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Green and Low-carbon Transition of Power Sector in Southeast Asia: Baseline and Pathway

10th

Research Team

GU Baihe	Associate Research Fellow, Institutes of Science and Development, Chinese Academy of Sciences
LI Ying	Associate Director Specialist, FECO, MEE
YU Xinyi	Senior Program Manager, FECO, MEE
LIN Hui	Department of S&T Management, Institutes of Science and Development, Chinese Academy of Sciences Director, Research Fellow
XING Ying	Associate Research Fellow, Institutes of Science and Development, Chinese Academy of Sciences
GUO Jianxin	Associate Research Fellow, Institutes of Science and Development, Chinese Academy of Sciences
ZHU Yongbin	Associate Research Fellow, Institutes of Science and Development, Chinese Academy of Sciences
CHENG Duowei	Assistant Research Fellow, Institutes of Science and Development, Chinese Academy of Sciences
WANG Mingyue	Assistant Research Fellow, Institutes of Science and Development, Chinese Academy of Sciences
SHENG Yuhui	Doctoral student, School of Public and Management, University of Chinese Academy of Sciences
LIU Yuxuan	Doctoral student, Institutes of Science and Development, Chinese Academy of Sciences
YU Donghui	Postgraduate student, Institutes of Science and Development, Chinese Academy of Sciences
YANG Jiawen	Postgraduate student, Institutes of Science and Development, Chinese Academy of Sciences
LIU Jing	Research Assistant, Institutes of Science and Development, Chinese Academy of Sciences
WANG Chen	Postgraduate student, Sino-Danish College, Chinese Academy of Sciences
CHEN Zhuo	Postgraduate student, School of Public and Management, University of Chinese Academy of Sciences, Chinese Academy of Sciences
ZHOU Yilin	Project assistant, BRIGC
Chinese experts:	
JIA Dan	Researcher, China Photovoltaic Industry Association
AN Yan	Associate Research Fellow, Strategic Planning Research Institute of China National Nuclear Corporation (CNNC)
International experts:	
Venkatachalam Anbumozhi	Director of Research Strategy and Innovation, Economic Research Institute for ASEAN and East Asia
Nguyen Quoc Khanh	Senior Individual Expert on Energy and Climate, Vietnam

* The authors and advisors of this policy study serve in their personal capacities.

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Executive Summary

The latest energy crisis in early 2021 has further exposed the world's high dependency on fossil fuels. Renewable energy, on the other hand, has seen a constant drop in its costs due to the improvement in technology and economic growth. Being more competitive, it has become a main driver for the green and low-carbon transition of economic growth in many countries around the world. The energy mix and power supply structure in the Southeast Asia are generally dominated by fossil fuels, especially in the coal power and gas power sector. Although renewable energy boasts good resource endowments, non-hydro renewable energy is still underdeveloped, and the development stage of Southeast Asian countries have seriously restricted the process of their green and low-carbon transition. Therefore, international cooperation will play an important role in their green and low-carbon development.

This report summarizes the current status of energy transition globally and the actions taken by the international community. It then analyzes the low-carbon development status of the power sector in Southeast Asia, including the characteristics of power resource, power grids, low-carbon policies related to the power sector transition and international power investments in the region. On this basis, the study further identifies the opportunities and challenges in the process of low-carbon transition of the power sector in Southeast Asia, and selects two typical countries, Indonesia and Vietnam, for an in-depth case study on the objective planning, transition obstacles and demands for international cooperation of the power sector in Southeast Asian countries. Next, the study includes a summary of the development experience of renewable energy in China, to provide best practice references for Southeast Asian countries. Finally, the report puts forward recommendations for low-carbon transition of the power sector in Southeast Asia and for China to conduct cooperation with Southeast Asia in such transition.

The main findings and conclusions of the report are as follows:

I. As energy transition is an urgent matter globally, countries around the world have accelerated actions in clean renewable energy.

The spread of the global energy crisis has led to a general increase in energy prices, and the geopolitical conflict can also have a certain impact on global energy security. The energy crisis that began in Europe has eventually spread across the globe and lead to the soaring prices of the three traditional energy sources—natural gas, coal and oil. Meanwhile, the outbreak of the geopolitical conflict in Russia, one of the world's major exporters of energy, will trigger turmoil in global energy markets. As the negative impact of a development path that is highly dependent on fossil fuels is increasingly prominent, it is vital to accelerate the development of renewable energy and raise the level of electrification. So far, most countries have set carbon-neutral or net-zero emission targets and countries around the world should strengthen their low-carbon transition efforts. Some countries have reached consensus on phasing coal or coal reduction, and strengthen efforts on renewable energy.

II. The energy mix of Southeast Asia is dominated by fossil fuel, while non-hydro renewable energy is growing rapidly.

Installed power capacity in Southeast Asia has continued to grow over the past 20 years, with the total power generation in Southeast Asia increased by three folds. In 2020, the installed capacity of fossil fuel took up 66.5% of the total capacity, among which coal-fired power accounted for 1/3. Southeast Asia's coal power plants are at a early stage, with an average life span of 12 years, but there is still much room for technological upgrading and renovation of coal power. The installed capacity of the renewables rise from 19.1% in 2005 to 33.5% in 2020, mainly driven by hydropower. Non-hydro renewable power generation has also been growing rapidly in recent years. Given its abundant yet underdeveloped renewable energy resource, the Southeast Asia sees huge potential in renewable energy development.

III. Overseas countries show a high degree of involvement in power plant construction in Southeast Asia, with overseas investment driven by local demand and increasing renewable energy investments.

Overseas countries are involved in more than 60% of Southeast Asian power projects, mainly for EPCM and equipment exports. China, Japan, France, ROK and the United States are the countries most involved in power investment in Southeast Asia. China and Japan mainly invest in engineering equipment, while the United States and ROK focus on equity investment. The structure of power investments by overseas countries in Southeast Asia is highly compatible with the power supply structure in the region. Most investment is allocated in Indonesia, Vietnam and Thailand. Historic statistics show that overseas investment has been dominated by fossil fuels, but in recent years overseas investment in renewable power in Southeast Asia has started to increase. **In terms of renewable power, Chinese investments have mainly flowed to hydropower and PV power projects.** Hydropower investment is concentrated in countries with relatively rich hydropower resources, such as Cambodia, Laos, Vietnam and Myanmar. PV investment is mainly concentrated in Vietnam, the Philippines, Malaysia and other countries. Hydropower has been a key area of overseas renewable investment.

IV. Low-carbon transition of the power sector in Southeast Asia faces both opportunities and challenges.

Opportunities: There is a strong future demand for electricity in Southeast Asia and a huge potential of renewable energy resources in Southeast Asia. The renewable energy development targets is already in place for ASEAN as a whole and for Southeast Asian countries. There is a declining cost and rapid development of renewable energy globally and sees gradual improvement of international cooperation in Southeast Asia.

Challenges: The accelerated withdrawal of coal power will exacerbate energy supply security risks and cause challenges such as asset stranding and just transition. There is still insufficient policy support for power sector transition and weak government enforcement. The market has a low level of electricity and the development of clean energy is impeded. There is an urgent need for improvements in grid infrastructure and in slow progress in ASEAN interconnection. The funding gaps for transition is huge and lack of effective market financing mechanisms.

V. Recommendations for cooperation in green and low-carbon transition of the power sector in Southeast Asia

Recommendations for low-carbon transition of the power sector in Southeast Asia: First, the transition to renewable power should be an integral part of post-COVID economic recovery to prevent large investment into the coal power sector. **Second**, it is essential to gradually reduce the proportion of coal power in Southeast Asia's future power generation structure, promote the transition of coal power to flexible backup services, and advance the clean and efficient transformation of coal power. **Third**, promote market-based reforms of electricity and create a favorable environment for the development of renewable power in the region. **Fourth**, Southeast Asian countries should improve their market investment and financing mechanisms, strengthen environmental and risk assessment of the financial sector, and broaden the funding sources for renewable power. **Fifth**, it is important to enhance political trust, seek inter-regional power cooperation, to promote the interconnection of ASEAN power grids. **Sixth**, it's necessary to pay attention to just transition, formulate their respective strategic plans for just energy transition and develop systematic approaches to issues such as technological innovation and talent cultivation in different regions and industries during the transition. **Seventh**, making full use of the technology, capital and experience from international cooperation to accelerate the development of renewable power.

Recommendations for China's cooperation with Southeast Asia in promoting low-carbon transition of the power sector in the region: First, China should actively engage in dialogue and cooperation with Southeast Asian countries to share its best practices in power sector transition and provide transition plans tailored to local conditions. **Second**, it's necessary to strengthen clean power investment and trade cooperation with Southeast Asian countries, thus shifting to a manufacturer and exporter of renewable power generation equipment. **Third**, promoting its green investment and financing cooperation with Southeast Asian countries, to strengthen pre-project assessment of overseas investments and financing, and uphold local just transition. **Fourth**, China should actively support Southeast Asian countries in upgrading their power grids, improving cross-border power grid interconnection, promoting the development of smart grids, distributed energy systems and energy storage technologies and the establishment of international standards in these areas, so as to promote an integrated renewable energy resources.

Fifth, China should take pragmatic actions to promote international cooperation on supply chains, ensure the security and stability of supply chains, and cooperate with Southeast Asian countries to make supply chains greener and more low-carbon, thus providing economically and technically viable options for low-carbon energy transition.

Chapter 1. New Landscape of Global Energy Transition

The spread of the global energy crisis has led to a general increase in energy prices, and the geopolitical conflict is also having certain impact on global energy security. In 2021, the price of natural gas, coal and oil, the three conventional energy resources, soared worldwide, and the energy crisis started in Europe eventually spread around the world. Taking the Dutch TTF natural gas futures prices as example, the lowest and highest TTF futures prices in 2021 were 15.5 euros/MWh on March 3 and 187.8 euros/MWh on December 21 respectively, a difference of approximately 12.1 times. The surge in natural gas prices has stimulated the demand for alternatives such as coal and oil, which likewise have seen sharp rises in prices. The difference between the highest and lowest Newcastle coal futures prices was around 3.4 times in 2021, which was 1.7 times for Brent oil futures. The marked rise in the prices of the three conventional energy resources spread all over the world along global train chains, ultimately leading a global energy crisis. Meanwhile, Russia, as an important energy exporter in the world, plays a pivotal role in global energy supply. For Europe, imports of oil and gas from Russia has been around 25% and 35% respectively. Therefore, the outbreak of the geopolitical conflict can trigger turmoil in global energy markets and generate a significant impact on global energy supply and the future global energy landscape.

As the disadvantages of a development path that is highly dependent on fossil fuels is increasingly prominent, it is vital to accelerate the development of renewable energy and raise the level of electrification. On the one hand, energy shortages arise from fossil fuel dependence amid the global energy crisis and consequently endangered national energy security, such as the recent power shortages in India, Japan, China and many European countries. On the other hand, as global carbon budgets shrink, fossil fuel is gradually stepping off the stage of history, and the global demand for fossil fuels will decline dramatically, with the share of fossil fuel in end-use energy consumption expected to fall from 65% in 2019 to around 20% by 2050, when carbon neutrality will have been achieved. Renewable energy will replace the fossil fuel to a large extent due to its large scale development and the popularity of electrification, in which low-carbon power such as PV and wind power will make greater contribution due to its declining costs. It is expected that under the carbon neutrality target, global combined installed wind and solar power capacity will increase more than 15 folds from the 2019 level by 2050[1].

It is imperative for countries around the world to strengthen their low-carbon transition efforts, and so far, most countries have set carbon-neutral or net-zero emission targets. The Working Group I of the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC) revealed global warming of 1.09°C[2], which is further closer to the threshold of the temperature control target set in the *Paris Agreement.* Countries need to step up their low-carbon transition efforts to narrow or even bridge the gap with the target. Most countries have taken corresponding low-carbon transition actions. As of June 9, 2022, 132 countries had proposed or would propose carbon neutrality or net zero emission targets, of which 74 countries had specified their carbon neutrality targets through verbal commitments, policy statements or legislation, with four countries, including Barbados, Bhutan, Maldives and South Sudan, having set the toughest deadline of 2030 for carbon neutrality. In addition, 17 countries have written their carbon neutrality targets into law, mostly in Europe, including Germany, France, Sweden and Russia[3].

Some countries have agreed on coal phase-out targets, and are redoubling their efforts to develop renewable energy. The outcome of COP26—the *Glasgow Climate Pact*—has for the first time set out clear requirements for countries to phase down coal power plants that have not been retrofitted with emission reduction facilities. Besides, over 70 countries and organizations have signed the *Global Coal to Clean Power Transition Statement*. As of mid-2021, 21 countries had promised to phase out coal within a fixed timeline, most of which, however, are developed countries of the G20 members and from the EU[4]. Meanwhile, most countries have raised their renewable energy development targets in the updated NDCs. For example, the EU has raised the 2030 target share of renewable energy in the primary energy mix from 32% to 40%, the US Biden administration has promised to achieve “zero-carbon power” by 2035, and Southeast Asia countries Indonesia and Malaysia have raised the share of renewable energy in the primary energy mix to 23% and 31% respectively by 2025.

Chapter 2. Status of Low-carbon Development of the Power Sector in Southeast Asia

2.1 Development characteristics of the power sector in Southeast Asia

2.1.1 Overall installed capacity of the power sector in Southeast Asia

Installed capacity has continued to grow over the past 20 years. From 2005 to 2020, the total installed capacity in Southeast Asia reached 285GW, including 150GW of new one, representing an annual average growth rate of about 6.6%. The total power generation in the region has tripled over the past 20 years, and population growth and economic development will support the growth of installed power capacity of the region, which is one of the most economically dynamic regions in the world. According the ACE [5], the total planned installed capacity will reach 334GW by 2025.

Fossil fuel still plays an important role in installed incapacity. As indicated by the energy mix of installed power, fossil fuel accounts for more than 75% of the total installed capacity in South Asia's power sector, and as of 2020, the proportion still took up to 66.5%. Coal takes up roughly 1/3 of the total installed capacity, with Indonesia, Vietnam and Malaysia ranking the top three in the region in this regard. Over the past 20 years, the total power generation in Southeast Asia has increased threefold, with coal power generation playing a dominant role, which has risen sixfold, while gas power generation has more than doubled, and the share of oil-fired power has fallen by around 80%. By 2020, coal power generation already accounted for about 40% of the total generation, and the demand for coal will remain high in the future. The overall share of installed fossil fuel capacity will fall to 62.4% by 2025 as planned, but of new installations, coal power installations are still as high as 20GW, or about 1/5 of the total existing renewable energy installations, most of which come from Indonesia, Vietnam and the Philippines.

The share of installed capacity of renewable energy is growing at a faster rate. The share in Southeast Asia grew from 19.1% in 2005 to 33.5% in 2020, with the growth mostly taking place in the past decade. The actual share of installed capacity of renewable energy in the region of 2020 was only 1.5% short of the expected renewable power development target for 2030. It is mainly due to the rapid increase in hydropower and PV power installations, which rose from 24.9GW and almost zero in 2005 to 59.5GW and 22.9GW in 2020 respectively, with a tenfold increase in PV power installations over the past five years. In countries such as Laos, Vietnam, Cambodia and Myanmar, the share of installed capacity of renewable energy reached or exceeded half of the total in 2020. In 2020, renewable energy accounted for about 82% of new installations. To break it down, new PV power installations occupied the largest share, reaching 11.18GW, and new hydropower installations, which dominate the current power supply structure, registered 6GW or so. The installed capacity of renewable energy generation in the ten ASEAN member states increased by almost 50% in 2019 compared with 2015, from 17.7% to 21.7% of the total generation. According to the statistics of projects under construction[6], new renewable energy installations will reach 30GW by 2025, by which the share of installed renewable power capacity will have increased to 37.6%, with wind power (12.4GW), PV power (6.7GW) and geothermal power (4GW) dominating the increase.

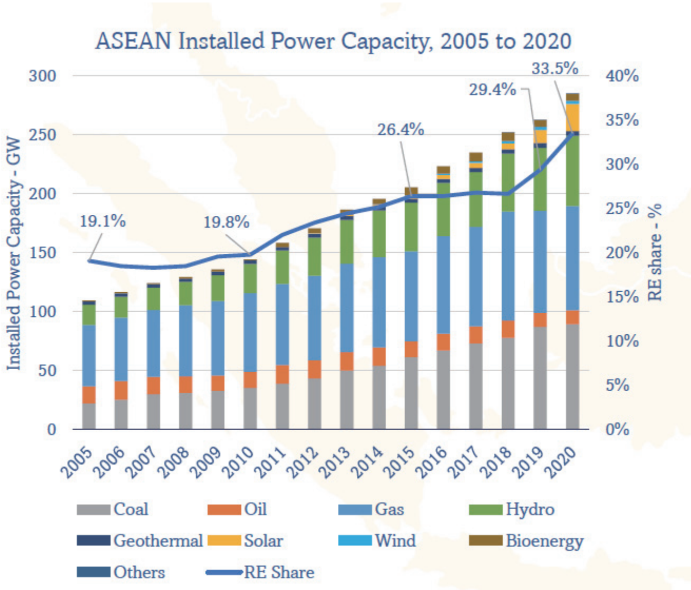


Figure 2-1 Trends in cumulative installed power capacity and changes in the share of renewable energy in Southeast Asia, 2005-2020

(Source: ASEAN Power Updates 2021)

2.1.2 Coal power development in Southeast Asia

Southeast Asia is witnessing a clear trend of coal reduction and phase-out, but coal power remains a main

source of power generation and a large number of new coal power projects are continuing. As of 2021, Southeast Asia had canceled or suspended more than 140GW of coal power plant installations, equivalent to the sum of installed power capacity in Indonesia and Vietnam in 2020. Although a large number of coal power projects have been canceled or stopped, many new ones are still moving forward. In 2021, more than 70GW of coal power projects were planned or under construction in Southeast Asia. Indonesia and Vietnam are still the backbone supporting the future development of coal power, with combined coal power installations planned and under construction in the two countries accounting for 76% and 86% respectively of the total in the region. Additionally, 2.2GW of new coal power installed capacity in Indonesia, Vietnam and Cambodia were put into operation in 2021.

Table 2-1 Summary of coal power installed capacity in different states in Southeast Asia (MW)

	Planned	Under construction	Cancelled
Brunei	0	0	0
Indonesia	16285	11839	36520
Malaysia	0	0	900
Myanmar	0	0	21225
Thailand	655	0	12551
Laos	6726	0	700
Cambodia	0	1765	4880
Vietnam	18160	9840	48565
Philippines	3365	1621	15788
Total	45191	25065	141129

(The collection is based on the CASISD Southeast Asian Power Plant Database[1])

The retirement or renovation of young coal power plants remains a key challenge facing Southeast Asian

[1]The CASISD Southeast Asian Power Plant Database is a power plant database covering the ten countries in Southeast Asia, created by the Project Team based on Global Coal Plant Tracker, Global Gas Plant Tracker, Global Solar Power Tracker, Global Wind Power Tracker, Global Power Plant Database and Platts World Electric Power Plant Database in conjunction with the relevant data found.

countries. An IEA report[7] shows that Southeast Asia has the youngest coal power units. According to the Southeast Asian Power Plant Database, the average life span of the coal power plants currently operating in Southeast Asia is approximately 10.6 years, which is consistent with relevant research findings[8]. While Vietnam, the Philippines and Indonesia have made promises of phasing out coal power, the retirement of young coal power plants remains a key challenge in Southeast Asian countries. Indonesia, Vietnam, Thailand and the Philippines are countries with a high number of coal power installations in service. The proportion of coal power units with a service period of less than 10 years has exceeded 50% by installed capacity in Indonesia, Vietnam and the Philippines and even reached 88% in Vietnam. Earlier at the COP26 climate summit, Vietnam pledged to stop the development of new coal power plants and to completely withdraw from coal power over the next decade. However, there are still 28GW of coal power plants under construction or planned in Vietnam, and 17GW is expected to come into service by 2025. To meet its coal withdrawal commitment, Vietnam will face problems regarding the early retirement or clean transformation of a large amount of coal power capacity, and the stability of its power system. On the whole, the high proportion of young coal power plants, in conjunction with the continued planning of new coal power projects will expose Southeast Asia to the early retirement and renovation of a large amount of coal power capacity, and added with a high risk of asset stranding.

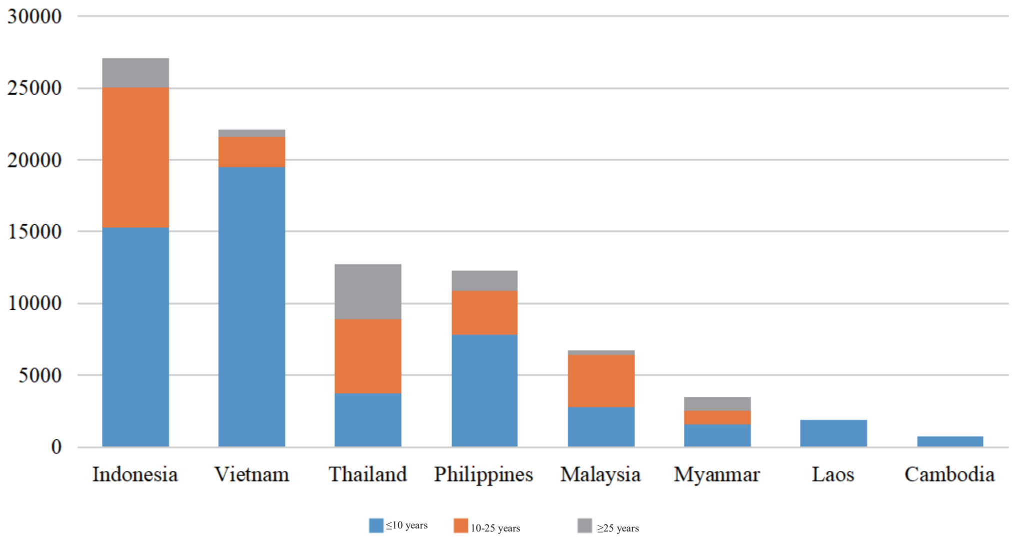


Figure 2-2 Installed capacity of coal power plants with different service times in Southeast Asian countries (MW)

(Collated based on the CASISD Southeast Asian Power Plant Database)

In Southeast Asia, there is an increasing trend of cleaner coal power technologies, but there is still great room for technological upgrading and transformation of existing coal power units. Of the coal power plants operating in Southeast Asia, more than 70% are subcritical, and only 14% and 8% use supercritical and ultra-supercritical technologies. The Manjung power plant in Malaysia was the first large ultra-supercritical coal power unit in Southeast Asia. Since then, coal power units in Indonesia, Vietnam, Thailand and Cambodia have begun to adopt the ultra-supercritical technology one after another. Additionally, in coal power plants under construction and planned in Southeast Asia, the share of subcritical units has decreased significantly, both to less than 15% and at the same time, the share of supercritical and ultra-supercritical units has jumped to over 40%. Despite unclear technologies adopted by some power plants, the available results suggest that there is a growing trend towards cleaner coal power technologies and that building new and efficient coal power plants is a crucial step in driving a low-carbon transition in the region.

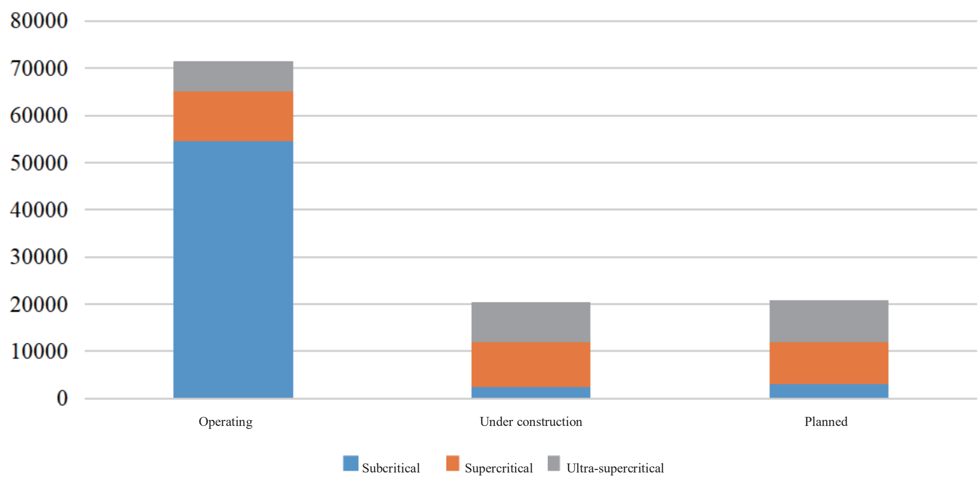


Figure 2-3 Installed capacity corresponding to different power generation technologies in coal power plants in different states in Southeast Asia (MW)

(Collated based on the CASISD Southeast Asian Power Plant Database)

With more than 100GW of gas power projects in the pipeline, the opportunities and risks are noteworthy for natural gas in Southeast Asia's energy transition. A GEM report[9] notes that Southeast Asia is a global leader in the planned installation of gas power plants. According to the Southeast Asian Power Plant Database, in 2021, installed gas power capacity under construction and planned in the region exceeded 17GW and 100GW respectively. Currently, the planned installed capacity of gas power generation is already twice as much as the planned installed coal power capacity, and the increased installed capacity in gas power plants planned and under construction is close to the canceled or suspended installed coal power capacity. On the one hand, with gas power accounting for nearly a third of Southeast Asia's total power generation in 2020, natural gas is a key energy source for maintaining the safety and stability of energy systems in the region and driving the scale development of renewable power. At the same time, however, the recent growth of natural gas production in the region has not been able to meet the growing demand. Although Southeast Asia is still a net exporter of LNG, as the market demand for LNG increases, countries in the region will gradually become net importers of LNG, and with global gas market volatility and price rises, Southeast Asia also faces multiple challenges in advancing the development of new gas power projects.

Table 2-2 Summary of installed gas and coal power capacity in different states in Southeast Asia (MW)

Gas				Coal			
Country	Planned	Under construction	Canceled or suspended	Country	Planned	Under construction	Canceled or suspended
Brunei	0	0	0	Brunei	0	0	0
Cambodia	4800	0	350	Cambodia	0	1765	4880
Indonesia	6650	3635	2200	Indonesia	16285	11839	36520
Malaysia	1500	3442	1950	Singapore	0	0	0
Myanmar	9980	388	275	Laos	6726	0	700
Philippines	11806	650	4620	Malaysia	0	0	900
Singapore	400	0	0	Myanmar	0	0	21225
Thailand	10560	8240	0	Philippines	3365	1621	15788
Vietnam	55215	1050	45710	Thailand	655	0	11726
Laos	0	0	0	Vietnam	18160	9840	48565
Total	100911	17405	55105	Total	45191	25065	140304

(Collated based on the CASISD Southeast Asian Power Plant Database)

2.1.3. Renewable power development in Southeast Asia

The growth of renewable power in Southeast Asian countries has been driven mainly by the growth of

hydropower over the past two decades, while non-hydro renewable power generation has also been growing rapidly in recent years. From 2005 to 2020, installed hydropower capacity in Southeast Asia rose from 17GW to 59GW. Hydropower accounted for more than half of the total installed renewable energy capacity by 2020. The Mekong Basin countries, such as Cambodia, Myanmar and Vietnam, were major contributors to the increase in hydropower installations, and the installed capacity of large hydropower projects in the region increased from 6GW to 26GW from 2006 to 2016. 83%, 47% and 46% of the total installed hydropower capacity are in Laos, Myanmar and Cambodia respectively. In recent years, non-hydro renewables have been growing rapidly, with the proportion of non-hydro renewable installations risen to more than 34% in 2020. Non-hydro renewable power capacity has grown nearly tenfold over the past decade, to which the growth of PV power generation has contributed 70%, with such growth mainly contributed in Vietnam, Thailand and the Philippines.

