level of fossil fuel extraction and high employment intensities. The effect is strongly negative after 2030, when the fossil fuel phase-out accelerates. By 2050, there are 1.7 million jobs lost due to the loss of fossil fuel supply investment, and 4.4 million jobs due to declines in fuel extraction activities, which require policy intervention to retrain workers for other jobs and avoid major disruptions to living standards. These occupations are typically concentrated in specific regions and have a regional impact, emphasising the need to consider the diverse geographic effects to develop focused policy interventions.

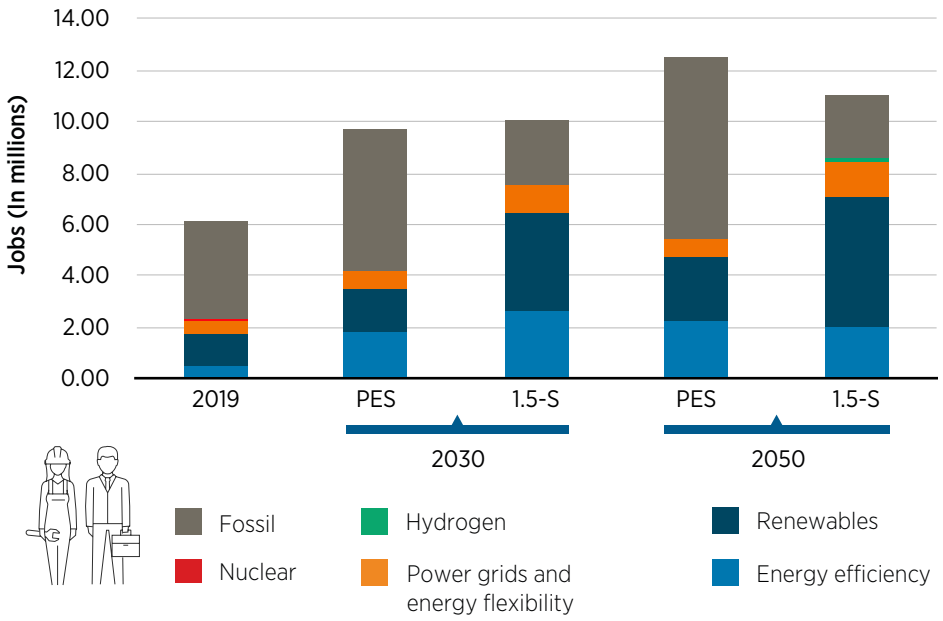
Trade has a negative impact on employment throughout the transition period, although trade's impact is minor (Figure 19). The impact of the driver on employment is mainly influenced by the change in non-energy sector trade. It is a result of competitiveness changes in international markets and a shift towards higher goods imports driven by increased consumer expenditure as discussed in the trade patterns detailed in the GDP drivers in Chapter 3, Section 3.



Energy sector jobs

The 1.5˚C Scenario creates more jobs in the energy sector in the first decade than the PES. In 2030, the energy sector employs over 10.3 million people under the 1.5˚C Scenario, compared to 9.7 million in the PES. By 2050, the energy sector would have a total of 11 million jobs in the 1.5˚C Scenario compared to 12.6 million in the PES. This difference in employment between the 1.5˚C Scenario and the PES in 2050 is due to the loss of jobs in the fossil fuel sector, which would be almost entirely offset by jobs created by the front-loaded construction of new plants and infrastructure (including investments in energy efficiency) (Figure 20).

Figure 20 Overview of energy sector jobs in Southeast Asia under the PES and the 1.5˚C Scenario, by sector, 2019-2050



Note: 1.5-S = 1.5°C Scenario; PES = Planned Energy Scenario.

