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BRI Green and Low-carbon Transition of ASEAN Member States –Potentials and Opportunities

Acknowledgement

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Contents

Executive Summary

I. Background and Goals

At present, green and low-carbon transition has become a global consensus, and the development of green industries such as clean energy will bring new economic growth and inject new momentum into global economic recovery Member states of the Association of Southeast Asian Nations (ASEAN) are now in a critical period of economic development and industrial transformation and upgrading. ASEAN made a joint statement before COP26 that they've achieved an energy intensity reduction of 21%, surpassing its aspirational target set in 2018, and calling upon developed countries for cooperation. According to *the ASEAN Plan of Action on Energy Cooperation* (*APAEC) 2016-2025 Phase II: 2021-2025*, the ASEAN member states will deliver an energy intensity reduction target of 32% by 2025 based on the 2005 level. On Renewable Energy (RE), ASEAN will aim to achieve its aspirational targets of 23% share of RE in Total Primary Energy Supply (TPES) and 35% share of RE in installed power capacity, which faces a large gap in funds, technology and energy infrastructure.

Home to the world's largest solar photovoltaic (PV) and wind power equipment, China's PV installation accounted for 76% of the global total and wind more than one half. The country's installed capacity of PV and wind power both lead the world. China and ASEAN's cooperation in green and low-carbon transition is at a historical juncture of huge opportunity. In the *Action Plan for Carbon Dioxide Peaking Before 2030* issued by the Chinese government, the overall planning of the work required to make the Belt and Road Initiative (BRI) a green initiative, and to strengthen cooperation with other participants on green infrastructure, green energy, and green finance. China will make overseas projects more environmentally sustainable, develop a BRI energy partnership characterized by green development and inclusiveness, and expand the export of new energy technology and products. The role of cooperation platforms such as the BRI International Green Development Coalition and the *Green Investment Principles* will be brought into full play.

China and ASEAN are made to be partners in their green and low-carbon energy transition. Since the adoption of the *ASEAN-China Strategy on Environmental Cooperation* in 2009, the two sides have established mature policy dialogue mechanisms in the field of environment and climate, making practical cooperation happening in response to climate change, capacity building on

biodiversity protection, and many other aspects. According to the latest *Framework of ASEAN-China Environmental Cooperation Strategy and Action Plan 2021-2025*, the two sides will maintain closer ties in this field.

Moreover, at the 76th Session of the United Nations General Assembly, Chinese President Xi Jinping stated that it will step up support for other developing countries in developing green and low-carbon energy, and will not build new coal-fired power projects abroad. It shows that China's focus on investment and financing overseas will shift. China and ASEAN have become each other's largest trading partners. China's investment in and cooperation with ASEAN in RE will inevitably be strengthened. However, ASEAN member states are different in resource endowment, economic development, and industrial structure, and the two sides are not consistent in their optimal transformation paths. Thus, it's in an urgent need to carry out studies to determine the key areas and direction for the two sides' next-stage cooperation.

II. The Status-quo of ASEAN's Green and Low-carbon Development

Located at the crossroads of Asia and Oceania, the Pacific and Indian Oceans, southeast of Asia, the ASEAN region has a unique geographical advantage in pursuing economic and social development. As their economy and population continued to grow in recent years, the carbon emissions of the ten ASEAN member states by energy sources continued to rise, increasing from 693 $MtCO_2$ in 2000 to 1,610 $MtCO_2$ in 2019[1]. ASEAN's future economic growth, if no robust mitigation actions taken, would bring huge amounts of greenhouse gas emissions. With carbon neutrality becoming a global trend, it is well noted that ASEAN member states have upgraded their National Determined Contributions (NDCs) in 2021, by considering common but differentiated responsibility and respective capability, which are not ambitious enough. Currently, nearly half of all ASEAN member states still have yet to committed to coal exit, making ASEAN's low-carbon transition all the more urgent.

[1] Source: IEA. 2020. Data and statistics. https://www.iea.org/data-and-statistics/data-browser?country=MASEAN&fuel=CO2%20emissions&indicator=CO2BySource

Table: Committed Timetable of ASEAN Member States for Carbon Peaking & Neutrality

Country	Carbon Peak	Carbon Neutrality
Brunei Darussalam	-	-
Cambodia	-	-
Indonesia	2030	2060
Laos PDR	-	2050
Malaysia	-	2050
Myanmar	2030	-
the Philippines	2030	-
Singapore	2030	To halve emissions from its peak by 2050, with a view to achieving net zero emissions as soon as viable in the second half of the century.
Thailand	2030	2065
Vietnam	-	2050

(Source: NDCs and Long-Term Low-Emissions Development Strategy (LEDS) of ASEAN Member States)

III. ASEAN-China Cooperation in Green and Low-carbon Energy Transition under the BRI Framework

As Chinese President Xi Jinping announced that China will step up support for other developing countries in developing green and low-carbon energy, and will not build new coal-fired power projects abroad, green and low-carbon energy cooperation will play a more important role in the BRI cooperation. A report of the World Economic Forum believes that the BRI plays a leading role in boosting economic growth and avoiding the carbon lock-in effect in emerging and developing economies, by accelerating the construction of low-carbon infrastructure.

There is a huge potential for energy cooperation between China and the BRI participating countries. In recent years, China's power enterprises have made steady progress in foreign investment since 2010, with the steady advancement of "going global" and the implementation of the BRI. According to the National Bureau of Statistics, in 2020, the foreign investment flow in the fields of electricity, heat, gas, water production and water supply reached USD 2.78 billion, a year-on-year increase of 10.3%. By the end of 2020, the stock of China's foreign direct investment (FDI) in these areas amounted to USD 39 billion. In 2019, Chinese-funded enterprises signed 318

power projects in the BRI participating countries, recording 56.5% of the total overseas power projects, with the project value of USD 32.28 billion, accounting for 68.4%.[2]

China has significant advantages in developing RE cooperation with the BRI participating countries. As the world's largest manufacturer of solar panels, wind turbines, batteries and electric vehicles, China also boasts rich experience in and great potential for green and low-carbon cooperation with ASEAN member states. According to an IEA report, China remains the leader of renewable electricity capacity between 2021 and 2026, which is forecast to increase by nearly 8 million kW, accounting for 43% of the global growth. With its commitment to calling off new coal-fired power projects abroad, China will make full use of its edges in RE, to further consolidate and propel the low-carbon transition process for the BRI countries. China's overseas energy investment and cooperation right now are mainly conducted through overseas project contracting, in which equity investment is playing an increasingly important role.

IV. Key Issues Concerning ASEAN's Green and Low-carbon Transition

ASEAN's transition in RE has long attracted attention from all parties. Previous studies pointed out that generally, ASEAN member states are highly dependent on fossil fuels, and most of them continue to lack fully transparent land permitting procedures for RE development. Barriers can also be found in lengthy permitting processes, unsteady incentives and unclear grid regulations.

The 6th ASEAN Energy Outlook (AEO6) predicted that by 2040, ASEAN's demand would increase by 146%, compared to 2017. Fueling the rising demand, the region's TPES in 2040 is 2.5 times higher than in 2017. In the APAEC Target Scenario (APS), ASEAN's TPES by 2040 is estimated to be 1,139 Mtoe[3].

[2] Source: SINOSURE. The Handbook of Country Risk 2021. Beijing: China Financial & Economic Publishing House, September 2021.

[3] Million ton oil equivilant.

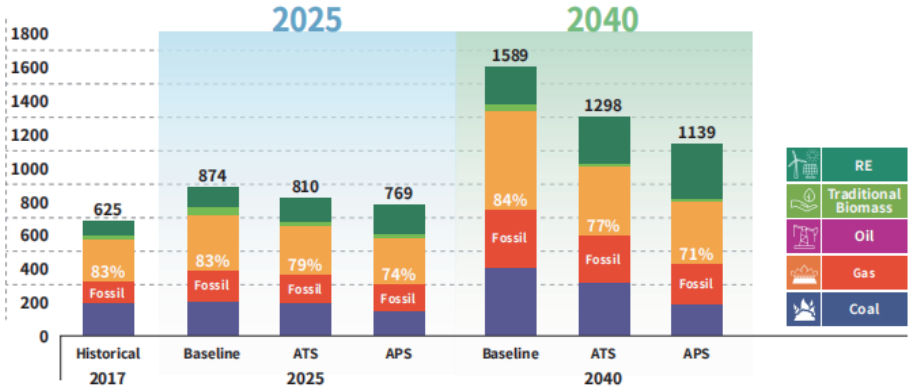

Figure. ASEAN Primary Energy Supply (Mtoe) by Fuel[4]

Four major problems or challenges were found in ASEAN's development of regional energy cooperation, including funds, policies, technologies, and barriers. ASEAN focuses on seven programme areas in the APAEC, namely ASEAN Power Grid, Trans-ASEAN Gas Pipeline, Coal and Clean Coal Technology, Energy Efficiency and Conservation, RE, Regional Energy Policy and Planning, and Civilian Nuclear Energy. Moreover, it is noted that ASEAN has high demand for fossil energy, such as coal, at the current stage.

In addition to financing, ASEAN faces special geographical conditions featuring lofty mountains, dense rivers and jungles, thus placing higher requirements and challenges for its power technologies from generation to transmission. The level of smart grid, meanwhile, varied among member states. A weak power system will affect the stability of operation and scale of transaction of ASEAN's interconnection. Most ASEAN member states still gave priority to filling the gap in power infrastructure. To integrate RE into their development plans and increases its proportion in primary energy, members of this region will need science-based supporting policies from policymakers, as well as energy development plans conducted in the light of local conditions.

To this end, this report will analyze the characteristics of 10 ASEAN member states in four categories: (1) Indonesia, far greater economic volume and emission scale than other countries; (2) Vietnam, Thailand, Malaysia, and the Philippines, relatively sound economic development, with large potential for rising emissions and national strategies; (3) Myanmar, Cambodia, and Lao PDR, relatively slow or moderate in the economy growth with potential for RE development; and

[4] Baseline Scenario is the business as usual without any policy intervention. ASEAN Target Scenario (ATS) is taking consideration the national targets of RE and energy efficiency. APAEC Target Scenario (APS) is taking into account the regional target stated in the APAEC.
Source: AEO6

(4) Singapore and Brunei, small in size but developed in the economy, playing an exemplary role in clean energy technology and green finance, etc.

1. Indonesia

Indonesia's economic size, population and total emissions far exceeds those of other ASEAN member states. If the transition achieved, Indonesia will has the largest potential for emission reduction. The country still faces a large capital gap to realize coal exit, and grid improvement is needed to the deployment of RE power generation.

The continuous development of coal-fired power plants poses a major challenge to Indonesia's greenhouse gas emission reduction goals. The short, medium and long-term plans for coal phase-down in the power sector are still unclear. An interconnected grid has not yet been formed among the islands of Indonesia. Areas with abundant renewable resources but limited consumption capacity cannot deliver clean electricity to areas with large demand, limiting the rapid development of RE. On May 27, 2021, Indonesia announced that it would phase out its coal-fired power generation. Strong political determination and policy support in reducing emissions shown by Indonesia, though, the target cannot be achieved overnight. For the next step, Indonesia needs to give play to the market mechanism, to stimulate the development of RE and low-carbon industries.

First, to expand the scale of financing in the energy transition by exploring the establishment of a carbon market. In November 2021, the Law on Harmonization of Tax Regulations Indonesia (HPP Law) was regulated, allowing a pilot carbon emission trading. Through the HPP Law, the government provides a tax on carbon in the steam power plant (PLTU) sector and coal sector. The fare is a minimum of Rp. 30,000 (about USD 2) per kilogram of carbon dioxide equivalent (CO_2e)[5]. The terms related to carbon tax will be enforced on April 1, 2022. Once implemented, Indonesia's carbon tax system will have a positive impact on the transformation of the electricity market and the development of RE, bringing funds to energy transition. Market measures such as carbon tax, also need to be continuously improved and fine-tuned in practices, to avoid an indirect burden for the living cost of residents and impacts on the level of economic green recovery. Indonesia's carbon tax and China's carbon trading market construction are two different carbon pricing paths, but both require estimation and verification of carbon emissions of all industries. The two sides could launch experience exchanges in this field, to improve their respective mechanisms.

[5] Source: https://www.double-m.co/en/the-law-on-harmonization-of-tax-regulations-indonesia-uu-hpp/

Second, to strengthen the connectivity of grid infrastructure and to improve the capacity of RE consumption. Rich in RE resources, Indonesia is blessed with abundant geothermal, biomass, hydropower and solar energy, yet the utilization rate is not high. A nationwide power grid system has not been built. A study of IESR, Indonesia's think tank, shows that achieving zero carbon emissions in the Indonesian energy system by 2050 is technically and economically feasible, while its PV installed capacity is required to improve by a large margin. Indonesia should strengthen the construction of grid infrastructure, especially the level of provincial power connectivity and energy storage, to improve the consumption and installed capacity of RE.

2. Malaysia, the Philippines, Thailand and Vietnam

Among Southeast Asian countries, Vietnam, Thailand, Malaysia, and the Philippines are developed relatively well in economy and policy and practice foundations for RE. However, they are all encountering the common issues in green and low-carbon transition, trapped by the middle-income status and challenged by sustainable development transition. First, the four countries were equipped with national strategies and aspirational policies to develop RE, while facing a reality that coal power takes up a large share; second, strict restrictions on foreign investment to take part in the energy sector, limiting to the financing of domestic RE industry.

In 2020, Vietnam overtook Thailand and emerged as the leader in solar electricity adoption in the ASEAN area, with a total capacity of PV reaching 16.5 GW. Vietnam proposes a possibly higher target of solar capacity in its latest National Power Development Plan (PDP8), which was postponed for a few times and is said to lower the level of deduction due to internal issues.

Thailand boasts huge potential for PV development, whose edge in automotive industry is expected to be transformed into terminal electrification such as NEVs. However, the power of Thailand relies heavily on imports, in an urgent need to improve its local RE mixes such as PV and biomass.

With RE occupying around 17%, Malaysia is rich in renewable resources, mainly hydropower, solar and biomass. In 2019, Malaysia released its blueprint of electricity supply industry 2.0 (MESI2.0), which intended to promote more independent enterprises to enter the power sector, but the shareholding of foreign-invested electric power projects is restricted to a maximum of 49%. The Philippines also enjoys a potential for wind and PV power resources, active in promoting the RE development.

For the next step, actions are suggested to be taken centering on the following aspects:

First, to further strengthen the top design of power investment environment, providing more external financial support for coal exit and energy transition. The economic prospects of the above-mentioned four countries are promising, with a solid foundation for attracting international funds, but the capital needed for de-carbonization of their power system is huge. It is advised to introduce or implement the feed-in tariff (FIT), renewable portfolio standards (RPS), and Net Metering, to relax restrictions on the proportion of equity investment in power projects, and draw in carbon trading and green bond financial instruments, etc. Fuel subsidies on the use of coal, oil and natural gas for power generation shall be removed, since it competes with the economic feasibility of proposed RE projects. In this way, the energy investment environment would be further improved, the vitality of market financing stimulated, and the funding gap filled up. Policy and standard connectivity should be strengthened within the region, with the coverage of smart grid improved and the resilience enhanced through regional electricity trading.

Second, to step up the supporting facilities of PV, wind power and other RE projects and storage, to contribute to the NDC targets. With clear RE strategies, the four countries put in place policies concerning PV and wind power that enjoyed immense potential. Looking forward, the scale and speed of developing PV and wind power should be boosted. In building supporting facilities, the grid's ability to absorb RE should be improved, gradually reducing the proportion of fossil fuels in primary energy, and promoting relevant countries to achieve their NDC targets.

3. Cambodia, Myanmar, and Laos PDR

Myanmar, Cambodia, and Laos are all in the lower reaches of the Mekong River, relatively lagging behind in economic development and simple in industrial structures. Rich in hydropower, wind and solar resources, the three countries did not show any features of high energy consumption or emissions. Problems, however, were found in their process of green and low-carbon transition: (1) the economy is underdeveloped, with the population scattering more in remote rural areas, featuring low urbanization and electrification rates; (2) environmental laws and regulations are not mature, along with the capital market falling behind and inferior local financial market; and (3) the public is weak in addressing climate change and in lack of understanding of RE.

Some areas in the above three countries are experiencing a lack of electricity or no electricity at all. A low rate of electrification will lead to the use of fuels such as firewood and charcoal to meet daily-life needs. In expanding RE investments, the three countries also faced challenges from

macroeconomic requirements, regulatory policies and financing shortages. Safety accidents occurred at hydropower stations in Laos, which reduced local people's acceptance to this area.

For the next step, it is suggested that the three countries should prioritize actions in the following two areas:

First, to promote the construction of grid infrastructure and develop off-grid power generation to improve the accessibility of electricity.

Myanmar is short of power supply, with around 68% electricity access rate in 2019[6]. The rural areas, taking a large share of the population, in the three countries are distant from the power grid. Power shortage is one of the most critical problems. For example, the rural population of Myanmar accounts for 70%. By expanding the existing grid and adding medium and low-voltage distribution networks, more towns and households can be connected to grid electricity. And the off-grid electrification systems should be built, including solar systems and micro-grids, to supply power for rural communities.

Second, to formulate RE policies to achieve green and low-carbon energy transition at lower costs.

Myanmar and Lao PDR boast huge potential in the development of hydropower and solar power. However, hydropower is susceptible to seasons, which is volatile and easy to be affected by the environment. The current penetration rate of solar PV is low, lack of strategic layout, and clear development direction. In the future, it is advised to specify goals of RE development, with vigorous efforts being deployed on PV, biomass and water conservancy. International cooperation should be strengthened and incorporated into ASEAN's energy network, to increase the penetration rate of RE in various sectors, in order to achieve an "overtaking". In developing RE, countries could carry out energy transactions with ASEAN member states, providing a driving force for economic development and green and low-carbon transition.

4. Brunei Darussalam and Singapore

Lack of RE resources endowment is an outstanding issue in Singapore and Brunei's process of green transition. However, the two countries, economically advanced, are able to lead ASEAN's green transition as demonstrators and green finance centers. With small populations and land areas, Singapore and Brunei enjoyed a high level of economic growth and boasted a high Human Development Index (HDI). Situated in tropics, they are abundant in solar energy, but lack of RE resources such as hydropower, wind, and geothermal energy. Although there is little investment

[6] Source: https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=MM

potential in RE projects, though, the two countries, small-sized but high-quality, could serve as important financial hubs and bridges in ASEAN, to boost the development of the region's green projects.

For the next step, it is suggested that both countries prioritize actions in the following two areas:

First, to play a demonstration role and to establish a RE power system.

The current power generation structure of Singapore and Brunei are dominated by natural gas, which accounts for more than 95%. Limited by their own resources, the two countries lack the endowment of wind, hydropower, thermal, and tidal energy, but are rich in solar resources, which enables their development of rooftop photovoltaics to conserve land. Mature in waste-to-energy technology, Singapore could play an exemplary role for other ASEAN member states, to conduct a RE power system that combines PV and waste incineration plants.

Second, to give full play to the role as financial centers, strengthening regional and international green finance cooperation.

Strengthening regional and international cooperation are the key areas that ASEAN would focus on RE strategy in the future. Both Singapore and Brunei developed well in the financial industry in the ASEAN region. Singapore, in particular, as one of Asia's financial centers, saw an early evolution of the financial industry, playing an important role in the development of ASEAN's green finance. Singapore can also act as a benchmark given that it has been a pioneer in the carbon tax deployment in the region. The two countries should give full play to the role of financial sectors, to lesser the restrictions on RE investment in ASEAN as a whole, attract more international funds to join ASEAN's RE market, and help ASEAN member states achieve their NDCs and green and low-carbon transition.

Chapter 1. Background

At present, green and low-carbon transition has become a global consensus, and the development of green industries such as clean energy will bring new economic growth and inject new momentum into global economic recovery Member states of the Association of Southeast Asian Nations (ASEAN) are now in a critical period of economic development and industrial transformation and upgrading. ASEAN made a joint statement before COP26 that they've achieved an energy intensity reduction of 21 %, surpassing its aspirational target set in 2018, and calling upon developed countries for cooperation. According to *the ASEAN Plan of Action on Energy Cooperation* (*APAEC) 2016-2025 Phase II: 2021-2025*, the ASEAN member states will deliver an energy intensity reduction target of 32% by 2025 based on the 2005 level. On Renewable Energy (RE), ASEAN will aim to achieve its aspirational targets of 23% share of RE in Total Primary Energy Supply (TPES) and 35% share of RE in installed power capacity, which faces a large gap in funds, technology and energy infrastructure.

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China and ASEAN are made to be partners in their green and low-carbon energy transition. Since the adoption of the *ASEAN-China Strategy on Environmental Cooperation* in 2009, the two sides have established mature policy dialogue mechanisms in the field of environment and climate, making practical cooperation happening in response to climate change, capacity building on biodiversity protection, and many other aspects. According to the latest *Framework of ASEAN-*

China Environmental Cooperation Strategy and Action Plan 2021-2025, the two sides will maintain closer ties in this field.

To this end, with the support of NRDC, BRIGC initiated the collaborative project of *Identifying Key Issues and Opportunities for cooperation between China and ASEAN Countries in pursuing Green and Low-carbon Transition*. BRIGC organized experts from China and ASEAN member states to conduct researches on key areas of low-carbon transition in ASEAN, and provide different policy recommendations for each country based on its resource endowment, economic development, industrial structure, etc., and give guidance for BRI international cooperation in green transition.

Taking into account the status-quo, policy, industrial and economic status, energy demand and renewable energy development potential of ASEAN member states, the report intends to gather a wide range of stakeholders to analyze the challenges and key issues that ASEAN countries face in the process of achieving green and low-carbon transition and carbon neutrality, identify the potential and opportunities for ASEAN-China cooperation under the framework of the BRI, point out the directions for BRI low-carbon investment and regional cooperation, and provide recommendations and support for practical cooperation between China and ASEAN countries on green and low-carbon transition under the BRI framework.

Chapter 2. Green and Low-Carbon Transition in ASEAN

2.1 Basic Information on Addressing Climate Change

ASEAN is located in southeast Asia, with a total area of 4,435,600 square kilometers. With the Pacific Ocean in the east and the Indian Ocean in the west, it is at the crossroads of Asia and Oceania, the Pacific Ocean and the Indian Ocean, and the Strait of Malacca is the "throat" of this intersection. Among ASEAN Member Sates, Laos is the only landlocked country. Vietnam, Laos and Myanmar are bordered by China on land. Indonesia is the largest country in ASEAN, with its population, area and economic aggregate accounting for about 40% of ASEAN's total, and it is the largest archipelagic country in the world. Malaysia is located in the center of ASEAN and has obvious geographical advantages, closely guarding the Straits of Malacca, connecting ASEAN at sea and on land. Singapore is located at the southern end of the Malay Peninsula, the entrance and exit of the Straits of Malacca, as well as at the "crossroads of the sea", with superior geographical position. Vietnam is located at the southeast end of Indo-China Peninsula, surrounded by the sea on three sides, with a narrow terrain in S-shaped, superior natural environment and abundant resources and minerals.

2.1.1 Emission Status

ASEAN's carbon emissions continue to rise. The total carbon emissions of the 10 countries increased from 693 $MtCO_2$ in 2000 to 1485 $MtCO_2$ in 2018, and its proportion in the world total emissions also increased from 2.98% in 2000 to 4.43% in 2018. According to the IEA report, with the continuous growth of demand in fossil fuels, the total emissions of ASEAN will reach 2400 $MtCO_2$ in 2040[7]. The carbon emissions of ASEAN countries also show consistent convergence with the size of their respective economies. For example, Indonesia, which is the largest economy in ASEAN, is also the largest emitter in ASEAN, accounting for 35.9% of total ASEAN emissions. The second and third largest emitters are the two middle-and high-income countries in ASEAN, Thailand and Malaysia. Attention should be paid to five low-and middle-income countries, namely Myanmar, Cambodia, Vietnam, the Philippines and Laos, whose total emissions only account for 27% of ASEAN's total. Relatively speaking, there is a large room for economic growth for these five countries, and their carbon emissions are expected to continue to rise in the future.

7 IEA, 2019. Southeast Asia Energy Outlook 2019. https://www.iea.org/reports/southeast-asia-energy-outlook-2019

While the main emission sectors of ASEAN countries differ among different national conditions, the electricity sector in included for all ten countries. In 2018, the largest emitters of GHGs in Indonesia are the power generation, transport and industry sectors. The largest emitter in Cambodia is the transport sector, whose emissions even exceed those from the power generation sector. Rich in oil and gas resources, Brunei's main emitters are the power generation, other energy industry and transport sectors. Myanmar's agriculture is the main industry, with more than 60% of the population engaged in agriculture. Therefore, the agriculture sector is also one of the main emitters in Myanmar. Besides, Myanmar is also relatively rich in natural gas resources, so other energy industries also generate more emissions. Vietnam, the Philippines, Malaysia and other countries have the same major emitters, namely power generation, industry and transport.

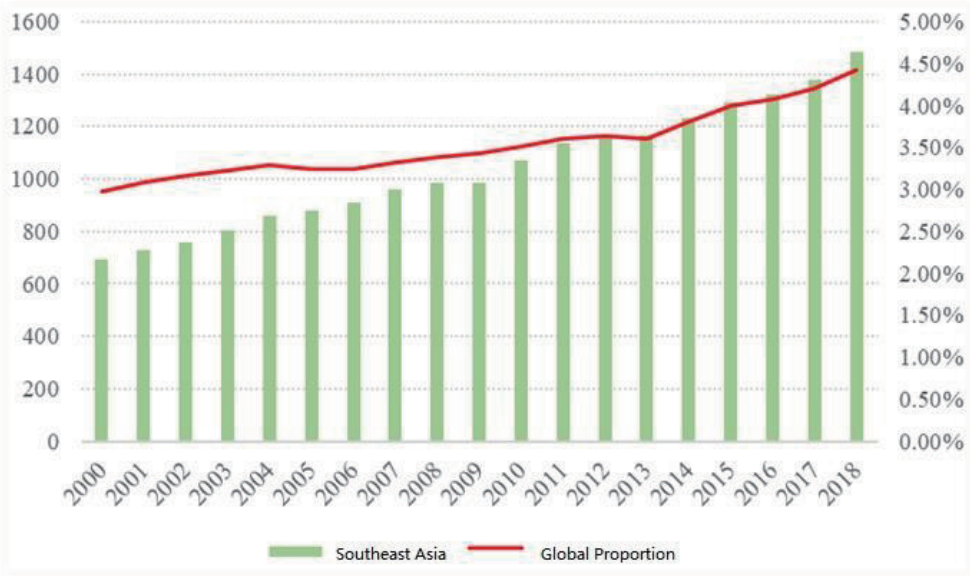


Figure 2-1. ASEAN's Total Carbon Emissions（MtCO2）

Source: IEA

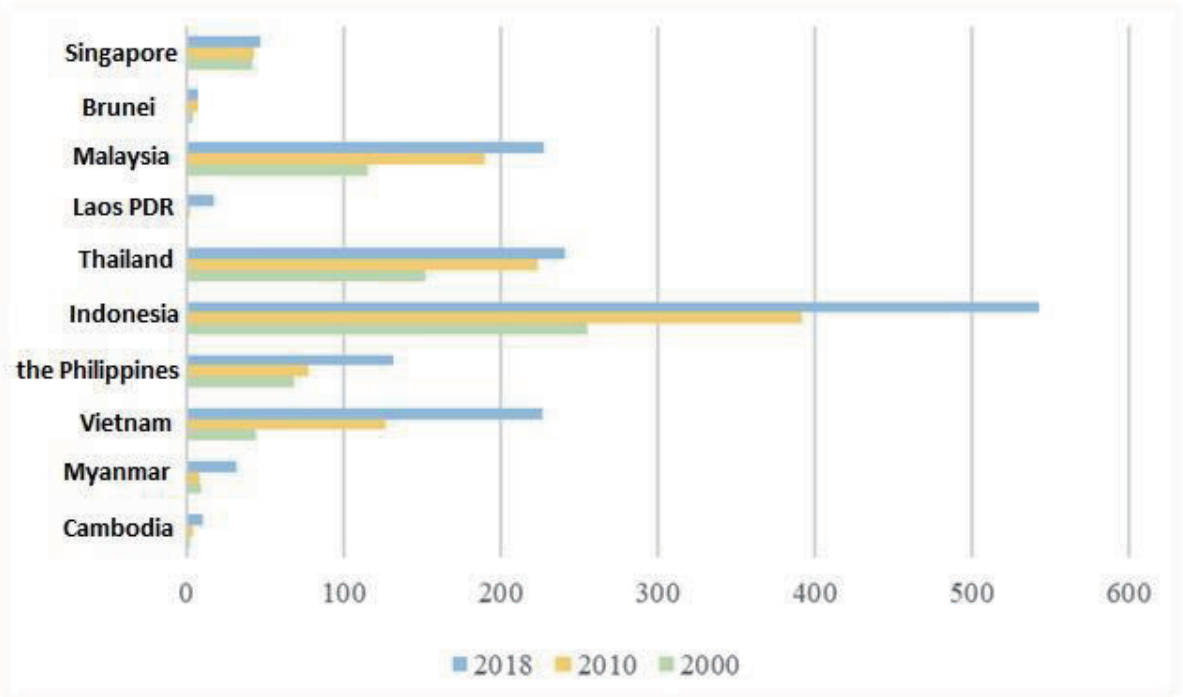


Figure 2-2. Carbon Emissions of ASEAN Member Sates (MtCO2)

Source: IEA

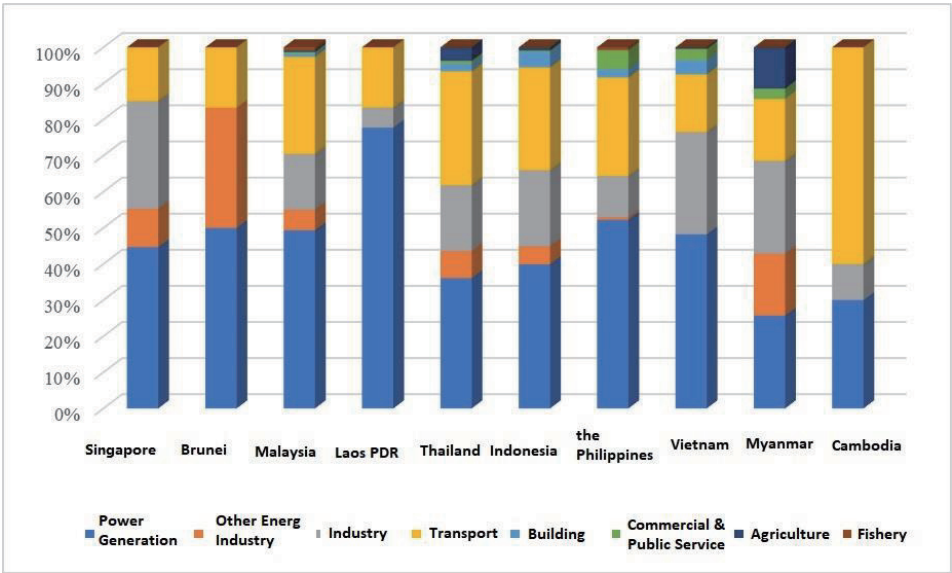


Figure 2-3. Emissions by Sector of ASEAN Member Sates in 20188

Source: IEA

[8] Other energy industries in the figure include self-use oil refining, solid fuel manufacturing, coal mining, oil and gas mining and emissions from other energy production industries.

2.1.2Nationally Determined Contributions

Generally speaking, ASEAN countries' commitment to Nationally Determined Contributions (NDCs) is insufficient. ASEAN countries are different in their climate change targets and major energy response measures and policies. Singapore and Malaysia use emission intensity as emission reduction indicators. Other countries have adopted relative emission reduction targets, among which Brunei, the Philippines and Cambodia are highly motivated to reduce emissions because they are extremely vulnerable to climate change, and the absolute emission reduction compared with the benchmark scenario is as high as 60%-70%. Singapore's first NDC states a target of 36% reduction in emissions intensity from 2005 levels by 2030, while the updated NDC augments the target to peak emissions at 65 $MtCO_2e$ around 2030 (Table 2-1). After updating the NDC, Vietnam raised the emission reduction targets and target years (Table 2-2), but still lacks ambition. Thailand's updated goals have not been significantly improved, but it has reiterated that addressing climate change should be included in the national strategy (Table 2-3). Cambodia has formulated a rigorous framework for measurement, reporting and verification (MRV), significantly improving transparency and NDC tracking, but the goal has not been significantly improved (Table 2-4). Brunei has increased the share of renewable energy, raised the share of electric vehicles, implemented carbon pricing, reduced overall industrial emissions, and strengthened power management in both supply and demand (Table 2-5). The Philippines has promised to reduce its emissions by about 75% by 2030, of which only 2.71% is unconditional (Table 2-6). Laos' first NDC target adds the details of emission reduction of various sectors on the basis of the plan (Table 2-7). Indonesia has maintained its climate commitment in the first NDC (Table 2-8); Malaysia has adjusted the conditional emission reduction commitment in the first NDC to all unconditional emission reduction (Table 2-9). Myanmar is the last ASEAN member state to submit the NDC and only set up the absolute value of emission reduction (Table 2-10).

