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Renewable Energy to Replace Coal Power in Southeast Asia

Pragmatism to Deliver a Sustainable Bright Future

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REI – Renewable Energy Institute

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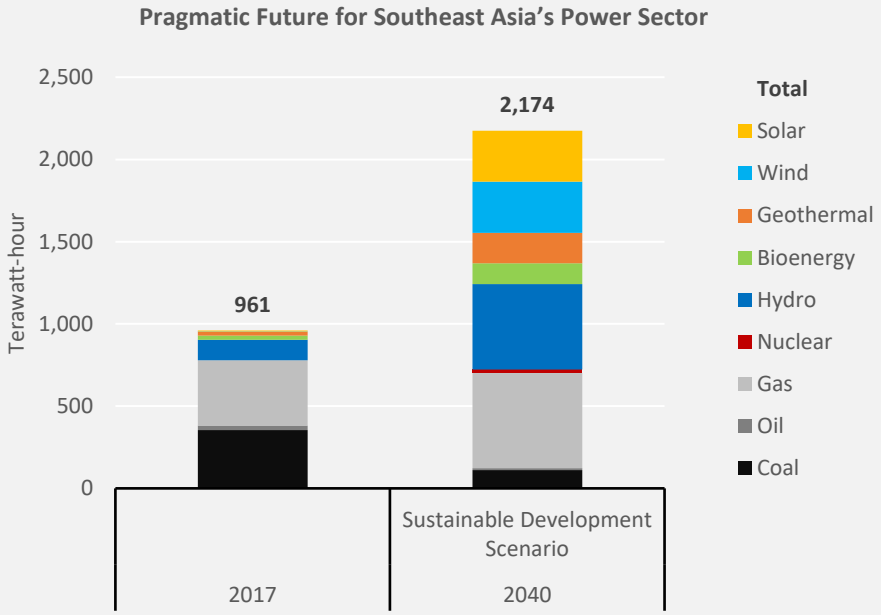
EXECUTIVE SUMMARY

From Cambodia, Laos, Myanmar, Thailand, and Vietnam in the Mekong river basin, to Brunei, Indonesia, Malaysia, the Philippines, and Singapore in the Malay archipelago, Southeast Asia is a diverse region with a large growing population, home of quickly expanding economies consuming increasing amounts of energy, particularly fossil fuels and especially heavily polluting coal for electricity generation. Worsening pollution from greenhouse gas emissions is putting heavy stress on local, regional, and global environments and is incompatible with the immediate climate crisis.

Southeast Asia's power sector growth is the main reason behind the region's rising energy consumption and carbon dioxide emissions. Electricity demand in Southeast Asia substantially increased since the beginning of the century and it is projected to more than double by 2040, with populations in most countries still consuming relatively low amounts of electricity and some areas, especially rural ones, still lacking electricity access. On the supply side, coal plays a major role, but this cannot continue because of the fuel negative environmental impacts. It will have to be greatly replaced by renewable energy (essentially hydro, bioenergy, geothermal, wind, and solar photovoltaic) and energy efficiency.



Note: marine that is negligible is included in "Hydro."
Source: International Energy Agency, World Energy Outlook 2018 (November 2018).

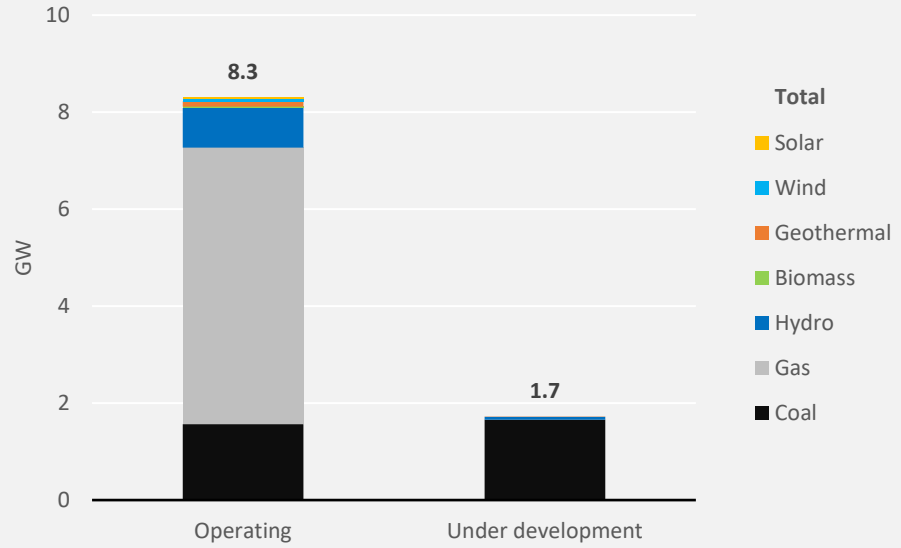
Southeast Asia is blessed with a significant renewable energy potential from abundant various resources. This potential is currently largely underexploited as demonstrated by limited deployment of technologies, in particular solar and wind. Yet, some countries have already developed strong performant domestic renewable energy manufacturing industries which could certainly contribute to deliver the region's power sector energy transition – granted additional conditions are right.

The overall framework to ensure successful deployment of renewable energy technologies in Southeast Asia is still a work in progress. Further cost reductions, more ambitious targets supported

by effective policies, and market conditions that favor competition and customer choice, as well as more robust electrical grid infrastructures would all benefit greatly to renewable energy expansion.

For decades Japan and Southeast Asian countries have been trading various commodities. These commercial relationships have become increasingly significant over time. Whereas Japan's exports to Southeast Asian countries are rather centered on machinery and transport equipment, as well as manufactured goods and chemicals, its imports are more diversified. Focusing on the power sector only, Japan exports generating technologies to Southeast Asian countries, finances and participates in the development of power plant projects there, principally burning gas and more recently coal – notwithstanding stranded asset risks, and conversely imports these two fossil fuels to generate electricity domestically.

Japanese Power Companies' Attributable Power Plant Capacity by Technology in Southeast Asia 2019 (%)



Notes: As of early September 2019. Negligible oil capacity included in "Gas." Excludes insignificant "Hydro" capacity from unidentified shares in a couple of projects.
Sources: J-POWER, JERA, Chugoku, Kansai, Kyushu, Shikoku, and Tohoku Electric Power Companies' corporate materials.

Increasing renewable energy cost competitiveness and worsening climate crisis are likely to heavily weigh on Japan-Southeast Asia's trade relationship in the power sector, possibly leading to a new commercial era. In this framework, Japan could be a powerful ally supporting the region's energy transition by becoming much more forward-thinking. On the supply side, this will require Japanese public & private financial institutions and power companies to significantly – and exclusively – participate in renewable energy power plant projects in Southeast Asian countries. And on the demand side, this will require the numerous Japanese businesses established in the region to firmly request 100% renewable energy procurement options to meet their electricity consumption.

To realize and optimize possible new trade relationships in the power sector, it will be both Southeast Asian countries and Japan's shared responsibility to switch mindsets; from conservative to progressive, and demonstrate pragmatic leaderships.

There is nothing less at stake than delivering Southeast Asia's sustainable bright future.

INTRODUCTION

Southeast Asia is a dynamic and diverse region in many regards. It is characterized by significant demographic and economic growths. Also, by different levels of development and unevenly distributed natural resources.

Growing Southeast Asian countries are consuming increasing amounts of energy, and especially electricity. Since 2000 coal has taken a leading position in meeting these new demands, at the expense of the environment. Worsening pollution poses major human and economic risks in particular to some identified vulnerable countries in the region, and jeopardizes combat against climate change at the local and global scales.

As Southeast Asia's electricity consumption is projected to more than double by 2040, with populations in most countries still consuming relatively low amounts of electricity, and some areas, especially rural ones, still lacking electricity access, continued excessive reliance on coal power is not an option. Instead, pragmatism imposes to greatly expand renewable energy and energy efficiency to deliver a sustainable bright future to the region.

Renewable energy can provide affordable and clean electricity to power-hungry Southeast Asia. Nevertheless, to fully seize opportunities obstacles hindering renewable energy massive expansion need to be faced. This requires a much-needed, drastic but realistic shift of paradigm.

Japan as a historical trade partner of Southeast Asian countries should play an important role again in accompanying power infrastructure developments that will turn Southeast Asia into a perennial rich region.

With this report, Renewable Energy Institute encourages decision makers in Japan, particularly from public policymaking organizations and private businesses, to take part with really ambitious and progressive approaches in Southeast Asia's energy transition. That would certainly be profitable to all stakeholders in the medium to long-term.

Chapter 1: Key Energy Related Developments in Southeast Asia since 2000

1. Background; Demography, Economy, Energy, and Environment

Southeast Asia is a diverse region with a large growing population, home of quickly expanding economies consuming increasing amounts of energy, particularly fossil fuels and especially heavily polluting coal for electricity generation. Worsening pollution from greenhouse gas emissions is putting heavy stress on local, regional, and global environments and is incompatible with the immediate climate crisis.

– Throughout this section a number of statistical indicators are provided. For more details about comparisons between Southeast Asia and China, India, and Japan, please refer to Appendix A on page 46. For details about each country in Southeast Asia, please refer to Appendix B on page 46. –

Southeast Asia is a diverse and dynamic region in many regards:[a]

From a demographic point of view, the region's population grew from 524 million to 654 million people, or +25% between 2000 and 2018.[1] That is roughly half the size of Asian giants China and India, which both have populations of 1.4 billion people. That is also 5 times bigger than Japan's population (127 million people).

Within Southeast Asia, Indonesia with a population of 268 million people in 2018 accounted for more than 40% of the region's total population. Far behind followed the Philippines and Vietnam, 107 million people and 96 million people, respectively. Brunei was the only country with a population below 5 million people (0.4 million).

In addition, since the beginning of the century, Southeast Asia's economy impressively increased from $1.2 trillion to $2.9 trillion, or +146%(!) – gross domestic product (GDP) in constant 2010 US dollar ($).[2] This is a remarkable progress. On a GDP per capita basis, that represented about $4,500 in 2018 – approximately 11 times less than in Japan, 40% less than in China, and more than double that of India. Thus, there is still plenty of room for emerging economies in the region to further develop.

At the regional level, Indonesia's economy is also dominant; almost 40% of Southeast's Asia GDP in 2018. However, its GDP per capita at around $4,300 was below the region's average, and 14 times smaller than that of leading economy Singapore at $58,200. In four countries; Cambodia, Laos, Myanmar, and Vietnam, GDP per capita was below $2,000.

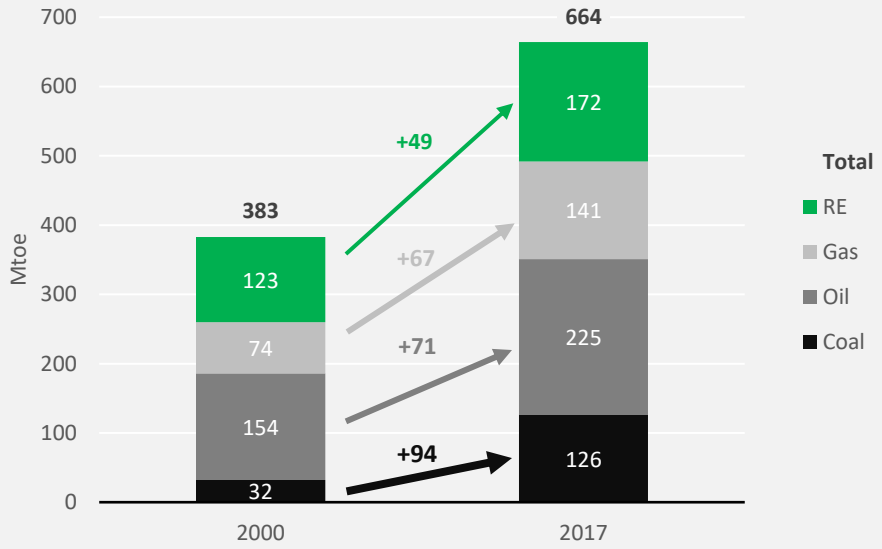
To fuel this growth, energy uses have significantly increased**. From 2000 to 2017, total primary energy demand (TPED) in Southeast Asia rose from 382 million tons of oil equivalent (Mtoe) to 674 Mtoe, or +76%.**[3] Compared to major Asian countries, TPED per capita in Southeast Asia at 1.1 toe in 2017, was about 30% that of Japan, nearly half that of China, and 1.6 fold higher than in India.

[a] In this report Southeast Asia is defined as the members of the Association of Southeast Asian Nations (ASEAN); Brunei Darussalam (hereinafter "Brunei"), Cambodia, Indonesia, Lao People's Democratic Republic (hereinafter "Laos"), Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam.

As for demography and economy, there are significant differences in terms of energy demand across Southeast Asia. With a TPED of 244 Mtoe in 2017, Indonesia was on top of this ranking as well, followed this time by Thailand and Malaysia; 138 Mtoe and 85 Mtoe, respectively. And on a per capita basis, oil & gas producer Brunei was the largest energy consumer; 8.5 toe, and Myanmar the smallest 0.4 toe.

Energy demand growth has largely been met by the expansion of fossil fuels consumption, in particular coal (mainly for electricity generation); +94 Mtoe, or one-third of the total increase in TPED (Chart 1)**.**

Chart 1: Southeast Asia Total Primary Energy Demand by Energy Source in 2000 and 2017



Source: International Energy Agency, World Energy Outlook 2018 (November 2018).

Coal boom has been favored by abundant reserves in the region. These are, however, quite unevenly distributed. Indeed, Indonesia alone concentrates 85-90% of Southeast Asia's coal reserves, and the rest is essentially in Vietnam and Thailand.[4] Moreover, it is important to note that Indonesia by far the biggest coal producer in the region (and the world's 4th largest in 2018, behind China, India, and the United States – in this order), is the only net exporter.[5] Also noteworthy is the fact that since 2015 coal consumption in Vietnam exceeds its production, and the gap just keeps increasing.[6]

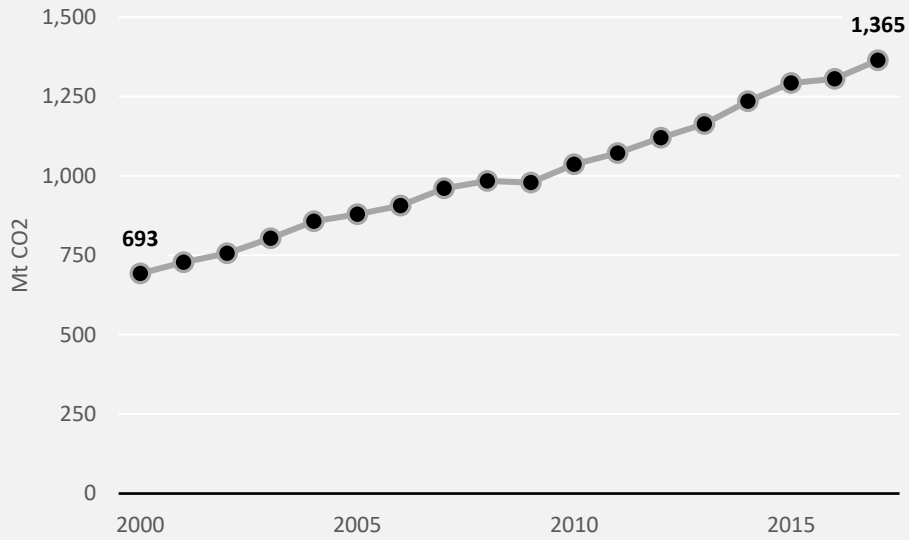
At a respectable distance from coal, other fossil fuels; oil (+71 Mtoe) and gas (+67 Mtoe) increased most. Rising oil consumption, for transport primarily, represents an ever-growing issue with regards to energy security (regional consumption of oil exceeded production of the fuel for about 25 years now, and this balance is continuously deteriorating), economics (outflow of money, risks related to price volatility, and financial burden of governmental subsidies – amounting to several billions of dollars throughout the region annually), and the environment.[7]

In comparison, the region's reliance on gas is – for the time being – less problematic. That is due to the fact that there are relatively important reserves of the fuel in Indonesia and Malaysia in particular, as well as in Myanmar and Vietnam to a lesser extent, and because regional production still exceeds consumption.[8] Furthermore, gas also has a lower carbon content than oil.