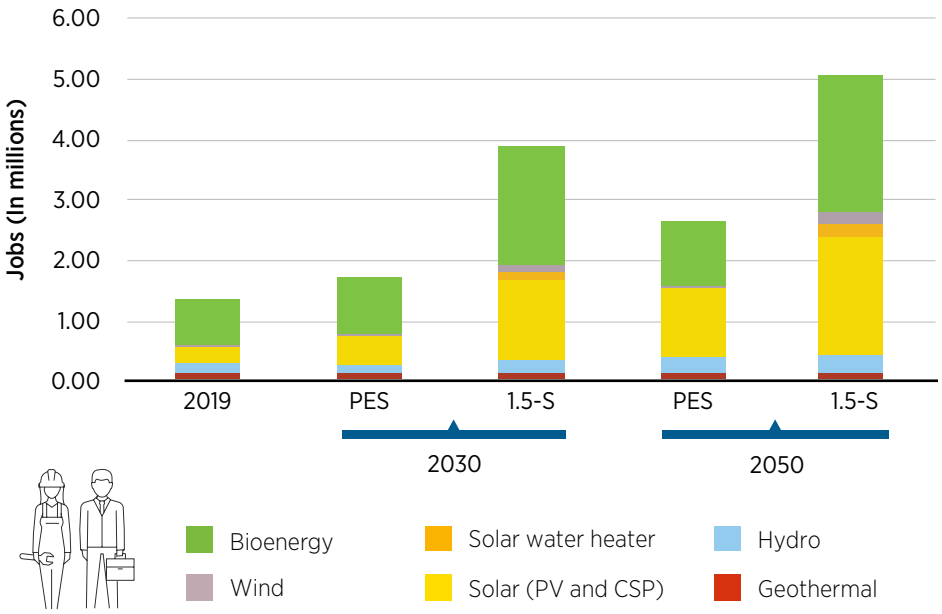
The renewable energy sector accounts for around 45.8% of total energy sector jobs (5.1 million jobs out of the total of 11 million) in the 1.5˚C Scenario by 2050. This is followed by jobs in fossil fuels accounting for 23.1% (*i.e.* 2.5 million jobs) and in energy efficiency with a share of 18.3% (*i.e.* 2 million jobs). Power grids and flexibility create 1.3 million jobs, representing around 11.5% of the total energy sector jobs. Nuclear, vehicle charging infrastructure and hydrogen each contribute less than 1%.

Renewables jobs

The renewable energy sector in Southeast Asia is expected to add substantially to job creation in the sector as the countries adopt the pathway for the 1.5˚C Scenario. While renewable energy job growth in the PES is modest, reaching 1.7 million in 2030 and 2.6 million in 2050, renewable energy jobs under 1.5˚C Scenario reach 3.9 million and 5.1 million jobs by 2030 and 2050, respectively (Figure 21).

Bioenergy and solar PV strongly dominate job creation in the renewables sector. Under the 1.5˚C Scenario, bioenergy accounts for 52.4% renewable energy jobs by 2030 (*i.e.* over 2 million jobs), and 45.4% (*i.e.* around 2.3 million jobs) by 2050. This is followed by solar PV technologies with 33.8% (*i.e.* 1.3 million jobs) and 38.9% (*i.e.* 2 million jobs) shares in 2030 and 2050, respectively. Hydropower jobs account for 6.3% in 2050 under the 1.5˚C Scenario. Solar water heater and wind energy account for 4% and 4.5%, respectively, in 2050 under the 1.5˚C Scenario.

Figure 21 Renewable energy sector jobs in Southeast Asia under the PES and the 1.5˚C Scenario, 2019, 2030 and 2050