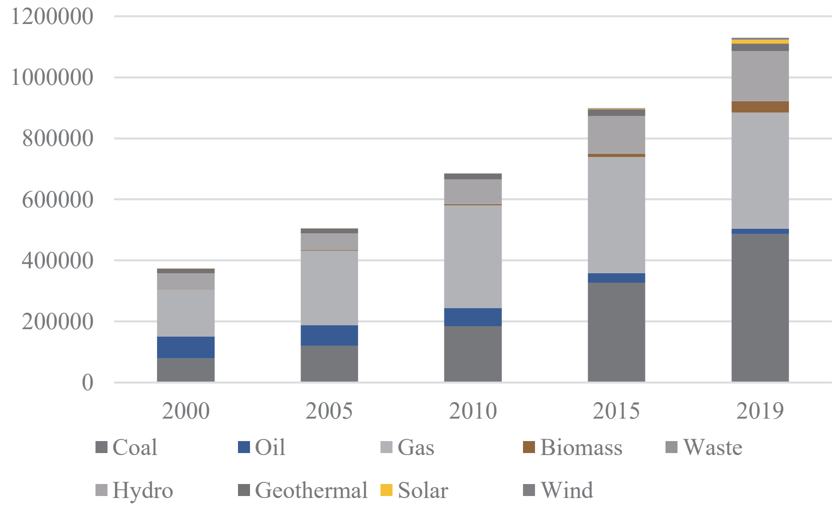


Figure 2-4 Power generation structure in Southeast Asia, 2000-2019 (GWh)

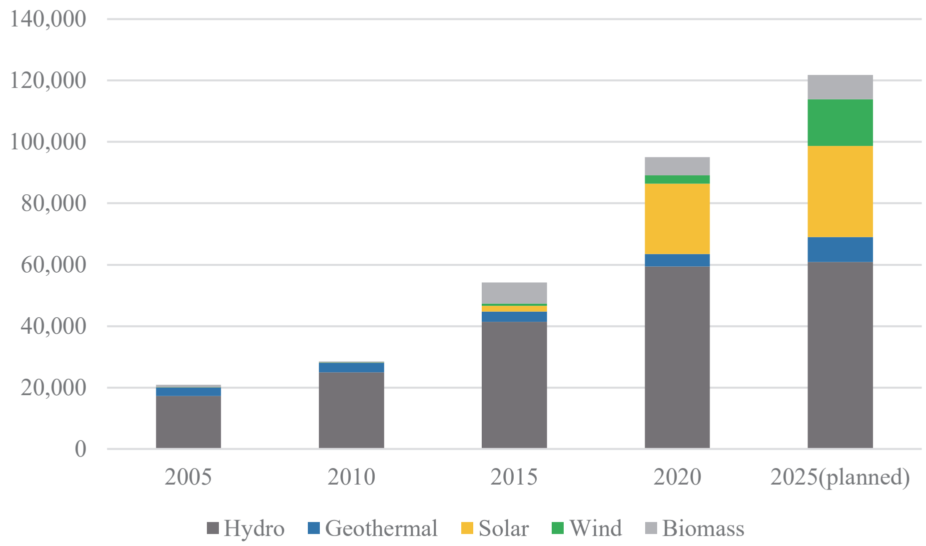


Figure 2-5 Structure of installed renewable energy capacity in Southeast Asia, 2005-2025 (with estimates for 2025 based on existing installed capacity) (MW)

PV and wind power are growing rapidly but unevenly in Southeast Asia, with most countries in the region still enjoying great room for development. The installed capacity of wind and PV power in Southeast Asia was less than 100MW before 2010, but rapidly increased to 708MW and 1,894MW respectively in 2015, and jumped to 2,665MW and 22,942MW respectively in 2020. The rapid increase in wind power installations was mainly attributed to the Philippines, Vietnam and Thailand, which together contributed 95% to the regional total by 2020. Meanwhile, PV power installations are growing more rapidly than wind power installations throughout Southeast Asia, mainly in Vietnam and Thailand. The growth of PV power installations between 2010 and 2015 was mostly credited to Thailand, while the growth over the past five years has been led by Vietnam, mainly due to appropriate policies, including both financial and technological ones, implemented in the country. In 2020, PV power installations in Vietnam and wind power installations in Thailand amounted to 16,656MW and 1,486MW respectively, accounting for 72.6% and 55.7%. According to the potential capacity of PV and wind power installations when the LCOE (levelized cost of energy) is lower than USD 150/MWh as shown in the RE Data Explorer[10], Thailand may have the largest potential installed PV power capacity, which is estimated to be 10,538GW or 34.5% of the total potential installed capacity in Southeast Asia, a threefold difference from the percentage of the existing installed capacity (12.4%). Myanmar boasts the most abundant wind energy resources and high solar energy resource potential in Southeast Asia, but the combined installed wind and PV power capacity there is less than 200MW[11]. With continuous advances in new energy technologies and declining costs, as well as ceaseless improvement of the policy environment, there is still plenty of room for the development of PV and wind power in most Southeast Asian countries.

Geothermal and biomass power presents a trend of stable development in Southeast Asia. Installed geothermal power capacity increased from 2,829MW in 2005 to 4,059MW in 2020. According to statistics of projects under construction, installed geothermal power capacity will increase to 8,113MW by 2025, mainly in Indonesia and the Philippines with rich geothermal energy resources, which are the world's second and third largest geothermal power producers respectively after the United States. The two countries together contributed about 25% to global geothermal power generation in 2021, and the proportion is expected to continue the steady growth trend in the future. Biomass power generation grew from around 1.6GW in 2006 to 7.2GW in 2016, with the growth mainly attributed to Indonesia, Malaysia and Thailand. Main biomass feedstock includes bagasse, rice husks, palm oil mill waste, wood chips and tree bark[12].

2.1.4. Status of power grids in Southeast Asia

Countries in Southeast Asia vary in terms of power grid development and face common problems such as insufficient reliability and difficulties in new capacity integration. Southeast Asia is dominated by emerging economies, most of which have provided over 90% of their population with access to electricity, which is low in a few countries such as Myanmar, Cambodia and Indonesia. Larger developing economies such as Vietnam, Malaysia, the Philippines and Thailand, where the grid coverage is high and power grids are well developed, mainly face problems such as insufficient reliability and difficulties in new capacity integration[13]. Indonesia has not yet built a unified grid system due to the special geographical constraints of its numerous islands, and poor capacity in grid development. In countries such as Myanmar and Cambodia, which have weak political and economic foundations, domestic power grids feature a small range of power transmission and distribution, poor reliability, and difficulties in power transmission to a wide range of areas, and are still at an initial stage. Besides, in large importers of electricity such as Cambodia, Singapore and Thailand, and exporters of electricity like Laos, power grids are developed also to increase grid interconnection in the region. [14]

Some countries in Southeast Asia have established power cooperation by building cross-border power grids, and trade in electricity between countries is mainly bilateral, with multilateral trade still in its infancy. So far, most of the cross-border trade in electricity in ASEAN has taken place between the Mekong countries. Cross-border power grids also exist between Malaysia and Indonesia and between Malaysia and Singapore. Cross-border power transmission capacity in Southeast Asia has reached 2,275MW, including 1,120MW of cross-border power grid connections between Thailand and its neighboring countries accounting for 50% of the total. In addition, the capacity of cross-border power transmission between Malaysia and Singapore and between eastern and western Malaysia amounts to 755MW[15]. Trade in electricity between Southeast Asian countries is mainly bilateral, with multilateral trade still in its infancy. With the intensification of regional integration, trade in electricity will shift from a bilateral model to a multilateral one, and eventually to a unified model. Since 2018, the Laos-Thailand-Malaysia-Singapore Power Integration Project (LTMS-PIP) has facilitated small-scale multilateral trade in electricity within Southeast Asia, and as of 2019, had delivered 250GWh of electricity from Laos to Malaysia via Thailand.

Table 2-3 Capacity of cross-border power lines between Southeast Asian countries in 2021

Interstate	Maximum capacity (MW)
Laos—Vietnam	200
Malaysia—Singapore	525
Sarawak-Kalimantan (Malaysia)	230
Thailand—Cambodia	120
Thailand—Laos	700
Thailand—Malaysia	300
Vietnam—Cambodia	200
Total	2,275

(Source: The 6th ASEAN Energy Outlook)

Several intra-regional and inter-regional power grid interconnection projects, represented by the ASEAN Power Grid (APG) project, are underway to enhance power interconnection in Southeast Asia. Major power interconnection projects in Southeast Asia include the intra-regional APG, the inter-regional Greater Mekong Subregion (GMS) cooperation and the Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC), among others. The APG aims to facilitate trade in electricity and enhance the integration of power systems by promoting strategic interconnection among ASEAN member states, including improving infrastructure development and trade in electricity mechanisms. As of 2019, seven of the 16 key power interconnection projects within the framework of the APG had been completed. In terms of inter-regional power cooperation projects, the GMS aims to enhance power grid interconnection between the five Mekong countries and China and a Cambodia-Bangladesh-China multilateral project with a capacity of 4GW is underway, which will continue to facilitate trade and investment through infrastructure improvements. The BIMSTEC project involving Myanmar and Thailand has also signed a memorandum of understanding on power trade and power grid interconnection between the parties involved. In the future, the clean energy grid sharing project between ASEAN and Australia will also enhance grid interconnection between Southeast Asia and Australia. [16]

Smart grids and mini-grids are highly applicable in Southeast Asia and therefore enjoy great room for development in the future. Power demand in Southeast Asia is growing at twice the global average rate. Such growing demand makes it particularly important to develop matched modern power infrastructure. Many emerging markets in Southeast Asia face serious power transmission and distribution problems, including intermittent power outages, power loss and theft. Introducing smart grids to these countries will not only increase the flexibility of power grids, but is also a practical move to meet the growing demand for electricity in these emerging economies. In countries with weak infrastructure and low electricity coverage rates, such as Myanmar and Cambodia, variable renewable energy (VRE) can hardly be integrated into power grids. The mini-grid technology can help solve the problem of access to electricity in remote areas and increase the utilization of the abundant wind power resources there. According to a Northeast Group study, Southeast Asian countries will spend over USD 9.8 billion on smart grids between 2018 and 2027, while many international organizations, including the United States Agency for International Development (USAID), are already working on smart grid cooperation projects in Southeast Asia[17].

2.2 Low-carbon transition policies of the power sector in Southeast Asia

Currently, many Southeast Asian countries are advancing the low-carbon transition of their power sector by laying down clear development paths and measures in terms of top-level design, market support and environmental regulation.

2.2.1 Development goals and strategic plans

The *ASEAN Plan of Action for Energy Cooperation (APAEC) 2016-2025* is a key policy document guiding Southeast Asian countries to address climate change, which aims to promote multilateral energy cooperation and integration and achieve the objectives of the ASEAN Economic Community. Specifically, Phase I (2016-2020) covers short to medium-term strategies with the theme of enhancing ASEAN energy interconnection and market integration to achieve the security, accessibility, affordability and sustainability of energy systems. Phase

II (2021-2025) involves more ambitious targets and initiatives based on Phase I to enhance energy transition and adapt to future sustainable energy development, with a particular focus on accelerating energy transition and strengthening energy resilience through greater innovation and cooperation.

Southeast Asian countries have also developed corresponding low-carbon transition goals and strategic plans for their own national conditions. For example, Vietnam will support its target of achieving net zero emissions by 2050 through legislation, while Thailand, as the rotating chair of the Asia-Pacific Economic Cooperation (APEC), and Indonesia, as the host country of the G20, have also set targets to achieve net zero emissions by 2060 and 2070 respectively. Meanwhile, ASEAN as a whole and Southeast Asian countries have set renewable energy development targets. For example, ASEAN has proposed to increase the share of renewable energy in the primary energy mix to 23% and the proportion of installed renewable power capacity in the total to 35% by 2025. Also, Indonesia, Malaysia and the Philippines have planned their renewable power installation targets. Moreover, they have successively introduced energy policies and concrete measures to provide policy guarantees for the low-carbon transition. Recently, countries such as the Philippines and Vietnam are updating their energy sector development plans to limit new coal power projects and develop green and clean energy.

2.2.2 Industry support and market incentives

In recent years, Southeast Asian countries have also made great efforts in energy transition support and incentives, including introducing FIT policies, self-consumption options, competitive bidding, tax credits, preferential loans, capital subsidies, tradeable and renewable energy certificates, etc. For example, Malaysia started to change its traditional way of bidding and embarked on competitive bidding for Large-Scale Solar (LSS) Programmes to promote renewable power deployment. In addition, during the pandemic, some Southeast Asian countries mitigated the impact of COVID-19 on the energy sector through various fiscal stimulus packages, such as subsidies and price discounts, liquidity support, exemptions and relaxations, and new energy projects and programs[18].

Of the existing support incentives, FITs have gradually become the core policy to promote the development of renewable power. As a result of technological advances and cost reductions for renewable energy generation, FITs have been adjusted several times in various countries, and the specific mechanisms are still evolving. Currently, countries with significant growth in installed renewable energy capacity, such as Indonesia, Malaysia, the Philippines, Thailand and Vietnam, have generally developed and implemented FITs, which are subject to regional and national ceilings on the cost of power generation in Indonesia and the LCOE plus additional subsidies for returns on investment in different technologies in other countries. Malaysia and Thailand have both taken into account different installed capacity quotas for renewable energy technologies when setting integrated tariffs, and provided additional incentives for specific regions, effectively boosting renewable energy investments. In addition, Malaysia has established a sound and transparent FIT application platform to optimize application and power purchase agreement signing processes. Thailand's higher tariffs than other countries have directly contributed to the increase in renewable power installations.

2.2.3 Environmental protection and regulatory policies

Several countries in Southeast Asia have enacted policies and laws related to environmental protection and renewable green development[19]. For example, Singapore has introduced policy documents such as the *Climate Action Plan 2020* and the *Green Plan 2030*, and the comprehensive *Environmental Protection and Management Act*; Vietnam has enacted the *National Strategy for Environmental Protection until 2020 and Vision toward 2030*, and the *National Action Plan on the 2030 Agenda for Sustainable Development*, and at the same time, the National Assembly of Vietnam has recently adopted the *Law on Environmental Protection (Amendment)*, which has entered into force on January 1, 2022.

In terms of air quality standards, except for Myanmar, all Southeast Asian countries have enacted ambient air quality standards, which are regularly reviewed and updated. Among them, Singapore has set more stringent criteria for six control targets in relevant standards, and is the first country in Southeast Asia to publish PM2.5 concentrations on a daily basis. Despite a gap between the overall ambient air quality standards of Southeast Asian countries and those of developed countries, some countries have closed the gap with the US and the EU in terms of concentrations of traditional pollutants such as sulfur dioxide and nitrogen dioxide by updating their standards. Thailand and Laos have even established pollution emission standards for power plants. In addition, some Southeast Asian countries have included environmental protection in their investment or foreign investment laws[20]. For example, Indonesia is more concerned about pollution from energy investments, and has therefore specified the polluter's obligation to dispose of waste generated by his activities or behaviors in the *Environmental Management Law*.

Southeast Asia has also cooperated on regional environmental policies and regulations. For example, ACE has been entrusted by the AFOC to conduct a baseline study on CO_2 emissions from coal power plants in the region through the ASEAN Climate Change and Energy Project (ACCEPT), with a view to setting emission standards for coal power plants[21]. Meanwhile, the ASEAN Senior Officials on the Environment Meeting (ASOEN) is held annually, with seven working groups on areas such as climate change, environmental sustainability, biodiversity and marine environment taking charge of research in related areas to provide strategic guidance for advancing ASEAN environment cooperation. Furthermore, ASEAN has maintained regular exchanges with its international partners on environmental issues, including the ASEAN-Japan Dialogue on Environmental Cooperation, the ASEAN-EU High-level Dialogue on Environment and Climate Change, the East Asia Summit Environmental Ministers' Meeting, and partnership meetings on specific topics.

2.3 Status of international cooperation in the power sector in Southeast Asia

Based on the Southeast Asian Power Plant Database, this section analyzes overseas enterprises' investments in Southeast Asian power plants. It focuses on two types of investment: one is equity investment and the other is engineering equipment investment. Due to the lack of data related to investment amount, installed capacity is used in this section to reflect the investments made by overseas enterprises.

2.3.1 Overall investments by overseas enterprises in power plants in Southeast Asia

Overseas countries have a high level of involvement in the investment in power development in Southeast Asia. Of the existing power projects operating in Southeast Asia, installations involving overseas investments account for over 60%. Engineering equipment investments are an important form of overseas investments, supporting a gross installed capacity of 160GW, while the installed capacity involving equity investments has already amounted to nearly 50GW. Figure 2-6 shows the temporal trend of the cumulative installed capacity involving the two types of investments. It suggests that the total installed capacity involving overseas investments has seen a continued upward trend over the past two decades. After 2009, the production capacity in which overseas countries invested continued to stay high each year and the cumulative installed capacity involving equity and engineering equipment investment in 2021 has reached more than twice the level of 2011.

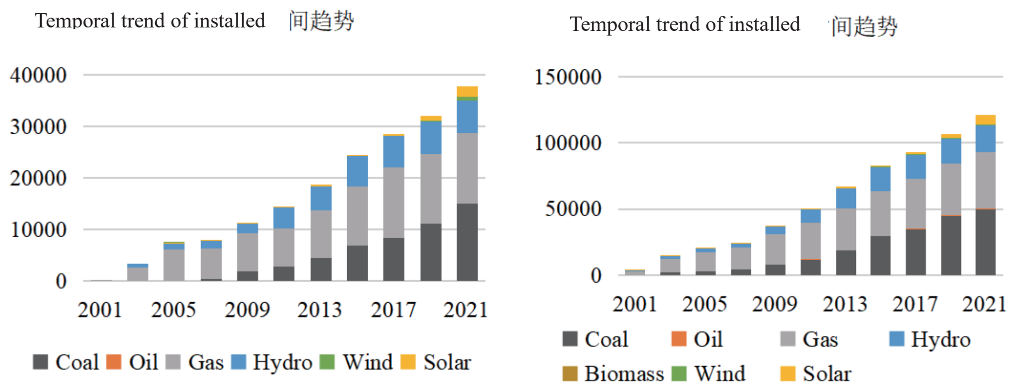


Figure 2-6 Installed capacity involving overseas investments in Southeast Asia's power sector, 2001-2021 (MW)

China and Japan are countries most involved in power investment in Southeast Asia, with far more equity and engineering equipment investment in installed capacity than other countries. South Korea, France and the US are second-tier investors. Other countries such as Germany, Australia and the UK have mainly invested in Southeast Asia's power sector in the form of engineering equipment investments.

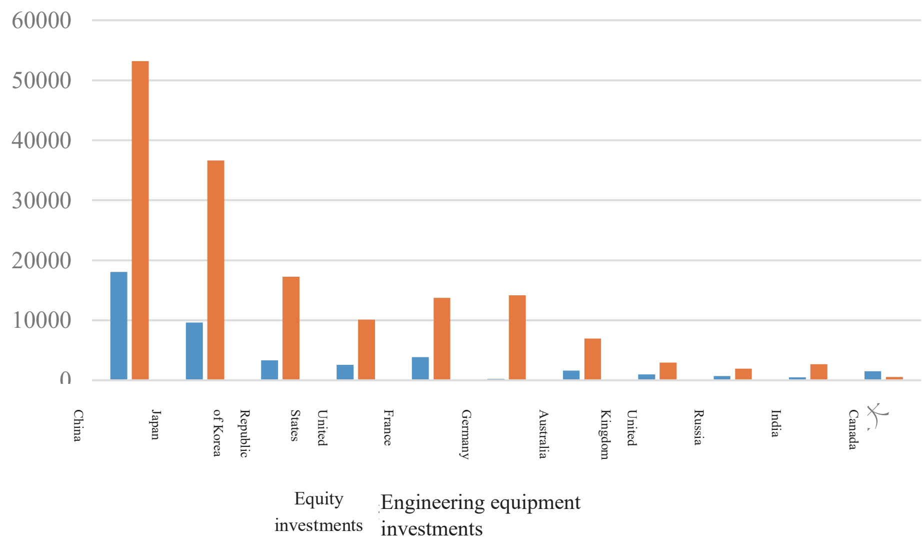


Figure 2-7 Cumulative installed capacity involving overseas investments in Southeast Asia, 2001-2021 (MW)

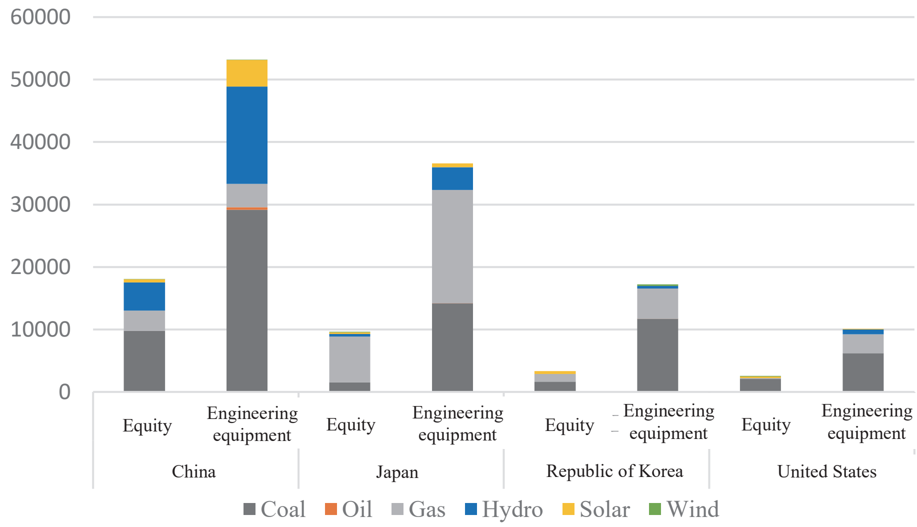


Figure 2-8 Structure of cumulative installed capacity involving equity and engineering equipment investments from China, Japan, Korea and the US in Southeast Asia, 2001-2021 (MW)

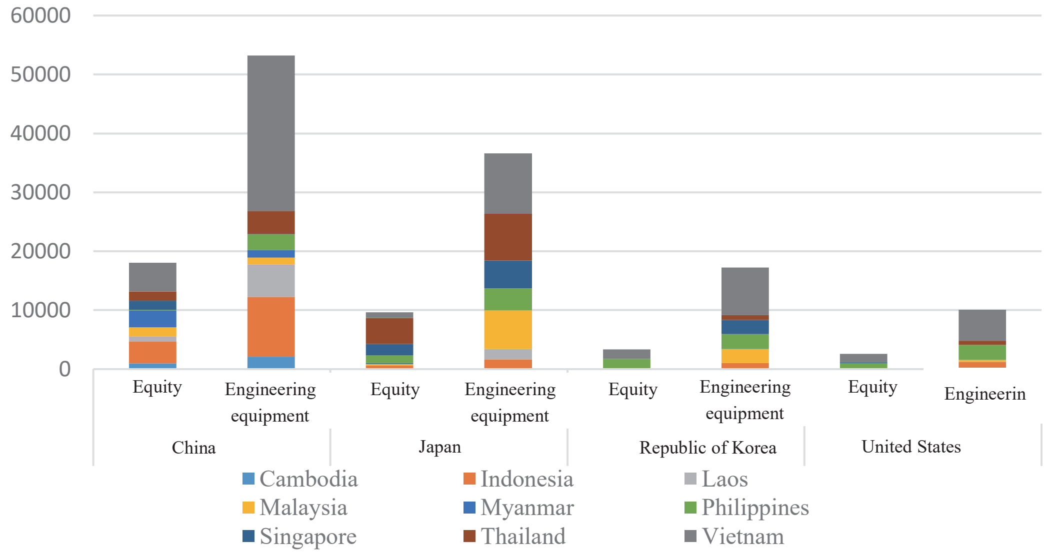


Figure 2-9 Cumulative installed capacity involving equity and engineering equipment investments from China, Japan, Korea and the US in Southeast Asian countries, 2001-2021 (MW)

The structure of power investments by overseas countries in Southeast Asian countries is highly compatible with the power supply structures of Southeast Asian countries. In terms of installed capacity involved, overseas investments have mainly flowed into Indonesia, Vietnam and Thailand. Figure 2.2.5 shows the structural characteristics of power investment by overseas countries in Southeast Asia. In terms of investment structure, overseas countries' investment in Southeast Asian countries are consistent with local power structures and are demand-oriented. For example, overseas investment are dominated by coal power in Indonesia, Vietnam and Malaysia, gas power in Thailand and Singapore, and hydropower in Laos and Myanmar. In addition, the wind and PV power markets in Vietnam have also attracted huge overseas investment. In terms of installed capacity involved, Indonesia, Vietnam and Thailand rank the top three in Southeast Asia, and have also attracted the most overseas investments in the power sector. Overseas equity and engineering equipment investments in the three countries all account for more than 50% of the corresponding total investments.

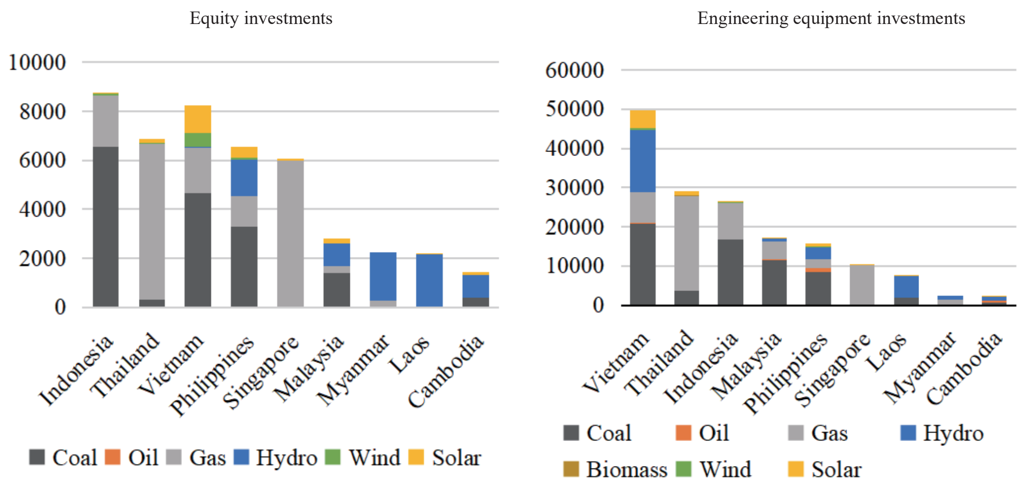


Figure 2-10 Structure of cumulative power investments by overseas countries in Southeast Asian countries, 2001-2021 (MW)

Overseas countries' investments in Southeast Asia's power sector have mainly flowed to fossil fuels, but investments in renewable power have gradually increased in recent years. Hydropower has been a key area of overseas investments in renewable energy, and PV power has been growing rapidly in recent years. Coal and gas power have been a focus of overseas investment, with combined installed capacity invested exceeding 65% of the total. In terms of renewable power, hydropower has been a key area of overseas investments. Since 2001, overseas countries have been involved in the investment in hydropower projects in

Southeast Asia, with over 70% of installed renewable energy capacity flowing to hydropower and the installed hydropower capacity involving engineering equipment investments soaring from 0.9GW in 2001 to 4.5GW in 2015. Overseas investments in non-hydro renewable energy have mostly flowed to PV power projects, mainly in Vietnam, the Philippines and Thailand. After 2015, investments in PV power installations grew significantly and the installed PV power capacity involving equity and equipment investments from overseas countries in 2021 increased sixfold and sevenfold respectively, compared with the 2015 levels. China is one of the largest PV power investor in Southeast Asia, with around 65% of PV engineering equipment installations in the region coming from China, followed by Germany and Japan.