In last place, renewable energy (RE) consumption increased by 49 Mtoe. About 60% of this growth came from bioenergy alone for various purposes; buildings, industry, electricity, and transport. The rest from hydro, geothermal, wind, and solar. The predominance of traditional biomass, and its unsustainable and unsafe usages as a fuel for cooking and heating is nonetheless a threat in terms of air pollution.

Increasing consumption of fossil fuels has resulted in a significant augmentation of greenhouse gas (GHG) emissions in the region. **Between 2000 and 2017, carbon dioxide (CO2) emissions from fuel combustion grew from less than 700 million tons (Mt) to almost 1,400 Mt, or +97%** (Chart 2).

Chart 2: Southeast Asia CO2 Emissions from Fuel Combustion 2000-2017



Note: no data available for Laos.
Source: International Energy Agency, Statistics Data Browser (accessed September 27, 2019).

In 2017, these emissions were essentially concentrated in five countries; Indonesia (496 Mt CO2), Thailand (244 Mt CO2), Malaysia (211 Mt CO2), Vietnam (191 Mt CO2), and the Philippines (126 Mt CO2). On a per capita basis, however, the picture was completely different with Brunei and Singapore being the two biggest emitters with about 16 t CO2 and 8 t CO2, respectively.

In 2017, at 2.1 t CO2 per capita Southeast Asia's emissions were still relatively low compared with levels estimated in Japan 8.7 t CO2 and China 6.7 t CO2, and a little higher than in India 1.6 t CO2. Nonetheless, this does not mean that increasing GHG emissions in the region would be without consequence for the environment at local, regional, and global scales.

Indeed, Southeast Asia is one of the world's most vulnerable regions to climate change and therefore in dire need of building resilience.[9] In particular, it is under the serious threat of weather extremes and rising sea levels associated with global warming. For instance, it has been observed that typhoons and floods are becoming more intense and frequent in Vietnam.

In addition, from 1998 to 2017, Myanmar (#3), the Philippines (#5), and Vietnam (#9) were among the top 10 countries most affected by climate change in terms of fatalities and economic losses.[10] And Thailand (#13) and Cambodia (#19) were not far behind. In this period, the annual average death toll of climate change related events in Myanmar reached about 7,050. And in the Philippines the over

300-climate change related events monitored over this 20-year span resulted in annual average losses amounting to approximately $3 billion (purchasing power parity).

Thus, human health, ecosystems, and economic activities such as agriculture and tourism are especially at risk in the region.[11]

Moreover, at the local level, Jakarta in Indonesia and Hanoi in Vietnam are already among the most polluted capital cities in the world. In these two cities, air quality is considered unhealthy for sensitive groups, and there are risks of experiencing irritation and respiratory problems.[12]

Since the world, through the Paris Agreement of 2015, is aiming at strengthening the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels, evolutions regarding GHG emissions in Southeast Asia are of international interest as well.[13] Foreign investments and energy expertise should therefore pursue relevant efforts to support emerging economies in the region to embrace sustainable development pathways.

Because coal power is the first and by far the fastest-growing source of CO2 emissions in Southeast Asia; 28% of total CO2 emissions in 2017 – an increase of about +370%(!) since 2000, urgent action in the power sector is required to advance cost competitive environmentally friendly alternatives.[14]

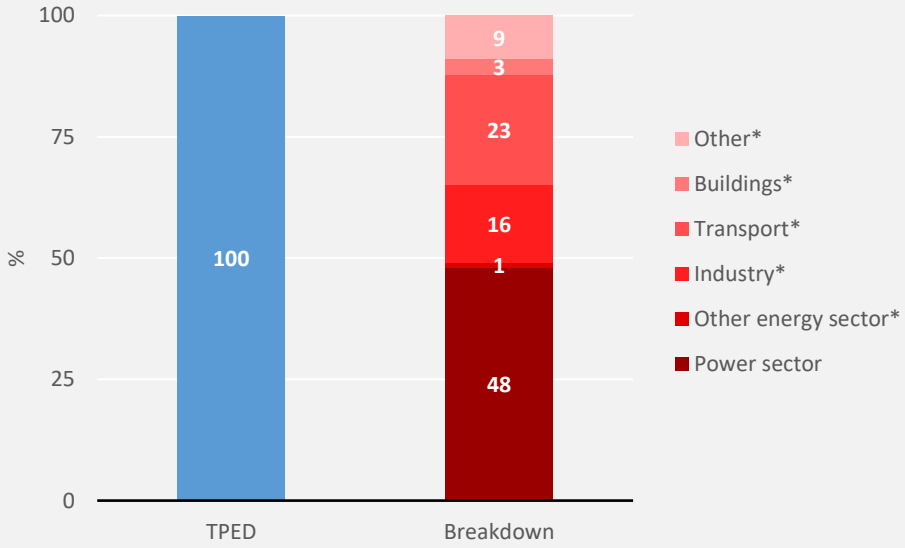
2. Power Sector Developments

Southeast Asia's power sector growth is the main reason behind the region's rising energy consumption and carbon dioxide emissions. Electricity demand in Southeast Asia substantially increased since the beginning of the century and it is projected to more than double by 2040, with populations in most countries still consuming relatively low amounts of electricity and some areas, especially rural ones, still lacking electricity access. On the supply side, coal has played a major role, but this cannot continue because of the fuel negative environmental impacts. It will have to be greatly replaced by renewable energy and energy efficiency.

– Throughout this section a number of electricity statistics are provided. For more details about comparisons between Southeast Asia and China, India, and Japan, please refer to Appendix C on page 47. For details about each country in Southeast Asia, please refer to Appendix D on page 47. –

Rising electricity demand is the main factor driving up Southeast Asia's primary energy consumption. Between 2000 and 2017, nearly half of the region's increase in TPED came from the power sector alone (Chart 3)**.**

Chart 3: Southeast Asia Total Primary Energy Demand Growth by Sector 2000-2017



Note: *excluding electricity.
Source: International Energy Agency, World Energy Outlook 2018 (November 2018).

Increasing electricity demand has essentially resulted from growing needs in industry (including manufacturing and mining) and buildings (including residential and services).

From 2000 to 2017, total electricity generation in Southeast Asia increased from below 400 terawatt-hours (TWh) to about 1,000 TWh.[15] Compared to major Asian countries, annual electricity generation per capita in Southeast Asia at 1.5 megawatt-hour (MWh) in 2017 was roughly 5-6 times smaller than in Japan, a third that of China, and a third higher than in India.

In 2017, Indonesia was the largest electricity market of the region (255 TWh), followed by a trio of Vietnam (199 TWh), Thailand (187 TWh), and Malaysia (165 TWh). The Philippines (94 TWh) and Singapore (52 TWh) were other sizable markets. Total electricity generation was the smallest in Brunei and Cambodia (around 5 TWh). On a per capita basis, however, Brunei and Singapore had the largest annual electricity generation at 9-10 MWh. Malaysia trailed behind at about 5 MWh. At the end of this ranking, Cambodia, Indonesia, Myanmar, and the Philippines did not generate more than 1 MWh per capita (Table 1 on next page).

Table 1: Southeast Asian Countries Total Electricity Generation and Electricity Generation per Capita 2017

Country	Total electricity generation (TWh)	Electricity generation per capita (MWh)
Brunei	4	9.8
Cambodia	7	0.4
Indonesia	255	1.0
Laos (2015)	17	2.5
Malaysia	165	5.3
Myanmar	22	0.4
Philippines	94	0.9
Singapore	52	9.3
Thailand	187	2.7
Vietnam	199	2.1

Note: "Electricity Generation" differs from electricity consumption because it includes energy industry own use as well as losses, and does not take into account cross-border electricity trade.
Sources: for electricity generation International Energy Agency, Statistics Data Browser (accessed September 27, 2019), for all countries except Laos from Lao People's Democratic Republic Ministry of Energy and Mines, Lao PDR Energy Statistics 2018 (May 2018). And for population The World Bank, Population, total – updated September 24, 2019 (accessed September 27, 2019).

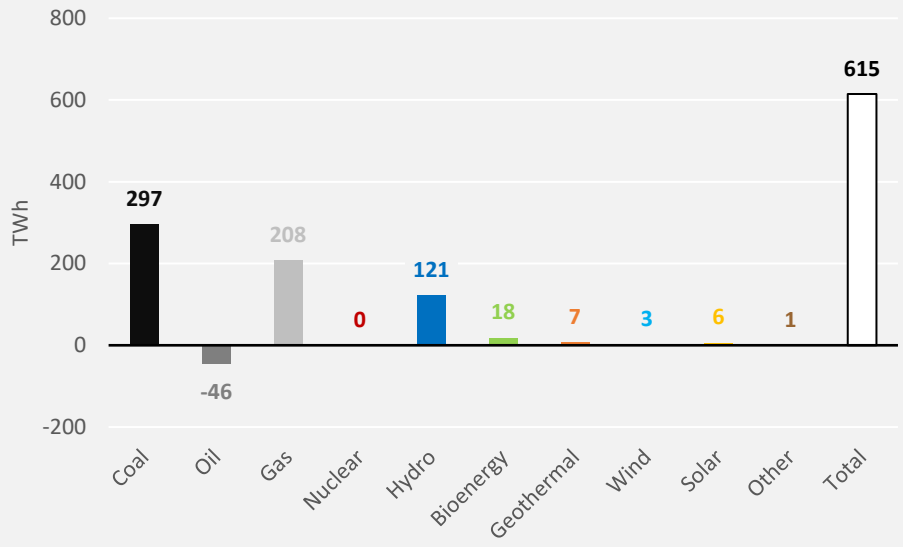
It is critical to note here that as of 2017, still 58 million people (equivalent to the populations of countries like Italy or South Africa)**, or 9% of the region's entire population, still did not have access to electricity.**[16] Though major accomplishments have been realized since 2000 – most notably in Laos, important efforts remain to be done.

In rural areas of Myanmar and Cambodia only 45-50% of populations had access to electricity in 2017. To a lesser extent in terms of proportions, electricity access was still a quite meaningful challenge in small islands of Indonesia and the Philippines as well. Finally, poor populations in urban slums in some of these countries were also without access to electricity.

As Southeast Asia keeps developing, the International Energy Agency (IEA) projects total electricity generation in the region to more than double between 2017 and 2040, reaching between very roughly 2,200 TWh and 2,500 TWh depending on scenarios.

On the supply side since 2000, coal (+297 TWh) and gas (+208 TWh) power increased most (Chart 4 on next page)**.** Hydro was a distant third (+121 TWh). Other RE saw increases that were either moderate (bioenergy; +18 TWh) or limited (geothermal, wind, and solar power; +15 TWh combined). Nuclear power did not see any positive development with still not a single reactor in operation throughout the region, despite some more or less recent punctual interests (notably in the Philippines and Vietnam) which have not yet overcome economic and safety concerns. Only electricity generated from oil decreased (-46 TWh).

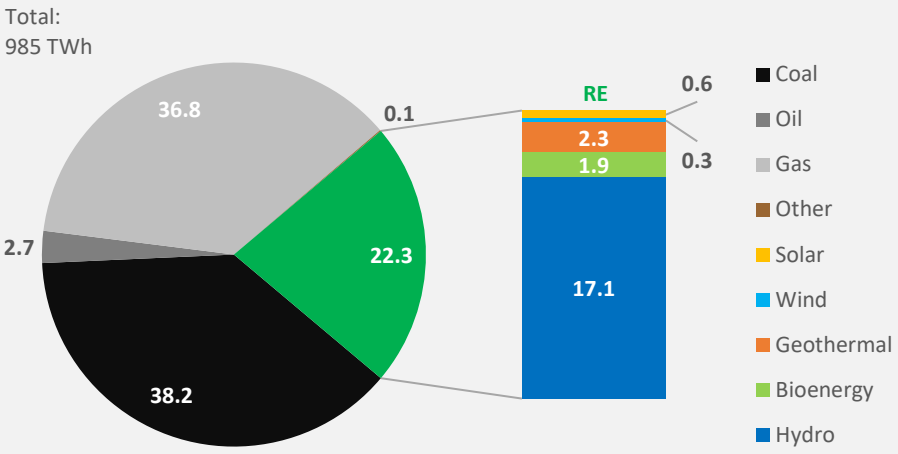
Chart 4: Southeast Asia Change in Electricity Generation 2017-2000



Note: no data available for Laos.
Source: International Energy Agency, Statistics Data Browser (accessed September 27, 2019).

As a result of these developments, the share of coal power in Southeast Asia electricity generation mix significantly increased from 21% in 2000 to 38% in 2017, eventually becoming the main power source in the region in 2017. In the meantime, that of oil collapsed from 19% to 3%. And while gas power share decreased from 42% to 37%, that of RE increased from 17% to 22% (Chart 5).

Chart 5: Southeast Asia Electricity Generation Mix 2017 (%)



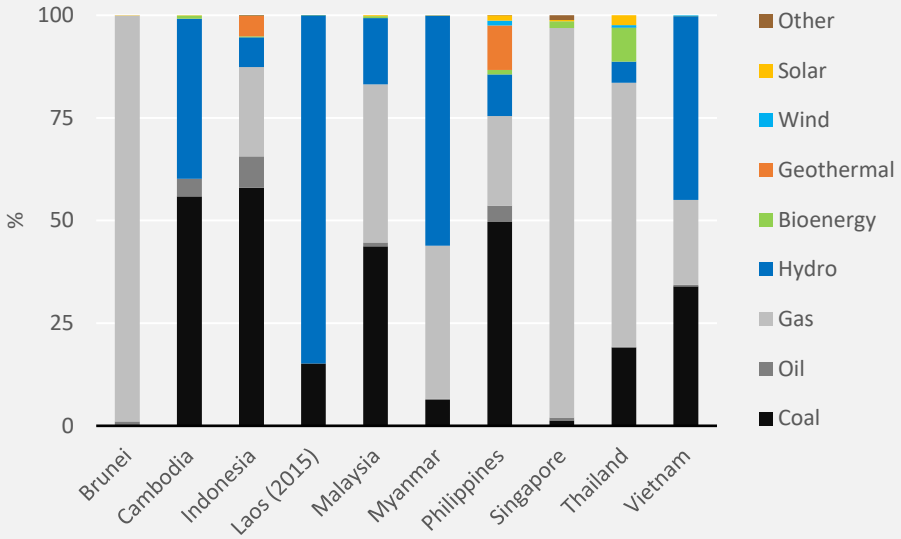
Note: no data available for Laos.
Source: International Energy Agency, Statistics Data Browser (accessed September 27, 2019).

In comparison, the shares of coal and gas in electricity generation in 2017 in China, India, and Japan were; 68% and 3%, 74% and 5%, 33% and 37%, respectively. In these three countries, RE also accounted for most of the rest.

One 2018 important fact could not be captured through IEA's available data (up to 2017): coal has certainly widened the gap with gas in Southeast Asia, owing to marked increases in Vietnam and Indonesia.[17]

Whereas fossil fuels heavily dominate electricity generation at the regional level (75-80%), substantial differences, however, exist at the national level (Chart 6)**.**

Chart 6: Southeast Asian Countries Electricity Generation Mix 2017



Sources: International Energy Agency, Statistics Data Browser (accessed September 27, 2019), for all countries except Laos from Lao People's Democratic Republic Ministry of Energy and Mines, Lao PDR Energy Statistics 2018 (May 2018).