Table 2-1: Singapore's NDC

Category	First NDC	Updated NDC
GHG targets	Reduce emissions intensity (EI) by 36% from 2005 levels by 2030	Peak emissions at 65 $MtCO_2e$ around 2030, to achieve a 36% reduction in EI from 2005 levels
GHG coverage	(1) CO_2, (2) CH_4, (3) N_2O, (4) HFCs, (5) PFCs, (6) SF_6	(1) CO_2, (2) CH_4, (3) N_2O, (4) HFCs, (5) PFCs, (6) SF_6, (7) NF_3
Time frame	2021 to end of 2030	2021 to end of 2030
Conditionality element	Unconditional NDC only	Unconditional NDC only
Targets by mitigation sector	Increase renewable energy (RE) share up to 8% of peak electricity demand	Energy: Achieving 350 MWp in 2020 and at least 2 GWp by 2030 Transport: Imposing vehicle quota system to cap vehicle growth, setting zero-growth rate for cars and motorcycles
Sector coverage	(1) Energy, (2) industrial processes and product use, (3) agriculture, (4) land use, (5) land-use change and forestry, (6) waste	(1) Energy, (2) industrial processes and product use, (3) agriculture, (4) land use, (5) land-use change and forestry, (6) waste

Table 2-2: Vietnam's NDC

Category	First NDC	Updated NDC
GHG targets	8% (unconditional) up to 25% (conditional) GHG reduction by 2030 compared to BAU	7.3% (unconditional) GHG reduction or 52.9 $MtCO_2e$ by 2025; 9% (unconditional) or 83.9 $MtCO_2e$ up to 27% (conditional) or 250.8 $MtCO_2e$ GHG reduction by 2030
GHG coverage	(1) CO_2, (2) CH_4, (3) N_2O, (4) HFCs, (5) PFCs, (6) SF_6	(1) CO_2, (2) CH_4, (3) N_2O, (4) HFCs
Time frame	1 January 2021 – 31 December 2030	1 January 2021 – 31 December 2030
Conditionality element	Unconditional and Conditional NDC	Unconditional and Conditional NDC
Targets by mitigation sector	Forestry: 45% forest cover by 2030	GHG reduction in five priority areas: Energy: 5.5% or 51.5 $MtCO_2e$, Agriculture: 0.7% or 6.8 $MtCO_2e$, LULUCF: 1% or 9.3 $MtCO_2e$, Waste: 1% or 9.1 $MtCO_2e$, Industrial Process: 0.8% or 7.2 $MtCO_2e$ GHG reduction in five priority areas with international assistance Energy: 11.2% or 104.3 $MtCO_2e$ Agriculture: 2.8% or 25.8 $MtCO_2e$ LULUCF: 1.3% or 11.9 $MtCO_2e$ Waste: 2.6% or 24 $MtCO_2e$ Industrial Process: 0.1% or 0.8 $MtCO_2e$
Sector coverage	(1) Energy, (2) agriculture, (3) LULUCF, (4) waste	(1) Energy, (2) agriculture, (3) LULUCF, (4) waste, (5) industrial process

Table 2-3: Tailand's NDC

Category	First NDC	Updated NDC
GHG targets	20% (unconditional) up to 25% (conditional) GHG reduction by 2030 compared to BAU	20% (unconditional) up to 25% (conditional) GHG reduction by 2030 compared to BAU
GHG coverage	(1) CO_2, (2) CH_4, (3) N_2O, (4) HFCs, (5) PFCs, (6) SF_6	(1) CO_2, (2) CH_4, (3) N_2O, (4) HFCs, (5) PFCs, (6) SF_6
Time frame	2021-2030	2021-2030
Conditionality element	Unconditional and Conditional NDC	Unconditional and Conditional NDC
Targets by mitigation sector	**Energy:** (1) 20% RE share in power generation by 2036, (2) 30% RE share in end use energy by 2036, (3) 30% reduction of energy intensity (compared to 2010) by 2036	**GHG reduction under the NDC Roadmap:** Energy: 72 $MtCO_2e$ Transport: 41 $MtCO_2e$ Industrial Process: 0.6 $MtCO_2e$ Waste: 2.0 $MtCO_2e$ **GHG reduction targets put forward in sectoral action plans:** Energy: 117.56 $MtCO_2e$ Transport: 35.42 $MtCO_2e$ Industrial Process: 2.25 $MtCO_2e$ Waste: 1.53 $MtCO_2e$
Sector coverage	Economy-wide (inclusion of LULUCF will be decided later)	Economy-wide (excluding LULUCF)

Table 2-4: Cambodia's NDC

Category	First NDC	Updated NDC
GHG targets	(1) 27% GHG reduction by 2030 compared to BAU or equivalent to 3.1 $MtCO_2e$, (2) LULUCF contribution of 4.7 tCO_2e/ha/year	GHG reduction of 64.6 $MtCO_2e$/year by 2030, a 41.7% reduction compared to BAU (59.1% contributed by FOLU)
GHG coverage	(1) CO_2, (2) CH_4, (3) N_2O	(1) CO_2, (2) CH_4, (3) N_2O
Time frame	2020-2030	2020-2030
Conditionality element	Conditional NDC only	Conditional NDC only
Targets by mitigation sector	**Energy Industries:** 16% GHG reduction by 2030 compared to BAU or equivalent to 1.8 $MtCO_2e$ **Manufacturing Industries:** 7% GHG reduction by 2030 compared to BAU or equivalent to 0.727 $MtCO_2e$ **Transport:** 3% GHG reduction by 2030 compared to BAU or equivalent to 0.39 $MtCO_2e$ **Other:** 1% GHG reduction by 2030 compared to BAU or equivalent to 0.155 $MtCO_2e$ **LULUCF:** 60% forest cover of total land area or equivalent to 4.7 tCO_2eq/ha/year	**Energy:** By 2030, compared with BAU, the emission reduction will be 21.3%, equivalent to 38.1$MtCO_2e$. **Industry:** By 2030, compared with BAU, the emission reduction will be 9.1%, equivalent to 5.9$MtCO_2e$. **Food and land use (FOLU):** By 2030, compared with BAU, the emission reduction will be 59.1%, equivalent to 38.1$MtCO_2e$. **Agriculture:** By 2030, compared with BAU, the emission reduction will be 9.6%, equivalent to 6.2$MtCO_2e$. **Waste:** By 2030, compared with BAU, the emission reduction will be 0.9%, equivalent to 0.6$MtCO_2e$.
Sector coverage	(1) Energy industries, (2) manufacturing industries, (3) transport, (4) other, (5) LULUCF	(1) Energy, (2) industry (IPPU), (3) transport, (4) building, (5) FOLU, (6) agriculture, (7) waste

Table 2-5: Brunei's NDC

Category	First NDC	Updated NDC
GHG targets	40% reduction of CO_2 emissions from morning peak hour vehicle use by 2035 compared to BAU	20% reduction of GHG emissions by 2030 relative to BAU or 5.9MtCO_2e
GHG coverage	CO_2	(1) CO_2, (2) CH_4, (3) N_2O
Time frame	2035 (target year)	1 January 2021 – 31 December 2030
Conditionality element	Unconditional NDC only	Unconditional NDC only
Targets by mitigation sector	**Energy:** (1) 63% reduction of total energy consumption by 2035 compared to BAU; (2) 10% RE share of total power generation by 2035; (3) 45% reduction in energy intensity, using 2005 base year **Transport:** 40% reduction of CO_2 emissions from morning peak hour vehicle use by 2035 compared to BAU **LULUCF:** 55% forest reserves of total land area, compared to the current level of 41%	**Energy:** (1) at least 30% RE share of power generation mix by 2035; (2) at least 10% GHG emissions in the power sector through energy efficiency and conservation on both the supply and demand sides; (3) impose carbon price on all industrial facilities by 2025 **Transport:** 60% EV share of total annual vehicle sales by 2035 **Industrial:** achieve zero-routine flaring and reducing other industrial emissions by adopting the 'As Low As Reasonable Possible' (ALARP) principle **Forestry:** increase forest reserves from 41% to 55% by increasing the carbon sink through reforestation with a target of planting 500,000 trees by 2035 **Waste:** reduce municipal waste to landfills to 1kg/person/day by 2035
Sector coverage	(1) Energy, (2) land transport, (3) forestry	(1) Energy, (2) IPPU, (3) Agriculture, (4) FOLU, (5) waste

Table 2-6: The Philippines' NDC

Category	First NDC
GHG targets	By 2030, compared to BAU, a projected GHG emissions reduction and avoidance of 75%, equivalent to 2414.7MtCO_2e, of which 2.71% is unconditional, equivalent to 90.52MtCO_2e
GHG coverage	(1) CO_2, (2) CH_4, (3) N_2O, (4) HFCs, (5) PFCs
Time frame	2030
Conditionality element	Unconditional and Conditional NDC
Targets by mitigation sector	/
Sector coverage	(1)Energy，(2)Transport，(3)Industry，(4)Agriculture，(5)Waste

Table 2-7: Lao PDR's NDC

Category	INDC	First NDC
GHG targets	/	60% GHG emission reductions compared to BAU, or around 62,000 $ktCO_2e$ in absolute terms
GHG coverage	/	(1) CO_2, (2) CH_4, (3) N_2O, (4) HFCs, (5)PFCs, (6)SF_6
Time frame	2015-2030	2020-2030
Conditionality element	Unconditional and Conditional NDC	Unconditional and Conditional NDC
Targets by mitigation sector	**Energy:** (1) Achieve 30% RE (excluding large hydro) by 2025 (2) Share of biofuels to meet 10% of transport fuels, equivalent to 1,468,000 $ktCO_2e$ by 2025 (3) 90% rural households electrified by 2020 (4) Expansion of large hydro to 5,500 MW by 2020 and to 20,000 MW by 2030 with an annual GHG emission reductions of 16,284 $ktCO_2$; **Transport:** develop road networks, reduce vehicle driving distance and develop public transportation **LULUCF:** Increase forest cover to 70% by 2020, equivalent to GHG emission reductions of 60,000-69,000 $ktCO_2e$	**Energy:** (1) Achieve 13GW total hydropower capacity in the country by 2030 with an average abatement of 2500 $ktCO_2e/y$ (unconditional) (2) Introduction of 50,000 energy efficient cook stoves by 2030 with an average abatement of 50 $ktCO_2e/y$ (unconditional) (3) By 2030, increase the total installed capacity of solar and wind to 1GW with an average abatement of 100 $ktCO_2e/y$; increase the total installed capacity of biomass to 300MW with an average abatement of 84 $ktCO_2e/y$; achieve 10% reduction of final energy consumption compared to BAU with an average abatement of 280 $ktCO_2e/y$ (conditional) **Transport:** (1) By 2030, New Bus Rapid Transit system in Vientiane Capital and associated Non-Motorized Transport (NMT) component achieve an average abatement of 25 $ktCO_2e/y$; Lao-China Railway achieve an average abatement of 300 $ktCO_2e/y$ (unconditional) (2) 30% Electric Vehicles penetration for 2-wheelers and passengers' cars in national vehicles mix by 2030, with an average abatement of 30 $ktCO_2e/y$ (conditional) (3) Biofuels to meet 10% of transport fuels by 2030, with an average abatement of 29 $ktCO_2e/y$ (conditional) **LULUCF:** By 2030, reduce emissions from deforestation and forest degradation and enhance forest carbon stocks with an average abatement of 1,100 $ktCO_2e/y$ (unconditional); increase forest cover to 70% of land area with an average abatement of 45,000 $ktCO_2e/y$ (conditional) **Agriculture:** 50,000 hectares adjusted water management practices in lowland

		rice cultivation by 2030, with an average abatement of 128 $ktCO_2e/y$ (conditional) Waste: Implementation of 500 tons/day sustainable municipal solid waste management project by 2030, with an average abatement of 40 $ktCO_2e/y$ (conditional)
Sector coverage	(1) Energy, (2) Transport, (3) Land Use Change and Forestry (LULUCF)	(1) Energy, (2) Transport, (3) Agriculture, (4) Land Use Change and Forestry (LULUCF), (5) Waste

Table 8: Indonesia's NDC

Category	**First NDC**	**Updated NDC**
GHG targets	29% (unconditional) and 41% (conditional) GHG emission reductions compared with BAU by 2030	29% GHG emission reductions or 832.01 $MtCO_2e$ (unconditional) and 41% GHG emission reductions or 1,176.29$MtCO_2e$ (conditional) compared with BAU by 2030
GHG coverage	(1) CO_2, (2) CH_4, (3) N_2O	(1) CO_2, (2) CH_4, (3) N_2O
Time frame	2030	2030
Conditionality element	Unconditional and Conditional NDC	Unconditional and Conditional NDC
Targets by mitigation sector	**Energy:** energy efficiency measures to be carried out by all energy consuming sectors; implementing clean coal technologies in power plants; inceasing the share of RE to 19.6% of total power mix (unconditional) and sustainable power production to 132,74 TWh (conditional)；100% additional natural gas pipeline; 100% SPBG **FOLU:** reducing the rate of deforestation, avoiding forest degradation, land rehabilitation, peatland restoration **Agriculture:** total use of land for low emission crops up to 926,000 hactares (conditional) and 908,000 hactares (unconditional) in 2030; implementation of water efficiency up to 820,000 hactares in 2030; manure management for biogas accounts for 0.06% of the toal; the share of feed supplement for cattle is 2.5% **Waste:** solid waste, domestic and industrial liquid waste **IPPU**：increase blended cement and reducethe clinker to cement ratio from 80% in 2010 to 75% in 2030; increase efficiency through utilization and recycle of raw materials; ammonia plant revitalization and revamping	**Energy:** energy efficiency measures to be carried out by all energy consuming sectors; implementing clean coal technologies in power plants; inceasing the share of RE to 19.6% of total power mix (unconditional) and sustainable power production to 132,74 TWh (conditional)；100% additional natural gas pipeline; 100% SPBG **Agriculture:** total use of land for low emission crops up to 926,000 hactares (conditional) and 908,000 hactares (unconditional) in 2030; implementation of water efficiency up to 820,000 hactares in 2030; manure management for biogas accounts for 0.06% of the toal; the share of feed supplement for cattle is 2.5% **FOLU:** reducing the rate of deforestation, avoiding forest degradation, land rehabilitation, peatland restoration **Waste:** solid waste, domestic and industrial liquid waste **IPPU**：increase blended cement and reducethe clinker to cement ratio from 80% in 2010 to 75% in 2030; increase efficiency through utilization and recycle of raw materials; ammonia plant revitalization and revamping

Sector coverage	(1) Energy, (2) Forestry and other land uses (FOLU), (3) Agriculture, (4) Waste, (5) IPPU	(1) Energy, (2) Forestry and other land uses (FOLU), (3) Agriculture, (4) Waste, (5) IPPU

Table 2-9: Malaysia's NDC

Category	First NDC	Updated NDC
GHG targets	By 2030, the intensity of greenhouse gas emissions will be reduced by 45% compared with the 2005 level (35% unconditional and 10% conditional).	By 2030, the intensity of greenhouse gas emissions will be 45% lower than the 2005 level.
GHG coverage	(1) CO_2, (2) CH_4, (3) N_2O	(1) CO_2, (2) CH_4, (3) N_2O, (4) HFCs, (5) PFCs, (6) SF_6, (7) NF_3
Time frame	2021-2030	1 January 2021 – 31 December 2030
Conditionality element	Unconditional and Conditional NDC	Unconditional NDC
Targets by mitigation sector	/	/
Sector coverage	(1) energy, (2) industrial process and product use (IPPU), (3) agriculture, (4) land use change and forestry (LULUCF), and (5) waste.	(1) energy, (2) industrial process and product use (IPPU), (3) agriculture, (4) land use change and forestry (LULUCF), and (5) waste.

Table 2-10: Myanmar's NDC

Category	INDC	First NDC
GHG targets	/	244.52 $MtCO_2e$ unconditionally, and a total of 414.75 $MtCO_2e$, subject to conditions of international finance and technical support by 2030
GHG coverage	/	CO_2
Time frame	2030	2030
Conditionality element	Conditional NDC	Unconditional and Conditional NDC
Targets by mitigation sector	**Forestry:** By 2030, reserved forests (RF) and protected public forests (PPF) will account for 30% of the total land area, and protected area system (PAS) will account for 10% of the total land area. **Energy:** (1) By 2030, the total installed hydropower capacity will reach about 9.4GW, accounting for about 38% of primary power generation. (2) At least 30% of electricity in rural areas comes from renewable energy. (3) Improve energy efficiency, and realize the potential of saving electricity by 20% of the predicted total power consumption by 2030. (4) Improve the energy efficiency of cookware, and distribute about 260,000 stoves in 2016-2016.	**Energy:** (1) Increasing the total share of renewable energy (solar and wind) to 53.5% (from 2000MW to 3070MW) by 2030, and decreasing the share of coal by 73.5% (from 7940MW to 2120MW) by 2030. Under its unconditional target, in the energy sector Myanmar will achieve avoiding 105.24 $MtCO_2e$ by 2030 from the BAU and a conditional annual target of avoiding 144.0 $MtCO_2e$ emissions by 2030 (2) Through the distribution of 5.1 million fuel-efficient cookstoves Myanmar will achieve a cumulative emissions reduction of approximately 12.99 $MtCO_2e$ during 2021-2030. The government has set an unconditional target to support the distribution of one

	Transportation: Reduce emissions caused by transportation departments, especially road transportation. Agriculture: Reduce the emissions from burning agricultural residues and planting rice in the agricultural sector.	million LPG stoves by the private sector resulting in an emission reduction of 14.94 $MtCO_2e$ by 2030. (3) Improvement of energy efficiency of the residential sector by 7.8%, the industrial sector by 6.63%, the commercial sector by 4%, and other sectors by 1.36%, avoiding a cumulative of 0.133 $MtCO_2e$ as a conditional energy efficiency target. (4) Developing renewable energy. The government has set a new NDC conditional target for mini-grid development, that will further increase renewable energy access to the total off-grid rural population of 3.6m people, power generation (88.82MW), and GHG emission avoided will be 0.874 $MtCO_2e$ by 2030. The government's NDC unconditional target will increase renewable energy access through mini-grids to the total off-grid rural population of 2.7m people, power generation (66.62MW), and GHG emission avoided will be 0.719 $MtCO_2e$ by 2030. **Agriculture:** Through promotion of tree planting and agroforestry, Myanmar will achieve a conditional cumulative target of sequestrating 10.4 $MtCO_2e$ over the period of 2021-2030 and raise the average tree canopy cover across 275,000 ha of its agricultural land with <10% tree canopy cover per hectare. **FOLD:** A conditional target of reducing deforestation by 50% by the year 2030, resulting in a cumulative emissions reduction of 256.5 $MtCO_2e$ (against the 2005-2015 baseline) over the period of 2021- 2030, and an unconditional target to reduce deforestation by 25% by the year 2030, resulting in a cumulative net emissions reduction of 123.6 $MtCO_2e$. **Transport:** Priority will be given to electric vehicles, the development of a Shipping Energy Efficiency Management Plan (SEEMP) and a Green Shipping Strategy
Sector coverage	(1) energy, (2) transportation, (3) agriculture, (4) land use change and forestry (LULUCF), and (5) waste.	(1) energy, (2) transportation, (3) agriculture and (4) land use change and forestry (LULUCF)

Source: ASEAN Centre for Energy, NDC Registry

To sum up, the economic development level of ASEAN countries is relatively low but the growth rate is relatively fast, and the overall emission level of ASEAN countries is not high. **Without robust mitigation actions and effective measures to promote the green and low-carbon transition, ASEAN's future economic and population growth would bring huge amounts of greenhouse gas emissions.** With carbon neutrality becoming a global trend, the NDCs submitted by ASEAN Member Sates are not ambitious enough. It is all the more urgent for ASEAN to accelerate its low-carbon transition. Among the ten ASEAN Member Sates, Laos and Malaysia have set their own carbon-neutral targets (both in 2050) through policy announcements. Singapore proposed to achieve carbon neutrality as soon as possible in the second half of the century, but hasn't released details of its carbon neutrality commitments. Thailand and Vietnam made the commitment to realize carbon neutrality by 2065 and 2050 respectively at COP26. Indonesia is expected to have its carbon emissions peak by 2030 and and achieve carbon neutrality by 2060 or earlier, but the details are still under discussion. The Philippines and Myanmar both put forward the commitment to have carbon emissions peak by 2030, while Cambodia and Brunei have not submitted their carbon neutrality targets (Table 2-11).

Table 2-11: Committed Carbon Peak & Neutrality Timetable of ASEAN Member Sates

Country	Carbon Peak	Carbon Neutrality
Singapore	2030	To halve emissions from its peak by 2050, with a view to achieving net zero emissions as soon as viable in the second half of the century.
Vietnam		2050
Thailand	2030	2065
Cambodia		
Brunei Darussalam		
the Philippines	2030	
Lao PDR		2050
Indonesia	2030	2060
Malaysia		2050
Myanmar	2030	

Source: Nationally Determined Contribution (NDC) and Long-Term Low-Emissions Development Strategy (LEDS) of ASEAN Countries

2.2 Regional Energy Development Planning

2.2.1 Status Quo of Energy Development in ASEAN

With huge momentum for economic growth, ASEAN is expected to become the world's fourth largest economy by 2030 with a collective GDP projected to nearly triple by 2040[9]. Fueling that growth will require significant amounts of energy. However, affected by the COVID-19 pandemic, the energy sector, which is vital to economic growth, is in urgent need of greater integration and innovation in the areas of trade, investment, human capital and regulatory coherence.

The 6th ASEAN Energy Outlook (AEO6) pointed out that the region's demand in primary energy is projected to increase by 146% from between 2017 and 2040. ASEAN's total primary energy supply (TPES) is projected to grow by 2.5 times from 625 Mtoe in 2017 to 1589 Mtoe in 2040 in the baseline scenario. By 2025, the region's TPES is expected to reach 874 Mtoe. In the APAEC Targets Scenario (APS), by 2040, fossil fuels will continue to provide 70% of the energy mix[10]. ASEAN's total final energy consumption (TFEC) is expected to reach 518 Mtoe by 2025 and 922 Mtoe in 2040. By 2025, the region's TFEC is expected to be 474 Mtoe in AMS Targets Scenario (ATS) and 450 Mtoe in APS[11].

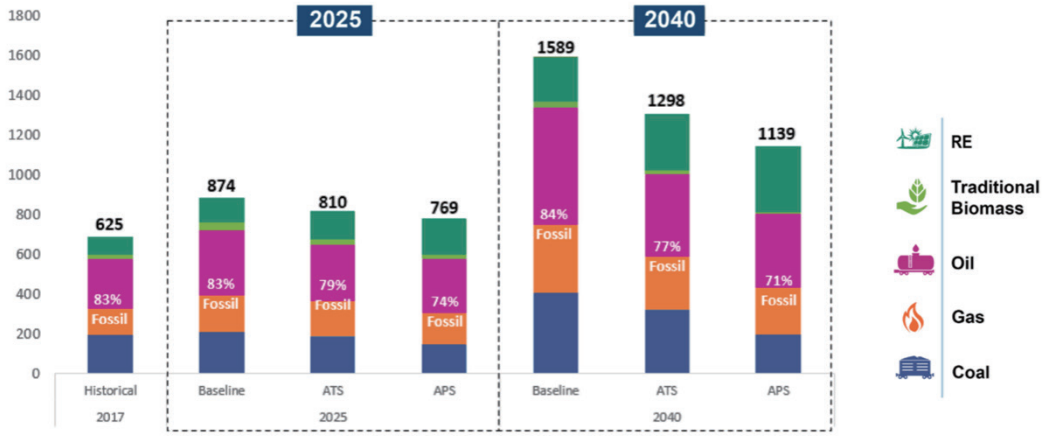


Figure 2-4. ASEAN's Total Primary Energy Supply

Source: AEO6

[9] ASEAN Centre for Energy (ACE). 2021. ASEAN Power Updates 2021. Report. Available at https://aseanenergy.org/asean-power-updates-2021/

[10] ASEAN Centre for Energy (ACE). 2020. The 6th ASEAN Energy Outlook. Report. Available at https://aseanenergy. org/the-6th-asean-energy-outlook/

[11] ASEAN Centre for Energy (ACE). 2020. (2021-2025) ASEAN Plan of Action for Energy Cooperation (APAEC) 2016-2025 Phase II. Available at https://aseanenergy.org/asean-plan-of-action-and-energy-cooperation-apaec-phase-ii-2021-2025/

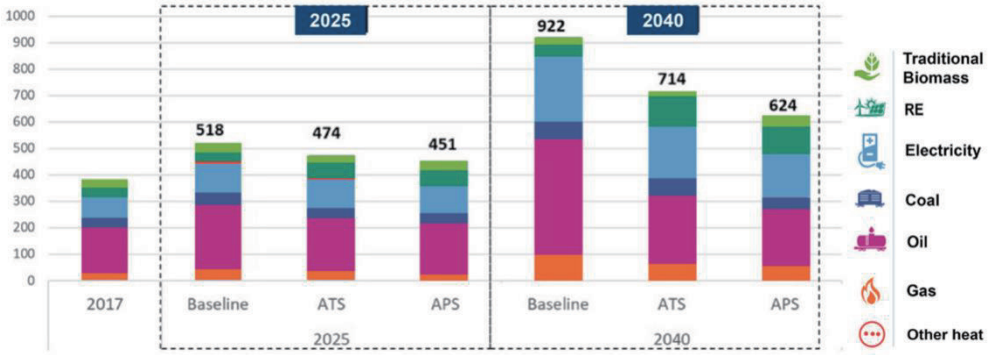


Figure 2-5. ASEAN's Total Final Energy Consumption

Source: AEO6

2.2.2 ASEAN Plan of Action for Energy Cooperation (APAEC)

To promote synergy between energy development and environmental protection, ASEAN implemented APAEC Phase I: 2016-2020, and achieved an Energy Intensity (EI) reduction of 21% by 2018, surpassing its aspirational target of 20% in 2020. This clearly showed a shift by ASEAN towards low carbon economy. ASEAN has made progress in the promotion and establishment of MEPS for home appliances through the endorsements of the Regional Policy Roadmap on Harmonisation of MEPS for air-conditioners (AC) by the 35th AMEM and for Lighting by 37th AMEM. On air-conditioners, seven AMS have established their National Roadmaps adopting the ISO 5151: 2010 as the testing standard method for EE performance of AC. Further works will be continued in APAEC Phase II for both AC and lighting and most likely to expand to include motors, transformers, and the like. The Guidelines for the Integration of Energy Efficiency into the ASEAN Electrical and Electronic Equipment (EEE) Mutual Recognition Agreement (MRA) announced at 37th AMEM in 2019 was another key achievement.

Based on the success of APAEC Phase I, APAEC Phase II set a more aggressive EI reduction target of 32% by 2025 based on 2005 levels. The theme of the APAEC Phase II is "Enhancing Energy Connectivity and Market Integration in ASEAN to achieve Energy Security, Accessibility, Affordability and Sustainability for All" and the sub-theme is "Accelerating Energy Transition and Strengthening Energy Resilience Through Greater Innovation and Cooperation". The theme and sub-theme reflect the key elements of the 35th ASEAN Leaders Summit on connectivity and sustainability within ASEAN and in ASEAN's relations with the international community.

During APAEC Phase II, ASEAN will **expand multilateral power trade**, accelerate the realization of ASEAN Power Grid (APG) , and increase the share of RE in installed power capacity to facilitate energy transition. According to strategies and action plans under APAEC Phase II, ASEAN will give priority to building, transport and industrial sectors and enhance the engagement of the private sector, research institutions and financial institutions. Currently, major progress has been made in cross-border power trade, creating new opportunities for the utilization of RE and LNG in power generation.

ASEAN, as a preferred investment destination, provides many opportunities for RE development in terms of market, resources, and efficiency which can attract foreign direct investments (FDI) to the RE sector. With the improvement of technology and digitalization, new and advanced RE technologies will also be explored such as waste-to-energy, RE-based hydrogen, energy storage and concentrated solar thermal. ASEAN has managed to achieve 13.9% share of RE in the ASEAN total primary energy supply in 2018. Moving forward, these efforts are expected to help meet the 23% RE share in TPES and 35% share of RE in ASEAN installed power capacity by 2025.

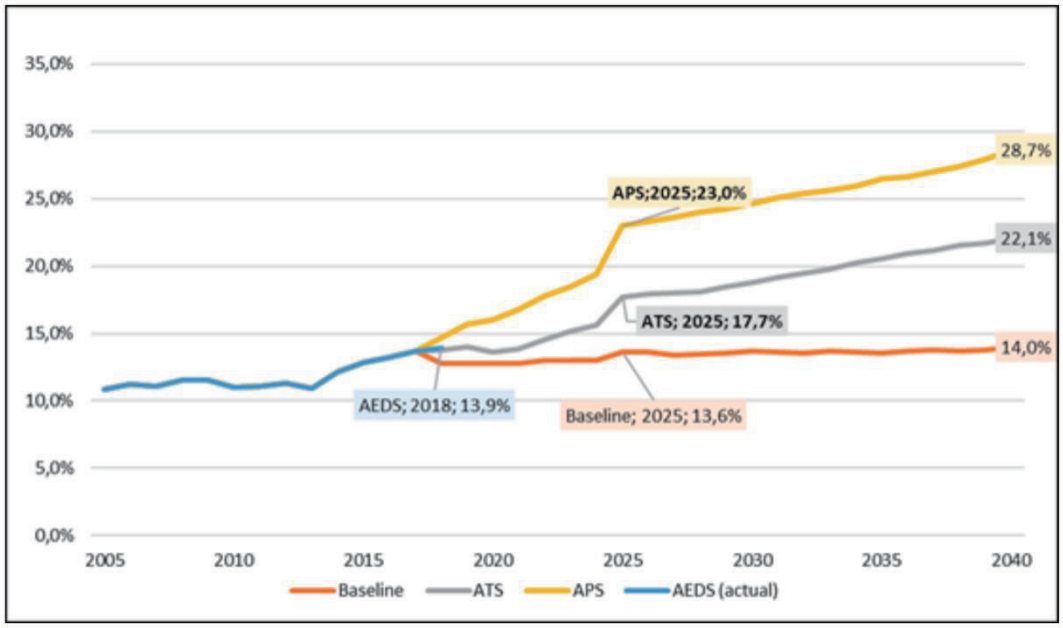


Figure 2-6. Status of ASEAN Renewable Energy Share in TPES

Source: APAEC Phase II

In 2020, AMS had 285 GW of installed power capacity in total, in which Indonesia, Vietnam, and Thailand accounted for around 2/3 of the total capacity, and coal, gas, and hydro contributed more

than 80%. Approximately 22 GW of capacity was added in 2020. About 82% of the ASEAN new capacity in 2020 was renewable, which is a notable new trend. Lao PDR created new hydro capacity, while Vietnam significantly increased its solar capacity[12].

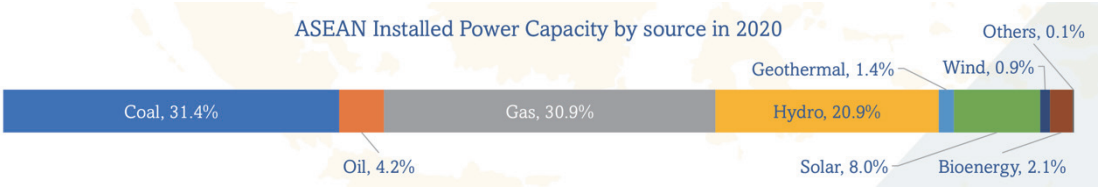


Figure 2-7. ASEAN Installed Power Capacity by Source in 2020

Source: ASEAN Power Updates 2021

The power sector plays an important role in stimulating RE development in the region. RE share witnessed a continuous increase especially since 2018. RE share was 33.5% in 2020, only 1.5% gap from 2025 target. **Most of the increase in RE has been in hydro and bioenergy**, while solar and wind began to increase sharply in 2015. Despite different RE potential among the AMS, all their shares of RE increased.

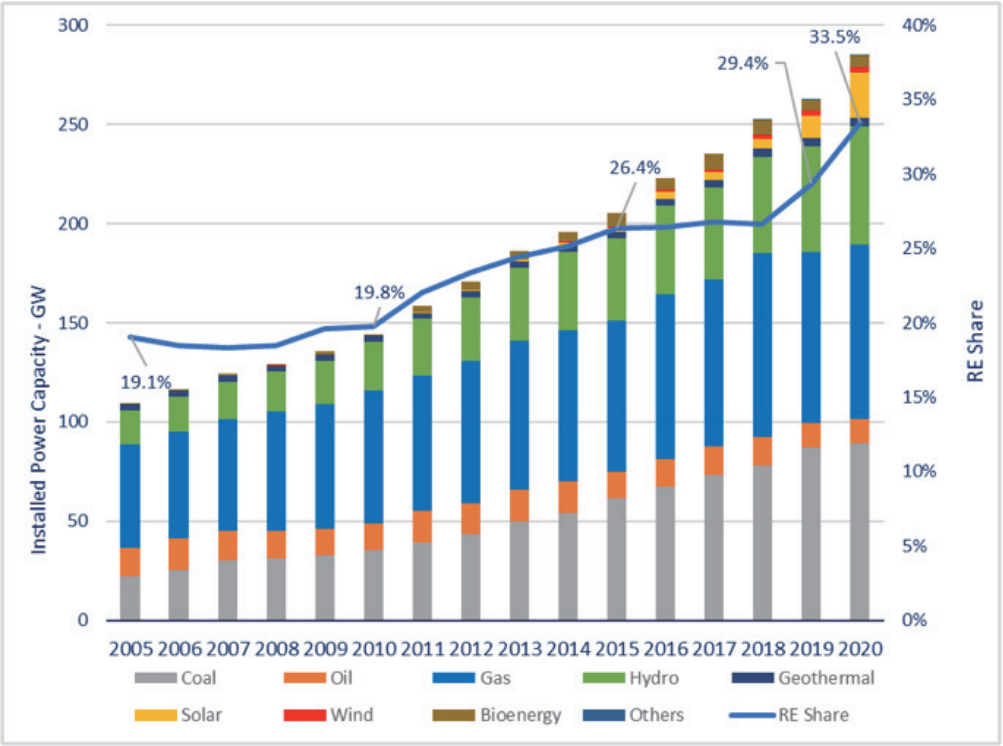


Figure 2-8. ASEAN Installed Power Capacity, 2005 to 2020

Source: ASEAN Power Updates 2021

[12] ASEAN Centre for Energy (ACE). 2021. ASEAN Power Updates 2021. Report. Available at https://aseanenergy.org/asean-power-updates-2021/

By 2025, the share of RE in installed power capacity will be 33% in ATS and 48% in the APS. The RE share in installed capacity is dominated by hydro (19%), followed by solar power (7%) in the ATS. Solar will triple its installed capacity in the APS, and the shares in installed capacity will increase to 20% of total capacity.

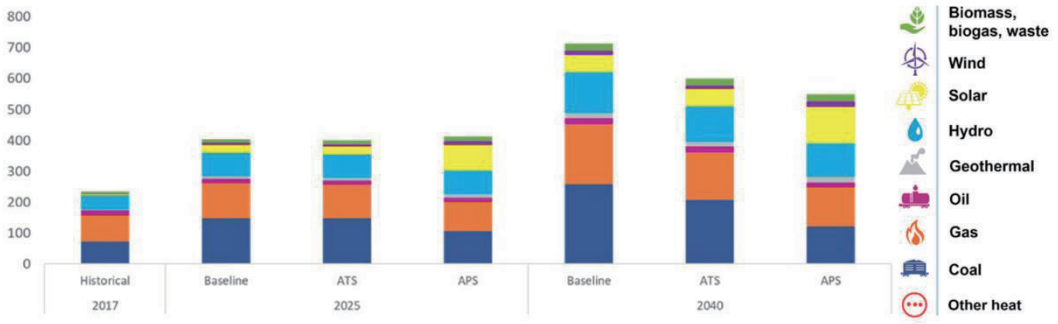


Figure 2-9. ASEAN Installed Capacity

Source: 6th ASEAN Energy Outlook

Currently, **solar and wind become the core of more RE development in the ASEAN region**. Through fuel switching, energy efficiency improvement and the deployment of advanced sustainable energy technologies, including LNG power generation, coal upgrading, HELE coal-fired power generation and CCUS, more than 60% of the newly installed capacity up to 2025 will come from renewable. This means a 37.6% share of RE in 2025, which is 2.6 units above the regional target.

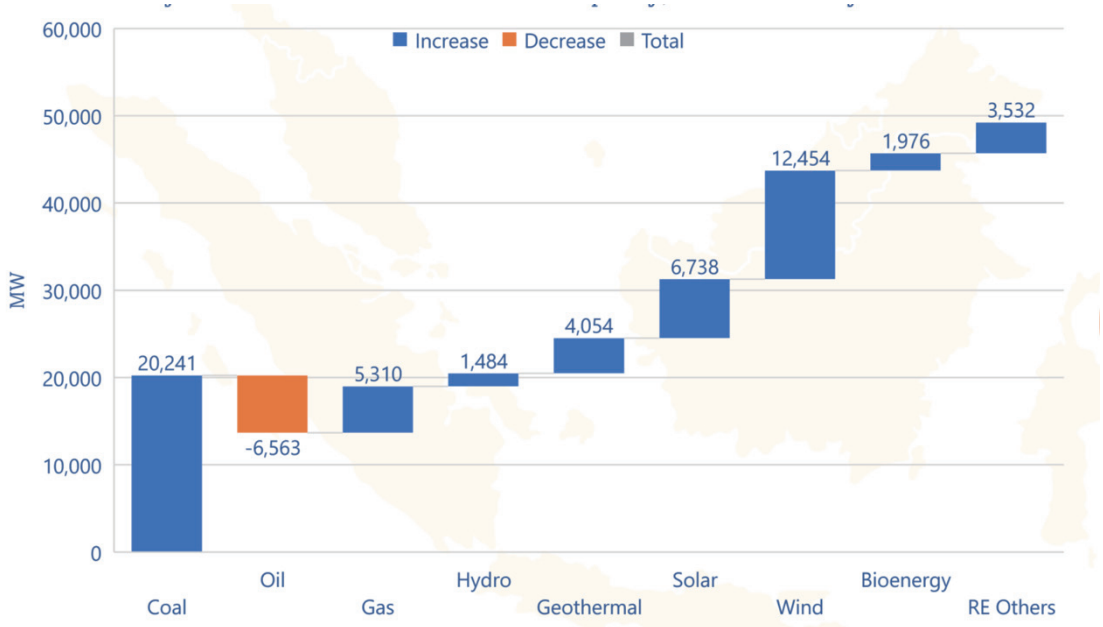


Figure 2-10. Projected Additional Installed Power Capacity, 2021 to 2025 by Source

Source: ASEAN Power Updates 2021

2.2.3 International Cooperation and Capacity Building

Several studies and capacity building activities were also conducted to promote the technical and financial aspects of RE projects. For example, ACE and GIZ conducted a joint study on the levelized cost of electricity (LCOE) for selected RE technologies in ASEAN and as well as a study on insurance and guarantee schemes of RE in ASEAN. Meanwhile, the Renewable Energy Sub-Sector Network (RE-SSN) is responsible for carrying out the implementation of renewable energy programme to increase the diversity of energy supply security and to reduce the environmental impact of energy use in the region. In APAEC Phase II, RE-SSN will develop and promote the long-term ASEAN RE Roadmap which will take into account the findings and recommendations of AIMS III and 2nd ASEAN RE Outlook.