2.3.2. China's investments in the power sector of Southeast Asia

China's power investment in Southeast Asia continue to rise, with the focus on future investments shifting to renewable energy. Over the past 20 years, the cumulative installed capacity involving Chinese power investment in Southeast Asian countries has continued to grow. As of 2021, the cumulative installed capacity involving Chinese equity and engineering equipment investment approached 20GW and 60GW respectively, both exceeding 40% of the overall overseas investments. In addition, cumulative data shows that China has gradually increased renewable power investment in recent years, with a clear trend toward cleaner investment. As China announced that it will strongly support green and low-carbon energy development in developing countries and will not build new coal-fired power projects abroad, the country will focus on investing in renewable energy development.

For renewable power, Chinese investments have mainly flowed to hydropower and PV power projects. Specifically, hydropower is a beneficiary of China's long-term investment and a main sector of China's renewable power investment in Southeast Asia. The volume of PV power investments has increased significantly in recent years. In 2021, the installed capacity involving Chinese engineering and equipment investment in PV power projects in Southeast Asia exceeded 4GW, equivalent to a quarter of new PV installations in Vietnam in 2020. In terms of investment destinations, China has channeled its hydropower investments mainly to Cambodia, Laos, Vietnam and Myanmar, which are relatively rich in hydropower resources. In contrast, PV power investments have been mainly directed to Vietnam, the Philippines and Malaysia, with Vietnam receiving the most investments, significantly higher than any other country, due to the country's great efforts to promote PV development in recent years. At the end of 2020, Vietnam jumped to the third place in the global ranking of new installed capacity, making it one of the hottest PV markets in Southeast Asia. The structure of cumulative installed capacity involving Chinese renewable power investments in Southeast Asian countries from 2001 to 2021 is shown in Figure 2-12.

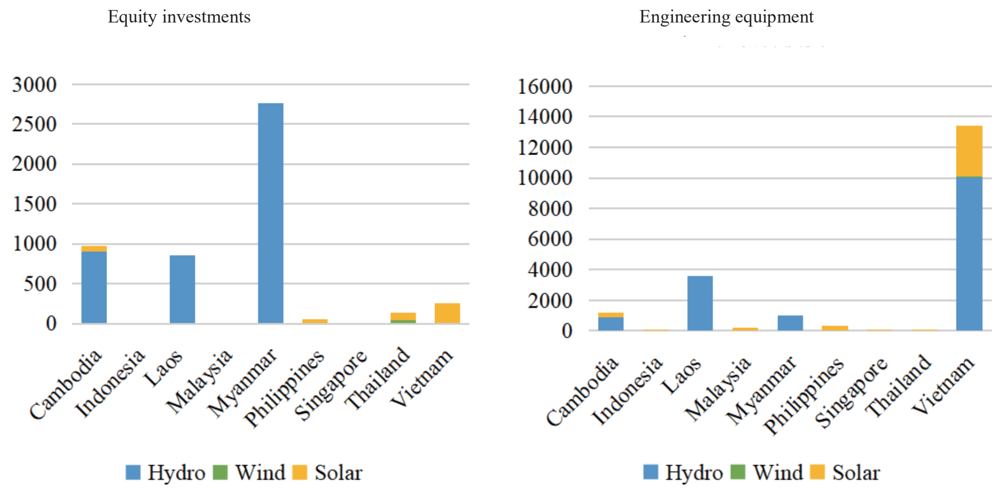


Figure 2-12 Structure of cumulative installed capacity involving Chinese renewable power investments in Southeast Asian countries, 2001-2021 (MW)

Chapter 3. Low-carbon Transition of the Power Sector in Southeast Asia: Opportunities and Challenges

3.1 Opportunities for the low-carbon transition of the power sector in Southeast Asia

3.1.1 Strong electricity demand in Southeast Asia in the future

Southeast Asia is one of the fastest-growing regions in the world in terms of power demand, according to IEA report. Driven by the growing use of electrical appliances and air conditioners, as well as increasing consumption of goods and services, power demand in Southeast Asia has been rising at an average rate of over 6% over the past 20 years. As estimated by IRENA[22], energy demand for power generation will grow by 95% by 2025 compared to 2016. Meanwhile, the IEA forecasts that electricity consumption in Southeast Asia will continue to rise at an average rate of 4% per year until 2040 when the total electricity consumption will be twice as much as it was in 2020. Renewable energy is key to meeting the ever-growing energy demand that can support economic development while balancing energy security and environmental sustainability, and therefore becomes an vital source of low-cost energy resources desperately needed by Southeast Asia at the current development stage. ASEAN Center for Energy (ACE) estimates show that the share of renewable power in Southeast Asia will increase from 15% at present to about 50% by 2040.

3.1.2 Huge potential of renewable energy resources in Southeast Asia

Southeast Asia enjoys huge, but mostly untapped potential of natural endowments for renewable energy. Southeast Asia has the best potential for hydropower development in the world, especially in Indonesia, Myanmar, and several lower Mekong countries. For instance, the hydropower potential in Laos alone registers about 26GW, estimated by OECD. Further, the region has very strong global radiation levels (references for PV facilities), averaging 1.5-2MW/m^2 per year. Indonesia, the Philippines and Vietnam also have prominent wind resources, with an average wind speed of 6-7m/s. In terms of geothermal, ocean energy and biomass resources, Indonesia and the Philippines are among the countries with the most developed geothermal energy resources in the world; archipelago countries such as Indonesia, the Philippines and Singapore have abundant ocean energy potential; Southeast Asia boasts rich bioenergy resources from agricultural and forest residues, industrial and urban waste, and traditional energy crops. These excellent natural endowments provide a reliable basis for further growth of renewable energy.

3.1.3 Renewable energy development targets set by ASEAN and Southeast Asian countries

By 2025, the share of renewable energy in the primary energy mix of ASEAN countries will reach 23%. Most countries have specified a clear direction for future renewable energy development in their NDCs, and the decarbonization of the power sector is in line with their development philosophy. Indonesia, Singapore and Myanmar have set targets and strategies for moving towards carbon neutrality; the Philippines and Vietnam are updating their energy sector development plans to limit new coal power projects and develop clean and green energy. The ACE estimates that under the scenario where each country fully meets its national energy efficiency and renewable energy targets, the share of the total installed renewable energy capacity will reach 37% by 2040, with PV power growing fastest at an annual average rate of 10.4%. To meet the targets planned by ASEAN countries, installed PV power capacity will have to jump from 32GW to 83GW between 2020 and 2025, while installed hydropower capacity will have to rise from 59GW in 2020 to 77GW.

Table 3-1 Climate targets and renewable energy development targets of Southeast Asian countries

Country	Climate targets and renewable energy development targets
Brunei	By 2035, a 63% reduction in energy consumption compared with the 2015 level, and an increase in the share of power generation from renewable energy to 30%; a 40% reduction in vehicle emissions; 55% forest coverage
The Phillipines	By 2030, a 70% reduction in greenhouse gas (GHG) emissions compared to the baseline scenario; 15GW of installed renewable power capacity
Malaysia	By 2030, a 35% reduction in carbon intensity, or a 45% reduction under the conditional emission reduction scenario (compared with in 2005); by 2025, a 31% share of installed renewable power capacity.
Cambodia	By 2030, a 41.7% reduction in emissions (of which 59.1% come from fossil fuels) under the conditional emission reduction scenario; by 2030, a 55% share of installed hydropower capacity, a 6.5% of biomass energy and a 3.5% share of solar PV power in the total installed capacity
Singapore	By 2030, a 36% reduction in carbon intensity compared with in 2005 and carbon peaking; by 2030, 2GW of installed PV power capacity
Thailand	By 2030, a 20% reduction in emissions under the unconditional emission reduction scenario, or a 25% reduction under the conditional emission reduction scenario; by 2037, a 30% share of renewable energy in end-use energy consumption, an increase in the share of installed renewable power capacity and renewable power generation to 36% and 20% respectively; by 2036, an increase in the share of renewable energy in energy consumption by the transport sector to 25%.
Viet Nam	By 2030, a 15-20% share of renewable energy in the total primary energy consumption and by 2050, a 25-30% share; by 2030, 31-38GW of installed PV and wind power capacity. By 2030, an increase in installed offshore wind power capacity to 4GW and by 2045, an increase to 36GW
Indonesia	By 2030, a 29% reduction in emissions under the unconditional emission reduction scenario, or a 41% reduction under the conditional emission reduction scenario; by 2025, an increase in the share of renewable energy in the primary energy mix to at least 23% and by 2030, an increase to 31%
Myanmar	By 2025, a 20% share of installed renewable power capacity; by 2030, 9.4GW of hydropower generation and a 30% share of renewable energy in rural electrification.
Laos	By 2025, an increase in the share of renewable energy in the total energy consumption to 30%

(Source: The 6th ASEAN Energy Outlook and IRENA)

3.1.4 Declining costs and rapid development of renewable energy

Cost is a major determinant of renewable energy use in Southeast Asian countries. The declining costs of PV and wind energy have provided sufficient economic impetus for the development of other renewables in Southeast Asia. According to IRENA, global costs of solar PV and offshore wind power generation in 2018 fell by 73.8% and 22% respectively compared with the 2010 levels. The LCOE levels of PV and wind power globally have fallen to within the range of fossil fuels, demonstrating that the efficiency of renewables is already competitive worldwide. However, IRENA estimates show that the LCOE levels of PV power in Southeast Asia averaged USD 0.19 per KWh in 2016, higher than the Asian average of USD 0.10 per KWh, indicating still great potential for reduction of installed PV power costs in Southeast Asia. The LCOE levels of onshore wind energy in Southeast Asia show a similar pattern to PV energy. Moving forward, the region as a whole is expected to reduce costs of renewable energy through measures such as focusing on the implementation of relevant policies, lowering the soft costs (e.g., licenses, power grids and land acquisition) associated with project development and improving the efficiency of regional supply chains.

3.1.5 Positive trend in international cooperation in Southeast Asia

International cooperation in technical assistance, technology deployment, investment & financing and capacity building is critical to a clean, low-carbon transition and to achieving conditional NDCs in Southeast Asia. Over the past few years, international cooperation models have been increasing from financing to technical solutions. China has been an important energy partner of Southeast Asia and as General Secretary Xi Jinping announced in 2021 to halt new coal-fired power projects abroad, green energy cooperation between China and Southeast Asia will become a key area of regional energy cooperation. The year 2022 has seen the official kick-off of the *Regional Comprehensive Economic Partnership* (RCEP), which was signed by 15 countries including ASEAN and China, Japan, Korea, Australia and New Zealand. The launch of the largest regional economic and trade agreement in Southeast Asia will open up broad prospects for international cooperation in the region. Against the backdrop of the official launch of the RCEP and the advancement of low-carbon transition in various countries, green international cooperation in Southeast Asia is gradually improving and will help bridge the real-world gaps and support the low-carbon transition of the power sector.

3.2 Challenges for low-carbon transition of the power sector in Southeast Asia

3.2.1 The accelerated withdrawal of coal power will exacerbate energy supply security risks and raise challenges such as asset stranding and just transition

Fossil fuels, especially coal, are a main source of energy for the current and future economic development in Southeast Asia. The growing demand for energy and electricity is a major challenge to Southeast Asia's low-carbon transition. The latest AEO6 study shows that while Southeast Asia is improving its energy efficiency to meet renewable energy targets, fossil fuels are expected to continue to dominate ASEAN's future energy landscape, with the total energy consumption to increase from 375MTOE in 2017 to 922MTOE by 2040, to which coal will contribute 47%. Meanwhile, the region's power consumption will grow at a rate of 4.1% per year, a level twice that of the rest of the world. As one of the fastest-growing regions in the world in terms of power demand, Southeast Asia will continue to maintain a high level of dependence on coal power and the accelerated withdrawal of coal power will aggravate the power system and energy security risks in the region amid global clean energy transition.

With the accelerated withdrawal of coal power, the fossil energy sector, as a high-carbon asset, is at high risk of asset stranding. For the power sector, IEA data shows[23] that 1,715GW of installed capacity in the sector would face earlier stranding under the scenario of a 2°C rise, with stranded power assets to pose a financial risk of USD 3.7 trillion to utilities by 2060. In Southeast Asia, where coal is a main source of electricity, the low-carbon transition of the power sector will gradually break the old manufacturing, production, transportation, and consumer markets in related industries and reshape the patterns of industrial and supply chains, thus triggering systematic economic risks that could further affect the stability of financial markets and lead to high stranded assets. A Carbon Tracker report[24] notes that over 70GW of coal power plants are currently being planned or under construction in Southeast Asia, with USD 124 billion of coal power investments at risk.

The high-speed development of the coal industry in Southeast Asia has created a large number of jobs for local people, especially in Indonesia and Vietnam, and the continued contraction of the coal industry and the reduction in domestic coal use or exports will have a certain impact on the traditional coal industry with serious socioeconomic impacts by creating a significant unemployment impact on both the coal industry and its workers and posing a huge challenge to social stability in coal-intensive areas[25]. However, the overall response to just transition is weak in Southeast Asia, with only three countries, namely the Philippines, Singapore and Malaysia, laying down regulatory issues such as skill requirements, workers' rights and inclusive growth in their laws[26].

In addition, low-carbon jobs have not yet been clearly defined at a regional level in Southeast Asia. The uncertain relevant standards cannot provide accurate guidance for promoting the transformation of coal enterprises or skill training for workers.

3.2.2 Inadequate policy support for power sector transition and weak government enforcement require more effort

Southeast Asian countries have actively encouraged the development of the power sector in recent years and have formulated a range of supporting policies. However, the lack of overall planning and market evaluation has led to frequent policy adjustments and instability. On the one hand, different energy transition philosophies, which can lead to large adjustments to energy policies and inconsistency in transition targets[27]. At the same time, realities and market changes are under-evaluated, bringing frequent changes to policy implementation. In terms of subsidy policies, high fossil fuel subsidies have to some extent weakened the government's determination to promote renewable energy, and a number of factors such as insufficient FIT incentives, unclear guidelines for integrating renewable energy into power grids, obscure review and approval procedures for power purchase agreements and complex land licensing procedures, lengthy land acquisition periods and demanding local content requirements for foreign investment, have also led to slow progress and high costs of renewable projects, thus hindering the further development of renewable power.

3.2.3 Low marketing levels of electricity and impeded the development of the clean power sector

Southeast Asian countries have different power sector structures: Singapore and the Philippines have high levels of marketing of the power sector by separating it from the retail competition and system operation; Thailand and Indonesia have vertically integrated state-owned power companies that generate electricity and operate power grids; Vietnam is now undertaking electricity system reforms to transition to an electricity retailing market. Currently, Southeast Asia generally has a low level of marketing of electricity, with an absence of market competition incentives and with power purchase agreements and the long-term contract system for fuel supply not conducive to the release of market flexibility. Moreover, quite a few power tycoons possess a majority of coal power assets. For example, Indonesia's PLN owns most of the country's coal-fired power plants and continues to acquire coal mines in the country, forming an inseparable community of interests between the power sector and the coal industry. With the traditional coal industry's obstruction and the unstable development of the renewable energy industry, the transition to renewable power is losing steam in Southeast Asia.

3.2.4 Weak technology R&D and innovation for clean energy

Some Southeast Asian countries are less able to innovate in clean energy technologies, with low levels of core technology R&D. At their current levels of development, clean coal technologies and renewable power technologies are unable to effectively support the region's low-carbon transition targets. Due to factors such as low capital input, insufficient policy guidance, inadequate market mechanisms and lack of momentum, Southeast Asia has a low degree of transformation and uncompetitive costs of relevant technologies, which have further affected the application of these technologies. Meanwhile, a shortage of talent has also restricted the pace of transition in Southeast Asia. According to the existing policies in Southeast Asia[28], it is expected that by 2025, the demand for jobs directly related to solar and wind energy alone in the region's renewable energy sector will have already exceeded 80,000. However, due to the absence of talent training and management mechanisms, which has resulted in weak attraction to talents and backward specialty development, the talent output in Southeast Asia cannot meet the speed at which the renewable energy market is expanding, implying a large talent demand gap.

3.2.5 The urgent need for improvements in grid infrastructure and slow progress in ASEAN's power interconnection

Southeast Asia suffers from weak power grid infrastructure. Power transmission and distribution systems are generally inefficient and inflexible, and some countries have yet to complete a unified power grid that covers the entire country. And the large-scale connection of wind and PV power stations to power grids has further increased the difficulty in grid scheduling and management. As power grids are unable to cope with intermittent renewable power, relevant projects tend to have the risk of power rationing. For example, PV projects of Indonesia's IPPs developers are often called off by PLN regional companies, which is particularly true for remote islands out of the Java-Bali grid, preventing the integration of renewable energy into power grids. In addition, ASEAN cross-border interconnection is critical to enhancing the flexibility of the ASEAN power sector and fulfilling the ASEAN regional renewable energy development targets, but the overall progress is slow due to factors such as lack of financial support, unsound management systems and inadequate technologies. Although most Southeast Asian countries have cross-border power grid projects, they are mainly bilateral and power trading is mostly not directed (like Power Purchase Agreement).

3.2.6 Large funding gaps for transition and a lack of effective market financing mechanisms

In the IEA's Stated Policies Scenario (STEPS) and Sustainable Development Scenario (SDS), the annual average energy investment is expected to reach USD 130 billion and USD 190 billion respectively by 2030. From the perspective of existing renewable energy investments in Southeast Asia, the investments in Vietnam, despite occupying the largest share of total investments, are only one-third of those in Chile, which ranks 20th in the world[29]. Therefore, the lack of financial resources remains one of the issues facing energy and power sector transition in ASEAN. On the one hand, ASEAN is dominated by developing countries with low levels of economic development and great fiscal pressures. Meanwhile, many countries have weak financial and capital markets, where domestic markets have limited experience in financing clean energy assets, and financing models and management mechanisms are not yet mature, making it more difficult to access long-term financing. The absence of unified standards of risk assessment in Southeast Asia and the fact that information disclosure mechanisms are not yet well developed across countries are also important reasons for the difficulty in financing in the region, which further hinders the flow of funds in Southeast Asia.

Chapter 4. Low-carbon Transition of the Power Sector in Southeast Asia: a Case Study of Vietnam and Indonesia

4.1 Low-carbon transition of the power sector in Vietnam

4.1.1 Status of Vietnam's Power Sector

Electricity accounts for the highest share in the final energy consumption mix and has high growth. Between 2010 and 2019, electricity production (including imported electricity) increased from 100.4 billion kWh to 240.1 billion kWh reaching an average annual growth rate of 10.2%, 1.8 times higher than the GDP growth over the same period. Growth in 2020 slowed to 2.42% and 3.9% in 2021 due to COVID-19 pandemic. Total electricity consumption in 2021 was 256.7 billion kWh. The industrial and residential sectors are the main drivers of this growth. By the end of 2021, more than 99% of households had access to electricity.

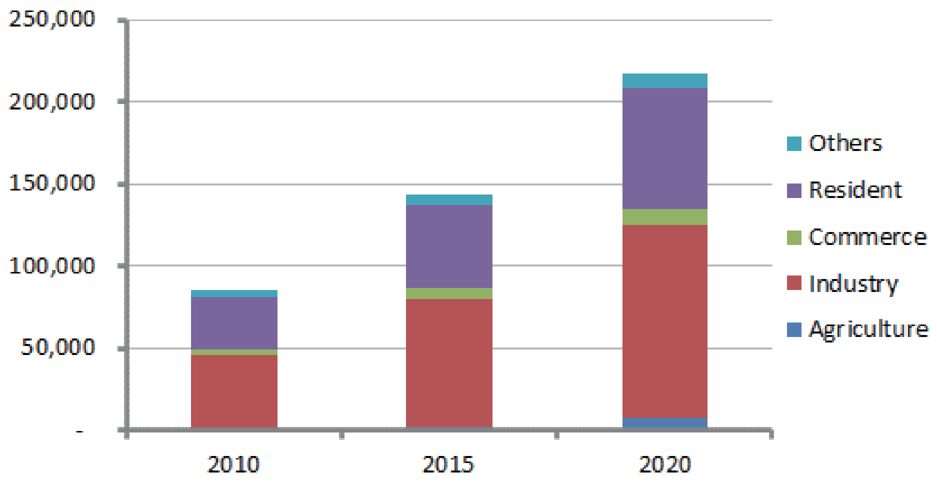


Figure 4-1: Final consumption of electricity by sector (in million kWh)

Despite this, per capita electricity consumption in Vietnam is still lower than that of Thailand and significantly below the average consumption level of OECD countries (Figure 4-2). But it is high in relation to GDP (4.3).

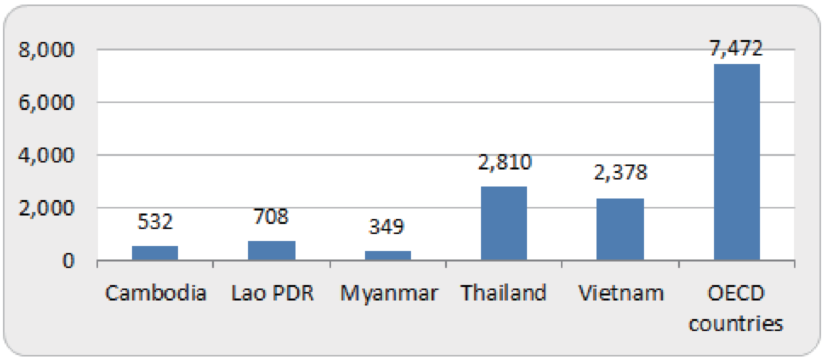


Figure 4-2: Per capita electricity consumption in Vietnam and selected country in the region in 2018 in KWh per person (Source: World Development Indicators)

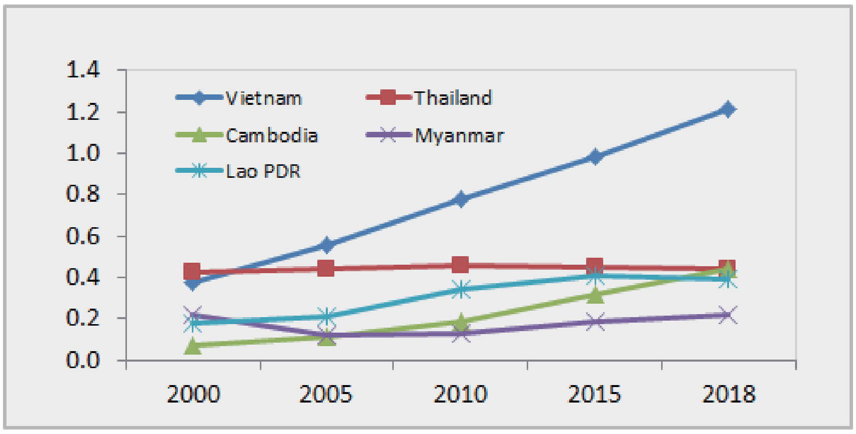


Figure 1-3: Energy consumption intensity to GDP in Vietnam and selected countries in 2000-2018 in KWh/USD (Source: World Development Indicators)

In order to meet this increasing demand, the installed capacity of the power system has increased more than 10 times in the period 2010-2020, from 6,400 MW in 2010 to over 69,300 MW in 2021. Along with the increase in installed capacity, the power mix has undergone several changes. In 2000, hydropower comprised the highest share in the power mix, accounting for 54% of the total installed capacity. By 2005, the share of hydroelectricity had decreased to 37%, replaced by gas power which accounted for 39%. In the period 2010-2015, hydropower remained the main source, but coal power started to develop strongly. Coal installed capacity increased nearly 9 times in the period of 2005-2015, from about 1,500 MW in 2005 to 13,250 MW in 2015, accounting for 33% of the total installed capacity by 2015.

The revised Power Development Plan 7 (the revised PDP7) for the 2016-2020 period with a vision to 2030 continued to focus on coal power development with the goal of coal power accounting for 43% of the installed capacity by 2030. Vietnam does not have sufficient coal reserves to meet this level of coal demand with domestic supply and would need to rely on imports, which has raised energy security concerns. In addition, planned coal plants are not popular in the areas where they are to be located due to environmental pollution concerns, nor are they consistent with climate commitments. Considering this, and fearing electricity shortage, the Government of Vietnam has sped up renewable energy development. Supported by a series of preferential policies (see 4), renewable energy has prospered in the period 2016-2020, especially in the two years of 2019 and 2020. By the end of 2020, the total installed capacity of renewable energy reached 17,500 MW, an increase of 8.4 times compared to 2015, accounting for 25.4% of the total installed capacity of the system. The structure of installed capacity in 2020 is as follows: Hydropower (30.3%), Coal power (29.7%), Renewable energy (25.4%), Gas power (10.3%), the rests are oil power and electricity imports from Lao and China. The transition to RE continued in 2021 with nearly 4000 MW wind power added into the system, making RE share in the system increase to 26.9%, or 21015 MW in the total of 78120 MW capacity.

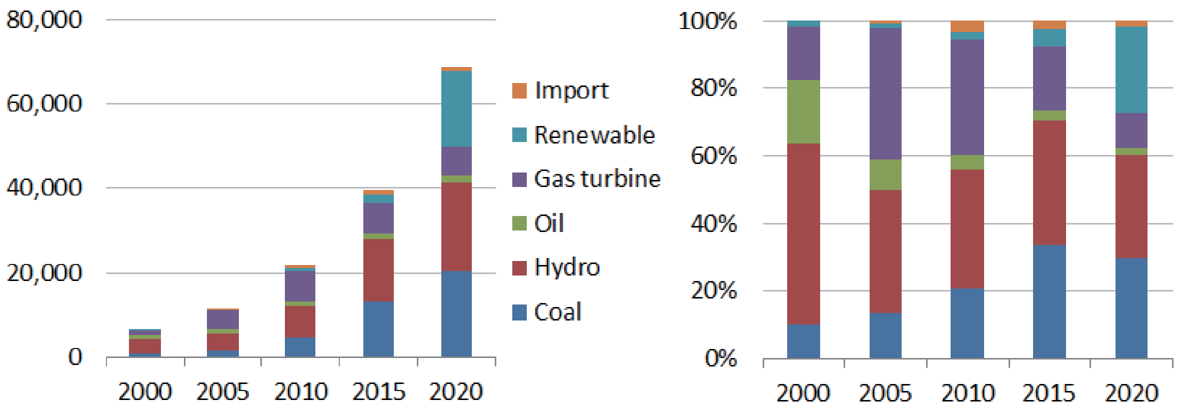


Figure 4-4: Evolution of power source in 2000-2020 period: (A)-by installed capacity MW, (B)- by share %

The rapid development of Variable RE (VRE) is higher than the planned one in the revised PDP7 and has resulted in a number of structural issues for the power system, including congestion and curtailment in South–Central Vietnam and concerns regarding system stability across the national grid. It is clear that further deployment of VREs will require major shifts in how the power system is structured and operated.