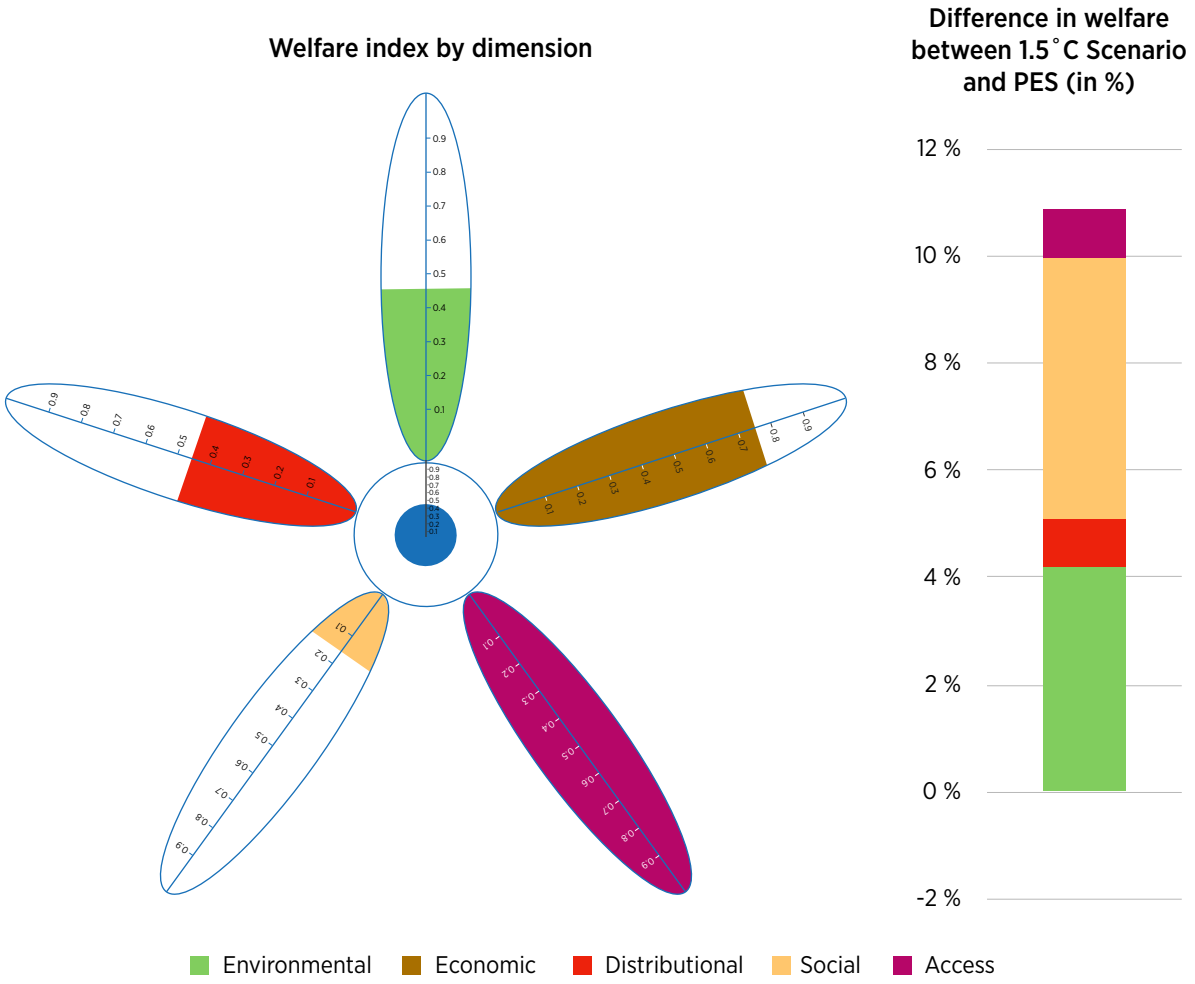
Note: CSP = concentrating solar power; PV = photovoltaic; 1.5-S = 1.5°C Scenario; PES = Planned Energy Scenario.

3.5 WELFARE

While Southeast Asia's economies and job markets clearly benefit from the energy transition, the largest benefit of all is experienced in human welfare. IRENA quantifies the impact of the energy transition through its Welfare Index (IRENA, 2021a), which captures five dimensions: economic, social, environmental, distributional and access. The welfare improvement for Southeast Asia is 10.9% higher under the 1.5˚C Scenario compared to the PES by 2050 (right panel in Figure 22), a difference that demonstrates how much a proactive climate policy could do for people, the planet and economies. Figure 22 (left panel) presents the Welfare Index and its dimensional breakdown for the 1.5˚C Scenario

by 2050 and the relative difference in welfare indices, broken down by dimensional contributions, between the PES and the 1.5˚C Scenario, by 2050 for the region.

Figure 22 Welfare Index by dimension for the 1.5˚C Scenario (left) and difference in welfare between the 1.5˚C Scenario and the PES (right), 2050



Note: Left panel: The five petals are on a scale from 0 to 1 and represent the absolute values of the five dimensions of the welfare Index. The number in the centre is also on a scale from 0 to 1 and represent the absolute value of the overall welfare Index.