Box 1. USAID Clean Power Asia

The United States Agency for International Development (USAID) Clean Power Asia Program began to work with Lower Mekong countries (Cambodia, Laos, Thailand and Vietnam) and other Association of Southeast Asian Nations (ASEAN) member states (including the Philippines and Indonesia) in 2017 to encourage power sector investments in environmentally friendly, grid-connected renewable energy (RE) sources. In the past 5 years, $16.3 million has been invested to incorporate climate targets into energy planning, and build an enabling policy and regulatory environment for low-emission growth. Through collaborating with project developers, investors, governments and other donors, the Program attracts public and private investment in renewable power. Through expanding the size of RE (solar, wind, small hydro and biomass residue), the Program brings significant benefits. While directly bringing down the cost of energy, it enables access to reliable energy, improves air quality, protects human health, promotes economic growth, alleviates cross-border conflicts and improves food safety.

USAID Clean Power Asia's goal was to accelerate the regional transition to a high performing, low carbon power sector, that was to be accomplished with three interconnected outcomes: high renewable energy scenarios included in energy planning; improved enabling policy, regulatory, and technical environment for renewable energy deployment; and increased investment in and deployment of grid-connected renewable energy projects. Despite the challenges due to COVID-19 restrictions on travel and meeting with stakeholders, USAID Clean Power Asia has contributed to the proposal, adoption, and/or implementation of 16 new policies and regulations across multiple countries. Over $7 billion of investment has been mobilized in renewable energy investments, resulting from installation of more than 9,000 MW of renewable energy capacity. Based on these policies and installed RE projects, USAID Clean Power Asia has contributed to preventing over 93 million tons of carbon dioxide equivalent in greenhouse gas emissions being released into the atmosphere over the next 15 years. By now, the Program has helped to close a deal of $283 million between the Thai company B. Grimm Power PLC and solar power developer Truong Thanh Viet Nam Group ((TTVN). The 257 MW Phu Yen Project jointly developed by the two companies is able to provide electricity for over 50,000 households. In Thailand, the Program cooperated with six Thai companies to procure and implement rooftop solar installations with a total capacity of 7.6 MW and a total value of over $10 million. Besides, USAID Clean Power Asia helped retail giant Big C to complete a deal of $4.8 million to kickstart a rooftop solar project with a capacity of 3.6 MW.

2.3 The Economy

2.3.1Industry and Economic Development

ASEAN's economy has been on a positive trend, with uneven development among member states. ASEAN is one of the most active regions in global economic growth. In the past decade, ASEAN witnessed an average annual GDP growth of 5.4%, far higher than the world average (3.3%). The total combined GDP of ten ASEAN Member Sates (AMS) grew from $ 612.2 billion from 2000 to $ 3.0022 trillion in 2020. ASEAN's share of world GDP rose from 1.8% in 2000 to 3.5% in 2020. Except for Brunei and Thailand, whose annual GDP growth rate fall behind that of the world's average in some years, other AMS witnessed an economic growth rate higher than the world's average. **However, it should be noted that although the overall economic growth of ASEAN is relatively fast, there is still a certain gap between its actual economic development level and the world average level.** The per capita GDP of AMS, except for that of Singapore and

Brunei, fall behind the world's average. According to the the classification standards of the World Bank, ASEAN Member Sates, except Singapore, Brunei and Malaysia, are middle and low-income countries. Singapore has the highest GDP per capita of over $ 60,000, followed by Brunei with a GDP per capita in line with that of developed countries. However, other ASEAN Member Sates have a GDP per capita of less than $ 4,000, with Myanmar standing at the last of the line with a GDP per capita of only $ 1,330. The imbalance regional development is obvious.

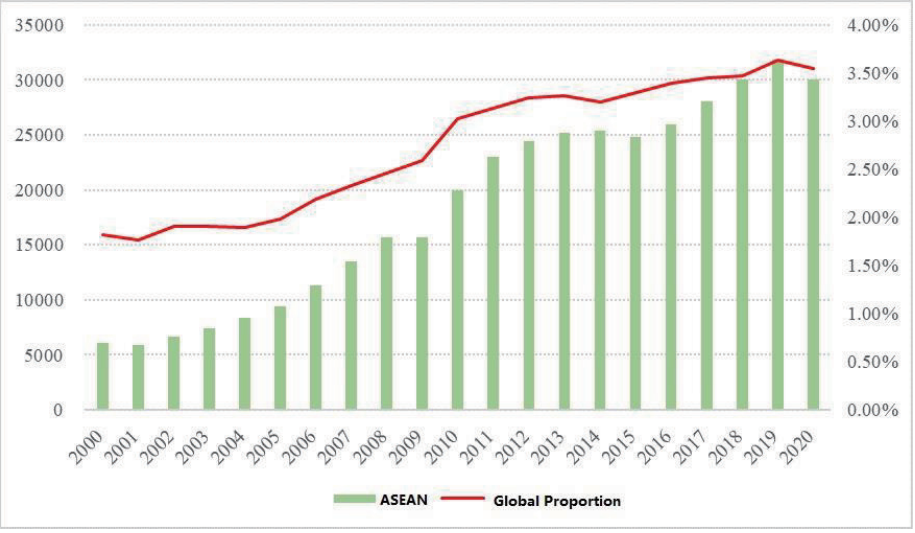


Figure 2-11. Total GDP of ASEAN and its Share of World GDP (US$ 100 million)

Source: World Bank

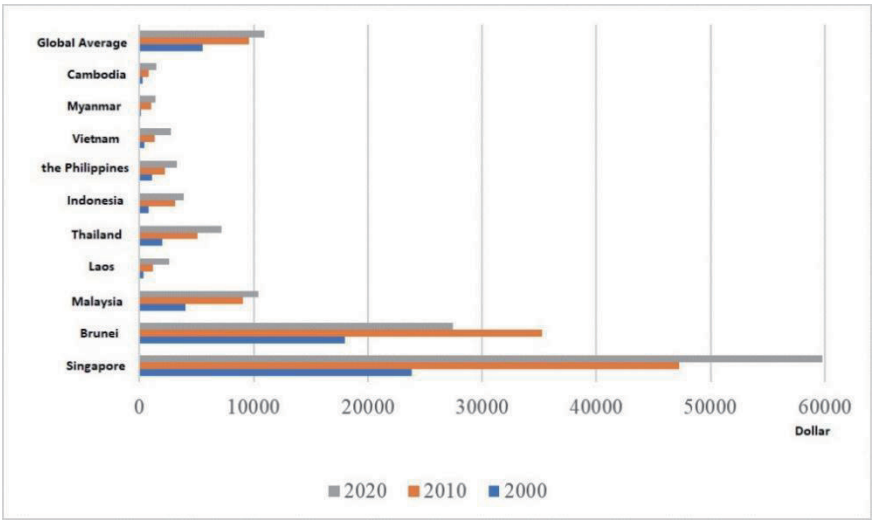


Figure 2-12. GDP per capita of ASEAN Member Sates (US$)

Source: World Bank

The economic development of ASEAN is uneven, and the population growth tends to be flat. Statistics show a decline in ASEAN annual population growth. The annual population growth fluctuated between 0.5% and 1.5% in the period of 2015 to 2020, which is in line with the 1.094%

world average. Indonesia is the largest country among ten AMS in terms of both economic size and population. As a middle and high-income country, Thailand ranks the second in economic size, with a population that is only 1/4 of that of Indonesia. As the only developed and high-income country in ASEAN, Singapore has a high level of economic development and a population that is only slightly higher than that of Brunei. Small in economic size, Brunei has a GDP per capita that is only second to that of Singapore.

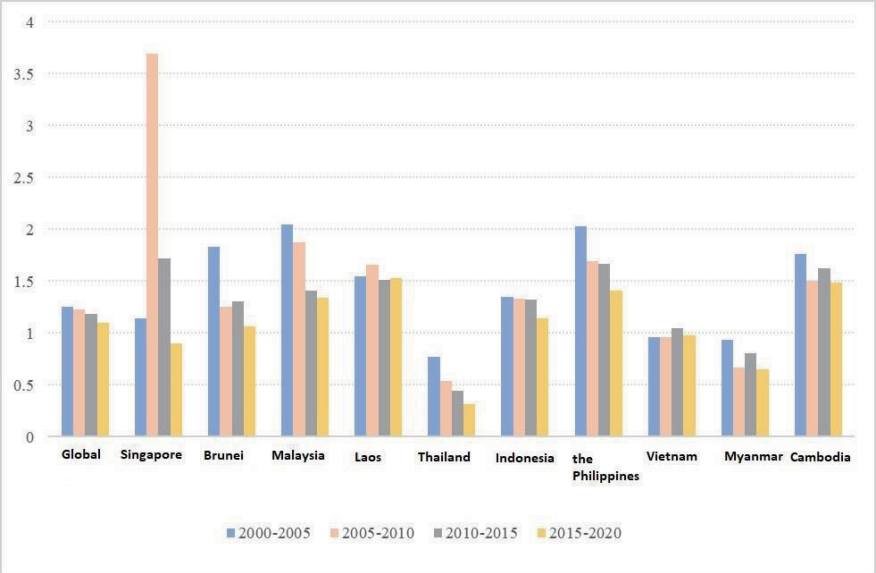


Figure 2-13. Average Annual Population Growth Rate of AMS every Five Years (%)

Source: United Nations, World Population Prospects

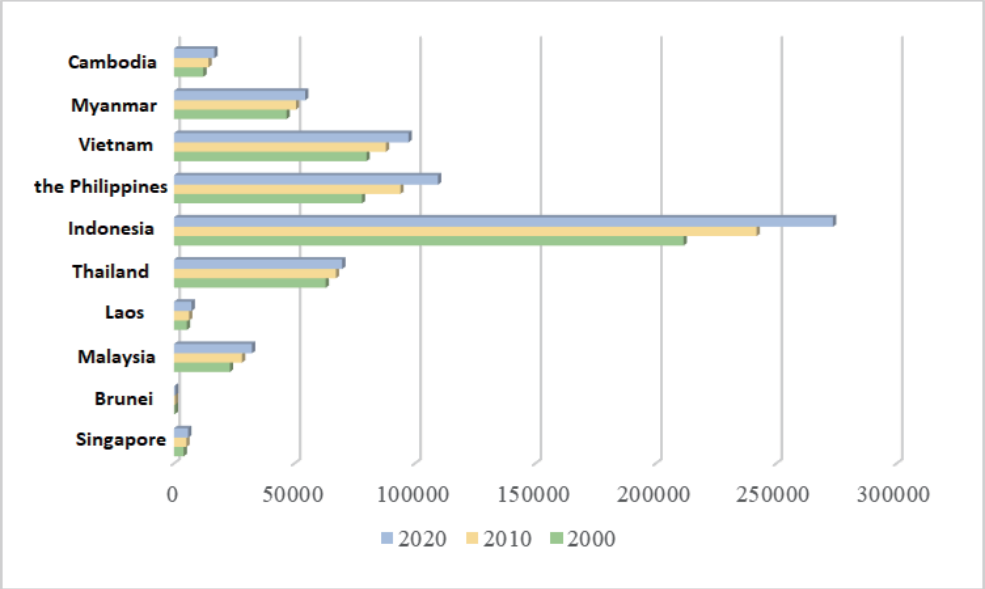


Figure 2-14. Population of AMS (1000 people)

Source: United Nations, World Population Prospects

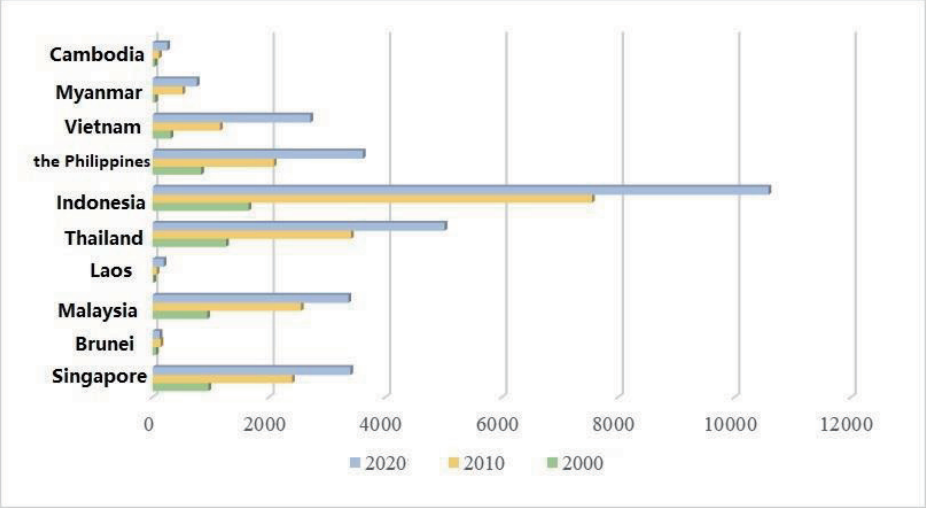


Figure 2-15. Total GDP of AMS (US$ 100 million)

Source: World Bank

2.3.2Foreign Direct Investment

Foreign Direct Investment (FDI) inward flows to ASEAN experienced an upward trend, with China being the largest trade partner. ASEAN total foreign trade reached USD 2.82 billion in 2019, a year-on-year decline of 0.34%. Compared with the previous year, ASEAN's exports declined by 0.9% to USD 1.42 billion and ASEAN's imports increased by 0.23% to USD 1.39 billion. China, EU, USA, Japan and South Korea have long been among the top five trading partners of ASEAN. In 2019, the total import and export volume of ASEAN to China and the United States increased, while the total import and export volume to the European Union, Japan and the Republic of Korea decreased. AMS are highly dependent on foreign trade. Most countries' foreign trade in goods accounts for more than half of their GDP, Cambodia and Malaysia's trade in goods is higher than their GDP, and Singapore and Vietnam's trade in goods is about twice their GDP.

Table 2-12: Trade between ASEAN and Major Trading Partners in 2019 (Unit USD 100 million)

Trading Partner	Import and Export Volume	Share %	Import	Share %	Export	Share %
China	5078.6	18.0	3053.9	21.9	2024.6	21.9
EU	2805.5	10.0	1266.7	9.1	1538.9	10.8
USA	2945.9	10.5	1109.9	8.0	1836.0	12.9
Japan	2259.2	8.0	1160.8	8.3	1098.3	7.7
South Korea	1564.8	5.6	971.2	7.0	593.6	4.2

HK, China	1109.9	3.9	187.9	1.3	922.0	6.5
Globe	28152.0	100	13920.5	100	14231.5	100

Source: Country (region) Guide for Foreign Investment Cooperation

Affected by the COVID-19 epidemic, the investment in seven countries showed a downward trend, among which Thailand and Malaysia experienced a larger decline. Generally speaking, Brunei, Cambodia, Laos, Myanmar and Vietnam were less affected. In 2020, the three largest recipient countries of foreign direct investment are Singapore, Indonesia and Vietnam, accounting for more than 90% of the ASEAN total. All AMS experienced a decline in FDI.

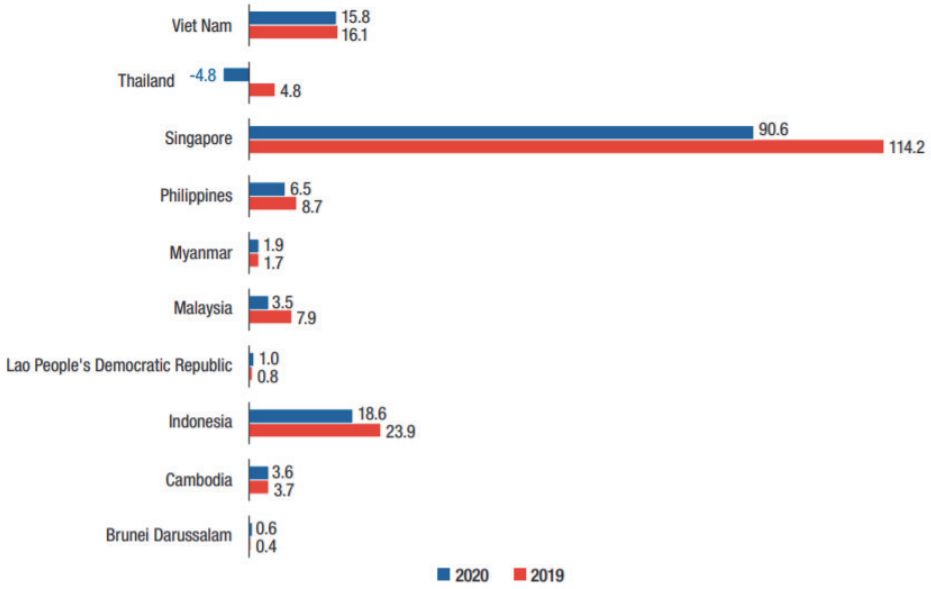


Figure 2-16 ASEAN's FDI in 2019 and 2020 (Unit: USD billion)

Source: ASEAN Secretariat

In the period of 2009 to 2019, China's direct investment in ASEAN countries showed a rapid growth trend (Table 2-13). In 2019, China's investment in ASEAN accounted for 9.4% of China's total foreign investment, while the stock ratio changed only slightly. Among AMS, Singapore has the highest degree of cooperation, followed by Indonesia and Vietnam.

Table 2-13: Amount and Stock of China's FDI in ASEAN (Unit USD billion)

	FDI				**Stock**	
Target country	**2009**	**2010**	**2018**	**2019**	**2010**	**2019**
China's global foreign investment	57	69	143	137	317	2199
ASEAN	2.6	4.4	12.5	13.0	14.3	109.8
Brunei	0.01	0.02	-0.01	-0.01	0.04	0.4

Cambodia	0.2	0.5	0.8	0.7	1.1	6.5
Indonesia	0.2	0.2	1.9	2.2	1.1	15.1
Laos	0.2	0.3	1.2	1.1	0.8	8.2
Malaysia	0.05	0.2	1.7	1.1	0.7	7.9
Myanmar	0.4	0.9	-0.2	-0.04	1.9	4.1
the Philippines	0.04	0.2	0.06	-0.01	0.4	0.7
Singapore	1.4	1.1	6.4	4.8	6.1	52.6
Thailand	0.05	0.7	0.7	1.4	1.1	7.2
Vietnam	0.1	0.3	1.1	1.6	1.0	7.1
ASEAN's share in China's total FDI (%)	5	6	8.7	9.4	4.5	5.0

Source: ASEAN Secretariat

2.4 Ecology and Environment

2.4.1 Forest Coverage

ASEAN has a high forest coverage, but faces the risks of degradation. The region has superior sunlight, temperature and water conditions and the highest light-temperature potential productivity. The north of Indo-China Peninsula and Malay Archipelago have high forest coverage, the greatest capacity for carbon sequestration (over 500gC/m^2) and the best ecological environmental conditions. Most of the farmland area and mixed area of agriculture and forestry in the Indo-China Peninsula is subject to the impact of human activities, with a low carbon sequestration capacity (below 210gC/m^2) and is in need of more protection.

The decline in forest coverage will create obstacles and pressure for AMS to realize their NDCs. However, the popularization of renewable energy will also reduce the demand for wood as fuel in rural areas. The total forest area in Malaysia decreased from 18.8 million hectares to 17.68 million hectares in the period between 1990 and 2008. Since 2009, with the government taking actions in afforestation and forest conservation, the forest area in Malaysia has been on an upward trend. Today, Malaysia has a forest coverage rate of 67.60%, reaching 19.11 million hectares. **The development of agriculture, the use of fuelwood and charcoal in rural areas and the illegal chopping of trees contribute to Myanmar's rapid forest loss.** Currently, firewood and charcoal account for 70% of fuel consumption in rural Myanmar. In the period of 2010 to 2020, the forest area in Myanmar reduced from 314,410 km^2 to 285,439 km^2, with an average annual decrease of about 3000 km^2. **The forest coverage of Thailand has been declining over the past years. It is worth noticing that the Thai government plans to increase its forest coverage rate to 55% by 2037.** According to the World Bank, from 2010 to 2020, the country has seen an overall decrease, though slightly, in its forest cover, from 200,730 square kilometers in 2010 to 198,730 km^2 in 2020.

2.4.2 Biodiversity

ASEAN has rich biodiversity resources, making biodiversity conservation a top concern in developing hydro power and other RE projects. The ten ASEAN Member Sates occupy only 3% of the world's area but are home to 18% of all living species on Earth. Three AMS, Indonesia, Malaysia and the Philippines, are included in the 17 mega-diverse countries identified by the UNEP. The whole region, covering the Sunda Islands, Wallachia, Indo-China Peninsula, and the Philippines, is considered a biodiversity hotspot, breeding a large number of endemic species. Among all regions across the world, AMS took the lead in the number of endemic plant, bird and mammal species. Forest, sea and freshwater ecosystems stored rich biodiversity resources for ASEAN region. ASEAN's forest ecosystem is one of the key habitats of global biodiversity, containing the highest proportion of country-endemic bird (9%) and mammal species (11%) and the second-highest proportion of country-endemic vascular plant species (25%). Co-governed by Malaysia, Indonesia and Brunei Darussalam, Borneo, the world's third and Asia's largest island, is one of the most important centers of biodiversity on Earth, with an estimated tree diversity of 1,175 species, and about 6,000 endemic plant species. ASEAN is also renowned for harboring the richest marine biodiversity in the world. The Coral Triangle, an area in the Indo-Pacific defined by the coasts and marine territories of Indonesia, Malaysia, the Philippines (AMS), Papua New Guinea, Solomon Islands and Timor Leste, harbors more than 600 species of hard coral and over 1,300 reef-associated fish species. Except for forests and marine, ASEAN is also home to various major ecosystems of lakes, rivers, and wetland, with a total area of about 2 million km^2, accounting for 45% of ten AMS' aggregated land area. There is a migratory site along the East Asian-Australian Flyway, particularly for water birds. The Greater Mekong Subregion, which straddles China, Lao PDR, Myanmar, Thailand, Cambodia and Vietnam, provides the richest species in the world, and abundant resources for biological study and biodiversity protection.

With rich biodiversity resources, ASEAN Member Sates are ecologically sensitive and fragile. Therefore, biodiversity conservation must considered as a priority in developing hydropower and other renewable energy projects. ASEAN Member States, except for Singapore, are developing countries. The tension between economic growth and eco-envirnmental protection is becoming increasingly obvious. To address eco-environmental deterioration and biodiversity loss, many ASEAN Member States have taken active actions. For example, the National Parks Board of Singapore implemented the National Conservation Master Plan (NCMP) to enhance the biodiversity conservation efforts initiated by the NBSAP. Malaysia has developed programs,

including the National Green Technology Policy, to mainstream biodiversity into sustainable development. Policies, such as the Malaysian National Plan of Action for the Coral Triangle Initiative, Environmental Quality Act, and National Agro Food Policy, among others, safeguard biodiversity in the areas of agriculture, fisheries, and pollution prevention and reduction. Regional cooperation platform also played its role, in which the ASEAN Centre for Biodiversity created a Clearing House Mechanism (CHM), sharing information of biodiversity, experience of protection, best practices and decisions.

2.4.3 Environmental Pollution

ASEAN's environmental pollution is getting increasingly severe. Environmental issues, since the 1980s, have become a key factor affecting the region's social and economic sustainability. In response to the deteriorating situation, ASEAN has established many cooperation mechanisms, signed a number of declarations, initiatives and agreements, and actively cooperated with countries and environmental organizations outside the region. However, little progress has been made. In general, the pollution and deforestation are the top environmental issues for ASEAN.

Table 2-14: ASEAN's Environmental Issues, Causes, and Consequences

Classification		Causes	Consequences
By environmental factors	Air pollution	Regional and transboundary seasonal smoke and haze; deforestation and forest fires; vehicular congestion and emissions; extensive land clearance and forest fires for pulp wood and oil palm production; ambient concentrations of carbon dioxide.	Causing respiratory diseases, harm to public health and impacts on daily life and social events; adverse effects on AMS relations; loss of biodiversity
	Water pollution	Freshwater resources polluted by domestic / industrial wastes & sewage runoff; deficiencies in urban infrastructure - unmanaged industrial wastes and municipal effluents and waste; tourist developments in coastal regions beyond carrying capacity; sporadic development and destruction of watersheds; extensive aquaculture & overfishing; unmanaged aquaculture; marine pollution.	Ground water contamination; waterborne disease; inadequate water supply; coastal degradation and loss of mangrove habitat; loss of biodiversity
	Soil pollution	Excessive mineral extraction; soil erosion; sedimentation.	Land degradation and soil erosion.
By human activities	Industrial environmental pollution	Solid wastes; hazardous materials and hazardous waste; electronic waste.	More wastes and exacerbating urban pollution.

	Urban environmental pollution	Rapid and unmanaged urbanization and deficiencies in urban infrastructure; lack of sewage disposal facilities; inadequate water supply & sanitation infrastructure.	Traffic congestion, urban heat island, and life quality decline.
	Agricultural environmental pollution	Illegal forest cutting; extensive land and forests clearance; shifting cultivation.	Loss of nutrients, shrinking farm lands, and frequent floods and droughts.

2.4.4 Natural Disasters

Among all regions in the world, ASEAN is the most vulnerable to natural disasters, which means both opportunities and challenges for the development of renewable energy. On the one hand, the frequent occurrence of flood, hurricane and other natural disasters as a result of climate change helps to improve the awareness of AMS in addressing climate change and developing renewable energy. On the other hand, extreme weather events might affect site selection for some PV power and wind power projects. Reducing the risk of natural disasters is one of the priorities for ASEAN to realize the goals of the *Sendai Framework for Disaster Risk Reduction 2015-2030* and UN 2030 Agenda for Sustainable Development. In the period of 2004 to 2014, ASEAN accounted for over 50% of global fatality from natural disasters and suffered USD 91 billion in financial losses from the impacts of typhoons, storm surges, floods, drought, and earthquakes[13]. Natural disasters are widely existed and frequently occurred, however, the public awareness, management and education for hazards prevention is insufficient. According to the Indonesian government's data in 2017, less than three percent of Indonesian households know how to respond to natural disasters[14]. More than 20 typhoons take place every year in the Philippines, five of which are typically destructive, taking a toll on not only infrastructure but also human life. It is estimated that approximately 70% of the population who live in coastal areas and low-lying deltas in Vietnam, are exposed to the risk of flooding [15].

[13] The Asian Development Bank (ADB), 2021. Six ways Southeast Asia strengthened disaster risk management.
[14] https://www.statista.com/statistics/920857/indonesia-risk-index-for-natural-disasters/
[15] https://www.who.int/vietnam/health-topics/disasters

Chapter 3. The Status-quo of ASEAN's Green and Low-carbon Development

3.1 Indonesia

Indonesia, known as the Country of Thousand Islands, is situated in the southeast of Asia. Spanning across both hemispheres, two oceans (the Pacific and the Indian) and two continents (Asia and Oceania), the world's largest archipelagic country boasts a total of 17,508 islands. It holds some major channels for international trade like the Strait of Malacca, Sunda, and Lombok. Indonesia, the largest country in ASEAN, accounts for about 40% of the region's population, area, and economy , covering a land area of 1.9 million km^2 and oceans of 3.17 million km^2. Being a low- and middle-income country in the ASEAN region, its total GDP in 2020 was USD 1.06 trillion, with a per capita GDP of USD 3,869. Indonesia is ASEAN's most populous country and the world's most populous Muslim destination, with a total population of 273 million in 2020, ranking fourth across the globe.

Foreign capital plays an important role in promoting Indonesia's economic development. The Indonesian government values improving the investment environment, to attract foreign capital. Before the financial crisis in 1997, it attracted about USD 30 billion of foreign investment each year, which dropped sharply after the crisis. In 2017, a total of USD 32.24 billion of foreign capital intake was delivered, marking a year-on-year increase of 8.5%. In 2019, the number turned to IDR 423.1 trillion (approximately USD 30 billion), the main sources of which were Singapore, China, Japan, and the United States.

Indonesia's total emissions in 2018 were 541 million tons of carbon dioxide. Among the carbon emission sectors, electro-thermal production took the largest share, accounting for 39.93%, followed by transportation (28.47%) and industry (21.07%), and its construction sector (4.25%) came to the top of ASEAN.

3.1.1 Industrial Structure

Indonesia is the largest economy in ASEAN, with agriculture, industry, and service industry playing a critical role in the national economy. In 2020, Indonesia's primary industry accounted for 13.7% of GDP, the secondary for 38.26%, and the tertiary for 44.4%. Rich in oil and gas resources though, it has witnessed declined production in recent years, as its oil exploration and development relied on external manufacturers. The mining industry stands high in the country's economy, taking 10% of GDP in output value. Indonesia is also a major coal exporter in the world,

whose coal export, one of the main tasks of the country's coal industry for a long period, has led the world for three consecutive years from 2017 to 2019. Coal mining in Indonesia is mainly open-pit, with production depending on foreign technology and equipment, and loose management. Its manufacturing sector, under industrialized, is more inclined to carry forward an outbound development mode. The main sectors are mining, textiles, and light industry, among others, with the output of tin, coal, nickel, gold, silver, and other minerals ranking top level.

As one of the leading agricultural powerhouses, Indonesia covers an arable land of about 80 million hectares and a population of approximately 42 million engaged in agriculture. With 54.25% of forest coverage (100 million hectares), Indonesia features the world's third largest tropical forest country, seeing 30 million people make their living on forestry. Besides, as the largest archipelagic country, it is known for its rich fishery resources, nourishing as many as 7,000 species of marine fish. It's estimated that the potential catch is over 8 million tons per year, with the currently developed marine fishery production accounting for 77.7% of the total. Tourism resources are also abundant in Indonesia. In 2018, it welcomed 15.81 million foreign visitors, who were mainly from Malaysia, China, Singapore, Timor-Leste and Australia.

For industrial products, Indonesia is dominated by minerals, textiles, electronics, iron and steel, and chemicals, while agricultural and forestry products include palm oil, rubber, plywood, pulp, paper, coffee, and cocoa. Less developed in its level of industrialization, Indonesia enjoys more than 30 types of sectors in the manufacturing industry, to name but a few: textiles, electronics, wood processing, steel, machinery, automobiles, pulp, paper, chemicals, rubber processing, leather, shoemaking, food, and beverage. Among them, textiles, electronics, wood processing, steel, machinery, and automobiles are important categories for export earnings. In 2020, Indonesia's crude steel production was estimated to be 9.3 million tons, ranking 19th in the world and second in ASEAN, following only Vietnam. Its output of direct reduced iron is 200,000 tons. As an importer of steel, Indonesia's net import volume of steel in 2020 was 4.2 million tons, the 9th in the world. Blessed with unique natural conditions, the country enjoys a humid and rainy climate, abundant sunshine, and a short crop growth cycle. The main economic crops are palm oil, rubber, coffee, and cocoa. In forestry, plywood, pulp, and paper took a lion's share of its export products, of which rattan made up 80-90% of global export. In 2020, Indonesia's palm oil production ranked first in the world, accounting for 59% of the total.

3.1.2 Energy Mix

Indonesia is known for its sound resource endowment, rich in oil, natural gas, and coal. With abundant oil and gas resources, Indonesia finds complex geological structures and boasts 66 sedimentary basins, of which 36 have completed exploration activities, and 15 are producing oil and gas. Indonesia joined the Organization of Petroleum Exporting Countries (OPEC) in 1962. Since 2004, it has become a net oil importer. In January 2009, it was suspended as a member of OPEC. In 2020, Indonesia's proven reserves of oil were 2.4 billion barrels (340 million tons), and the output was 743,000 barrels per day (36.4 million tons), both of which marked substantial decrease compared to that of the year 2000 (5.1 billion barrels & 1.456 million barrels per day) and 2010 (4.2 billion barrels & 1.003 million barrels/day). Its natural gas leads the ASEAN. In 2020, Indonesia's proven natural gas reserves were 1.25 trillion cubic meters, 0.67% of the world's total. The production peaked at 87 billion cubic meters in 2010 and has declined almost year by year since then, reaching 63.2 billion in 2020. In addition, Indonesia also has the largest coal resources among ASEAN countries. In 2020, the proven reserves of coal were 19.3 billion tons, and the potential could be more than 90 billion, making 3.2% of all. As the largest coal exporter, India provides about 26% of global exports, mainly to China, India, and other countries.

Oil (42.02%) takes the major part of Indonesia's energy consumption mix. From 2000 to 2018, the proportion of oil gradually decreased, while that of coal added up year by year, arriving at 29.50% in 2018, natural gas 22.63%, and non-fossil energy 5.84% (Figure 3-1).

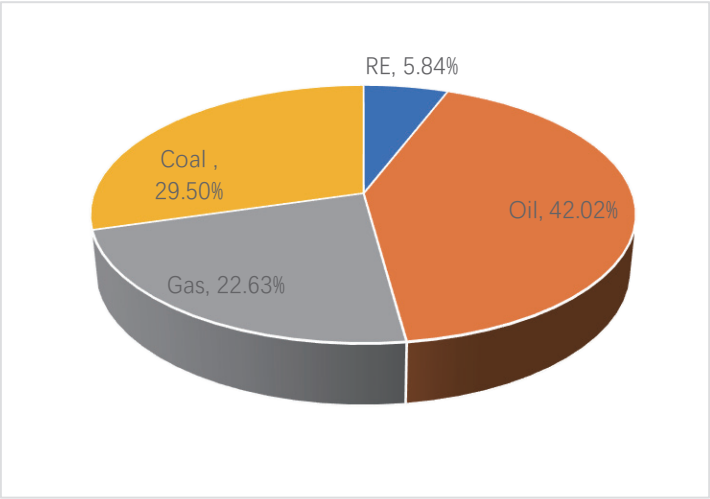


Figure 3-1. Indonesia's Energy Consumption Structure in 2018

Source: IEA

Indonesia's power generation structure is dominated by coal power (around 50%). On May 27, 2021, Indonesia announced that it will phase out its coal-fired power. Power penetration rate in the country has rapidly elevated from 73.37% in 2012 to 95.35% in 2019. In 2018, Indonesia's annual electricity consumption was about 245 billion kWh, and about 897 kWh per capita. According to the Indonesia National Electricity Supply Business Plan (RUPTL) 2021-2030, released by PLN, Indonesia's national power utility, the estimated social electricity demand in 2030 will be 408.01 million kWh, and 1396 kWh per capita. The average annual growth rate of power consumption between 2021 and 2030 will be 5.53%. Domestic electricity consumption would be 164.55 million kWh, 40.33% of the total; industrial will reach 130.01 million kWh (31.86%), and commercial will reach 85.94 million (21.06%).

As of June 2020, installed capacity in Indonesia is approximately 71 GW. The majority of production uses coal and gas, while the installed capacity for renewable energy is 10.5 GW. The country's power generation capacity composition is still dominated by coal, followed by gas.

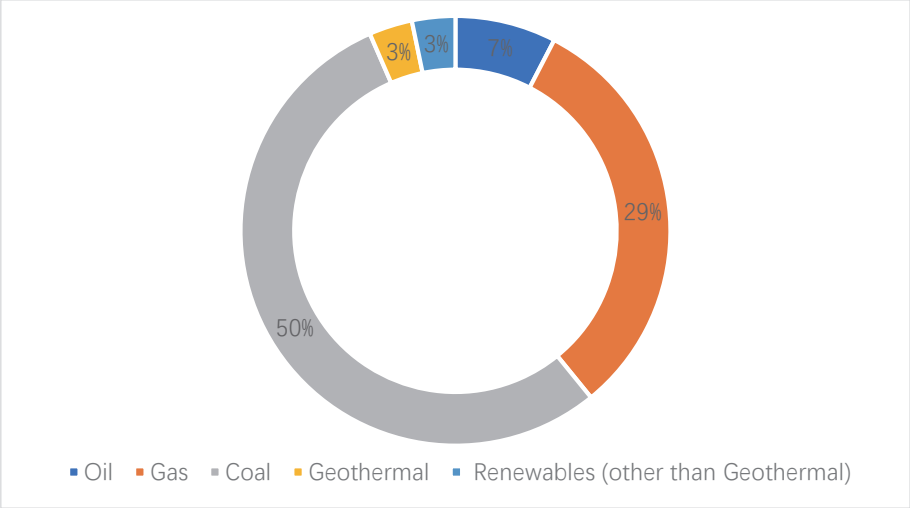


Figure 3-2. Indonesia's Power Generation Capacity in 2020

Source: IEA

In 2019, Indonesia's total power generation was about 283,800 GWh (25.77% of ASEAN), and its per capita was at the middle level among ASEAN countries. As the main choice of Indonesia's power generation, coal accounted for 56.39% in 2019, followed by natural gas (20.94%), oil (5.24%), and non-fossil energy (17.43%).