4-1: Price incentives for solar and wind power projects

RE type	Support mechanism	Price level	Governing legal document
Solar power	FIT	• 9.35 US cent/kWh, excluding VAT for both utility scale and rooftop solar types that achieve COD before 30 June, 2019, with standardized PPA for 20 years	Decision 11/QĐ-TTg, dated 11 April, 2017
		• 7.09 US cent/kWh, excluding VAT for utility scale systems with COD **before 31 December 2020**, with standardized PPA for 20 years • 8.38 US cent/kWh, excluding VAT for rooftop solar systems with **COD before 31 December 2020**, with standardized PPA for 20 years	Decision 13/2020/QĐ-TTg, dated 6 April 2020
Wind power	FIT	• 7.8 US cent/kWh, excluding VAT for both onshore wind projects applicable before 1 November 2018, with standardized PPA for 20 years	Decision No. 37/2011/QD-TTg dated 29/6/2011
		• 8.5 US cent/kWh, excluding VAT for onshore wind projects with **COD before 1 November 2021** applicable from 1 November 2018, with standardized PPA for 20 years • 9.8 US cent/kWh, excluding VAT for offshore wind projects with **COD before 1 November 2021** applicable from 1 November 2018, with standardized PPA for 20 years	Decision No. 39/2018/QD-TTg dated 10/9/2018

Currently, Vietnam has power trade with Laos, Cambodia and China. Specifically, Vietnam imports from Laos and China and exports to Cambodia. Electricity imports from Laos exceeded 1.4 billion kWh in 2021, an increase of over 20% from 2020. Imports are expected to gradually increase over time with more hydropower projects in Laos exporting power to Vietnam. In contrast, imports from China have been reduced to zero in 2021.

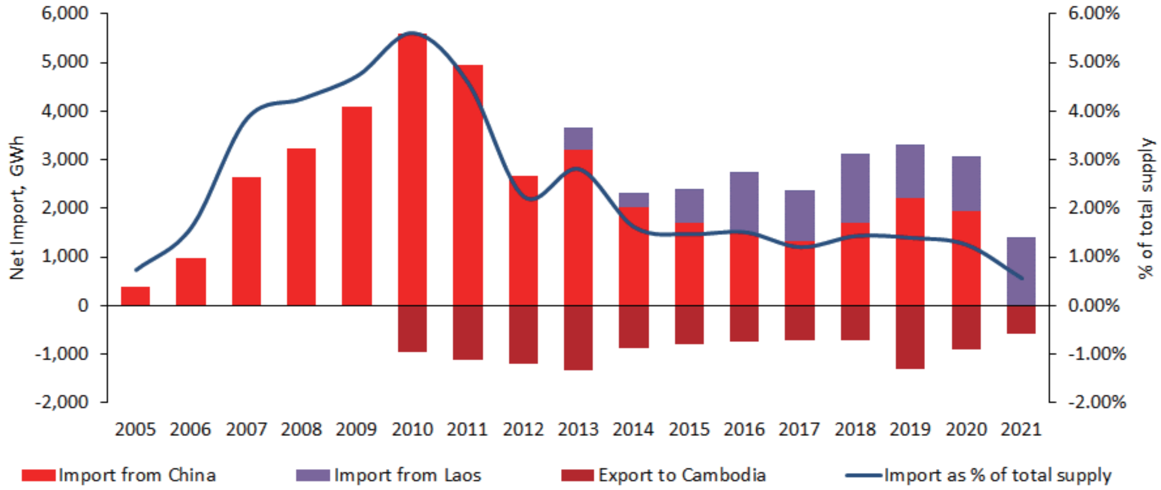


Figure 4-5: Historical cross-border power flows in Vietnam

Along with these developments, the government of Vietnam has started market reforms, aiming at introducing a retail electricity market. The Electricity Law was effective from 1 July 2005 and amended in July 2013 stipulates 3 stages in the development of a competitive electricity market: Competitive generation market, wholesale market and finally retail market. Prime Minister's Decision No.63/2013/QD-TTg in 2013 sets out the roadmap for the implementation as illustrated in the figure below:

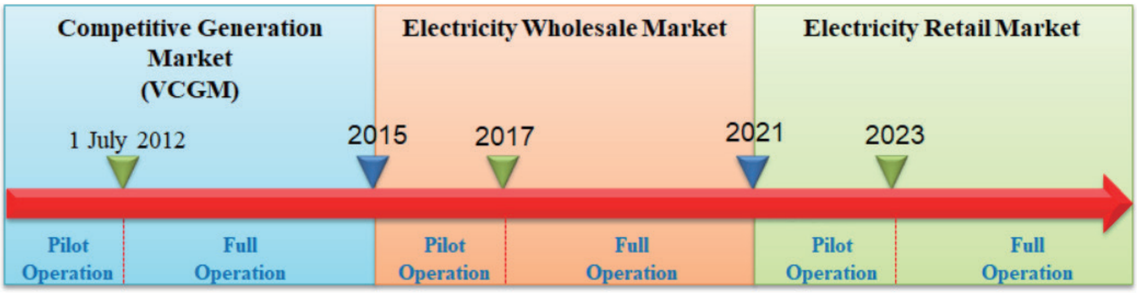


Figure 4-6: Vietnam Electricity Market Reform Implementation Roadmap

The competitive generation market currently accounts for 44% of the capacity at 100 power plants. The remainder are large strategically important hydropower plants (11 plants accounting for 14% of capacity, or power plants with long-term PPAs (110 plants accounting for the remaining 38% of capacity). Currently, Vietnam is in the second stage of power market development – the Wholesale Electricity Market (WEM) and is establishing it according to the detailed design approved under Decision 8266/QD-BCT which is illustrated in figure 4-7. Under this power market phase, 5 power companies (PCs), and large customers, qualified new wholesalers shall be allowed to buy power in the spot market. The Electricity Power Trading Company (as a subsidiary of the EVN) shall perform the task of purchasing electricity from power plants that do not participate in the competitive wholesale electricity market and selling these electricity quantities to PCs. The electricity system and market operator is the National Load Dispatch Center which is a subsidiary of the Vietnam Electricity Corporation. In the competitive wholesale electricity market, the National Load Dispatch Center will be transformed into a financially autonomous entity of the Vietnam Electricity Corporation. However, this has not been implemented as mentioned below and therefore is moved to the next phase of the power market development – the retail electricity market.

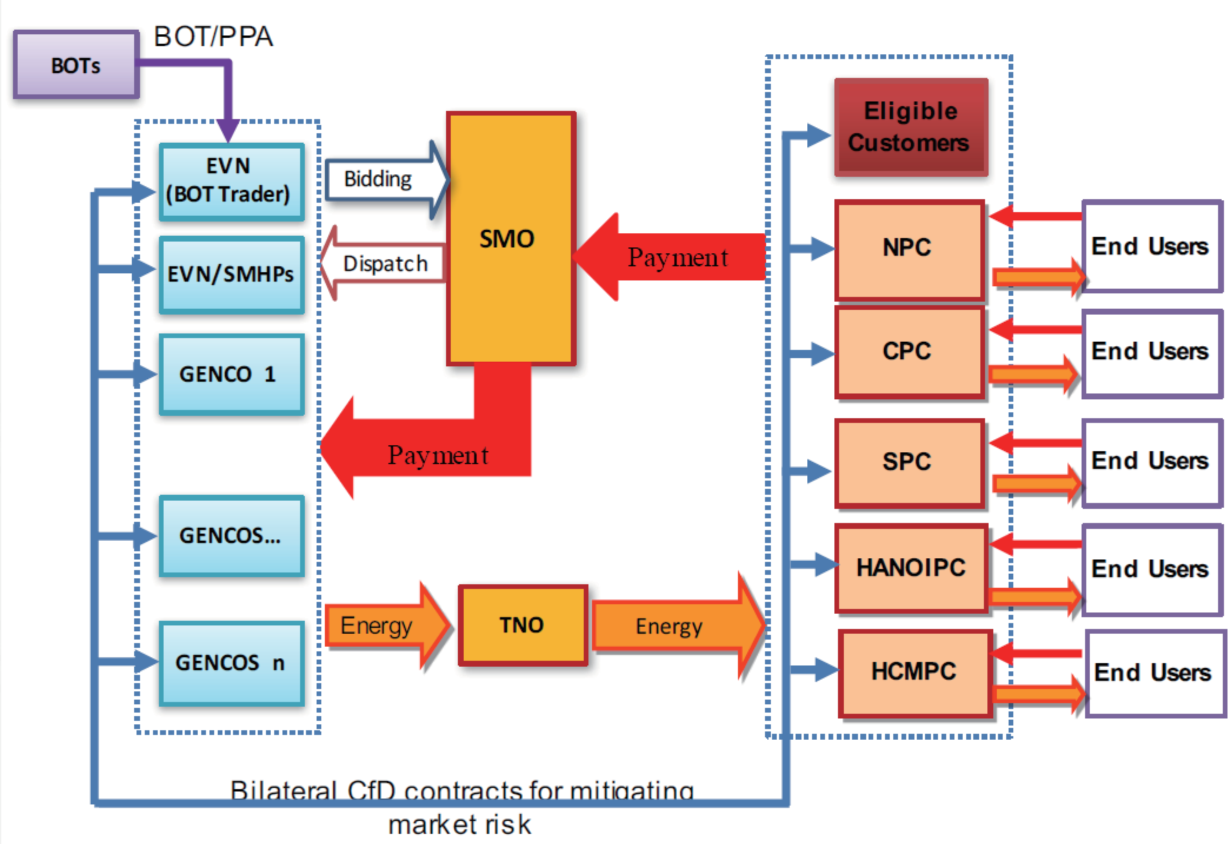


Figure 4-2: Vietnam Wholesale Market Structure

(Source: ERAV report at VEPG meetings)

On 7 August 2020, MOIT issued decision No. 2093/QD-BCT approving the design of Competitive Retail Electricity Market (REM). MOIT/ERAV is proceeding with preparation works to introduce the REM which includes: (i) transforming NLDC into a limited company operating the power system and electricity market, (ii) developing a power sector restructuring plan for the REM, and (iii) completing a system of legal documents to allow RE generators to sign Direct Power Purchasing Agreement (DPPA) with electricity consumers. At this stage, customers (end-users) can buy electricity from the spot market (applicable for large consumers) or an electricity retailer of their choice. This is illustrated by the following figure (figure 4-8)

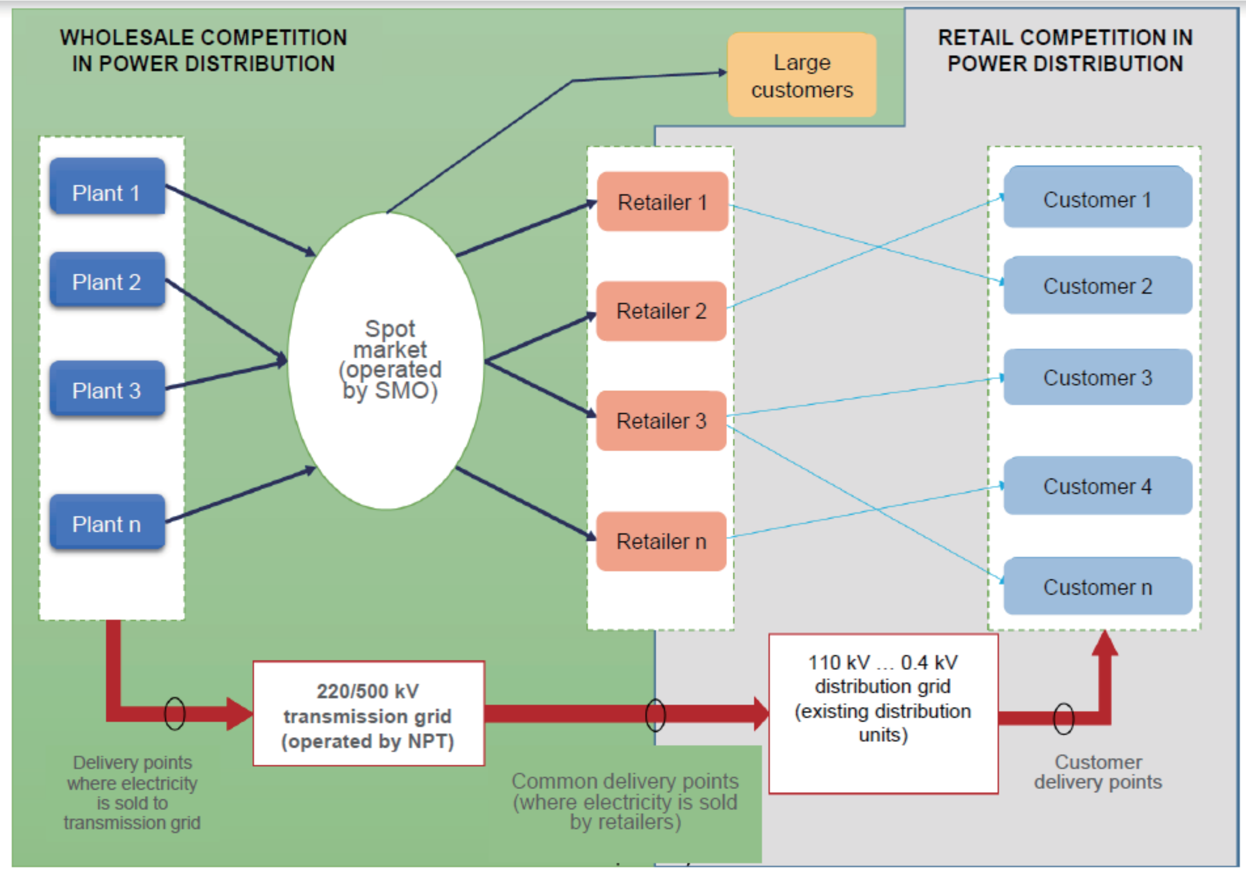


Figure 4-3: Illustration of retail electricity market (Source: ERAV report at VEPG meetings)

4.1.2 Institutional arrangement in Vietnam's power sector

Various government agencies are involved in the power sector as shown in Figure 4-9. At the central level, the government and the Prime Minister issue decrees, regulations, and mechanisms to manage energy activities, approve energy development strategies, and plan and decide on policies for energy tariffs, large-scale projects, or especially important projects.

Within the government, the Ministry of Industry and Trade (MOIT) is directly in charge of activities related to the energy sector including the power sector. Among various obligations, the ministry (i) submits the national development strategy, and plan for the energy sector[2] to the Prime Minister for approval, and implements it; (ii) spreads circulars that guide the implementation of the government's and Prime Minister's decrees and decisions, (iii) issues standards, regulations and technical/economic norms under its authority; (iv) manages and regulates

[2] The Planning law which is in effect in 24th November, 2017 stipulates two master plans: The National Integrated Energy Master Plan and Power Development Plan.

energy production and use; (v) formulate and implement regulations on the electricity market, (vi) organizes the preparation of retail electricity tariffs and research, proposes mechanisms and policies on electricity tariffs and submits them to the government for approval; and (vii) decides on generated electricity price frameworks and auxiliary service fees.

MOIT responsibilities in the power sector are concentrated in the Electricity and Renewable Energy Authority (EREA); and Electricity Regulatory Authority of Vietnam (ERAV). In the power and renewable energy fields, EREA prepares and organizes appraisal of power development strategy and plan, plan to link the power system of Vietnam with other countries in the region and national plan on renewable energy development; publishes a list of planned power projects to attract investments in the construction and undertakes the management of their implementation; issues solutions for improving management and operation of the power system; directs, plans and encourages investments in renewable energy development.

ERAV helps the minister regulate electricity activity by (i) issuing electricity operation licenses; (ii) reviewing frameworks of electricity generation and electricity wholesale prices as well as electricity transmission, distribution and service fees, which are prepared by the electricity units for the ministry to approve and issue; (iii) asking the minister to issue regulations on preparing, reviewing, obtaining feedback and approving retailed electricity selling tariffs; (iv) compiling decisions, regulations and guidelines on establishing and managing the activities of the competitive power market.

Three big state-owned companies in the energy sector are EVN, PVN and VINACOMIN, which respectively operate in three areas in the energy sector, namely the power sector, oil and gas sector, and coal sector. These companies are under direct control and report to Commission for the Management of State Capital at Enterprises (CMSC), but they are subject to the direction, guidance of MOIT in terms of profession.

EVN (Electricity of Vietnam Group) is a vertically integrated utility, but its current mandate and structure are changing, resulting from a process of power sector unbundling that started in the mid-2000s. However, by 2019, EVN was still the single buyer (implemented through its subsidiary called Electric Power Trading Company) and had the most power-generating capacity and wholly owned the National Power Transmission Corporation (NPT) and five distribution companies (PC). EVN has a dominant share in power generation at 53% of the total installed capacity of the whole power network in 2019. The remainder is owned by other state corporations/groups (Petro Vietnam, VINACOMIN), foreign investors (under the BOT scheme) and domestic private investors (under the IPP scheme). These power plants sell electricity to EVN under long-term power purchase agreements or via the spot market. EVN also owned the National Load Dispatch Centre (NLDC) which is System and Market Operator. EVN will experience further reform as Vietnam moves towards the retail electricity market. Further details on the sector reform are provided in Section 2.2.

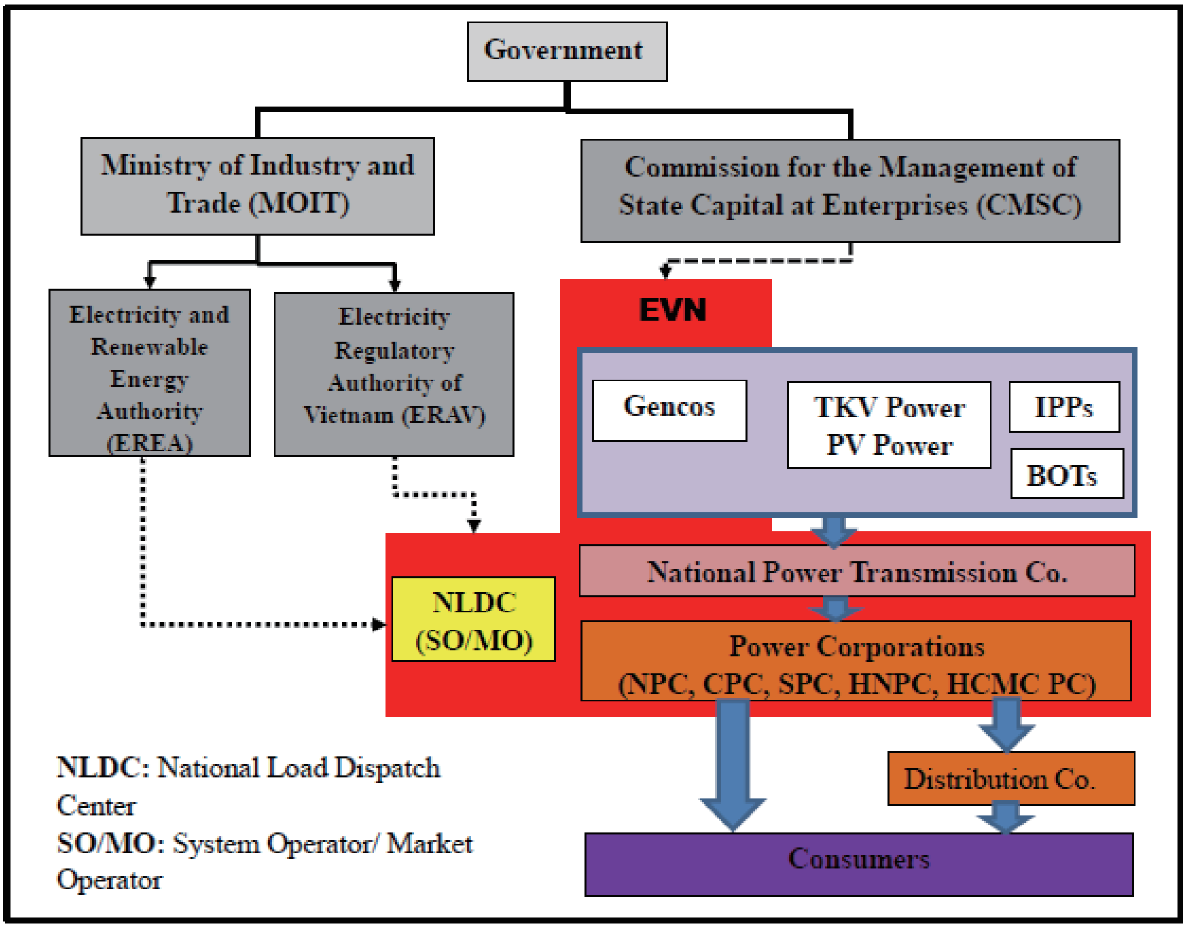


Figure 4-9: Institutional arrangement in the power sector in Vietnam (Source: Nguyen The Huu, Smart Grids in Vietnam-Market development, Frameworks and Project Examples)

4.1.3 Key policies for Vietnam's low carbon power transition

Below is a summary of the most relevant policies in line with transitioning Vietnam's energy sector to one that promotes low GHG emissions

- Vietnam Renewable Energy Development Strategy to 2030 with the vision to 2050
- The National Green Growth Strategy

- Resolution 55 of the Politburo on orientations of Vietnam's National Energy Development Strategy to 2030 and outlook to 2045
- Vietnam's Nationally Determined Contribution (NDC) and announcement by our Prime Minister at COP26 on achieving net-zero emission in 2050 and phasing out of coal in the 2040s.
- The Power Development Plan 8

Vietnam Renewable Energy Development Strategy to 2030 with vision to 2050: This policy addresses renewable energy development and was approved under Decision 2068/QDTTg dated 25 November 2015[30]. It sets a renewable energy target for 38% of total electric generation in 2020, 35% in 2025, 32% in 2030, 38% in 2040 and about 43% in 2050. This is equivalent to an increase from 58 billion kWh in 2015 to about 186 billion kWh in 2030 and 452 billion kWh in 2050. It also set out renewable energy targets for thermal energy uses and discusses mechanisms and policies so that the targets can be met, which include: Deployment of Renewable Portfolio Standard (RPS), FIT and other incentives for RE projects. However, it missed discussions of technical measures to ensure effective integration of such large RE percentages such as storage options, capacity market and ancillary services.

Resolution 55 of the Politburo[31]: This resolution reconfirmed the commitment to renewable energy development by highlighting the task of developing breakthrough mechanisms to encourage and promote the exploitation and use of renewable energy to replace fossil fuels, and developing a roadmap for phasing out coal. The target set was the share of renewable energy sources in the total primary energy supply reaching 15-20% in 2030 and 25-30% in 2045.

The National Green Growth Strategy[32]: This strategy aims to change the development pathway for the country toward reduced dependency on natural resources, improved productivity and environmental protection. To that end, the strategy has three strategic tasks: Reducing GHG emissions, Greening production, and Greening lifestyles. The time span of the strategy is 2011-2030 with the vision to 2050. In 2014, the Prime Minister approved the action plan to implement a national green growth strategy for 2014-2020. The MPI is now preparing the action plan for 2021-2030, and given the recent discussions on the circular economy, this process is drawing greater attention from various stakeholders.

Vietnam Nationally Determined Contribution (NDC): At COP21 in Paris in 2015, Vietnam with other countries ratified the Paris Agreement, committing to cut GHG emissions through the Intended Nationally

Determined Contributions (INDCs). The Vietnam INDC[33] sets Vietnam's mitigation targets of 8% by 2030 below business as usual estimated at 787.4 million tCO_2e, and up to 25% with the support of international finance) and key sectors and prospective mitigation actions for achieving these targets. In the 2020 updated NDC, Vietnam expanded the scope of GHG emission categories to include emissions from industrial processes therefore GHG emission by 2030 is estimated at 927.9 million tCO_2e and at the same time, increases the voluntary GHG emission reduction target to 9% by 2030 and up to 27% conditional to receipt of additional international support[34].

Table 4-2: Reduction contribution by sectors per updated NDC

Sector	Contribution with domestic resources		Contribution with international support		Total contribution with both domestic resources and	
	Compared to BAU scenario (%)	*Reduced amount ($MtCO_2e$)*	*Compared to BAU scenatrio (%)*	*Reduced amount ($MtCO_2e$)*	*Compared to BAU scenario (%)*	*Reduced amount ($MtCO_2e$)*
Energy	5.5	51.5	11.2	104.3	16.7	155.8
Agriculture	0.7	6.8	2.8	25.8	3.5	32.6
LULUCF*	1.0	9.3	1.3	11.9	2.3	21.2
Waste	1.0	9.1	2.6	24.0	3.6	33.1
IP	0.8	7.2	0.1	0.8	0.9	8.0
Total	**9.0**	**83.9**	**18.0**	**166.8**	**27.0**	**250.8**

Note (*): *GHG absorption increase.*

At COP26 in Glasgow, UK, the Vietnamese Prime Minister announced the most ambitious GHG reduction target, cutting GHG emissions to reach net-zero emission by 2050, and pledged to phase out coal by the 2040s. Vietnamese Prime Minister is instructing line ministries to develop an action plan to implement the commitment.

The Power Development Plan 8 (PDP8): Guided by the above policies and commitments, the PDP8 is now being prepared. On 8th October 2021, MOIT submitted the Power Development Plan for 2021-2030 with a perspective to 2045 (better known as PDP8) to the Prime Minister for approval after its endorsement by the appraisal committee. This is the third version of the PDP8 since it was published on MOIT website for public comment in February 2021. This version was further refined after COP26 to reflect the Prime Minister's commitment to reaching net-zero emissions in 2050. The most recent draft was submitted on 27 April 2022 which is expected to be final and is summarized below.

Two cases of demand and therefore two cases of power mixes are submitted in which the high case is proposed as the operating plan to ensure a reasonable reserve margin.

In the base case, power demand is expected to grow with an AAGR of 8.6% in 2020-2030 from 215.2 billion kWh in 2020 to 491.2 billion kWh in 2030, then slow down to 4%/year during 2030-2045, reaching 886.9 billion kWh in 2045.

In the high case, the growth is expected to be higher, at 9.4%/year during 2020-2030 and 5.0%/year during 2030-2045. The demand in 2030 is 530.4 billion kWh, and in 2045 is 1101.1 billion kWh.

To meet this expected demand (i.e., high case) while complying with the environmental commitment, Vietnam expects to double the system capacity in 2030 and double again in 2040, i.e., every 10 years as shown in the below table.

Table 4-3: Power capacity mix per the draft PDP8 (version April 2022) in MW

	2020	2025	2030	2035	2040	2045
Hydro (large and small)	20,859	26,795	28,946	33,654	34,414	35,139
Coal	22,070	28,867	37,467	37,467	37,467	37,467
Gas (natural gas, LNG, Hydroge	7,398	14,386	38,830	46,330	46,330	46,330
Gas (ICE)	-	-	150	5,100	19,500	27,300
Oil	1,624	561	-	-	-	
Near and onshore wind	538	13,616	16,121	26,600	41,300	55,950
Offshore wind	-	-	7,000	16,000	38,500	64,500
Solar farm	8,736	8,736	8,736	25,034	47,893	75,987
Rooftop solar	7,755	7,755	7,755	7,932	13,273	20,679
Other RE (biomass, biogas, W2I	338	980	1,230	3,090	4,960	5,210
Storage (PSH, BESS)	-	-	2,450	7,350	17,550	28,950
Import	1,272	4,453	5,000	7,742	10,242	11,042
Captive Power		1,450	2,700	3,300	4,500	4,500
	70,590	**107,599**	**156,385**	**219,599**	**315,929**	**413,054**

Renewable energy (wind, solar) is strongly emphasized in planning, particularly after 2030. By 2045, the installed capacity of wind and solar power is expected to reach 217 GW, equivalent to 12.75 folds the size in 2020. Notably, offshore wind starts to come into play in 2030 with 7 GW, aggressively growing to more than 64 GW in 2045. By 2045, RE capacity including small hydro is expected to make up 55.6% of the total installed capacity, increased from 30% in 2020. The rest are large hydro, coal, gas, import and balancing sources (PSH and BESS[3]). Coal and gas combined make up the most in 2020 but decreases in the planning period (its share

[3] Pumped storage hydro (PSH) and Battery Energy Storage (BESS)

in 2020 was 44% and 27% in 2045). However, in absolute values, there is still 15.4 GW of coal power planned for 2021-2030, raising concerns regarding the feasibility of this plan both financially and technically.

