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Biomass and Coal Co-combustion in the ASEAN Region (Phase 2)

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Abbreviations and Acronyms

ADB	Asian Development Bank
AMS	ASEAN member state
ASEAN	Association of Southeast Asian Nations
CCT	clean coal technology
CES	Clean Energy Scenario
CFB	circulating fluidised bed
CFPP	coal-fired power plant
CHP	combined heat and power
CO_2	carbon dioxide
COVID-19	Novel Coronavirus (2019-nCoV)
DEDE	Department of Alternative Energy Development and Efficiency, Ministry of Energy (Thailand)
DOE	Department of Energy (Philippines)
EAC	Electricity Authority of Cambodia
EdC	Electricité du Cambodge (National Electricity Company of Cambodia)
EGAT	Electricity Generating Authority of Thailand
ERIA	Economic Research Institute for ASEAN and East Asia
FIT	feed-in tariff
GDP	gross domestic product
GHG	greenhouse gas
IPP	independent power producer
JCM	Joint Crediting Mechanism
JCOAL	Japan Coal Energy Center
MME	Ministry of Mines and Energy (Cambodia)
MSW	municipal solid waste
NRE	new and renewable energy
PDP	Power Development Plan (Thailand)
PKS	palm kernel shell

PLN	Perusahaan Listrik Negara (National Electricity Company of Indonesia)
PPA	power purchase agreement
REF	Reference Scenario
SPM	suspended particulate matter
USC	ultra-supercritical
WG	Working Group

Chapter 1

Background, Objectives, and Methodology of the Study

1. Background

Electricity demand in the Association of Southeast Asian Nations (ASEAN) region is increasing as its economy grows steadily. Power plant development is expected to proceed towards a well-balanced optimal generation mix of coal, gas, and renewables to address the surging demand.

The Joint Ministerial Statement of the 36th ASEAN Ministers on Energy Meeting acknowledged that, with the rising demand for coal use to generate power up to 2040, ASEAN member states (AMS) have their shared view that coal is strategically important, given its affordable generation cost and abundant availability in the East Asia Summit region. Accordingly, most ASEAN governments foresee coal to remain a major generation source even in the long run. Yet they are also committed to making utmost endeavours in reducing emissions to address climate change issues by introducing renewable energy and facilitating the cleanest-possible utilisation of coal. As the declaration says, utilisation of clean coal technology (CCT) is vitally important.

During the initial development period in the ASEAN region, regardless of the generation source, the development of large power plants to supply electricity to urban and/or industrial areas was initiated to bolster overall national development. Now that the fruits of national development are to be shared broadly with all people in each member state and the region, the relevant governments are pressured to facilitate the development of smaller-scale power plants – 100 MW or less – in the areas yet to enjoy the benefits of electricity. However, a high-efficiency ultra-supercritical (USC) boiler that is deemed to be the most environmentally compliant amongst the broadly available technologies may not apply to such a smaller-scale power plant. Circulating fluidised bed (CFB) firing technology that enables high efficiency even on low-rank coals is more excellent even over USC if such smaller-scale power generation is required.

Full-fledged biomass utilisation is one of the important issues for the AMS, for which agriculture and forest industry remain the crucial industry sectors. Most of the residue is treated as waste either through incineration or landfill, which may cause environmental degradation if continued in the coming future. These wastes, converted as fuel, are of different varieties in terms of types, grades, and characteristics and are sufficient in quantity.

In summary, such biomass resources are ready for utilisation and are expected to be one of the most promising renewable fuels for smaller-scale power generation in addressing the issues of CO_2 emissions reduction and rural electrification that is crucial to rural development. However, biomass resources are intermittent as the rest of the renewable resources since they are seasonal.

Coal, being an available generation source, in this context may be complementary with biomass resources and vice versa. This is because biomass resources may realise significant CO_2 emissions reduction that may not be achieved if such a smaller-scale power plant is operated on coal only.

The Study on Biomass and Coal Cofiring in the ASEAN Region (the phase 1 study) (ERIA, 2019) was conducted to finally provide a proposal for CO_2 emissions reduction and better energy security through coal and biomass cofiring on CFB boilers in the ASEAN region. The phase 1 study formulated two models from the member states: (i) biomass-rich coal producer, i.e. Indonesia, and (ii) biomass-rich coal importer, i.e. the Philippines, both of which have a high potential for cofiring.

The phase 1 study, as discussed in the next chapter, made a policy proposal of the applicable methods of cofiring and measures for dissemination with required policy instruments that are to be in place. Also discussed are the outcomes of the techno-economic evaluation of the two models in terms of the advantages of utilising own resources, better national energy security, better environmental compliance – all of which are expected to benefit the AMS through cofiring.

2. Objectives

This phase 2 study aims to identify the required measures suitable to the respective AMS and guidelines for ASEAN to facilitate biomass utilisation focusing on cofiring through best practices. The phase 1 study had highlighted the interest and concern of the AMS in biomass utilisation and cofiring in their policy context of renewable energy development enhancement and CO_2 emission reduction. It identified the following two models, plus additional cases for further consideration:

(1) Indonesia – 50 MW CFB, domestic coal
(2) The Philippines – 50 MW CFB, imported coal
(3) Thailand – cofiring on a mine-mouth subcritical or biomass gasification/small-scale gas engines.

The phase 2 study is expected to identify and indicate examples of best practices, including the outcome of phase 1, and formulate guidelines for an optimal policy framework for ASEAN to facilitate biomass utilisation focusing on cofiring. The phase 2 study will analyse the measures to be taken and the role to be played by cofiring in addressing the forthcoming issue of grid fluctuation due to the massive introduction of renewables.

3. Methodology

(1) Formulation of by-country strategies for cofiring technology introduction, implementation, and dissemination

The phase 1 study identified two models for which the policy proposal would be made before phase 2 study started.

While the Working Group (WG) members were highly concerned about including cofiring as part of their policy measures for CO_2 emission reduction and better energy security, they desired to obtain further practical information about the measures to be taken that are tailored for each AMS.

Accordingly, phase 2 will focus on identifying and formulating by-country strategies to facilitate the introduction, implementation, and dissemination of cofiring by conducting the following on topics such as the introduction of potential cofiring technology in each AMS, issues to be addressed, envisaged best practices, policy measures to be taken, benefits and advantages, etc.:

- Electronic communication with WG members for information and advice to formulate the optimal strategy for each target AMS
- Collective discussions at the two-time WG meetings as referred to below (item 2).
- Internet surveys to enhance the accuracy of the strategies to be formulated.

(2) Two-time WG meetings

Two-time WG meetings were planned and conducted online, for which the members for the phase I study were requested through the relevant government institutions and utilities to stay on in the WG for phase 2.

The purpose of each WG meeting was as follows:

- First WG meeting: Discussion on topics such as introducing in each AMS of potential cofiring technology, issues to be addressed, envisaged best practices, policy measures to be taken, benefits and advantages, etc.
- Second WG meeting: Presentation of draft report by the Japan Coal Energy Center (JCOAL) that covers proposals for each AMS. Discussion on the draft for incorporating comments and advice from the WG members.

Chapter 2
Overview of the Phase 1 Study

1. Outcomes

Cofiring of agricultural waste and coal could significantly contribute to reducing CO_2 emissions compared with simple coal combustion for power generation. Since ASEAN countries are generally rich in biomass resources, the cofiring of biomass and coal could play an important role in combating climate change. For this study, we compared two cases with the endorsement of fuel resources. Case 1 focused on Indonesia as a biomass-rich and coal-producing country and case 2 focused on the Philippines as a biomass-rich and coal-importing country. The study also calculated the levelised cost of electricity to check whether the electricity cost produced from the cofiring of biomass and coal is economically feasible compared with the electricity cost produced from coal-fired power generation only.

The results showed that biomass and coal cofiring is not feasible under the current tariff situation. It will require putting in place the right incentives, such as a feed-in tariff (FIT) or other kinds of incentives.

Therefore, a further consideration shall be given to identifying tailor-made country-specific models with optimal capacity and technologies as well as envisaged incentives.

2. Policy Recommendations

2.1. The adaptability of biomass cofiring power development plan

Table 2.2-1 shows the current power situation and the biomass potential of each country. All countries can potentially expand the application of biomass and coal cofiring to mitigate against greenhouse gas (GHG). Biomass cofiring is also beneficial to mitigate regional environmental impacts such as sulphur oxide, nitrogen oxide, and suspended particulate matter (SPM) since biomass usually has less heteroatom and ash compared to coal.

Table 2.1. Current Power Situation and Biomass Potential

Country	Capacity (GW)	Renewable Capacity (%)	Biomass Resources	Biomass Potential (MWe)	Current Tariff Incentive, FIT
Cambodia	1.87				
Indonesia	60.79	0.1	Oil palm waste (incl. POME) Sugarcane residue (bagasse) Wood waste rice (hull, straw) Corn (cobs, stalks) Coconut (shell, husk, fronds), etc.	32,654	FIT is not applied. Using reference price for each system
Philippines[a]	23.81	7.2	Rice (hull, straw) Corn (cobs, stalks) Coconut (shell, husk, fronds) Sugarcane residue (bagasse) Hog and chicken manure	4,449.54	Php 6.5969/kWh (for approval) (FIT)
Thailand	43.07	15.28			4.00–5.50 ฿/kWh

[a] All data on the Philippines were provided by the WG member from the Department of Energy (DOE), Philippines.
FIT = feed-in tariff , POME = palm oil mill effluent.

Another advantage of biomass cofiring is the use of agricultural waste. As described in Section 2.2.3, a significant volume of agricultural waste to be applied for cofiring is expected in ASEAN countries.

2.2. The advantages and spillover effect of biomass cofiring

As an affordable and reliable energy source, coal could contribute to enhance universal access to electricity in the ASEAN region as long as environmental measures, such as flue gas control and GHG emission reduction, are taken appropriately. The advantages and spillover effects are as follows:

(1) Biomass in coal-fired power plants (CFPPs) is to be used as direct and effective mitigation measures of CO_2 in the power sector of countries that use coal as the main energy source, such as those in the ASEAN region. CO_2 emission is reduced proportionally by increasing the blend ratio of biomass with coal since biomass is recognised as a carbon-neutral substance.

(2) Agricultural waste, such as palm kernel shell (PKS), empty fruit bunch, sugar cane, rice husk, and food waste, in the ASEAN region is thought to be a potential domestic energy resource. It can also reduce underutilised waste. Biomass can be used in a wider type of boiler such as CFB, small pulverised boiler, and USC of larger capacity.

(3) The effectiveness of biomass as an alternative fuel in a CFPP is to mitigate CO_2 emissions and reduce plant operation costs if biomass is efficiently collected from the surrounding areas. Since one issue in using agricultural waste as biomass fuel is the seasonal volume change, i.e. supply stability, cofiring with coal can compensate for the plant's total energy input by optimising the coal–biomass ratio with seasonal variation.

(4) Although applicable biomass resources and the current utilisation situation are different in each country, biomass cofiring in a CFPP might increase regional employment through the collection, selection, and torrefaction processes in the surrounding areas.

Considering the above-mentioned, expediting the realisation of biomass and coal cofiring in CFPPs in the ASEAN region is deemed crucial in addressing both CO_2 mitigation and surging energy demand.