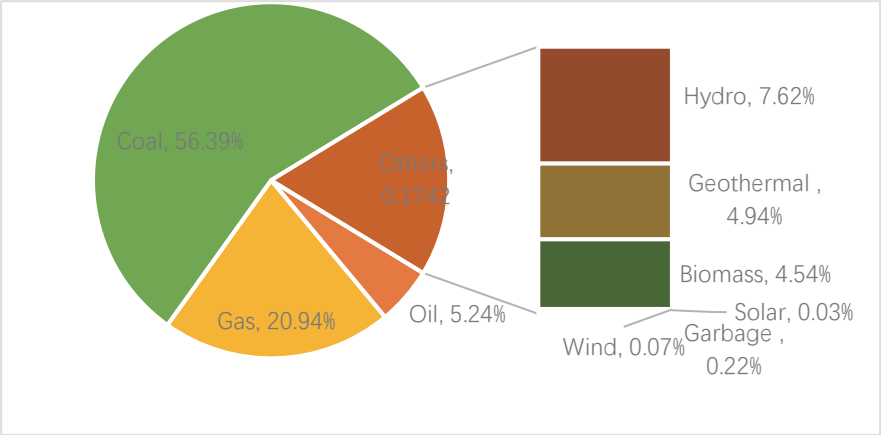


Figure 3-3. Indonesia's Power Generation Structure

Source: IEA

From 2000 to 2019, Indonesia's primary energy supply grew at an annual average rate of 2.6%, with oil and coal currently taking the top two largest shares. According to the country's national energy plan and policy, by 2025, renewable energy (RE) will come in at least 23% of the primary energy mix, fuel installed capacity falling below 25%, coal 25%, and gas 22%. By 2025, the proportions would be 31%, under 20%, 25%, and 24% respectively. Under the influence of biofuel-related policies, the rate of biofuels (mainly palm oil) has increased significantly during the past five years.

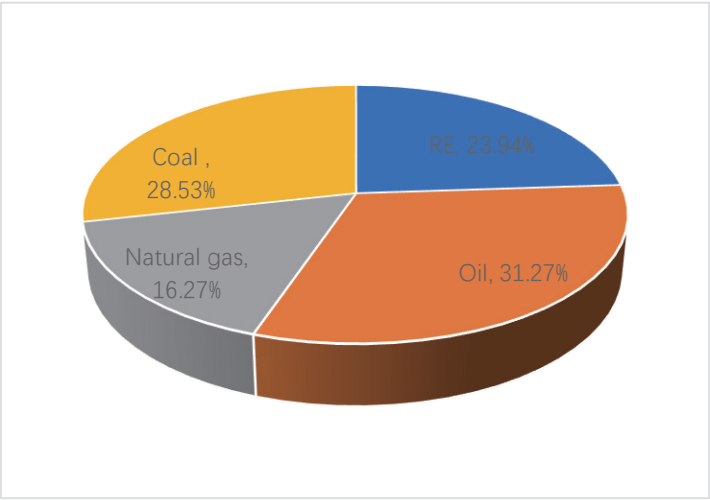


Figure 3-4. Indonesia's Primary Energy Supply Structure in 2019

Source: IEA

Though facing a large demand for infrastructure, Indonesia has practical problems to be solved in facilities and projects of connectivity and power grid. Indonesia, an archipelagic

country, has not yet established a unified power grid system, due to its special geographical environment, terrain constraints, and insufficient capacity for building power grids. The power coverage rate is only 65% across the country, representing relatively poor reliability of power supply. The government is actively seeking to make power interconnection with neighboring countries, to meet the development needs of power load and improve reliability. West Kalimantan now imports 230 MW of electricity from Malaysia, through a 275kV high-voltage line of 128 kilometers. Interconnection with Malaysia and Singapore will be further strengthened in the future as planned.

3.1.3 Renewable Energy

Indonesia is rich in renewable energy resources. The annual water production is about 3.9 trillion cubic meters, marking it as the world's fifth largest water reservoir, of which Kalimantan and Papua are blessed with the most abundant water resources, and Java, Sumatra, and Sulawesi, home to more populations, seeing the most hydropower development. Indonesia's annual theoretical reserves of **hydropower** are about 75.091 million kWh, as it is mini-micro hydro, with a technically developable installed capacity of 19.385 million kW. Onshore **wind** energy resources are average, as its vast land area is composed of most islands. The wind speed in most areas is 4-5m/s, just a few to 7m/s-8m/s, mainly in southwestern Sulawesi, north coast of the Timor Sea, and northeast of the Arafura Sea, representing high in the south and low in the north. According to the analysis of the mesoscale data platform, the development potential of wind power in Indonesia is about 11.8 million kW. Being the renewable energy with the most development potential in Indonesia, **solar** power provides average radiation of around 4.8kWh/m^2, and potential photovoltaic reserves of 536 million kW. Located on the equator, Indonesia enjoys sufficient sunshine throughout the year (15 hours of sunshine per day), with no distinction between cold winter and hot summer. **Geothermal** reserves are also ample in the country. Nearly 17,000 islands are covered by volcanoes, enabling the world's largest geothermal potential, which accounts for about 40% of the total. As shown in the latest data from Indonesia's Ministry of Energy and Mineral Resources (ESDM), the country's potential geothermal resources boast approximately 295.44 million kW of power generation capacity. In terms of biomass, it is estimated that Indonesia produces 146.7 million tons of biomass per year (equivalent to about 470 GJ), owning a power generation potential of 49.5 million kW, while the current installed capacity is only 1.6 million kW.

The Indonesian government has provided more support and incentives for the RE industry through legislation. Since the 2009 *Electricity Law*, the government has allowed private participation in the electricity sector. Primary energy source will be used optimally. The use of domestic energy sources will be prioritized in the national interest. According to provisions of the *Law Concerning Environmental Management (1997)* and the *Job Creation Law (2020)*, sustainable development of the environment refers to a full consideration of the limited capacity and resources in advancing economy, so as to satisfy both people nowadays and future generations. The *Employment Creation Law* made reforms to environmental protection and forestry, and simplified related procedures. It requires Environmental Impact Assessment (AMDAL) for investment or contracted projects, stipulating that enterprises must obtain environmental permits issued by the Ministry of Environment, and specifying penalties for environmental damage, such as imprisonment and fines.

The Indonesian government has set the target of RE Mix of 23% by 2025 (11% currently). With Independent Power Plants (IPPs) as priorities, it decides not to build new coal-fired projects in 2023, and plans to phase out all coal power by 2056 and replace them with clean energy. From 2021 to 2030, Indonesia plans to increase the capacity of power plants by about 40.9 million kW, which is equivalent to an additional 58.7% of the present. Thermal, still the main type of power plants built by the government, now celebrates an installed capacity of 19.48 million kW (47.63%), including coal-fired 12.49 million (30.54%) and gas 3.48 million (8.51%). However, due to the pressure of carbon emissions, the government decided not to build new coal-fired plants after 2023. The next decade will be critical for Indonesia to transition to renewable energy. According to RUPTL, medium and mini/micro hydropower plants will be 1.12 million kW (2.73%), 4.63 million of hydropower (11.31%), 3.24 million of PV (7.93%), and about 1.11 million of other complementary power plants such as wind, solar, water, and gas (energy storage perhaps)[16].

To achieve the government's goal of RE Mix at least 23% of the primary energy structure by 2025, Perusahaan Listrik Negara(PLN) plans to develop and utilize various types of renewable energy, to name: geothermal, hydropower, wind, and small distributed solar, biomass, biofuel, biogas and others. PLN also encourages research on other types of new energy, such as solar thermal and ocean. As predicted, between 2017 and 2026, Indonesia will build 4.4 GW of geothermal power, 4.6 GW of hydropower, and 1.65 GW of micro/mini hydropower. Meanwhile, by 2020, new coal

[16] SPIC, 2021. Research Report on Country and Regional Development.

projects would be controlled within 9 GW[17]. On May 27, 2021, Indonesia announced that it would gradually phase out domestic coal power, and PLN also followed by no new coal-fired plants after 2023.

Occupying around 18%, RE power generation in Indonesia is mainly composed of hydropower, geothermal, and biomass. Thanks to its rich geothermal, wind, solar, and hydropower resources, Indonesia is blessed with huge potential for development, though relatively insufficient utilization rate. The development rate of hydropower resources only accounts for about 7.6% of the theoretical reserves, PV only for about 0.03%, and wind just around 0.1%.

In 2019, hydropower, geothermal, and biomass accounted for 7.62%, 4.94%, and 4.54% of the total respectively, while waste-to-energy, solar power, and wind for less than 1%. In 2020, the Ministry of Energy and Mineral Resources announced that the total investment in energy conservation and new renewable energy was USD 1.36 billion, of which, the amount in geothermal reached USD 702 million, biomass USD 108 million, and other new RE totaled USD 540 million. By the end of 2020, the total installed capacity of new and renewable energy was 10.467 million kW, an increase of 176,000 kW over last year. In 2021, the target set by the government was 11.373 million kW, and the investment goal in energy conservation and renewable energy was USD 2.05 billion, of which geothermal was USD 730 million, biomass USD 68 million, other new RE USD 1.2 billion, and energy conservation investment USD 10 million. ESDM pointed out that starting from 2021, the proportion of new RE in the primary energy supply would increase to 14.5%, 15.7%, 17.9%, 19.5% and 23% respectively in the next five years.

Table 3-1: Indonesia's RE Potential and Utilization Rate

No.	Types of Energy	Potential (MW)	Installed Capacity (MW)	Utilization
1	Geothermal	29544	1808	6.12%
2	Hydro	75000	5124	6.83%
3	Mini-micro Hydro	19385	206	1.06%
4	Biomass	32654	1840	5.63%
5	Solar	207898	90	0.04%
6	Wind	60647	1.1	0.00%
7	Ocean Waves	17989		

Source: Data R&D Center, China Energy Media Group

[17] Power China, 2020. Indonesia's renewable energy storage and development.

3.1.4 Energy Efficiency

Large room for Indonesia to improve its energy efficiency. Indonesia has set a goal of reducing energy consumption by 1% each year between 2005 and 2025, the commercial sector and households by 15% in particular. ESDM is in charge of energy conservation, and the Directorate-General of New Renewable Energy and Energy Conservation (DGEBTKE) is responsible for operations. Policies concerning energy efficiency and conservation have been in effect since 2009, stipulating that buildings and factories consuming 6,000 tons of oil or above must submit reports to the government on a regular basis.

Potential left for Indonesia to play in clean coal technology and clean coal power. At present, coal power technology in ASEAN is mainly subcritical, leaving a large space for further development and energy efficiency. In 2019, ACE released the *Cleaner Coal Utilization Roadmap in ASEAN*, to actively promote the use of clean coal. One of the key objectives, proposed in the *ASEAN Plan of Action for Energy Cooperation 2016-2025*, is to carry out study on and promote clean coal technologies, such as supercritical and ultra-supercritical. Indonesia is the largest emitter in ASEAN, president Joko Widodo pointed out at the Leaders' Summit on Climate, and it will vigorously develop new energy sources to achieve the climate target. On the one hand, efforts to phase out old coal-fired plants should be stepped up, to encourage more investments in RE power stations. Clean coal technologies, on the other, should be utilized to reduce greenhouse gas production. By improving the energy efficiency standards, Indonesia will promote the transformation and upgrading of coal power plants, set up incremental threshold, and advance flexible restructuring of existing units. Measures will be taken to strengthen scientific and technological innovation in the field of clean and efficient use of coal, aiming at higher energy efficiency and lower coal consumption. In mapping out medium and long-term strategy, Indonesia will conduct coal exit in an orderly manner, to withdraw from high-energy consumption, high-emission, and low-efficiency plants. It will push forward the intensive and efficient development of large coal-fired power bases. No new coal-fired power plants will be built in developed areas where conditions permit.

More to improve for Indonesia's industrial energy efficiency. IE1 motors occupy the main market share, but there is still a chunk of IE0 ones. As the largest economy in ASEAN, Indonesia's total industrial energy consumption ranks the first. Seven major fields (i.e. paper, textile, cement, fertilizer, steel, ceramics, and palm oil) consumed 70% of industrial energy. In lower proportion though, industrial power consumption is inclined to mount gradually. With a continuous growth,

it is expected to exceed 150 billion kWh by 2050, of which motors will consume over 115 billion kWh. However, the share of industrial electricity consumption has been declining, from 56% in 1990 to about 33% in 2015. Forecasts showed that the proportion of Indonesia's industrial electricity consumption will go down to 27% by 2050. Progress of Minimum Energy Performance Standards (MEPS) has been slow, first version of remaining unfinished until 2019. Such a specification identifies Indonesia's MEPS as IE1, the specific implementation is yet to be approved. It is predicted that the energy-saving potential of the country's motor system could reach 12 billion to 29 billion kWh each year by 2050. In the cement industry, the agglomerate ratio was cut from 80% in 2010 to 75% in 2020. Efficiency was improved through raw material utilization and carbon dioxide recovery, such as recycling of carbon dioxide in the iron and steel industry, smelters, and improved processes for waste utilization.

Less efforts made for energy conservation of buildings, thus large room for further emissions. Energy conservation is mandatory for commercial buildings but voluntary for residential and industrial buildings. Indonesia now plans to cut emissions of oil and coal consumption in the residential and commercial sectors, by increasing the use of natural gas. Considering that Indonesia is home to the world's fourth largest population, the utilization rate of air-conditioning is still at a low level at present, a vast gap to cover in the future. MEPS was only carried out for air-conditioning units and lighting systems, and Level IV labeling policies were conducted for refrigerators. No High Energy Performance Standards (HEPS) were implemented.

A large amount of transport emissions, but lagging in infrastructure. Certain potential for boosting energy efficiency in the transport sector. Indonesia, an archipelagic country with few direct borders with its neighbors, extends its external communication mainly through sea and air, suffering from delayed transport development. The total length of Indonesian highways is 340,000 kilometers, but the quality of the roads was unsatisfactory. Construction of expressways was stagnated. By the end of 2014, the total mileage of expressways was less than 1,000 kilometers, railways 6,458 kilometers, and narrow-gauge railroads 5,961 kilometers. Railways transport in Java and Sumatra was developed, in which the ones in Java recorded 4,684 kilometers long, accounting for 73.6% of the nation's total railway length. Air transport shows a good sign of growth. According to the statistics of the United States *The World Factbook* in 2008, there are 652 airports in Indonesia. The country's *National Medium Term Development Plan 2015-2019* envisions 15 new airports to be built. Waterways, including inter-island, traditional, ocean, and special shipping, are Indonesia's edging transport. A total of 21,579 kilometers of waterway

channels and about 670 ports of various types are found in this country. Yet the transportation infrastructure was relatively backward, seeing the capital Jakarta struggling from severe traffic jams, which ranks the 12th among the most congested cities in the world. Transport, following the electro-thermal, becomes the second largest emission sector in Indonesia, contributing to increasingly growing emissions in recent years. In 2018, the number was 154 million tons (28%). In terms of energy consumption, oil consumed of the road transportation sector took more than 60% of the total, the highest and fastest-growing end energy consumption in the country. In 2017, it consumed 570 million BOE, accounting for 46.58% of the total; while in 2007, the amount was 270 million (28.74%).[18]

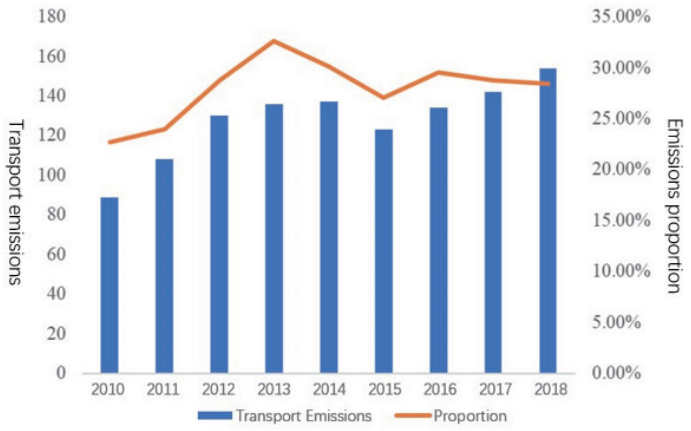


Figure 3-5. Indonesia's Transport Emissions Ratio

Source: IEA

The Ministry of Public Works and Public Housing (PUPR) has set a target of extending the length of Indonesia's toll roads to over 5,000 kilometers from 2,000 km by 2024. Indonesian president Joko Widodo announced plans in 2019 to spend USD 70 billion on toll roads connecting Indonesia to other countries.

3.2 The Philippines

Located in the southeast of Asia, the Philippines is facing Chinese Taipei across the Bashi Channel to the north, Indonesia and Malaysia across the Sulawesi Sea and the Balabac Strait to the south and southwest, the South China Sea to the west, and the Pacific Ocean on the east. With a total

[18] Ministry of Energy and Mineral Resources, 2017. Handbook of Energy & Economic Statistics of Indonesia, the Ministry of Energy and Mineral Resources of Indonesia.

area of 299,700 square kilometers, the Philippines is home to more than 7,000 islands, large and small, of which 11 major ones including Luzon, Mindanao, Palawan, and Samar, account for 96% of its land. Its coastline is about 18,533 kilometers long. As a low- and middle-income country (LMIC) in ASEAN, the country's total GDP in 2020 was USD 361.5 billion, and USD 3,299 per capita. The population of the Philippines in 2020 was 109 million.

Data released by the Central Bank of the Philippines (BSP) showed the net inflows of foreign direct investment (FDI) in 2019 was USD 7.647 billion, a year-on-year decrease of 23.1%, mainly from Singapore, the United States, Japan, South Korea, China, Thailand, Chinese Taipei, Mauritius, Hong Kong, and Germany. Investments went into finance and insurance, power and gas energy supply industries, manufacturing, real estate, transportation and warehousing, construction, and communications, among others.

In 2018, the Philippines emitted a total of 132 million tons of carbon dioxide, with electro-thermal production accounting for 52.27%, and transport and industry for 27.27% and 11.36% respectively. Basically, no emission was found in agriculture.

3.2.1 Industrial Structure

The Philippine industrial structure is dominated by the tertiary industry, with the service sector (exporting labor services as a mainstay) taking over 60% of the GDP. In 2019, in the GDP composition of the Philippines, agriculture, industry, and service industries accounted for 8.3%, 30.3%, and 61.4% respectively[19]. The industrial output value was 5.63 trillion pesos, a year-on-year increase of 5.2%; and that of the mining, manufacturing, construction, and electrical gas and water resources supply accounted for 0.6%, 15.3%, 6.7%, and 2.6% of the GDP, respectively. Industries with the highest output value in manufacturing are electronic components, food processing, and chemical products. In 2019, the chemical output value was about USD 26 billion, maintaining an average annual growth of 7% since 2010.[20] The Philippines is one of the world's major labor-exporting countries. According to statistics, in 2019, the remittances of Philippine overseas workers reached USD 33.5 billion, accounting for 8.89% of the GDP, a year-on-year increase of 3.9%. In terms of tourism, the number of tourists visiting the Philippines in 2019 increased by 15.24% year-on-year, hosting 8.26 million person-times, and the proportion of tourism output value in the GDP also arrived at 12.7% in 2019, a lift of 0.4%. The output values of transport, communications, and warehousing were 1.1 trillion pesos, 4.9% of the GDP.

[19] CAITEC, 2021. Countries (Regions) Handbook of Overseas Investment Cooperation, the Philippines (2020).
[20] CNCIC, 2020. The Philippines.

3.2.2 Energy Mix

Deficient in fossil energy resources, the Philippines is rich in tidal, geothermal, and biomass resources. Oil and gas are relatively scarce in the Philippines. By the end of 2010, the proven oil and natural gas were 138.5 million barrels and 98.5 billion cubic meters, most of which were stored in the Malampaya gas field. In terms of RE, the Philippines is blessed with more tidal energy resources, seeing a development potential of approximately 170 GW. Wind energy in this country is more concentrated in the northern area. Geothermal resources are rich (4 GW to be developed), while biomass boasts a potential of 0.24 GW.

Petroleum is the main energy consumed in the Philippines. In 2018, oil consumption accounted for 47.59%, followed by coal (34.82%), which has been growing year by year; natural gas (6.84%), and renewable energy (10.75%).

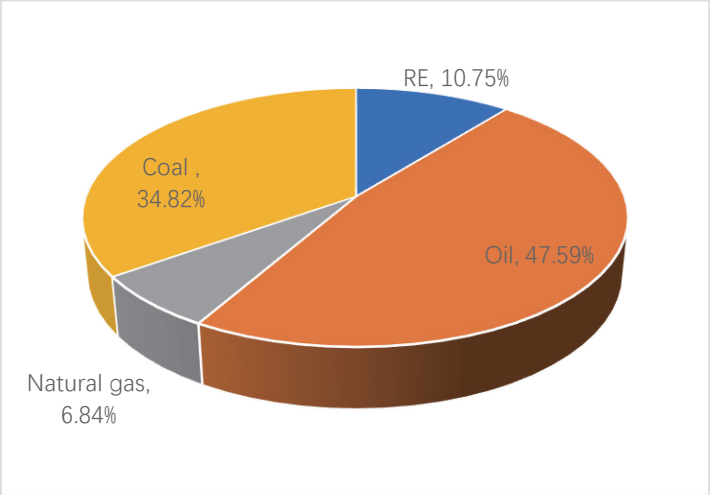


Figure 3-6. Energy Consumption Structure in 2018, the Philippines

Source: IEA

The current power generation structure in the Philippines is dominated by coal power, accounting for nearly half. The problems of electricity shortage in the Philippines have been serious, giving birth to high electricity prices, where residential and industrial bills were among the highest in the world. As of 2019, the electricity access rate in the Philippines was 98%. In 2018, the total installed capacity of the Philippines was 23.815 million kW, of which coal power was 8.844 million kW(37.14%), and clean energy such as geothermal and wind power was 7.227 million kW(30.35%). To elevate its level of power generation, the government privatized its national electric facility to develop renewable energy, which resulted in high electricity prices. The total power generation in 2019 was 99,000 GWh, seeing a relatively low level of per capita

production. The country's power structure is dominated by coal, which accounted for 52.35% in 2019, followed by natural gas (21.51%), oil (3.2%), and non-fossil energy (22.94%).

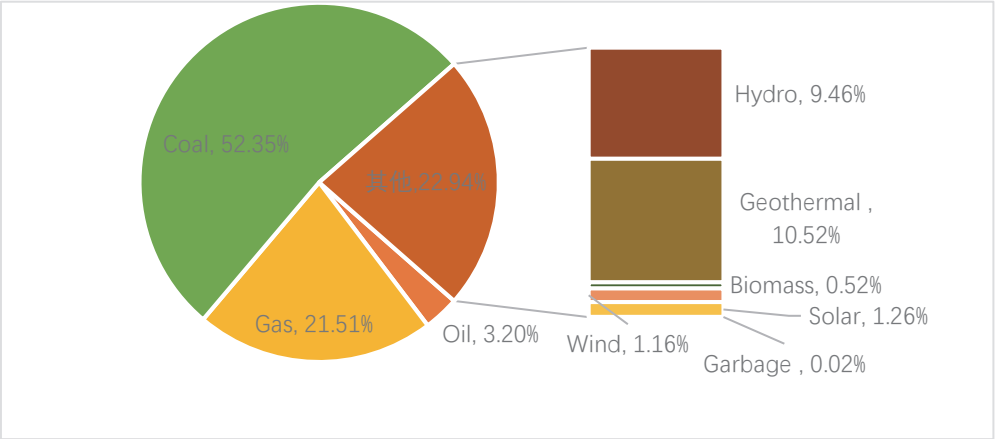


Figure 3-7. Power Generation Structure of the Philippines

Source: IEA

The Philippines did not enjoy a well-rounded infrastructure, failing to deliver a connected grid across the country. The Philippine power system covers three main islands, Luzon, Visayas, and Mindanao, forming three power grids. Among them, the Luzon power grid is the most sophisticated, which is a backbone network of 500kV high-voltage. The Visayas comes next, with a maximum voltage level of 230kV, connecting to the surrounding islands through several submarine cables. Mindanao, the weakest, is now equipped with 138kV as the highest. The Philippines reorganized its power market in 2015, enabling market participants to conduct electricity transactions more conveniently. It has also established grid norms and standards for renewable energy, as well as foreign investment legislation, showing advantages in cross-border trade. Due to the special geographical environment, the Philippines is undergoing slow progress in its domestic power grid. Not yet been interconnected, the country is still focusing on domestic development, rather than giving priority to external links. Planning to connect the Visayas and Mindanao power grids, the National Grid Corporation of the Philippines (NGCP) is currently advancing its Mindanao-Visayas Interconnection Project (MVIP), costing 52 billion pesos (approximately USD 1 billion), with a 450 MW initial capacity and a 618-kilometers power transmission distance. According to the ASEAN Power Grid (APG) initiative, the Philippines will join the ASEAN interconnection project by unifying with Malaysia's power grid in the future.

3.2.3 Renewable Energy

With geothermal, hydropower, solar, and wind as main power supplies, the Philippines is highly motivated to develop renewables. Having been promoting RE development, the Philippines passed the *Renewable Energy Act* in 2008 and has carried forward feed-in tariffs for renewable energy since 2012. In its *Power Development Plan 2017-2040* (PDP), the country is projected to focus more on RE, which started to implement the Renewable Portfolio Standard (RPS) in 2020 and launched a trading platform for renewable energy certificates. In June 2020, the Climate Change Commission of the Philippines passed a resolution stating that no new coal-fired power plants will be built thereafter. It shall deliver on its mandates by pursuing four action tracks: (1) formulating a new version of the *National Renewable Energy Plan* (NREP) 2021-2040; (2) implementing the Green Energy Option Program; (3) fully advancing the RPS; and (4) reforming the RE policies and legal frameworks. Among the Philippine RE power generation, the proportion of geothermal currently is the highest in ASEAN countries (10.52%), with hydropower accounting for 9.46%, and solar, wind, biomass, and waste for 1.26%, 1.16%, 0.52%, and 0.02% respectively. The Philippines has regulated the minimum grid-connected ratio and allowed power companies to buy back excess electricity from users who have installed RE equipment (100 kW and below). After signing the service contract with the Renewable Energy Management Bureau, developers could celebrate price guarantees within the RPS for no less than 12 years. It also made a series of plans to develop battery energy storage projects, and rooftop and power station-level PVs.

Table 3-2: Statistics of RE Projects under the *Renewable Energy Act 2008*, the Philippines

(as of September 30, 2021)

RE Categories	Project Amount		Potential Capacity (MW)		Installed Capacity (MW)	
	Commercial	Domestic	Commercial	Domestic	Commercial	Domestic
Hydropower	421	2	12,473.820	1.560	1,103.110	-
Marine	8	-	24.000	-	-	-
Geothermal	36	-	883.200	-	1,928.070	-
Wind	92	1	6,954.400	1.000	442.900	0.010
Solar	250	40	16,531.751	9.990	1,168.597	6.640
Biomass	61	22	171.360	3.100	614.110	179.270
Subtotal	868	65	37,038.53	15.65	5,256.79	185.92
Total	933		37,054.18		5,442.71	

3.2.4 Energy Efficiency

The Philippines has further room for improvement in energy efficiency and energy-saving standards. Compared to 2005, the Philippines has set a goal of reducing energy consumption

intensity by 45% by 2035. The Department of Energy (DOE) and the Energy Utilization Management Bureau (EUMB) are in charge of energy conservation tasks, which have promulgated the Energy Efficiency and Conservation (EE&C) Law and formulated relevant regulations. It is stipulated that buildings/factories consume 1,000ktoe and above in one quarter, and 2,000ktoe and above within a year and must submit reports to government agencies on a regular basis.

Potential for energy conservation in industrial power consumption. For the industrial sector, electricity consumption reached 25 billion kWh in 2016, which is estimated to be 52 billion kWh by 2050. The proportion of the industry has been declining since 1990, from a peak of over 45% to 32% in 2016. As predicted, the power supply of the Philippine industrial sector will remain stable at 32% for a long time. The electricity price is USD 0.25/kWh (approximately RMB 1.77), more than twice that of China and three times or more of other ASEAN countries. In implementing the *Energy Efficiency and Conservation Roadmap 2017-2040*, the Philippines aims to achieve economic growth and development by promoting efficiency and reducing intensity, to ensure energy security. It touched upon the introduction and production of MEPS for motors, as well as other industrial equipment such as pumps, enforcing special projects in industries with high energy intensity, e.g. cement, construction and sugar refinery. Professional experience and suggestions were offered to these projects, on the energy conservation of motor systems. The energy-saving potential of the Philippine industrial motor system, as forecasts showed, is between 1.87 billion and 4.7 billion kWh, which is expected to reach between 3.9 billion and 9.8 billion kWh by 2050.

Energy efficiency and conservation of buildings (commercial only, instead of residential and industrial). In 2007, the *Guidelines on Energy Conserving Designs of Buildings* was implemented, explaining energy conservation from different aspects of building design, such as lighting, power supply, air conditioning, and ventilation systems, etc. On June 22, 2015, the Department of Public Works and Highways approved the Philippines Green Building Code as a national standard, which helped ensure the improved energy efficiency of buildings through a gamut of standards. This manual, rather than a rating criteria, is composed of a series of minimum requirements for all motors: (1) All motors for mechanical equipment over 5 kW shall be provided with variable speed drive and high-efficiency motors. (2) All motors of cooling towers shall be provided with variable speed driver and high efficiency motors. (3) All motors for domestic pumps shall have high efficiency motors. MEPS was carried out for air-conditioners, refrigerators,

and lighting systems, with the label of energy efficiency as Level V (new labels in design). No HEPS was implemented.

The Philippines plans to modernize its public transport, which took a large share in emissions. Dominated with roads and ocean shipping, the Philippines is less developed in railways. Close to the geographical center of East Asia, it is the only country that is able to reach major capital cities within 4 hours, though falling behind in infrastructure. The mileage of roads is about 200,000 kilometers, with a total of 8,166 bridges and a total length of 364 kilometers. Railways, about 500 kilometers existed, are mainly concentrated on Luzon Island. There are nearly 300 airports across the country, with domestic routes covering more than 40 cities. As of water carriage, the total length is 3,219 kilometers, including over 400 major ports, most of which are in need of expansion and upgrading to accommodate large-tonnage ships and cargo. The *Public Utility Vehicle Modernization Program* (PUVMP), launched by the government, was to encourage the development of public transportation. From 2010 to 2018, carbon emissions in transport have been increasing year by year, recording 36 million tons in 2018, accounting for 27%, the second largest emitter in the Philippines.

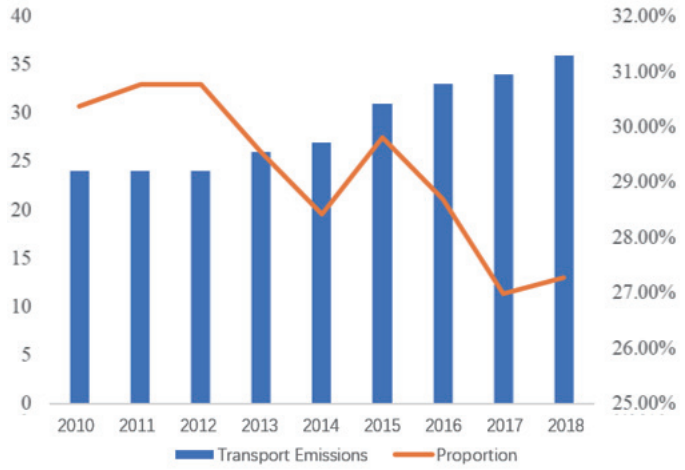


Figure 3-8. Transport Emissions and its Proportion, the Philippines

Source: IEA

3.3 Vietnam

Located at the southeastern tip of the Indochina Peninsula, Vietnam is surrounded by sea on three sides. Its terrain, long and narrow, slightly S-shaped, embraces a superior natural environment and rich resources and minerals, represented by coal, iron, bauxite, copper,and rare earth, among

others. Vietnam is now home to a population of 96.2 million, of which 55.8 million are laboring population over 15 years old.

In 2019, Vietnam attracted USD 38 billion in foreign investment agreements, a year-on-year increase of 7.2%, and the actual funds in place were USD 20.38 billion, a 6.7% annual raise. By the end of 2019, it has absorbed 30,827 FDI projects, with a cumulative contracted investment amount of USD 362.6 billion. A total of 125 countries and regions invested in Vietnam in 2019. Among them, South Korea ranked first totaling USD 7.92 billion (20.8%), followed by Hong Kong, China, (USD 7.87 billion), and Singapore (USD 4.5 billion). Affected by the trade frictions between China and the US, China and Hong Kong's investment in Vietnam has increased significantly, respectively growing by 65% and 143.5%.

In 2018, Vietnam's total CO_2 emissions were 226 million tons, of which electro-thermal production accounted for 48.23%, industry for 28.32%, transport for 15.93%, construction for 4%, and commercial and public services for 3%. Agriculture accounted for less than 1%, and barely any emissions were found for other sectors.

3.3.1 Industrial Structure

Tending to be coordinated, Vietnam's primary, secondary, and tertiary industries account for 14%, 34%, and 42% respectively. In 2019, Vietnam's agriculture, forestry, and fishery industries increased by 2.01%, the industrial construction by 8.9%, and the service industry by 7.3%, which contributed 4.6%, 50.4%, and 45% to GDP growth respectively, accounting for 13.96%, 34.49% and 41.64% of the total. The main drivers of economic growth are processing and manufacturing (up by 11.29%) and market services (transportation and warehousing growing by 9.12%). Its wholesale and retail trade was also mounted by 8.82%, and the finance, banking, and insurance up by 8.62%.

In terms of agriculture, forestry, and fishery, Vietnam's planting area in 2019 decreased by 102,200 hectares, producing 43.45 million tons of rice, a year-on-year reduction of nearly 600,000 tons. Other major products include corn (4.76 million tons), sweet potatoes (1.4 million tons), sugar cane (15.27 million tons), cassava (10.11 million tons), peanuts (438,800 tons), soybeans (75,900 tons), vegetables (1.795 million tons), and beans (161,900 tons). The country contributed to the afforestation of 273,600 hectares and exploited 16.1 million cubic meters of timber. The total amount of aquatic products was 8.2 million tons (up by 5.6%), including 5.925 million tons of fish and 1.035 million tons of shrimp. In 2019, Vietnam's processing and manufacturing

industry expanded by 8.86%, power production, transmission, and distribution by 9.14%, and water supply, sewage, and waste treatment by 7.72%, seeing the mining industry down by 1.29%.

3.3.2 Energy Mix

Vietnam is rich in fossil energy resources and has good conditions for renewables. Vietnam's crude oil reserves are about 4.4 billion barrels, the 28th in the world; natural gas reserves are 1 trillion cubic meters. The scale of crude oil exploitation in Vietnam ranks the 36th, oil export the 4th in Southeast Asia. In 2019, Vietnam extracted 13.08 million tons of crude oil (4.1 million for export, an annual growth of 3.6%) and 10.22 billion cubic meters of natural gas. Thailand, China, Japan, and Australia are the main buyers. Vietnam's first oil refinery, Dung Quat Oil Refinery, was officially put into operation on May 30, 2010, with a total investment of over USD 3 billion and an annual processing of 6.5 million tons of crude oil, satisfying 40% of Vietnam's demand for refined oil products. According to the *BP Statistical Review of World Energy*, the total amount of proven coal in Vietnam in 2020 was 6.5 billion tons, accounting for 0.6% of the world. Vietnam's RE resources are also superior, abundant in solar, hydropower, and wind. Solar radiation is an average of 4.6kWh/m^2 per day, and the potential of solar power generation can reach 13 GW; in terms of wind power, offshore wind power development boasts a coastline of more than 3,000 kilometers, enjoying relatively concentrated wind resources, mainly in the central and southern central coasts, central highlands, and south coasts. It is estimated that Vietnam's wind potential is 27.75 GW.