The largest welfare improvements under the 1.5˚C Scenario are in the social and environmental dimensions. The social dimension is informed by two indicators: health impact and social expenditure. This dimension is boosted vastly under the 1.5˚C Scenario owing to significant improvements in public health that stem from reduced air pollution and lower heat stress, while social expenditure remains similar under the PES and 1.5˚C Scenario. Under the PES, the reliance on fossil fuels is expected to entail large negative health impacts in Southeast Asia. The low level attained on the social dimension under the 1.5˚C Scenario (0.16 by 2050 on a scale from 0 to 1) (left panel of Figure 22) is due to low levels of social expenditure, indicating potential for further measures to provide added improvements on this dimension.

The environmental dimension is the second-largest driver in improving welfare in the 1.5˚C Scenario. Almost all these welfare benefits are due to much-reduced CO_2 emissions, mitigating the effects of climate change on the region. By contrast, material consumption in Southeast Asia under both the PES and the 1.5˚C Scenario continues to increase, dragging down the absolute environmental dimension (left panel of Figure 22). It highlights the need for much greater policy engagement to reduce the region's material footprint, even beyond IRENA's model assumptions.

Benefits from the energy transition are also anticipated for ASEAN's energy access. Basic energy access improves significantly under the PES, reaching an index value of 0.91 by 2050, and Southeast Asia reaches universal energy access under the 1.5°C Scenario pathway from 2030, reaching its maximum value of 1. Under both the PES and 1.5°C Scenario, ASEAN's energy consumption reaches the sufficiency level, assumed at 20 kWh/capita/day in line with the literature (Millward-Hopkins *et al.*, 2020),[36] in the first half of the first decade (*i.e.* 2021-2025). This implies that the energy accessed is not only basic, but also sufficient, under both scenarios, reaching the maximum index value of 1 (left panel of Figure 22).

The economic dimension experiences limited improvement under the 1.5˚C Scenario. It is informed by two indicators: consumption and investment, and non-employment.[37] Non-employment is calculated as the share of the working-age population (aged 15 to 64 years) that is neither employed nor young (aged 15-24) and getting an education. Non-employment is used instead of unemployment or employment metrics because of its more comprehensive gauging of the social implications of paid work, which is the main goal of a welfare index. Under the 1.5˚C Scenario, the consumption and investment indicator sees no improvement over the PES and goes negligibly negative. However, by 2050, Southeast Asia experiences a slight improvement in the non-employment indicator in the 1.5˚C Scenario. Overall, the dimension sees no improvement under the 1.5˚C Scenario over the PES.