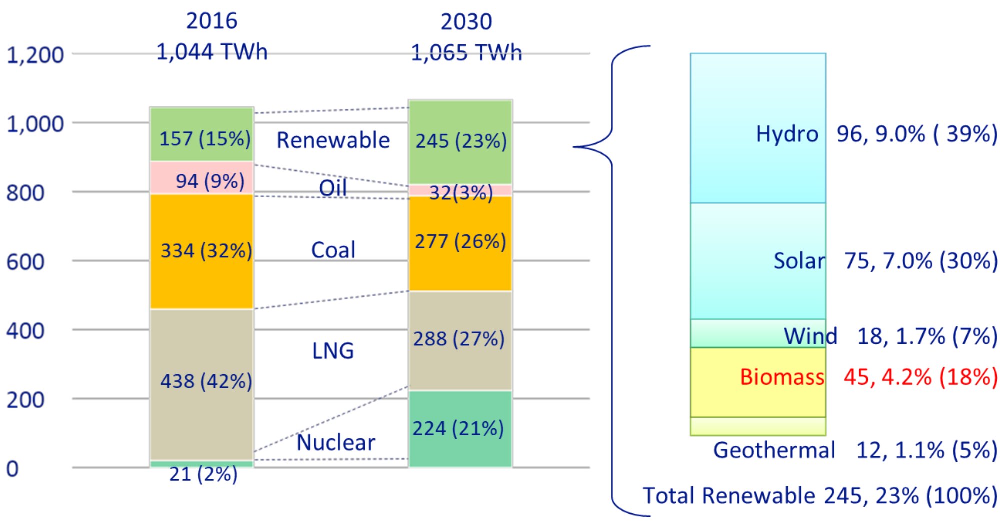
2.3. Policy recommendations to expedite biomass cofiring

Policy recommendations are summarised below. The respective countries should consider the realisation of the following measures. External support through bilateral or multilateral collaboration would expedite the possibility of the realisation.

(1) Authorisation by the government to use biomass as renewable energy in the energy development plan of each country

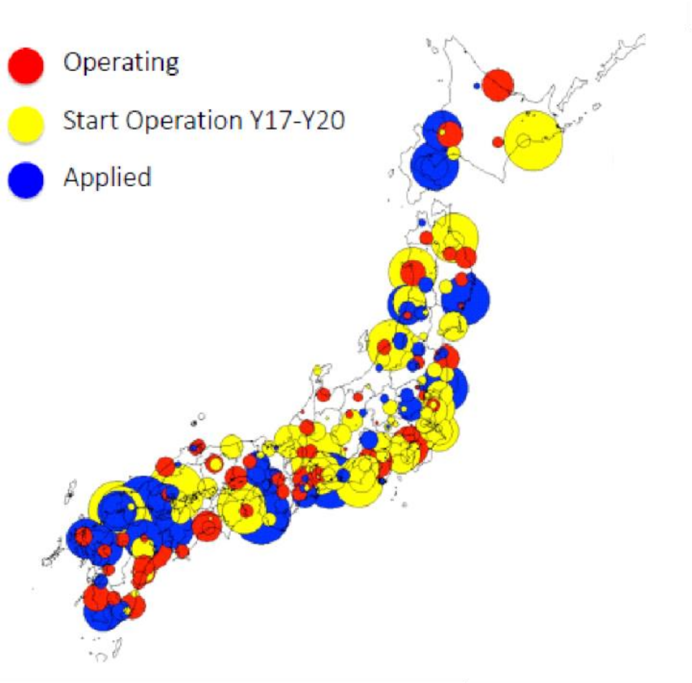
In Japan, the target of biomass utilisation is clearly shown by the government (Figure 2.2-1). Expected in 2030 is 45 TW of biomass generation out of total renewables of 245 TWh. Most of the biomass generation will be accomplished by cofiring with coal. Along with the government's target, many plants are commissioning or are being planned by the major electric power companies and new joint venture companies (Figure 2.1).

Figure 2.1. Generation Forecast in Japan, by Source



Source: METI (2015).

Figure 2.2. Biomass Power Plant in Japan



The diameter of the circle shows the capacity.

Source: Fuji Biomass Energy Sdn Bhd (2018).

(2) *Tariff and other financial incentives for biomass cofiring*

Tariff incentives for biomass cofiring, such as FIT, should be considered in accelerating investments in biomass cofiring. If FIT has been introduced, its rate for each renewable source should be optimised according to the renewable target and energy mix. In this study, US ¢ 13–16/kWh is recommended as a FIT for further dissemination of biomass use in the ASEAN region.

Also recommended is the establishment of a special purpose financial scheme solely for the biomass utilisation project.

(3) *Development of biomass collection scheme*

A continuous and stable agricultural waste collection process is essential in establishing biomass cofiring in a coal-fired plant. For example, the PKS is already treated commercially as an energy source depending on the agricultural waste resources. Most of the waste from cereal crops is thought to apply to biomass energy. An integrated collection function should be located at the centre of the collection area and transportation system to utilise such biomass sources. If local farmers, business owners, and related organisations were allowed to handle the collection and transport of biomass in the region, the efficiency of biomass delivery can be improved.

The establishment of a cooperative association is also beneficial. A cooperative association is exempt from taxation, while a corporation is not. Also, activities conducted by such a cooperative association contribute to the local economy and create jobs. Furthermore, these will be regarded as the corporate social responsibility activities of the operator.

In this connection, authorisation by the government of a plant for biomass cofiring and capacity of the collection function is considered to expedite the realisation of the biomass utilisation project by public or private participators.

(4) Support by the regional government for jobs related to the collection of biomass waste

Since the collection of agricultural waste is labour intensive, hiring enough workers to collect, transport, and pelletise it, if required, is extremely important. Initiatives by the regional government for securing jobs are recommended. This also has the advantage of using labour in the agriculture sector during off season.

Several financial support schemes, such as subsidy for the number of employees, a discount interest rate for investment, etc., can be considered. Support for the establishment of a cooperative association might also be effective in securing the required workers.

(5) Collaboration to realise biomass cofiring projects

Technical collaboration, as bilateral and/or multilateral cooperation between ASEAN countries and a country with the experience and applicable technologies, is recommended to materialise the biomass cofiring project.

This kind of collaboration is effective, especially for introducing applicable technologies such as CFB boiler for combustion of agricultural waste with coal. Public-based cooperation with a country with technology is highly recommended.

Chapter 3

By-Country Reviews and Recommendations

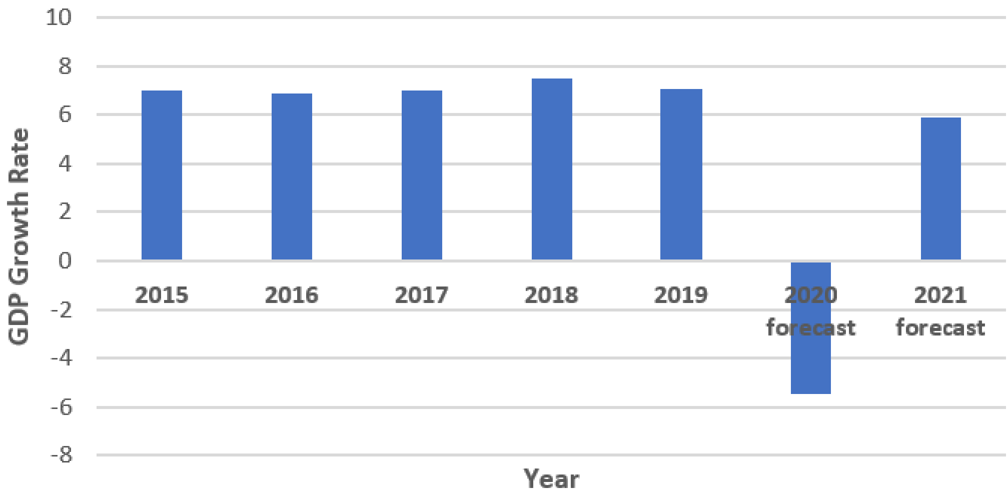
1. Cambodia

1.1. Economic growth

Cambodia recorded outstanding economic growth at 8% in 1998–2018. In 2015–2019, the average gross domestic product per capita exceeded 7%. The latest confirmed gross national income per capita in 2018 is US$1,380. Cambodia has now joined the group of lower-middle-income countries.

Though GDP growth rate will be going down to -5.5% (forecast) in 2020 due to the global COVID-19 pandemic, it is also forecasted to go up to as high as 5.9% (forecast) in 2022 (Figure 3.1-1).

Figure 3.1. GDP Growth, 2015–2021



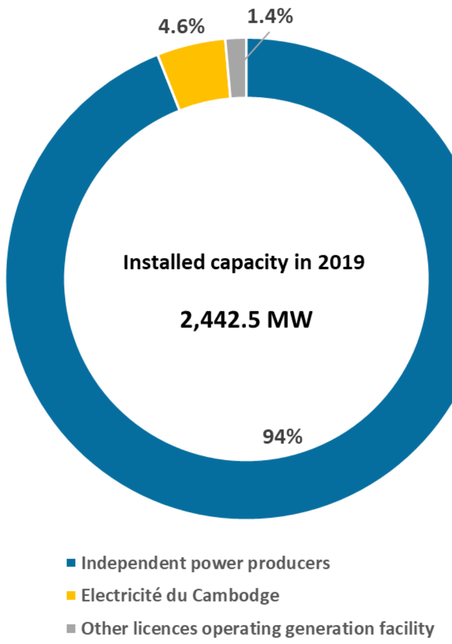
GDP: gross domestic product.
Source: ADB (2020).

1.2. The present situation of the power sector in Cambodia

As the country has experienced such high growth since the end of the war and has been in urgent and great demand for electricity, it is understandable that Cambodia has been relying on independent power producers (IPPs) for actual power development and operation.

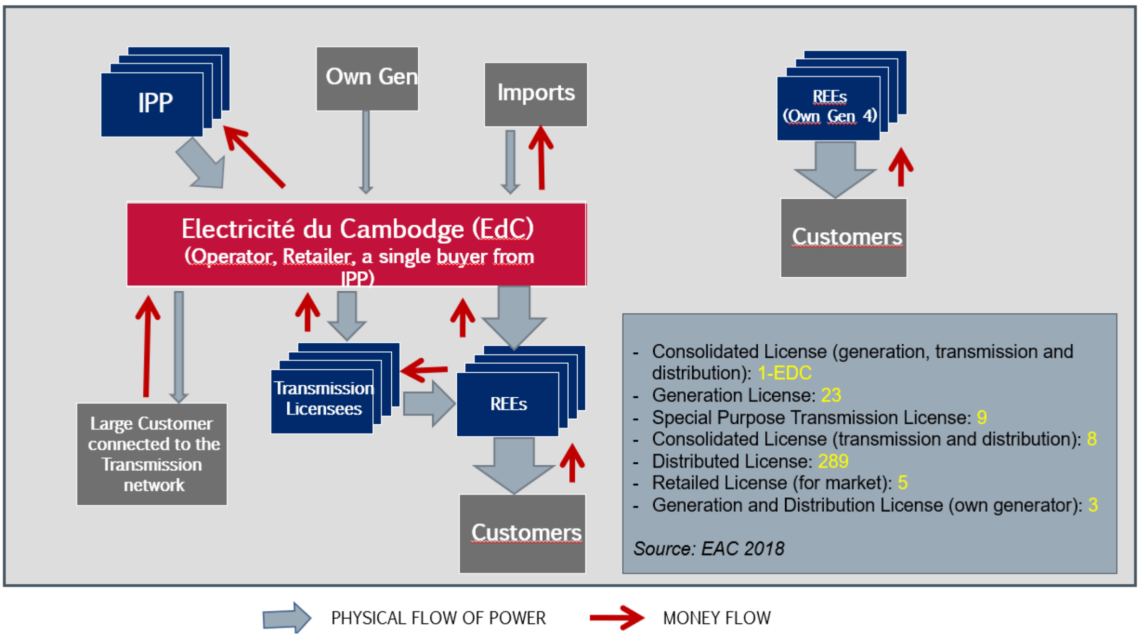
As of the end of 2019, the installed capacity of the IPPs accounted for 94% (Figure 3.1-2). The actual generated capacity reached 96%. Since growth is forecasted to continue except in 2020 when the COVID-19 pandemic affected the global economy, including that of Cambodia, the role of the IPPs in the country's power sector will remain important in the years to come.