Energy consumption in Vietnam is dominated by coal, featuring a growing trend. In 2018, of the total energy consumption, coal, oil, natural gas, and RE accounted for 45%, 26%, 8%, and 21%, respectively. In recent years, coal demand in Vietnam's domestic market has been growing steadily. Over the past five years, its domestic coal demand has increased from 18 million tons in 2007 to 24.8 million tons in 2012. It published the *Coal Development Plan to 2020 and Outlook to 2030*, according to which, looking forward to 2030, the total coal output would reach 55 million tons in 2015, 60 million by 2020, 65-70 million by 2025, and 65-75 million tons in 2030.

In 2020, the Communist Party of Vietnam passed a resolution on the *Orientation of Vietnam's National Development Strategy to 2030 and Outlook to 2045*, aiming to achieve 175 million to 195 million tons of oil equivalent (toe) of the primary energy supply by 2030 and 320 million to 350 million tons by 2045. In 2030, the total consumption of end energy would reach 105 million to 115 million toes, and in 2045 160 million to 190 million toes. The primary energy consumption intensity in 2030 would be between 420 to 460kgoe per thousand USD GDP, and in 2045 dropping

to 375-410kgoe[21]. In addition, the refinery would meet at least 70% of domestic demand to ensure a strategic reserve of refined oil for at least 90 days. The capacity to import LNG would be about 8 billion cubic meters in 2030 and about 15 billion in 2045. The energy saving rate of end energy consumption would reach about 7% in 2030 and about 14% in 2045. Compared with normal development, greenhouse gas emissions from energy activities will be reduced by 15% by 2030 and 20% by 2045.

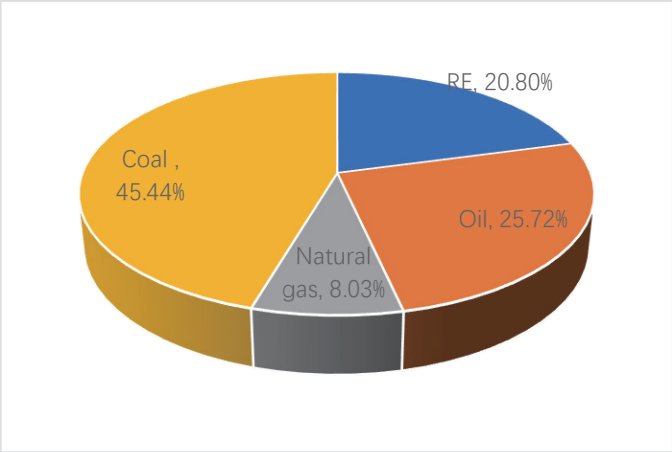


Figure 3-9. Energy Consumption Structure in Vietnam

Source: IEA

Vietnam's power generation structure is dominated by coal and hydropower. As of the end of 2020, Vietnam's total installed power capacity was about 69 GW (including rooftop solar), second in ASEAN (second only to Indonesia). Among them, the installed capacity of coal-fired power generation was about 21 GW; hydropower about 21 GW; solar (including rooftop) 17 GW; and wind, biomass and the imported less than 1 GW. From 2011 to 2020, Vietnam's total installed power capacity has grown by an average of 12.9% annually, in which the coal-fired elevating at the fastest rate of 18%, followed by hydropower at 9.2%. RE (wind and solar) accounted for nearly 26% of total installed electricity capacity, while gas and oil barely showed any progress. In 2019, Vietnam's total power generation was 240TWh, of which coal accounted for the largest proportion (47%), followed by hydropower at 34%, and all non-fossil energy at 35%. According to the Orientation, the goal is that by 2030, the total installed capacity of electricity will reach 125 GW to 130 GW, with power generation at 550 to 600 TWh.

[21] Souce: http://www.mofcom.gov.cn/article/i/jyjl/j/202002/20200202938776.shtml

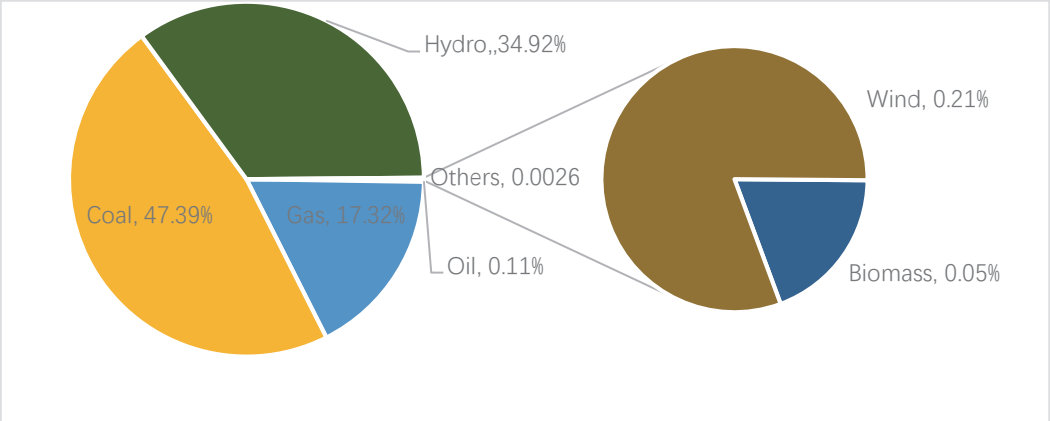


Figure 3-10. Power Generation Structure, Vietnam

Source: IEA

3.3.3 Renewable Energy

Vietnam's RE power generation now takes hydropower as the principal, with a low utilization rate of other renewables. To meet its growing power demand, Vietnam needs to boost 6,000 to 7,000 MW of capacity annually before 2030, at a cost of USD 148 billion (Table 3-3). The government encourages the development of biomass, solar, and wind, fortifying the share of RE power generation, which is now not widely utilized. Vietnam plans to extend the share of RE to over 10% of the total power generation mix by 2030. According to its overall RE development plan, the government schedules to elevate the installed capacity of wind power to 800MW in 2020 and 6 GW in 2030, and that of solar to 4 GW and 12 GW. It would also take some policy measures to facilitate the use of renewables, such as feed-in tariff (FiT) scheme, new public-private partnership (PPP) framework, power purchase agreement, corporate income tax relief or reduction, preferential land lease policy, and research and technology funding for pilot projects. In April 2017, Vietnam launched a 9.35 cents/kWh FiT subsidy, which triggered a boom in photovoltaic installations. In November 2019, Nguyen Xuan Phuc, Prime Minister of Vietnam, urgently stopped the subsidy policy, turning to bid on solar power prices. FiT mechanisms were applied for wind and biomass. However, the rapid growth of solar power generation, coupled with the instability of PVs, led to an overloaded grid from time to time, and Vietnam does not yet enjoy the energy storage technology that can guarantee stable baseload power. To address this problem, Vietnam's Power Development Plan VIII (PDP8) plans to invest USD 32.9 billion before 2030, and an additional USD 52.1 billion for grid upgrading before 2045. In 2018, the U.S. Trade and Development Agency (USTDA) provided a grant to Vietnam Electricity (EVN), a state-owned

company, to study the feasibility of deploying advanced energy storage technologies, including the management and storage system of battery energy. These technologies will help EVN reduce power shortages and losses, to support increased RE generation across the country.

Table 3-3: Vietnam's Power Supply of Renewables

Renewables	Potential Capacity (MW)	Actual Installed Capacity (MW)
Small Hydro	7,000 (technical)	1,648 (∽23.5%)
Wind	27,763 (technical)	189.2 (∽6.8%)
Biomass	318,630 (theoretical)	270 (∽0.84%)
Solar	7,140 (commercial)	8 (0.1%)
Geothermal	350	0
Solid Waste	400	2 (0.5%)

Source: Vietnam Renewable Energy Report 2018

3.3.4 Energy Efficiency

Vietnam passed and implemented the *Law on Economical and Efficient Use of Energy* in 2003, setting labels for high energy efficiency.

Large room for improvement in industrial energy efficiency. Since 2000, Vietnam's industrial electricity consumption has grown rapidly, reaching 76.5 billion kWh by 2016. With such a growth rate maintained, the power consumption of its industrial sector will be 247 billion kWh in 2050, making it the largest industrial power-consuming country in ASEAN. Industrial power consumption has witnessed and is still undergoing a quick rise since 2000, accounting for more than 54% by 2014 and expected to exceed 57% in 2050, which would make Vietnam the only one surpassing 50% in industrial electricity consumption among ASEAN countries. It's also the first ASEAN country to implement the MEPS for motors, setting at IE1 in 2014. Most of new motors sold in Vietnam, as inferred, are labeled as IE1 for energy efficiency. The stock is mainly IE1 and IE0, with perhaps a small number of multinational Vietnamese factories of IE2 and IE3. It is estimated that the energy-saving potential of Vietnam's motor system ranged from 5.7 billion kWh to 14 billion kWh in 2016, ranking among the top in ASEAN countries. Due to the continuous expansion of the total and share of industrial power consumption, however, the country enjoys huge potential in energy conservation of motor systems, which could reach 18.6 billion kWh to 46 billion kWh by 2050.

MEPS was settled for three types of equipment in the construction sector: air conditioners, refrigerators, and lighting systems.

Vietnam's transportation is dominated by highways, followed by water carriage. As the main mode of transport in Vietnam, national roads, provincial roads, and expressways weave the country's transport network. By the end of 2019, the total mileage of the above three types of roads that have been put into use was about 47,000 kilometers, including 17,300 kilometers of national roads, 27,700 kilometers of provincial roads, and 2,000 kilometers of expressways. In 2019, the highway system transported approximately 5.14 billion passengers (an annual increase of 11.2%) and 1.684 billion tons of goods (increasing by 9.7%). Vietnam's roads are connected with those of China, Laos and Cambodia.

With respect to railways, the country extends a network length of 3,160 kilometers, covering three types of gauge width, mainly the meter gauge (85%), the standard gauge and the 1435 mm track. In 2019, Vietnam transported a total of 8 million passengers through railways, witnessing a sharp decline of 6.9% year-on-year. 5.2 million tons of goods were shipped in rails, also a 9.1% of decrease.

Currently, Vietnam has 22 airports in operation, including 10 international ones. The total operating capacity is 95 million passengers per year. The country is managing and developing inland waterways of 19,000 kilometers, mostly natural, 6,700 kilometers of which were national-level internal routes. Load draft in the north is ensured to be 2-2.5 meters and 3+ meters in the south. The freight and passenger volume of inland river transport are second only to road transport. Vietnam has published plans for developing transport, the resolution of constructing an infrastructure supporting system, making Vietnam a modern-oriented industrialized country by 2020, *Vietnam Expressway Development Plan to 2020*, *Vietnam's Transport Development Plan up to 2020 and Outlook to 2050*, to name a few.

3.4 Malaysia

Seated at the center of Southeast Asia, Malaysia holds the Strait of Malacca, connecting the land and oceans of ASEAN. Enjoying geographical advantages, the country is situated near the equator, featuring a tropical rainforest and monsoon climate, which sees hot and rainy days all year round, rather than obvious seasonal differences. The temperature changes little, with the average daytime temperature between 31-33°C, and nighttime 23-28°C (the plateau area as low as 16-18°C). Rainfalls are abundant throughout the year, with an average annual precipitation of 2000-2500 mm. Each year, Malaysia enjoys the northeast monsoon from October to next March, the rainy season with more rainfalls; and from April to September, here comes the southwest monsoon, bringing along dry weather and less rainfall. The economic and trade ties between China and

Malaysia are highly interdependent, enjoying a large scale and a solid foundation. In the process of promoting the Belt and Road Initiative (BRI) and international production capacity cooperation, Malaysia took the lead in responding and participating, becoming a key juncture of the 21st Century Maritime Silk Road. As a middle-income country in ASEAN, its total GDP in 2020 is USD 336.6 billion, and the per capita GDP marks USD 10,400. Except for the impact of the pandemic in 2020, Malaysia's economy has been in stable growth. As of 2020, Malaysia's population was recorded as 32.37 million. (Data source: World Bank) Its main sources of foreign capital are Japan, the European Union, Singapore, China, South Korea, and the United States. In 2018, Malaysia attracted about MYR 80.5 billion in FDI.

In 2018, Malaysia's total carbon emissions were 227 million tons, of which electro-thermal production accounted for 49.34%, transportation and industry for 26.87% and 15.42%, other energy industries for 5.73%, and construction, commerce, and public services, fishery, and agriculture all less than 1%.

3.4.1 Industrial Structure

The tertiary industry takes the principal role in Malaysia's industrial structure. The service industry accounts for about 60% of the GDP, of which tourism takes 16%. In 2018, Malaysia's agriculture, mining, manufacturing, construction and services accounted for 7.1%, 7.1%, 22.3%, 4.7% and 57.7% of the GDP respectively. The agricultural output value was MYR 101.29 billion (7.1%), a year-on-year increase of 1.8%. The manufacturing industry, witnessed a 3.8% of annual growth, was MYR 316.36 billion (22.3%). The government encourages processing industries based on domestic raw materials, focusing on the development of electronics, automobiles, steel, petrochemicals, and textiles. In 2019, Malaysia's mining output value marked MYR 101.57 billion (7.1%), largely based on the exploitation of oil and natural gas, seeing a decrease of 1.5%. While for the service industry, Malaysia's biggest industrial sector, its output value was recorded at MYR 819.22 billion (57.7%), a year-on-year increase of 6.1%. 60.3% of employees employed in Malaysia were devoted in the service industry. Tourism, an important part of the service industry, attracted 26.1 million tourists in 2019, creating 15.9% of the GDP and bringing 3.6 million jobs, accounting for 24% of Malaysia's employment. The output value of the construction industry was MYR 66.25 billion (4.7%), slightly going up by 0.1%. Green economy and green tourism have become the new normal of Malaysia's economic development.

3.4.2 Energy Mix

Malaysia is rich in oil, gas, and renewable energy resources. Malaysia is the second largest country in oil and gas production among ASEAN countries. In 2020, Malaysia's proven reserves of oil and natural gas were 2.7 billion barrels (360 million tons) and 0.91 trillion cubic meters, and the output was 596,000 barrels per day (27.24 million tons), and 73.2 billion cubic meters. At present, its oil reserves are second only to Vietnam, ranking second in Southeast Asia. A trend of decreasing fluctuations as shown in the output. In 2000, the output was 724,000 barrels per day, and in 2010, the number became 733,000, a drop of 10.1% in production in 2020 compared to that of 2019. Malaysia's natural gas resources are second only to Indonesia in ASEAN. Since 2000, its natural gas reserves have decreased by about 15%, yet no obvious decreasing trend in output.

In terms of renewable resources, Malaysia is relevantly richer in solar energy and water resources, and the development potential of biomass is 0.6 GW. As the world's second-largest producer and exporter of palm oil and related products, Malaysia generated a large amount of palm waste with the booming of palm plantation and supporting industries, boasting huge economic potential and broad prospects by using this biomass waste as fuel for power generation.

Malaysia's energy structure is dominated by natural gas and oil, consumption of which in 2018 was 37.43% and 36.28%. Coal consumption has risen from 4.09% in 2000 to 19.67% in 2018. The share of RE has been growing, reaching 6.62% in 2018.

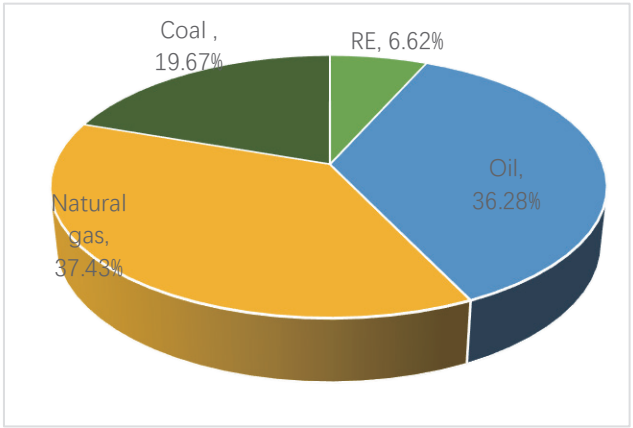


Figure 3-11. Energy Consumption Structure of Malaysia in 2018

Source: IEA

In 2019, Malaysia's power generation in all was 170,500 GWh, accounting for 15.48% of ASEAN, per capita generation ranking the third. **Its power generation structure was dominated by coal**, accounting for 45.34% in 2019, followed by natural gas (37.48%), petroleum (less than 1%), and

non-fossils (16.57%). With the installed capacity of 33.763 million kW, the power consumption of Malaysia's whole society is 156 billion kWh, a coverage rate of 99%, and per capita consumption of 4,971 kWh. Coal power, in the installed capacity structure, accounts for 31.1%, with natural gas for 43.6%, hydropower 18.2%, diesel 3.8%, biomass 2.3%, PV 0.8%, biogas 0.2%, and the clean energy 21.5%.

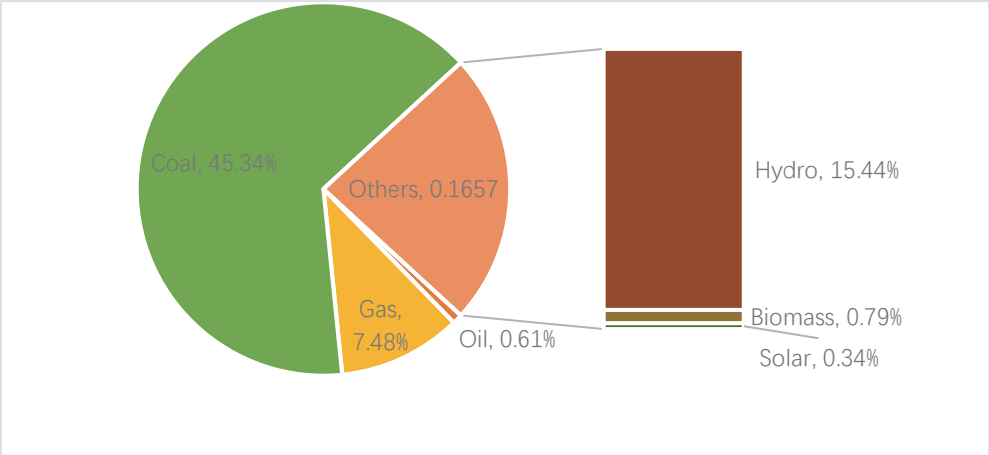


Figure 3-12. Malaysia's Power Supply Mix

Source: IEA

3.4.3 Renewable Energy

RE power generation accounted for about 17% in Malaysia, mainly hydropower, solar, and biomass. In 2019, Malaysia announced a ten-year blueprint plan for the power sector, i.e. the *Malaysia Electricity Supply Industry 2.0* (MESI 2.0), which aims at introducing liberalization across the industry from fuel sources, generation, and transmission, to distribution and retail in Peninsular Malaysia. From power purchase agreement (PPA) franchising to power capacity and energy markets, it will also encourage more independent power producers (IPPs) to enter the sector. Malaysia has made positive efforts in developing RE, achieving a high degree of marketization in hydropower. In 2019, hydropower accounted for 15.44% of its total power generation, while biomass was less than 1%. Recently, in Malaysia's new *Energy Transition Plan*, it proposed to deliver its green energy goals through "bioenergy", and to promote RE development through net energy metering (NEM), FiT, Large Scale Solar (LSS), self-consumption (SELCO) and other incentives. RE-related laws and regulations were also published, to name: *Electricity Supply Act 1990*, *Electricity Regulations 1994*, *Environmental Quality Act 1974*, and *Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987*. Regulations involving IEA of investments were the *Environmental Impact Assessment (EIA)*

Procedure and Requirements in Malaysia (1990) and the *Environmental Impact Assessment Guideline in Malaysia* (1994).

The average annual rainfall in Malaysia is about 3,000 mm, making a total annual surface runoff of about 566 billion cubic meters, and groundwater 64 billion. Thus, **water resources** generated each year is about 580 billion cubic meters, per capita supply around 22,100. At present, the installed **hydropower** capacity in Malaysia is about 6,073MW, with large-scale projects basically concentrated in the Sarawak area (nearly 5 GW into operation), and small ones in the peninsula. Sarawak is enjoying more or less 70% of hydropower across the entire region, which still enables 20 GW of room for further development. In terms of **wind** resources, due to its equatorial position, Malaysia undergoes an annual average wind speed lowering than 5m/s in most areas, so there is no commercial value for large-scale development. Only a few sites in the northern part of Sabah boasts a wind speed of about 7m/s, which meets certain development conditions.

Malaysia is rich in **solar** resources, with an average sunshine level of about 1,400-1,900 kWh/m^2 and a potential installed capacity of 6,500MW. The current installed capacity is 282MW, most of which are small projects below 5MW. The Energy Commission (Malay: *Suruhanjaya Tenaga*, ST), for the next step, will continue to organize the bidding for large-scale PV ground stations. Phase III is now being executed, with some Phase I projects already in production. Malaysia also encourages large rooftop programs, offering subsidies for energy management contracts. On the other hand, home to a chunk of palm forests, the country is blessed with huge potential for developing **biomass energy**. It is estimated that Malaysia's biomass could reach 1,340MW in 2030. Besides, with an emerging economy, its expected power generation of **waste** (360MW) **and biogas** (490MW) is also promising.

Up to June 2020, the Ministry of Energy and Natural Resources has launched the fourth round of LSS project tenders. According to statistics, there are more than 4.12 million buildings in Peninsular Malaysia enjoying the potential to install rooftop solar equipment. If all set, 34WG of electricity in total could be generated. In releasing the *Green Technology Master Plan (2017-2030)*, it outlines the aspirational targets for installed RE capacity at 23% by 2025 and 30% by 2030[22]. Among RE power generation, hydropower accounted for the largest proportion (15.44%) in 2019. Excluding large-scale hydropower plants, solar accounted for 68%, far greater than other RE sources such as biomass (17%), small hydro (5%), solid waste (4%) and biogas (2%). In

[22] Source: https://www.mida.gov.my/zh-hans/industries/services/other-services/other-services-utilities/

addition, Petronas Malaysia stated that it will increase investment in hydrogen. IEA predicts that Malaysia's RE demand will more than double by 2040, accounting for about 16% of the total.

According to ST's forecasts, the average annual growth rate of electricity consumption in Malaysia between 2018 and 2025 is 1.8% and 1.53% by 2035. Therefore, the government's focus will be on developing RE, mainly hydropower and PV, while fossil projects would be carried out within limits. The current plan is expecting 10-13 GW of new project arrangements by 2025, including 7-10 GW of thermal ones, around 2 GW of hydropower, and 1 GW of large-scale ground-mounted PV LSS. Large enterprises and industrial parks are still in need of large-scale self-provided power plants. Waste-to-energy will have certain potential in the future.

In the next 5-10 years, Malaysia is welcoming a cleaner power structure, with its highlight on large-scale PVs and hydropower projects, making a market potential of more than 2 GW. Meanwhile, its current production of waste is 21,000 tons each day, but there is no evidence of large-scale waste-to-energy stations in operation – a huge potential. With its extensive palm oil industry, on the other hand, Malaysia enjoys a sound prospect for developing biomass plants through utilizing by-products.

3.4.4 Energy Efficiency

Malaysia has set a target of reducing energy consumption in residential, commercial and industrial sectors by 8% by 2025. MEGTW and ST are in charge of implementing energy conservation policies, and formulating regulations, policies and plans for EE&C. In terms of management, it is stipulated that buildings/factories consuming over 3,000 kWh within half a year must provide energy reports to government agencies on a regular basis. The *Green Technology Master Plan (2017-2030)* released made it clear that by 2025, electricity consumption would be cut down by 10% and by 15% by 2030.

Despite the great potential for energy saving in industrial electricity consumption, Malaysia faces insufficient standards and policies. The proportion of industrial electricity consumption (IEC) in Malaysia has increased year by year since 1990, reaching a peak of 55%, but continued to decline after 1998. Although it rebounded slightly after 2013, it is estimated to fall in the future. By 2050, Malaysia's IEC will reach 157 billion kWh, seeing a possible drop to 35%[23]. To promote its industrial development and reduce the cost of enterprises, the country implemented a Special Industrial Tariff (SIT), which was launched in 1996. Low industrial electricity prices led to an overdue investment return, bringing difficulties to the promotion of high-efficiency motors and

[23] Source: Topten, 2019. Motor Energy Efficiency Study of the ASEAN Region.

energy conservation in Malaysia. Starting from 2016, it has been cutting down the electricity subsidy at an annual rate of 2% until the complete cancellation in 2020. Malaysia launched a promotion and research programme in 2014, to study industrial high-efficiency motors, covering papermaking, cement, food and beverage, petrochemical and steel industries. A total of 18 companies and nearly 5,000 motors were involved, delivering a result that 87% of the motors in key industries were of IE1, while the rest 13% were IE2. ST under the Ministry of Energy, Science, Technology, Environment & Climate Change (MESTECC) is responsible for the formulation of MEPS. The *Efficient Management of Electrical Energy Regulation 2008* (EMEER2008), one of Malaysia's policies related to energy-consuming, covers 1,800 key enterprises. However, ST disclosed that only 500 companies (less than 30% of the total) met the requirements of the regulation. Another document related to the high-efficiency use of electricity is the *Electricity Supply Act 1990*, which mentioned that any equipment and installation shall meet the requirements in respect of the efficient use of electricity. Neither of these two regulations specifically mentioned high-efficiency motors. Energy-saving potential of Malaysia's motor system in 2016, as forecasts showed, was between 5.1 billion kWh and 13 billion kWh. With the continuing growth of the total IEC, the potential would reach between 11.8 billion kWh and 29.4 billion kWh by 2050.

The construction sector is playing a positive role in improving the energy efficiency and conservation of residential, commercial and industrial buildings. MEPS was promoted in 2013, covering air conditioners, refrigerators and lighting systems. No HEPS is adopted at present.

Carbon emissions in transport entered a steady stage, as Malaysia's transport infrastructure is comprehensive. The government made active efforts in developing public transportation, to achieve the goal of emission reduction. The expressway network is relatively developed. As of 2017, the total length of Malaysia's highways was about 237,000 kilometers. Rails, connecting the north and south of the peninsula, are facing Thailand's railways in the north and leading to Singapore in the south. In 2018, Malaysia's railways carried a total of 3.527 million passengers and 5.944 million goods, and transported 102 million passengers and 966,000 tons of goods by air, as it's home to 8 international airports.

In terms of water carriage, Malaysia is underdeveloped in its inland water transport, with 95% of trade completed by sea. In 2018, the total volume of ocean transport was 570 million tons. Enjoying a relatively complete transportation infrastructure, it planned to achieve a 40% utilization rate of public transportation by 2030 (the current proportion is 20%). Carbon emissions in this sector rocketed around 2013, entering a steady stage after peaking in 2014. In 2018, the amount of emissions marked 60 million tons, accounting for 27% of all industries, second only to electro-thermal.

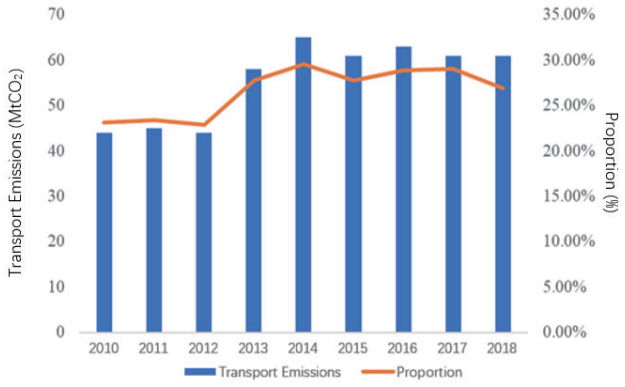


Figure 3-13. Transport Emissions and its Share, Malaysia

Source: IEA

3.5 Singapore

Singapore, dubbed as the "garden city" country, is situated at the southern tip of the Malay Peninsula, at the entrance of the Strait of Malacca and the "crossroads of the sea", enjoying a superior geographical location. Since its independence in 1965, the country has made remarkable achievements in nation-building, growing into one of the most dynamic emerging economies in the world with promising prospects. As a high-income power in ASEAN, Singapore's total GDP in 2020 was USD 340 billion, with a per capita GDP of USD 60,000. It's blessed with a stable and growing economy. By the end of 2020, Singapore has become home to 5.85 million people. It attracted a total of USD 1.91 trillion in FDIs up to the end of 2019, which mostly centered on financial services and manufacturing industries. The main sources of direct investment are the United States, Japan, the United Kingdom, the Netherlands, and China.

In 2018, Singapore's total carbon emissions were 47 million tons, of which electro-thermal production accounted for 44.68%, and industry and transportation for 29.79% and 14.89%. Other

sectors, to name construction, commercial and public services, and agriculture, had less emissions recorded.

3.5.1 Industrial Structure

Singapore's industrial structure is dominated by the tertiary industry. Light industry plays a major role. In 2019, Singapore's GDP was USD 372.1 billion, and its per capita GDP was USD 65,166, in which manufacturing accounted for 24.5%, wholesale and retail for 16.4%, commercial services 14.1%, finance and insurance 13.1%, and transportation and storage 6.3%. Exports in 2019 shared 27.9% of the GDP, consumption for 36.0%, and investment 23.1%. Electronics is one of Singapore's traditional industries, with an output value of SGD 135.23 billion, 41.88% of the total manufacturing industry.

As the world's third largest oil refining center and one of the oil trading hubs, as well as Asia's pricing center for oil products, in 2019, Singapore saw an output value of refined oil for SGD 38.262 billion (11.9%), and the precision engineering created SGD 38.32 billion (11.4%) and 93,400 jobs. Biomedical, a strategic emerging industry that Singapore has focused on in recent years, delivered an output value of SGD 36.27 billion (10.8%) in 2019, and the number of employees was 24,400. Marine engineering achieved SGD 11.11 billion (3.3%), welcoming 55,300 employees.

Singapore's industrial products are mainly high value-added manufacturing products. Known as a high-value manufacturing hub, the industry in Singapore has transformed from labor-intensive to knowledge-based research. Main products include: semiconductors, computers, equipment for data storage, industrial devices, telecommunications and consumer electronics products, semiconductor lead and ball bonders, horizontal auto-inserters, etc.

3.5.2 Energy Mix

Scarce in natural resources though, Singapore enjoys rich solar energy as of RE. No oil or gas field is found in Singapore, whose energy depends on imports. However, as a core oil trader, the country is well-developed in the oil industry. Limited by its geographical and environmental conditions, Singapore fails to embrace RE resources, such as hydropower, tidal, and wind, except for solar energy. The annual average solar irradiance is 1580kWh/m^2 per year, about 50% higher than that of countries in the temperate zone.

Singapore's energy consumption structure is dominated by oil, accounting for 86.22% in 2018; followed by natural gas (13%), and coal and RE (both less than 0.5%, see Figure 3-14).

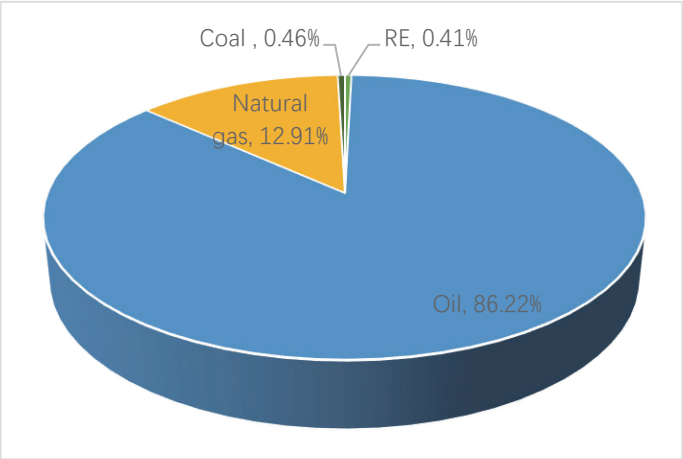


Figure 3-14. Singapore's Energy Consumption Structure in 2018

Source: IEA

Natural gas makes the main part of Singapore's power generation structure, accounting for about 95%. In absolute terms, in 2018, Singapore took 4.78% of the ASEAN countries in power generation, but the per capita was second only to Brunei. In 2019, the amount became 5.3 GWh, with natural gas as the principal (95%, see Figure 3-15), and non-fossil for 3.14% (of which, waste-to-energy for 2.19%).

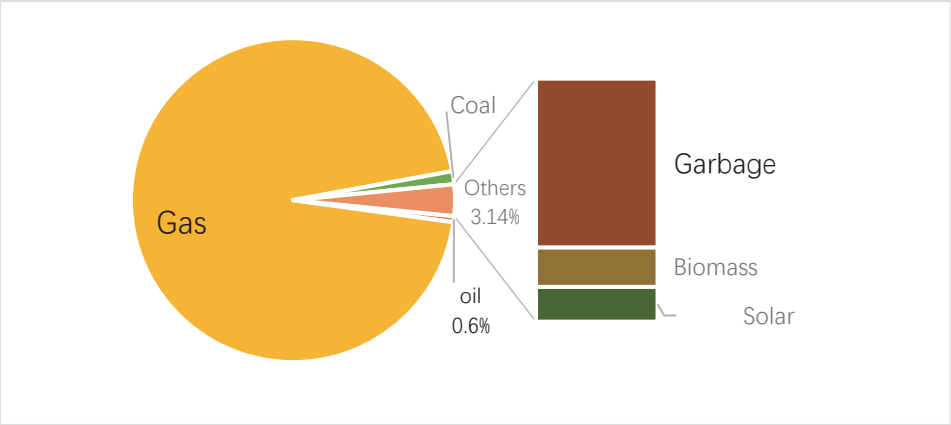


Figure 3-15. Power Generation Structure in Singapore

Source: IEA

3.5.3 Renewable Energy

Singapore's RE power generation gives first place to waste-to-energy, biomass and solar. Lying in the equatorial low-pressure zone, coupled with the gentle terrain, neither wind nor hydropower is ideal for Singapore to generate power. However, with abundant sunshine and tropical conditions, it is blessed with rich solar energy, a RE resource with substantial development potential[24]. From 2008 to 2017, solar PVs grew steadily in Singapore. The number of plants has increased from 30 to 2109, realizing leapfrog development. A total of 50 transmission substations equipped with solar irradiance sensors and PV installations across the island, celebrating the installed capacity of large-scale industrial and commercial PV over 1MW. It released the *Sustainable Singapore Blueprint 2015*, proposing to advance the deployment of solar PV and peak the country's electricity demand of 8% by 2030. In 2021, the *Singapore Green Plan 2030* charted targets to increase solar energy deployment by five-fold to at least 2 GW, which can generate enough electricity to power more than 350,000 households a year. Through the widespread use of smart LED lights and solar energy, Singapore is expected to reduce the city's building energy consumption by 15%. In 2019, Singapore's solar power generation accounted for only 0.45% of the total, and biomass for 0.51%, with large room for future development.

3.5.4 Energy Efficiency

Singapore has set an energy-saving target to reduce energy consumption intensity by 36% from 2005 to 2030. The Energy Market Authority (EMA) and the National Environment Agency (NEA) are responsible for energy conservation, and formulating EE&C policies, plans, and regulations, which came into force in 2013. In terms of management, it is stipulated that buildings or factories consuming oil of 1,290 kilotons or above, must be reported to government agencies of their energy management information. The carbon tax will be raised to any industrial facility that emits direct GHG emissions above 25 $ktCO_2e$ annually, covering 80% of Singapore's companies. It is the first country in Southeast Asia to impose a carbon tax.

Singapore is active in improving industrial energy efficiency. Measures were taken to improve industrial energy efficiency, including increasing funding for energy conservation of industrial enterprises, exploring ways to elevate the efficiency of the entire system by integrating similar industries and imposing a carbon tax on industrial facilities.

[24] Source：East Asia Summit Clean Energy Forum, 2018. Development of Renewable Energy in ASEAN Countries – Singapore.

Singapore is vigorous in improving the energy efficiency of all buildings, including commercial, residential and industrial ones. It has developed MEPS and Super Low Energy Building (SLEB) program, to enhance the standards for home appliances, and support research and adoption of cost-effective, energy-efficient, and renewable energy solutions. MEPS was promoted in Singapore, covering air conditioners, refrigerators and lighting systems, which have been enforced across the country. No HEPS is found at present.