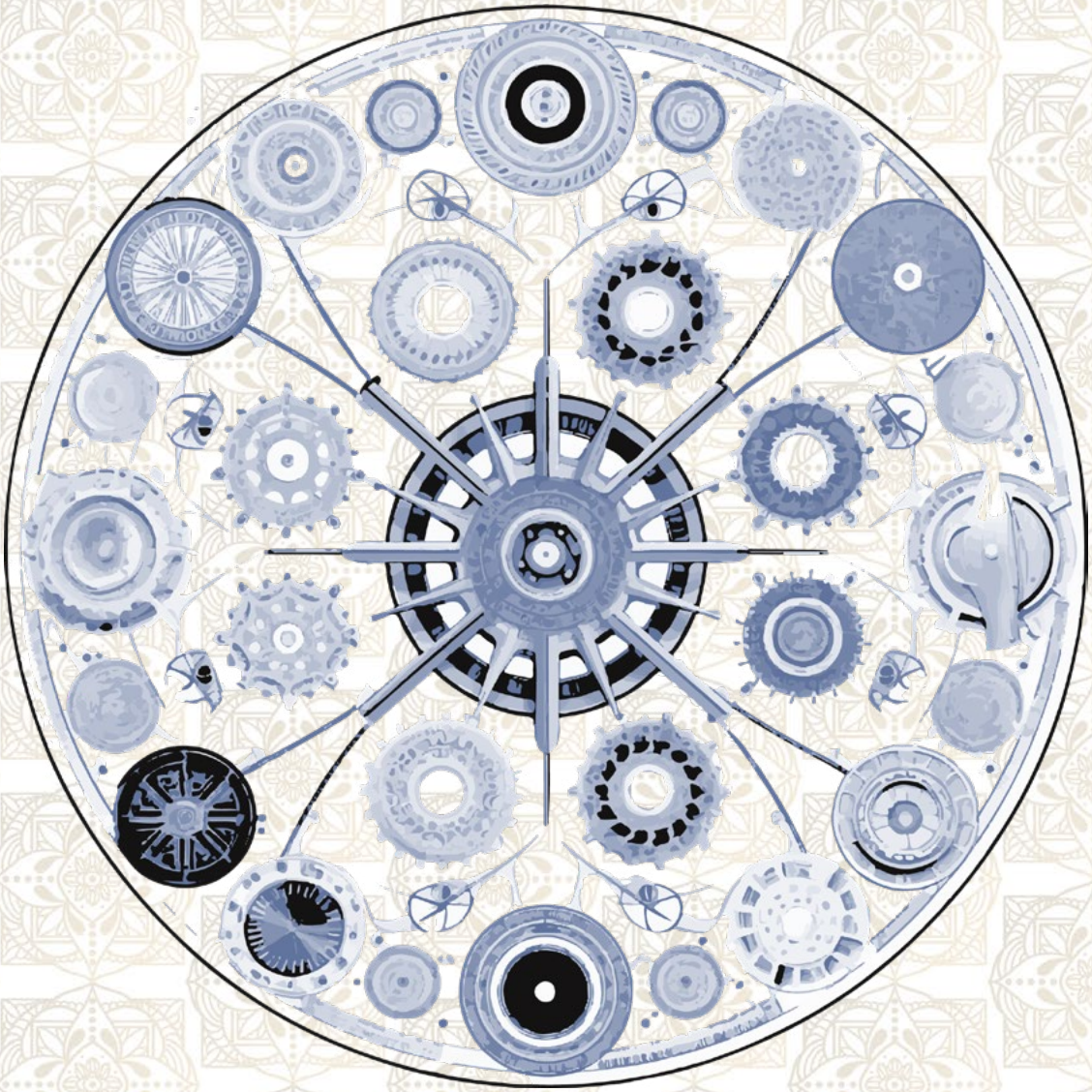
The distributional dimension increases under the 1.5˚C Scenario compared with the PES in Southeast Asia (right panel of Figure 22). The income distribution experiences only a small improvement over the PES. This is due to the limited available fiscal space. While receiving international co-operation flows, there are reduced carbon tax revenues with a decreasing reliance on fossil fuels, a loss of value in the oil and gas sector (lower global oil prices and lower extraction volumes), and an increase of the public expenditure (subsidies to support the transition, public transition-related investment). The absolute distributional index reaches 0.46 under the 1.5˚C Scenario by 2050 in Southeast Asia (left panel of Figure 22), compared to 0.44 under the PES. This is higher than the global index of 0.36 in the 1.5˚C Scenario, although it indicates significant room for improvement. The policies included in the climate policy basket in the 1.5˚C Scenario directly target the improvement of income distributions (both intra and inter), and more must be done to alleviate structural distributional inequalities in the region.

The Welfare Index and its dimensional indexes (left panel of Figure 22) provide an indication of where to focus policy action to improve welfare in Southeast Asia. Under the 1.5˚C Scenario, an overall welfare index of 0.48 by 2050 on a scale from 0 to 1 highlights the energy transition benefits to the people of Southeast Asia, yet there is also significant potential for additional measures to deliver further improvements in welfare. The social dimension offers the greatest opportunity for further improvement, with a focus on the implementation of policies addressing increases in social spending. The environmental and distributional dimensions also offer significant room for improvement. Policies addressing the reduction in the consumption of materials would produce improvements in the environmental dimension. To further strengthen the economic and distributional dimensions, more attention should be paid to policies that increase wealth distribution and create more flexibility for governments in their spending choices (fiscal space), which in turn enables improvements in income distribution.