Indeed, in Brunei, Indonesia, Malaysia, the Philippines, Singapore, and Thailand fossil fuels accounted for about 75-100% of these six countries' total electricity generation in 2017. Excluding Singapore, all the other countries aforementioned had some types of domestic fossil fuel reserves (oil & gas and/or coal).

The situation was quite different in countries of the Mekong river basin – with the exception of Thailand. In Cambodia, Laos, Myanmar, and Vietnam hydropower generated between approximately 40% and 85% of these four countries' total electricity generation in 2017.

Finally, it can also be observed that located on the Ring of Fire (an arc around the Pacific Ocean characterized by many active volcanoes) Indonesia and the Philippines are both tapping into their geothermal power potential. And that Thailand, which economy is heavily based on agriculture – leading to the production of large amounts of agriculture waste (e.g. solid waste from rice, sugarcane, cassava, corn, rubber and palm production) that can be converted into usable energy, has started to develop electricity generation from biofuels.[18]

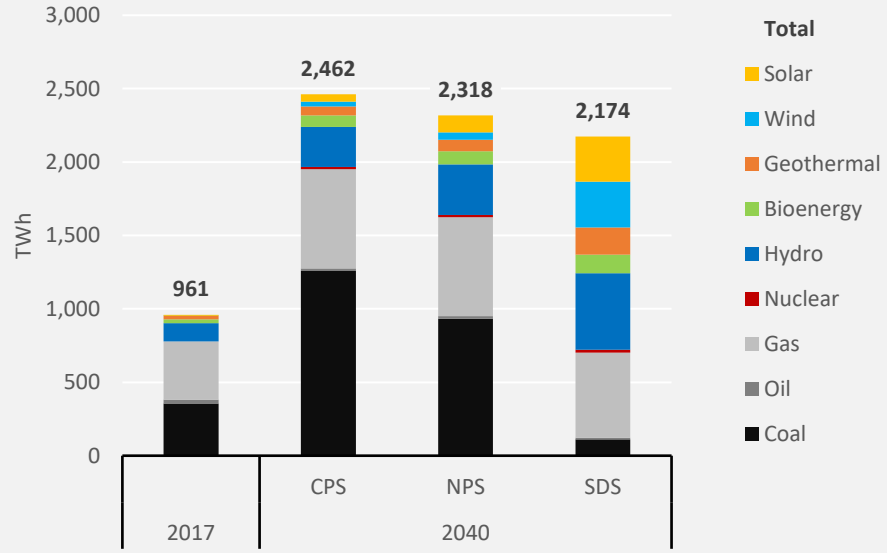
As Southeast Asia's electricity consumption is expected to strongly increase in the coming decades, the region has different possible futures in front of itself.

The IEA, in its *World Energy Outlook 2018*, describes these "possible futures" through three scenarios; "Current Policies Scenario" (CPS), "New Policies Scenario" (NPS), and "Sustainable Development Scenario" (SDS). The CPS is a scenario considering no change in policies from today. The

NPS broadens the scope to include announced policies and targets. And the SDS that is compatible with goals related to climate change, universal energy access and clean air.[b] Thus, the SDS is the preferable option.

Based on IEA's projections, the future of Southeast Asia's power sector could look very different in 2040 depending on energy policies implemented in the region (Chart 7).

Chart 7: Possible Futures for Southeast Asia's Power Sector



Note: marine that is negligible is included in "Hydro."
Source: International Energy Agency, World Energy Outlook 2018 (November 2018).

And the message could not be any clearer; RE and energy efficiency are key to deliver a sustainable bright future to Southeast Asia. In this future, RE accounts for two-thirds of the region's total electricity generation in 2040 – nearly a 45-percentage points increase from today's level, with hydro, wind, and solar as major driving forces. Energy efficiency advances enable to reduce total electricity generation by 12% compared with a business-as-usual approach (CPS). Electricity generation from coal power is cut by two-thirds from current level. Gas may experience limited growth. And nuclear power may be considered as inessential since completely negligible; less than 1% of total electricity generation in 2040.

Being pragmatic requires following the SDS path, the only way to a prosperous future. In this journey, countries of Southeast Asia will have to seize opportunities and face obstacles hindering RE massive expansion in the region. This will necessitate a much-needed, drastic but realistic shift of paradigm.

[b] More specifically, the objectives of the SDS are derived from the Sustainable Development Goals of the United Nations, providing an energy sector pathway that achieves: universal access to affordable, reliable and modern energy services by 2030, a substantial reduction in air pollution, and effective action to combat climate change. The SDS is fully aligned with the goal of the Paris Agreement to hold the increase in the global average temperature to well below 2 degrees Celsius above pre-industrial levels.

Chapter 2: Strategies for Renewable Energy to Outcompete Coal Power

1. Renewable Energy Largely Untapped Potential

Southeast Asia is blessed with a significant RE potential from abundant various resources. This potential is currently largely underexploited as demonstrated by limited deployment of technologies, in particular solar and wind. Yet, some countries have already developed strong performant domestic RE manufacturing industries which could certainly contribute to deliver the region's power sector energy transition – granted additional conditions are right.

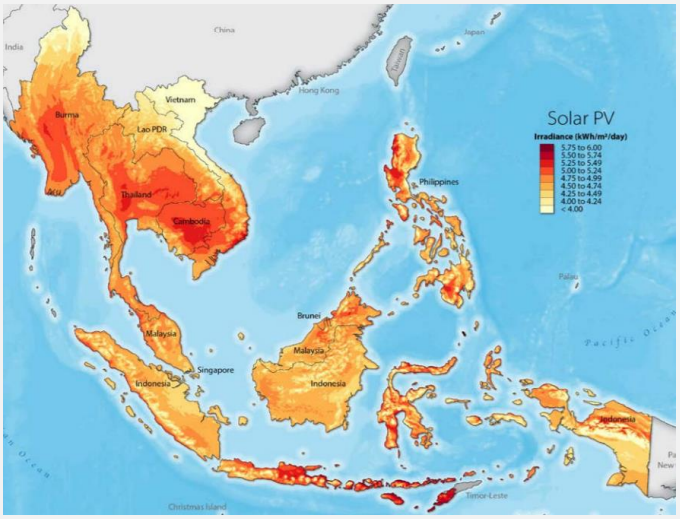
RE potential in Southeast Asia is significant with various abundant resources:[19]

The region has some of the best untapped hydropower potential in the world. Technical potential is substantial and largely unexploited in many countries, and especially in Indonesia and Myanmar; about 75 gigawatts (GW) and 50 GW of technical potential, respectively, out of which only 6 GW and 3 GW, respectively, were turned into installed capacity at the end of 2018.[20] There is also quite a lot of room for growth in Cambodia, Laos, and Malaysia.

Technical potential may, however, be limited by economic viability. Social acceptance, and environmental impacts are other critical variables of hydropower projects that cannot be overlooked. Constructions of dams result in displacing populations and modifying land use with consequences on river ecology and surrounding nature, notably. Opposition to projects has already been manifested in Cambodia, Laos, Myanmar and Vietnam for examples.[21] Properly dealing with these challenges is necessary to ensure successful developments and fully unlock the technology very promising potential across the region.

In addition, solar irradiance throughout Southeast Asia is very strong, averaging over 1,500-2,000 kilowatt-hour per square meter annually, enabling capacity factors of 20% and above (Map 1).

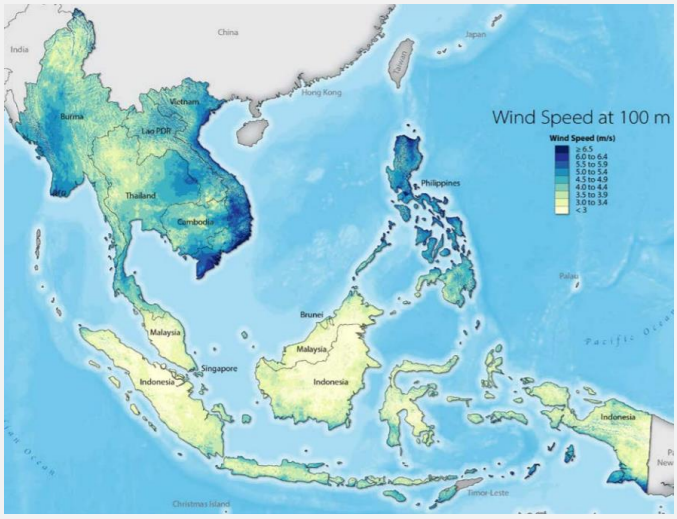
Map 1: Solar Resource Potentials of Southeast Asian Countries



Note: Myanmar was formerly known as "Burma" (indicated in this chart).
Source: United States Agency for International Development and National Renewable Energy Laboratory, Exploring Renewable Energy Opportunities in Select Southeast Asian Countries (June 2019).

In comparison, wind resources are less favorable, but in some countries such as Myanmar, the Philippines, Thailand, and Vietnam there are regions along the coasts and inland where wind speeds average between 6 and 7 meters per second, allowing for capacity factors higher than 30% (Map 2).

Map 2: Wind Resource Potentials of Southeast Asian Countries



Note: Myanmar was formerly known as "Burma" (indicated in this chart).
Source: United States Agency for International Development and National Renewable Energy Laboratory, Exploring Renewable Energy Opportunities in Select Southeast Asian Countries (June 2019).

Suitable land areas for solar and wind power vary greatly depending on countries (Table 2). For solar PV, Thailand and Myanmar have most of the suitable land areas in the region with about 293,000 square kilometers (km2) and 214,000 km2, respectively. For wind, Myanmar and Vietnam have most of the suitable land areas with around 161,000 km2 and 104,000 km2, respectively. Cambodia and the Philippines are other countries with important suitable land areas for both technologies. Suitable land areas are more limited, especially for wind, in Indonesia, Laos, and Malaysia. Brunei and Singapore are the most constrained.

Table 2: Suitable Land Areas for Solar PV and Wind in Southeast Asian Countries

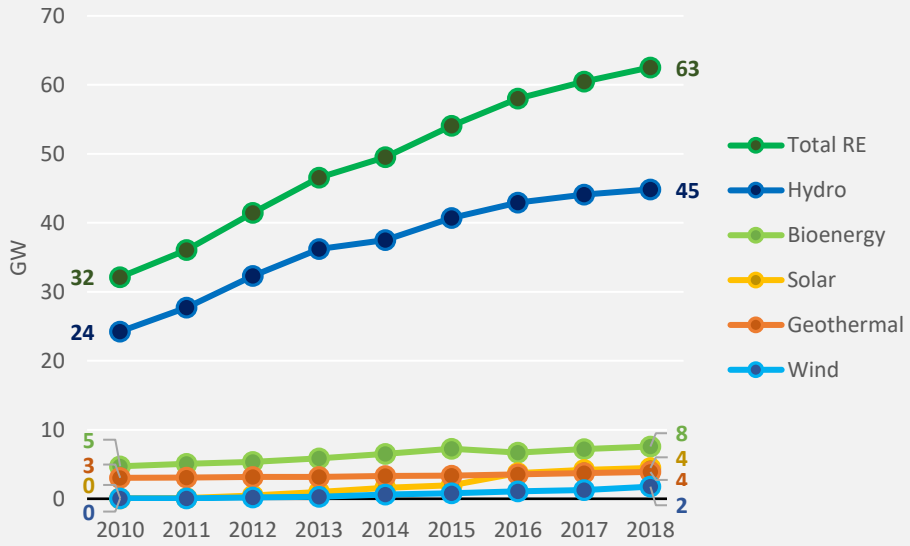
Country	Suitable Land Areas (km2)	
	Solar PV	Wind
Brunei	431	6
Cambodia	88,830	23,082
Indonesia	29,228	16,551
Laos	35,496	4,344
Malaysia	54,575	526
Myanmar	214,347	160,564
Philippines	53,062	72,337
Singapore	60	7
Thailand	292,713	79,718
Vietnam	79,069	103,591

Note: moderate technical potential scenario and projects with levelized cost of electricity below $150/MWh.
Source: United States Agency for International Development and National Renewable Energy Laboratory, Exploring Renewable Energy Opportunities in Select Southeast Asian Countries (June 2019).

Finally, geothermal potential is significant in Indonesia and the Philippines, and bioenergy supply potential is very large across the entire region.

Even though Southeast Asia is a RE-rich region, technology deployment in the power sector has not really lived up to its potential until now. Indeed, as of 2018, total RE installed capacity in Southeast Asia reached a modest 63 GW, with a net predominance of hydropower that has supported more than two-thirds of RE installed capacity expansion since 2010 (Chart 8).

Chart 8: Southeast Asia RE Installed Capacity 2010-2018

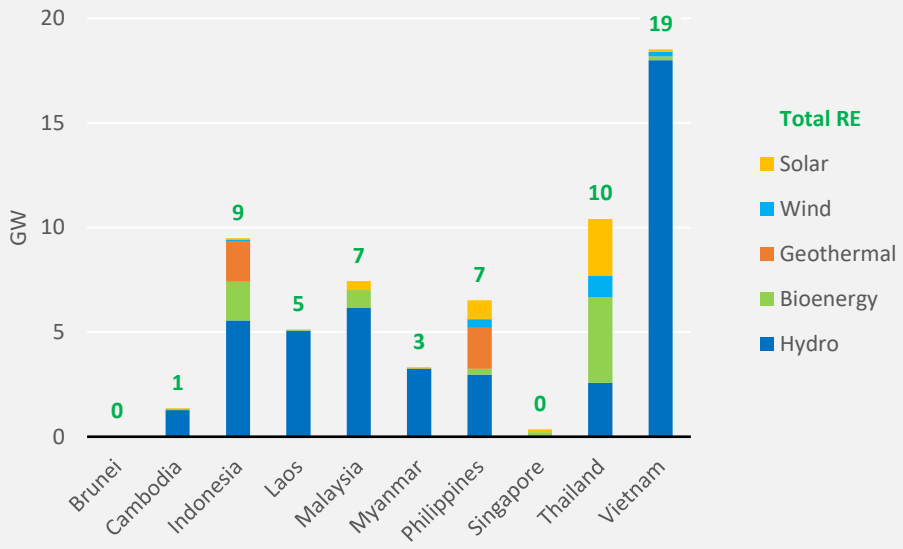


Source: International Renewable Energy Agency, Renewable Energy Statistics 2019 (July 2019).

Compared to global developments, solar and wind expansions have been particularly unspectacular in Southeast Asia; only 4 GW and 2 GW, respectively. In 2018, China had 175 GW of solar and 185 GW of wind installed capacity, India 27 GW and 35 GW, and Japan 56 GW and 4 GW.[22]

Moreover, in the cases of solar (essentially solar photovoltaic (solar PV)) and wind (essentially onshore wind) roughly 60% of each technology installed capacity was concentrated in Thailand alone. And a majority of countries did not demonstrate any noticeable progress in deploying solar and wind power (below 0.1 GW installed capacity for each technology) (Chart 9 on next page).

Chart 9: Southeast Asian Countries RE Installed Capacity 2018



Source: International Renewable Energy Agency, Renewable Energy Statistics 2019 (July 2019).

Looking into more details at each country's RE installed capacity portfolio, some interesting points may be highlighted:

At the end of 2018, hydropower was almost the only RE technology installed in four countries; Vietnam – the undisputed leader (18 GW), Laos (5 GW), Myanmar (3 GW), and Cambodia (1 GW).

Thailand was not only the region's leader for solar (3 GW) and wind power (1 GW), but also for bioenergy (4 GW). Biopower in Thailand is mainly dominated by solid biofuels (80% of bioenergy installed capacity in the country), the rest is based on biogas and renewable municipal waste.

Indonesia and Malaysia had also started to develop bioenergy power plants, about 2 GW for the former and 1 GW for the latter. In these two countries biopower is also largely dominated by solid biofuels.