Developed in facilities, public transportation is the major way of traveling in Singapore. 15% of Singapore's land area is used for road construction, forming a network with 8 expressways as the trunk line. By the end of 2018, the total mileage of roads was 3,500 kilometers, including 164 kilometers of highways. Since 2011, the number of motor vehicles remained at around 960,000. Speaking of rail transit, as of 2019, the total length of railways was recorded 228.1 kilometers, including 199.3 kilometers of MRT with 122 stations (transfer ones not counted repeatedly), and 28.8 kilometers of LRT with 42 stations. Singapore is also a pivotal hub of air transport in the Asia-Pacific region. In 2019, Changi International Airport handled 68.3 million passengers, 2 million tons of cargo, and more than 382,000 aircraft movements, making it one of the busiest airports in the world. The country is also the world's most bustling port, one of Asia's major transits, and the largest fuel supplier. The port of Singapore now extends more than 200 routes, connecting 600+ ports in 123 countries and regions, with 5 container terminals and 54 berths for container ships. It is the second largest container port in the world after Shanghai, China. The cargo volume of the port was 626 million tons, and the container throughput was 37.2 million TEUs, accounting for 5% of the global. A total of 4,437 ships were registered in Singapore, with a gross tonnage of 97.32 million tons by the end of 2019. Public transportation, a core component of Singapore's city transport, carried 63% of the morning peak traffic, which is still increasing in recent years. Constrained by its land resources, there is almost no room for additional transportation areas as per the current land use planning. Singapore plans in its fiscal budget that by 2040, all buses would be replaced with clean energy.

3.6 Brunei Darussalam

Brunei is located in the northwest of Kalimantan Island, bordering the South China Sea in the north, and adjacent to Sabah and Sarawak to the east, west and south, with a land area of 5,765 square kilometers. Brunei belongs to the Islamic monarchy, with the Sultan as head of state, the government and religious leader. The Sultan enjoys high prestige and is deeply loved by the people. Blessed with a harmonious society, simple and honest people, and long-term political

stability, Brunei is a high-income country among in ASEAN. Its total GDP in 2020 was USD 12 billion, the per capita as USD 27,500. The economy has experienced a negative growth for many years. By the end of 2020, the total population of Brunei is 440,000. UNCTAD's *World Investment Report 2020* shows that in 2019, Brunei's foreign investment flow was USD 275 million, and the stock was USD 7.127 billion by the year-end. According to statistics from the Ministry of Commerce of China, China's direct investment in Brunei in 2019 was USD 4.05 million, and the stock USD 427 million.

In 2018, Brunei's total carbon emissions were 6 million tons, with electro-thermal production accounting for 50%, other energy industries for 33.33%, and transportation 16.67%. Barely zero emission was spotted in other sectors.

3.6.1 Industrial Structure

With a monotonous economic structure, Brunei is highly dependent on oil and gas. Brunei has formulated a 30-year long-term development plan, i.e. *Wawasan Brunei 2035*. In order to reduce excessive dependence on oil and gas, Brunei encourages economic diversification, including accelerating the expansion of the downstream industry chain, increasing efforts to attract foreign investment, supporting the development of small and medium-sized enterprises, and highlighting infrastructure construction and interconnectivity. It also attaches importance to developing tourism and promoting privatization, striving to build the country into an international financial center, with a focus on agriculture, forestry, and fishery. In 2019, its agriculture, industry, and service respectively accounted for 1%, 61.48%, and 37.55% of its GDP. Oil and natural gas remained the pillars of the economy (56% of the GDP), which contributed 81% of fiscal revenue and 85% of foreign trade exports. Other sectors, besides oil and gas, name government services, finance, wholesale and retail, real estate, education, as well as construction, making about 43.67% of the GDP. Dependent on imports of industrial equipment, agricultural products, and daily necessities, Brunei encouraged import substitution industrialization and export-oriented industries. In terms of agriculture, it boasts only a small amount of rice, rubber, and pepper, and tropical fruits such as coconut and papaya. Vegetables, fruits, decorative plants, and flowers can partially meet the needs of the domestic market, while the self-sufficiency rate of meat, rice, and fresh milk is still very low, 90% of which are still in need of imports. Beef and its products are mainly imported from Australia and India. The government has devoted itself to progressing rice planting in recent years, but with little success and far from the target. With a coastline of 162 kilometers, Brunei enjoys rich fishery resources within the 200 nautical mile fishing area. Clean waters and

no typhoons ensured a fit environment for fish and shrimp breeding. There are 50 aquatic farms across the country, and 50% of the domestic consumption of fishery products relied on imports. Fishery, listed as a key industry, was promoted by government policies, to protect marine resources and develop aquaculture.

3.6.2 Energy Mix

Brunei is rich in oil and gas resources, as well as solar energy as of RE. Oil and gas exports are main source of income for Brunei. According to the *bp Statistical Review of World Energy 2020*, the proved reserves of oil and natural gas in Brunei are 1.1 billion barrels (150 million tons) and 222.3 billion cubic meters, with the output as 110 thousands of barrels per day (5.4 million tons) and 12.6 billion cubic meters. Oil reserves did not see material changes, but significant decline in ouput. In 2000, the output was 193 thousands of barrels per day, while the number in 2010 was 172 thousands of barrels per day, a substantial downward trend compared to that of 2020.

Natural gas also embraced an obvious downturn, from 356.8 billion cubic meters in 2000 to 293.7 billion cubic meters in 2010, a slowing decrease. Output of gas, however, was showing an increasing trend. In 2000 and 2010, the output was 11 billion and 12 billion cubic meters respectively, even arriving at a climax of 13.3 billion in 2015. With abundant oil and natural gas resources though, Brunei is scarce in RE, mainly solar energy. The total annual solar radiation ranges from 1,550 to 1,850 kWh/m^2. Most areas, benefiting from the average spatial distribution, enjoyed the most abundant solar energy and large potential for further development[25]. Onshore wind resources are ordinary, with an average speed on land about 3m/s-5m/s, and at sea 10m/s-12m/s[26].

Brunei's energy consumption mix is mostly shared by natural gas, which accounted for 82.51% in 2018, followed by oil (17.84%), and RE (less than 0.01%) (see Figure 3-16).

[25] East Asia Summit Clean Energy Forum, 2019. ASEAN's Energy Transition Series – Brunei.
[26] East Asia Summit Clean Energy Forum, 2018. Development of Renewable Energy in ASEAN Countries – Brunei.

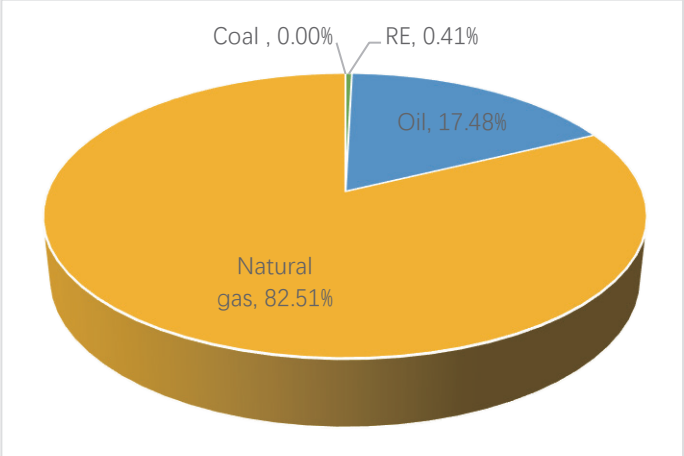


Figure 3-16. Energy Consumption Structure in 2018, Brunei

Source: IEA

The vast majority of Brunei is dominated by gas power generation (98%). Brunei's total power generation is the least among ASEAN countries, with a total of 4,296 GWh in 2019, while the largest in per capita. In 2019, natural gas accounted for 98.86%, with a small amount of petroleum, zero coal, and 0.05% non-fossils, all of which were solar power (see Figure 3-17).

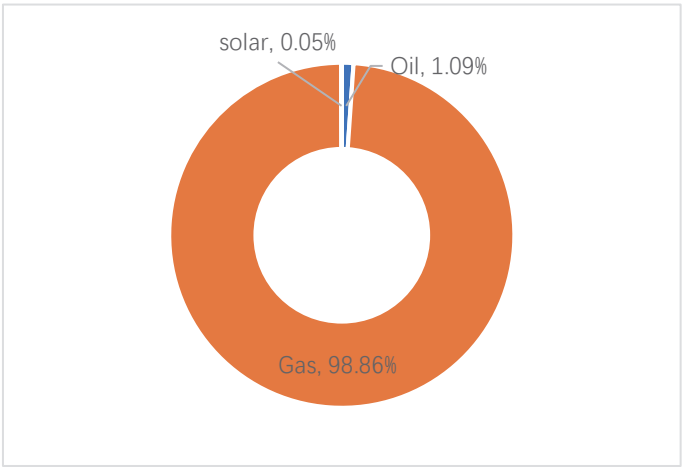


Figure 3-17. Power Generation Structure, Brunei

Source: IEA

3.6.3 Renewable Energy

Brunei's only RE source currently comes from the 1.2MW Tenaga Suria solar PV power plant. In August 2014, the Department of Energy, the Minister's Office (PMO), proposed its target to increase the share of RE in the total power generation mix by 10% in 2035, and at the same time to reduce energy intensity by 45% on the basis of 2005. Small in its land area, despite that, Brunei

embraces robust solar radiation, enjoying an average PV utilization of 1,600-1,950 hours per year. It also planned to develop offshore wind power projects with a total capacity of 18-20 MW. In biomass, municipal solid waste would be used to generate electricity.

3.6.4 Energy Efficiency

Brunei actively improves its energy efficiency and reduces energy consumption intensity. Brunei has set a target to reduce energy intensity by 45% on the basis of 2005. Energy conservation is undertaken by the Department of Energy, PMO, which formulated the EE&C policy in 2004 as the Energy Act. **Brunei has set MEPS for power plants to improve efficiency**. In terms of power management strategy, Brunei National Climate Change Policy (BNCCP) planned to reduce GHG emissions by at least 10% by 2035 through better supply and demand management of power consumption and improved energy efficiency. All new power plants are required to meet a minimum efficiency of 48%. In integrating RE and alternative energy, Brunei tends to reduce the consumption of natural gas, to meet domestic electricity demand.

Brunei strives to reduce emissions from the industrial sector. Brunei's goal is to reduce the carbon intensity of industry by achieving zero emissions as defined by the World Bank's standards, and to deliver an overall reduction in industrial emissions by 2035. Total emissions of volatile organic compounds would be cut down in a remarkable manner from oil and gas industrial facilities onshore and offshore. A carbon pricing policy for the industrial sector has also been developed. By 2025, Brunei would introduce a carbon pricing mechanism that applies to all industrial facilities emitting above the limit, requiring them to report their GHG data.

Brunei has established policies for the voluntary energy-saving of commercial and residential buildings. It promoted MEPS which covers air conditioners, refrigerators and lighting systems, requiring a voluntary use of these standards. No HEPS is adopted.

Least developed in public transportation, travels in Brunei mainly depends on private cars. As of the end of 2018, the total length of Brunei's highways was 3,708.41 kilometers. It is one of the countries with the highest proportion of private cars in Southeast Asia. In 2018, 11,140 new vehicles of various types were registered. In contrast, public transportation is underdeveloped. Only 8 bus lines, 72 buses and 83 taxis were found in the country. In June 2016, the Telisai-Lumut Highway Project undertaken by a Chinese company in Brunei was completed and opened to traffic, with a total length of 18.6 kilometers.

In terms of air transport, in 2018, Brunei International Airport took off and landed 14,535 aircraft, seeing 1.864 million passengers and cargo throughput of 22,900 tons. No railway facilities were

spotted in the country. Water carriage is an important mode of transportation in Brunei. In 2018, a total of 371 ships of various types were registered in Brunei, mainly fishing boats, passenger ships and government vessels. The main destinations of Brunei shipping are Singapore, Hong Kong, Kuala Lumpur, Manila and other surrounding ports. The cargo throughput was 1.817 million tons, of which 1.743 million tons were inbound and 74,000 tons were outbound.

3.7 Myanmar

Myanmar is located in the northwestern part of China-Indochina Peninsula in Asia, between latitude 9°58' and 28°31' north and longitude 92°20' and 101°11' east. Myanmar is bordered by China to its north and northeast, Laos and Thailand to its east and southeast, the Bay of Bengal and the Andaman Sea in the Indian Ocean to the southwest, and Bangladesh and India to the west and northwest. The country has a coastline of 2,832 kilometers and a territory of 676,600 square kilometers.

According to Myanmar's statistics, as of the end of April 2020, a total of 51 countries and regions have invested in 1,999 projects in 12 sectors in Myanmar, with a total investment of USD 85.167 billion. The top five sources of cumulative direct investment were Singapore (USD 23.013 billion), China (USD 21.289 billion), Thailand (USD 11.375 billion), Hong Kong, China (USD 9.667 billion) and the United Kingdom (USD 4.904 billion).

Myanmar's economic growth and carbon emission are the fourth lowest in ASEAN, only higher than Brunei, Laos and Cambodia. According to the World Bank and IEA, Myanmar's GDP in 2020 arrives at USD76.186 billion, accounting for 3% of ASEAN's total, with a per capita GDP of USD 1,400.22. Myanmar's emissions in 2017 were 30.4 $MtCO_2$, accounting for about 2% of the total emissions of the ten ASEAN countries.

3.7.1 Industry Structure

In the financial year 2017-2018, the share of primary, secondary, and tertiary industries in Myanmar was 23.3%, 36.3%, and 40.4% respectively, which denotes the increasing importance of industry and services. In addition, due to economic and technological constraints, Myanmar's high-energy-consuming industries have not yet achieved scale, and the labor-intensive textile industry is the mainstay of Myanmar's industry. In recent years, Myanmar's rich and low-cost labor market has shown its advantages. Besides, the labor-intensive processing and manufacturing industries represented by the textile and garment industry is booming in Myanmar. In the transitional fiscal year of 2018, Myanmar's textile exports reached USD 2.225 billion, accounting for 25.2% of Myanmar's total exports in the same period, and

ranking the first in terms of export value. Myanmar's steel, chemical, automotive, engineering machinery, ship and marine engineering industries, however, lag behind and have not yet achieved scale due to constraints in its economic and technological development. Its major industries include oil and gas extraction, small-scale machinery manufacturing, textile, dyeing, rice milling, wood processing, sugar production, paper making, fertilizers and pharmaceuticals. In February 2020, Myanmar released the 2nd Five-Year National Export Strategy (NES) for 2020-2025, which prioritizes six sectors including gems and jewelry, basic agricultural products, textiles and garments, machinery and electrical equipment, forestry and fisheries, and digital products, while supporting the growth of five service sectors including digital products, logistics, quality control, trade information, as well as innovation and entrepreneurship. **Although Myanmar's industrial energy-intensive sectors are currently underdeveloped, emissions from the industrial sector continue to increase year on year**. In 2018, emissions from the industrial sector (excluding sectors such as energy extraction) reached 9 $MtCO_2$ in Myanmar, making it the largest sector in terms of emissions (Figure 3-18). According to the Directorate of Investment and Company Administration (DICA) under the Ministry of Investment and Foreign Economic Relations (MIFER), as of April 2020, Myanmar has attracted a total of USD85.167 billion in foreign investment, mainly in the oil and gas, power, manufacturing, and transportation and communications sectors[27]. Myanmar's industries may bring more emissions in the future.

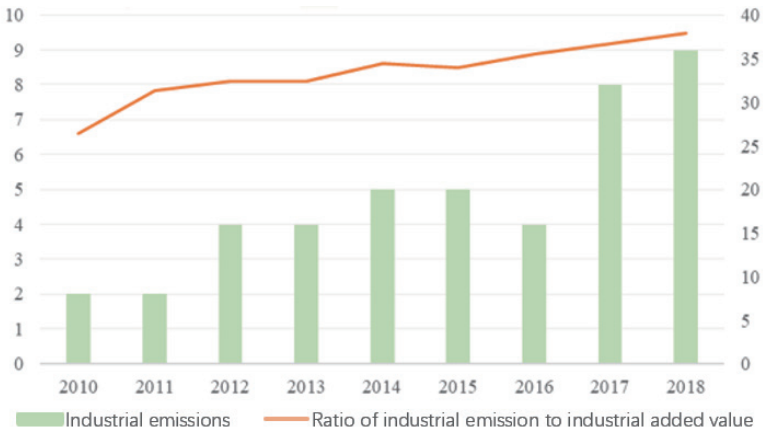


Figure 3-18. The Ratio of Industrial Sector Emissions in (Mtco2e) Industrial Value Added in Myanmar

Data source: IEA, World Bank

[27] CAITEC, Ministry of Commerce, 2021. Guide for Countries and Regions on Overseas Investment and Cooperation —Myanmar (2020 Edition)

Table 3-4: Guide for Countries and Regions on Overseas Investment and Cooperation —Myanmar (2020 Edition)

No.	Industries	Projects (number)	Approved Foreign Investment (100 million USD)	Ratio (%)
1	Oil and gas	154	227.73	26.74
2	Electricity	27	222.04	26.07
3	Manufacturing	1282	120.56	14.16
4	Manufacturing	62	111.20	13.06
5	Real estate	63	63.63	7.47
6	Hospitality	85	31.51	3.70
7	Mining	71	29.05	3.41
8	Animal husbandry & fishery	70	7.89	0.93
9	Agriculture	35	4.27	0.50
10	Industrial Park	7	3.27	0.38
11	Architecture	2	0.38	0.04
12	Other industries	141	30.14	3.54
	Total	1999	851.67	100.00

Source: Guide for Countries and Regions on Overseas Investment and Cooperation —Myanmar (2020 Edition)

Agriculture is the pillar industry of Myanmar's national economy. The expansion of agricultural land in Myanmar in recent years, however, has reduced forest coverage. Currently, Myanmar's rural population accounts for about 70% of the total population. They depend on agriculture and animal husbandry for their livelihoods. Myanmar's major crops include conventional crops such as rice, wheat, corn and beans, and industrial crops such as rubber, sugarcane, cotton and palm. In recent years, beans have overtaken rice as Myanmar's major agricultural product exported to generate foreign exchange. In the transitional fiscal year of 2018, Myanmar's agricultural exports amounted to USD 534 million, among which USD 280 million came from beans which accounted for more than half of the agricultural exports. The second largest export volume is that for rice, which stood at about USD 164 million. It is also important to note that Myanmar's forest coverage is decreasing year by year due to farming, deforestation and reclamation (Figure 3-19). Agricultural parks are built to cultivate industrial crops such as rubber and cash crops such as sugar cane, and thus forests are replaced by agricultural land. According to the World Bank, from 2010 to 2018, Myanmar's agricultural land expanded by 3,630 square kilometers, while the forest area decreased by 23,177 square kilometers.

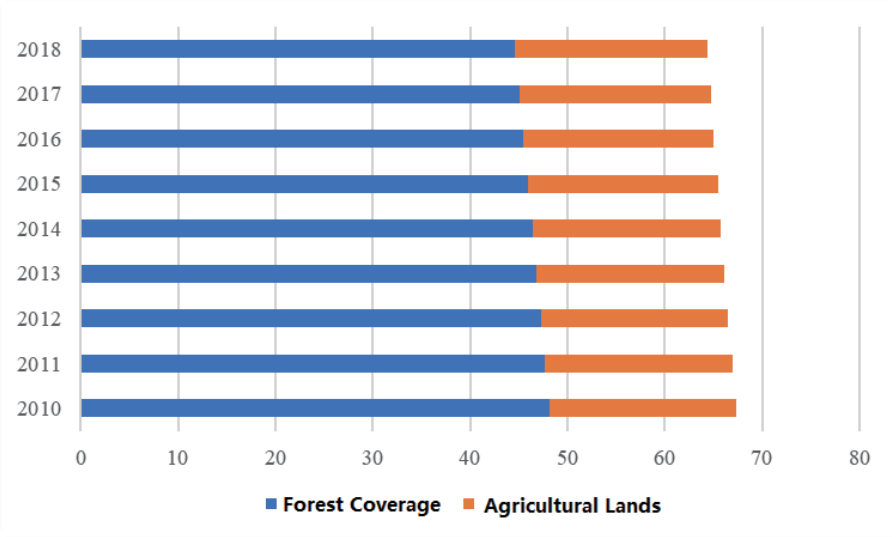


Figure 3-19. Comparison of Forest Coverage and Agricultural Lands in Myanmar

Source: World Bank

3.7.2 Energy Mix

Myanmar is rich in oil and gas resources, and its current energy consumption relies heavily on fossil energy. It has large reserves of oil and natural gas in both inland and coastal areas. According to the Ministry of Electricity and Energy of Myanmar, the country has 206.9 million barrels of oil reserves. Besides, Myanmar is a country with abundant natural gas reserves in the region. Its proven natural gas reserves reached 330 billion cubic meters, while the reserves in unproven offshore geological sedimentary basins may reach 12.68 trillion cubic meters. According to IEA's data for 2018, Myanmar's major energy consumption is fossil energy, totaling 12.25 Mt of oil equivalent, or 80% of total energy consumption. The largest consumption comes

from oil, which accounts for 48% of total energy consumption, followed by natural gas at 29%. Myanmar's coal consumption does not account for a high percentage (Figure 3-20).

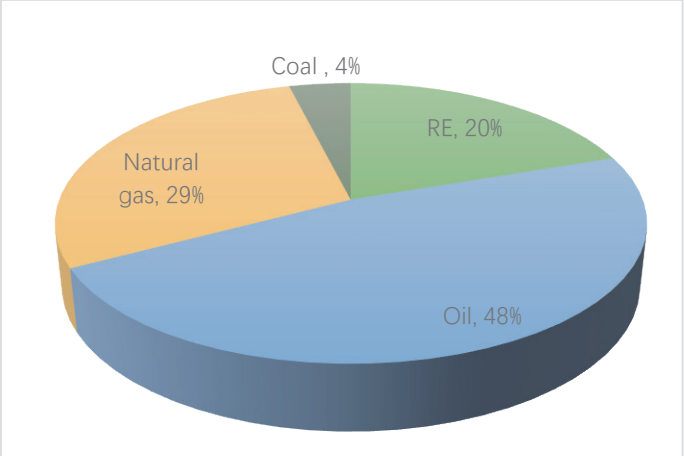


Figure 3-20. Myanmar's Energy Mix in 2018

Source: IEA

Myanmar's power mix is dominated by hydropower, while the low power generation capacity results in adequate power supply. According to the IEA, hydropower is the major source for electricity generation in Myanmar, which produced 14,126 GWh of electricity or 58% of the total in 2019. The second largest source for power generation is natural gas, which produced 8,798 GWh of electricity or 36% of the total. Coal power accounts for only 6% of the total (Figure 3-21). As of 2019, there are 57 hydropower, gas and coal-fired power plants in Myanmar, with hydropower accounting for up to 57.7% of the total installed capacity and natural gas accounting for 36.6%. According to the World Bank, as of June 26, 2019, Myanmar has 166.32km of distribution lines built or under repair, and 11,350 substations installed. The supply of electricity in Myanmar cannot satisfy the demand, with electricity supply in 2018 at 3.36 GW while demand reaching 3.587 GW. From 2019 to 2022, the demand for electricity is expected to grow at 12%, arriving at 5.723 GW by 2022. The Myanmar government intends to achieve universal access to electricity by 2030, while the access rate in Myanmar in 2018 was only 43%. Besides, as the dry season is the peak period of electricity demand, Myanmar is plagued by the large discrepancy between the peak and low periods of electricity demand and a shortage of electricity supply in the dry season due to its heavy reliance on hydropower. Myanmar's underdeveloped power sector has led to a low electricity access rate, which in turn hindered economic development to a certain extent. Although Myanmar is also part of the Southeast Asia Power Connectivity Project, insufficient investment, procurement delays and lack of human resources for project design are

the main challenges facing the country. In addition, problems at the administrative level in Myanmar also affects the process of building interconnectivity of power grids with neighboring countries.

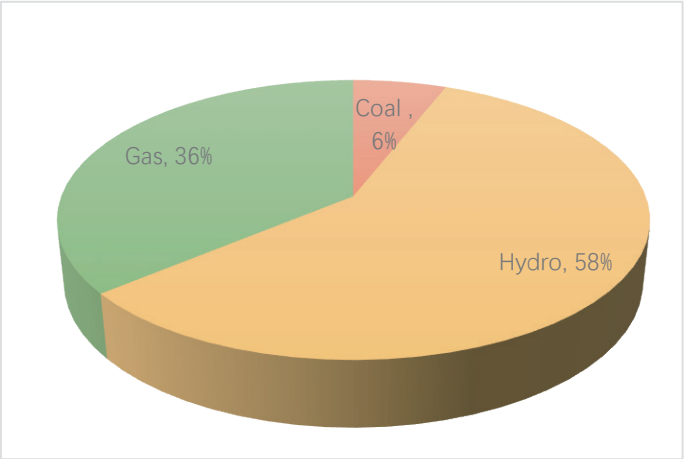


Figure 3-21. Myanmar's Power Supply Structure in 2019

Source: IEA

At present, Myanmar's electricity consumption is mainly for residential and industrial use, with 49.3% of electricity consumed by residents, 30.4% by industry, 18.5% by commerce and 1.8% by others. Yangon-Nay Pyi Taw-Mandalay, located in the central and southern regions of Myanmar, is the main political, economic and cultural center of the country, as well as an important center for electricity consumption, with Yangon Region accounting for about half of the country's total electricity consumption, Mandalay Region accounting for about a quarter of the total electricity consumption, and the rest of the regions and states having low electricity consumption and great space for power consumption. The rest of the provinces and states have great potential for power consumption. About two-thirds of Myanmar's territory has no access to electricity, and the rural population accounts for about 70% of the country's population, while about 84% of the rural population has no access to electricity. According to Myanmar's national electrification plan, the country's electricity coverage is planned to increase to 55% by 2021, 75% by 2026 and 100% by 2030.[28] At the current rate of grid construction, it will take 40 years to achieve full electricity coverage by 2030. **Therefore, it is important to not only build the grid at the lowest cost, but also utilize mini-grids and off-grid photovoltaic (PV) systems to supply electricity to the huge**

[28] Myanmar National Electrification Plan (NEP), 2014. https://www.seforall.org/sites/default/files/Myanmar_IP_EN_Released.pdf

number of rural households, especially those far from the grid, and also contribute to the development of renewable energy in Myanmar.

3.7.3 Renewable Energy

Myanmar has a huge potential for clean energy development; its large rural population requires the construction of mini-grids and off-grid PV systems to ease the demand for electricity in rural areas. Myanmar is rich in water resources, with a theoretical **hydropower** reserve of over 150 million kW, and an economically exploitable installed capacity of 53.94 million kW. 60% of the hydropower reserves are located in the eastern mountainous states of Kachin and Shan, and 15% in Mandalay and Sagaing. At present, no more than 10% of the hydropower resources have been exploited, which means there is a huge space for the development of hydropower. In terms of **wind power** resources, the average wind speed in Myanmar is 5.26m/s, with the highest wind speed reaching 6.67m/s. The average wind power density in the country is 216.6W/m^2, with the highest average power density in the country being 345W/m^2. No wind power station is installed across the country. The country has rich **luminous energy** resources, of which 21% of the country's land area is covered by first-class light, with huge potential for photovoltaic power generation. Currently, the construction of PV power stations is in the initial stage with broad prospects. Myanmar has proven natural gas reserves of 637.2 billion cubic meters. Gas power plants have a short construction period and can be put into operation quickly. The Myanmar Ministry of Electricity supports the development of gas power plants as they can ease the pressure on Myanmar's power supply in the short term with immediate results. By contrast, the prospect of developing coal-fired power is weak due to climate and other constraints, though the country has proven coal reserves of 270 million tons. At present, Myanmar has a low level of clean resource development. The volume of potential solar power generation for the country is about 52,000 TWh/year, while that for wind power and hydropower are 365.1 TWh/year and 108 GW respectively. Taking hydropower as an example, the power generation capacity for hydropower that is technically exploitable is 46 GW, while the current domestic hydropower installation is 3.225 GW, accounting for only about 7% of the power generation capacity for hydropower that is technically exploitable. The potential for clean energy resources in Myanmar is huge.

As for relevant legal provisions, the *Electricity Law* of Myanmar stipulates that domestic and foreign investors operating power generation businesses may apply to the government department

with approval authority in accordance with the law. The authority department may approve the investor to operate large power projects (over 30MW) managed by the Union Government with the consent of the Union Government, and the relevant provincial and state governments may approve small and medium-sized power projects (under 30MW) managed by the provinces and states in accordance with the law. Domestic and foreign investors authorized to operate power projects and wish to sell electricity to the national grid must apply to the relevant government authorities for approval. Those who are authorized to operate power generation businesses shall apply to the agency that approves business license if they jointly operate the business with other enterprises or institutions, or mortgage, sell or lease the whole business or part of the business. With the consent of the Myanmar government, the departments concerned have the right to set electricity tariffs for each region and may change them in due course. Myanmar currently has only one comprehensive law on environmental protection—the *Environmental Protection Law*. No complementary individual laws, implementing regulations or environmental standards are in place, except for the *Environmental Impact Assessment Procedures*. According to the regulations of the Myanmar Investment Commission (MIC) on the approval process of power projects, when an investor initiates an investment project in Myanmar, an IEA report approved by the Ministry of Environmental Conservation should be annexed to the investment permit application form submitted to the MIC. Now, in view of the low efficiency and lengthy approval process of the environmental authorities in Myanmar, MIC only requires investors to provide the first draft of the IEA report for the project; the approval by the Ministry of Environmental Conservation can be submitted afterwards.

Myanmar is also formulating its national policies on renewable energy, which will be submitted to the United Nations Framework Convention on Climate Change (UNFCCC) once it is endorsed and issued. Myanmar Climate Change Policy No. 28, Myanmar Climate Change Strategy (2018-2030) and Myanmar Climate Change Master Plan (2018-2030) are also relevant to the sustainable development of low-carbon energy transportation and industrial systems in the energy and power sectors. Relevant regulations and policies also include the Renewable Energy Law, Renewable Energy Regulations, Renewable Energy Incentive Scheme, etc.

Myanmar is in urgent need of an ambitious plan for power projects to meet its electricity demand. According to the *National Electricity Plan of Myanmar*, the country's installed capacity for electricity generation will reach 28.78 million MW in 2030, with a shortfall of about 23 million

MW. Myanmar has pledged in the latest Nationally Determined Contributions that renewable energy will account for 11% of the installed capacity by 2030, equivalent to 2,000 MW.

Table 3-5: Renewable Energy and Hydropower Projects under Development in Myanmar

No.	Renewable Projects	Capacity	Remarks
1.	Minbu Solar Project	170 MW	40 MW completed
2.	Manaung Hybrid Solar Project	8.25 MW	On-going
3.	Chaung Tha Wind Power Project	30.0 MW	Pre-Feasibility
4.	MoEE Solar Tender *	1060 MW	Tender process
	Total RE (Wind, Solar)	**1268.25 MW**	
5.	Shweli-3 Hydro Power Project	672MW	11.69% complete as of Mar 2020
6.	Deedoke Hydro Power Project	60 MW	1.727% complete as of Mar 2020
7.	Upper Yeywa Hydro Power Project	280 MW	44.41% complete as of Mar 2020
8.	Middle Paunglaung Hydro Power Project	152 MW	5.17% complete as of Mar 2020
9.	Upper Kengtawng Hydro Power Project	51 MW	57.85% complete as of Mar 2020
10.	Upper Balu Chaung Hydro Power Project	30.4 MW	45.49% complete as of Mar 2020
11.	Thahtay Hydro Power Project	111 MW	57.38% complete as of Mar 2020
12.	Nan Paw Hydropower Project	20 MW	10% complete as of March 2020
	Total hydropower	**1376.4 MW**	

Source: Myanmar's updated NDC

3.7.4 Energy Efficiency

The promotion of energy-efficient stoves and LPG stoves to replace wood burning in rural areas can significantly improve energy efficiency and reduce both deforestation and carbon emissions. In 2015, Myanmar's grid coverage was only 34% nationally and only 16% in rural areas. Almost the entire rural population relies on firewood for cooking, which is the main cause of deforestation in the country, according to the Myanmar government. The country currently has the third highest deforestation rate in the world. Myanmar is expected to increase the use of energy-efficient stoves by 5.1 million between 2021 and 2030, which means a CO_2 emissions reduction by a cumulative 12.99 million tons. On the other hand, traditional wood and charcoal stoves in the private sector will be gradually replaced by LPG stoves. The Myanmar government plans to distribute 1 million LPG stoves to the private sector, which can reduce CO_2 emissions by 14.94 million tons by 2030. In addition, Myanmar has set a series of energy efficiency improvement targets for 2030 for different sectors: 7.8% for the building sector, 6.63% for the industrial sector, 4% for the commercial sector, and 1.36% for other sectors. This series of targets for energy efficiency improvement are intended to support Myanmar's 2030 conditional target of improving energy efficiency by 20%. Therefore, Myanmar needs assistance in developing

technologies for both renewable energy and fossil energy, formulating heating and cooling standards, setting baseline data and taking mitigation actions[29].

3.8 Thailand

Thailand is located in the middle of the China-Indochina Peninsula, bordered by the Gulf of Thailand and the Pacific Ocean in the southeast and the Andaman Sea and the Indian Ocean in the southwest. It is bordered by Myanmar in the west and northwest, Laos in the northeast, Cambodia in the east, and Malaysia in the south. Thailand covers an area of 513,000 square kilometers, second only to Indonesia and Myanmar in Southeast Asia. More than 50% of the country is covered with plains and lowlands. The topography of Thailand is high in the north and low in the south, sloping from northwest to southeast. Its topography includes both fertile and vast central plains, the rolling northeastern highlands, the jungle-dense northern mountains, and the beautiful southern peninsula.

The 2020 edition of the *World Investment Report* released by UNCTAD shows that Thailand absorbed a foreign investment of USD 4.146 billion in 2019. By the end of 2019, the stock of foreign investment in Thailand stood at USD 254.416 billion. Japan is the largest source of investment, followed by China and the United States. According to China's Ministry of Commerce, China's direct investment in Thailand in 2019 reached USD 1.37 billion. By the end of 2019, the stock of China's direct investment in Thailand was USD 7.19 billion. In 2019, the volume of investment by Thai companies in China was USD 106 million; the cumulative direct investment of Thai companies in China was USD 4.375 billion by the end of 2019.

Thailand ranks second among the ten ASEAN countries in terms of both economic volume and total carbon emissions, after Indonesia. According to World Bank data, Thailand's GDP in 2020 was USD 501.795 billion, second only to Indonesia among the ten ASEAN countries, accounting for 17% of ASEAN's total; Thailand's GDP per capita was USD 7,189 in 2020. In 2017, Thailand's total carbon emission reached about 244.3MtCO_2, also accounting for about 17% of the total ASEAN emissions, which makes Thailand the second largest emitter in ASEAN.

3.8.1 Industry Structure

Industry is the largest contributor to Thailand's economy, with the automotive industry being the country's largest pillar industry; therefore, the shift of its auto industry into one

[29] The Republic of the Union of Myanmar，2021. NATIONALLY DETERMINED CONTRIBUTIONS. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Myanmar%20First/Myanmar%20Updated%20%20NDC%20July%202021.pdf

based on new energy would be the key in Thailand's industrial transformation. The rise of industry (especially heavy industry), which has replaced agriculture as the largest industry, has been one of the most powerful drivers of Thailand's rapid GDP growth in recent years. The value added of industry reached 33% of the GDP in 2020. The automotive industry is the largest pillar industry in Thailand with an export volume exceeding domestic sales. Since 2012, Thailand's largest export commodity has been automobiles, with the top five export destinations being Australia, the Philippines, Saudi Arabia, Indonesia, and Malaysia. In 2018, Thailand was the world's 12th largest producer of motor vehicles, the 5th largest producer of light commercial vehicles, and the largest manufacturing base for motor vehicles in ASEAN[30]. In 2019, Thailand's vehicle production volume was 2,013,710 units while vehicle sales reached 1,007,552 units. The production and sales of new energy vehicles increased compared to the past, but not significantly compared to traditional vehicles. With the support of relevant industrial policy planning, new energy vehicle sales reached 11,200 units in 2017 and more than 30,000 units in 2018, of which light hybrid and micro-hybrid electric vehicles accounted for more than 67% while plug-in and pure electric vehicles accounted for about 33%. Earlier, Thailand also formulated a plan, "Thailand 4.0", for the industrial sector to move toward high-quality growth; the plan prioritized the development of the automotive industry as the nation's the primary goal, which has made the new generation of vehicles represented by new energy vehicles the government's key development industry (Table 3-6). According to the Thai Minister of Energy, a supporting policy on energy for the development of the EV industry is being formulated in cooperation with relevant government departments, while a national electric infrastructure development plan has been set up in response to the advent of the EV industry. According to the National Energy and Environment Development Plan 2015 (EEP 2015), the initial target is to build sufficient charging stations and provide adequate power support for the 1.2 million electric vehicles in the country by 2036.