Table 1-4: share of power mix according to PDP8 version April 2022

	2020	2025	2030	2045
Large hydro	24%	20.2%	15.2%	6.7%
Coal	31.3%	26.8%	24.0%	9.1%
Gas	10.5%	13.4%	24.9%	17.8%
Wind	0.8%	12.7%	14.8%	29.2%
Solar	23.4%	15.3%	10.5%	23.4%
Other RE	6.0%	5.7%	4.1%	3.0%
Others (imports and balancing sources)	4.1%	6.0%	6.5%	10.8%

It is expected for this plan Vietnam will need about 84 million tons of coal in 2030. While the country can produce 40 million tons, a large part of this demand will have to be imported. The prospect for gas is not brighter as the majority of demand has to be met by imported gas, exacerbated by the lack of infrastructure and legal foundations for the import.

The PDP8 also covers the development of a transmission grid i.e., 220 kV and above. The 500 kV grid network acts as a backbone system running North to South to enable power trade between regions. There are 3 lines of 500 kV in which line 1 and line 2 are in operation, and line 3 is under construction. 220 kV grid acts as a regional transmission system. The below table provides an inventory of the transmission grid as of 2020.

Table 4-5: Inventory of transmission grid in 2020

Items	Unit	2020
500 kV line	Km	8,527
500 kV transformer	MVA	42,900
220 kV line	km	18,477
220 kV transformer	MVA	67,824

It is reported that the North-South grid in recent years has been operating under strain due to the high development of renewable energy, higher than what was planned in the Power Development Plan 7 revised.

Therefore, the PDP8 set out the following guidelines for the transmission grid development

- Ensure safe and reliable operation of the system, able to integrate high penetration level of renewable energy sources
- Synchronous development of power source and grid, on the basis of effective and reasonable exploitation of local energy resources, prioritizing local demand-supply balancing, no construction of new in-regional transmission grid during 2021-2030; limit the construction of inter-regional transmission grid during 2031-2045
- Construct/ upgrade transmission grids to meet N-1 standard (i.e., Transmission is still guaranteed even if one transformer/circuit fails).

New transmission grids that need to be constructed or upgraded have been estimated accordingly. Generally, the required new transmission grid in 2021-2030 is 1.6 times larger than the existing quantity in 2020, and this same amount is required in 2031-2045 although more transformers are required than new lines (see the below figure for details).

The investment capital required for 2021-2030 is estimated at $146.5 billion, including $101 billion for power sources and about $14.4 billion for grid networks. For 2031-2045, the required investment cost is significantly higher, estimated at $346 billion. On average, the required investment capital is $14 billion per year, a huge number that EVN cannot afford for sure. For the grid network, the required investment capital averages $ 1.44 billion per year in 2021-2030 and $ 1.23 billion in 2031-2045 is significantly higher than the realized investment capital by NPT in the last year in the range of $0.6 billion (net investment capital in VND 12,778 billion as per NPT annual report) and also higher than NPT charter capital at VND 24,596 billion as per NPT 2017 financial statement. This poses challenges for NPT in securing sufficient capital. The major drawback to this task is the low transmission fee, currently at around VND 100/kWh, a figure which has decreased in recent years. One of the solutions to this challenge is to allow the private sector to invest in the transmission grid. The electricity law is being revised to legalize this type of investment, and approval of this revised law was already made by the National Assembly last year.

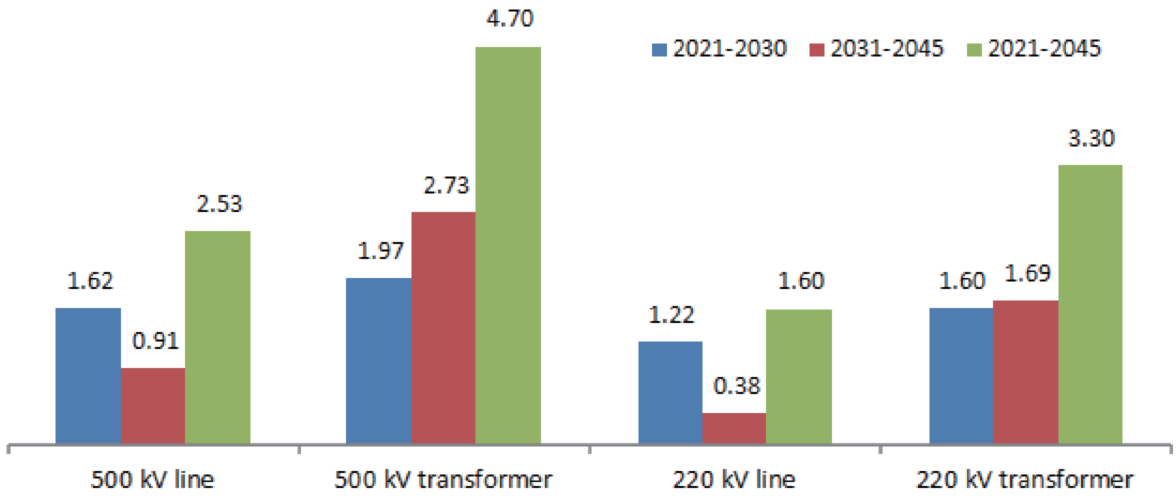


Figure 4-10: Required new transmission grid by periods, 2020=1

4.1.4 Key challenges/obstacles to the transition process

The high growth of electricity demand: the Revised Power Development Plan 7 (PDP7 revised) forecasted growth at 8% per year in the 2021-2030 period. To meet this increasing demand, the power system expects to double in 2030 and double again in 2045. Therefore, the challenge is not only to use green technologies to replace fossil fuel-based power plants that reach their life ends but also to new capacity to meet the increasing demand. This is exacerbated by additional demand due to increasing usage of Electric Vehicles which has now become a trend and electrification of other usages to implement the Prime Minister's announcement on reaching net-zero emission by 2050.

Such a required development would pose great challenges to the system in terms of feasibility. Firstly, fossil fuel-based power presently plays an important role in the power supply, accounting for 44% of the installed capacity and providing 59% of generation output in 2021 with coal at 46.3%. Moreover, about 9 GW of new coal-fired power plants are under construction, PPAs have been signed and therefore cannot be canceled. Secondly, RE resources concentrate in the centre and the south, in provinces that have low local power demand, so grid upgradation is needed to transport this capacity if realized to load centres including to the north. Thirdly, there is a need to deploy new technologies such as storage technologies (Battery Energy Storage System (BESS), Pump Storage Hydro (PSH)) and Flexible power sources (such as Internal Combustion Engine) and other ancillary services to be able to integrate high share of Renewable energy. Also, new fuels that are environmentally friendly such as Hydrogen, Ammonia needs to be deployed. All of these lead to huge demand for capital and subsequently lead to higher electricity prices. This is a great challenge because the current retail tariff is low and is kept low intentionally over the last years to support socio-economic development (presently at 7.5 US cents/kWh on average).

4.1.5 International Cooperation in Vietnam's energy sector

Many donors are active in the energy sector. The key ones and their main activities are presented below.

The World Bank (WB): WB has wide-ranging programs in the energy sector. As with other lenders because of changes to ODA regulations effectively restricting loans, particularly to EVN, all current WB projects are grant-based TA focusing on data analytics, planning, policy development and advocacy.[4] More substantively, the World Bank's focus in the sector has been the promotion of the transition to a low-carbon energy sector and institutional reform (with a view to promoting long-term financial sustainability of the sector. Current projects and programs in the sector include:

- Transmission Efficiency Project –loan project with TA component, working with EVN/NPTC to upgrade and expand transmission infrastructure;
- EE for Industrial Energy Project – grant and loan project to promote energy efficiency in the industry working with MOIT;
- GCF EE for Industry Risk Sharing Facility – grant and loan-based project to underwrite loans for energy efficiency investments with MOIT and commercial banks;
- PC Credit Rating – grant for assisting EVN and other state-owned ESI companies obtain credit ratings to allow them to generate investment capital from international bond issues
- RE Mapping (wind, solar, hydro, biomass) –a project with EVN to map RE resource potential in Vietnam
- Solar Auction Design and Implementation - conducted with MOIT to design regulations for solar auctions
- LNG Strategy – with MOIT
- Developing EE Targets and Mandatory EE Regime for VN - conducted with MOIT
- Power Sector Development Policy Series – support for the development of a wholesale electricity market with ERAV

[4] With the exception of a legacy project for transmission line improvement with EVN, NPTC and EE support projects with MoIT/commercial banks.

- Power Sector Development Policy Series – analysis of cross-subsidisation of end-user tariffs with ERAV
- E-Mobility – development of a national framework for e-mobility
- OffShore Wind Roadmap and Implementation Support – development of offshore wind
- Power Sector Development Policy Series
- Lao Vietnam Interconnector – for the export of excess hydropower capacity

The World Bank is also involved in donor coordination in the sector as chair of the VEPG.

International Finance Corporation (IFC): IFC has a significant portfolio of projects in Vietnam, being involved in both investment advisory and provision of financial products to the private sector. These include:

- Direct project finance for renewables deployment including hydro (small with lower ESG risks), solar (utility-scale and roof-top), and wind (on and off-shore);
- Support for intermediaries in the sector including loans for green projects to banks (USD 700 m) and support for first green bond issues;
- Interconnector development with Lao PDR to export RE – not looking at hydropower because of ESG risks, but rather wind and solar;
- LNG sector support for degasification facilities and power plants, including feasibility studies.

Asian Development Bank (ADB): ADB has an extensive portfolio of projects in Vietnam, although as with World Bank recent lending to the energy sector has been constrained by policy changes relating to ODA. As a result, ADB is placing more emphasis on lending at commercial rates through the private sector arm (PSOD). Key energy sector projects include:

- Power Transmission Investment Program–Tranche 3
- Ha Noi and Ho Chi Minh City Power Transmission Development Sector project
- Power Sector Reform Program
- Integrated Resource Planning with Strategic Environmental Assessment for Sustainable Power Sector Development in the Greater Mekong
- "Harmonizing the GMS Power Systems to Facilitate Regional Power Trade"
- Viet Nam: Municipal Waste-to-Energy Project
- Southeast Asia Energy Sector Development, Investment Planning and Capacity Building Facility

- Pilot Solar Auctioning Project in Viet Nam

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ): GIZ has a substantial program in climate change adaptation and biodiversity, TVET, energy and sustainable economic development in Vietnam, with over 240 people employed across different programs. Energy has been a priority area since 2013 and a thematic area of cooperation for GIZ since 2017. The energy sector program is extensive with a focus on energy efficiency and renewable energy, including smart grids, bioenergy, rooftop solar, PV systems in aquaculture/agriculture and longer-term energy transitions. Current projects include:

- Smart Grids for Renewable Energy and Energy Efficiency – including the comparison of the performance of internationally available and local technologies, developing a legal framework for demand response, and capacity building;
- Renewable energy and energy efficiency (4E), Phase II and Phase III – To further develop legal and the regulatory preconditions and related capacities for investment in renewable energy and energy efficiency as well as to further strengthen related capacities for implementation;
- Programme for Energy Efficiency in Buildings – working on regulatory framework and supporting the creation of incentive systems that mobilize private sector investment in energy efficiency in buildings and provide long-term planning security for private investors.
- Bioenergy Project – looking at the role of bioenergy in electricity and heat generation;
- Clean, Affordable and Secure Energy for Southeast Asia – focusing on the broader transition to a cleaner more sustainable energy sector across the region.

In addition, GIZ has a number of planned projects including:

- Solar-Aquaculture Habitats – developing solar technologies for aquaculture
- Commercial & Industrial Rooftop Solar – development of regulatory frameworks, capacity building and technology cooperation
- Viet Nam Energy Transition Project – The project aims to support the implementation and achievement of energy-related goals.

However, GIZ might cut or scale back these projects due to changes in the German government's priorities following the global geopolitical conflict.

European Commission (EC): The EC has been active in the Vietnamese energy sector for several years and has been the co-convener of the VEPG since 2017. Most of EC funding is channeled to GoV using direct budget support, conditional on the meeting of agreed performance objectives. Another TA has been given on an ad hoc basis on demand to MOIT and ERAV. This includes support for RE investment, support for EE, and engagement with MARD through SNV to support biogas programs. Support has also been given for the development of different financing modalities for EERE, including equity funding for early-stage project development and work on domestic green bonds. Other involvement in the climate and environment sector more generally has included support for mangrove rehabilitation and support for the conduct of an SEA of PDP8 as well as associated EIA regulations. On-going projects include:

- Energy Sector Policy Support Programme to enhance Access to Sustainable Energy in Rural Areas of Vietnam – Sector Reform Contract (Budget Support)
- EU Vietnam Energy Facility
- Supporting hydroelectric electricity production increase in Vietnam
- Civil society meets RE&EE – training, seminars and communication skills to boost RE&EE as a key tool for sustainable development and green growth strategy in Vietnam (E-Enhance)
- Support Vietnam EREA/MOIT to Conduct a Strategic Environmental Assessment (SEA) of the National Power Development Plan 8 in the Period 2021-2030 with Vision to 2050 (PDP8)
- Biomass Gasification Technology – Sustainable Energy Solution for Agri-Food Processing and Waste Management in Rural Areas of Vietnam
- The Vietnam Sustainable Energy Transition direct budget support Program is also planned for implementation in 2021. This includes a focus on promoting EE and RE, as well as support for the energy information system in Vietnam.

Japanese International Cooperation Agency (JICA): JICA (through the Japanese Bank for International Cooperation (JBIC)) has historically been the largest foreign lender to the power sector in Vietnam. This includes sovereign loans for the development of power plants including thermal power plants, hydropower and transmission systems. As well as non-sovereign loans direct to private companies in the sector, more recently for RE energy projects. In addition, JICA has provided TA to MOIT for the development of energy management systems, and to MONRE for the development of MRV systems for use in the NDC process.

Currently, JICA is undertaking a data collection survey on the power sector in Vietnam, to identify suitable projects in transmission and distribution to facilitate the development of renewable energy projects in Central and Southern Vietnam. Not mentioned in the interview with JICA, JBIC continues to be involved in the financing of a number of coal fired power plants including the controversial Vung Ang 1 and 2 coal-fired thermal power plants. These are expected to rely on imported coal, both projects have been delayed due to extended negotiations and issues with raising finance for these projects.

United States Agency for International Development (USAID): Has been supporting the development of long-term energy strategies, including a reduction in the reliance on coal, promotion of RE and LNG, industrial Energy Efficiency (EE) and EE&RE at the municipal level through the development of urban energy plans, which include provision for distributed energy production and storage, demand response and electric vehicles. USAID has also been giving more general support for the development of private sector involvement in the energy sector. Current projects include:

- Vietnam Low Emission Energy Program (V-LEEP I): provides support to the Government of Vietnam to develop and implement long-term energy strategies, mobilize private investments for renewable energy, and improve compliance with industrial energy efficiency.
- Vietnam Low Emission Energy Program (V-LEEP II): supports Vietnam’s energy sector transformation to a clean, secure, and market-driven sector by mobilizing investment in the deployment of advanced energy systems, enhancing power system flexibility, and increasing competitiveness.
- Vietnam Urban Energy Security (VUES): works with Da Nang and Ho Chi Minh cities to improve the enabling environment for distributed energy deployment and investment, supports the adoption of innovative energy solutions, and mobilizes private investments for distributed energy solutions.

United Nations Development Program (UNDP): The UNDP has a long history of engagement in EE projects, including street lighting, buildings and SMEs as well as broader advocacy work related to RE and sustainability in the energy sector. Support for EE has been focused on SMEs (working with GIZ on financing for EE at SMEs), the development of EE standards, certification and labelling for appliances, promotion of municipal LED lighting, working on building EE through retrofitting, energy audits, building codes and design standards with MOC and the National Assembly (including the new law on construction and work with developers). UNDP is also working on E-mobility with MBI motors. UNDP is also involved in research into 1) EERE investment in Vietnam; 2) Life-cycle analysis for solar and wind focusing on end-of-life disposal/recycling; and, 3) Supporting PDP8, investment from domestic and international private sectors for RE in VN. The UNDP also acts as co-chair of the Vietnam Energy Partnership Group (VEPG).

The Vietnam Energy Partnership Group (VEPG) is a platform between the GoV and Development Partners to strengthen the partnership between the two sides, for the effective and efficient utilization of external support to the Energy Sector. Established in June 2017, the overall objective of VEPG is to work towards effective and efficient international support to sustainable energy development in Viet Nam, in line with national law and international agreements of which Viet Nam is a member. The VEPG Steering Committee is chaired by a Vice-Minister of the Ministry of Industry and Trade (MOIT). The group's High Level Meeting took place on June 21st, 2017 to establish the VEPG Secretariat and start the activity of the VEPG. Technical Working Groups (TWGs) established include:

- Renewable Energy;
- Energy Efficiency;
- Structural Energy Sector Development and Reform including Power Market Reform;
- Access to Energy;
- Energy Data & Statistics.

Each TWG has a co-chair held by a GoV representative and a co-chair held by a Development Partner. The renewable energy TWG is chaired by MOIT/EREA and co-chaired by the German Embassy in Vietnam.

UK Foreign & Commonwealth Office (FCO): Currently the United Kingdom's FCO engagement in the energy sector of Vietnam is largely focused on political advocacy relating to achieving an agreement at COP 26. The FCO has some engagement with EE and climate change adaptation in Vietnam, but most of the involvement is in the energy transition through the Energy Transition Council (ETC). The ETC brings together governments, civil society and the private sector in an effort to realize a just and rapid transition to low-carbon energy systems. Most of the engagement with Vietnam is thus focused on the development of low carbon pathways, enhancement of the level of ambition in Vietnam's NDC and development of an enhanced regulatory framework for investment. Ongoing initiatives under the Prosperity Fund ASEAN Low Carbon Energy Programme include:

- Development of Energy Efficiency Foundation for Vietnam to offer funding, awareness raising and technical support from a single institution. The intervention will focus on the design of an appropriate structure for the national EE Fund, and also provide recommendations on the delivery approach of the Foundation, potential funding sources, and roles and responsibilities of key stakeholders.
- Support for Minimum and High Energy Performance Standards (MEPS and HEPS) for electric motors (Regional Intervention working across Malaysia, Myanmar, Philippines, Thailand, Vietnam);
- Promote improved EE target setting and performance by companies in the food and beverage sector, through the adoption of Energy Management Systems (Regional Intervention working across Malaysia, Myanmar, Philippines, Thailand, Vietnam);
- Support the creation of a market for ESCOs to implement paid-from-savings EE projects in government facilities: This work package will attempt to establish new regulatory procedures for government agencies to follow in order to legally procure and contract with ESCOs to develop, implement and fund EE projects in government facilities and receive multi-year payments from reduced energy costs (Savings).
- Support MOIT to deliver the VNEEP3, including Developing an MRV System for the rubber sector as well as a baselining and benchmarking study; and, Developing a Best Available Technology review of the rubber sector;
- Develop a pilot EE project implemented by a cement or steel company that demonstrates a bankable IGA and project-based financing.

Danish International Development Agency (DANIDA): Denmark has a five-year energy program in Vietnam, the "Danish Energy Partnership Programme III". The program objectives mainly focused on planning and providing TA to assist Vietnam in a transition to a low-carbon energy sector. This includes capacity development for long-range energy sector planning, capacity development for RE Integration into the Power System, and low-carbon development in the industrial sector.

SNV Netherlands Development Agency (SNV): SNV has been working in Vietnam since 1995. Its team works with communities, government agencies, and businesses in remote and poor areas of the countries to strengthen their capacity to effectively reduce poverty. Its work focuses on energy, Reducing Emissions from Deforestation and Forest Degradation (REDD+) and Sustainable and Inclusive Agriculture. In the energy sector, SNV is very successful in the biogas program with the Ministry of Agriculture and Rural Development (MARD) through developing a commercially viable biogas market to increase sustainable lighting and heating services and to provide fuel for household cooking in rural areas. Up to 2020 when the program was closed, the program supported the construction/installation of 55,000 digesters and created about 1,000 jobs annually. Total of 3.07 million carbon credits were issued and generated €7 million of revenue which contributed to 50% of the program's operating costs. Recently, SNV is interested in Agrivoltaics which is a land-use approach in which agricultural production and electricity production from solar PV (APV) is combined on the same land. As a first step, SNV conducted a study in early 2020 to examine the financial feasibility of the APV approach in Vietnam[35].

Chinese support: China is one of the key financiers for coal power. Per report by the World Bank, of $8 billion committed for 5 GW of coal power which is under construction, 25% comes from China. However, China is also key to Vietnam's solar success. Around 99 percent of the installed solar panels in Vietnam come from China, some of which are assembled domestically. Aside from equipment, Chinese businesses have also provided EPC (engineering, procurement, and construction) contractors for solar projects. Some contractors are supported by Chinese Banks, which then allows them to provide flexible payment schedules to the project developers in Vietnam and gives them a competitive edge[36].

Other donors are also active in the sector including UNIDO, UNOPS, GGGI, KfW, AfD, KOICA, the Embassy of Italy and the Embassy of Luxemburg. GGGI (municipal waste-to-energy) is largely involved in promoting waste-to-energy projects and TA assists in the development of these. In particular, AfD's lending is focused upon improving existing hydropower projects and transmission lines, and KfW is involved in lending for a number of projects including smart grids/transmission and distribution systems, energy efficiency and RE development. UNOPS is also facilitating capacity building and experience sharing between Southeast Asia's largest growing fossil fuel markets (Vietnam, Indonesia and the Philippines) through the establishment of an

Energy Transition Partnership (ETP). With close links to the COP/NDC process, the ETP aims to build an understanding of practical approaches and reforms that could accelerate the transition in these countries.

4.1.6 Policy implications for Vietnam's low-Carbon power transition

Based on the above and with consideration of China's Strength and Advantages in RE and EE development, it has been able to identify 6 themes as shown in high-level terms in the below.

Regional grid interconnection study: The purpose is to explore power trade options across borders to accelerate transition process. This initiative would take advantages of available energy sources in each country and therefore is beneficial to all participating countries. The interconnected power network in the Europe is a clear example of its benefits for a high RE. In fact, this idea has been pursued since long by the ADB and recently by the Asian Centre of Energy (with funding from USAID) but progress in terms of moving it to implementation phase unfortunately has not been seen.

Energy efficiency enforcement: This initiative will share experiences in conducting sectoral benchmarking, formulation and enforcement of MEPS regulations and deployment of ESCO to support the implementation.

Green finance: As mentioned in the previous section, Vietnam will need huge finance to invest in green technologies to replace fossil fuel-based power plants that reach their life ends and new capacity to meet the increasing demand. This is a huge challenge for Vietnam. To accelerate the transition process, Vietnam is in bad need of access to concessional funding products.

Carbon market development: Vietnam aims to develop the carbon market in 2028. This initiative will share experience in operating the carbon market and provide technical support for future market participants on how to participate in the market. Emission from the energy sector represents a dominating share of the national emission, in which power generation and consumption again account for the biggest portion. In this regard, this initiative will address enterprises/entities from both production and consumption. The cooperation could be in the form of twining between the designated entity in Vietnam (in this case Department of Energy Efficiency and Sustainable Development of MOIT) and the Chinese counterpart.

Coal re-operationalisation study: This includes the formulation of a strategy for the role and operation of coal-fired power during the transition, and techno-economic scoping for capacity payments and other market options to facilitate re-operationalisation. As said above, coal power presently accounted for 32.5% of system capacity, equivalent to 25.4 GW and about 9 GW are under construction. There is a need to develop a plan for the role and operation of these coal fleets to accelerate the energy transition process. ADB is proposing a mechanism so-called ETM (Energy Transition Mechanism) whereby coal-fired power plants will be acquired and retired early but there is a concern about the feasibility of this plan. The support could include experience sharing and technology transfer.

Renewable energy supply chain: This involves developing a strategy to draw investment in RE technology and related infrastructure/facilities and share experience in the implementation. The objective is to reduce investment costs and at the same time to make further socio and economic contributions to the country/provinces. It is worth noting that per the draft Power Development Plan for the 2021-2030 period with a vision to 2045 (PDP8), 64.5 GW capacity of offshore wind is planned in 2045. Implementation could be made through twinning with the Chinese counterpart. Potential partners from Vietnam include Binh Thuan, Ninh Thuan, Quang Tri and Daklak provinces. These are the provinces that have positioned themselves as RE centres. Or with MOIT if the collaboration is made at the national level.

4.2 Low-carbon transition of the power sector in Indonesia

4.2.1 Status of Indonesia's Power Sector

Indonesia is the largest consumer of electricity and producer of CO_2 in Southeast Asia. It is estimated that Indonesia's total emissions contribute around 7 % of the global emission[38]. According to Indonesia's Second National Communication of 2010, national GHG emissions were estimated to be 1.8 $GtCO_2e$ in 2005. This represents an increase of 0.4 $GtCO_2e$ compared to 2000. Most emissions (63%) are the result of land use change and peat and forest fires, with the combustion of fossil fuels contributing approximately 19% of total emissions. Figure 4-11 shows Indonesia's emissions in comparison with other countries. During the last decade, Indonesian emissions growth is relatively high. It's higher than the world emissions and lower-middle-income countries. The growth rate of its energy carbon intensity is among the highest in the world. This has contributed to the fact that in 2010 Indonesia's total CO_2 emissions (even excluding LUCF) is among the largest in the world. It is the fourteenth biggest emitter in the world.