Figure 3.2. Installed Capacity in 2019, by Producer



Source: EAC (2019).

Figure 3.3. Electricity Market Structure



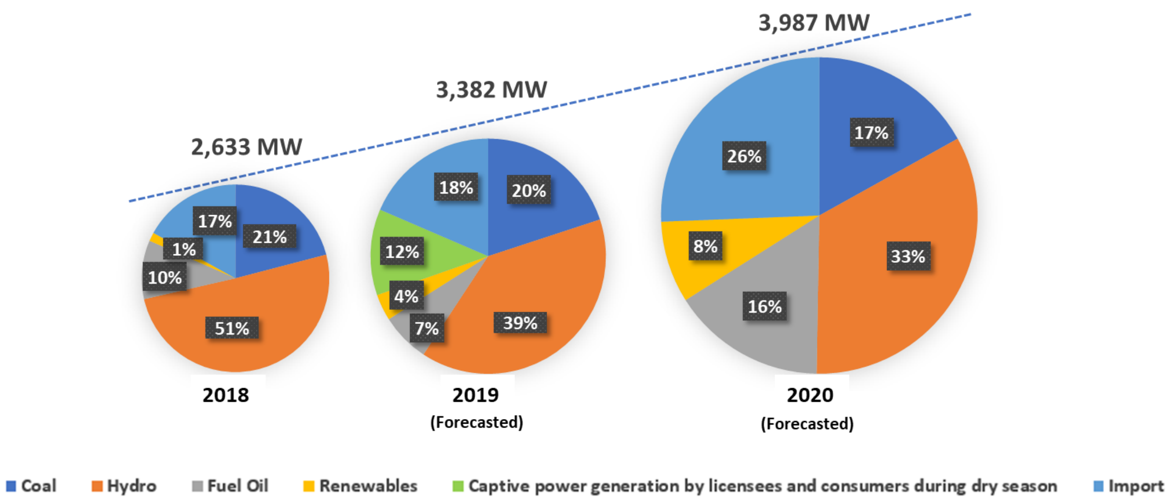
IPP = independent power producer, REE = rural electricity enterprise.

Source: Country presentation by Cambodia's representatives at the First WG Meeting (online) for the Phase II Study, 16 June 2020.

Electricité du Cambodge (EdC) is the sole operator, retailer, and a single buyer from the IPP Figure 3.1-3.

The demand and supply of electricity in Cambodia will be continuously growing at a fast pace, as per the economic growth mentioned in the previous section. The government anticipated the growth and development of power supply by over 50% in 2018–2020 (Figure 3.1-3).

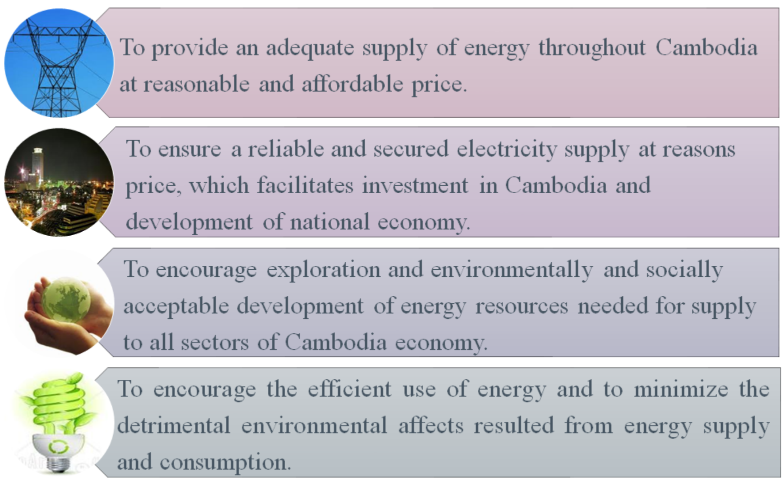
Figure 3.4. Power Growth, by Fuel, 2018–2020



Source: EAC (2019).

Cambodia set out its national energy policy consisting of the following four pillars:

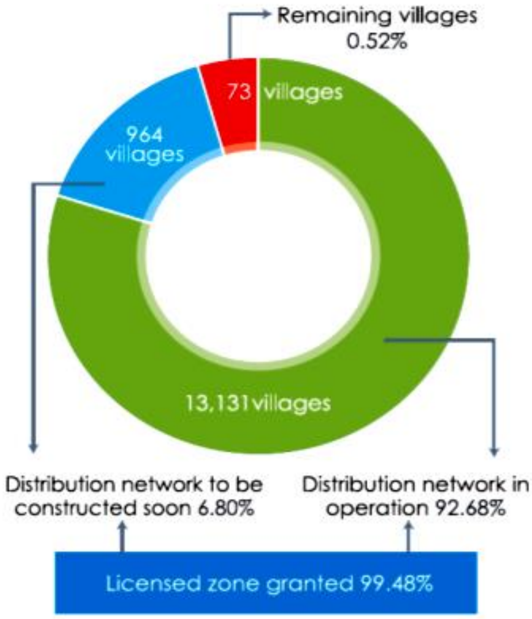
Figure 3.5. Four Pillars of Cambodia's National Energy Policy



Source: Country presentation by Cambodia's representatives at the First WG Meeting (online) for the Phase II Study, 16 June 2020.

Thanks to the government's strenuous endeavours to ensure 100% electricity access and better quality of power to all its people, access to electricity amongst rural households increased from 6.56% to 86% in 2000–2017. In 2019, the national electrification rate increased to 92.68% in terms of areal electrification (Figure 3.6). Almost 100% of households in the urban areas were electrified, and those in rural areas, about 70%.

Figure 3.6. Progress of Village Electrification in Cambodia



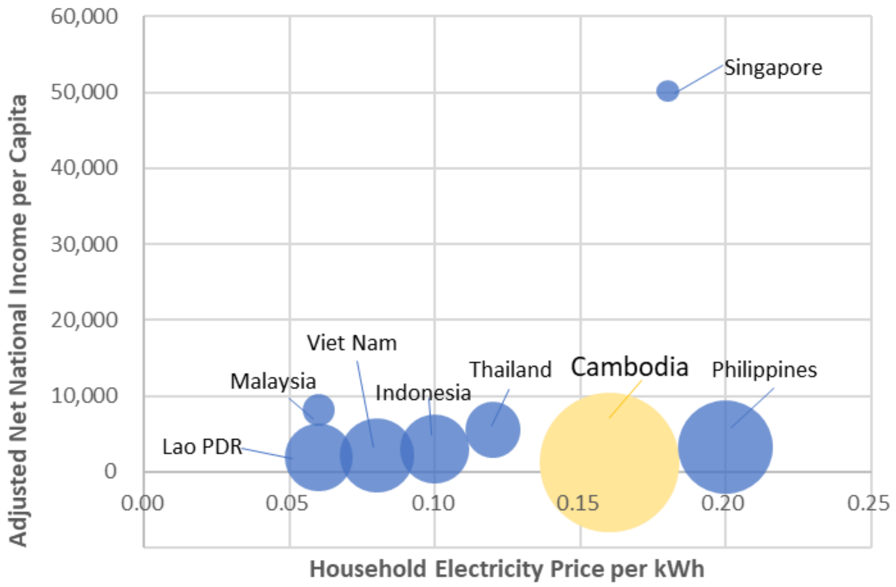
Source: Country presentation by Cambodia's representatives at the First WG Meeting (online) for the Phase II Study, 16 June 2020.

However, electricity quality is presently not well ensured. 'Electrification' does not mean all covered households enjoy a 24/7 power supply. According to REN21, 72% of Cambodia's population had electricity access in 2018, and 5 million people are still without electricity (REN21, 2020).[1]

The other issue to be addressed in the context of better electricity access is tariff.

[1] REN21 is a major think tank and governance group involving a number of governments and international organisations to facilitate the introduction of renewable energy.

Figure 3.7. Electricity Price against Income per Capita



Source: Study Team, based on price information from GlobalPetrolPrices.com.

The electricity price in Cambodia as shown above, in absolute terms, is not the highest in ASEAN. However, if compared with the income level, the tariff is the highest (Figure 3.1-7).

The government expresses serious concerns about the electricity price and has set appropriate and affordable electricity prices as part of its power sector goals.

In the meantime, the country is committed to the Paris Agreement through its voluntary CO_2 emissions reduction target of 27% in 2030 compared to 2010. In the energy sector, a 16% reduction is targeted. In this context, the choice and combination of generation sources are keys to addressing both energy and environmental requirements.

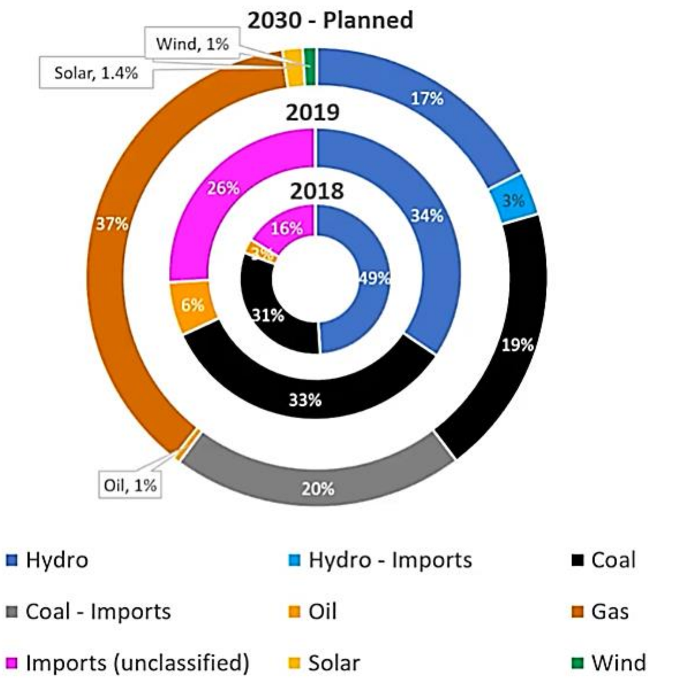
Table 3.1. Mitigation Actions in Key Sectors: Aggregate Reduction by 2030

Sector	*Priority actions*	*Reduction as Gg CO_2eq and % in the year 2030 compared to the baseline*
Energy Industries	National grid connected renewable energy generation (solar energy, hydropower, biomass and biogas) and connecting decentralised renewable generation to the grid. Off-grid electricity such as solar home systems, hydro (pico, mini and micro). Promoting energy efficiency by end users.	1,800 (16%)
Manufacturing Industries	Promoting use of renewable energy and adopting energy efficiency for garment factory, rice mills, and brick kilns.	727 (7%)
Transport	Promoting mass public transport. Improving operation and maintenance of vehicles through motor vehicle inspection and eco-driving, and the increased use of hybrid cars, electric vehicles and bicycles.	390 (3%)
Other	Promoting energy efficiency for buildings and more efficient cookstoves. Reducing emissions from waste through use of biodigesters and water filters. Use of renewable energy for irrigation and solar lamps.	155 (1%)
Total Savings		**3,100 (27%)**

Source: UNFCCC (n.d.).

While Cambodia has a high potential for renewable energy and is keen to develop and utilise it according to the foregoing emission reduction target, 100% renewable energy may not be an option towards 2030 (Figure 3.8). As a country with a growing population and economy, Cambodia will continue pushing up the power demand for the years to come. This will require a massive scale of capacity addition and enhanced supply security with non-intermittent thermal power generation combined with hydropower and other renewables.