Table 3-6: Top 10 target industries in "Thailand 4.0"

[30] Institute of International Trade and Economic Cooperation, Ministry of Commerce, 2021. Country (region) guide for foreign investment and cooperation: Thailand (2020 Edition). http://images.sh-itc.net/202106/20210603135530506.pdf

Traditional industries:	Future industries:
Next-generation automobile manufacturing	Industrial robot
Intelligent electronics	Aviation and logistics
High-end tourism and medical tourism	Bio-energy and biochemical engineering
Agriculture and biotechnology	Digital economy
Food deep processing	Medical centers

Source: Ernst & Young, 2020

The share of agriculture in Thailand's GDP stays at around 10%, yet its agricultural development displacing forest resources is a hidden problem for Thailand's low-carbon development. The decline of Thailand's share of agricultural value added from 36% in the 1970s to about 10% today did not reduce the country's dependence on agriculture. Farm produce is one of Thailand's key export commodities, with major products including rice, natural rubber, cassava, corn, sugar cane, and tropical fruits. **Thailand is the world's top rubber producer and exporter, as well as the top exporter of cassava and rice.** The country produces about 4.5 million tons of rubber annually, accounting for one-third of the global total. The majority of rubber produced is exported, with annual exports accounting for 40-45% of total global rubber exports. Rubber exports generated USD 4.602 billion in revenue for Thailand in 2018. The country's cassava production is the third largest in the world and 60% is used for export. The country's rice exports, however, dropped markedly from 11 million tons in 2018 to 7.58 million tons in 2019, mainly due to the appreciation of the Thai baht by 40%. According to the 2016 report of the Food and Agriculture Organization of the United Nations, Thailand was among the countries in Southeast Asia that saw a net decrease in forests of 10,562 thousand hectares and a net increase in agricultural land of 13,484 thousand hectares (Table 3-7).

Table 3-7 Countries with Net Increase in Agricultural Land Area and Net Decrease in Forest Area (2000-2010)

Region	Country	Net decrease of forest	Net increase of agricultural land
		Thousand hectares	Thousand hectares
Africa	Angola, Benin, Burkina Faso, Cameroon, Chad, Ethiopia, Guinea, Liberia, Madagascar, Malawi, Mali, Niger, Senegal, Sierra Leone, Uganda, Tanzania, Zambia, Zimbabwe	-19821	31190
Asia	Cambodia, Indonesia, Myanmar, Philippines, Sri Lanka, Thailand	-10562	13484
Europe	Finland	-227	74
Central America	El Salvador, Haiti, Honduras, Panama	-1421	545
South America	Argentina, Brazil, Paraguay, Peru	-29834	32068
Total		-61865	77287

Source: Food and Agriculture Organization of the United Nations, 2016

3.8.2 Energy Mix

Thailand's energy and power supply structure is heavily reliant on fossil energy and imports; the share of renewable energy as a source for power generation is not significant, denoting a huge potential for PV development. According to the IEA's data in 2019, Thailand's largest source of power generation is derived from natural gas (64%) and coal (20%), reaching 115,640 GWh and 36,408 GWh, respectively (Figure 3-22). The energy source for Thailand's installed power generation facilities is mainly coal and natural gas, with 6,059 MW of installed capacity using coal as the source in 2017, ranking fourth among ASEAN countries[31]. Although around 26% of the installed capacity uses renewable energy as the source, the actual power generation with renewable energy accounts for only 12% of the total (excluding hydropower). In particular, the dominant energy source—solar energy—generates only 4,537 GWh of power, accounting for a small proportion of 2% of the total capacity. It is worth noting that Thailand has a comparative advantage in biomass energy due to its well-developed agriculture. In 2019, biomass power generation accounted for 9%, which is the highest proportion among renewable energy. In April 2019, Thailand adopted the *Thailand Power Development Plan 2018-2037 (PDP2018)*, which, on the basis of PDP2015, adapts to the changing electricity demand in the country and helps to

[31] ACE, 2019. Cleaner Coal Utilization Roadmap in ASEAN https://aseanenergy.org/study-on-cleaner-coal-utilization-roadmap-in-asean/

increase the share of renewable energy and meet emission reduction targets as early as possible, so as to foster low-carbon sustainable development of the industry. According to the new plan, Thailand's installed electricity capacity will reach 77.211 GW in 2037, of which 20.766 GW will be generated from renewable energy sources; about 15 GW of PV capacity will be installed by 2037, including 12.7 GW from household rooftop PV program and 2.7 GW from nine floating PV projects on dams operated by the state-run power authority. Besides, about half of the electricity generated will come from photovoltaic power. It is also important to note that Thailand is heavily dependent on imports for energy, with nearly 42% of its energy use coming from imported energy sources, according to the data released by the World Bank in 2014. In addition, according to the *Analysis of Implementation and Prospects of ASEAN Power Interconnection Projects* by the Energy Foundation, Thailand imports the largest amount of electricity in the ASEAN region, with 19,825 GWh in 2016, much higher than Vietnam, the country that ranked second (2,396 GWh).

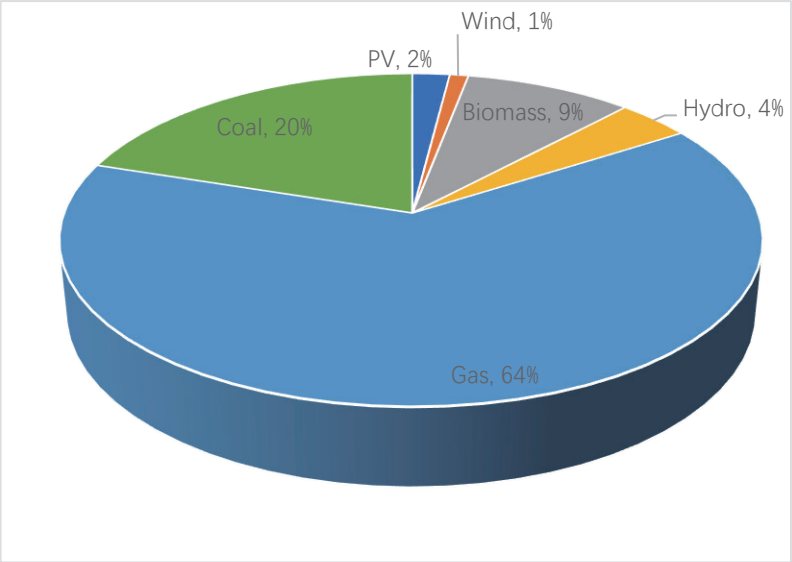


Figure 3-22. Thailand's Power Supply Structure in 2019

Data source: IEA

3.8.3 Renewable Energy

Thailand has rich solar energy resources, with advantages in biomass energy derived from well-developed agriculture as well as restraints in the wind and water energy resources. Thailand is rich in solar energy resources. The total solar irradiance (TSI) per year in the central

part of the inland exceeds 1,750kWh/m^2, and the annual sunshine hours reach 1,800, which makes Thailand a region blessed with abundant **solar** resources and great advantages. Its capacity of exploitable PV technology is 1,560.5 GW, ranking third in ASEAN, after Myanmar and Cambodia. According to the data in the *Study on PV Scale Development Innovation Model in ASEAN Countries*, Thailand has 39,012km^2 of available land for PV development, accounting for 7.6% of Thailand's land area, 1,560.5 GW of exploitable PV technology, and a huge potential in power generation from PV up to 2,040TWh/a. Thailand's **hydro energy** resources are mainly distributed in the Menam River and the Mekong River. Most sections of the Mekong River have deep troughs and canyons, which makes it a perfect site to build dams. Statistics show that the theoretical hydro energy reserve for the Mekong River is 58,000MW, while exploitable hydro energy is estimated at 37,000MW, with an annual power generation capacity of 180,000 GWh. Nonetheless, 33% of the hydro energy resources of the Mekong River is distributed in Cambodia and 51% in Laos. Since Thailand enjoys only a small proportion of the Mekong River's hydro energy and the fact that the river is an international river that marks the border between Thailand and Laos, the room for hydro energy development in Thailand is quite small. The Menam River, due to its small river fall, is not suitable for high dams and large reservoirs and thus has limited hydropower resources. In terms of **wind energy** resources, the areas with the largest wind speed in Thailand are mostly located in the high mountains in central and western Thailand, with an average wind speed of above 6.0m/s. However, the complicated terrain and steep gradient make construction difficult. The wind resource in northern and southern plain areas is modest with an average wind speed of below 4.0m/s. The central and eastern regions are endowed with relatively good wind resources, with wind speeds between 5.0m/s and 5.5m/s, and even approaching 6.0m/s in some areas.

Thailand's agricultural advantage also provides plenty of scope for the growth of the bioeconomy. For more than a decade, Thailand has devoted significant government resources to creating and engaging in a sustainable economy. This includes a move towards biofuel, biochemical and biotechnology sectors. In 2004, Thailand formulated the *National Biotechnology Framework*, which helped create the conditions and capacity for the country to achieve its biotechnology development goals. This was followed by the *National Biotechnology Policy Framework* for 2012-2021, which aims to encourage innovation, enhance overall competitiveness, and increase productivity in the bioeconomy. Other subsequent policies include the *Alternative Energy Development Plan (AEDP)* in 2015 and the Growth Plan on Thailand's 4.0 economy since

2015. As over 55% of the energy consumed in Thailand in 2017 was purchased from abroad, securing a stable supply of domestic energy production remains a top priority for the government. To achieve the carbon-neutral energy target by 2065, Thailand focuses on innovation and R&D, particularly in the areas of low carbon power generation, carbon capture and storage, as well as the sectors of bioenergy and the hydrogen economy where carbon capture and storage is applied. The transportation sector will prioritize carbon reduction measures in public transport infrastructure and networks. The renovation and construction of public electric vehicle fast charging networks and hydrogen refueling stations should be accelerated. Thailand's new energy policy framework for achieving the carbon neutrality target by 2021 released by the Ministry of Energy has rolled out the following measures: (1) Policies. Increase the share of renewable energy generation to at least 50% by 2030, and the share of electric vehicles to at least 30%, so that the energy efficiency can be improved by at least 30% by 2037; facilitate the transformation of the energy system through carbon reduction, digitalization, local decentralization, deregulation, and electrification. (2) Set up a framework for the transformation of the energy system in the electricity sector. Support the development of cutting-edge technologies such as smart energy management and energy storage systems through grid modernization; support P2P and net metering markets through the establishment of smart mini-grids; support the trend of low-carbon electrification, the development of pure electric vehicles and the construction of electric vehicle infrastructure. (3) Develop a framework for alternative energy sources. Increase the proportion of power generation based on renewable energy to 50% by 2050 and integrate energy storage in the long term to mitigate the impact of rising energy prices. The following moves are also required for the transformation of the energy system: increasing the domestic output of renewable energy; promoting the distributed generation, building mini-grids, and bolstering grassroots economies; digitizing renewable energy control center platforms in grid-connected and off-grid areas; putting in place incentives and policies to support renewable energy investment and boost market growth; and facilitating the R&D of renewable energy technology investments, bioeconomy, hydrogen energy, and biojets.

Some of the major barriers facing the energy sector include insufficient transmission line capacity, lack of investment support from financial institutions, lack of technical resources, and low public acceptance. The development of renewable energy also faces the same problems. Thailand has initiated support mechanisms such as feed-in tariffs, tax incentives, government grants and venture capital. But, to speed up the deployment of renewable energy, incentives must be put in

place to encourage technology developer collaboration and technology sharing, to enable larger-scale technology transfer. International financial support for clean energy technologies, intellectual property purchases and technology transfer will also lend valuable support to developing countries to accelerate the deployment of renewable energy technologies.

3.8.4 Energy Efficiency

The key to Thailand's transition to a low carbon economy is the development of advanced technologies to support the Thailand 4.0 strategy. The implementation of smart energy, particularly the smart grid initiative, is a national policy under the master plan released by the Ministry of Energy. In the future, Thailand's power generation will be compatible with environmentally friendly development goals. To this end, it is essential to develop smart grids as it can enhance the overall power management system. According to the policy, state-owned companies have to invest nearly 200 billion baht (USD 6.354 billion) in building smart grids by 2036 to boost energy supply capacity, improve energy efficiency, enhance grid flexibility and reduce carbon emissions. Recently, the National Electricity Authority of Thailand also launched a master plan for the development and upgrading of the national electricity transmission network in the next decade, with the total investment estimated at no less than 240 billion baht for 17 specific projects. According to the overall development plan, the National Electricity Authority of Thailand will promote the implementation of the upgrade plan for the grid in two phases during the next 10 years from 2021 to 2030. The investment budget for the first 5 years of the first phase of the plan (2021-2025) will reach 136,405 million baht, while that for the second 5 years (2026-2030) will be 106,162 million baht. The total budget for the two phases is 242,567 million baht.

3.9 Laos

Laos is the only landlocked country in the northern part of the China-Indochina Peninsula, bordered by China to the north, Cambodia to the south, Vietnam to the east, Myanmar to the northwest and Thailand to the southwest. The length of the Mekong River in Laos is 1,800 kilometers. Laos has a land area of 236,800 square kilometers and a population of 6,914,000. The country is rich in mineral resources. Lying at the extension of China's Sanjiang Metallogenic Belt, Laos is endowed with rich reserves of gold, silver, copper, iron, sylvine, bauxite, lead, zinc and other minerals. The country enjoys abundant hydropower resources, with more than 60% of the Mekong River hydroelectric energy reserves distributed in Laos, more than 20 rivers having a length of over 200 km, and more than 60 hydroelectric power stations enjoying rich hydro energy. It is also blessed with abundant land resources, long sunshine hours, sufficient rainfall, and a well-

developed agricultural industry. In recent years, the country has maintained political stability and rapid economic growth.

According to UNCTAD's *World Investment Report 2020*, Laos attracted 557 million USD in foreign investment in 2019 and 9.93 billion USD in cumulative foreign investment by the end of 2019. China is the biggest source of FDI in Laos, followed by Thailand, Vietnam, South Korea, France, the United States, Japan, Malaysia, and Australia.

Laos' economic volume is only higher than Brunei's among the ten ASEAN countries. The country has a low carbon emission which ranks third from the bottom. According to the data from the World Bank, Laos' GDP in 2020 was USD 19.1 billion, accounting for only 1% of the aggregate GDP for ASEAN countries; the GDP per capita in 2020 was USD 2,630.2. According to IEA data, the country's carbon emissions in 2017 were 18MtCO_2 , accounting for 1.3% of ASEAN's total emissions.

3.9.1 Industry Structure

The industrial structure of Laos is not characterized by high energy consumption or high emissions. The country's main pillar industries are energy and minerals as well as tourism. The data shows that in 2020, the ratio of the three industries in Laos was 16.20% : 32.08% : 40.64% (Figure 3-23). For tourism, the city of Luang Prabang and the temple of Vat Phou in Laos have been included in the list of World Cultural Heritage. Other famous attractions include Pha That Luang and Wat Haw Pha Kaew in Vientiane, Khon Phapheng Falls in Champasak, and the Kuang Si Waterfall in Luang Prabang, to name just a few. Since the opening up of the country, tourism has become an emerging industry in the economic development of Laos. In recent years, Laos has signed cooperation agreements with more than 500 foreign tourism companies, opened 15 international tourism ports, and taken measures to increase investment in tourism infrastructure, reduce visa fees, and relax border tourism procedures, all of which fostered sustainable tourism development. According to the Travel and Tourism Competitiveness Report (TTCR) released by the World Economic Forum, Laos ranked 94th out of 136 economies, with more than 4 million tourists visiting the country in 2018. In terms of the energy and mineral industry, up to now, the Eighth Five-Year Plan (2016-2020) for energy and mineral development in Laos is well implemented, which ensured the smooth development of the industry. In terms of the mining industry, the Lao government has approved 193 companies to engage in geological exploration and mineral exploitation, including 69 geological exploration companies, 43 project consulting companies and 81 mineral exploitation companies. In the past five years, the energy and mining

industries have paid a total of 1.754 billion USD in taxes to the government, accounting for 16% of the GDP, of which USD 1.02 billion and USD 734 million come from the power and mining industries respectively.

Agriculture in Laos is dominated by rice farming; improvements in rice cultivation methods can both increase yields to address food security issues and boost emissions reductions. Rice is the main staple food crop in Laos and is essential to food security and employment. More than 80% of the country's farmers grow rice, and rice farming uses about 60% of the country's arable land. However, Laos' mountainous terrain, tropical climate with frequent monsoons, soil erosion, and lack of suitable rice varieties combined with inadequate fertilizer use have limited rice production and threatened the livelihoods of this agricultural society. As 72% of the country's paddy fields is dependent on natural rainfall, increasingly variable rainfall patterns precipitated by climate change are expected to have a devastating impact on rice production. Laos has also experimented with a range of rice farming models, such as the IAEA's collaboration with the FAO of the United Nations to support Lao farmers to increase rice yields by 60% through the use of better soil and nutrient management practices identified through stable isotope technology. The Lao government is also initiating water management practices in 75,000 hectares of lowland paddy fields with financial and technical support. These practices include: 1) capacity building for rural communities in Myanmar; and 2) retrofitting irrigation systems to reduce the anaerobic decomposition of organic matter in paddy field soils, which is expected to reduce an average of 128ktCO_2 per year from 2020 to 2030[32].

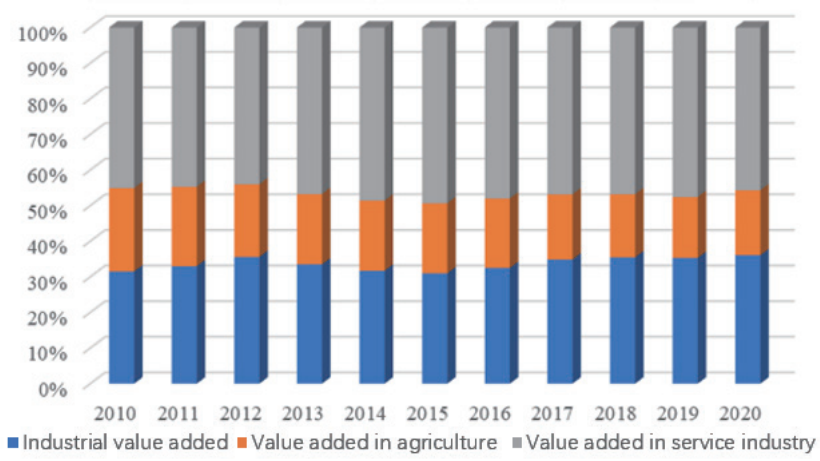


Figure 3-23. Share of Value-added for Different Industries in Laos by Year

[32] Lao People's Democratic Republic Peace Independence Democracy Unity Prosperity, 2021. Nationally Determined Contribution (NDC). https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Lao%20People's%20Democratic%20Republic%20

Data source: World Bank (industry and agriculture data), FTI (service sector data)

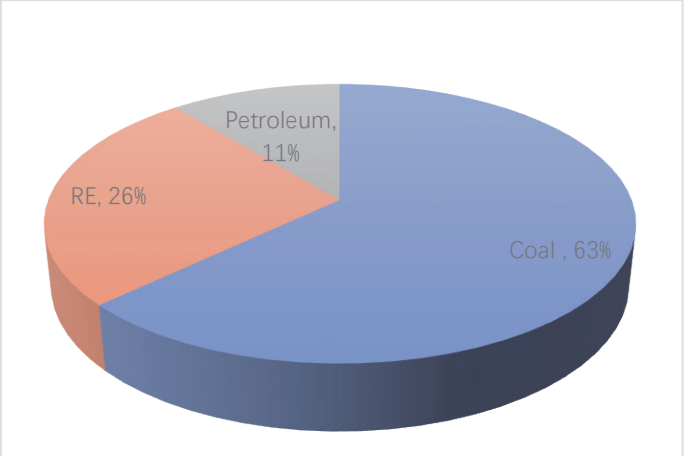
3.9.2 Energy Mix

Coal is an important energy resource in Laos and the dominant source of energy consumption in the country. Due to financial and technological constraints, the reserves of oil and gas resources in Laos are unknown. There are two main types of industrial coal in Laos: lignite and anthracite, with a total reserve of about 640 million tons, mainly located in the northwestern part of the country. According to the distribution of coal resources in Laos and the analysis of reliable coal supply, the main provinces in Laos that can meet the requirements for building large-scale coal power plants are Sayabuly, Saravan, Phongsaly, Oudomxay, Luang Namtha, and Xiengkhuang. Lignite accounts for a large proportion of the total industrial coal reserves, with reserves of about 576 million tons, accounting for more than 90% of the total reserves. Coal is mainly distributed in the Hongsa Basin, Viengphoukha Basin, Khangphaniang Basin and Mong phane Basin. The total reserve of lignite in the Hongsa Basin of Sayaburi Province, an important coal base located adjacent to Thailand, is around 510 million tons, accounting for about 80% of the total coal reserves for industrial use in Laos. At present, Laos has built a large thermal power plant with an installed capacity of 1,800MW in Hongsa and exports most of its electricity to Thailand. At present, Laos still relies entirely on imported fuel, while natural gas and coal gas are still to be exploited in the country. In the early 1990s, British Petroleum explored oil and gas in southern Laos and concluded that there was a possibility of oil and gas distribution in the Savannakhet and Pakse plains in southern Laos. However, no further results have been produced so far because Laos has no seaport, no refinery, and more importantly, no financial and technical support[33]. According to IEA data, in 2018, although Laos has a

[33] General Institute of Hydropower Planning and Design, 2020. Case Study of Renewable Energy Development in ASEAN Countries.

relatively high ratio of renewable energy consumption, which stood at 26%, the main source of energy consumption is still coal, which accounts for 63% of the total consumption (Figure 3-24).

Figure 3-24. Energy Mix in Laos in 2018



Data source: IEA

Based on concrete data in the power industry, in 2019, Laos has an installed capacity of 9.064 million kW, with a national electricity coverage rate of 90%, a social electricity consumption of 6.59 billion kilowatt hours, and a per capita electricity consumption of 941-kilowatt hours. **At present,** the electricity market in Laos is saturated. Report to the Policy Department of the Ministry of Energy and Mines of Laos, only in March did the domestic electricity load and electricity supply in Laos reach a balance in 2019 and 2020, with an electricity load of about 1,200MW; in the rest of the months, the supply exceeded the demand, with the maximum electricity supply capacity exceeding the electricity load by about 550MW in 2019 (August) and by about 800MW in 2020 (August), which denotes a worsening situation. In 2019 and 2020, electricity supply exceeded demand throughout the year, especially during the rainy season, with 450 GWh of electricity loss in the peak month (August)—the month with the highest amount of abandoned electricity—in 2019 and 650 GWh of electricity loss in the peak month (August) in 2020. In the **future**, there are more power projects under construction in Laos that will be gradually put into operation in the next few years, while the growth of electricity load demand is much lower than the growth of power supply capacity. In the dry season (January, February, March and April), there will be a balance between the domestic electricity load and power supply in Laos in 2025, while the power supply capacity of the power system will exceed the actual power load demand in the remaining months, especially in the rainy season (June, July, August and September), with a maximum of the excess energy of about 800MW. By 2030, with the rapid

growth of electricity demand in Laos and enhanced connectivity in the power grid with neighboring countries, the imbalance between electricity supply and demand in Laos will be eased; Laos can strike a balance between the load of the power system and demand in the rainy season, while importing about 700MW of electricity from neighboring countries to bridge the loading gap. The grid network of Laos is divided into four regions: North, Central 1, Central 2 and South. The country has one national dispatch center and three regional dispatch centers. The highest voltage of the grid is 500KV, a grid mainly used for the transmission of electricity to Thailand. The northern and central regions are now connected through the 230KV chain network of Nassai-Langprabang-Ben Thanh. The grid within each district is mainly 115kV. The country's power grid has not yet achieved nationwide coverage, and the transmission and distribution network currently covers only 92.39% of households. The four sub-regions are not yet connected to the high-voltage main grid, while some rural and remote mountainous areas still have no electricity supply and thus the need to import electricity from Thailand, Vietnam and China. In terms of network transmission reliability, a large number of single-circuit and single-loop structures in the power grid and long transmission distances between power centers and load centers result in a high volume of power supply loss and low reliability. The line loss rate of the power grid in Laos is in a continuous climb, reaching 12.10% by the end of 2019. The country faces an urgent need to upgrade the power grid.

3.9.3 Renewable Energy

Rich in hydro and solar energy resources, hydropower is one of the main sources of power generation in Laos. It is worth noting that Laos takes thermal power as a supplementary power source to hydropower, and in the future the country still plans to build thermal power plants. In terms of **hydropower**, Laos has a dense network of rivers, with the main rivers being the Mekong River and its tributaries, as well as the upper section of the Nam Sam River and the Nam Ma River. The Lao Mekong River Commission believes that the developable installed capacity is over 35,000 MW. According to the statistical estimation of the Kunming Institute of Power Construction Corporation of China on the resources of 61 main rivers in Laos and the mainstream of the Mekong River in Laos, the theoretical reserves of major rivers in Laos amount to 55,097.4MW and the technically exploitable capacity is 25,323 MW. As for solar energy, Laos has a tropical rainforest climate, with abundant sunshine and strong monsoon winds. Winter is better for solar power generation, while the summer has more rain which reduces the power generation capacity. The average sunshine per year in Laos is 2420 hours, with 4 sunshine hours

per day in summer and 8 sunshine hours per day in winter, which is higher than the world average. Solar irradiance in Laos ranges from 2.0 to 5.0 kWh/m/day, with an average of 4.0 to 4.5 kWh/m/day. According to Global Horizontal Irradiation, the average solar irradiance of Laos is 1700 kWh/m^2. In comparison, the average solar irradiance of the "country best-positioned for solar power" is around 1800 kWh/m^2, which shows that Laos is relatively rich in solar resources. According to the IEA's data for 2019, Laos mainly relies on **hydropower**, which accounts for 65% of power generation, while biomass and photovoltaic power generation are also used at 45 GWh and 17 GWh respectively, both accounting for less than 1% of the total (Figure 3-25). It is important to note that although Laos has only one thermal power plant in operation, the plant is mainly used to export electricity to Thailand. Nonetheless, the country still has future plans for thermal power plants. For example, in May last year, the government signed an agreement with two companies on a feasibility study to develop a proposed 1,000 MW coal-fired power plant in the country's southern province of Sekong; the plant will be fueled mainly by cheap and high-emission lignite and is scheduled to put into operation in 2027, exporting electricity to neighboring countries such as Thailand, Cambodia and Vietnam. In addition to the newly approved projects, more coal-fired power plants are in the pipeline. Last October, Laos reached an agreement with Cambodia to sell the country power from two other new coal-fired power plants with a total installed capacity of 2,400 megawatts. The projects, which will also be located in Sekong province, are scheduled to be commissioned in phases from 2024 to 2027.

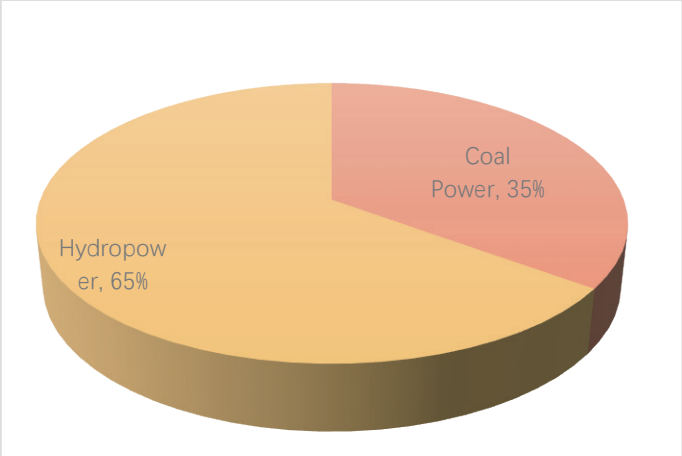


Figure 3-25. Power Supply Structure in Laos in 2019

Data source: IEA

Laos has introduced a series of laws to support the sustainable development of the energy sector. The revised ***Electricity Law*** in 2017 encourages all market players to invest in power generation to meet the demand for electricity for all people in urban and rural areas, and also to export

electricity as commodities to generate foreign exchange. The relevant policy stipulates that foreign investors in the power industry can invest in Laos in three ways, including "joint operation by agreement", "joint ventures" and "wholly foreign-owned enterprises". There aren't any special provisions for the power industry, and foreign investors can hold a controlling stake. The Lao ***Law on Environmental Protection*** stipulates that individuals or organizations must be responsible for the prevention and control of pollution in water, land, air, garbage, toxic chemicals, radioactive substances, vibration, sound, light, color and odor in the implementation of projects; discharge of excessive sewage and wastewater into ditches or water sources is prohibited; emission of smoke, gas, odor, toxic chemicals and dust that exceed the air quality index is prohibited; the production, import, use, transport, storage and disposal of toxic chemicals or radioactive substances must be carried out in accordance with relevant regulations; garbage shall not be dumped at areas other than designated sites and the area for dumping must be specified before any act of littering, incineration, landfill or disposal; the import, transport and movement of hazardous substances through waterways, land or airspace in Laos are prohibited. Laos has also amended the ***Environmental Impact Assessment Procedures*** on February 16th, 2010. The amendment introduced a strict set of IEA procedures and further improved the public participation system.

The government also supports investment through relevant policies. It requires that the share of renewable energy other than water in the primary energy supply should reach 30% by 2025. Among them, biomass energy should reach 40MW by 2025 and 100MW by 2030; solar energy should reach 300MW by 2025 and 600MW by 2030; and wind power should reach 600MW by 2025 and 1,500MW by 2030. Blessed with abundant resources and low cost of power generation, the country aims to build itself into "an accumulator for Southeast Asia". After decades of development, Laos has built a close interconnection with neighboring countries in the power industry with policy, economic and infrastructural support. For example, Vietnam and Cambodia are in a period of rapid economic growth, with a rapid increase in electricity demand and a large gap in power supply, and thus need to import electricity from neighboring countries. Thailand is constrained by resources and other factors and faces a high electricity cost, and therefore the need to import cheap electricity from Laos to reduce its own electricity costs. Currently, Laos has signed MOUs with Thailand, Cambodia and Vietnam for 9,000MW, 2,900MW and 5,000MW of cross-border electricity sales; as of now, only 6,676MW, 235MW and 627MW are used respectively with shortfalls in installed capacity of 2,324MW, 2,665MW and 4,373MW. In

addition, Laos is also doing trade with Myanmar and China and is also actively promoting the signing of MOUs on electricity trade (300 - 500MW capacity with Myanmar and 1,000 - 3,000MW with China). In 2020, Southern Power Grid and Laos National Electricity Company EDL have set up Laos National Transmission Company, which serves to promote the construction of grids with a voltage of 230kV and above in Laos and with neighboring countries, in an effort to enhance the interconnectivity between Laos and neighboring countries. Besides, to solve the problem of domestic power consumption, the Lao government has been promoting cross-border power trade with neighboring countries, and the power market in Laos can be further expanded by then.

3.9.4 Energy Efficiency

Currently, the fuels used for cooking in Laos are not clean and not efficient. Laos is also committed to improving transportation efficiency in the transportation sector. According to CEIC (CEIC Economic Database) data, despite the increase in the number of households adopting clean and efficient cooking technologies in Laos, the percentage was only 5.62% in 2016. Therefore, the promotion of energy-efficient cooking stoves in Laos can significantly save energy consumption in the cooking process and reduce emissions (Figure 3-26). Laos proposes to add 50,000 energy-efficient cooking stoves in the first phase in Vientiane Capital, Savannakhet, and Champasack. In addition, the transport sector is the second largest contributor to emissions in Laos, and improvements in transport efficiency will also contribute to energy savings and emission reductions (Figure 3-27). On the one hand, Laos actively promoted the construction and operation of the China-Laos Railway, with a groundbreaking ceremony held at the end of 2015 and a commencement ceremony in December 2016. The China-Laos Railway is scheduled to be officially opened to traffic in December 2021, which will drive the development of the Mohan/Boten Economic Cooperation Zone. China-Laos Railway is the first electrified railroad in Laos, and the Phonghong traction substation is the first traction substation completed, which plays an exemplary role in the construction of subsequent traction substations, which is critical for China-Laos Railway project and railroads in Laos to achieve electrification. Upon completion, the railway can reduce private trips and freight turnover, with an estimated average reduction of 300ktCO_2 per year from 2020 to 2030. On the other hand, Laos will be committed to the

construction and application of BRT (Bus Rapid Transit system), which is expected to reduce an average of 25ktCO_2 per year from 2020 to 2030.[34]

Figure 3-26. Percentage of Population in Laos Using Clean Fuels and Cooking Technologies

Data source: CEIC

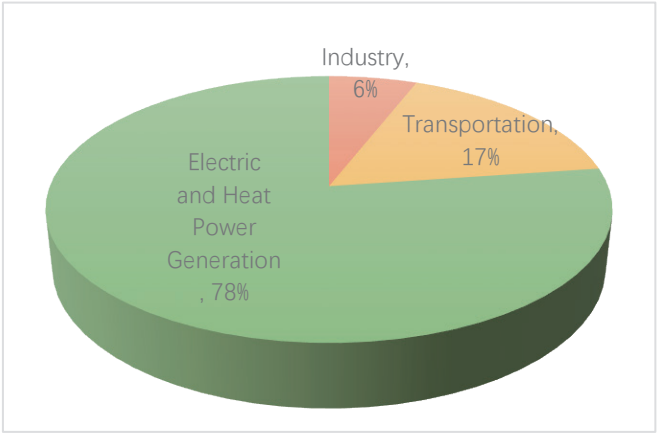


Figure 3-27. Share of Major Emission Sectors in Laos, 2019

Data source: IEA

3.10 Cambodia

Cambodia is located in the southern part of the China-Indochina Peninsula in Asia, bordering Vietnam in the east and southeast, Laos in the north, Thailand in the west and northwest, and the Gulf of Siam in the southwest. The Mekong River runs from north to south across the whole of its territory. The country covers an area of 181,035 square kilometers, with a coastline of about 460 kilometers. Phnom Penh, the capital covering 678 square kilometers, is the country's political, economic, cultural and educational center as well as a transportation hub. Cambodia is rich in high-grade timber such as teak, ironwood, rosewood, ebony, and many kinds of bamboo. The timber reserve is about 1.1 billion cubic meters. Forest coverage reaches 61.4% and forests are

[34] Lao People's Democratic Republic, 2021. Nationally Determined Contribution (NDC).

mainly distributed in the eastern, northern and western mountainous areas. Mineral deposits mainly include oil, natural gas, phosphate, precious stones, gold, iron and bauxite. The Tonle Sap Lake is the largest natural freshwater lake in Southeast Asia and is known as the "Fish Lake". The southwest coast is also an important fishing ground that produces a lot of fish and shrimp.

Cambodia absorbed USD 4.748 billion in foreign investment in 2019, according to the Cambodian Development Council. Among them, China is the largest source of foreign investment, with an agreed investment of USD 3.716 billion, accounting for 80% of the total foreign investment in Cambodia. The top three sources of foreign investment in Cambodia in 2019 are China (USD 3.716 billion), the British Virgin Islands (USD 463 million), and Japan (USD 299 million). The main areas of investment are infrastructure, banking, manufacturing, and agriculture. According to the *World Investment Report (2020)*, Cambodia absorbed a foreign investment of USD 3.706 billion in the year 2019, and the stock of foreign investment in Cambodia was USD 34.03 billion at the end of 2019.

The scale of bilateral trade and economic cooperation between China and Cambodia has been expanding. China has been the largest source of foreign investment in Cambodia for many years in a row. According to China's statistics, in 2019, bilateral trade between China and Cambodia amounted to USD 9.43 billion, up by 27.7%; non-financial direct investment in Cambodia amounted to USD 690 million, up by 7.2%; newly signed engineering contracts in Cambodia amounted to USD 5.58 billion, up by 93.6%; and completed turnover was USD 2.78 billion, up by 54.1%. Investment cooperation between the two countries in the fields of electricity, agriculture, tourism development, special economic zones, information and communication has achieved positive results, making important contributions to the socio-economic development of Cambodia.