Indonesia had not started to make inroads in bioenergy only, but also in geothermal (2 GW). Geothermal power was also developed at a similar scale in the Philippines (2 GW), making these two countries the world's 2nd and 3rd largest geothermal power markets, behind the United States.[23]

Finally, RE developments in Brunei and Singapore were minor.

If Southeast Asian countries have thus not yet become RE superpowers in terms of installed capacity, some of them – driven by foreign investments – have, however, started playing significant roles as producers and exporters of solar PV panels.[24]

That is for example the case of Malaysia, Thailand, and Vietnam. Vietnam and Malaysia have module manufacturing capacities of 7.2 GW and 6.5 GW, respectively. And they both host facilities owned by about 10 different manufacturers. The Thai industry is somewhat smaller.

Beyond trade opportunities, such as exporting solar panels to India, **RE power industries have created thousands of jobs in Southeast Asia.**

For instance, in Malaysia more than 54,000 people were working in solar PV in 2018. Around 17,000 of these jobs were in component manufacturing.

Beyond the solar industry, The Philippines is the world's 10th largest job market for wind power. It employs nearly 17,000 people. Still in the Philippines, the geothermal power industry represents over 7,000 jobs. And in Vietnam hydropower is also an important source of employment.

Having developed these domestic manufacturing capacities may certainly help Southeast Asia embracing local opportunities in expanding electricity generation from RE in the region, and finally reaping all the benefits associated with the energy transition in the power sector. Massive deployment of RE will, however, require overcoming a number of economic, political, and electricity market structural obstacles.

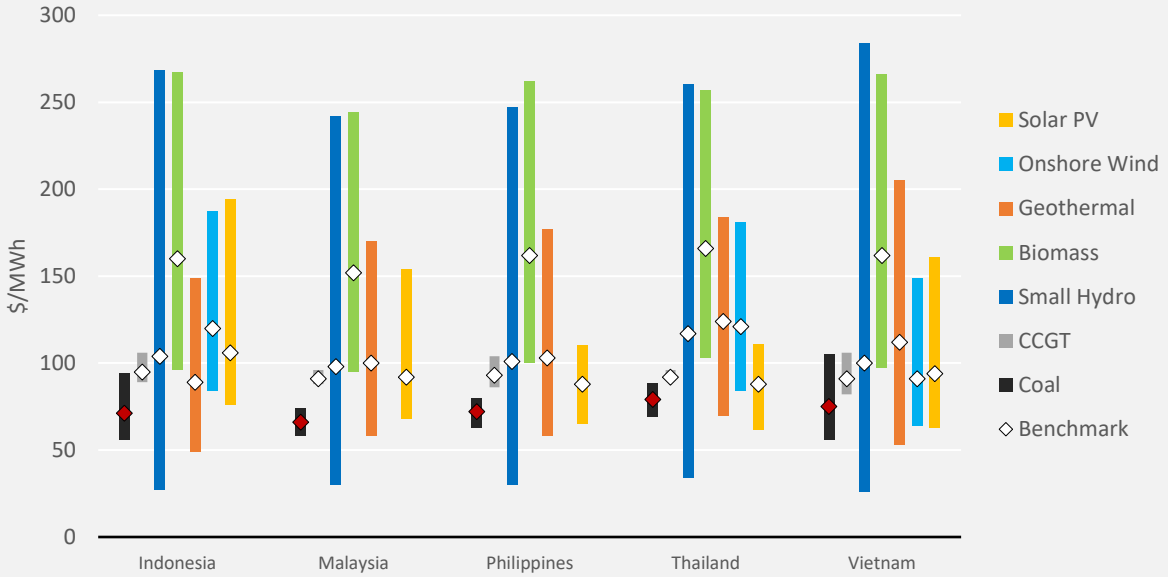
2. Facing Hindering Obstacles

The overall framework to ensure successful deployment of RE technologies in Southeast Asia is still a work in progress. Further cost reductions, more ambitious targets supported by effective policies, and market conditions that favors competition and customer choice, as well as more robust electrical grid infrastructures would all benefit greatly to RE expansion.

Costs of generating electricity

The first obstacle hindering RE growth in Southeast Asia is of economic order. That is **RE technologies – on a benchmark basis – are relatively more expensive than coal power, the most cost-efficient technology for new electricity generation at the moment** (Chart 10 on next page)**.**

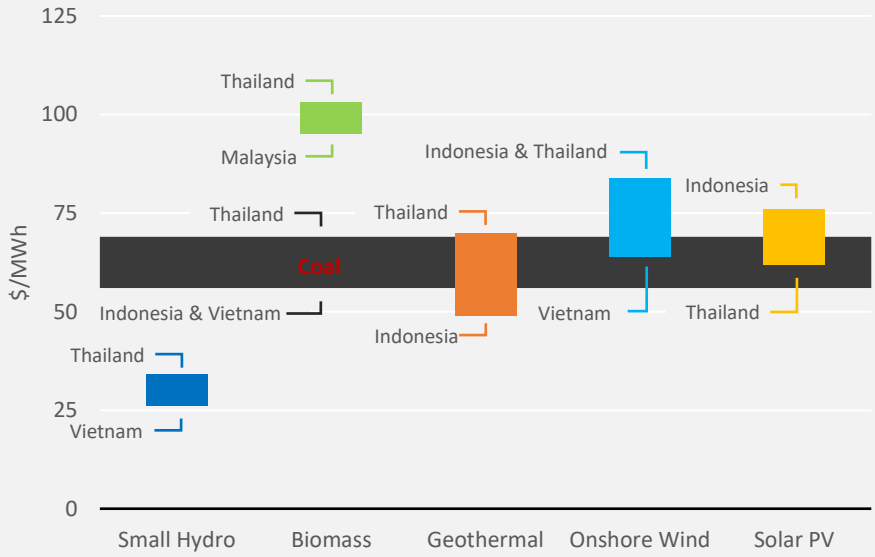
Chart 10: Unsubsidized LCOE by Generating Technology in Selected Southeast Asian Countries 2019-1H



Source: BloombergNEF, Levelized Cost of Electricity (subscription required – accessed July 10, 2019).

However, beyond this key finding a number of additional observations should be carefully considered. Among which, LCOE of most competitive projects for both RE and coal (Chart 11):

Chart 11: Unsubsidized LCOE of Most Competitive RE and Coal Power Projects in Southeast Asia 2019-1H



Note: selected countries include Indonesia, Malaysia, the Philippines, Thailand, and Vietnam.
Source: BloombergNEF, Levelized Cost of Electricity (subscription required – accessed July 10, 2019).

Small hydropower (5-50 megawatt (MW)) – under favorable conditions – beats coal power in all the region's five largest electricity markets; Indonesia, Malaysia, Philippines, Thailand, and Vietnam. Under optimal conditions, with a levelized cost of electricity (LCOE) as low as about $25-35/MWh, small hydropower may even be just half the cost of these countries' most competitive coal-based electricity.

Geothermal power may also be competitive with coal, especially in Indonesia. Geothermal relative cost competitiveness with coal is not as strong in Malaysia, the Philippines and Vietnam, and it is clearly weaker in Thailand. Yet, even in these four countries under optimal conditions geothermal power may be on par with or cheaper than coal power at around $55-70/MWh.

Compared to hydro and geothermal, biomass appears to be the least cost competitive among conventional RE technologies. It currently does not represent a serious threat to coal power, except maybe in Thailand based on a recent auction (see page 29).

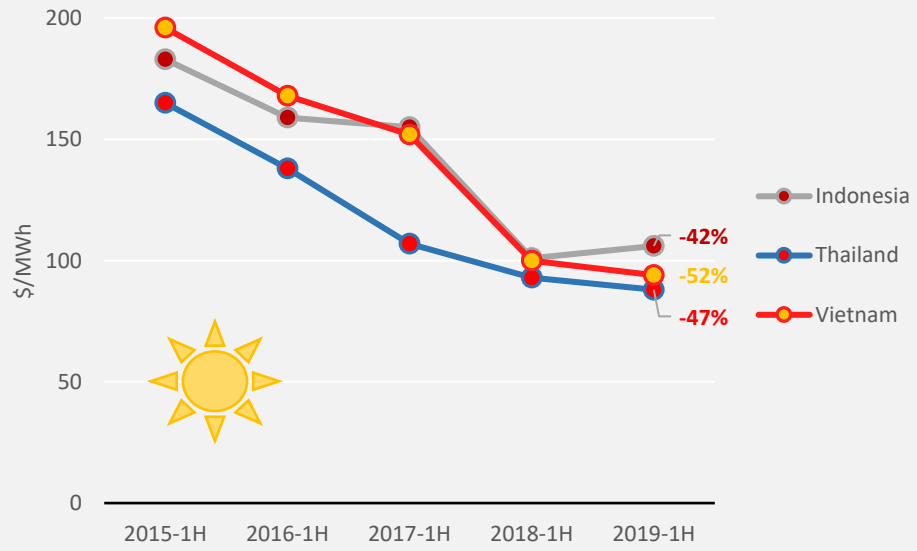
Finally, come solar PV and onshore wind:

Solar PV is now within coal power LCOE range, and is most cost competitive with coal in Thailand with a benchmark LCOE a little below $90/MWh. Solar PV LCOE is at a similar level in the Philippines, but coal power is more affordable in the Philippines than in Thailand; about $70/MWh against around $80/MWh (benchmarks). LCOE of solar PV is a little higher in Malaysia and Vietnam $90-95/MWh. And relatively expensive in Indonesia; a little over $105/MWh. Most competitive solar PV projects across the region have LCOE of $60-65/MWh. In comparison, the world's record-low price for solar PV was reached in Portugal during the summer 2019; about $16/MWh – or 3.5-4.0 times less.[25]

The situation of onshore wind is more complicated. For now, only in Vietnam the technology has really demonstrated that it could be a credible alternative to coal power with a benchmark LCOE of roughly $90/MWh, and most competitive projects at approximately $65/MWh. LCOE of best onshore wind projects in Indonesia and Thailand were significantly higher than those in Vietnam; $85/MWh, and LCOE of typical projects above coal range.

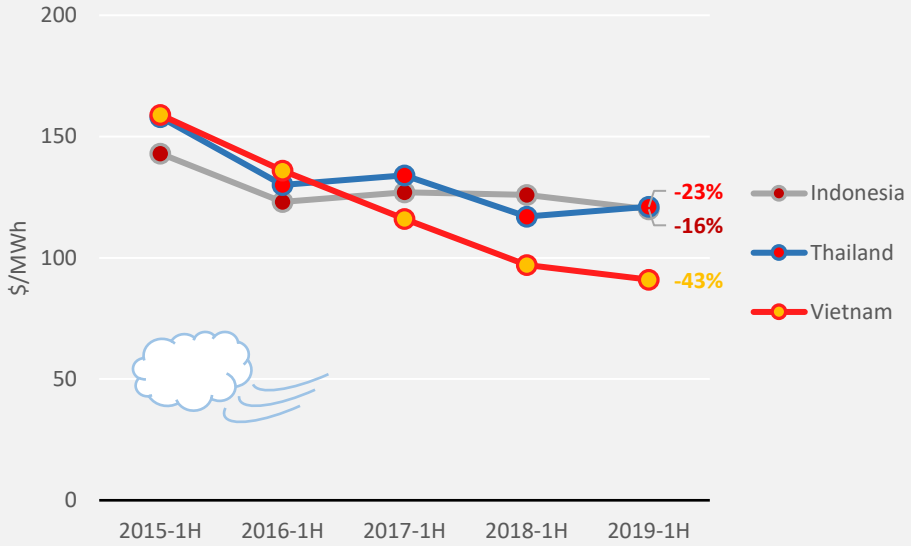
As a result, the picture is quite grey with RE a bit at disadvantage for the time being. **Nevertheless, the truth of today may not be that of tomorrow.** Indeed, looking at cost reduction trends of solar PV and onshore wind is quite instructive and may provide insights at what the future may look like (Charts 12 & 13, Chart 13 on next page).

Chart 12: LCOE Reduction of Solar PV in Indonesia, Thailand, and Vietnam 2015-1H to 2019-1H



Note: only benchmark values are displayed.
Source: BloombergNEF, Levelized Cost of Electricity (subscription required – accessed July 10, 2019).

Chart 13: LCOE Reduction of Onshore Wind in Indonesia, Thailand, and Vietnam 2015-1H to 2019-1H



Note: only benchmark values are displayed.
Source: BloombergNEF, Levelized Cost of Electricity (subscription required – accessed July 10, 2019).

In the past five years, the LCOE of both technologies has been significantly reduced, especially that of solar PV; between about 40% and 50% in Indonesia, Thailand, and Vietnam (and roughly 15-45% for onshore wind). These decreases result mainly from industrial learning curves observed throughout the world. Increasing deployment of solar PV and onshore wind with improved technologies and economies of scale have enabled substantial cost reductions particularly in manufacturing of PV modules and wind turbines.[26] **Important progresses have thus been accomplished, and more are expected to come.**

Indeed, according to BloombergNEF's latest *New Energy Outlook 2019*, in Indonesia, Malaysia, the Philippines, and Thailand new solar PV LCOE will be cost competitive with new coal from 2021-2022, and that of new onshore wind from the second half of the 2020s and before 2030.[27]

In addition, according to a recent analysis led by Carbon Tracker, in Vietnam by 2020 it will be cheaper to invest in new solar PV than new coal, and by 2021 for new onshore wind.[28] Furthermore, as soon as 2022, it could even be cheaper to build new solar PV and onshore wind than operate existing coal plants. These changing cost dynamics indicate significant stranded asset risks.

This imminent new favorable economic reality in which RE will outcompete coal power in Southeast Asia will have deep implications for investment decisions in electricity generating facilities to be built in the region in the upcoming years.

Energy policies in the power sector[29]

Recognizing benefits in terms of energy security, energy access, economic competitiveness, and social and environmental sustainability associated with RE and energy efficiency, Southeast Asian countries have taken important initial steps in developing enabling policies and related regulatory

frameworks. Yet, ample opportunities remain for improvement; not only to promote clean solutions, but also to really establish a level playing field.

At the regional level, in the framework of the Association of Southeast Asian Nations (ASEAN) that brings together all the ten Southeast Asian countries studied in this report, member states collectively aim to secure 23% of their primary energy from modern, sustainable, RE sources by 2025 (no specific target for the power sector). They also aim to reduce overall energy intensity by 30% by 2025, compared with 2005 levels.

At the national level, all countries in the region have adopted medium- and long- term targets for RE and have also formally joined the Paris Agreement and committed to nationally determined GHG reduction targets.

Since this report essentially focuses on the power sector, the following will discuss Southeast Asian countries' RE policies (targets and policies implemented illustrated with examples) in this sector only. It will also discuss issues related to expected coal power expansion, fossil fuel subsidies, and carbon pricing, the latter two – again – in the power sector only.

Though there is no regional target for electricity generation from RE, all countries in Southeast Asia have advanced various types of plans for RE expansion at the national level to be realized within the decade or the next two decades from now (Table 3 on next page).