Figure 3.8. Installed Capacity in 2018, 2019, and 2030, by Fuel



Source: Energy Lab (2020).

Table 3.2. indicates over 708 GWh deficit in supply by hydropower in 2019 against 2018 while the installed capacity did not change.

Table 3.2. Power Supply in 2018–2020, by Source

Power Sources	2018			2019			Plan for 2020		
	MW	GWh	%	MW	GWh	%	MW	GWh	%
1. Domestic Generation									
Coal	551.20	3,056.56	31.39%	675.00	3,919.45	32.62%	675.00	4,182.04	29.91%
Hydro power	1,329.70	4,737.01	48.64%	1,329.69	4,028.54	33.53%	1,329.69	4,090.82	29.26%
Fuel Oil	266.82	299.31	3.07%	227.45	698.82	5.82%	627.45	1,373.09	9.82%
Renewable Energy	39.27	79.38	0.82%	123.57	157.52	1.31%	333.57	215.06	1.54%
Captive power generation by licensees and consumers during dry season	-	-	-	400.00	182.00	1.51%	-	-	-
Total Domestic Generation	**2,186.99**	**8,172.26**	**83.91%**	**2,755.71**	**8,986.33**	**74.80%**	**2,965.71**	**9,861.01**	**70.53%**
2. Import Power Sources									
Thailand	135.50	409.98	4.21%	227.30	1,153.52	9.60%	277.30	1,011.68	7.24%
Vietnam	277.00	1,090.98	11.20%	323.45	1,764.11	14.68%	323.45	1,510.67	10.80%
Laos	36.00	65.55	0.67%	76.00	110.63	0.92%	421.00	1,597.83	11.43%
Total Import	**448.50**	**1,566.51**	**16.09%**	**626.75**	**3,028.26**	**25.20%**	**1,021.75**	**4,120.17**	**29.47%**
3. Total Power Sources	**2,635.49**	**9,738.77**	**100%**	**3,382.46**	**12,014.59**	**100%**	**3,987.46**	**13,981.18**	**100%**
4. Increase over prev. year	**313.49**	**1,665.92**	**17.11%**	**746.97**	**2,275.82**	**23.37%**	**605.00**	**1,966.59**	**16.37%**

Source: Salient Features of Power Development in Kingdom of Cambodia, EAC 2019

Source: EAC (2019).

The deficit was addressed by coal and imported electricity from neighbouring countries. Hydropower is the long-standing mainstay of power generation in Cambodia, which is said to have a further potential of 10,000 MW by hydro. However, recent climate uncertainty has affected the output of the existing hydropower in the country. This situation may continue in the coming years.

We should also pay attention to the surging of the volume of imported electricity from 1,566.51 GWh (16.09%) in 2018 to 3,028.16 GWh (25.20%) in 2019. It is forecasted to decrease in 2020 and will be so due to the global COVID-19 pandemic. However, as mentioned, the economies of Cambodia and the AMS are expected to be back on track in 2021. Accordingly, the issue of possible import dependence for ensuring the required volume of power supply will remain to persist.

1.3. Coal-fired power generation in the midterm power development in Cambodia

Table 3.3 lists the existing and incoming CFPPs in Cambodia.

Table 3.3. Existing and Incoming Coal-Fired Power Plants in Cambodia

No.	Power Plant	Company	Location	Operation	Sell to	Ins. Capacity (MW)	COD
1	100MW CEL Coal Fired Power Plant	CAMBODIAN ENERGY LIMITED	Shihanuk Ville	In Operation	EDC	120	02-Dec-2013
2	135MW CEL II Coal Fired Power Plant	CAMBODIAN ENERGY II CO., LIMITED	Shihanuk Ville	In Operation	EDC	150	15-Apr-2020
3	270MW C.I.I.D.G Coal Fired Power Plant	C.I.I.D.G ERDOS HONGJUN ELECTRIC POWER CO., LTD	Shihanuk Ville	In Operation	EDC	270	19-Mar-2015
4	135MW C.I.I.D.G Coal Fired Power Plant	C.I.I.D.G ERDOS HONGJUN ELECTRIC POWER CO., LTD	Shihanuk Ville	In Operation	EDC	135	01-Jan-2017
5	CAMBODIA INTERNATIONAL INVESTMENT DEVELOPMENT GROUP CO., LTD	CAMBODIA INTERNATIONAL INVESTMENT DEVELOPMENT GROUP CO., LTD	Shihanuk Ville	Under Construction	EDC	700	N/A
6	BOTUM SAKOR ENERGY COMPANY LIMITED	BOTUM SAKOR ENERGY COMPANY LIMITED	Koh Kong	Planed for Construction	EDC	700	N/A
7	HAN SENG COAL MINE CO., LTD	ODDOR MEANCHEY POWER INDUSTRIAL CO., LTD	Oddor Meanchey	Under Construction	EDC	265	N/A

Source: Country presentation by Cambodia's representatives at the First WG Meeting (online) for the Phase II Study, 16 June 2020.

For the midterm, the government plans to develop over 5,000 MW power plants, out of which in 2020–2030 coal will be 1,500 MW (24%) or 2,750 MW (53%). Hydro accounts for 47% in both cases, and if all envisaged coal or gas power plants come to be gas plants, gas would be 1,500 MW (29%).

Table 3.4. Power Development Plan, 2017–2030

Year	Power Plant to be Developed	Fuel	Capacity (MW)
2017	The 1st Coal power plant (for the 2nd step)	Coal	135
2018	Hydro Power Plan Lower Sesan Krom-II with capacity	Hydro	400
2019	Coal plant (in place of hydro power Areng that is in pending)	Coal	135
2020	Coal plant (for the 2nd step) of the 2nd coal plant with capacity	Coal	200-250
2021	Coal plant (for 3rd step of the 2nd coal plant) with capacity	Coal	200-250
2022	Hydro Power Plant Salamunthun with capacity	Hydro	70
	Hydro Power Plant Rissey Chrum Kandal with capacity	Hydro	70
	Hydro Power Plant Veal Thmor Kombot with capacity	Hydro	100
	Hydro Power Plant Prak Larng with capacity	Hydro	120
	The 3rd Coal plant with capacity	Coal	200-250
2023	The 2nd Hydro Power Plant Battambang with capacity	Hydro	36
	The 1st Hydro Power Plant Stung Pursat with capacity 40MW	Hydro	40
	Stung Chey Areng Hydro Power Plant with capacity 108 MW	Hydro	108
2024	The 4th Coal plant with capacity 400-500MW	Coal	400-500
2025	Hydro Power Plant (Step-I) with capacity 600MW	Hydro	600
2026	Sambo Hydro Power Plant (Step-II) with capacity 600MW	Hydro	600
	Coal plant/ The 5th Nature Gas with capacity 300 MW	Coal/Gas	300
2027	Sambo Hydro Power Plant (Step-III) with capacity 600MW	Hydro	600
	Coal Plant/ The 6th Nature Gas with capacity 300 MW	Coal/Gas	300
2028	Coal Plant/ The 7th Nature Gas with capacity 300 MW	Coal/Gas	300
2029	Coal Plant/ The 8th Nature Gas with capacity 300 MW	Coal/Gas	300
	Seasan Krom-I Hydro Power Plant with capacity 96 MW	Hydro	96
2030	Coal Plant/ The 9th Nature Gas with capacity 300 MW	Coal/Gas	300
	Total		5,190

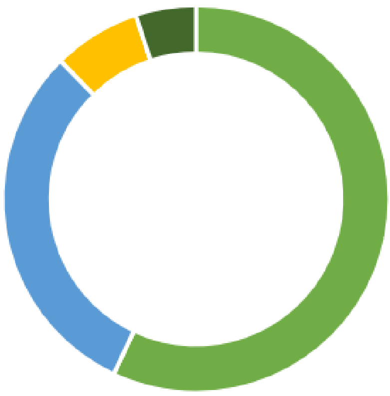
Source: Adapted from MME (2020).

1.4. Biomass power generation in Cambodia

Cambodia is catching up with the rest of the AMS in terms of renewable energy development. As of 2020, the country has made significant progress in solar power development. The MME envisages that the country will have 450 MW grid-connected solar power installed by the end of 2021. Cambodia now aims to increase the solar energy share in the power mix by at least 15% in the next few years. In the meantime, wind power is one of the least explored renewable resources in Cambodia. However, the southern parts of the Tonle Sap River and coastal regions have such high potential, according to the Asia Wind Energy Association (2020).

Biomass (biofuels and waste) makes up most of Cambodia's primary energy mix, mainly due to traditional charcoal use in households as cooking fuel. Since charcoal use is not sustainable as it induces illegal logging and deforestation and health problems, it has been gradually replaced by liquefied petroleum gas in recent years. So, biomass, which once accounted for as much as 82% in the primary energy mix in 1998, now comes to be only 57% (Figure 3.9).

Figure 3.9. Cambodia Total Primary Energy, by Source



Source: IEA (2020).

ADB estimates that Cambodia could produce about 15,000 GWh of electricity from biomass (ADB, 2018). However, biomass utilisation in the power sector is not quite popular in Cambodia.

Table 3.5 shows that the total installed capacity of biomass power plant is 70.27 MW; as of June 2020, 34.2 MW is not running. Biomass power as of now contributes 1% in terms of installed capacity and it would be less in terms of generation capacity.

Table 3.5. Biomass Power Plants in Cambodia

No.	Power Plant	Company	Fuel	Location	Operation	Sell to	Ins. Capacity (MW)	COD
1	PPS Biomass Power Plant	PHNOM PENH SUGAR CO., LTD	Bagasse	KOMPONG SPEU	In Operation	EDC	25	Dec-2012
2	IED Biomass Power Plant	IED-INVEST (COAMBODIA) CO., LTD	PADDY HUSK/WOOD	PREH VIHEA	In Operation	EDC	2	Sep- 2007
3	ANGKOR BIO COGEN	ANGKOR BIO COGEN	PADDY HUSK	KANDAL	In Operation	Rice Mill	2	13-Sep-2007
4	KSI Biomass Power Plant	KOH KONG SUGAR INDUSTRY COMPANY LIMITED	BAGGAGE	KOH KONG	Internal Use	EDC	8	02-Jan-2017
5	KAMADHUNU VENTURE (CAMBODIA) Biomass Power Plant	KAMADHENU VENTURES (CAMBODIA) LIMITED	BAGASSE	KRATIE	Not Running at all	EDC	26.2	27-Feb-2014
6	S.L GARMENT Biomass Power Plant	SL GARMENT PROCESSING CAMBODIA CO., LTD	FIRE WOOD	PHNOM PENH	Not Running at all	EDC	4.5	03-Aug-2006
7	*SOMA ENERGY CO., LTD	SOMA ENERGY CO., LTD	PADDY HUSK	KAMPONG THOM	Not Running at all	BVC	1.5	N/A
8	ECOCAM	ECOCAM	GARBAGE	PHNOM PENH	Not Running at all	-	2	N/A

Source: Country presentation by Cambodia's representatives at the 1st WG Meeting (online) for the Phase II Study, 16 June 2020.

According to the MME, fuel tree planting is recommended as a major energy resource in the Master Plan because of the following reasons.[2]

- Agricultural residues are generally well utilised.
- The sizes of agricultural products–processing factories, such as rice mills, sugar mills, and cashew nuts mills, are generally small; therefore, stable and sufficient supply of residues through a year is questionable.
- Planned and stable fuelwood supply is possible in the case of tree planting.
- Even in the case of the cultivation of energy trees, the fuel cost holds only a small fraction of total electricity generation cost (11% for 13 kWh monthly electricity consumption per household). Using agricultural residues does not reduce the cost dramatically.
- The purchasing cost of cultivated trees is not high (about $20/t). Using agricultural residue could be more expensive when transportation cost occurs.
- Wood biomass is generally the best fuel for gasification.