[36] *The sufficiency level is estimated to be between 11.6-30.4 kWh/capita/day across all 119 countries depending on the scenarios considered.*

[37] *Indeed, while unemployment and employment are evaluated as shares of the labour force, non-employment is defined on the basis of the entire working-age population (not only the part of it belonging to the labour force). Hence, beyond a short-term lack of paid work, it also captures a long-term lack of paid work (which is excluded from the labour force).*

04 Conclusion



Over the past 50 years, Southeast Asia has made significant strides, both in terms of economic and social development, and in raising the standard of living for its citizens. However, growth and development have also led to many strains in the existing development model that will need to be addressed to secure future development and safeguard living standards. More than anything else, this means designing a model of utilising the region's natural resources sustainably, to which the region's socio-economic development is tied. While the past few years, especially during the COVID-19 pandemic, have stretched resources and forced a focus on near-term priorities, the region's socio-economic outlook in the near-medium and long-term critically depends on its ability to reshape its own development narrative.

The energy transition offers the region tremendous economic, employment and social welfare benefits. To achieve these benefits, the region will need to move towards a much more proactive policy agenda that takes advantage of the opportunities renewable energy and energy efficiency offer the region. Long-term prospects will rely heavily on the success of efforts aimed at addressing climate concerns together with economic agendas such as investments, complemented by policies designed to address the climate vulnerable population, shifting demographic patterns and various socio-economic agendas governing individual Southeast Asian economies.

The energy transition will bolster the region's economic and welfare prospects in the coming years. The analysis presented in this report shows that a comprehensive and more ambitious energy transition will lead to improved socio-economic outcomes. Under the 1.5˚C Scenario, the GDP of Southeast Asia is expected to be 3.4% higher than in the PES over the 2021-2050 period. Greater household consumption, trade surplus and international co-operation flows, as well as higher transition-related investment, are the main drivers of this GDP difference. Economy-wide employment will be 1.1% higher under the 1.5˚C Scenario over the PES on the same period, providing jobs to 11.5 million people in the energy sector alone. Renewables provide over 5 million jobs, which is double the number of renewable energy jobs expected in the PES. Other transition-related technologies provide an additional 3.4 million jobs under the 1.5˚C Scenario compared to the PES.

Welfare improves by over 10.9% under the 1.5˚C Scenario by 2050 compared to the PES, led by the social and environmental dimensions. Further measures have the potential to bring about even greater increases in welfare in Southeast Asia. The detailed results provide clear indications of where to focus policy action to improve welfare. The greatest potential for improvement exists in the social dimension, with a focus on the introduction of measures to raise funding for social programmes. The environmental and distributional dimensions also offer significant room for improvement. Improvements in the environmental dimension would result from policies aiming to reduce material usage. Policies that promote wealth distribution and generate greater fiscal space, which in turn allows improvements in income distribution, should be given more attention to further strengthen the economic and distributional characteristics.

Southeast Asian countries have been exerting tremendous efforts to achieve their combined economic and environmental objectives. There are several innovative policies and measures in place to support the energy transition through land-use systems to reduce GHG emissions and pollutants, reduce vulnerability and increase adaptive capacity to climate change, conserve biodiversity, and strengthen rural livelihoods. Many of these are discussed in this report.

Achieving the energy transition will require a substantial increase of investments from the current level. The ASEAN region will require an estimated investment of USD 210 billion per year until 2050 to achieve the energy transition goal (IRENA, 2022b), but securing adequate money for projects requires unique combinations of financial instruments, risk mitigation, sources of funding and business models that vary from those typically used for conventional energy projects.

A way forward

The energy transition is a gradual process, and policy makers will need to ensure harmony between energy policy and other areas of national policy over an extended period to ensure a rapid, inclusive and just transition. Addressing justice and fairness is required to ensure the support and buy-in by all, including national stakeholders and citizens, to deliver benefits equitably, to ensure no one is left behind, to ensure costs do not fall disproportionately on disadvantaged groups, and to ensure the energy transition supports rather than counteracts social welfare and equality. To achieve the central objective of the region, which is to bring clean and sufficient energy to all and facilitate a just transition from fossil-based to renewables-based economies, the energy transition policy framework should be holistic. The multiple facets of the interactions among the energy, economic and social systems can be addressed more effectively with holistic planning and synergistic implementation than an approach relying on a limited number of interventions. Some of the key recommendations can be divided into three categories: economy-wide, integrated/cross-sectorial and energy sector (Table 2).