Cambodia's economic development level is the third lowest among the ten ASEAN countries, only higher than Brunei and Laos; its carbon emission is the second lowest, only higher than Brunei. According to the World Bank, Cambodia's GDP in 2020 was USD 25.3 billion, accounting for only 1% of ASEAN's total. According to the IEA, Cambodia's carbon emissions in 2017 were 10.8 $MtCO_2$, accounting for only 0.78% of ASEAN's total emissions.

3.10.1 Industry Structure

Tourism is the largest pillar industry in Cambodia. The country's other two core industries are the garment and construction industries. According to the Ministry of Industry, Science, Technology and Innovation of Cambodia, there were 1,730 factories nationwide in 2019, employing approximately 1.04 million workers, including 1,069 textile, garment, footwear and bag factories with 923,300 workers employed, representing an increase of 5% YOY. The minimum wage for workers in the garment and footwear industry was USD 190 per month in 2019. The output value of the industrial and handicraft sector was USD 14.875 billion, up by 13%, including USD 3.69 billion for industries serving the domestic market, up by 11%; the output for export industries (apparel, bags and footwear) reached 9.325 billion, up by 11%. Other export industries such as rice, sugar, feed, tires, beer cans, beer, beverages, tobacco, hangers, jewelry, sports equipment, toys, plastic products, cosmetics, furniture and electric equipment are worth USD 1.96 billion, up by 27%. According to the Cambodian Ministry of Land Planning and Construction, a total of 4,446 construction projects were approved nationwide in 2019, up by 55% YOY, with an investment volume of USD 9.35 billion, up by 79% YOY. The share of tourism in Cambodia fluctuates around 40% in all years except for a drop to 36% in 2020 due to the COVID epidemic. Cambodia is a country rich in tourism resources. Its government is actively developing its unique tourism resources to boost local economic development.

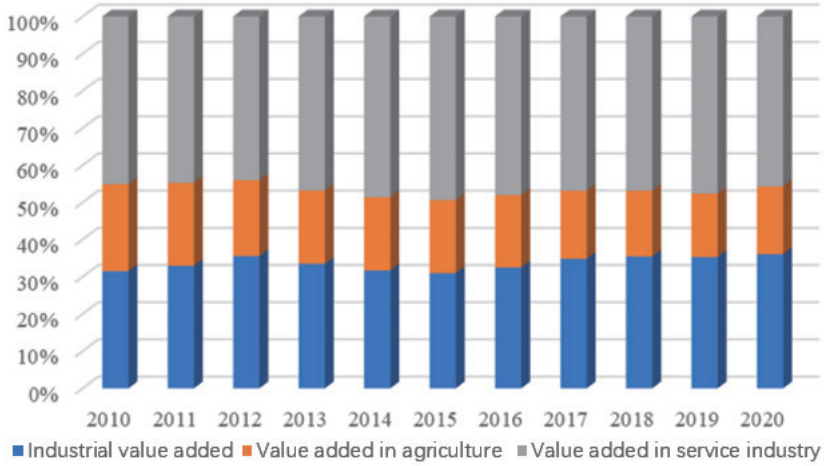


Figure 3-28. Share of Value Added for Different Industries in Cambodia by Year

Data source: World Bank (industry and agriculture data), FTI (service sector data)

The agricultural sector is important in Cambodia, but inappropriate use of agricultural land in relation to forests will result in significant emissions for Cambodia. Agriculture plays a significant role in Cambodia's national economy, with the value added of agriculture accounting

for more than 20% of the GDP in 2020 (Figure 3-28). Despite the constraints such as poor infrastructure and backward technology, as well as the lack of capital and human resources, agricultural industry in Cambodia faces a huge market potential due to its rich resources, favorable natural conditions and sufficient labor force. The Cambodian government has prioritized agriculture in its development and made every effort to improve agricultural production and its investment environment, fully exploiting its potential and advantages for a bigger market. In 2018, Cambodia's agricultural GDP reached USD 5.478 billion, of which plantation industry accounted for 58.1%, aquaculture for 24.1% and animal husbandry for 11.1%. In 2019, the paddy rice plantation covered 3.33 million hectares nationwide, with a total grain output of nearly 10.88 million tons, down by 0.9% year-on-year. The Cambodian government attaches great importance to grain production and export, with 621,000 tons of rice exported in 2019. The area for rubber plantation was 40.6 hectares in 2019, with 240,000 hectares for rubber tapping, producing 280,000 tons of rubber, all of which were exported with an income of USD 370 million. In May 2019, bananas were exported to China for the first time. Cambodia has nearly 5,000 hectares for banana production, with a total of 150,000 tons of bananas produced in 2019, all of which were exported to other countries. According to Sunniya Durrani-Jamal, country director of Cambodia Resident Mission of the Asian Development Bank (ADB), by 2030, greenhouse gas emissions from inappropriate use of woods and agricultural land, mainly deforestation and land clearing, will account for 49% of Cambodia's annual greenhouse gas emissions. Cambodia proposed some agriculture-related plans in its updated NDC, such as reducing carbon emissions by promoting manure management through composting processes and distributing 100 million seedlings to the public and local communities.

3.10.2 Energy Mix

Cambodia is relatively rich in oil and gas resources. Its main energy consumption comes from oil, with a relatively high proportion of renewable energy consumption. Cambodia has identified 6 oil-bearing sedimentary basins (2 offshore and 4 onshore) with a total area of 116,000 km^2, of which 38,000 km^2 or 1/3 of the total area is near the Gulf of Thailand. These basins have the potential for oil and gas resources. The two offshore basins are the extension of the Khmer Basin in the Paleocene epoch and the Kompong Som Basin from the Mesozoic era into the sea. The offshore Kompong Som Basin, also known as the Ponjong Basin, cuts across the eastern part of the continental shelf. Recently, 600 million barrels of oil reserves have been identified in the inner continental shelf area of Kampong Som Bay. **Based on the released information, it is**

estimated by the Ministry of Industry, Mines and Energy that Cambodia has the potential for large-scale gas deposits and medium-scale oil deposits with commercial value. The Ministry of Industry estimates the potential resources for natural gas in Cambodia at (4740-8520) x 108m^3, and potential oil reserves are estimated at (220550) x 106 barrels or (30-75) x 106t, of which commercial oil fields may contain more than x 106 barrels or 23 x 106t offshore. The lack of sufficient information from field investigation hinders the current estimates of larger reserves, while the hydrocarbon potential of the onshore basin is even more speculative. According to the IEA, Cambodia's main energy consumption in 2018 was from oil, accounting for up to 54%. The share of renewable energy consumption in Cambodia is also relatively high among ASEAN countries, arriving at 24% (Figure 3-29). It is important to note that Cambodia is not rich in coal reserves and has thin coal seams, which are not of great value for industrial mining. However, its coal consumption also reaches 22%, which is associated with its power generation structure.

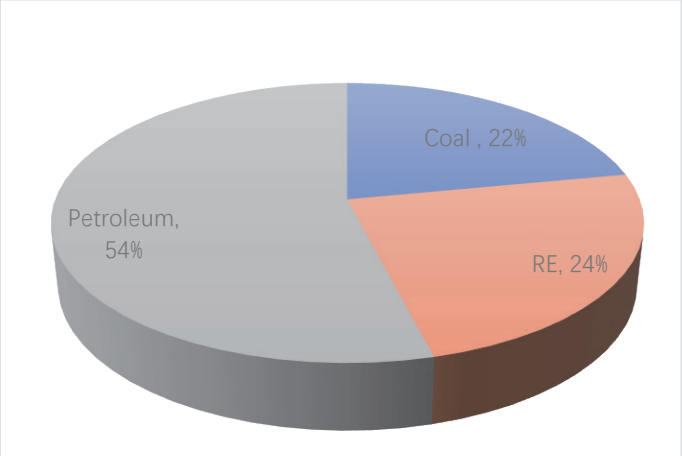


Figure 3-29. Energy Mix in Cambodia in 2018

Data source: IEA

3.10.3 Renewable Energy

Cambodia is rich in hydropower resources with a high proportion of hydropower; thermal power is a complementary power source. Cambodia also has abundant solar energy and biomass energy due to its resource endowment and industrial structure. Cambodia has a huge potential for hydropower, with a total deposit of 10,000 MW; the capacity of hydropower plants completed and those under construction accounts for only 13% of the total deposit. Cambodia is rich in solar energy resources, with about 134,500 square kilometers of the country's 181,000 square kilometers of the territory being suitable locations for solar energy development, with an average daily solar irradiation of 5 kWh/m^2. The year 2019 saw a small leap in solar energy

development in Cambodia, with cumulative installed solar capacity reaching 99 MW for the year, an increase of 70 MW compared with the end of 2018, up by 241.38%. Cambodia's rich biomass resources mainly include agricultural residues such as rice husk and sugarcane bagasse, forestry production residues, and livestock, and poultry manure. At present, the Cambodian government is actively seeking foreign financial support and advanced technology to develop its biomass energy. However, the power supply structure of Cambodia in 2019 show that 37% of the power generation in Cambodia came from coal (Figure 3-30). The vulnerability of hydropower to the drought season has led to its unstable power supply. That's why Cambodia has focused more on thermal power over the past few years. After the massive blackout in 2019, the Cambodian government decided to rapidly expand its power supply and opted for thermal power generation. Up till now, Cambodia has three thermal power plants in operation, all located in Sihanoukville province, with a total generation capacity of 640 MW. Two other power stations with a total generating capacity of 800 MW are under construction. The government has approved another new power station in Oddar Meanchey province besides the Botum Sakor power station.

Cambodia is accelerating the development of the PV industry, but so far no specific development targets have been set; poor grid infrastructure is another urgent issue to be addressed. Although the Cambodian government wants to solve part of the power supply shortage problem through the development of renewable energy, it has not set specific development goals for renewable energy or even for the PV industry. In the past, there were optimistic views about the potential of photovoltaic development in Cambodia (Figure 3-31), but due to infrastructure, financial situation and lack of specific targets and measures, the development of PV has been delayed and the project has not been implemented on schedule. The Cambodian government announced in 2017 that it would build a 100 MW national PV plant, which is a remarkable move in recent years; as of 2019, 60 MW of bidding has been completed, with no further news on the remaining 40 MW. Apart from that, in 2019, the Cambodian government approved photovoltaic projects at 140 MW and 120 MW in order to expand access to electricity; it is reported that some of these projects have been supplied with modules last year and this year. In 2020, the Cambodian energy authorities indicated that they will suspend the development of hydropower in the next 10 years, and turn to photovoltaic, natural gas and other resources. Specific policies are still being studied and formulated. As the PV industry is still in its infancy, market growth and continuity are expected to be very limited before policies and supporting measures are formulated and

perfected. However, with effective improvement measures and clear policies, the PV industry in Cambodia may embrace the opportunity for market growth.

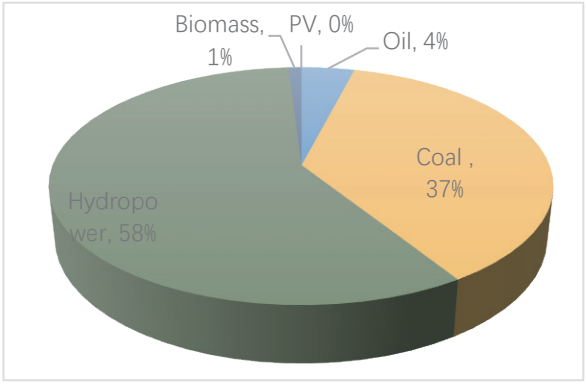


Figure 3-30. Cambodia's Power Supply Structure in 2019

Data source: IEA

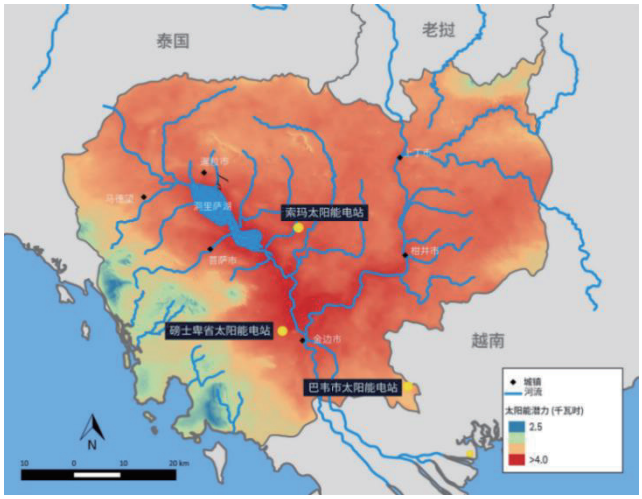


Figure 3-31. The Potential for Cambodia's PV Industry

Source: Chinese-Foreign Dialogue, 2019

Cambodia has made significant progress in formulating climate change policies, particularly in integrating climate change into the main body of national and district-level planning. The Cambodian government has delineated and implemented the *Cambodia Climate Change Strategic Plan 2014-2023*, with action plans made by each ministry and department concerned. Cambodia's first biennial report was submitted in August 2020, and preparation work on the third national communication is underway. A national monitoring and evaluation framework to address climate change has also been established with regular climate public expenditure reviews conducted.

Cambodia has incorporated renewable energy development into the country's NDC. Related plans include: reducing energy use, improving energy efficiency, increasing the use of renewable energy, carbon offset, waste management and recycling; in the power sector, reducing greenhouse gas emissions through renewable energy generation; in the energy sector, making good use of solar home systems (SHS), direct current/alternating current (AC/DC) mini-grids, solar battery charging stations and other existing technologies; incorporating renewable energy (solar, wind, hydro, biomass) into the energy mix to reduce imported energy and increase the use of clean energy.

3.10.4 Energy Efficiency

Cambodia aims to improve its energy efficiency by renovating the garment and construction industries, including retrofitting the boilers, setting energy-saving standards, and using efficient refrigeration technologies. For the **garment industry,** energy efficiency improvement measures include upgrading high-efficiency boilers (26 boilers with an emission reduction of 0.03 MtCO2 e/year), sewing machines (3,500 new motors with GHG emission reduction estimated at 0.002 MtCO2 e/year), washing machines (130 new washing machines with GHG emission reduction estimated at 0.0002 $MtCO_2e$/year), drying machines (65 new dryers with an estimated GHG emission reduction of 0.0001mtCO2e/year), compressors (40 new compressors with an estimated GHG emission reduction of 0.0007MtCO2e/year), and lighting (150,000 new high-efficiency lighting systems with an estimated GHG emission reduction of 0.005$MtCO_2e$/year). Measures for the **construction industry** include putting in place standards and enforcement/certification for new buildings and those undergoing major renovations (in preparation) and using efficient transformers/motors in utility power/buildings/industry; in response to the future growth in cooling demand, the Cambodian government proposed to reduce GHG emissions through energy efficiency retrofits for public buildings and adoption of climate-friendly cooling technologies in all the buildings in the public sector. Other energy-saving policies include adding labels on energy consumption and standard product information to increase the market share of high-end, high-efficiency appliances, and replacing traditional ship kilns with rotary kilns in the brick-making industry.

Chapter 4. Key Issues and Cooperation Opportunities in ASEAN's Green and Low-carbon Transition

4.1 The Status-quo of Cooperation on the BRI Green and Low-carbon Transition

Green and low-carbon cooperation on energy will play a bigger role in BRI cooperation. In September 2021, Chinese President Xi Jinping announced that China would support green and low-carbon energy development of developing countries and stop building new coal-fired power projects overseas. China's pledge to halt new overseas coal-fired power projects has been widely recognized by the international community. A report released by the World Economic Forum and PwC points out that the international community needs to invest USD 66 trillion in global infrastructure in emerging economies by 2030. In this context, BRI offers a new development model by accelerating low-carbon infrastructure development. The initiative can play a leading role in decoupling economic growth from carbon emissions in emerging and developing economies. China can provide low-carbon technologies to these economies in the implementation of the BRI.

China and the countries along the Belt and Road have huge potential for energy cooperation. In recent years, Chinese power enterprises have steadily increased their overseas investment. Since 2010, under the nation's call of "go global" and with the implementation of BRI, we see a rapid increase in outbound investment by Chinese power enterprises. According to the bulletin of National Bureau of Statistics, the overseas investment flow in electricity, heat, gas, water production and water supply reached USD 2.78 billion in 2020, an year-on-year increase of 10.3%. By the end of 2020, the stock of outward foreign direct investment in electricity, heat, gas, water production and water supply in China reached USD 39 billion. With the urbanization drive and population growth, the energy demand of BRI participating countries is on the rise and has become a hot spot for China's overseas energy cooperation and investment. Significant progress has been made in coal power, nuclear power, hydropower and non-hydropower renewable energy. In 2019, Chinese enterprises have signed 318 power projects with BRI participating countries, accounting for 56.5% of overseas power projects, with the project value amounting to USD 32.28 billion, accounting for 68.4% of the total for overseas projects.

China has significant advantages in cooperation on renewable energy with BRI participating countries. China is the world's largest producer of solar panels, wind turbines, batteries and electric vehicles, and also has extensive experience and potential to cooperate with Southeast Asian countries in green and low-carbon development. Chinese energy construction enterprises occupy a major share in both Chinese and global contracting markets. In 2020, among the enterprises undertaking foreign contracting projects, 25 of the top 100 enterprises in terms of turnover were power enterprises, which is the same as the previous year; among the top 100 enterprises in terms of the number of new contracts signed, 25 are Chinese power enterprises, which is higher than the previous year. China's share in the international renewable energy market is also growing year by year, and has become one of the world's major suppliers of renewable energy solutions and advanced technologies for the industry. Large Chinese companies occupy a leading position in the global renewable energy value chain. IEA reports that China's renewable energy generation capacity will continue to lead the global energy market with an expected growth of nearly 8 million kW between 2021-2026, accounting for 43% of the world's incremental renewable energy capacity. With China halting the construction of overseas coal-fired power plants, China's strengths in renewable energy will further support and drive the low-carbon energy transition in BRI countries. For example, the Adama wind power project in Ethiopia is China's first international wind power EPC project, and also the first new energy project contracted overseas that has adopted Chinese standards, technology, equipment and capital. The project has a very good demonstration effect in Africa. The wind power project in Mozura, in which State Power Investment Corporation (SPIC) participated in the construction, is SPIC's first successful attempt at third-party market cooperation in clean energy. The project provides a boost for Montenegro to achieve the strategic goal of developing 33% of new energy, with 95,000 tons of carbon dioxide emission reduction per year. Among the wind power projects initiated from 2014 to 2018 through equity investment in participating countries, 80% are located in South and Southeast Asia, with a total installed capacity of 397.5 MW and 1362 MW under construction or planning, contributing a total of 1759.5 MW of installed wind power capacity to the region. In addition to equity investment, the total installed capacity of PV power plants built by Chinese enterprises in BRI participating countries through equipment exports from 2014 to 2018 reaches about 8440 MW. Three of the top five countries in terms of the size of PV equipment exports by China are located in South and Southeast Asia—India (5800 MW), Thailand (1060 MW) and the Philippines (250 MW). In addition, Chinese PV companies also regard Southeast Asia as an

important overseas manufacturing base for PV modules. In the Southeast Asia PV base cluster in countries such as Vietnam and Thailand, there is a total of 12 Chinese PV companies participating in the construction of PV module factories, with a capacity of more than 7 GW, according to public information sources.

Overseas project contracting is an important way of energy investment and cooperation in China. China's experience in overseas investment project cooperation has shifted from project assistance, to EPC (engineering, procurement, and construction), and to the current "integrated" project construction. Chinese energy enterprises have accumulated rich experience in construction investment, construction design and equipment manufacturing. They have played a part in the construction of Southeast Asian power infrastructure in various forms including equity investment, financial support, EPC and equipment export. They are motivated to engage in overseas investment and export with their competitive strengths. Chinese equipment, technology and capital have thus entered into the overseas power market. Generally speaking, in the ten years between 2009 and 2018, EPC was the main path for China to participate in overseas coal-fired power projects. The long duration and cost recovery cycle of power projects and the increase in large-scale projects endowed the central enterprises and state-owned enterprises with obvious advantages. Chinese enterprises such as Power China International Group Limited and China Gezhouba Group International Engineering Co., Ltd. under China Energy Engineering Corporation excel in terms of the volume of newly signed contracts in 2020.

Equity investment is occupying an increasingly important position in China's overseas project investment. Under the traditional EPC model, Chinese enterprises were only construction or equipment providers with only short-to-medium-term economic benefits, not the key decision-maker for project investment and operation. Subsequently, China's overseas coal investment in the power industry is gradually changing from EPC to equity investment. Starting from 2012, the first overseas coal-based power projects in which China participated in the form of equity investment were put into operation. According to statistics, the installed capacity of projects built by Chinese enterprises with equity investment exceeded that of EPC projects for the first time in 2018, with good prospects for future development.

4.2 Key Issues and Opportunities for Cooperation

4.2.1 Regional Overview

ASEAN Plan of Action for Energy Cooperation (APAEC) has proposed seven priority areas for regional cooperation: Establishing ASEAN Power Grid (APG); Trans-ASEAN Gas Pipeline

(TAGP); Coal and Clean Coal Technology (CCT); Energy Efficiency and Conservation (EE&C); Renewable Energy (RE); Regional Energy Policy and Planning (REPP); and Civil Nuclear Energy (CNE). A report pointed out that **there are four major issues and challenges for ASEAN to carry out regional energy cooperation in terms of finance, policy, technology, and barriers.** Renewable energy transition in ASEAN countries has received long-standing attention from various parties. Previously, studies show that ASEAN countries generally have a high level of fossil energy dependency and most ASEAN countries still lack a fully transparent land licensing process for renewable energy development. The complex procedures for acquiring, preserving and transferring land use rights in many ASEAN countries, along with long land acquisition periods and expensive acquisition costs, have led to project development delays and cost overruns. The cumbersome and lengthy project approval process, changing policies in the short term and ambiguities in the guidelines on grid connections for renewable energy have resulted in low investment efficiency in the industry. Some countries are less competitive due to frequent changes in feed-in tariff policies or low incentives. Higher feed-in tariffs in other countries have led to a surge in applications for specific types of power facilities, while excessive deployment has in turn led to the removal of related incentives.

In addition to the conventional financing issues, the geographic conditions in ASEAN—a mountainous region with a dense network of rivers and jungles—put forward high requirements for power technology in both power generation and transmission. At the same time, countries vary in terms of the intelligence level of their power grids, with the stability and scale of transactions of ASEAN's interconnected grid being affected by weak power grids. An assessment of the *Power Development Plans* of ASEAN countries shows that most ASEAN countries have not yet aligned their power grid planning with the plan on ASEAN connectivity, with a tendency of prioritizing their domestic needs for power supply in grid planning. Therefore, ASEAN countries need to build separate power infrastructures for the ASEAN interconnection projects, which not only adds additional construction costs but also brings technical challenges in project construction, operation, and maintenance.

10 ASEAN member states are divided into four major categories. Among them, Indonesia is categorized separately due to the fact that its economic volume and emission scale far exceed other countries. Vietnam, Thailand, Malaysia, and the Philippines enjoy better economic conditions and the potential increases in emissions. Meanwhile, these countries attach great importance to the development strategy of renewable energy and thus can be put together for

analysis in focus. Myanmar, Cambodia, and Laos have relatively underdeveloped economies, but with higher potential for renewable energy development. Singapore and Brunei are smaller in the area with relatively developed economies, they can play an exemplary role in the development of clean energy technology and green finance.

4.2.2 Analysis on Indonesia

Indonesia's economic size, population and total emissions far exceed those of other ASEAN countries, with the highest potential for emissions reduction upon completion of its transition. The most important issues facing its green energy transition include **a large funding gap to achieve coal retirement and its scattered grid is not conducive to the consumption of renewable energy generated.**

Indonesia has abundant coal reserves. It is the world's fifth-largest coal producer and largest coal exporter. Coal power accounts for a relatively large share of primary energy. Coal power generation accounts for 56.39% of the total in 2019. According to the Indonesia National Power Business Plan (RUPTL 2018-2027), the installed capacity of coal power will reach 57 GW in 2027, or 48.8% of the total installed capacity. The continued development of coal-fired power plants poses a significant threat to Indonesia's GHG emission reduction targets. There is an urgent need for Indonesia to develop plans in the short, medium, and long term for the orderly phasing out of coal in the power sector. In addition, a unified power grid has not yet been formed in the islands of Indonesia. Areas with abundant resources but limited capacity for consumption are unable to transmit clean renewable energy power to areas with higher electricity demand, which hinders the development of renewable energy.

Indonesia has demonstrated strong political commitment and policy support to emissions reductions, but it is unlikely to achieve the target overnight. On May 27, 2021, Indonesia announced that it will phase out coal-fired power in the country. Indonesia's national power company PLN announced that no new coal-fired power plants will be built after 2023, demonstrating a strong commitment to emissions reduction supported by national policies. In late 2021, Indonesia announced that it would explore the establishment of a carbon market to accelerate its energy transition. However, affected by the global energy supply crisis, Indonesia imposed a one-month ban on coal exports to maintain domestic energy security, which revealed the challenges the country faces in the energy transition.

The next step for Indonesia is to further develop market mechanisms to boost the development of renewable energy and low-carbon industries.

First, expand the scale of financing in energy transition with explorations in establishing a carbon market. In November 2021, Indonesia issued a presidential regulation to allow pilot carbon trading and enacted a law on tax regulation, which puts in place a carbon tax on the power and coal sectors from April 1, 2022 (with a minimum pricing of 30,000 IDR per kilogram, or about 2 USD per kilogram, for carbon dioxide equivalent). The carbon tax system, once implemented, will exert a positive impact on the transition of the power industry and the development of renewable energy, while channeling more funds to the country's energy transition. At the same time, market instruments such as the carbon tax need to be continuously improved and fine-tuned according to the actual implementation to avoid any indirect increase in the cost of living for residents which would in turn impede the green economic recovery. Carbon tax is a different path of carbon pricing compared with China's carbon emission trading market, but they are both based on the estimation and certification of the carbon emissions of each industry. Therefore, exchanges in this field can help improve both mechanisms.

Second, enhance the connectivity of the grid infrastructure so as to improve the consumption capacity of renewable energy. Indonesia has excellent renewable energy resources, with rich geothermal energy, biomass, hydro energy, solar energy, etc., and a modest utilization rate. According to a study by the Indonesian think tank IESR, it is economically and technically feasible for Indonesia to decarbonize its power system by 2050 on the condition that the installed capacity of PV power is improved by a large margin. To this end, Indonesia should strengthen its grid infrastructure and improve the connectivity and energy storage capacity of provincial grids, so as to boost the capacity of renewable energy consumption and prepare for the increase of installed renewable energy capacity.

4.2.3 Analysis on Vietnam, Thailand, Malaysia and the Philippines

Vietnam, Thailand, Malaysia and the Philippines are all countries in Southeast Asia with good economic foundations, certain policies and practice basis for renewable energy development and a clear national strategy. But they all face the challenge of crossing the middle-income trap and achieving the transition of sustainable growth. They are faced with common problems in achieving green and low-carbon energy transition: **First**, they have national strategies and strong ambitions for renewable energy development, but a large share of their power comes from coal. **Second,** there are strict restrictions on foreign investment in the energy sector, which poses certain limitations to financing in this industry.

Among them, **Vietnam** has a total installed PV capacity of 16.5 GW in 2020, surpassing Thailand to become the first in ASEAN. The upcoming *Eighth Edition of the National Power Development Plan* (PDP8) may set higher targets for PV capacity in 2030, but the release was postponed for several times due to various factors with the possibility of lowering the requirements. At COP26, Vietnam signed the *Global Coal to Clean Power Transition* with a pledge to scale up renewable energy and not to build new coal-fired power plants without carbon capture facilities, demonstrating energy transition ambitions. **Thailand** has a great potential for PV development, and the strengths of the automotive industry are expected to translate into end-use electrification trends such as new energy vehicles. However, Thailand, whose electricity is heavily dependent on imports, is in dire need of various ways to upgrade its energy mix, including PV and biomass. In **Malaysia,** 17% of the power is generated from renewable energy, with abundant renewable energy resources dominated by hydropower, solar power and biomass power generation. The IEA predicts that Malaysia's renewable energy demand will be more than double in 2040, accounting for about 16% of total power generation. Malaysia released the blueprint of Malaysian Electricity Supply Industry 2.0 (MESI 2.0) in 2019, which intends to invite more independent enterprises to enter the power sector, except that there is a 49% cap for the equity held by foreign investment in power projects. **The Philippines** has a huge potential for wind and photovoltaic power generation with active measures on renewable energy development. The Philippine *Renewable Energy Act* (An Act Promoting the Development, Utilization and Commercialization of Renewable Energy Resources and for other purposes), which was enacted in December 2008, is the first comprehensive renewable energy legislation in Southeast Asia. It draws on the advanced experience of developed countries in the development of renewable energy and puts in place generous fiscal incentives for the development and utilization of renewable energy with a sound institutional framework.

In addition, electricity prices in the Philippines are extremely high with unstable power supply for two reasons: first, dependence on fossil fuel and a lack of resilience to energy price fluctuations; and second, insufficient competition in the power sector and old power infrastructure locally. Vietnam announced ambitious strategic goals during COP26. Faced with a huge financing gap, Vietnam upgraded its coal power target in the *Eighth Edition of the National Power Development Plan* (PDP8) at the end of 2021 amid the global energy crisis. In addition, cross-border power cooperation is still in its infancy, with weak cross-border interconnection, low voltage and small-scale power transactions. Bilateral cross-border power trade between countries in the China-

Indochina Peninsula is mostly carried out in the form of point-to-network transmission or one grid carrying part of the load for neighboring countries. The Malay Archipelago is divided by the sea with no channel for power transmission between islands; the limited grid regulation capacity also restricts the development of renewable energy.

In the next step, the four countries can prioritize actions in the following areas.

First, further strengthen the top-level design of the power investment environment to attract more external financial support for the orderly retirement of coal capacity and energy transformation. The above four countries have better economic development prospects and excellent basic conditions for attracting international funds, but the amount of funds required for the de-carbonization of power systems is equally huge. The countries should introduce and strengthen the implementation of feed-in tariff mechanism (FIT), renewable portfolio standard (RPS), net metering tariff policy (Net Metering), and relax the restriction on the proportion of equity investment in power projects while phasing in financial instruments such as carbon emissions trading and green bond, so as to improve the energy investment environment, boost the market financing vitality, and bridge the financing gap for energy transformation. Fossil fuel subsidies, which make renewable energy less economical, should also be removed. At the same time, the region should encourage the synergy in policy standards, improve the scale of grid coverage and intelligence, and enhance the resilience of the grid through regional power trading.

Second, accelerate the development of PV, wind power and other renewable energy projects and support technology for energy storage, to facilitate the realization of the NDC targets. The four countries have a clear national strategy for renewable energy, with different degrees of policy support for PV and wind power and a huge potential for photovoltaic, wind power generation. Going forward, the countries need to improve the development scale and speed of PV and wind power, and to improve the grid's ability to consume renewable energy by building supporting energy storage projects, gradually reducing the proportion of fossil energy in the primary energy so that countries can achieve their respective NDC targets.

4.2.4 Analysis on Myanmar, Cambodia and Laos

The major challenges that Myanmar, Cambodia and Laos have in common on the green and low-carbon energy transition are two-fold. Firstly, the economies are underdeveloped with a high proportion of rural population scattered in remote rural areas, with an extremely low urbanization rate and poor access to electricity. Secondly, environmental laws

and regulations are not complete, while the capital market is underdeveloped with a weak financial market locally.

The economies of the three countries are underdeveloped, with GDP per capita of USD 1228, USD 1793 and USD 1219 respectively. The industrial structure is not characterized by high energy consumption and high emissions. Yet the countries face a high proportion of rural population scattered in remote rural areas, an extremely low urbanization rate and poor access to electricity. Some areas in the three countries face electricity shortages or have no access to electricity at all, and the poor access to electricity led to the use of firewood, charcoal and other fuels to meet their daily needs. In terms of policies and regulations, the environmental regulations in the above three countries are not complete yet. The capital markets are underdeveloped with weak local financial markets. In the future, the expansion of renewable energy investment will face macroeconomic, regulatory and financing challenges. The three countries are all located the downstream of the Mekong River, with rich hydropower resources and scenery resources.

To enhance mutual trust in cooperation, a regional cooperation platform should be established to foster the alignment of planning in different countries so as to enhance the influence in cooperation areas such as the ASEAN power grid. On this basis, unified power trading standards should be established to identify market structures as well as grid codes and standards. Based on the in-depth study of the planning and design, system operation and maintenance norms and standards in different regions, we can expand from local markets to the establishment of a regional power market based on commercial principles by carrying out market-oriented pilot projects, breaking down barriers and establishing a harmonious and unified bilateral cross-border power interconnection and trade legal and regulatory framework within ASEAN with provisions on tax, tariff and third-party access as well as over-grid fees.

Going forward, the three countries should prioritize actions in two areas.

First, promote the construction of grid infrastructure and develop off-grid power generation to enhance power accessibility.

Myanmar’s current electricity supply is inadequate, with an access rate of about 68% in 2019. As the three countries have a large proportion of the population living in rural areas that are too far away from their power grids, the lack of electricity supply is one of the key issues. For example, Myanmar has 70% of its population living in rural areas. More towns and households can be connected to the power grid by expanding the existing grid and adding medium and low-voltage

distribution networks. Besides, off-grid electrification systems including solar systems and mini-grids can be developed to supply electricity to remote rural communities in the three countries.

Second, formulate renewable energy policies to achieve a green and low-carbon energy transition at a lower cost.

Myanmar and Laos have great potential in hydropower and PV. However, hydropower is not stable due to issues such as drought, and the utilization of hydropower can have impacts on the ecological environment. At present, the three countries have a low access rate of PV, with no strategic deployment and unclear prospects for the time being. In the future, efforts can be made to clarify the countries' own renewable energy development goals, increase the deployment of PV, biomass and hydropower storage facilities, strengthen international cooperation and integrate themselves into the regional energy network. They can increase the penetration rate of renewable energy in various sectors so as to boost the development of renewable energy. The countries can also engage in energy trading with other countries in the region, fully utilizing their advantage in renewable energy to drive economic growth as well as green and low-carbon transition.

4.2.5 Analysis on Singapore and Brunei

Singapore and Brunei have small population and small territories. **Their problem in green transformation is mainly the poor renewable energy resources. With developed economies, they can play a demonstration role and function as green financial centers to drive the green transformation of other countries in the region.** Singapore and Brunei have a per capita GDP of about USD 52,099 and USD 27,955 respectively. Singapore and Brunei have a high level of economic development and a high human development index (index/ranking of 0.925/5 and 0.865/30, respectively, in 2015). They lack renewable energy resources such as hydropower, wind and geothermal energy, but rich in solar energy resources. Although Singapore and Brunei have smaller investment potential in energy projects, they can play exemplary roles as important financial hubs in ASEAN, and function as bridges to support the green transformation in the region.

Going forward, the two countries can prioritize actions in two areas.

Firstly, play an exemplary role in building power systems for renewable energy.

Singapore and Brunei's current energy mix is dominated by natural gas, which accounts for more than 95% of the power generated. The two countries lack other renewable energy resources such as wind, hydro, thermal, and tidal energy. Due to their location in the tropics, both countries have rich solar energy resources. Therefore, roof-mounted photovoltaic and other forms of power

generation can be promoted to save land use. In addition, Singapore has mature waste-to-energy technology. The establishment of renewable energy systems that combine PV with waste-to-energy technology can have a demonstration effect on other ASEAN countries.

Secondly, leverage the advantages of financial center to strengthen regional and international cooperation in green finance.

Strengthening regional and international cooperation is one of the key areas of ASEAN's future strategy on renewable energy. Both Singapore and Brunei are more developed in ASEAN in terms of financial performance. In particular, Singapore had an early start in developing the financial sector and has become one of the financial centers in Asia. It is vital to the development of green finance in the region. Singapore is also a pioneer in implementing carbon tax in the ASEAN region, providing a good benchmark for other ASEAN countries. The role of the financial industry in both countries should be fully leveraged to gradually loosen investment restrictions on renewable energy in ASEAN as a whole, attract more international funds to enter the renewable energy market in ASEAN countries, and help ASEAN countries achieve their NDC targets and realize green low-carbon transition.

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