In the context of the country's need for added massive power capacity and its desire to accelerate poverty alleviation, wood biomass power generation either by cofiring at the existing or incoming coal-fired power plants or dedicated firing would be an excellent option with the following advantages:

- Biomass is the most labour-intensive renewable fuel, in the sense that procurement and preliminary processing require a major workforce, so large-scale job creation is anticipated.
- If appropriately used in a sustainable manner through well-organised management, wood biomass would even help prevent deforestation, as illegal logging is not being sufficiently regulated.
- In the case of cofiring, wood biomass is the most suitable biomass fuel for cofiring with coal, in terms of not requiring specific pretreatment except the simple cutting and drying process.

1.5. Policy recommendations

Cambodia is still in its early stage of using biomass to generate power. Whether biomass is used to generate power and how much electricity is available from those biomass power plants seem to be at the discretion of each industrial power plant using biomass. And agricultural biomass is mostly well utilised and little surplus is expected.

In this context, the study team fully agrees with the policy indicated in the preceding chapter that Cambodia will pursue the possibility of wood biomass utilisation by tree planting.

[2] The information was additionally provided in the private communication between the MME and the Team on 23 October 2020.

(1) Wood biomass for power: options

Regarding the policy and social values of generating with biomass, both biomass firing and cofiring would be excellent opportunities to facilitate village electrification, community development, and environmental compliance.

- *Biomass cofiring at CFPPs*
  Since there are incoming CFPPs that are nationally planned, it is possible to incorporate into the specifications the cofiring of biomass to a technically possible extent.[3] Benefits to community development through increased local jobs are also anticipated. By implementing cofiring, which uses biomass as part of the fuels, environmental compliance and public acceptance enhancement would be possible in addition to substantial emission reduction.
- *Biomass firing*
  Community-based and small-scale off-grid biomass power generation combined with local forest management activities will benefit community development and village electrification.

(2) Recommendations for policy arrangements

The study team envisages that the following policy arrangements will ensure the benefits of biomass use to generate power in Cambodia.

a) Conduct a basic study to identify wood biomass resources' availability in terms of amount, areas, and prices. Collaboration with forestry experts shall be crucial since the study must consider a sustainable tree planting and wood biomass utilisation method.
b) Following the basic study, conduct a model study for biomass collection and procurement with the community and community-based organisations' roles in mind.
c) Biomass technologies are also to be studied in close cooperation with biomass power–related technology specialists.
d) Literature study complemented with some interviews to identify financing schemes for dedicated biomass firing would be helpful.
e) In parallel with the previous studies, the government is expected to make policy efforts to consider and set up incentives for biomass cofiring at existing and incoming CFPPs. Wood biomass cofiring has been implemented in many countries, including Japan. Thus, no major studies may be required to recommend power plant producers for biomass cofiring.
f) Based on the outcomes of the studies in a), b), and c), a model project of dedicated biomass firing well connected to the community and community-based organisations is to be planned and implemented.

[3] Japan's CFPPs have about 2%; 5% may be possible in others depending on the specifications of the plant.

2. Indonesia

2.1. Energy mix

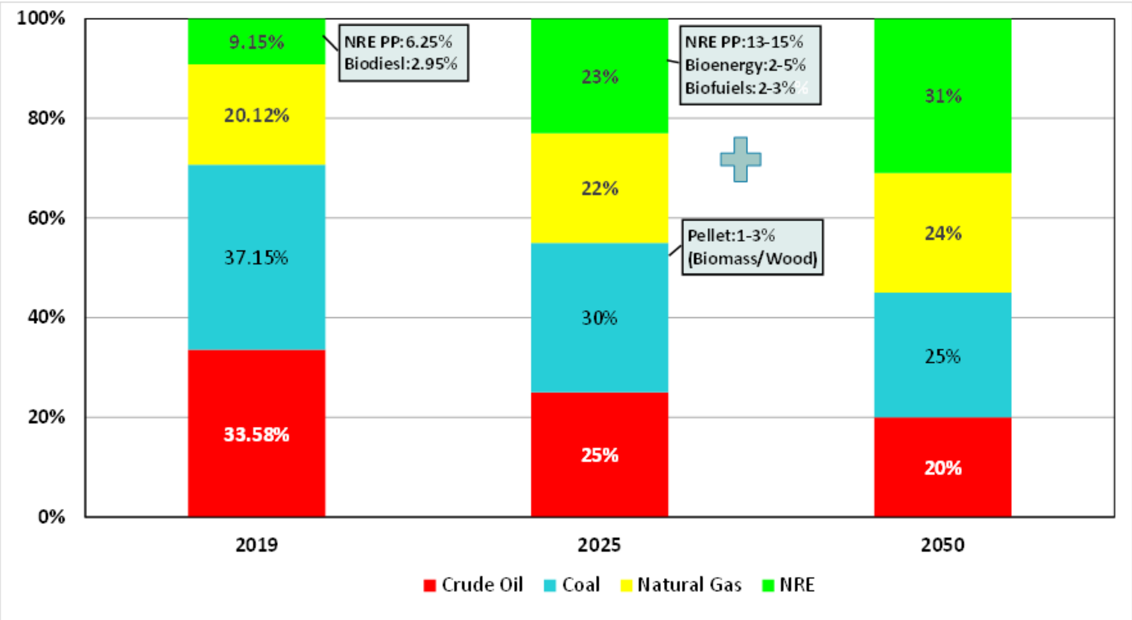
Indonesia is endowed with fossil fuel resources such as crude oil, natural gas, and coal, and uses these fossil resources as main energy sources. In 2019, fossil energy accounted for 90.85% (coal = 37.15%, oil = 33.58%, and gas = 20.12%) of energy mix.

However, as the reserves of fossil fuels declined and the production of oil and natural gas stagnated, Indonesia initiated an energy policy that calls for the increase in the use of new and renewable energy (NRE) sources. This is to diversify energy sources and curtail the use of fossil energy to reduce CO_2 emissions towards the mitigation of climate change.

Figure 3.2-1 shows the realisation and future target of the national energy mix (RUEN) which was formulated in 2017. Accordingly, the share of NRE in the total energy mix will increase from 9.15% in 2019 to 23% in 2025, and to 31% in 2050, which will be the largest energy mix in 2050.

In 2019, NRE contributed 9.15% of the total energy mix, which consisted of 6.2% of the NRE power plant and 2.95% in biodiesel. To achieve 23% target of NRE share in 2025, the government will increase NRE power plants and boost bioenergy utilisation. The bioenergy power plants are expected to contribute around 2%–5%, while biodiesel utilisation will contribute around 2%–3%. In addition to pursuing the target, the government will implement biomass cofiring in CFPPs, which is expected to increase the NRE portion by 1%–3%. At present, biomass used for cofiring in CFPPs is not included in the NRE and is classified in coal by the rules of the Indonesian government.

Figure 3.10. The Realisation and Target of National Energy Mix



NRE = non-renewable energy.

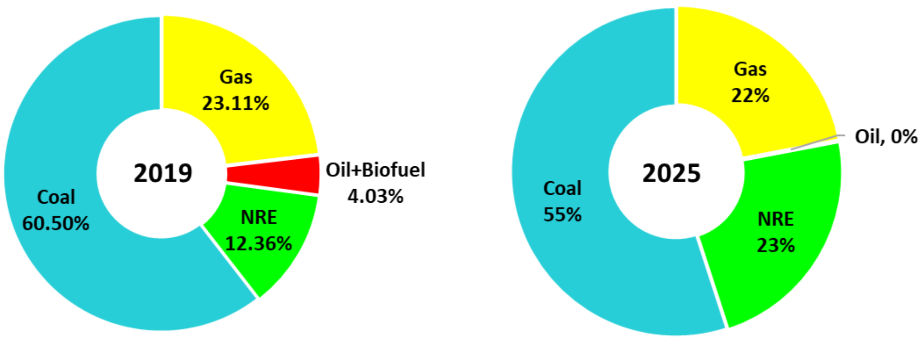
Source: Country presentation by the Indonesia's representative at the First WG Meeting for the Phase II Study, 16 June 2020.

2.2. Power development plan

Figure 3.11 shows the actual primary energy mix of electricity generation in 2019, and the electricity plan for 2025 according to the National Electricity Comprehensive Plan (RUKN) (MEMR, 2019).

Coal accounted for 60.5% of the total power generation in 2019. In 2025, coal will still account for 55% but due to the decrease in resources and high costs of oil, oil will be nearly zero except for small diesel power generation in the islands. On the other hand, in addition to hydropower and geothermal power, biomass power generation will increase so that power generation by NRE will account for 23% in 2025.

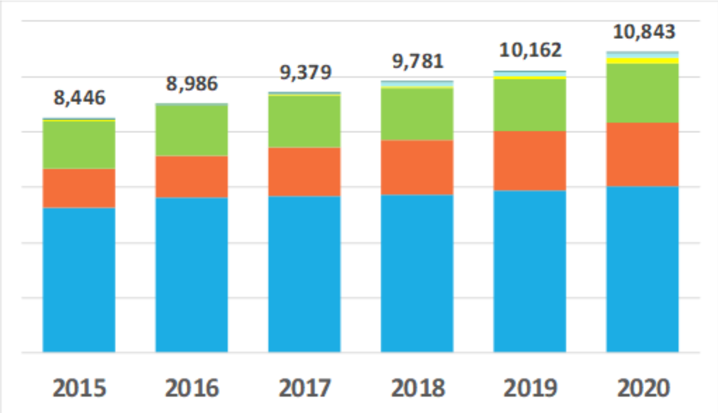
Figure 3.11. Power Generation Energy Mix



Source: Country presentation by Indonesia's representative at the First WG Meeting for the Phase II Study, 16 June 2020.

Figure 3.12. shows the amount of NRE power generation from 2015 to 2020. NRE power generation capacity is steadily increasing every year. Bioenergy power generation is the third-largest after hydropower and geothermal power.

Figure 3.12. Non-renewable Energy Power Plant Capacity



Unit: MW

	2015	2016	2017	2018	2019	2020
Hybrid	4.0	4.0	4.0	4.0	4.0	4.0
Wind power	1.5	1.5	1.5	143.5	154.3	154.3
Solar PV	33.4	43.1	50.9	60.2	97.4	231.9
Bioenergy	1,741.7	1,783.1	1,856.8	1,882.8	1,889.8	2,131.5
Gerthermal	1,438.3	1,533.3	1,808.3	1,948.3	2,130.6	2,270.7
Hydro	5,227.5	5,620.9	5,657.3	5,742.1	5,885.5	6,050.7

Source: Country presentation by Indonesia's representative at the First WG Meeting for the Phase II Study, 16 June 2020.

2.3. Biomass potential and biomass power plant

(1) Biomass potential for electricity

The agriculture and forestry industry is one of the major industries in Indonesia. A significant amount of waste and sub-products are generated from these industries, which can be used as raw materials to generate power.

Table 3.6 shows the biomass energy potential for electricity. It is noted that municipal solid waste (MSW) is included in biomass energy in Indonesia.

The total biomass potential for electricity is 32,655 MWe. Palm oil waste has the largest potential because it is cultivated in large-scale plantations in Sumatra and Kalimantan. Palm kernel shell (PKS), empty fruit bunch, Palm oil mill effluent (POME), which are wastes from the production of palm oil, can be used for power generation. Jamali and Sulawesi, which have few palm plantations, have a lot of rice husks. Jamali, which has many urban areas, has a high possibility of using MSW to generate power. Even though every area has potential waste, only a few of them use it.