Table 3: Southeast Asian Countries RE Targets in the Power Sector

Country	Target	Most recent achievement (year)
Brunei	10% in power generation by 2035	0% in 2017
Cambodia*	Hydro 2.2 GW (approximately 80% of total installed capacity) by 2020	Hydro 1.3 GW installed in 2018
Indonesia	Total RE 16.7 GW planned new capacity additions 2019-2028 – breakdown: hydro 9.5 GW, geothermal 4.6 GW, solar and wind 0.9 GW each, biomass 0.8 GW, and marine 0.0 GW	Installed in 2018, total RE 9.5 GW – breakdown: hydro 5.6 GW, geothermal 1.9 GW, solar and wind 0.1 GW each, bioenergy 1.8 GW, and marine 0.0 GW
Laos	Total RE (excluding large hydro) 0.7 GW by 2025 – breakdown: small hydro 0.4 GW, and bioenergy, solar and wind 0.1 GW each	Installed in 2018, bioenergy, solar and wind 0.0 GW each. No data for small hydro.
Malaysia	20% of total installed capacity by 2025 (excluding large hydro)	4% in 2017
Myanmar	Hydro 8.9 GW and other RE 2.0 GW to account for 46% of total installed capacity by 2030-2031	Installed in 2018, hydro 3.3 GW and other RE 0.1 GW
Philippines*	Total RE 9.9 GW planned new capacity additions 2010-2030 – breakdown: hydro 5.4 GW, wind 2.3 GW, geothermal 1.5 GW, solar and biomass 0.3 GW each, and marine 0.1 GW	Added 2010-2018, total RE 1.7 GW – breakdown: solar 0.9 GW, wind 0.4 GW, bioenergy 0.2 GW, hydro and geothermal 0.1 GW each, and marine 0.0 GW
Singapore	Solar 0.4 GW by 2020, and 1 GW beyond 2020	Solar 0.2 GW installed in 2018
Thailand	Total RE 20.8 GW planned new capacity additions 2018-2037 (37% of total)	Installed in 2018, total RE 10.4 GW
Vietnam*	23% of domestic electricity supply by 2030, as well as total RE 49.1 GW by 2030 – breakdown: hydro (including pumped storage) 27.8 GW, solar 12.0 GW, wind 6.0 GW, and bio 3.3 GW	45% in 2017, as well as installed in 2018, total RE 18.5 GW – breakdown: hydro (including pumped storage) 18.0 GW, solar 0.1 GW, wind 0.2 GW, and bio 0.2 GW

Note: *100% by 2050 – target established by the Climate Vulnerable Forum (*Renewable Energy Policy Network for the 21st Century, Renewables Global Status Report 2019 (June 2019)*).
Sources: for targets International Renewable Energy Agency, Renewable Energy Market Analysis: Southeast Asia (January 2018), for all countries except Indonesia from Indonesia Ministry of Energy and Mineral Resources, Electricity Supply Business Plan (RUPTL) 2019-2028 (March 2019) (in Indonesian), Laos from Lao People's Democratic Republic Ministry of Energy and Mines, Renewable Energy Data in Lao PDR (December 2016), Malaysia from Malaysia Ministry of Energy, Science, Technology, Environment and Climate Change, YB Yeo Bee Yin launches new SEDA website featuring renewable energy microsite and net energy metering (NEM) calculator – May 14, 2019, Thailand from Thailand Ministry of Energy, Power Development Plan 2018 (April 2019) (in Thai), and Vietnam from Vietnam Prime Minister, Decision 428/QD-TTg – March 18, 2016. And for achievements International Energy Agency (electricity generation) and International Renewable Energy Agency (installed capacity) as previously reported, except for Malaysia from Malaysia from Malaysia Ministry of Energy, Science, Technology, Environment and Climate Change, Malaysia-Korea Energy Cooperation: Malaysia Renewable Energy Transition Roadmap (October 2018).

Three key observations can be advanced: ambitions differ significantly from a country to another, overall goals pursued are not particularly aggressive, and a lot of efforts remain to be done.

For instance, while Brunei targets to increase RE power generation from a current level of 0% to 10% by 2035 (unambitious compared with global standards), Vietnam plans to decrease the share of RE in its domestic electricity supply by half between 2017 (45%) and 2030 (23%) because it is more

largely supporting fossil power, and especially coal, to meet new power demand, which will be discussed more into details later in this section.

In addition, Indonesia is planning to triple its RE installed capacity by 2028 by adding new RE capacity totaling 16.7 GW. More than half of that is expected to come from hydro (9.5 GW), and most of the rest from geothermal (4.6 GW). Neither solar nor wind will grow by 1 GW.

Thailand is also planning to triple its RE installed capacity by adding new RE capacity totaling 20.8 GW, but in a longer timeframe (by 2037). Another difference with Indonesia is the portfolio of technologies targeted, with solar power expected to play a much bigger role with more than 10 GW of new solar power capacity to be installed in the next 20 years.

Moreover, Malaysia is planning a significant increase in RE (excluding large hydro) installed capacity share from only 4% to 20% between 2017 and 2025. Almost everything remains to be done though.

In the Philippines there is also a long way to go to achieve the country's 2030 goals. Only about 15% of the total RE capacity to be deployed in the period 2010-2030 had been installed at the end of 2018.

Finally, with the exception of Myanmar (essentially hydro), other countries (Cambodia, Laos, and Singapore) do not have outstanding targets in terms of RE capacity additions.

The path to meeting these targets sometimes appears challenging, and it is clear that more government actions are required to unlock the region's full RE potential.

Below is concretely described the most important support mechanisms implemented to promote RE technologies in Southeast Asia's power sector.

So far, Indonesia, Malaysia, the Philippines, Thailand, and Vietnam are leading RE policies in the region. Besides setting targets, these five countries have established the following key measures: guaranteed purchase of renewable power at set tariffs, additional incentives for project developers and investors, financing schemes to support projects, and permitting and licensing mechanisms and technical standards to facilitate grid interconnection.

In Southeast Asia, two policies which efficiency has been demonstrated worldwide have been adopted; feed-in premiums (FiP)/ feed-in tariffs (FiT) and auctions, with instructive results.

Among leading countries in terms of RE policies, Indonesia, Malaysia, the Philippines, Thailand, and Vietnam have all implemented feed-in policies (Table 4 on next page):

Until the end of 2018, Thailand was the most remarkable example of solar power expansion thanks to FiP and FiT in the region. This has changed in 2019 following the recent launch of Vietnam's first solar PV FiT (mid-2017). This scheme has resulted in a surge of solar power capacity in the country where 5 GW are now expected to be operational by the end of the year following a boom from January to June, before the FiT deadline offering a relatively generous tariff of $94/MWh expired.[30] In the Philippines and Malaysia, FiT also triggered solar power expansion, more moderate though because of various reasons related to different situations. Finally, in Indonesia the FiT framework is not very favorable to solar developments and has therefore resulted in limited capacity deployment.

In comparison to solar, feed-in policies incentives for wind power have often been perceived unattractive and have thus not led to widespread expansion of the technology in the region.

Table 4: Solar PV and Onshore Wind FiTs in Selected Southeast Asian Countries

Country	Tariffs ($/MWh)	
	Solar PV	Onshore wind
Indonesia	Maximum price paid to projects will be 85% of the regional generation cost, if it exceeds the national average generation cost. If regional generation cost is less than the national average cost, tariffs can be negotiated.	
Malaysia	72 kW-1 MW: 89 24 kW-72 kW: 93 4 kW-24 kW: 144 <4 kW: 148	X
Philippines	Capacity quota is now full. Extension of FiT is very unlikely.	
Thailand	187 ceiling price under competitive tender	200 ceiling price under competitive tender
Vietnam	94 (expired June 30, 2019) – new tariffs under consideration	85

Source: BloombergNEF, Prices, Tariffs & Auctions, and Country Profiles (subscription required – both accessed September 13, 2019).

A number of countries have recently held successful auctions. For instance, Cambodia (solar), Malaysia (solar), the Philippines (solar and wind), Singapore (solar), and Thailand (bioenergy and hybrid).[31] More specifically, in Thailand, after introducing competitive bidding for biomass and biogas in 2014, the small power producer hybrid firm scheme has been released in 2017 allowing small power producers (individual project sizes 10-50 MW) to use multiple RE sources in a single project.[32] In the first auction under the hybrid scheme, projects were awarded as low as about $55/MWh for biomass only and roughly $85/MWh for bioenergy + solar.[33] In 2016, Malaysia announced a first tender for 471 MW of solar PV to be delivered by 2019, the auction price was about $100/MWh.[34] In the Philippines, bids as low as approximately $45/MWh for solar and $70/MWh for wind were reached in 2018.[35] And most recently, in September 2019, Cambodia's first solar auction made the headlines by delivering a region record low winning bid at $39/MWh.[36]

As demonstrated by these examples, key policy tools to promote RE are thus already used in a number of Southeast Asian countries. Yet, their implementation remains to be optimized and expanded. For instance, promotion of more attractive tariffs when prices are too low, more aggressive pursuit of cost-cutting options when they could become too high. And extension of FiT policies, as well as organization of pluriannual auctions to ensure visibility of volume deployment.

In addition to RE policies directly related issues, other energy policies indirectly related to RE may not only hamper the deployment of RE technologies, but also compromise the region's climate change long-term sustainable development objectives. The main issue here is the incompatible promotion of fossil power, and in particular coal.

Alongside RE deployment, Southeast Asian countries, with the exceptions of Brunei and Singapore, are planning to expand coal power to various extents, substantially in the cases of Indonesia and Vietnam.

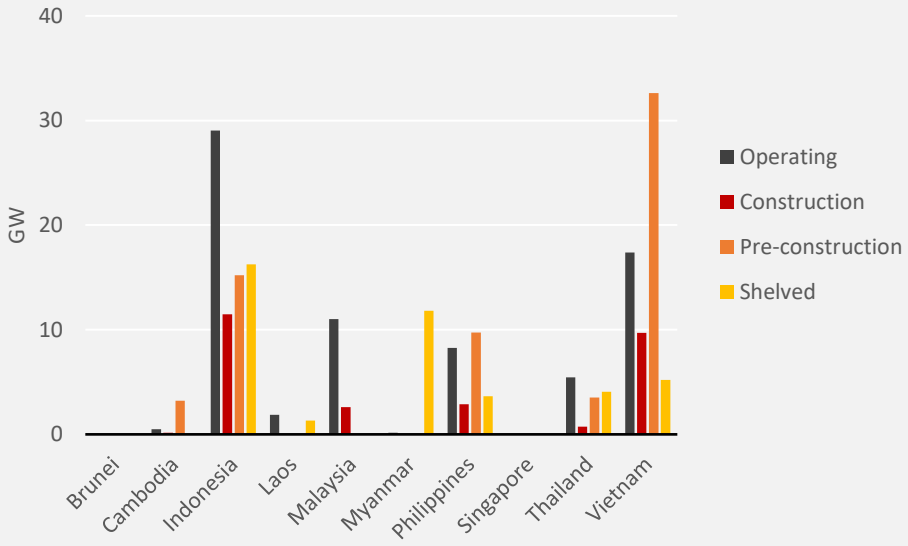
Indonesia plans to add 27 GW of new coal power capacity – about half of all new power capacity to be constructed in the country within the decade to come.[37] In Vietnam, coal share in domestic electricity supply is planned to increase from 34% in 2017 to 53% in 2030, nearly a 20-percentage points increase.[38] That is strikingly inconsistent with the country's 100% RE goal by 2050.

Myanmar has significant expansions plans; coal share in electricity generation from 6% in 2017 to 30% by 2030, of a smaller magnitude, however, when taking the country electricity market size into

account.[39] Coal power developments are also quite active in the Philippines with the government praising "baseload capacities" providing "stable and reliable power supply" as projects keep moving forward.[40] And prospects are currently somewhat more limited in Cambodia, Laos, Malaysia, and Thailand.

Some of these plans are well on their way of being materialized, others may be abandoned as they encounter issues (Chart 14).

Chart 14: Coal Power Capacity Status in Southeast Asia as of 2018



Source: Global Energy Monitor/Sierra Club/Greenpeace, Boom and Bust 2019: Tracking the Global Coal Plant Pipeline (March 2019).

In total, Southeast Asia had 74 GW of operating coal power capacity in 2018, and active plans for 92 GW; 28 GW in construction and 64 GW in pre-construction, and 42 GW shelved (which development may be resumed or abandoned).

Unsurprisingly, developments were most significant in Indonesia and Vietnam, both countries had about 10 GW of capacity under construction, and more in pre-construction. They were followed by the Philippines with 3 GW under construction and 10 GW in pre-construction. Active developments were less significant, but not negligible either, in Cambodia, Malaysia, and Thailand. Interestingly, there was no active development in Myanmar where about 12 GW were shelved because of strong civil society opposition fearing for people's health, environment, and livelihoods.[41]

Opposition to coal power is not limited to Myanmar, public protest again the dirtiest electricity generating technology has also been observed in Indonesia, the Philippines, Thailand and Vietnam for examples.[42] In the Philippines, several provincial and municipal governments like San Juan and Negros Occidental recently declared that they will become coal-free and look to RE as alternatives. This movement is driven by youth, communities, and non-governmental organizations who successfully pushed several local administrations to make a commitment to move away from coal.[43] And in Thailand in 2018, communities' protests over the harmful effects on health and the environment of new coal power plants in Krabi and Songkhla provinces drove the government to halt their

construction plans.[44] Instead, Thailand is now dynamically promoting RE expansion and maintaining gas as an important power source for electricity generation.[45]

Growing concerns about climate change and recognition of RE increasing cost competitiveness is also starting to weight on the financing of coal power stations in Southeast Asia. It was recently reported that the region's biggest banks said they would stop funding coal-fired power plants.[46] For instance, Singapore's DBS Group Holdings announced in April 2019 that it would cease financing new coal power projects from 2021 following the completion of existing projects in Indonesia and Vietnam, and will instead invest in RE projects such as solar power. Oversea-Chinese Banking Corporation also indicated that it would quit coal. In addition, over the past year, several Japanese commercial banks and trading houses (Mitsubishi UFJ Financial Group, Itochu, Sumitomo Mitsui Trust Bank, and Marubeni) and China's State Development & Investment Corporation have stated they will no longer invest in new coal capacity.[c] And Australia's largest insurance company QBE will also stop offering insurance for thermal coal facilities. Such moves by sending unequivocal messages to financial markets are real game-changers.

As a result, despite massive expansion plans, coal power is increasingly facing powerful headwinds from socio-environmental and economic & financial perspectives. Acting courageously on coal subsidies would certainly be the next step for Southeast Asia to further weaken coal power supremacy and embrace a more sustainable, and affordable development path.

This problem is particularly acute in Indonesia where the coal industry is heavily subsidized.[47] The annual average of government support for coal amounted to over $3 billion in Indonesia in 2016-2017, mostly in favor of coal-fired electricity consumption.[48] Strong fiscal support is provided, with the stated reason being to compensate electricity generators for the increase in coal prices and for having to sell electricity to domestic consumers under regulated prices, i.e. providing electricity at below-market levels (mainly targeted at households).

In addition, Indonesia benefits from significant support from international public financial institutions to promote coal; more than $3 billion - annual average in 2016-2017.

Vietnam coal industry was also supported by international public financial institutions; at least $2.6 billion per year in average in the same period.

In the power sector, fossil fuel subsidies are not limited to coal, however. Indeed, Myanmar for example provides subsidies to gas as an input to electricity generation.[49]

Ending these practices will be critical, so will be the establishment of some forms of carbon pricing to internalize negative externalities of generating electricity from fossil fuels, and thus reflect the true costs of these technologies.

In this regard, Singapore is a pioneer in Southeast Asia with the introduction of the region's first carbon tax in 2019 at about $4 per ton of emissions to start with (it is planned to double or triple by 2030).[50] Additionally, Indonesia and Thailand are currently considering the implementation of emissions trading systems.[51]

[c] Exceptions may be considered though.

Electricity market frameworks[52]

In many instances electricity market reform is incomplete, with overall limited competition (particularly at the supply level) and electricity subsidies still prevalent. Cross-border electricity trade takes place in Southeast Asia, and is especially dynamic in the Mekong river basin. It is expected to be developed further which will certainly contribute to efficiently integrate variable RE across the region.

Electricity markets in Southeast Asia are very largely semi-unbundled with competition from private independent power producers (IPPs) authorized at the generation level only. Network (transmission and distribution) and supply businesses are quite often regulated and exclusively dominated by national or regional public monopolies with the notable exceptions of the Philippines and Singapore.