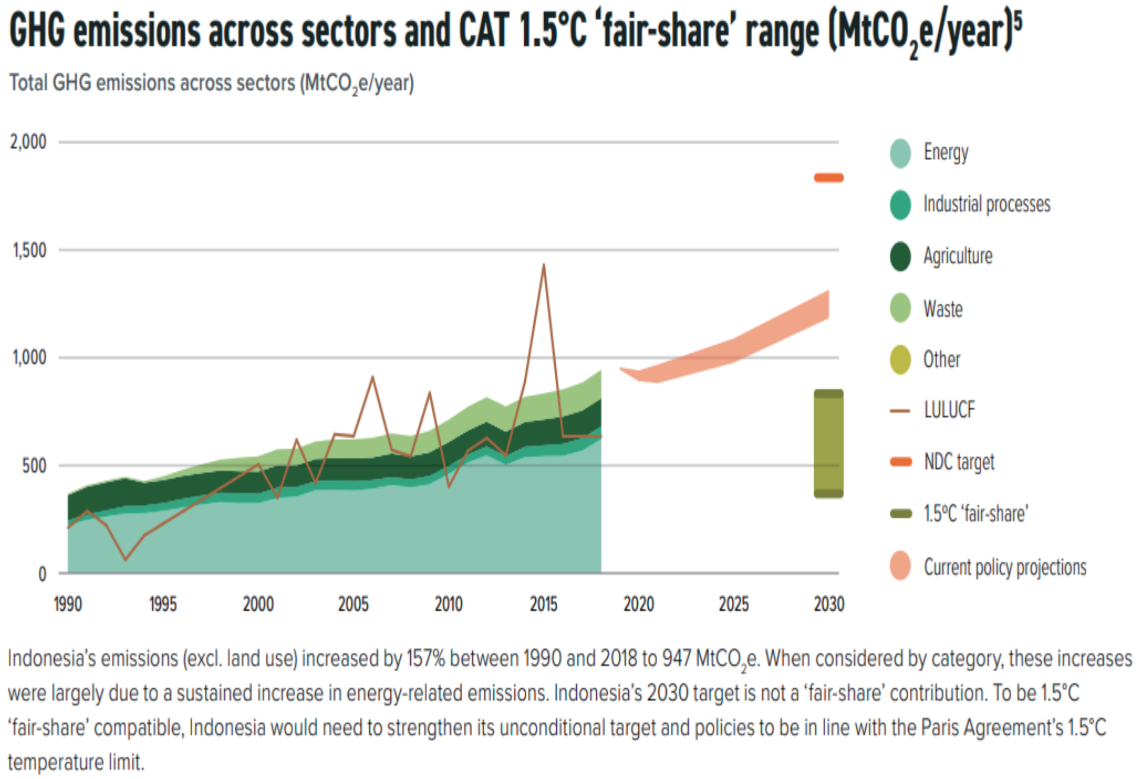
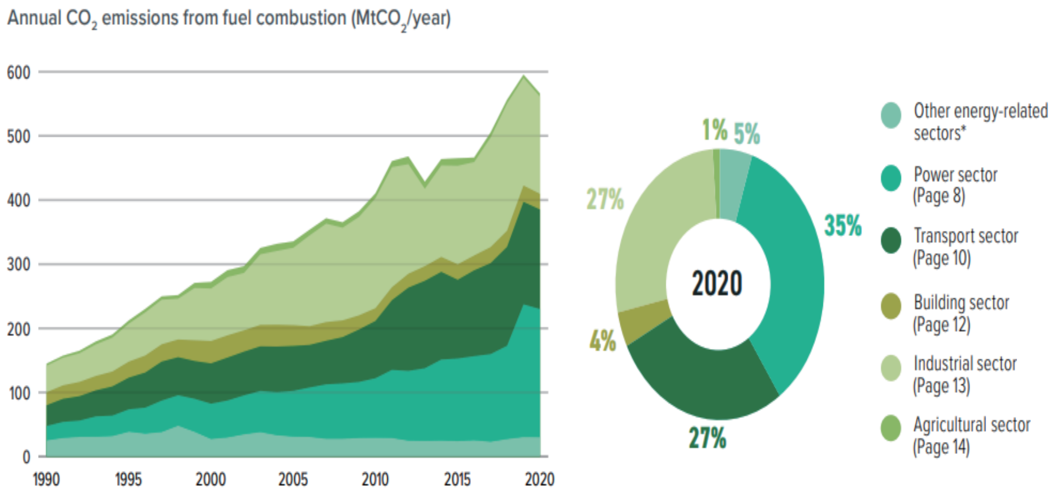


Fig 4-11 Carbon Emission profile of Indonesia – Historical and Projected

Based on Indonesia's First Biennial Update Report (BUR) submitted to UNFCCC in January 2016, national GHG emissions were 1.453 $GtCO_2e$ in 2012 which represents an increase of 0.452 $GtCO_2e$ from 2000 emissions. The main contributing sectors were LUCF including peat fires (47.8%) and energy (34.9%). The 2nd BUR reported a slight increase in emission level to 1.457 Gg CO_2e in 2016, which was dominated by emissions from LUCF including peat fires (43.59%) and energy (36.91%).

The largest driver of overall carbon emissions is coming from the energy sector, mainly from extracting and processing of fossil fuels as illustrated in Fig 4-12. It contributed more than 40 % of total national emissions in 2020. The energy system in Indonesia will be increasingly challenged to satisfy its economic development and social aspirations. The basic energy challenge facing Indonesia is threefold: 1) to supply enough energy to meet the demand and to provide access to modern energy services for those that are currently without; 2) to supply enough energy in an efficient and affordable way that balances the need of industrial competitiveness and human development in relation to economic integration; 3) to provide sustainable energy that takes into account local and global environmental issues such as climate change.



The largest driver of overall GHG emissions are CO_2 emissions from fuel combustion. In Indonesia, emissions have increased significantly since 1990, reaching a high of 620 $MtCO_2$ in 2018. The power sector is, at 35% the largest contributor, followed by transport and industry at 27% each.

Fig 4-12: Energy sector Sectors of Indonesia

According to the type of fuel consumption, coal is dominant – with about 54% of the national energy mix – followed by natural gas (26%) and coal (11%), with renewables accounting for about 8% in 2018. It is estimated that about 20% of primary commercial energy will be required for electricity generation by 2040. According to projections, Indonesia's oil imports are set to increase by 11 million barrels per day (mb/d) from 2018 to 2040, reaching almost 30 mb/d by 2040.

Given the robust growth in energy demand and the dominance of fossil fuels in the energy mix, energy-related carbon emissions in Indonesia are projected to grow by 169% from 587 metric tons of carbon (Mt-C) in 2015 to 1,581 Mt-C in 2040 under the BAU scenario Even under scenarios that have higher energy efficiency and a higher share of non-fossil fuels, carbon dioxide emissions will grow by 84% to 1,077 Mt-C in 2040. Coherent actions on energy efficiency, renewable energy, and other clean energy choices will contribute to the overall decrease in carbon emissions. According to ACE[39], energy efficiency and renewable energy combined will play an important role in reducing carbon emissions by 37.3% in ASEAN where Indonesia is the largest consumer by economic size and industrializing and increasing its vehicle fleet. ACE and IEA projected the annual growth of CO2 emissions from 2015 to 2050 to be 3.0% and 2.8%, respectively, in ASEAN, while the annual growth will be 0.8% globally, 1.4% in non-Organisation for Economic Co-operation and Development (OECD) Asia, and 0.3% in China[40].

4.2.2 Key policies and targets for Indonesia's low carbon power transition

The Indonesian energy transition strategy initially formulated in 2007, intended to provide an overview of the GHG mitigation action aimed to serve as guidance for:

- Securing sustainability of planning policies in addressing climate change issues.
- Strengthening institutional capacity for sustainable development.
- Streamlining GHG mitigation actions into national and sub-national development policies to achieve the national mitigation target.
- Strengthening Indonesia's position in the international climate change agenda.

Indonesia Aims to be carbon neutral by 2070 while maintaining its previous pledge to reduce emissions by 29% (depending on its own ability to finance decarbonization) or by 41% (with international support) by 2030[41]. At COP26, Indonesia signed the Global Call to Clean Power Transition declaration. The Minister of Energy and Mineral Resources also indicated that the government is considering retiring coal-fired power facilities with a total capacity of 9.3 GW before 2030, which needs around 426 trillion IDR according to the Indonesia Ministry of Finance (MEMR, 2021).

The COVID-19 pandemic is a severe setback for the energy sector. The State Electricity Corporation (PLN) faced a 15% decrease in electricity demand in 2020 and the government expanded electricity subsidies to protect the poorest 31 million households. Combined, this led to a 2020 first-quarter loss of US$2.8 billion for PLN, which decreased its investment planning by 50%. The energy outlook for 2021 is targeted to improve as Indonesia's economic growth recovers to pre-COVID-19 levels. Indonesia's COVID-19 reaction was aided by the energy industry, which will be critical to the country's economic recovery.

Indonesia's low-carbon energy transition strategy in the post covid-19 era is built upon three main pillars phasing out fossil fuels, boosting renewable energy, and increasing the energy efficiency measures

4.2.3 Transition path for Indonesia's fossil energy phase-down

Use of clean coal

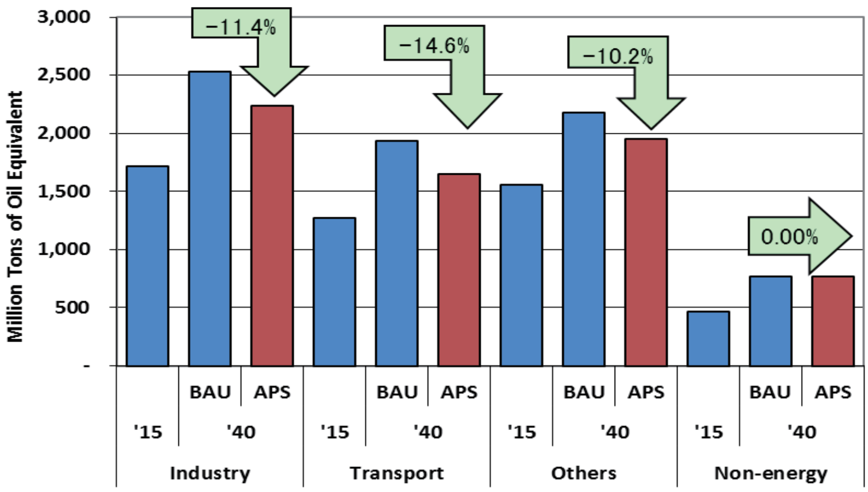
Coal is cheaper and abundant compared with other sources of energy in Indonesia and hence going with coal is indeed the natural choice for the region to fulfill its sharp increase in the energy demand to support economic development. At the same time, coal is the major source of air quality and greenhouse gas (GHG) emissions concerns in this region, accounting for 18% of carbon dioxide emission. To lessen the environmental impacts, Indonesia would need to utilize the latest and most efficient clean coal technologies. Although many advanced technologies that allow cleaner coal utilization are well developed, they have not been widely adopted due to financing constraints and limited technical knowledge. Apart from this concern, an additional challenge emerges from the increasing share of imported fossil fuel that obviously has alarming implications for CO_2 emissions and energy security. External costs related to air pollution from the combustion of fossil fuels will increase by 35%, from USD 167 billion annually in 2014 to USD 225 billion in 2025, which also equals 5% of the regional Gross Domestic Product (GDP) in 2025[42]. Consequently, ASEAN will see rising costs for energy supply and for controlling pollution.

The For andonesian government's pledge during COP26 on the phase-out of coal is a crucial step toward achieving the objectives of the low-carbon energy transition. The Minister of Energy and Mineral Resources has stated that the government is considering retiring coal-fired power plants with a total capacity of 9.3 GW before 2030. This plan needs around 426 trillion Rupiah according to the Indonesia Ministry of Finance. The goal of a low-carbon economy and net zero emission is intended to be achieved through the plan to terminate the coal-fired power plants, due to the fact that Indonesia aims to achieve carbon neutrality by the year 2060 or sooner.

With the growing energy demand, limited resource endowment, and also a need to minimize GHG emissions from energy production and utilization (Fig 4-13); it is vital to adopt all the necessary measures to ensure that coal and other fuels are used with the highest efficiency possible.

Coal demand in Indonesia is set to triple by 2040, making coal to be the largest fuel in the energy mix[43]. This projected growth in coal provides many opportunities for Indonesia to deploy the most efficient coal technologies that are commercially available and to reduce the environmental footprint of coal-based electricity generation.

There are several alternative technologies for improving the efficiency of coal utilization. For example, the supercritical and ultra-supercritical technologies that are commercially available. Even higher efficiencies would be possible when advanced ultra-supercritical becomes available. Power plants using low-grade coals, such as lignite which is abundant in Indonesia, are candidates for more efficient power generation. Integrated gasification combined cycle (IGCC) may also offer higher efficiency and emissions reduction if this technology is more widely deployed in the region. High-Efficiency Low Emission (HELE) coal-fired power plants are already being built in Indonesia. Such HELE technologies paired with carbon capture and storage (CCS) would be an important low-carbon emissions option for Indonesia which is building up coal and natural gas-fired power plant capacity. The cost of reducing carbon emissions will be dramatically higher without CCS technology, which is estimated up to 70% higher internationally. The cost of deploying CCS on coal-fired power plants ranges from USD 60 to USD 90 per ton of carbon abated, which is cost-competitive with other forms of low-carbon energy systems.



BAU = business as usual, APS = alternative policy scenario.

Fig 4-13 Final Energy Consumption by Sector I two scenarios

For a developing country like Indonesia, climate mitigation efforts must be integrated with goals related to energy security, economic development, and many opportunities. Thus, like several ASEAN countries, it has included HELE coal-based power generation in its Intended Nationally Determined Contributions (INDCs). While pressing social development needs and resource constraints, it is useful to think of investments in clean technologies as a staged process where adjustments are made based on the level of development. Given the large heterogeneity of clean technology needs among the ASEAN countries, regional cooperation can help countries with similar development stages to overcome their barriers to clean technology deployment[44].

Use of Natural Gas

Natural gas is one of the most abundant energy resources that poses the best possible low carbon alternative to coal and oil. Within the ASEAN countries, Indonesia has emerged as a key source of natural gas with total proven reserves amounting to 2.8 trillion meter cubic in 2015. The APAEC framework also focuses on Trans-

ASEAN Gas Pipeline (TAGP) project, which identified eight possible gas interconnection projects. Four of them would originate from gas fields operated by Indonesia. However, in recent years, they have been losing their market share to other suppliers such as Australia, Qatar, and Russia. This has been attributed to the lack of a coordinated strategy to improve gas infrastructure and attract new investments that would create sources of production. High incidence of piracy in the Malacca Straits, the unregulated and insecure nature of the maritime trade, and any disruption of global trade will have divesting impact on LNG supply in Indonesia, wherein local production is dwindling amidst the increasing demand for LNG.

The abundant reserves of natural gas in For andonesia would allow the region to decouple its growth in electricity demand and its related emissions through fossil fuel mix by using natural gas. The realization of Trans-ASEAN Power Grid (TAPG) project and investments to develop maritime Southeast Asia as a LNG hub can help to facilitate greater trade in natural gas. Investments in infrastructure for the integration of gas transmission will make natural gas more accessible to countries in the region and also could alleviate concerns associated with energy security through energy supply diversification. Integrated gas transmission can help other countries, such as Myanmar, to join the regional gas trade more easily. Realizing such trade potential in natural gas, the Indonesian government should first address the political, institutional, and legal barriers. Governments can start by harmonizing the legal and institutional frameworks on LNG markets and formulate suitable financing options for the integrated gas pipeline and LNG hub.

Exploring alternative energy sources, including nuclear energy, is part of their strategies to ensure that energy supplies are secure, affordable, and environmentally sustainable. Indonesia is also exploring nuclear energy options and has changed its plan from building large units for the Java-Bali grid to building an initial small reactor near Jakarta.

There are several encouraging attempts for international l cooperation to foster low-carbon technologies. For example, under the framework of the ASEAN Plan of Action for Energy Cooperation (APAEC) 2016-2025, the region has set collective actions to strengthen cooperative partnerships in the promotion and utilization of coal and clean coal technologies. In supporting this plan and to further scale up clean technologies utilization, the implementation of clean technologies needs to be embedded in the long-term national energy programs that combine supply and demand side measures, cross-cutting functional and administrative boundaries, regional cooperation, and innovation process.

In addition to that, it is important to add renewable energy capacity to the country. The low carbon transition must be meticulously planned, with the development of renewable energy and energy efficiency as the top priorities. Removing coal from the energy mix while simultaneously expanding renewables is a critical step toward achieving net zero emissions.

4.2.4 Transition path for Indonesia's renewable energy development

Enhancement of Hydro and variable renewable energy technologies

Indonesia's future energy supply will be bigger, and the mix will be much cleaner than it is today. Greater use of renewable energy will play a key role to achieve cleaner and more sustainable energy supplies. With such significant accomplishment, a more ambitious target of 30% renewable share that includes solar, wind, bio, and mini-hydro is feasible to be achieved. Moreover, hydropower and geothermal are well-established renewable energy sources in Indonesia. The Country has 350 gigawatts (GW) of hydropower capacity installed or under construction, with the potential to quadruple the capacity to 1,204 GW by 2040. Hydro is one of the most affordable energy resources. Results from the Levelised Cost of Electricity (LCOE) study showed that the average cost of a hydro project is 0.044 USD/kWh (kilowatt hour), with the lowest value reaching 0.029 USD/kWh[45]. This is another reason for Indonesia to develop hydropower for electricity generation. Additionally, in 2016, utility-scale solar photovoltaics (PV) and onshore wind have seen record-low prices of 0.03 USD/kWh. Such progress in renewable energy prices shows a large potential to be integrated into existing grids while maintaining or improving power reliability and quality. This clean energy transition also comes at an important time for climate change action, with the Paris Agreement entering into force.

While various renewables have enjoyed significant cost reductions and are already economical in certain locations – including in remote areas, they have not entered the mainstream. Being cost competitive should be understood as factoring in environmental and other social costs that are external to economic development. However, capturing the externalities with subsidies or the imposition of taxes and mandates could increase energy prices and cramp further economic activities if it is not planned properly. More innovative policy instruments, price structures, and inter-sectorial coordination are needed as a part of a comprehensive strategy capturing externalities. Also, the more expensive electricity costs derived from renewable sources could undermine affordability. Policymakers are struggling to find a tradeoff between non-market based policy measures and strengthening old regulatory instruments that could bring a positive impact on renewable energy capacity. Given the current trend in GHG emissions and the latest round of stalled global climate talks, the traditional ways of problem-solving are no longer sufficient. Innovative actions that can accelerate the clean energy transition should be promoted to avoid the tragedy of commons[46].

In terms of large hydropower projects, the cost remains huge and addressing their environmental and social impacts remains a challenge. Nevertheless, hydropower projects can have strong positive outcomes if they are well-planned and executed. For small-scale hydropower projects, finding the best business model to access finance is the major challenge because, if aggregated, small-scale hydropower can be more expensive than large hydropower with a longer payback period. In Indonesia, small-scale hydropower entities and solar power utilities are usually for the purpose of rural electrification, which makes it not attractive for institutional investors. International investment with guarantees from the government should be welcomed to overcome this challenge. The government also needs to create more investment-friendly policies, such as long-term Feed-in Tariff (Fit), tax holidays, and low-interest loans by providing more incentives and financial support for project developers. The government can encourage public-private partnerships for this purpose. Another important challenge we may see in the development of hydropower is to increase the connectivity among the neighbours' Grid integration across the borders will boost hydro source deployment in Indonesian regions like Sumatra. With better and higher grid integration, provinces with abundant hydro potential can more easily export their electricity to Malaysia, Singapore, and the Philippines.

A significant for amprovement was made for an the 2021-2030 General Electricity Supply Plan (RUPTL) of PLN, where RE-based generation is given a bigger portion of 51.6%, equaling 20.9 Gigawatts (GW). 2021 to 2025 – MEMR would issue a number of regulations, including a law on NRE, conduct early retirement of coal-fired power plants, expand co-firing at coal-fired power plants, and convert diesel power plants to gas and NRE power plants. Starting in 2035, capacity addition would only come from RE sources. By 2025, the share of RE is targeted for 23% and will be dominated by solar PV. 2026-2030 – No additional capacity from coal-fired power plants, except those which have reached financial close or are under construction. 2036-2040 – the second stage of coal power plant retirement will be conducted, and the project will cover subcritical, critical, and some supercritical power plants. The share of RE will lift to 66%, with solar, hydro, and bioenergy power plants dominating the energy mix. Sales of conventional two-wheelers will be limited. 2041-2045, the first large-scale ocean current and nuclear power plants will enter Commercial Operation Date (COD). The share of RE will grow to 93% with solar, hydro, and bioenergy power plants dominating the energy mix. Sales of conventional four-wheelers will be controlled. From 2051 to 2060, the last stage of coal power plant retirement will be performed, and hydrogen will be massively developed for electricity generation. The renewable energy share will be dominated by solar, hydro, and wind power plants.

But challenges for the uptake of renewable energy include (i) involvement of governments in the promotion of renewable energy development, (ii) skilled labor to develop the renewable energy sources, (and iii) intellectual property rights enforcement that hampered the technology transfer from developed countries, and (iv) affordability and accessibility of renewable sources as well as locally sourced[47].

Integrating renewables in the cross-border energy Infrastructure Development and Trade

Integration of renewables into the grid systems of Indonesia will allow the optimum utilization of energy resources and further improve energy security. The region can supply energy and at the same time provides investment opportunities for its dialogue partners, such as China, Japan and South Korea. Brunei Darussalam, Indonesia, Malaysia, and Vietnam have considerable potential to produce oil and gas.

The main objective of regional power infrastructure development is to reap the full benefits of reduced investment costs, improved energy supply stability, and reduced emissions. There are two main priorities for energy infrastructure projects in ASEAN, namely the TAG, and APG. By the end of 2016, there were 13 bilateral gas pipeline interconnection projects in operation with a total length of 3,673 km connecting six countries – Indonesia, Malaysia, Myanmar, Singapore, Thailand, and Vietnam. As the gaps between demand and supply in ASEAN will become larger since the indigenous reserves are depleting, TAGP now also includes LNG as an option to secure energy supply. Many countries have initiated infrastructure construction to flow gas from outside ASEAN. Currently, LNG terminals are already in operation in Indonesia and Thailand. The construction of LNG receiving terminals has been progressing well in Indonesia, Malaysia, Singapore, and Thailand. In April 2016, there are six regional gas terminal operations with a total capacity of 22.5 metric tonnes per annum.

In terms of electricity infrastructure, ASEAN has identified three APG Priority Projects for completion and three additional APG projects that will commence construction shortly. Through these projects, power exchange and purchase for Indonesia are expected to triple from 3,489 MW in 2014 to 10,800 MW in 2020 and further increase to 16,000 MW post-2020.

The existing power trade between Indonesia and the rest of ASEAN is mostly established on a bilateral basis.

Given that progress has been largely focused on bilateral interconnections, the new strategy for ASEAN is to embark on multilateral interconnections. Further, if power interchange takes place between countries with different times in peak demands, then the investment needed could be reduced to maintain the reserve margin. Such regional grid interconnections will generate economic benefits for the entire region. However, the size of investment for linking different markets is most considerable. Prioritization of construction, taking into account the benefits and feasibility of each route, would help to avoid situations where construction of all planned routes commences at the same time and create implementation deficits.

Numerous potential barriers confront energy market integration, including technical, political, and environmental barriers. First, technical barriers are prevalent, ranging from grid synchronization and grid codes to electric power and natural gas pipeline technology. Second, power transfer among ASEAN countries is mainly hampered by the reluctance in giving up sovereignty for energy security[48]. The fundamental reason is they are in fact seeking maximum protection for their interests amidst the market opening and restructuring processes. Third, negotiations for trading agreements are commonly affected by unequal starting positions and differing energy security concerns. Political barriers and a lack of political trust in coordination among member countries can also hinder such negotiations. Fourth, regulatory barriers and distorted energy pricing from existing subsidy regimes in many ASEAN countries discourage the trading of energy on commercial terms, as the entities are selling energy at 65haracteri rates will have to pay for the energy at cost, with negative financial consequences. IEA[49] suggests that to a certain extent (on the basis of LCOE) many renewable technologies are cost-competitive compared with conventional sources even without subsidies for their generation. Finally, hydropower generation and the construction of multi-purpose projects are considered to have significant environmental repercussions. The construction of multipurpose projects, which include large reservoirs, means a disruption of riverine fauna and displacement of human settlements and agriculture. An integrated approach to energy market integration is needed, which would include building institutions to improve coordination and address multiple barriers.

4.2.5 Innovative financing mechanism of Indonesia's low-carbon energy transition

Indonesia has made several financial commitments to climate change adaptation and mitigation, such as Green Bonds and Green Sukuk[50]. Indonesia has designed its Green Bond and Green Sukuk framework to back or re-account Eligible Green Projects[51]. Issuance is guided with the aid of the Green Bond and Green Sukuk Framework, reviewed by the international independent reviewer Center for International Climate Research and graded with colours that indicate the degree to which eligible listed projects represent the country's long-term vision for carbon emissions reduction[52]. The issuance of Green Bonds will attract investors to enter into environmentally based development without the risks associated with individual projects.

Besides Green Bonds, Green Sukuk is the other alternative for low-carbon development financing. Green Sukuk is an innovative, *shariah*-compliant bond, where 100% of the return is restricted to financing or refinancing green projects. Green Sukuk has the capacity to connect the conventional social responsibility market with the Islamic financial market. Green Sukuk can also prove *Shariah* finance's viability, both in the Muslim and global markets[53]. Green Sukuk is a decent and promising approach to align with global trends where the world focuses on sustainability-based projects, particularly on the environment and reforestation[54].

The issuance of Green Sukuk is one of the government's endeavors in actualizing green financing. Green finance is an expansive term that can refer to sustainable development projects and initiatives, environmental products, and policies that support sustainable development. Green finance incorporates climate finance, but is not restricted to it and can include, for example, industrial pollution control, sanitation, or biodiversity protection. Mitigation and adaptation finance are explicitly identified with climate change-connected activities: mitigation finance refers to investments in projects and programs that contribute to reducing GHGs, whereas adaptation finance refers to investments that reduce the vulnerability of products and persons to climate change[55].

Indonesia is the first country to be issuing Green Sukuk at the global level. In March 2018, the government issued US$1.25 billion state sukuk on the global market. Green Sukuk will exclusively go to selected Eligible Green Projects. Indonesian Sukuk has been 66haracteri in the global market through positive press coverage. Indonesia's Green Sukuk have been distributed around the globe into high-quality accounts, mostly top-tier funds and banks, with 32% going to Muslin markets, 25% to Asia, 15% to the European Union (EU), 18% to the United States (US), and 10% to Indonesia. In the global market, new investors who are willing to invest in green projects have reached 29% of the total[56].

The Ministry of Finance mentioned three strategies that could be implemented to keep Indonesia focused on achieving low carbon energy transformation targets: (i) aligning action plans with the National Economic Recovery Policy; (ii) 66haracterize plans that can simultaneously restore the economy; and (iii) developing innovative funding schemes and policies to encourage the participation of non-government agencies[57].

Indonesia had sold Rp369 trillion worth of government bonds as of May 2020, an increase of 98.3% from the same period last year. The government is making plans to issue another Rp990 trillion worth of government bonds, including samurai bonds and diaspora bonds, from June to December of this year to cover the widening deficit. As with Indonesia's third global obligation issuance this year, the government is also offering sukuk[58]. According to Moody, Green Sukuk accounted for around 3% of sukuk issuance as of June 2020. Indonesia's Sukuk issuance is expected to increase by about 68.75% as the government unveiled an Rp695.2 trillion (US$47.3 billion) stimulus package to fight the pandemic[59].

Sukuk issuance in 2020 was set to be higher than in 2019 as the government needed to finance the widening state budget and the national economic recovery programme. As of 6 August 2020, the government issued a total of Rp236.82 trillion in domestic sukuk. The figure almost reached the 2019 amount, which was Rp258.28 trillion[60].

Indonesia has raised US$2.5 billion from a three-tranche global Sukuk offering to help the government fund the fight against COVID-19. Each tranche has been rated Baa2 by Moody's Investor Service, BBB by S&P Global Ratings Services and BBB by Fitch Ratings. The Sukuk was offered on the Singapore stock exchange and NASDAQ Dubai in the United Arab Emirates on 23 June 2020. The 10-year maturity sukuk brought in US$1 billion, and the 5-year and 30-year maturities amounted to US$750 million each. This issuance of a tenor of 5- and 10 years are the lowest issuance of global sukuk by the government on the global financial market and a tenor of 30 years is the largest in Asia.

The government designates the issuance of a 5-year tenor as Green Sukuk to show global commitment, leadership, and contribution to climate change finance. This is the third issuance in the global market, apart from that of retail Green Sukuk at the end of 2019[61]. This transaction is in line with the government's 2020 financing plan, including dealing with the impact of COVID-19, as well as strengthening Indonesia's position in the global Islamic financial market and supporting its development in the Asian region.