Table 3.6. Biomass Energy Potential for Electricity

(Unit: MWe)

	Sumatra	Kalimantan	Jamali	Sulawesi	Other	Total
Palm oil	8,812	3,384	60	323	75	12,654
Sugar cane	399	-	854	42	0	1,295
Rubber	1,918	862	-	-	1	2,781
Coconut	53	10	37	38	39	177
Rice husk	2,255	642	5,353	1,111	447	9,808
Corn	408	30	954	251	90	1,733
Cassava	110	7	120	12	22	271
Wood	1,212	44	14	21	44	1,335
Cow dung	96	16	296	65	62	535
MSW	326	66	1,527	74	73	2,066
Total	15,589	5,061	9,215	1,937	853	32,655

MSW = municipal solid waste.

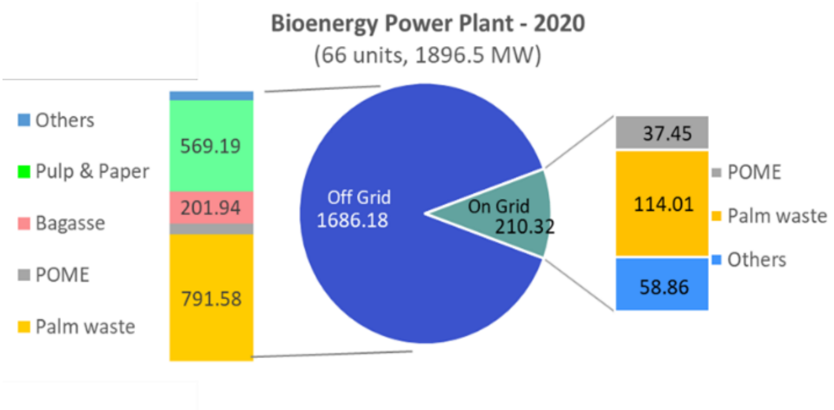
Source: Country presentation by Indonesia's representative at the First WG Meeting for the Phase I Study, 6 February 2019.

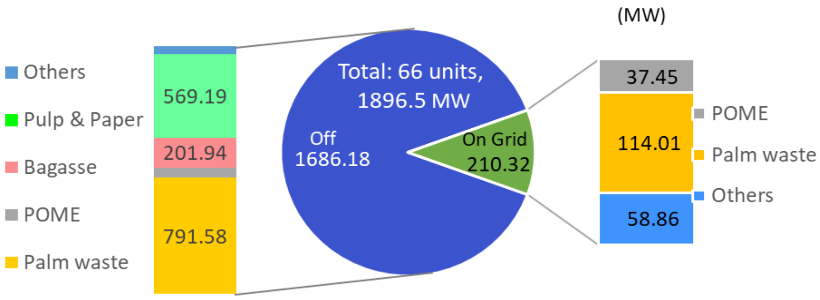
Bioenergy power generation in 2020 is 1,896.5 MW for 66 units (Figure 3.2-4). The details are as follows.

- Biomass power plant: 31 units, 146.52 MW
- Biogas power plant: 31 units, 42.35 MW
- MSW power plant: 3 units, 16.45 MW
- Crude palm oil power plant: 1 unit, 5 MW

The on-grid power is as low as 210 MW, while most biomass power generation is off grid in the palm oil, sugar, and pulp and paper industries.

Figure 3.13. Bioenergy Power Plant in 2020





POME = palm oil mill effluent.
Source: Country presentation by Indonesia's representative at the First WG Meeting for the Phase II Study, 16 June 2020.

(2) Biomass cofiring

(a) Current situation

To fulfil its commitment to increase NRE shares in electricity generation, the Perusahaan Listrik Negara (PLN) initiated a green booster programme, under which is biomass cofiring in its existing CFPPs. The PLN has conducted several tests on biomass cofiring trials on existing CFPP (Table 3.2-2). The boiler type tested was pulverised coal (PC) boiler and CFB, and biomass used was wood pellet, PKS, and MSW, which are suitable for PC boiler due to good 'grindability'.

As the results obtained from these tests are satisfactory, the PLN plans to conduct the next trials as shown in Table 3.7.

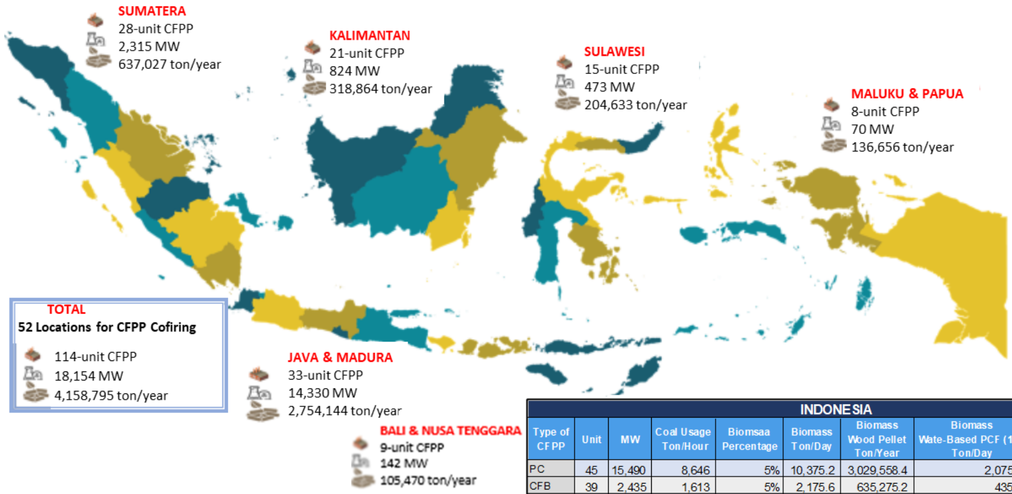
Table 3.7. Biomass Cofiring Tests on Existing CFPPs by PLN

CFPP	MW	Boiler	Location (Province)	Mixed Biomass	Mix Ratio	Biomass Feedstock Rate (tonne/day)	Test Result
Jeranjang	3×25	CFB	Lombok	MSW	1, 3, 5%	15	Good
Paiton	2×400	PC	East Java	Wood pellet	1, 3, 5%	432	Good
Indramayu	3×300	PC	West Java	Wood pellet	1, 3, 5%	684	Good
Tenayan	2×110	CFB	Riau	PKS	5%	192	Good
Ketapang	2×10	CFB	West Kalimantan	PKS	1, 3, 5%	22	Good
Next Plan							
Sintang	3×7	Stoker	West Kalimantan	PKS	1, 3, 5%	86	
Berau	2×7	Stoker	East Kalimantan	Wood	1, 3, 5%	58	
Anggrek	2×27.5	CFB	North Sulawesi	Wood	1, 3, 5%	55	
Talaud	2×3	Stoker	North Sulawesi	MSW	1, 3, 5%	2	
Ropa	2×7	Stoker	East Nusra	PKS	1, 3, 5%	58	
Bolok	2×16.5	CFB	East Nusra	Wood	1, 3, 5%	34	
Lontar	2×315	PC	Banten	Wood	1, 3, 5%	648	

CFB = circulating fluidised bed, MSW = municipal solid waster, PC = pulverised coal, PKS = palm kernel shell.
Source: Country presentation by Indonesia's representative at the First WG Meeting for the Phase II Study, 16 June 2020.

Figure 3.14. shows the biomass cofiring potential of PLN's CFPPs. The Java and Madura area, where a large CFPP is located, can generate maximum power. There is a large amount of biomass waste in Sumatera and Kalimantan area as described in Section 3.2.3. However, due to the small and midsized CFPPs, the amount of electricity generated is not very large. Total generation potential by biomass cofiring on PLN's CFPPs in Indonesia is 18.154 MW, and the annual used biomass is about 4 million tonnes.

Figure 3.14. Distribution of Biomass Cofiring Potential of PLN's CFPPs



INDONESIA								
Type of CFPP	Unit	MW	Coal Usage Ton/Hour	Biomsaa Percentage	Biomass Ton/Day	Biomass Wood Pellet Ton/Year	Biomass Wate-Based PCF (1%) Ton/Day	Biomass Wate-Based PCF (1%) Ton/Year
PC	45	15,490	8,646	5%	10,375.2	3,029,558.4	2,075.0	605,911.7
CFB	39	2,435	1,613	5%	2,175.6	635,275.2	435.1	127,055.0
Stocker	30	229	234	30%	1,684.8	491,961.6	56.2	16,398.7
	114	**18,154**	**10,493**		**14,235.6**	**4,156,795.2**	**2,566.3**	**749,365.4**

CFPP = coal-fired power plant, PLN = Perusahaan Listrik Negara (National Electricity Company of Indonesia).
Source: Country presentation by Indonesia's representative at the First WG Meeting for the Phase II Study, 16 June 2020.

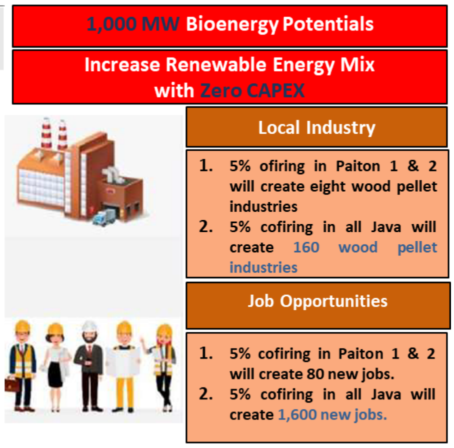
(b) Application of the benefits of biomass cofiring

The benefits of biomass cofiring are mainly the effective use of waste, the increase of renewable energy, and the reduction of CO_2 emissions. Additionally, biomass cofiring will develop the local industry and create jobs. Figure 3.15 shows an estimation of local industry development and job creation.

The cofiring at Paiton 1 & 2 power plants will create eight pellet mills and 80 jobs. Based on this estimation, the envisaged total capacity of CFPP in Jamali Grid for 5% cofiring with biomass is 1,000 MW, which is expected to create 160 pellet mills and 1,600 new jobs.

Figure 3.15. Industrial Development and Job Creation Benefits of Biomass Cofiring

No	Coal Fired Power Plants	Instaalled Capacity (MW)	Total (MW)	5% Co-Firing Potentials (MW)
1	PLTU Paiton 12	2x400	800	39.20
2	PLTU PEC Paiton 3	1x800	800	39.20
3	PLTU Jawa Power Paiton	2x610	1,220	60.27
4	PLTU PEC Paiton 78	2x610	1,220	59.78
5	PLTU Paiton 9	1x660	660	32.34
6	PLTU Tj. Awar-Awar	2x350	700	34.30
7	PLTU Pacitan	2x300	600	29.40
8	PLTU Rembang	2x300	600	29.40
9	PLTU Tj. Jati 12	2x660	1,320	64.68
10	PLTU TJ, Jati34	2x660	1,320	64.68
11	PLTU Adipala	1x660	660	32.34
12	PLTU Cilacap 12	2x300	600	29.40
13	PLTU Cilacap 3	1x660	660	32.34
14	Cirebon	1x660	660	32.34
15	PLTU Indramayu	3x330	990	48.51
16	PLTU Suralaya 1234	4x400	1,600	78.40
17	PLTU Suralaya 567	3x600	1,800	88.20
18	PLTU Suralaya 8	1x625	625	30.63
19	PLTU Celukan Bawang	3x142	426	20.87
20	PLTU Palabuhan Ratu	3x350	1,050	51.45
21	PLTU Lontar	3x300	900	44.10
22	PLTU Labuan	2x300	600	29.40
23	PLTU Banten	1x660	660	32.34
Total				1003.57