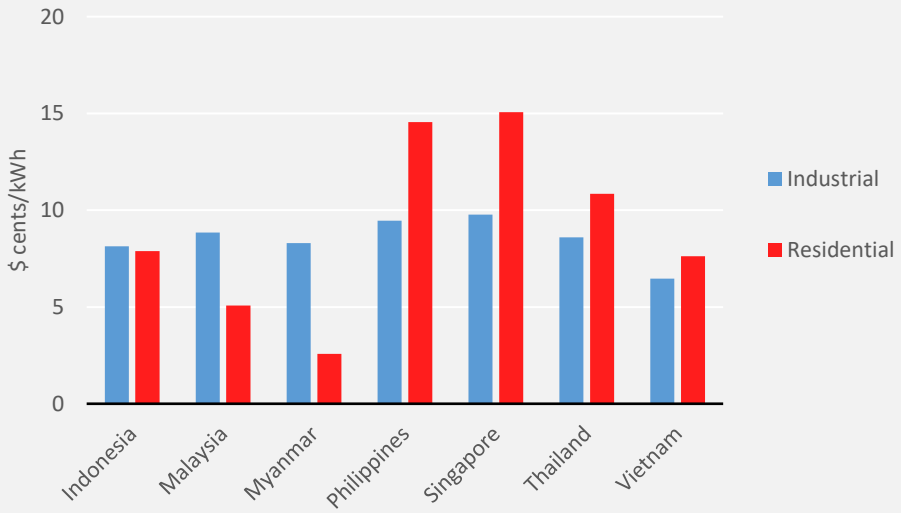
At the generation level, competition greatly varies among Southeast Asian countries. In Cambodia, Malaysia, the Philippines, Singapore, and Thailand IPPs are the most important players. In Indonesia and Vietnam IPPs play a key role as well, but the market is still dominated by national utilities; Perusahaan Listrik Negara (PLN) and Vietnam Electricity (EVN), respectively.[53]

Only the Philippines and Singapore have introduced wholesale electricity markets where the private sector can sell electricity through competitive processes.[54] Otherwise the single-buyer model is the most widespread in the region.[55]

Since at the supply level competition is restricted, end-user prices are heavily regulated and almost always subsidized resulting in artificially low prices; in 2017, maximum of $15 cents per kilowatt-hour (/kWh) for residential consumers in Singapore, and minimum of $3 cents/kWh for residential consumers in Myanmar (Chart 15). This may maintain short-term social peace, but this is unsustainable for domestic public power companies' balance sheets, and this may deter foreign capital seeking fair returns on their investments to finance new power plant projects in Southeast Asian markets.

It must be noted that progresses have been made, for examples in Indonesia, Malaysia, Thailand, and Vietnam, in gradually removing electricity subsidies, but there is still some way to go.[56]

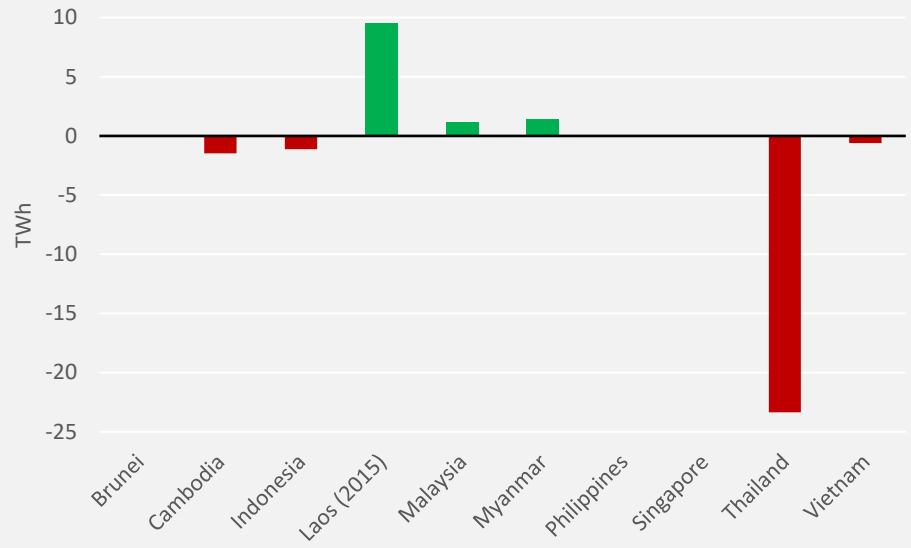
Chart 15: End-user Electricity Prices in Selected Southeast Asian Countries 2017



Source: BloombergNEF, Prices, Tariffs & Auctions (subscription required – accessed July 22, 2019).

Concerning cross-border electricity trade, it is particularly active in the Mekong river basin where Laos is the main electricity net exporter of the region; 9 TWh in 2015, and Thailand the main net importer; 23 TWh in 2017 (Chart 16).

Chart 16: Southeast Asian Countries Electricity Net Exports 2017



Sources: International Energy Agency, World Energy Statistics 2019 (September 2019), for all countries except Laos from Lao People's Democratic Republic Ministry of Energy and Mines, Lao PDR Energy Statistics 2018 (May 2018).

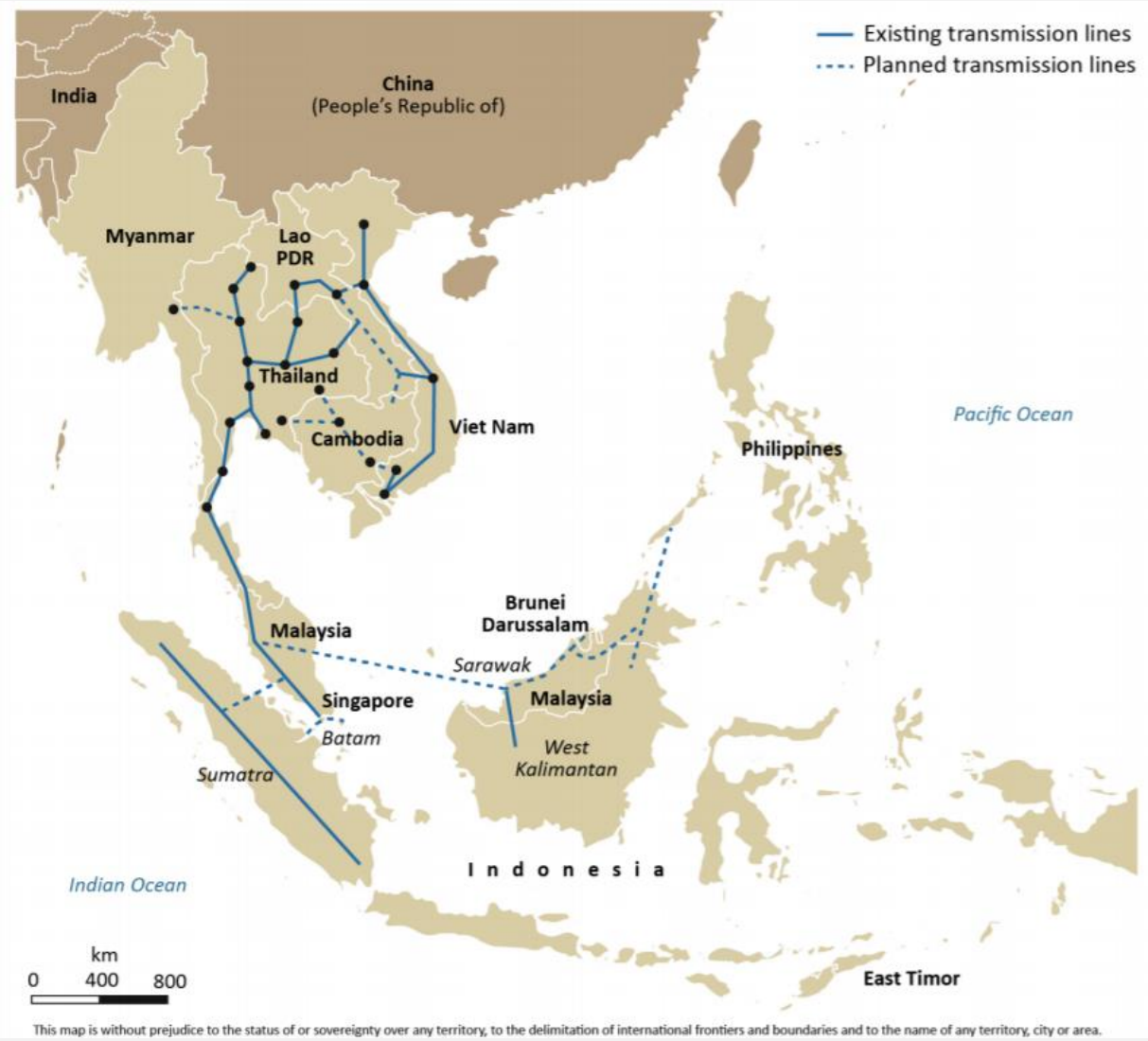
Elsewhere, cross-border electricity trade is currently either non-existent (Brunei and the Philippines) or limited (Indonesia, Malaysia, and Singapore). This may, however, change in the future as plans to develop a regional power grid, the ASEAN Power Grid (APG), are moving forward.[57]

Agreed in 1997, with the goals of strengthening Southeast Asia's energy security and improving economic efficiency of the regional power system, the APG is advancing at a moderate pace with interconnections being built exclusively on a bilateral basis. In addition, little progress has been made on the establishment of a regional multilateral power market. A concrete plan laying out the steps to achieve power network interconnection across Southeast Asia would help accelerating realization of this ambitious initiative.

As of early 2019, cross-border interconnections with a combined capacity of 5.5 GW existed in the region, projects worth 2.2-2.3 GW were under development, and another projects worth about 20 GW planned.

Map 3 on next page shows Southeast Asia power grid plans including existing and planned interconnections.

Map 3: Southeast Asia Power Grid Plans



Source: International Energy Agency, Establishing Multilateral Power Trade in ASEAN (August 2019).

Furthermore, it is recognized that international interconnections could help manage variability of solar and wind power. For example, it has already been acknowledged that Laos hydropower could be a good complement to Vietnam's significant wind power potential. Or maybe even solar power since in Vietnam, contrarily to Thailand, a number of RE projects (essentially solar) were recently ordered to curtail generation (up to 65% of capacity).[58]

Thus, whether it comes down to RE costs of generating electricity, energy policies in the power sector, or electricity market frameworks there is definitely room for improvement. And it is to a large extent the responsibility of policy makers in the region to take action and rapidly and fully seize the opportunity to transition to a more sustainable development pathway, that remarkable industrial progress in RE makes not only feasible but also profitable today. In this shift of paradigm, Japan, a historical trade partner of Southeast Asia, may become a powerful driving force.

Chapter 3: Japan-Southeast Asia Trade Relationships with a Focus on the Power Sector

1. Revisiting Historical Trade Relationships

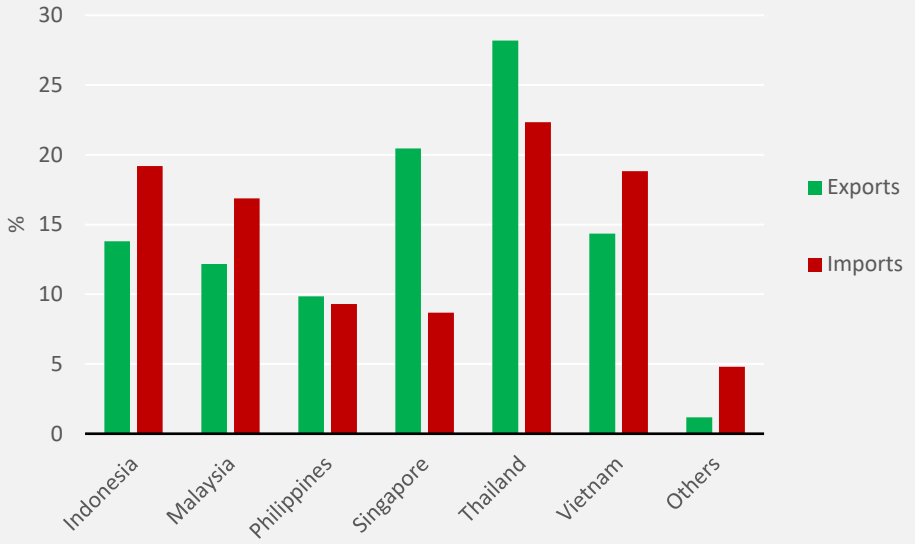
For decades Japan and Southeast Asian countries have been trading various commodities. These commercial relationships have become increasingly significant over time. Whereas Japan's exports to Southeast Asian countries are rather centered on machinery and transport equipment, as well as manufactured goods and chemicals, its imports are more diversified. Focusing on the power sector only, Japan exports generating technologies to Southeast Asian countries, finances and participates in the development of power plant projects there, principally burning gas and more recently coal – notwithstanding stranded asset risks, and conversely imports these two fossil fuels to generate electricity domestically.

Exchanges between Japan and Southeast Asia started in the early 1970s. The mid-1980s, against the backdrop of the Japanese yen (¥)'s rapid appreciation, saw a proliferation of Japanese companies entering Southeast Asian markets.[59] For many Japanese companies Southeast Asia has become a key investment destination, and countries in the region important business partners. Through Official Development Assistance (ODA), Japan has supported Southeast Asian countries with infrastructure development (e.g. road, bridge, airport and port, electric power facilities…), human resource development, and improvement of the trade and investment environment.

From 2000 to 2018, Japan-Southeast Asia trade grew substantially and remained relatively well-balanced. In this period, Japan's exports to Southeast Asia increased from ¥7.4 trillion ($68 billion) to ¥12.6 trillion ($116 billion) or +71%, and its imports from this region ¥6.4 trillion ($59 billion) to ¥12.4 trillion ($114 billion) or +93%.[60] **In 2018, value of commercial exchanges with Southeast Asia accounted for about 15% of Japan's total international trade.**

Japan's trade is particularly dynamic with six Southeast Asian countries; Thailand – Japan's main trade partner in Southeast Asia accounting for 28% of Japan's export value to the region and 22% of Japan's import value from the region, Vietnam, Indonesia, Singapore, Malaysia, and the Philippines (Chart 17 on next page).

Chart 17: Breakdown of Japan's Export/Import Value to/from Southeast Asian Countries 2018



Note: "Others" includes Brunei, Cambodia, Laos, and Myanmar.
Source: Japan Ministry of Finance, Trade Statistics of Japan – Values by Country (accessed July 26, 2019).

Regarding the commodities exchanged, Japan rather exports machinery (including electrical machinery) (e.g. power generating machines, integrated circuits), transport equipment (e.g. motor vehicles and parts of motor vehicles), as well as manufactured goods (e.g. iron and steel products) and chemicals (e.g. plastic materials) to Southeast Asia.[61] And it imports a relatively extensive range of products.

For examples, from Thailand Japan imports office machines, telephone sets, meat and fish, and meat and fish preparations. From Vietnam, clothing and accessories as well as footwears, insulated wires and cables, and also telephone sets. From Indonesia, mineral fuels (e.g. coal and liquefied natural gas (LNG)) and crude materials such as copper. From Singapore, Malaysia and the Philippines, medical products, LNG, and insulated wires and cables, respectively.

Another indicator of economic relationships is foreign direct investment (FDI) in manufacturing and non-manufacturing industries.[62] In this case, direction of flows is almost unidirectional. From 2014 to 2018 for instance, whereas Japan's FDIs in Southeast Asian countries reached ¥9.3 trillion ($86 billion), Southeast Asian countries' FDIs in Japan were 25 times smaller at ¥0.4 trillion ($3 billion). This demonstrates both Japan's financial power and appetite for controlling business ownership in Southeast Asia.