This transaction received great demand from qualified and diverse global investors, which shows investors' trust in Indonesia. In 2020, the distribution of investors for a 5-year tenor was 32% Islamic investors from the Middle East and Malaysia, 5% Indonesian investors, 40% Asian investors except for Indonesia, 12% US investors and 11% European investors. Meanwhile, for Sukuk with a tenor of 10 years, 31% were distributed to *sharia* investors, 5% to Indonesian investors, 34% to Asian investors except for Indonesia, 18% to US investors, and 12% to European investors. As for Global Sukuk with a tenor of 30 years, 10% was distributed to Islamic investors, 5% to Indonesian investors, 44% to Asian investors except for Indonesia, 8% to US investors, and 33% to European investors[62].

This issuance of Global Sukuk received a good reaction from global and local investors. With this large orderbook, Indonesia can reduce prices up to 70 basis points from the initial offering price and below the indicative fair value. The Global Sukuk is issued by SBSN Indonesia III Issuing Company, a legal entity established solely for the purpose of issuing government Sukuk.

4.2.6 International Cooperation in Indonesia's energy sector

To reach the Paris climate target, Indonesia must expand swiftly its renewable energy investments. Approximately US$100 billion per year is needed to meet energy transition objectives[63]. An enhanced investment framework for renewables and reforms that attract higher levels of private capital would help support sustainable economic recovery in Indonesia. Attracting the higher levels of capital require, 1) a reliable funding model for PLN, effective planning and better governance would help improve the financial and operational efficiency of the company; 2) an improved investment framework for renewables which could help increase competition and achieve generation at a lower cost.

For the power sector, the obstacle is the highly fragmented nature of Indonesia's grid, as well as operating concerns in off-grid areas. This covers land acquisition issues and finance opportunities for future projects that are currently limited by local banks.

There are several channels through which the international community is partnering with Indonesia on a bilateral and multilateral basis. The bilateral cooperation is 68haracterized as follows:

1) US- Indonesia

The U.S. Agency for International Development (USAID) has provided nearly $18 million for Clean Energy Development and to build Indonesian capacity to reduce carbon in land use and energy. The Indonesian government has continued to strengthen bilateral cooperation in the energy and mineral resources sector with the United States

2) Japan- Indonesia Energy Transitions Cooperation.

The partnership includes the preparation of an energy transition roadmap towards net-zero emissions based on the respective national targets, the development, and deployment of technologies that contribute to a real energy transition, support for efforts in multilateral for a to accelerate technological cooperation, and support for policy development, human resource development, and knowledge sharing on energy transitions. Broaden our engagement on trade and investment, improving mechanisms and capabilities that underpin a green economy transition including in regional energy trade and carbon markets, accessible green finance, and enhanced institutional and private sector collaboration.

3) France and Indonesia Strengthen Cooperation in Supporting Energy Transition in December 2021.

Mobilizing 500 million euros to support Indonesia in its energy transition from fossil-based to cleaner and more efficient energy

4) Australia-Indonesia Joint Statement on Cooperation on Green Economy and Energy Transition in October 2021

5) New Zealand- Indonesia: New Zealand will provide USD 3.6 million, to support Indonesia's transition to renewable energy. In 2017-2022, MEMR signed a Partnership Arrangement agreement with the Ministry of Foreign Affairs and Trade of New Zealand for the implementation of geothermal drilling projects.

6) Germany –Indonesia: The governments of Indonesia and Germany have agreed to support efforts toward a clean energy transition under the Clean, Affordable, Secure Energy (CASE) program in Southeast Asia. The German government plans to support climate and environmental protection projects in Indonesia with credits worth 2.5 billion euros by 2025

7) China– Indonesia Cooperation Potential: According to Indonesia's Investment Coordinating Board (BKPM), China has invested USD 4.8 billion or 16.7% of total foreign direct investment in Indonesia. With restrictions made by the G7, China's influence in Indonesia may strengthen, especially in supporting coal-based energy programs. Although Indonesia will start phasing out coal-fired plants in 2030, transforming coal into DME or synthetic fuel remains crucial to reduce LPG and fuel import dependency. Also, Indonesia plans to produce hydrogen energy which is sourced from coal. Thus, Indonesia will turn to China for capital provision. Meanwhile, the market opportunity in Indonesia offers a potential increase in China's state income.

The Belt and Road Initiative has great potential for renewable energy, such as hydropower, geothermal, bioenergy, solar photovoltaics (PV), wind, and ocean wave. Under the first generation of the IPP scheme, China started the development of the hydropower plants Asahan 3 and PLTA Poso. In the case of the Poso hydropower plant in Central Sulawesi, Poso Energy Ltd, part of the Kalla Group business, operated the project under the IPP scheme, but the turbine was imported from China. Chinese companies developed some of the large-scale hydropower plants in East Kalimantan and Sulawesi. In the meantime, China has substantially increased exports of PV components to Indonesia

8) Multilateral development financing is play an important role in promoting the development of a low-carbon economy[64]. Since 2015, USAID has supported Indonesia in the generation of 438 megawatts of renewable energy. USAID also helped reduce 6.9 million metric tons of GHGs since 2015, which will increase to 48 million metric tons by 2030, and mobilized $1.62 billion in private and public investments in clean energy. In 2019, as part of the AIF, ASEAN partnered with ADB and other major financing institutions to launch a US$1 billion financing facility to accelerate green infrastructure investment across Southeast Asia. The financing comes from the AIF (US$75 million), ADB (US$300 million), KfW (US$336 million), the European Investment Bank (€150 million), and Agence Française de Développement (€150 million)[65].

In November 2021, Indonesia and the International Renewable Energy Agency (IRENA signed a partnership that will see the two parties work closely to identify and implement decarbonization pathways aligned with a 1.5°C future.

4.2.7 Policy implications for Indonesia's low-Carbon Power transition

Indonesia has a strong commitment to supporting low-carbon transition in the power sector, which has been mainstreamed into the Five-Year 2020–2024 National Medium-Term Development Plan focusing on the gradual phasing out of fossil fuels and faster upscaling of renewable energy resources. As a key to further boosting economic growth, while not sacrificing environmental sustainability and social inclusivity, low-carbon power sector development needs a complete advancement technology strategy and financing system.

For this remarkable transformation to take place, the following actions are needed by key stakeholders and development partners in the coming years.

Strengthen policy commitment to stimulate markets for clean energy. Enabling market-oriented policies and regulatory framework to create stable and predictable investments, help overcome regulatory barriers, and ensure predictable revenue streams for the new low-carbon projects. Setting clear clean energy sectors targets, such as clean coal, renewable energy, and grid level energy efficiency, and formulating dedicated policies to implement them. For example, providing strong market signals that reflect the government's commitment to the low carbon energy sector development as a part of Net Zero/NDC targets is an urgent need. Depending on the provincial resource adequacy and context, complementary measures such as FiT, Feed-in Premium, removal of pervasive subsidies, and appropriate energy pricing can level the playing field for low-carbon power sector development. Learning from the successful and failed policy experiences of other developing and emerging economies in the region such as China would be an asset for Indonesia to move forward.

Mobilise private sector investments for low-carbon energy transition. Public funding will remain an important catalyst and will need to increase, but a major share of new investment will have to come from the private sector. To mobilise private investment, the new strategies pursued must focus on developing risk mitigation instruments and structured finance to develop renewable energy corridor projects. To scale up investments in projects that cut across provincial boundaries, traditional public finance channels need to combine with new private sector investments. Foreign Direct Investments (FDI) and International Financial institutions (IFI) such as Asin Infrastructure Investment Bank (AIIB) could be leveraged towards this objective.

Harness the cross-cutting impact of low carbon energy development. Access to reliable and cost-effective renewable energy and clean coal technology can have multiplier development impact in both advancement and access contexts. In particular, renewable energy and coal thermal efficiency solutions can expand the electricity access, increase productivity, and create jobs and bolster poverty alleviation in least-developed provinces. The wider development of low-carbon energy must be taken into account when implementing strategies for Sustainable Development Goals (SDGs) and Paris Agreement on climate change – as international commitment. There is a greater role for development partners like China in supporting this process by extending technology and economic cooperation.

Build Institutional and human capacity to support renewable energy uptake and clean fossil fuel development. From economic policy and regulations on international project development, a wide array of skills needs to be built up in the ministries, financing institutions, and agencies for promoting low-carbon technologies. Coordination is also vital between the different stakeholders in order to ensure, for instance, that physical infrastructure and complimentary soft measures such as standards such as grid codes, keep pace with accelerating low-carbon energy infrastructure development.

Enhance regional and international cooperation approaches. Regional approaches to connect the Indonesian grid with neighbouring countries and taking up common initiatives to improve the grid efficiency and standards can bring competitiveness, attract more investments, boost financial capacity, stimulate cross-border energy trade and enable common progress in accelerating the deployment of low-carbon technology. The Indonesian government and its development partners like China should tap into opportunities for multi-level stakeholder engagement and international cooperation on energy connectivity and cross-border energy trade.

Chapter 5. China's Experience in Renewable Energy Development: a Case Study of the PV Industry

China continues to maintain rapid growth of its installed capacity of PV power and continues to be the world's largest installer of PV power. Since the establishment of its first PV power station with a total installed capacity of 10Kw in 1983, China's PV power generation has gradually matured and run ahead of the rest of the world. To date, China is the largest PV market in the world. In 2021, China ranked first in the world in terms of new PV installations for the ninth consecutive year and in terms of cumulative PV installations for the seventh consecutive year. That year, China's wind and PV power generation not only exceeded 10% of the total power generation, reaching 11.2% but also grew at a rate of 32% and 27% per year respectively, making China a global leader in this respect[66].

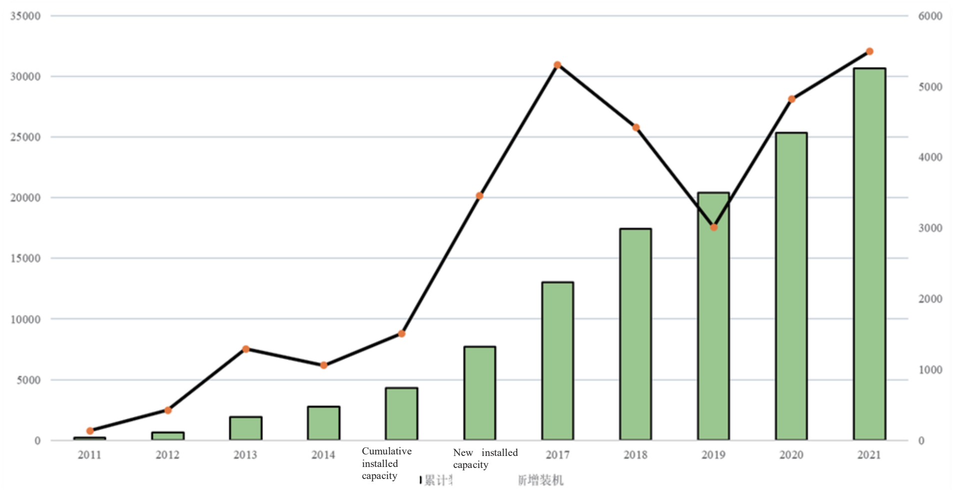


Figure 5-1 China's new and cumulative installed PV power capacity (104Kw)

(Source: National Energy Administration (NEA))

Centralized PV power is the main part of China's installed PV power capacity, while distributed PV power is growing rapidly and has become an important part of PV installations. Prior to 2021, centralized PV power was developing rapidly and occupied a dominant position in the total installed PV power capacity, but its pace of development is slowing down. As problems with the integration and costs of centralized PV power stations are increasingly prominent, distributed PV power has gradually become a backbone force that drives PV power generation in China. In 2021, a new installed capacity of distributed PV power registered 29GW, surpassing that of centralized PV power, which was 24GW, for the first time.

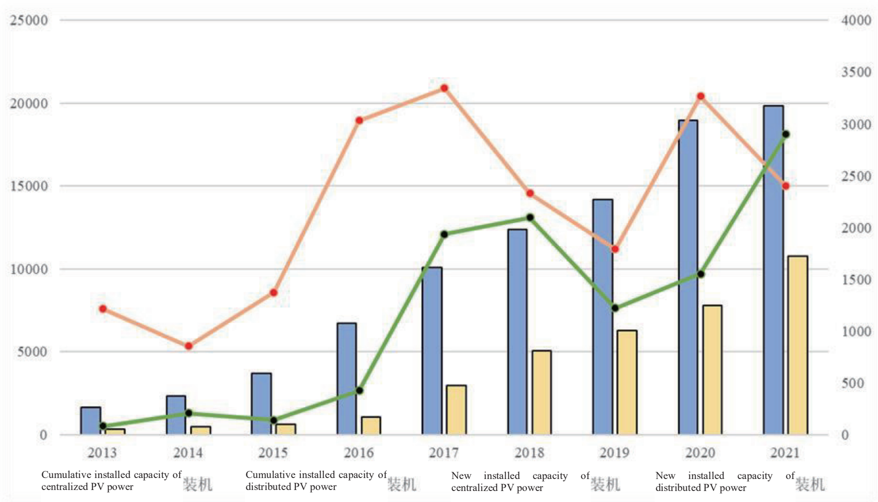


Figure 5-2 China's installed capacity of centralized and distributed PV power (104kW)

Source: National Energy Administration (NEA)

5.1 Development history of PV power generation in China

5.1.1 Prior to 2007: the initial stage of PV power generation

China began the construction of PV power generation projects in the 1970s, but due to the high costs of power generation, **PV installations were primarily small-power independent power systems and failed to develop on a large scale prior to 2000.** After 2000, China launched a series of support projects such as **Power Supply to Township** and the **Brightness Program** to solve electricity access problems in remote areas, which **enabled the small-scale application of PV power in China, but overall the market demand for PV power was low**. Statistics show that before 2007, 54% of completed PV projects were commercial projects (communication and industry, commercial demonstration projects), and the rest 46% required government and policy support; 94.9% were off-grid projects and the rest 5.1% were grid-connected ones (mainly grid connection in buildings and deserts).

Projects in this stage were mainly non-market-driven, which featured small capacity per project and a small quantity. For example, the "Electricity Access Program for Townships without Electricity in Western Provinces" launched by the National Planning Commission in 2002 aimed to provide more than 700 villages without electricity in seven western provinces with access to electricity through PV power and small-scale wind power projects. The 1MW grid-connected PV power system for Shenzhen International Garden and Flower Expo Park, completed in August 2004, aimed at filling the gap in the design and construction of megawatt-level grid-connected PV power projects in China. The high-voltage grid-connected PV power station at Yangbajing of Tibet, built in August 2005, enables for the first time a 100kW PV power station to be directly connected to a high-voltage power grid and run smoothly. In 2007, a 1MW PV building at Qianwei Village on Chongming Island of Shanghai was awarded for the first time an on-grid power price of RMB 4/kWh.

The legal status of renewable energy had been formally established, but there were still no specific policies for promoting PV power generation. On February 28, 2005, the Standing Committee of the 10th National People's Congress (NPC) adopted the ***Renewable Energy Law of the People's Republic of China*** at its fourteenth meeting, which came into effect on January 1, 2006. It is a milestone in the development history of renewable energy in China and injected a shot in the arm to the development of China's solar energy industry. Article 17 of the *Renewable Energy Law* states that "The State encourages units and individuals to install and use solar energy utilization systems, such as solar water-heating system, solar heating and cooling system and solar photovoltaic system." For concerns about the on-grid prices of solar power in the industry, Article 19 states that "Grid-connected power price of renewable energy power generation projects shall be determined by the price administration department under the State Council in light of the characteristics of power generated with different types of renewable energy and the conditions of different areas and on the principle that it is beneficial to the promotion of exploitation of renewable energy and that it is economically reasonable, and timely readjustment shall be made along with the development of technology for exploitation of renewable energy. The price for grid-connected power shall be made known to the public." In August 2007, the National Development and Reform Commission (NDRC) issued the *Mid- and Long-Term Plan for the Development of Renewable Energy*, which sets a clear target for the utilization of sunlight, solar heat and PV power: "to promote the development of solar power generation technologies in China and make strategic reserves for solar energy technologies, a number of demonstration stations for solar PV power generation and for solar thermal power generation will be built. The total installed capacity of solar power will reach 300MW by 2010 and 1,800MW by 2020."

5.1.2 2008-2012: preliminary marketization of PV power

As demand growth in Europe slowed down after the 2008 financial crisis, the prices of PV products plummeted.

Chinese PV enterprises generally suffered a cold winter, with exports of PV modules slumping. To support the development of PV as an emerging tech industry, China began to promote the launching of the domestic market. In 2009, government agencies launched successively concession bidding, solar PV building demonstration projects and the Golden Sun Program, and accordingly introduced fiscal incentives that were attractive enough to expand the domestic PV terminal market.

In the matter of PV power generation, China began to focus on subsidies in boosting its domestic demand for PV development. In July 2009, the Ministry of Finance (MOF), the Ministry of Science and Technology (MOST) and the NEA jointly issued the *Interim Measures for the Administration of Fiscal Subsidies for the Golden Sun Demonstration Program*. The three ministries planned to leverage more than 500MW of PV power generation demonstration projects through financial subsidies of around RMB 10 billion, and successfully put into action the development of the domestic PV market. The policy stipulated that for grid-connected PV power projects, the state would, in principle, provide subsidies equivalent to 50% of the total investment in PV power generation systems and their supporting transmission and distribution projects; independent PV power systems in remote areas with electricity would be subsidized at 70% of the total investment; projects for the industrialization of core PV power generation technologies and infrastructure capacity building would be supported mainly in the way of interest subsidies and subsidies. Individual PV power generation projects with an installed capacity of no less than 300kWp, a construction period of no more than a year in principle, and an operating period of no less than 20 years fell within the scope of projects subsidized by the state. Additionally, the policy also stated that the total assets of the owner unit of a grid-connected PV power generation project should be no less than RMB 100 million and its funding for the project should be no less than 30% of the total investment. Demonstration projects for the industrialization of key independent PV power generation technologies, and the development of standards were also included within the scope of subsidies. These included projects for the industrialization of key technologies such as purification of silicon materials, control inverters and on-grid operation, as well as the development of standards and specifications for solar resources evaluation, PV power generation projects and grid connection technologies, and the construction of testing and certification systems.

Anti-dumping and countervailing policies of the EU and the US prompted China's shift to the domestic PV market and the frequent introduction of favorable PV policies in China promoted the rapid

marketization of PV power at home. In the first half of 2011, a large amount of capital flooded into the PV market due to the impact of capital seeking profits globally, resulting in capacity expansion, while in the second half, the European debt crisis broke out and European countries, therefore, began to reduce subsidies for the PV industry, leading to a sharp deterioration of the European and American PV markets; the US Department of Commerce formally started anti-dumping and countervailing investigations on Chinese PV products. The following year, the EU also started an anti-dumping investigation into Chinese PV cells. This placed China's PV industry, which relied heavily on exports, into predicaments, with a large number of enterprises closed down and China's PV industry beginning to stagnate and even decline. At the same time, the government increased support for PV applications, and in August 2011, the NDRC issued the *Notice on Improving the Policies for On-grid Solar PV Power Prices*. The *Notice* stipulated that a national unified benchmark on-grid solar power price shall apply to non-bidding solar PV power generation projects. The benchmark on-grid solar power price for projects approved before July 1, 2011, completed and put into operation by December 31, 2011. and not yet priced by the NDRC was set at RMB 1.15 per kWh (tax-inclusive). The FIT for projects approved on or after July 1, 2011, except for those in Tibet, which was still subject to the price of RMB 1.15 per kWh, was RMB 1 per kWh. The MOF, the NDRC and the NEA issued the *Interim Measures for the Administration of the Collection and Use of the Renewable Energy Development Fund*, stating that the renewable power tariff surcharges payable by electricity users should be levied by grid enterprises on behalf of tax authorities and then be subsidized to power generation enterprises from the subsidy pool at the difference between the benchmark on-grid power price for renewable energy projects and the local benchmark power price for coal-fired power generating units with desulphurization equipment. In July 2012, the NEA issued the *12th Five-Year Plan for the Development of Solar Power Generation*, and launched a series of measures including demonstration areas for distributed PV power generation, during which the costs of PV systems fell rapidly and the PV market began to gradually pick up at home.

5.1.3 2013-2017: scale development of PV power generation

Realizing the shortcomings of the Golden Sun Demonstration Program (GSDP), the MOF issued the *Notice of the Ministry of Finance on the Liquidation of the Fiscal Subsidies for the Golden Sun Demonstration Program* to liquidate the GSDP projects in various provinces and cities, and "for projects that have not been completed on schedule, cancel the demonstration program and withdraw subsidies; for projects that have not been connected to power grids on schedule, withdraw subsidies temporarily and disburse upon application after they are connected to power grids". At this point, the GSDP period ended. Meanwhile, the anti-dumping and countervailing policies of the EU and the US prompted China to focus more and more on the domestic market for PV power.

A programmatic document for PV development was released, pushing PV power generation into an age of benchmark power prices by resource area and subsidy for every kWh of electricity. In July 2013, the State Council issued the *Opinions on Promoting the Healthy Development of the Photovoltaic Industry*, which not only proposed a specific target that "the annual average installed capacity of new PV power generation will be approximately 10GW from 2013 to 2015 and the total installed capacity will reach more than 35GW", but also made concrete arrangements in six areas such as planning, grid connection, power prices, financing, technology and production capacity for the first time. It also proposed to actively explore the application market from different segments such as distributed power generation, PV power stations and international markets. For example, the document encouraged the development of distributed projects by proposing to build 100 demonstration zones for the scale application of distributed PV power generation and 1,000 demonstration towns and villages for the application of PV power generation. Meanwhile, the policy specified that PV subsidies would be provided for a period of 20 years and proposed that benchmark power prices would be set by area, that subsidies would be funded by renewable energy power surcharges and that the settlements would be made between power grid enterprises and power generation enterprises. This policy indicated systematic central policy support for PV power generation since the 12th Five-Year Plan period, which was an unprecedented support policy for the PV industry, setting a clear target for the PV development scale in the next phase. On August 26, 2013, the NDRC issued the *Notice on Leveraging Prices to Promote the Healthy Development of the Photovoltaic Industry*, proposing to divide the country into three grades of solar resource areas according to differences in solar resources and development costs, and to develop different "benchmark on-grid power prices" for PV power stations in resource areas of different grades. Since then, PV power station projects have formally entered the stage of benchmark on-grid prices.

The gradual reduction in PV subsidies contributed to the rapid growth of installed PV power capacity in China, while the "leader board" program for PV power generation drove down the prices of PV power generation and advances in PV technologies and industry. With the decline in domestic module prices, the

NEA issued the *Notice on Improving the Policies for Benchmark On-grid Prices of Onshore Wind Power and PV Power* on December 22, 2015, proposing for the first time to lower benchmark power prices. For PV power generation projects registered and included in annual scale management after January 1, 2016, the new scheme provided for a benchmark tariff of RMB 0.8/kWh for Grade I resource areas, RMB 0.88/kWh for Grade II areas and RMB 0.98/kWh for Grade III areas. Meanwhile, the document stipulated that PV power generation projects registered and included in annual scale management before 2016 could enjoy the previous price if they were connected to power grids before June 30, 2016, and were subject to the benchmark prices set in 2016 if they were put into operation after that date. The introduction of the policy triggered a rush to install PV units before June 30 that year, known as the “630 rush”. Statistics show that the first half of 2016 witnessed up to 7.14GW of newly installed PV power capacity in China, nearly half of the total throughout 2015, and 22.5GW of new grid-connected capacity, of which about 11.3GW took place in June alone. In 2015, the NEA planned to implement a special PV support program—the “leader board” program. The program required projects to use advanced technology products in the building of demonstration bases and projects for PV power generation through advanced technologies. The technologies and modules used in the “leader board” program should be cutting-edge technologies and products, so as to build PV power generation demonstration bases with advanced technologies and new technology application demonstration projects. In the concrete implementation, the NEA would organize competitive bidding for a number of large, quality power station resources among developers. In 2016, eight bases on the “leader board” (with a combined capacity of 5.5GW) enabled a significant reduction in PV power prices through intense bidding, with the lowest bidding price being as low as RMB 0.45/kWh, close to the benchmark price of coal-fired power.

Thanks to policy support and high subsidy standards, distributed PV power generation showed a trend of rapid development. The *13th Five-Year Plan for Solar Energy Development* issued in 2016 requested the installed capacity of distributed PV power to increase by 10GW per year before 2020 and reach at least 60GW by 2020. During the same period, 100 distributed PV demonstration zones should be built, and distributed PV systems should be installed on the roof of 80% of new buildings and 50% of existing buildings. Due to the reduction in the target scale of centralized projects, as well as declining module prices but no adjustment to subsidies for distributed projects, the first half of 2019 saw 24.4GW of newly installed PV power capacity in China, including 17.29GW of centralized power stations, a 16% decrease year on year, and 7.11GW of distributed PV installations, a 2.9-fold increase year on year; distributed power projects tended to grow rapidly due to high subsidy standards. In the second half of 2017, distributed PV projects continued to soar, and according to the NEA statistics, installed PV power capacity increased by 53.06GW in 2017, including 33.62GW of PV power stations, an 11% increase year on year, and 19.44GW of distributed PV projects, a 3.7-fold increase year on year. Distributed projects became an important component of newly installed PV power capacity in terms of both installed capacity and growth rate.

5.1.4 2018 to the present: grid parity for PV power

Guide prices and market bidding have replaced benchmark on-grid prices, and on-grid PV power prices continue to decline and have moved toward parity. On May 31, 2018, the NDRC, the MOF and the NEA jointly issued the *Notice on Matters Concerning Photovoltaic Power Generation in 2018*, putting a sharp brake on the accelerating PV development in China by clearly stating that the withdrawal of PV power generation subsidies should be accelerated and subsidy intensity should be reduced. The document mainly proposed temporarily not to arrange for the development of ordinary PV power stations in 2018, and arrange about 10 million KW of capacity to support the development of distributed PV projects, support poverty alleviation through PV development and orderly promote the construction of leading PV power generation bases. PV power has gradually entered an era of grid parity. In 2019, in order to further improve the on-grid price mechanism for PV power generation, the NDRC changed the benchmark on-grid price mechanism for centralized PV power stations to guide prices, setting guide prices of new centralized PV power stations in Grade I~III resource areas to RMB 0.40, RMB 0.45 and RMB 0.55 per kWh respectively. PV power generation prices were regulated downwards at a faster pace, with the decrease in on-grid power prices for Grade I~III resource areas reaching 20%, 25% and 21.47% respectively. In the same year, the NDRC and the NEA issued the *Notice on Actively Promoting the Work Concerning Subsidy-free Grid Parity for Wind Power and Photovoltaic Power Generation* to promote subsidy-free PV projects nationwide. In 2021, the NDRC officially released the *Notice on Matters Concerning the Policies for On-grid Prices of New Energy Power in 2021*, which made it clear that for newly registered centralized PV power stations, industrial and commercial distributed PV projects and newly approved onshore wind power projects, central finance would no longer provide subsidies from 2021 onwards, and grid parity would be implemented. This heralds that the "grid parity" policy for new energy has been implemented.