Addressing climate change, including mitigation as well as adaptation efforts, must be a top priority on the regional political agenda. Establishing co-ordinated policies and targets for more ambitious emission reduction strategies across the countries of the region will require policy frameworks that allow for greater regional integration and co-operation. Policies and regulations that encourage greater local private-sector participation could play a fundamental role. Tapping into the existing strong manufacturing base and introducing supportive local content policies are critical to ensure that the energy transition will reach all facets of the development of the industrial sector, local markets and workforces.

The region should leverage existing resources to move up supply chains for greater value added. Designing concentrated efforts, such as targeted skills and technical training programmes; science, technology, engineering, and mathematics (STEM) education curriculums; apprenticeships; and more opportunities aimed specifically at disadvantaged and youth populations will allow the creation of the workforce. This will also require developing well-designed capacity development, skills training and co-operation across cross-cutting concerns such as gender equity, vulnerable groups and local communities.

Across the region, further support around R&D in renewables would support the region's energy transition. Policies should promote increased sharing of data, information and knowledge and dedicated funds directed to R&D work. The communication and collaboration between R&D stakeholders, such as governments, research institutes and universities, and policy makers should be more aligned to create complementary and achievable goals. Governments can support R&D by laying out clear and detailed science and technology plans (ACE, 2019).

Raising the commitments to renewables and energy efficiency measures is urgently needed. This should be combined with a gradual reduction and elimination of fossil fuel subsidies and redirection of support measures towards social services and sustainable development. Higher investment in interconnection infrastructures (like the ASEAN power grid initiative), increased energy storage capacity, and upgrades to smart grids to improve energy access and security throughout the region will be needed to achieve the energy transition. Upgrading existing power grids to utilise the technologic advances of smart grids will further support and enhance the benefits of interconnection.

As the energy transition advances, the world is beginning to see the benefits of basing energy supplies on renewables and cutting energy demand through greater efficiency. Southeast Asia has the potential to benefit immensely from the opportunities created by the energy transition if appropriate policies and frameworks are put in place.

Table 2 Challenge-opportunity framework for Southeast Asia

	Challenges	Opportunities
Economy-wide	Damages from climate change	Lower the damages through timely action and adaptation
	Constrained fiscal budget (exacerbated by COVID-19) and low government spending on social affairs	Fiscal support through international co-operation
	Infrastructure and financial gap	Acceleration of energy infrastructure development
	Declining trend of manufacturing	Improved manufacturing base for energy transtion related technologies (such EVs, storage etc.)
	High mortality rate related to indoor air pollution	Cleaner air and improved health
	Trade deficit	Trade surplus from less import of energy and supply of critical materials
	Vulnerable communities and displaced workers	More availability of quality and green jobs
Integrated or cross-sector	Research and development	Enhanced research facilities and capabilities to support transition technologies
	Skills and education readiness	Empowered local workforce
	Dependence on mineral resources	Greater value added by moving up the supply chain
Energy sector	Continued reliance on fossil fuels	Less reliance on fossil fuels leading to myriad of economic and human welfare benefits
	Lack of finance for energy infrastructures	Availability of funds through double dividend and other market based mechanisms
	High subsidies on fossil fuels	Redirect subsidies to sustainable energy technologies
	Lack of energy access	Universal energy access
	Clean cooking fuel access	Universal access to modern cooking fuels