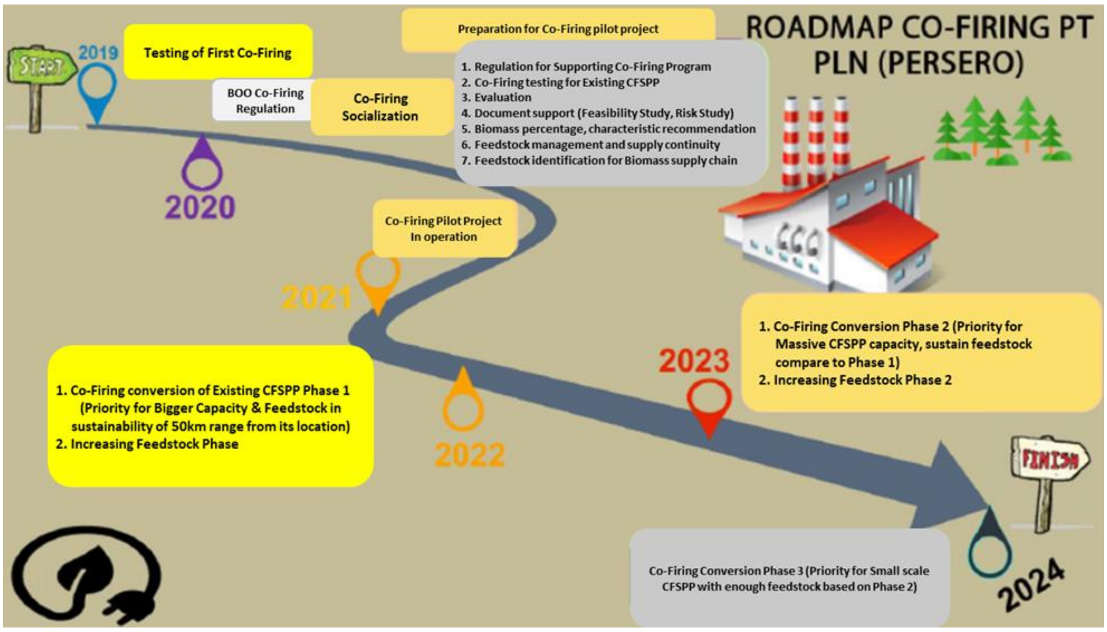


Source: Kanam (2020).

(c) Road map

Figure 3.16 shows the roadmap of cofiring, as prepared by the PLN which started the cofiring trial tests in 2019 and will continue until 2024. During this period, issues and problems related to cofiring will be clear. Finally, the target of starting the commercial operation of cofiring is after 2024.

Figure 3.16. Road Map of Biomass Cofiring



CFSPP = coal-fired steam power plant.

Source: Adapted from Country presentation by Indonesia's representative at the First WG Meeting for the Phase II Study, 16 June 2020.

2.4. Applicable biomass-to-energy technologies

As mentioned, various technologies have already been applied in Indonesia for the use of biomass. Table 3.8 shows the applicable biomass combustion technologies for power plants.

Biomass cofiring can be applied to existing large and midsized power plants. For small power plants in local areas, bioenergy power plants will be applied. For existing diesel power plants, biofuel will be used instead of diesel fuel. However, in applying biomass, it is important to understand the biomass characteristics such as 'grindability', contained corrosive components, moisture content, and so on.

Considering the foregoing circumstances, the team envisages that, in Indonesia, demand for biomass cofiring in the existing CFPPs would be higher than new biomass power plants, especially because of the required CO_2 emission reduction.

Table 3.8. Applicable Biomass Firing Technologies for Various Power Plants

Existing/New Power Plants (PPs)	Applicable Technology/System
Large/medium Coal-fired power plant (CFPP)	Cofiring with biomass for existing CFPP
Small biomass power plant (PP)	Bioenergy PP for local areas
Diesel PP	Adaption of biofuel

Source: Study Team.

2.5. Policy recommendations

Based on the national energy plan and the national electricity plan, it is necessary to increase the share of NRE. Hydro and geothermal are major renewable energies in Indonesia. In the future, the strong demand for solar power is expected to increase, while biomass will also increase as an important NRE.

The Government of Indonesia continues to increase renewable energy's contribution in the energy mix, including in the power generation sector. The government has provided various directives and regulations that are deemed to address well the power sector's requirements. Additionally, the government has formulated the strategic plan (Figure 3.17) and is promoting support to expand the use of biomass.

Figure 3.17. Strategic Plan for Biomass Use

1. Improve Bioenergy Business Governance , which includes drafting the Presidential Regulation on Electricity Purchase Price.
2. Increase the installed capacity of bioenergy power plant (project pipeline) by ensuring all parties involved to implement the commitment in developing bioenergy power plants, as stated in the RUPTL.
3. Develop CPO-based power plant.
4. Encourage agro-industries with captive power to sell their electricity surplus with excess power schemes.
5. Develop biomass cofiring in existing coal-based power plants.
6. Develop small-scale biomass power plants in the eastern part of Indonesia and in the frontier, outermost, and least-developed regions (3T) massively.
7. Develop energy forest and marginal lands utilisation for biomass through collaboration with the MoEF, other relevant ministries/agencies and local governments.
8. Encourage the use of agro-industrial waste, including the replanting of oil palm plantations for power generation.

Source: Adapted from the Country presentation by Indonesia's representative at the First WG Meeting for the Phase II Study, 16 June 2020.

Currently, the government is drafting a revision of the purchase price of electricity from renewable energy sources to make the sector more attractive for investment. As mentioned, the government is taking various measures to facilitate biomass utilisation. While the recent efforts by the government and the PLN for power generation with biomass are proceeding smoothly, the Team suggests the following measures to make the most of biomass utilisation for local power generation.

(1) Improvement of rural electrification and effective use of off-grid power

Now that the urban electrification rate has reached 99%, the government is trying to accelerate the electrification of 2,500 villages with over 10 million people. Biomass power would provide options for village electrification through the sales of off-grid captive power to the PLN or direct supply of such off-grid biomass power to the local area.

(2) A cooperative association for local biomass collection and transportation

Although ample amounts of corn and coconut waste are available in most parts of the archipelago, inefficiency in collecting and transporting biomass produced mostly by small-scale farmers would be a barrier for project implementation. With a cooperative association established afresh or in the existing cooperatives involving local farmers, business owners, and related organisations to handle the local collection and transportation, biomass procurement efficiency will be considerably improved. The establishment of a cooperative association might bring in some other economic benefits, such as tax exemption, etc., apart from contributing to the local economy and creating jobs. Looking at it from the PLN, working with such a cooperative association would enhance their corporate social responsibility.

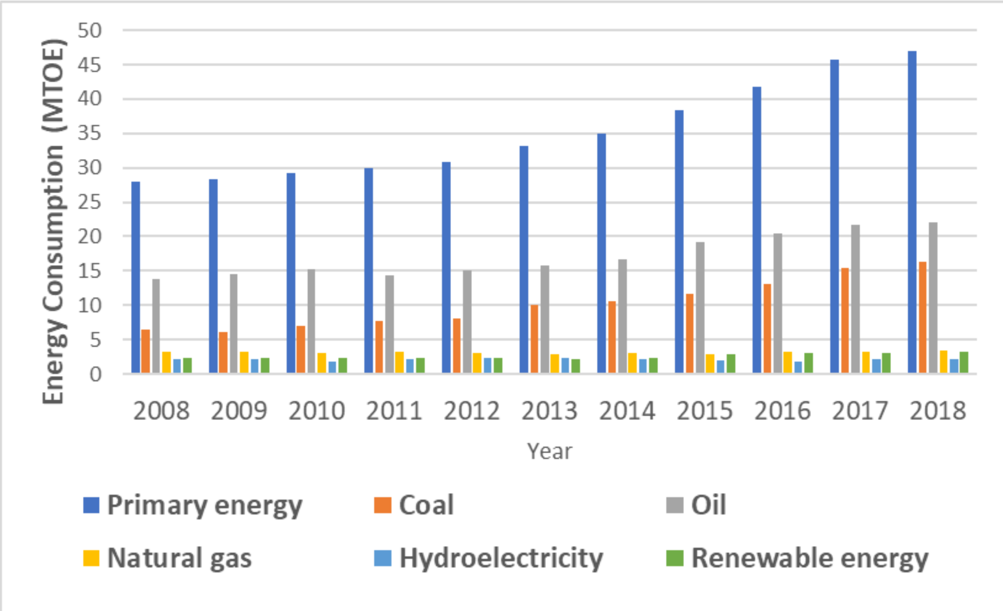
3. Philippines

3.1. Energy and status of CO_2 emissions

Figure 3.18 shows the changes in each primary energy consumption in the Philippines for 10 years, from 2008 to 2018. Figure 3.19 shows the changes in the total amount of primary energy, power generation, and CO_2 emissions. Figure 3.19 also shows that primary energy and power generation have increased 1.6 to 1.7 times over the last decade.

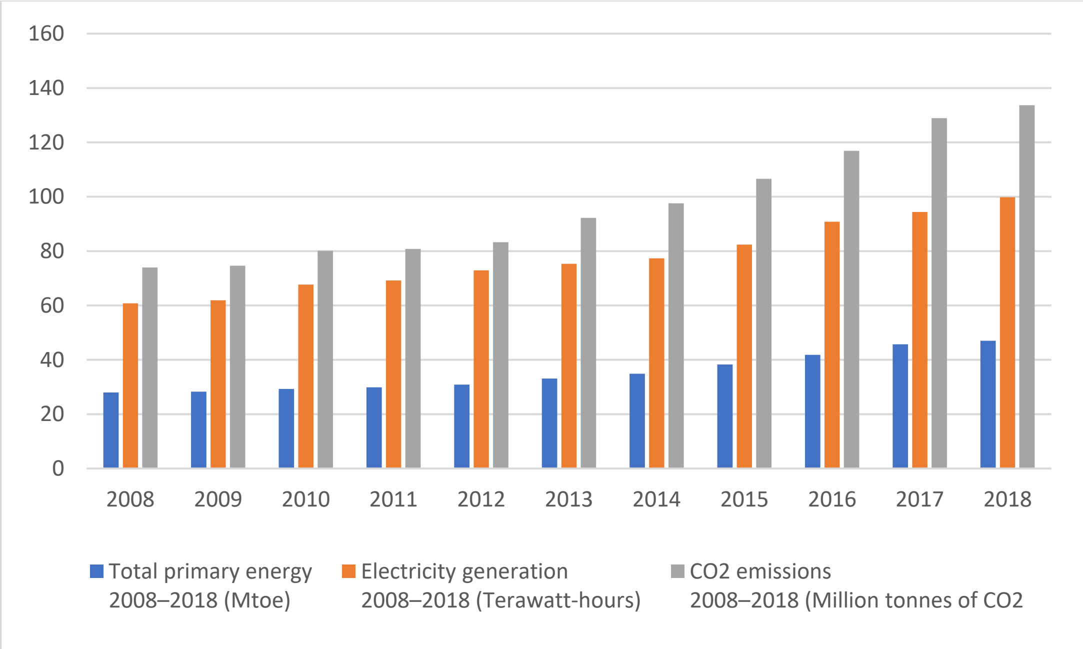
Of this, renewable energy was 1.3 times, while coal increased 2.5 times or more. As a result, CO_2 emissions were 1.8 times or more, more than the increase in primary energy.

Figure 3.18. Energy Consumption, 2008–2018



Source: BP Statistical Review of World Energy (2019).

Figure 3.19. Total Primary Energy and CO_2 Emissions, 2008–2018



Source: BP Statistical Review of World Energy (2019).