Renewable power development and accommodation mechanisms are being gradually established. While the development and utilization of renewable energy is speeding up, problems with the delivery and accommodation of hydropower, wind power and PV power have begun to emerge, which remain grim despite some relief. China is gradually introducing relevant policies to promote a long-term mechanism for renewable energy accommodation. In 2019, the NDRC and the NEA jointly issued the *Notice on Establishing a Sound Mechanism for Guaranteeing Renewable Power Accommodation*, the core of which was to identify the target share of renewable power in power consumption in provinces, or “weight of renewable power accommodation responsibility”. It aims to encourage provinces to prioritize the accommodation of renewable energy, solve the problem of hydropower, wind power and PV power curtailment, and at the same time prompt all kinds of market players to assume the responsibility for accommodation on an equal footing and form a long-term development mechanism led by renewable power consumption. The *Measures for the Administration of Monitoring and Statistics of Accommodation of Photovoltaic Power Stations* issued in 2021 states that power grid enterprises should monitor, collect, collate and verify the data on the operation of PV power stations, carry out work related to the monitoring and statistics of accommodation of PV power stations. At the same time, power grid enterprises should submit accommodation statistics of PV power stations for the previous month within their operating areas, including available power generation, actual power generation, restricted power generation and utilization ratio, by the 15th day of each month via the national new energy power accommodation monitoring and warning platform to the NEA, while the NEA should organize the national new energy accommodation monitoring and warning center to complete accommodation analysis and statistics verification according to relevant regulations.

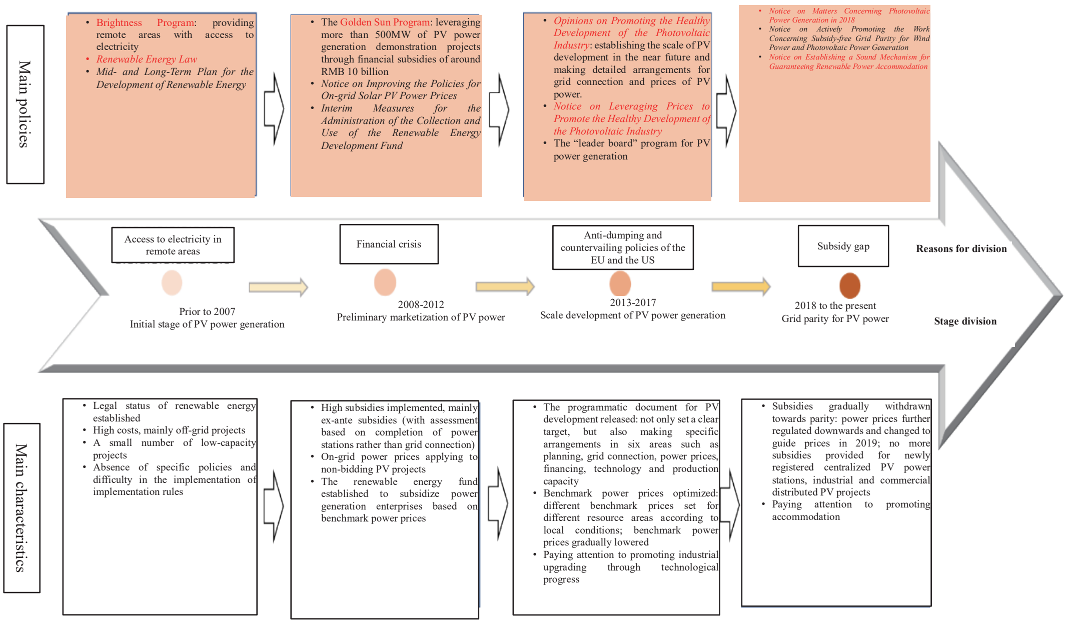


Figure 5-3 Development history of PV power generation in China

5.2 Summary of China's experience in the development of PV power generation

1. China attaches importance to the establishment of macro targets for guiding the development of PV power generation. At the initial stage of PV power development, China proposed to raise the total installed capacity of solar power to 300MW by 2010 and to 1,800MW by 2020 due to the development level and technological conditions at the time. In 2015, China submitted its NDCs under the Paris Agreement, promising to increase the share of non-fossil fuels in primary energy consumption to 15% by 2020 and to 30% by 2030, including increasing the installed capacity of solar PV power to around 100GW by 2020 (the actual cumulative installed capacity in 2014 was 28.05GW). In order to ensure the achievement of the PV development target in the NDCs, China included it in its *13th Five-Year Plan for Solar Energy Development*, and further raised the target installed capacity of PV power to 105GW. Meanwhile, the country introduced a range of favorable policies for PV development, such as fixed power prices and FITs, resulting in a booming PV industry. In 2020, China's actual cumulative installed capacity of PV power reached 254.4 GW, more than double the target.

2. China has established the legal status of the development of renewable energy including PV energy. The *Renewable Energy Law*, enacted in 2005, strengthened the development position of renewable energy in China, encouraged the accelerated implementation and application of PV power generation, and made instructions and arrangements for the implementation rules of PV development, such as the establishment of PV tariffs. Other normative documents for PV development include the *Interim Measures for the Administration of the Collection and Use of the Renewable Energy Development Fund*, which proposes to subsidize power generation enterprises through the renewable energy fund at the difference between the benchmark on-grid power price for renewable energy projects and the local benchmark power price for coal-fired power generating units with desulphurization equipment, the *Interim Measures for the Administration of Photovoltaic Power Station Projects*, which specifies the functions to be performed by various entities of PV power station projects, the principles and requirements for the construction of PV power station projects and relevant punishments for violations, and the *Measures for the Administration of Monitoring and Statistics of Accommodation of Photovoltaic Power Stations*, which sets out the functions to be performed by power stations, power grid enterprises and monitoring units in the process of monitoring, reporting and verifying the data on the operation of PV power stations.

3. China has developed a mature system of hybrid policy tools for the development of PV power generation. Policy tools can be summarized into three types, namely command-and-control policies, economic incentives and voluntary participation policies. Command-and-control policies include the *Renewable Energy Law*, the *Interim Measures for the Administration of Photovoltaic Power Station Projects*, the *Interim Measures for the Administration of the Collection and Use of the Renewable Energy Development Fund*, etc.; economic incentives include the *Notice on Leveraging Prices to Promote the Healthy Development of the Photovoltaic Industry*, and the capacity-based subsidies policy for distributed PV power generation, among others; and voluntary participation policies include the *Notice on Piloting the Green Power Certificate Issuance and Voluntary Subscription Trading Mechanism for Renewable Energy*, etc.

4. China has explored a variety of application scenarios for PV power generation in light of local conditions. As PV power generation becomes gradually mature, China has explored diversified PV power generation application scenarios. For example, agriculture and PV power generation have been combined on farmland or wasteland to promote the development and utilization of land, as in the case of Baofeng Agriculture and PV Integration Industry Base, the world’s largest agriculture + PV power plant, which has transformed a desert into a new model of “PV power generation over modern agriculture”; industrial and commercial distributed PV power and rural household rooftop PV power systems have been built in non-public areas, fully unleashing the potential for new PV installations; the construction of large PV and wind power bases have been promoted in deserts, gobies and desert areas in light of local conditions to push forward the large-scale development of renewable energy.

5. China focuses on achieving the goal of sustainable development through solar PV power generation. China is making full use of PV power generation technology to promote the achievement of the Sustainable Development Goals (SDGs) at the same time. For example, the Brightness Program has provided residents without electricity in remote areas with access to electricity through PV power generation, improving the accessibility of electricity. The Chinese government has invested approximately RMB 10 billion in the development of PV power generation projects in areas without electricity, with a total installed PV power capacity of more than 120 MW. By the end of 2001, there were still 7 million households and 30 million people having no access to electricity in China, but after more than 10 years of efforts, the problem of no access to electricity among some people had been completely solved by the end of 2015, with all parts of the country electrified; the penetration of PV power generation and the gradual maturation of related technologies have not only provided economical and practical renewable power, but also mitigated the negative impact of climate change; agriculture and PV integration is not only an attempt to explore new models of agriculture, but also has significantly improved the land utilization rate and facilitated the reuse of abandoned land; poverty alleviation projects through solar PV power generation in China are a new model and exploration of poverty alleviation by developing industries, with the aim to inject new vitality into economic growth in poverty-stricken areas through PV power generation which allows users to use the electricity generated and feed the excess back into the grid. By the end of 2020, the scale of poverty alleviation projects through PV power generation reached around 22GW, which could benefit about 3.2 million poor households, with a total of RMB 11.34 billion of subsidies allocated. The goal of assisting 2.8 million poor households set out in the *Poverty Alleviation Plan for the 13th Five-Year Plan Period* of the State Council has been successfully fulfilled.

Chapter 6. Policy Recommendations for Cooperation on Green and Low-carbon Transition of the Power Sector in Southeast Asia

6.1 Recommendations for low-carbon transition of the power sector in Southeast Asia

6.1.1 The transition to renewable power should be an integral part of post-COVID economic recovery to prevent large investment into the coal power sector

First, Southeast Asian countries should deepen their understanding of renewable power development at home. They should actively carry out relevant basic research and investigation such as estimation and assessment to map the actual development and cost-effectiveness of renewable power and gain an insight into the advantages of renewable power development and the challenges, so as to establish a foothold for further development of renewable power. **Second, Southeast Asian countries should gradually increase ambition based on the existing renewable power development targets.** They should write renewable power development targets into documents featuring higher coordination, such as NDCs and laws, to accelerate the development of renewable power. Also, they should actively develop and improve favorable policies for renewable power, such as FITs, fiscal subsidies and preferential loans to encourage and guide the implementation and market-based renewable power projects through incentives. **Finally, Southeast Asian countries should focus on the impact of renewable power development on other sectors and give play to its multiplier effect on economic and social development.** They should pay attention to the role of renewable power in promoting poverty alleviation, health, employment and other SDGs, such as increasing social productivity, creating jobs and promoting poverty reduction in underdeveloped areas, and formulate development plans and measures in specific areas. They should focus on the integration of renewable power into local production and life, for example, by implementing the new model of “PV + agriculture”, to develop renewable power generation while boosting agricultural development, thus creating greater benefits to economic and social development.

6.1.2 Reduce the proportion of coal power in Southeast Asia's future power generation structure, promote the transition of coal power to flexible backup services, and advance the clean and efficient transformation of coal power

First, countries in the region should discuss how to reduce the proportion of coal power according to their own development conditions. Coal power is still occupying an important position in Southeast Asia's power supply structure and as low-carbon transition of the power sector is speeding up globally and some Southeast Asian countries have set coal phase-out targets, a reasonable power sector transition strategy is particularly important for the region's development. Countries should explore the development of a timetable and roadmap for the phase-out of power generated from fossil fuels and the orderly replacement with renewable power, taking into account their respective realities such as economic development and resource endowments. In particular, countries that depend heavily on fossil energy, such as Indonesia and Vietnam, should adopt progressive renewable power replacement strategies that are in line with their own development conditions, so as to gradually reduce the share of coal power in Southeast Asia's future power generation structure. **Second, Southeast Asian countries should develop a strategy for the role and operation of coal-fired power generation during the transition.** For the large number of new coal power units planned or under construction in Southeast Asia, countries in the region should strengthen overall assessment of these units, manage them by category, strictly control new coal power projects, improve construction standards, phase down outdated capacity with a certain number of coal power units retained and renovated, and consider emergency backup plans. Meanwhile, it's important to strengthen cost control, change the way coal power is assessed, improve peak load regulation and compensation, enhance economic operation and management and the market environment, promote the shift of coal power to flexible backup services and accelerate the establishment of a new power system dominated by renewables. **Finally, enhancing the clean and efficient utilization of coal power infrastructure.** They should promote the research and development, commercialization and application of key technologies such as efficient coal combustion for power generation, clean coal combustion, biological and chemical carbon sequestration. It's important to take into account the differences between coal power units in service in operating hours, combustion technology and equipment types, to organize technological upgrading by type and in batches, thus promoting the upgrading of coal power units towards energy conservation and efficiency improvement.

6.1.3 Southeast Asian countries should promote market-based reforms of electricity and create a favorable environment for the development of renewable power in the region

For the power generation side, it is necessary to establish or improve tariff mechanisms, such as FITs, to stimulate the development of renewable power, and set price ranges for power market transactions, while restricting power transactions in energy-intensive sectors. Countries heavily reliant on coal power can gradually expand the coverage of FITs for coal power to ensure power supply security and further drive the power generation end, including renewable power such as PV and wind power, into the market, thus laying a foundation for fully market-based pricing on the power generation side. **For the power transmission and distribution side**, the marketization should be supervised by the government due to its monopoly feature. The government should take into account the overall progress of power marketization, set reasonable prices for power transmission and distribution through a strict review of factors such as transmission and distribution costs, benefits and capacity, and then weaken the impact of monopoly in the process of pricing through the price mechanism for transmission and distribution. **For the power sales and use side**, it is essential to decentralize the right to sell electricity exclusive to power grid enterprises and delegate it to eligible social entities, such as some electricity selling companies, after review and approval. By doing so, market competition of power prices can be strengthened. At the same time, government can consider allowing electricity users who meet the market access requirements to purchase electricity directly in the market.

6.1.4 Improve market investment and financing mechanisms, strengthen environmental and risk assessment of the financial sector, and broaden the sources of finding for renewable power

First, market investment and financing mechanisms should be established and improved to increase the effectiveness and sustainability of financing. Countries in the region should strengthen the participation of relevant entities such as government agencies, enterprises and financial investment institutions, to improve communication and coordination in functional division, investment management, project planning and standard setting, and establish multi-level investment and financing mechanisms. They should accelerate innovation in green investment and financing products, instruments and services at home, and promote financing for renewable power projects through government guidance, information disclosure and fund matching. Meanwhile, they should deepen international investment and financing cooperation by making full use of the platforms of international organizations and multilateral financial institutions. **Second, enhancing regulation of the financial sector to improve financial risk management.** They should improve the regulations and management systems of different departments, and strengthen the regulatory and restraint mechanisms in the financial sector through the disclosure of information on the project approval and supervision platform, the establishment of inspection, assessment and performance evaluation standards, incentives for keeping credit and punishments for breaking credit, and the entity credit commitment system, so as to promote the stable operation of the financial investment market. At the same time, they can carry out risk assessment, risk demonstration and real-time risk monitoring to improve financial risk management in multiple ways, including market risk control, technical risk management and international financial cooperation. **Finally, public-private financial cooperation should be enhanced.** They should give play to the planning and guiding role of public sector funding in leveraging the private sector to invest in renewable power projects by building a macro investment framework and formulating relevant plans, so as to broaden the sources of funding for renewable power projects. They should focus on developing investment risk mitigation tools and structured financing to improve the hybrid public-private financing model. In addition, they should pay attention to issues such as return on investment of private capital and responsibility assignment, to promote benign cooperation between public funds and private capital.

6.1.5 Enhance political trust, seek regional power cooperation, build a regional unified power market, and promote the interconnection of ASEAN power grids

First, political trust in Southeast Asia should be enhanced. Southeast Asian countries should enhance dialogue under the ASEAN cooperation mechanism, including promoting high-level policy dialogue and exchanges on the basis of the ASEAN Summit, and at the same time convene more meetings between institutions to communicate their concerns about energy security in power transactions, coordinate various plans and promote the implementation of their power cooperation commitments. **Second, power interconnection should be strengthened in Southeast Asia.** They should establish a clear and effective legal framework for bilateral and multilateral power trade and explore the establishment of a dedicated regional interconnection administration to take charge of trade details, technical procedures, fundraising and other aspects of projects. They should establish regional unified power trade standards, and define the market structure and grid norms.

Unified operation rules should be planned in maintenance and operation standards based on the characteristics of different countries. They should make full use of the functions of the ASEAN energy regulation network to actively promote the elimination of barriers to cross-border power trade and drive power trade to move towards multilateral cooperation. They should expand the current cross-border power trade and make attempts to establish a commercialized, integrated regional power market. At the same time, they should work together to advance the research on power transmission and distribution technologies, especially large-capacity, long-distance direct-current transmission projects.

6.1.6 Focusing on just transition, formulate respective strategic plans for just energy transition and develop systematic approaches to issues such as technological innovation and talent cultivation in different regions and industries during the transition

First, Southeast Asia should clarify the definition and standards of just energy transition at the regional level, and countries in the region need to make systematic strategic arrangements and strengthen legal protection. They should accelerate the discussion on just transition, promote the definition of concepts such as green technology industries, green jobs and green products and consensus on these definitions at the regional level, and form regional just transition standards to provide clear guidance for subsequent specific work. Besides, Southeast Asian countries should develop their own overall strategic plans for just energy transition with the overall strategic system in mind, form short- and long-term transition guidelines with clear targets and structures, and strengthen legal constraints and protection. They should establish a cross-sector coordination mechanism covering environmental, fiscal, financial, technological and labor sectors, promote communication among multiple stakeholders such as government institutions, enterprises and financial institutions, participate in the discussion on transition paths, systematically plan the transition goals for different areas and industries as well as technology, talent, regulation and other supporting measures to ensure that all citizens share the costs and benefits of transition. **Second, appropriate support should be provided for the transition of fossil fuel enterprises.** Short-term plans for the exit or transformation of fossil fuel enterprises should be laid down as early as possible to prevent the enterprises and employees concerned from falling into predicament during the transition. For enterprises negatively impacted by the transition, a just transition fund should be set up to provide appropriate subsidies to help them mitigate the economic losses caused by the transition, while additional technical and talent support should be given to enterprises with transition potential. Unemployed labor forces caused by the transition process should be properly arranged and provide them with skill training on sustainable development sectors, while alternative and new industries should be guided to create new jobs to fully include and accommodate this group of people.

6.1.7 Making full use of the technologies, capital and experience from international cooperation to accelerate the development of renewable power

First, they should explore the establishment of a stable international cooperation framework. Southeast Asian countries should make full use of the technologies, capital and experience from international cooperation to promote green investments and technological innovations that will bring down the cost of transition, establish a dedicated and stable policy and management framework for international cooperation, enhance capacity building for the power sector transition at home, take advantage of the financial support, technical assistance and personnel training provided by organizations such as multilateral development banks, the Asian Infrastructure Investment Bank (AIIB), think tanks and NGOs, and absorb and integrate green development concepts. **Second, they should carry out cooperation on power sector transition in a number of areas in light of local conditions, including infrastructure.** They should guide closer international cooperation on power infrastructure and cross-regional power interconnection, and extend explorations that take into account local conditions through international cooperation, for example exploring the application of grid connection options such as on-grid and off-grid options to improve power accessibility and exploring the development of smart grids and advanced power transmission and distribution technologies to improve power flexibility. It is also important to pay attention to the fluctuations in renewable power and its accommodation, align renewable development targets with actual development speeds, and explore the establishment of a mechanism for ensuring the accommodation of renewable energy by drawing on international experience. **Finally, they should gradually break down the barriers to international cooperation.** Southeast Asian countries should minimize market entry barriers, set up convenient channels for the entry of overseas investments, increase the simplicity of domestic land acquisition and licensing procedures for international renewable power projects, improve the collection and reporting of energy use data and other information, accelerate the development of non-hydro renewable power such as PV and wind power at home by taking advantage of their own resources and international cooperation, and achieve the coordinated development of all renewables.

6.2 Recommendations for China’s cooperation with Southeast Asia in promoting low-carbon transition of the power sector

6.2.1 Actively engage in dialogue and cooperation with Southeast Asian countries to share its best practices in power sector transition and provide transition plans tailored to local conditions

First, the dialogue and consultation mechanism on clean energy between China and Southeast Asia should be strengthened. Through China-ASEAN Dialogue on Climate Change and Ecological Environment and China-ASEAN Clean Energy Capacity Building Programme, which focus on core issues and needs such as clean energy technology, financing and capacity building, to broaden and expand high-end dialogue platforms for cooperation between Southeast Asia and China on renewable power projects. Based on multilateral cooperation platforms such as the BRIGC, it’s important to analyse the targeted demand of Southeast Asian countries and share China’s best practices in low-carbon development. **Second, clean power cooperation between China and the Southeast Asian subregion should be deepened.** On the one hand, China should promote discussions on power sector transition cooperation under China-Southeast Asian subregion cooperation platforms such as the Greater Mekong Subregion Economic Cooperation (GMS) mechanism. On the other hand, China should deepen clean power cooperation and exchanges with Southeast Asian countries with a good foundation for power cooperation, for example, adding topics concerning renewable power cooperation to the China-Laos strategic partnership for power cooperation. **Second, clean power cooperation between China and sub-national entities in Southeast Asia should be promoted.** On the one hand, China should ensure effective pairing for counterpart cooperation on power with sub-national entities in Southeast Asia, for example, pairing with Vietnam’s Ministry of Industry and Trade at the national level and for provincial and even city-level cooperation pairing with corresponding provincial and city-level power authorities. On the other hand, China should promote the conclusion of sister city agreements between Chinese provinces and cities and their Southeast Asian counterparts to push forward inter-city cooperation and friendly exchanges on power. **Finally, China should share its best practices in power sector transition through the above platforms for dialogue and cooperation.** China can provide best practices for the development of renewable power in Southeast Asian countries by summarizing its mature development experience and concrete application cases of lower-carbon power sector transition, such as FITs, the “leader board” program and other incentives at different stages of PV power development and China's experience in clean and efficient coal power technologies and ultra-high voltage (UHV) power transmission technologies, as well as its explorations into various PV application scenarios in line with SDGs.

6.2.2 Strengthening clean power investment and trade cooperation with Southeast Asian countries, and shifting to a manufacturer and exporter of renewable power generation equipment

First, China should participate in the cooperation on clean and efficient transformation of fossil fuel in Southeast Asia. Given the current situation that Southeast Asia has a large stock of inefficient fossil fuel installations, China can make full use of its technology and experience in clean upgrading and transformation of coal power, such as ultra-supercritical coal-fired power generation and circulating fluidized bed (CFB) boiler power generation technologies, coal gasification, coal liquefaction and other coal-to-electricity conversion technologies, as well as experience in controlling pollution from coal-fired power units, to promote clean upgrading and transformation of existing coal power units in Southeast Asian countries, with a view to improving power generation efficiency, reduce emissions and stabilize power supply. **Second, China should participate in renewable power projects in Southeast Asia in different ways.** State-owned enterprises should give full play to their advantages to undertake large projects to drive private enterprises which are flexible and energetic for innovation to participate in renewable power projects in Southeast Asia. Chinese enterprises should leverage their experience and advantages in EPC, clean power equipment exports, acquisitions and mergers and overall project management abroad to fully participate in the investment and cooperation in a wide range of projects from large renewable power projects to distributed power projects, based on a full understanding of the actual needs, resource endowments and potential risks in host countries. Enterprises should be encouraged to enter renewable power technology areas urgently needed for power sector transition in Southeast Asia, such as non-hydro renewable energy technologies and power transmission and distribution infrastructure, in an orderly and proactive manner.

6.2.3 Advancing its green investment and financing cooperation with Southeast Asian countries, to strengthen pre-project assessment of overseas investments and financing, and uphold local just transition

First, the negative list for overseas investment should be improved to further strengthen climate and

environmental factors in overseas investment and financing policies. China should improve the analysis and assessment of host countries' NDCs, power development plans, low-carbon transition needs and public demands, incorporate them into the pre-project risk assessment system and investment decision-making considerations, and gain a full understanding of the climate targets, environmental protection requirements and restrictions for power sector transition, so as to avoid project asset risks to high-carbon assets in stock and renewable power. **Second, exploring green investment and financing standards and green financial markets that are consistent with those of China for Southeast Asian countries.** Based on its own experience in green finance development, practices of AIIB and other international multilateral banks in green investment and financing models, and the existing developments in green finance in Southeast Asia, China can take the lead in working with Southeast Asian countries to develop common green finance principles and standards, taking into account their respective national conditions; explore the establishment of a regional financial market with Southeast Asian countries, where all countries share the development direction and model of green investments and financing, so that investors can quickly target potential investments, increase investment in the construction and promotion of shared market platforms and attract the deep involvement by more public and private green funds; support Southeast Asian countries in building carbon markets, and explore a mechanism for connecting Chinese and Southeast Asian carbon markets, so as to promote low-carbon power sector transition at lower emission reduction costs. **Finally, China should focus on upholding justice and fairness in the process of green transition of traditional industries in Southeast Asian countries through new ideas and emerging tools such as transition finance.** For example, countries that are heavily dependent on coal power and less developed should be prioritized in providing South-South cooperation funds and promoting the establishment of transition funds to reduce just transition challenges and asset stranding risks arising from the orderly phase-out of fossil fuel in these countries and enhance their ability to accomplish NDCs and energy transition.

6.2.4 Actively support Southeast Asian countries in upgrading their power grids, improving cross-border power grid interconnection, promoting the development of smart grids, distributed energy systems and energy storage technologies and the establishment of international standards in these areas, and propelling the integration of more renewable energy resources

First, support and cooperation should be strengthened with regard to grid upgrading in Southeast Asian

countries. China should allow full play to its financial, equipment and technological advantages as well as leading infrastructure investment and development experience, to actively support Southeast Asian countries in upgrading their power grids, expand engineering contracts and project investments in power grid infrastructure in these countries, launch technical and operational cooperation with power transmission and distribution enterprises, and help the transition of power grids in Southeast Asia. **Second, ongoing efforts should be made to promote the interconnection of power grids across borders.** China should expand cross-border power grid interconnection projects under regional economic cooperation such as the Belt and Road Initiative (BRI) and the GMS, strengthen cross-border power cooperation on interconnection with ASEAN power grids and promote the expansion of power trading with ASEAN. **Finally, cooperation on clean power technologies should be actively developed in Southeast Asia.** First of all, it is important to establish organizational coordination between the government and enterprises, introduce policies inclined towards overseas investment and cooperation by smart grid, distributed energy system and energy storage enterprises with the aim of promoting the development of clean power technologies, analyze existing practices and projects, and assess their potential for expansion. Secondly, it is necessary to further develop a multi-level clean power technology cooperation mechanism for the government, investors and third parties. The role of think tanks, universities, the public sector and other organizations in supporting the transfer and transformation of clean power technology achievements should be fully exerted.

6.2.5 Taking pragmatic actions to promote international cooperation on supply chains, ensure the security and stability of supply chains, and cooperate with Southeast Asian countries to make supply chains greener and more low-carbon and provide economically and technically viable options for low-carbon energy transition

First, China should work with Southeast Asian countries to develop strict policies and standards to regulate green supply chains. China can work with Southeast Asian countries under the RCEP framework to increase cooperation on green supply chains, such as cooperating to discuss and explore the development of environmental and climate policies and norms for links throughout the lifecycle of power cooperation from material supply, manufacturing, transportation, market circulation and installation and use, including green standards for raw materials and products, and market access thresholds. At the same time, China should consider developing differentiated standards for some countries with low levels of economic and technological development, and make dynamic adjustments with the gradual establishment of green supply chains. **Second, China should work with Southeast Asian countries to establish a transparent and efficient green supply chain information sharing platform.** Based on the BRI Environmental Big Data Platform, China should gradually establish an integrated network platform for information on the demand and supply of renewable power projects and the demand for green finance cooperation as well as information on the compliance of operating entities, such as emissions, and green labels, to help enterprises have a clear understanding of market supply and demand and local environmental and climate regulations and requirements when investing in overseas projects. **Finally, China should select key sectors and set up benchmark enterprises to promote the comprehensive development of green chains at home and in Southeast Asia in a progressive manner.** China should select sectors with a good foundation for cooperation or those that receive much attention as pilot sectors for green supply chains, such as palm oil, rubber and other bulk commodities. In light of local conditions, it's important to take into account the resource endowments of Southeast Asian countries. Meanwhile, considering the lack of environmental management experience among small and medium-sized enterprises (SMEs), China should select leading enterprises in the selected sectors as pilot enterprises for green supply chain management, so as to gradually drive the greening and low-carbon development of supply chains in all sectors and in all areas in China and Southeast Asia, including their cooperation on renewable power supply chains, through experience accumulation and brand and benchmark effects.

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