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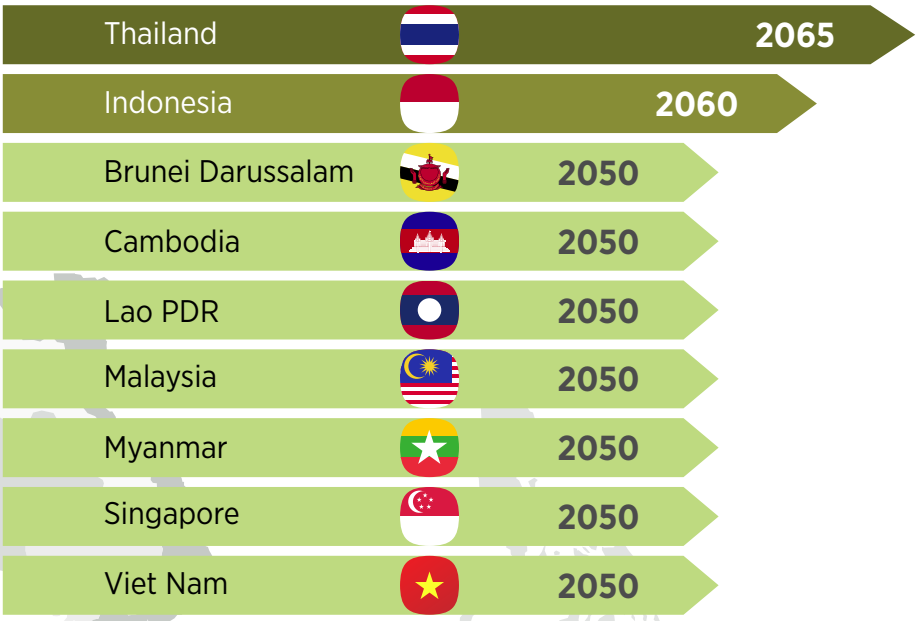
Annex A: NDCs in Southeast Asian countries

Most ASEAN countries have pledged to reach net-zero GHG emissions by 2050 (Figure 23), although current plans outlined in their NDCs do not yet support this goal.

Figure 23 Net-zero target and year for selected Southeast Asian countries.



In addition, a recent analysis from the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) has shown that many of the NDCs are not aligned with national development plans (UNESCAP, 2022). Of the outliers, the Philippines did not make a net-zero pledge. Indonesia and Thailand have target years further in the future (2060 and 2065, respectively). The latest NDCs and net-zero pledges made at COP26 can be found in Table 3.

Table 3 The unconditional and conditional NDCs in Southeast Asia

	NDC	
Country	**Unconditional**	**Conditional**
Brunei Darussalam	20% GHG emissions reduction relative to business as usual (BAU) by 2030	N/A
Cambodia	N/A	41.7% GHG emissions reduction by 2030 relative to BAU
Indonesia	29% GHG emissions reduction relative to BAU by 2030	41% GHG emissions reduction relative to BAU by 2030
Lao PDR	60% GHG emissions reduction relative to BAU by 2030	Targets indicated in kilotonnes of carbon dioxide equivalent ($ktCO_2eq$) per year for different sectors
Malaysia	Economy-wide carbon intensity reduction (against GDP) of 45% in 2030 compared to 2005 level	N/A
Myanmar	244.52 million tCO_2eq[38] by 2030	414.75 million tCO_2eq by 2030
Philippines	2.71% GHG emissions reduction relative to BAU by 2030	72.29% GHG emissions reduction relative to BAU by 2030
Singapore	Economy-wide GHG emissions in 2030 ≤ 65 million tCO_2eq to achieve a 36% reduction in emissions intensity from 2005 levels by 2030[39]	N/A
Thailand	20% GHG emissions reduction relative to BAU by 2030 economy-wide, excluding LULUCF[40]	25% GHG emissions reduction relative to BAU by 2030 economy-wide, excluding LULUCF
Viet Nam	7.3% GHG emissions reduction relative to BAU by 2025; 9% by 2030[41]	27% GHG emissions reduction relative to BAU by 2030

[38] *tonnes of CO_2 emissions equivalent (tCO_2eq).*

[39] *Singapore's enhanced NDC now states an absolute emissions target to peak emissions at 65 $MtCO_2eq$ around 2030. The Low-Emission Development Strategy builds on the enhanced NDC's target by aspiring to halve emissions from its 2030 peak to 33 $MtCO_2eq$ by 2050, with a view to achieving net-zero emissions as soon as viable in the second half of the century (The Ministry of Sustainability and the Environment [Singapore], 2020).*

[40] *Land use, Land-use Change, and Forestry (LULUCF).*

[41] *New information on July 27, 2022: Viet Nam's National Strategy on Climate Change 2050 has been issued under 896_QD-TTg_26072022 aiming for emissions reduction of 43.5% relative to BAU in 2030, peak in 2035, and net zero by 2050 (SGGP Online et al., 2022).*

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