Japan's FDIs in Southeast Asia accounted for 11% of the country's total FDIs in the past five years, and reached a peak of 18% in 2018. Thailand was the main destination of Japan's FDIs in the region in this period (finance and insurance, and transportation equipment). It was followed by Indonesia (similar types of investments as in Thailand) and Singapore (food and communications – substantial divestments took place in finance and insurance in 2016). In comparison, Japan's FDIs were less important in Vietnam (finance and insurance, and transportation equipment), Malaysia (mining and communications), and the Philippines (finance and insurance, and electric machinery). Brunei, Cambodia, Laos, and Myanmar combined accounted for only 3% of Japan's FDIs in Southeast Asia.

Focusing on the power sector only, Japan exports generating technologies to Southeast Asian countries, finances and participates in the development of power plant projects there.

Japan exports a number of power generating machines to Southeast Asian countries.[63] These include for examples; steam generating boilers, internal combustion engines, and water turbines. It also exports electrical power machinery such as electrical generators, electrical motors, and transformers. In this field, companies like Hitachi, Toshiba, Mitsubishi Heavy Industries, JFE Engineering, and IHI export their technologies.

In addition, Japan is a heavyweight investor in power plants financing in the region:

Between 2003 and 2018, Japanese public financial institutions; Japan Bank for International Cooperation (JBIC), Japan International Cooperation Agency (JICA), and Nippon Export and Investment Insurance (NEXI), have significantly supported coal power expansion in Indonesia (9 coal-fired power plant projects; e.g. Indramayu, Tanjung Jati B…) and Vietnam (11 projects; e.g. Thai Binh, Van Phong 1…), notably, by providing loans on favorable terms (e.g. low interest rates).[64] These projects are promoted on quite misleading grounds; "clean coal" or "low-pollution coal," and contributing to poverty alleviation.[65] Regarding Japan's "clean coal" exports in particular, as a matter of fact, overseas projects are not only emitting a lot of GHG, but simply dangerously beyond the country's own domestic acceptable air pollution standards.[66]

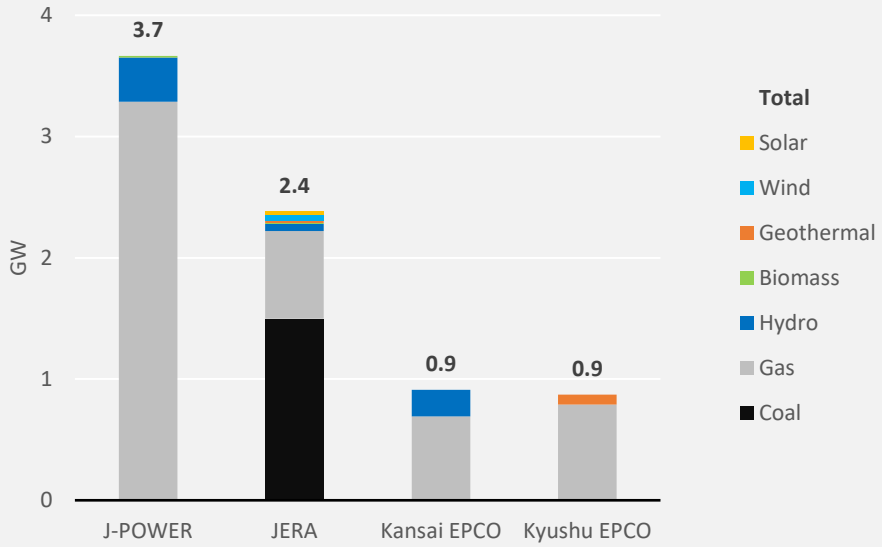
And despite recent powerful global trends in favor of actions against climate change, Japan remains – with China, South Korea, and India – one of the few last important providers of international public finance for coal today.[67d] During 2016-2017, Japan's international public finance exceeded $5 billion in annual average to promote coal overseas, and especially in Southeast Asia. More precisely, half of Japan's support went to Indonesia and Vietnam; about $1.3 billion and $1.2 billion per year, respectively. In these two countries, Japan's international public finance combined efforts were slightly higher than those of China and more than double those of South Korea, making it the leader among the laggards.

As for Japanese commercial banks and trading houses, even if some of them have stated that they will either no longer invest in new coal capacity (Mitsubishi UFJ Financial Group, Itochu, Sumitomo Mitsui Trust Bank, and Marubeni) or restrict their investments to projects using ultra-supercritical or more advanced technologies and higher efficiency (Mizuho and Sumitomo Mitsui Banking Corporation), they have also historically been major lenders to coal plant developers in Southeast Asia and are still actively participating in projects under construction.[68] For instance, Mitsubishi UFJ Financial Group, Mizuho, and Sumitomo Mitsui Banking Corporation are all currently financing several multi-billion dollars large coal power plant projects that will be completed in the next few years as for examples Tanjung Jati B and Batang in Indonesia, and Nghi Son 2 and Van Phong 1 in Vietnam.[69]

Moreover, several Japanese power companies have ownership totaling about 8 GW in operating power plant projects across Southeast Asia. Focusing primarily on fossil fuel (essentially gas and coal) power plant projects, J-POWER and JERA (joint-venture of Tokyo Electric Power Company (EPCO) and Chubu EPCO established in 2015) have been the most active, followed by Kansai EPCO and Kyushu EPCO (Chart 18 on next page).

[d] In comparison, identified European and American international public finance for coal is now negligible.

Chart 18: Japanese Power Companies' Attributable Operating Capacity by Technology in Southeast Asia 2018



Notes: based on participation ratio. Data reported from March to August 2018. JERA's "Hydro" includes recent capacity acquisition by Tokyo Electric Power Company in Vietnam (*Tokyo Electric Power Company, Overview of Coc San Hydropower Plant, Vietnam – November 9, 2018 (accessed August 2, 2019)*). Kansai Electric Power Company and Kyushu Electric Power Company's "Gas" includes a small portion of oil from Senoko thermal power plant in Singapore. Not displayed in this chart, Tohoku Electric Power Company also owns negligible hydro capacity in Vietnam.
Sources: J-POWER from J-POWER, Annual Report 2018 (September 2018), JERA from JERA, Our Business: Investment Projects – Overseas power Generation & Energy Infrastructure (accessed August 2, 2019) and List of Main Succession Assets (June 2016), Kansai Electric Power Company from Kansai Electric Power Company, Fact Book 2018 (August 2018), and Kyushu Electric Power Company from Kyushu Electric Power Company, Annual Report 2018 (July 2018).

For these four companies, gas accounted for 70% of their attributable capacity in the region in 2018. Coal nearly 20%, and RE a little more than 10%. Among RE, hydro (J-POWER and Kansai EPCO in the Philippines) was the dominant technology. Little progress – but not insignificant – could be observed for geothermal (Kyushu EPCO's Sarulla power station in Indonesia), solar and wind (JERA multiple projects in Thailand), in particular.

Regarding locations of these projects, more than half were in Thailand with a strong presence of J-POWER in gas projects. Philippines was the second preferred destination (25%) with a predominance of a couple of coal projects (Pagbilao and Sual) in which JERA takes part. Singapore was a distant third (13%) with the participations of Kansai EPCO and Kyushu EPCO in the Senoko thermal power plant (fuels: gas 85% and oil 15%).[70] Japanese power companies were also involved in power plant projects in Indonesia, Vietnam, and Laos (ranked by decreasing order of importance).

A few important developments took place in the first half of 2019. In May, Kyushu EPCO by indirectly acquiring about 6% of the shares of Electricity Generating Public Company (one of the largest IPPs in Thailand, in which Tokyo EPCO already invested in 2011) increased its attributable operating capacity in Southeast Asia by roughly 250 MW – mostly gas and coal.[71] In January, Chugoku EPCO acquired around 5 MW of existing hydropower capacity in Indonesia.[72] And a few months later, in May, together with Shikoku EPCO, it expanded its business in the region to Myanmar by adding almost 35 MW of gas power capacity (same amount acquired by its Japanese counterpart).[73]

As for new projects under development – to be commissioned/start operation in the next three years, Japanese power companies have ownership shares equivalent to about 2 GW, very largely coal capacity in Indonesia (Table 5).

Table 5: Japanese Power Companies' Power Plant Projects under Development in Southeast Asia

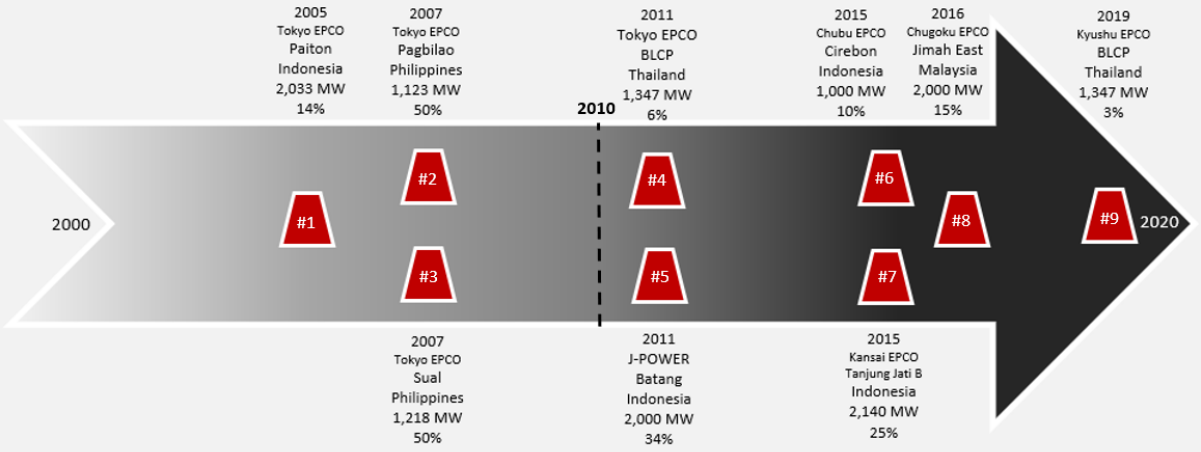
Company	Country	Technology	Attributable capacity (MW) / Company's share	Commissioning/ Start of operation
Kansai EPCO	Indonesia	Coal	535 / 25%	2021
	Indonesia	Hydro	23 / 49%	2019*
	Laos	Hydro	131 / 45%	2019**
	Myanmar	Hydro	<56 / unknown	2022
JERA	Indonesia	Coal	100 / 10%	2022
	Philippines	Coal	27 / 6%	2019
	Laos	Hydro	39 / about 2-3%	2019-2022
Kyushu EPCO	Philippines	Coal	14 / 3%	2019
	Laos	Hydro	20 / about 1-2%	2019-2022
J-POWER	Indonesia	Coal	680 / 34%	2020
Chugoku EPCO	Malaysia	Coal	300 / 15%	2019
Tohoku EPCO	Indonesia	Geothermal	10 / 10%	2020

Notes: *started commercial operation in May 2019 (*Kansai Electric Power Company, Commercial Operation Start of Rajamandala Hydropower Plant in the Republic of Indonesia – May 24, 2019 (accessed August 2, 2019)*). **Started commercial operation in September 2019 (*Kansai Electric Power Company, Commercial Operation Start of Nam Ngiep 1 Hydropower Plant in Lao People's Democratic Republic – September 6, 2019 (accessed September 12, 2019)*).
Sources: Kansai Electric Power Company from Kansai Electric Power Company, Fact Book 2018 (August 2018) and Development of Deedoke Hydropower Project in the Republic of the Union of Myanmar – August 17, 2018 (accessed August 2, 2019), JERA from JERA, Our Business: Investment Projects – Overseas power Generation & Energy Infrastructure (accessed August 2, 2019) and List of Main Succession Assets (June 2016), Kyushu Electric Power Company from Kyushu Electric Power Company, Indirect Shares Acquisition of EGCO in Thailand -Contributing the electricity business together with the high-growth companies in Asia- – May 14, 2019 (accessed August 2, 2019), J-POWER from J-POWER, Annual Report 2018 (September 2018), Chugoku Electric Power Company from Chugoku Electric Power Company, Annual Report 2018 (August 2018), and Tohoku Electric Power Company from Tohoku Electric Power Company, Annual Report 2018 (September 2018).

Though this amount of attributable capacity may not necessarily appear significant at first sight, looking at the broader picture provides meaningful insights. For instance, in the case of Indonesia, Japanese power companies own a combined 1.3 GW of coal power capacity under construction in three projects; Tanjung Jati B (Kansai EPCO), Cirebon (JERA), and Batang (J-POWER). These three projects total combined capacity is 5.1 GW. There is currently a total of 11.5 GW of coal power capacity under construction in the country. This means Japanese power companies through their ownership shares decisively contribute to 45% of coal power capacity under construction in one of the world's most dynamic coal power markets. That is everything, but negligible.

In addition, it must be noted that predominance of coal projects in Japanese power companies' expansion in Southeast Asia is an unprecedented unwelcome development at a time when low-carbon technologies should aggressively be deployed in the region. This is the result of increasing participations in coal power projects after 2010 (timeline on next page).

Timeline: Japanese Power Companies' Participations in Major Coal Power Plant Projects in Southeast Asia since 2000



Note: "Major Coal Power Plant Projects" means projects with a power capacity of 500 MW or more. For each project the participation year by power company, the name of the plant, the country where the plant is located, the plant power capacity (including that of new units in the cases of Paiton 813 MW – 14% share completed in 2012 and Pagbilao 388 MW – 25% share completed in 2018), and ownership share of the power company in the plant are indicated.
Sources: Tokyo Electric Power Company and Chubu Electric Power Company from JERA, Our Business: Investment Projects – Overseas power Generation & Energy Infrastructure (accessed August 23, 2019) and List of Main Succession Assets (June 2016), J-POWER from J-POWER, Annual Report 2018 (September 2018), Kansai Electric Power Company from Kansai Electric Power Company, Fact Book 2018 (August 2018), Chugoku Electric Power Company from Chugoku Electric Power Company, Annual Report 2018 (August 2018), and Kyushu Electric Power Company from Kyushu Electric Power Company, Indirect Shares Acquisition of EGCO in Thailand -Contributing the electricity business together with the high-growth companies in Asia- – May 14, 2019.

It may also be highlighted that Japanese power companies are strengthening their presence in Southeast Asia by reaching new countries and actively participating in the development of new projects there; Kansai EPCO in Myanmar (Deedoke hydropower plant project), and Chugoku EPCO in Malaysia (Jimah East coal-fired power plant project). This leaves Brunei and Cambodia as the only countries in the region where major Japanese power companies have no ownership stakes in power plant projects. In 2016, the entrance of Chugoku EPCO in Malaysia marked in fact a double novelty since this was also the first project of the Hiroshima-based company in Southeast Asia.

Finally, apart from electricity generation projects, Japanese power companies are also taking part in transmission and distribution activities (consulting, detailed design, construction…) in some Southeast Asian countries. That is notably the case of Kansai EPCO's subsidiary NEWJEC which has led a number of such electrical grid related projects in Indonesia, the Philippines, and Vietnam.[74]

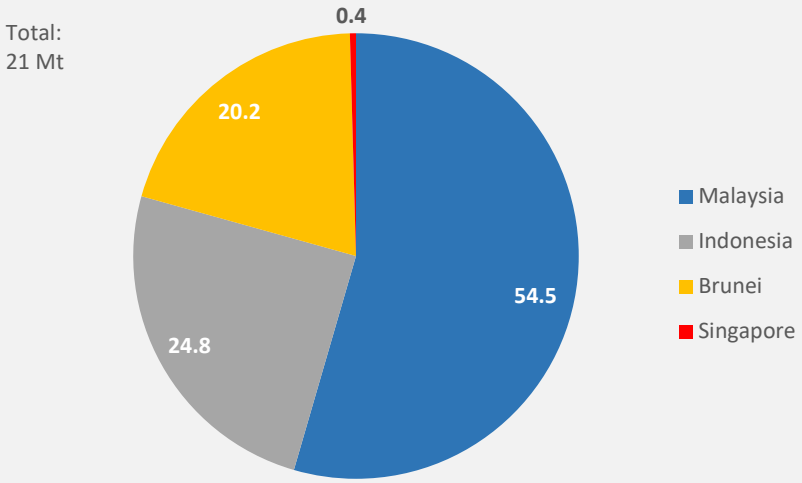
In a context of stagnating electricity demand and increased competition on the generation side, from solar PV especially, in Japan, strategies of large Japanese power companies targeting internationalization and high growth markets make perfect sense. In this regard, we may expect further engagement of these key actors in Southeast Asia.

On the other hand, deprived from fossil fuel resources (particularly gas and coal) and excessively relying on these fuels to generate electricity domestically, Japan is dependent on imports from a few Southeast Asia countries.

Combined gas and coal accounted for around 70% of Japan's total electricity generation in 2017, with a slightly bigger share for gas.

In 2018, roughly a quarter of Japan's LNG imports originated from Southeast Asian countries. Malaysia was by far the main LNG exporter of the region to Japan, followed by Indonesia and Brunei (Chart 19).

Chart 19: Japan's LNG Imports from Southeast Asian Countries 2018 (%)



Note: imports from Singapore are re-exports.
Sources: Japan Ministry of Finance, Trade Statistics of Japan – Liquefied Natural Gas Imports (accessed August 5, 2019).

Furthermore, in Japan, steam coal (also known as thermal coal) is by very far the type of coal that is the most broadly used to generate electricity in coal power stations.[75] In 2018, 12% of Japan's steam coal imports originated from Southeast Asia, essentially Indonesia.[76]

For years, all these developments may have been recognized by some as a "win-win" situation for both Japan and Southeast Asia. Economic and environmental fundamental changes currently taking place may, however, drastically reshape this historical trade relationship in a near future.

2. A New Era

Increasing RE cost competitiveness and worsening climate crisis are likely to heavily weigh on Japan-Southeast Asia's trade relationship in the power sector, possibly leading to a new commercial era. In this framework, Japan could be a powerful ally supporting the region's energy transition by becoming much more progressive. On the supply side, this will require Japanese public & private financial institutions and power companies to significantly – and exclusively – participate in RE power plant projects in Southeast Asian countries. And on the demand side, this will require the numerous Japanese businesses established in the region to firmly request 100% RE procurement options to meet their electricity consumption.

Pragmatism emphasizes the necessity for Southeast Asia to massively promote RE and energy efficiency, which are the most credible economic, environmental, social, and technical solutions against climate change. Critical thinking identifies hindering obstacles to be addressed by policy makers in the region to fully seize these low-carbon opportunities. And forward-thinking Japan may be the powerful ally Southeast Asia will partner with to realize its radical realistic shift of paradigm.

There are three key ways Japan may accompany and benefit from Southeast Asia's energy transition in the power sector; two on the supply side, and one on the demand side.

On the supply side, the first initiative will be for Japanese public & private financial institutions to redirect their investment from coal power to RE electricity.

Some major Japanese commercial banks and trading houses such as Mitsubishi UFJ Financial Group, Itochu, Sumitomo Mitsui Trust Bank, and Marubeni appear to have understood better and faster the ongoing shift of paradigm than Japanese public financial institutions by stating over the past year that they will no longer invest in new coal capacity.

Concerning Japanese public financial institutions, JBIC, JICA, and NEXI are already all familiar with RE financing in Southeast Asia. For instance, JBIC and JICA invested $1.1 billion and $0.5 billion, respectively, in RE projects in Southeast Asia between 2009 and 2016.[77] These investments made JBIC and JICA among the top 5 development finance institutions for RE projects in the region during this period, #3 and #5, respectively (the World Bank Group was the #1 of this ranking with $1.8 billion).[78] Though this is encouraging, compared to coal power, investments in RE remain much smaller. This signals opportunities to scale-up RE financing by redirecting funds allocated to coal power. With their reputations and substantial resources, Japanese public financial institutions could initiate a unique shock wave by exiting coal and supporting RE more instead. Rather than an act of courage, this would be a completely sound business decision, that may lead the region's financial dominoes to fall in quick succession.

In addition, massively investing in RE would also help mitigating the risks associated with their current investments in existing and under development coal power plants that could become stranded assets in a carbon constrained world. This "hedging" argument prevails for all investors.

Still on the supply side, the second initiative will be for Japanese power companies – especially the largest ones, already experienced and increasingly active in Southeast Asia, with solid technical expertise and robust financial resources – to significantly and exclusively participate in RE power plant projects in the region.

Until now, a number of large Japanese power companies have entered the hydropower market in Southeast Asia, among which Kansai EPCO and J-POWER have been the most dynamic. However, apart from geothermal power projects, commitments of these companies in the development of other RE power projects have been pretty scarce.

For instance, with the exceptions of JERA and Kyushu EPCO through their shares in Electricity Generating Public Company, large Japanese power companies have neither solar nor wind attributable capacity in Southeast Asia. This is in stark contrast with other Japanese companies which have recently made headlines for their successful participations in mega-solar power plant projects in Vietnam; Idemitsu Kosan, Sharp, and JGC Corporation.[79] With increasing cost competitiveness of both solar and wind power this situation is to become an abnormality that should trigger strategic realignments.

Moreover, the fact that Southeast Asian solar and wind power markets are still largely in their infancy with limited competition – including from expansionist European power companies – should whet Japanese power companies' appetite to become dominant first movers.

Finally, on the demand side, Japanese businesses established in Southeast Asian countries may also play an important role in promoting RE by pushing for 100% RE procurement options to meet their electricity consumption in the region.

In 2015, there were well over 10,000 Japanese companies in Southeast Asia.[80] Among these, very large Japanese businesses such as Toyota, Nissan, Honda, Hitachi, Canon, Japan Tobacco, Seven & I Holdings, Bridgestone, Toshiba, Nippon Steel, Komatsu, Kyocera, Sony, or Asahi Glass. In this regard, a number of Japanese companies active in the region have announced in recent years that they are targeting 100% RE electricity for their global operations (Table 6).

Table 6: Examples of Japanese Companies Established in Southeast Asia and Targeting 100% RE Electricity

Company	Sector	Target Year
AEON	Retail	2050
Fujitsu	Information and communication technology	2050
Konica Minolta	Technology	2050
Panasonic	Electronics	2050
Ricoh	Electronics	2050
Toda Corporation	Construction	2050

Source: RE100, Companies (accessed October 1, 2019).

This means that to achieve their goals these companies will also need to consume 100% RE electricity in Southeast Asia.

In their quests, they may find other Japanese businesses that will provide them with solutions to meet their objective. For example, in July 2019, Osaka Gas established a joint venture, OE Solar, to supply industrial and commercial consumers with electricity generated from solar power mainly in Bangkok, Thailand.[81]

It may also be envisioned that these new business approaches by Japanese public & private financial institutions and industrial & commercial organizations could be supported and coordinated by the Japanese government as a new diplomatic, economic, and environmental national strategy vis-à-vis Southeast Asian countries that could be a convincing and constructive alternative to China's new Silk Road the "Belt and Road Initiative."

At the same time, to facilitate all these positive changes that could be brought by Japanese organizations, Southeast Asian countries would certainly be well-inspired to further improve the overall framework for RE expansion across the region. Notably by setting more ambitious goals, implementing more effective energy policies, advancing with electricity market reform, and improving electrical grid infrastructure.

Thailand currently appears to be the most attractive market for RE investments in Southeast Asia. Among other countries of the region, Vietnam and the Philippines also offer particularly promising opportunities despite some barriers. And other countries such as Indonesia and Malaysia are for the time being lagging behind, but this is not irreversible.

Thus, to realize and optimize possible new trade relationships in the power sector, it will be both Southeast Asian countries and Japan's shared responsibility to switch mindsets from conservative to progressive, and demonstrate pragmatic leaderships. Neither have the conditions ever been so favorable to RE, nor the threat of climate change greater. Bold actions on both sides and collaboration will therefore be decisive.

CONCLUSION

Southeast Asia's electricity consumption is increasing quickly, driven by demographic and economic growths, as well as progress in electricity access.

On the supply side, since 2000, coal power has expanded most – eventually becoming the region's main source for electricity generation in 2017 – with tangible damaging impacts on the environment, as for example air pollution. Therefore, this unsustainable development pathway cannot be continued anymore. Renewable energy is clearly the identified pragmatic solution moving forward, starting immediately.

Hydro, biomass, geothermal, wind, and solar resources are abundant in Southeast Asia, yet their potential remains largely untapped.

Encouraging initiatives have started to be implemented, but room for improvement is significant to deploy renewable energy that will outcompete coal power on cost. For instance, more ambitious targets and aggressive energy policies, in addition to better electricity market structures (i.e. reform) and infrastructures (i.e. electrical grid). Facing hindering obstacles and advancing enabling strategies will certainly accelerate the region's much-needed energy transition that is inevitable.

Japan has been a historical long-term important trade partner of Southeast Asian countries. It is notably exporting power generating technologies, financing and participating in the development of numerous fossil power plant projects there. Historically, Japan's largest power companies have focused on gas power plant projects. More recently – and quite untimely – they have focused on deploying coal power.

Considering the imminent great opportunity of cost competitive renewable energy and serious climate crisis, Japan and Southeast Asian countries' trade relationships are likely to be heavily impacted, possibly leading to a new commercial era. It is thus time for Japan to become a powerful ally ambitiously and unequivocally promoting renewable energy in the region. Japan has everything to become this forward-thinking force: technological expertise, financial strength, and a vast network of influential companies already anchored in Southeast Asia both as electricity producers and consumers.

The most critical change to enable this shift of paradigm is a mindset switch in both Southeast Asia and Japan; from conservative to progressive. And there is nothing less at stake than delivering Southeast Asia's sustainable bright future.

APPENDICES

Appendix A: Southeast Asia, China, India, and Japan Statistical Indicators 2017 & 2018

Region/ Country	Population	GDP	GDP per capita	TPED	TPED per capita	CO2	CO2 per capita
Southeast Asia	654	2.9	4,494	674*	1.1*	1,365*	2.1*
China	1,393	10.8	7,755	3,063	2.2	9,258	6.7
India	1,353	2.8	2,104	882	0.7	2,162	1.6
Japan	127	6.2	48,920	432	3.4	1,098	8.7
Year	2018			2017			
Unit	million	$ trillion (2010 US$)	$ (2010 US$)	Mtoe	toe	Mt	t
Source	World Bank (1)	World Bank (2)	World Bank (1) & (2)	IEA	IEA / World Bank (1)	IEA	IEA / World Bank (1)

* Not including Laos for which no data is available.

Details of sources:

- World Bank (1): The World Bank, Population, total – updated September 24, 2019 (accessed September 27, 2019).
- World Bank (2): The World Bank, GDP (constant 2010 US$) – updated September 24, 2019 (accessed September 27, 2019).
- IEA: International Energy Agency, Statistics Data Browser (accessed September 27, 2019).

Appendix B: Southeast Asian Countries Statistical Indicators 2017 & 2018

Country	Population	GDP	GDP per capita	TPED	TPED per capita	CO2	CO2 per capita
Brunei	0.4	13	31,437	4	8.5	7	15.8
Cambodia	16	20	1,205	8	0.5	11	0.7
Indonesia	268	1,147	4,285	244	0.9	496	1.9
Laos	7	13	1,789	n/a	n/a	n/a	n/a
Malaysia	32	382	12,109	85	2.7	211	6.8
Myanmar	54	84	1,572	23	0.4	30	0.6
Philippines	107	322	3,022	58	0.6	126	1.2
Singapore	6	328	58,248	37	6.5	47	8.4
Thailand	69	442	6,362	138	2.0	244	3.5
Vietnam	96	188	1,964	78	0.8	191	2.0
Year	2018			2017			
Unit	million	$ billion (2010 US$)	$ (2010 US$)	Mtoe	toe	Mt	t
Source	World Bank (1)	World Bank (2)	World Bank (1) & (2)	IEA	IEA / World Bank (1)	IEA	IEA / World Bank (1)

Details of sources:

- World Bank (1): The World Bank, Population, total – updated September 24, 2019 (accessed September 27, 2019).
- World Bank (2): The World Bank, GDP (constant 2010 US$) – updated September 24, 2019 (accessed September 27, 2019).
- IEA: International Energy Agency, Statistics Data Browser (accessed September 27, 2019).

Appendix C: Southeast Asia, China, India, and Japan Electricity Statistics 2017

Region/ Country	Electricity Generation by Technology										Generation per capita
	Coal	Oil	Gas	Nuclear	Hydro	Bioenergy	Geothermal	Wind	Solar	TOTAL	
Southeast Asia*	376	27	362	0	169	19	23	3	6	985	1.5
China	4,485	10	183	248	1,190	79	0	295	131	6,635	4.8
India	1,134	25	71	38	142	45	0	51	26	1,532	1.1
Japan	352	70	398	33	90	21	2	6	55	1,068	8.4
Unit	TWh										MWh
Source	IEA										IEA / World Bank (1)

* Not including Laos for which no data is available.

Note: "Other" not shown, but included in "TOTAL."

Details of sources:

- IEA: International Energy Agency, Statistics Data Browser (accessed September 27, 2019).
- World Bank (1): The World Bank, Population, total – updated September 24, 2019 (accessed September 27, 2019).

Appendix D: Southeast Asian Countries Electricity Statistics 2017

Country	Electricity Generation by Technology										Generation per capita
	Coal	Oil	Gas	Hydro	Bioenergy	Geothermal	Wind	Solar	Other	TOTAL	
Brunei	0	0	4	0	0	0	0	0	0	4	9.8
Cambodia	4	0	0	3	0	0	0	0	0	7	0.4
Indonesia	148	19	55	19	1	13	0	0	0	255	1.0
Laos (2015)	3	0	0	14	0	0	0	0	0	17	2.5
Malaysia	72	2	63	27	1	0	0	0	0	165	5.3
Myanmar	1	0	8	13	0	0	0	0	0	22	0.4
Philippines	47	4	21	10	1	10	1	1	0	94	0.9
Singapore	1	0	50	0	1	0	0	0	1	52	9.3
Thailand	36	0	120	10	15	0	1	5	0	187	2.7
Vietnam	68	1	41	89	0	0	0	0	0	199	2.1
Unit	TWh										MWh
Source	IEA, all countries except Laos from Laos MEM										IEA / World Bank (1)

Details of sources:

- IEA: International Energy Agency, Statistics Data Browser (accessed September 27, 2019).
- Laos MEM: Lao People's Democratic Republic Ministry of Energy and Mines, Lao PDR Energy Statistics 2018 (May 2018).
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Appendix E: List of Abbreviations

APG: ASEAN Power Grid

ASEAN: Association of Southeast Asian Nations

CCGT: combined cycle gas turbine

CO2: carbon dioxide

CPS: Current Policies Scenario

EPCO: electric power company

FDI: foreign direct investment

FiP: feed-in premium

FiT: feed-in tariff

GDP: gross domestic product

GHG: greenhouse gas

GW: gigawatt

IEA: International Energy Agency

IPP: independent power producer

JBIC: Japan Bank for International Cooperation

JICA: Japan International Cooperation Agency

km2: square kilometer

kWh: kilowatt-hour

LNG: liquefied natural gas

Mt: million tons

Mtoe: million tons of oil equivalent

MW: megawatt

MWh: megawatt-hour

NEXI: Nippon Export and Investment Insurance

NPS: New Policies Scenario

ODA: Official Development Assistance

RE: renewable energy

SDS: Sustainable Development Scenario

Solar PV: solar photovoltaic

TPED: total primary energy demand

TWh: terawatt-hour

Endnotes

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