3.2. Power development plan

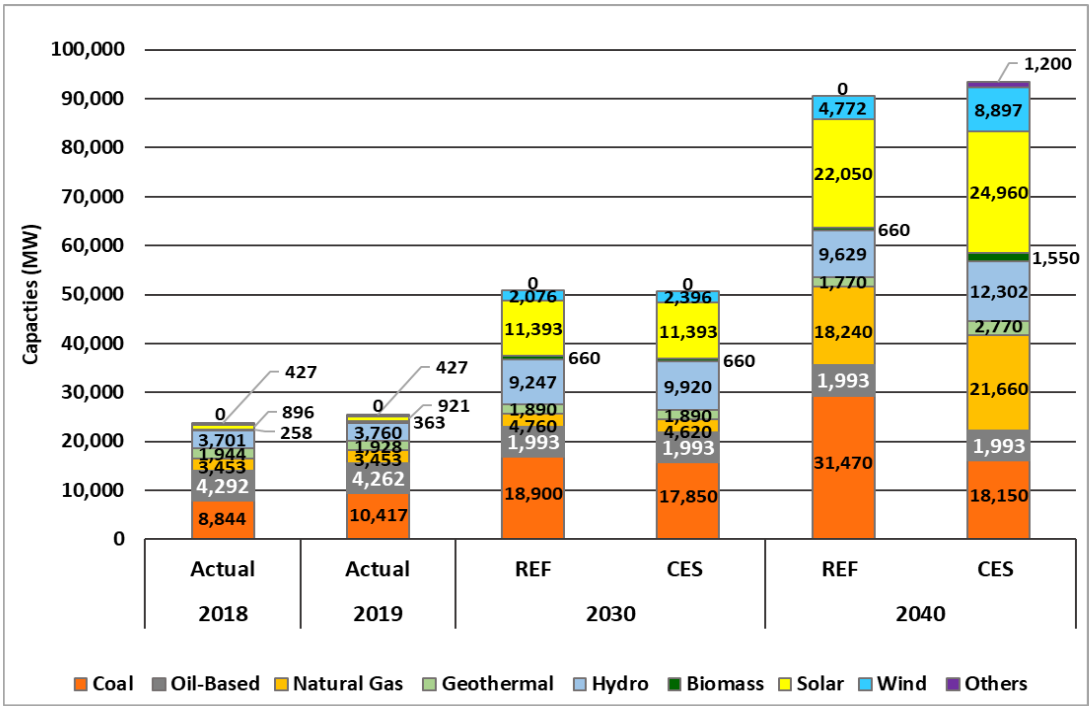
The Philippine government is currently soliciting opinions on the Philippine Energy Plan 2018–2040'. This energy plan shows two scenarios: the Reference Scenario (REF) and the Clean Energy Scenario (CES).

Regarding the power generation facilities, REF will generate 50,919 MW and CES, 50,722 MW. This is about two times in 2030, compared to the total amount of 25,531 MW at the end of 2019, and 1.8 times more in 2040, where REF is equal to 90,584 MW and CES, 93,482 MW. Figure 3.20 shows the 2018 and 2019 results of power generation facilities and the REF and CES plans for 2030 and 2040.

Regarding the 2019 results with the 2040 plans, REF plans to increase fossil fuels from 18,132 MW to 51,703 MW by about 2.9 times, and renewables from 7,399 MW to 38,881 MW by about 5.3 times. Coal, which has the largest proportion of fossil fuels, is planned to increase from 10,417 MW to 31,470 MW, about three times. Natural gas is the fastest growing fossil fuel during the period. It is forecasted to grow by 5.3 times from 3,453 MW in 2018 to 18,240 MW in 2040. Hydropower, which has the largest share in RE, is planned to be 2.6 times, from 3,760 MW to 9,629 MW. The largest growth in RE is solar power, which is a huge increase of about 23.9 times from 921 MW to 22,050 MW, surpassing natural gas and having the second-largest market share. In CES, CO_2 removal is clearly shown compared to the conventional plan. CES plans to increase fossil fuels from 18,132 MW to 41,803 MW by about 2.3 times, and RE from 7,399 MW to 51,679 MW by about seven times, which is a very large increase. Coal, which has the largest proportion of fossil fuels, is planned to increase slightly from 1.7

times to 10,471 MW to 18,150 MW. Natural gas will grow the most in fossil fuels, which is a significant increase of about 6.7 times from 3,453 MW to 21,660 MW, and it is planned to surpass coal. Hydropower, which has the largest share in RE, is planned to be about 3.3 times, from 3,760 MW to 12,302 MW. The largest growth in RE is solar power, which is a significant increase of about 27.1 times from 921 MW to 24,960 MW, surpassing natural gas and coal and having the top share.

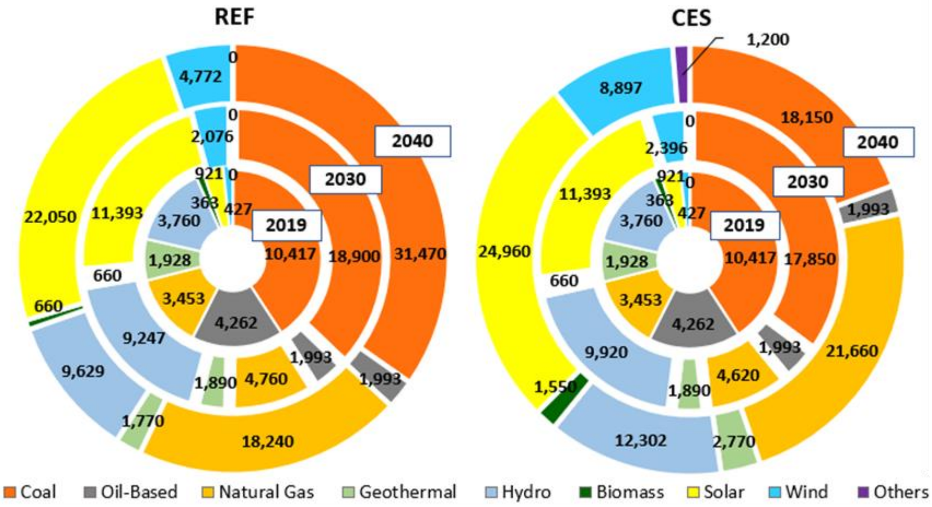
Figure 3.20. Total Installed Capacities by 2040, by Fuel (MW)



CES: Clean Energy Scenario, REF = Reference Scenario.
Source: DOE (2019).

Figure 3.21 shows the results of the comparison of power generation facilities between REF and CES in 2019 and the plans for 2030 and 2040.

Figure 3.21. Comparison of REF and CES



REF (MW)	2019	2030	2040
Fossil Fuel	18,132	25,653	51,703
RE	7,399	25,266	38,881

CES (MW)	2019	2030	2040
Fossil Fuel	18,132	24,463	41,803
RE	7,399	26,259	51,679

CES = Clean Energy Scenario, RE = renewable energy, REF = Reference Scenario.
Source: DOE (2019).

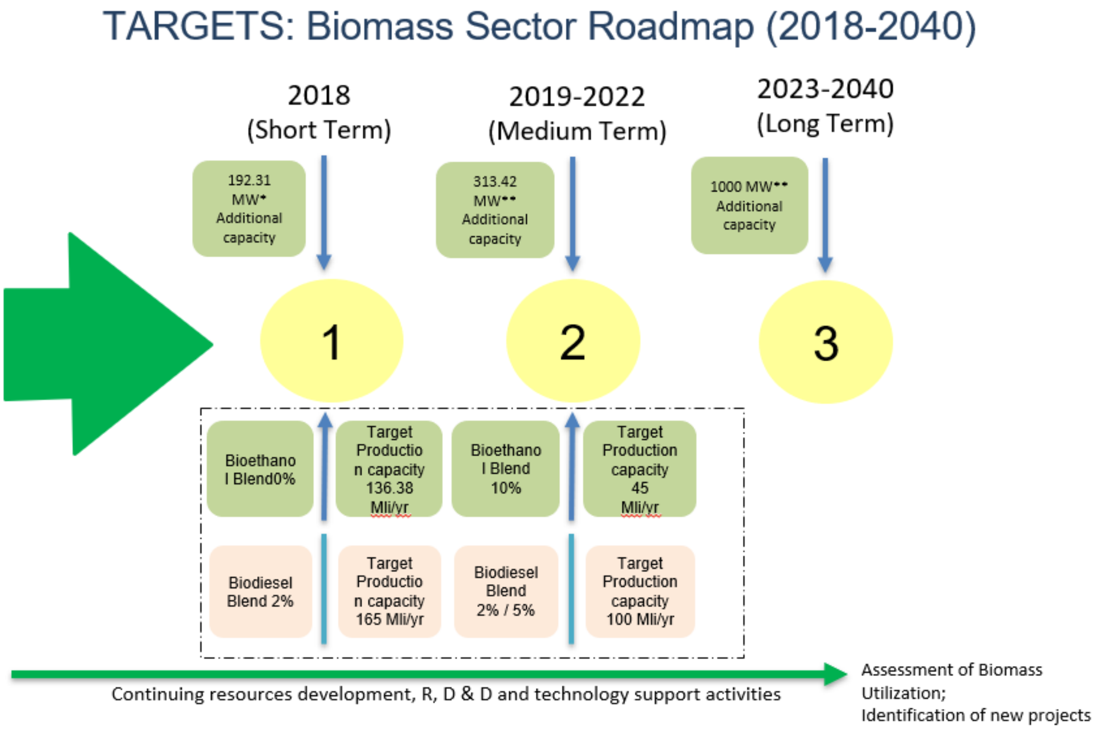
3.3. Biomass potential and biomass power plant

The Philippine Biofuels Act of 2006 requires the inclusion of biofuels in liquid fuels used in domestic automobiles. Therefore, the mixing of biodiesel in diesel automobile fuel and bioethanol in automobile gasoline has been promoted. However, it is only a little if mixed with automobile fuel, and it will be less than 200 MW in 2018.

The effective mixing of biomass with the fuel for power generation is also planned. In the 2040 plan, 1,550 MW of biomass is planned to be used.

Figure 3.22 shows the roadmap for the biomass sector.

Figure 3.22. Biomass Sector Roadmap



Source: Country presentation by Philippine representatives at the First Working Group Meeting (online) for the Phase II Study, 16 June 2020.

The capacity of biomass power generation facilities is planned to be 1,550 MW in the CES in 2040, which is extremely small at less than 2% of the total capacity of the power generation facility of 93,482 MW. It is planned to grow less than solar and wind power.

Biomass is expected to increase the capacity of power generation facilities to promote the CES.

3.4. Applicable technologies for biomass-to-energy

The total installed capacity for power generation in 2040 in the CES is 93,482 MW, which is about 3.7 times the actual value of 25,531 MW in 2019. The power generation facilities that use coal as fuel are planned to be about 1.7 times larger, and the ratio will be about 20%. Since there is concern that CO_2 emissions will increase in future energy plans in the CES, how to position biomass is essential.

The Philippines is made up of thousands of islands with a relatively small grid capacity. The surrounding islands also have many off-grid areas. As a result, power generation facilities are small to medium scaled. Most CFPPs are subcritical pressure power generation facilities of 400 MW or less, and most of them are CFB of 200 MW or less.

The following requests were made during the Philippine Department of Energy (DOE) and JCOAL meeting in December 2019.

- A 150 MW class CFB boiler is installed but the DOE would like to install one with a larger capacity.
- The DOE would like to continue the coal-fired power generation using CCT with high efficiency and low emission.

While the Philippine government announced that there would be no more new CFPPs to achieve climate change objectives, coal-fired power generation facilities are supposed to remain a crucial part of the national electricity mix even in the long term. Biomass is carbon neutral and widely available in the country, as the previous study indicates. In this context, biomass utilisation at CFPPs through cofiring is expected to prevent increased CO_2 emissions. As biomass is widely accepted in other countries, it would be a recommendable option to the Philippines as well.

There are technology and fuel options available. In addition to cofiring at PC boiler or CFB boiler, dedicated biomass firing would also be applicable depending on a project's requirements and conditions.

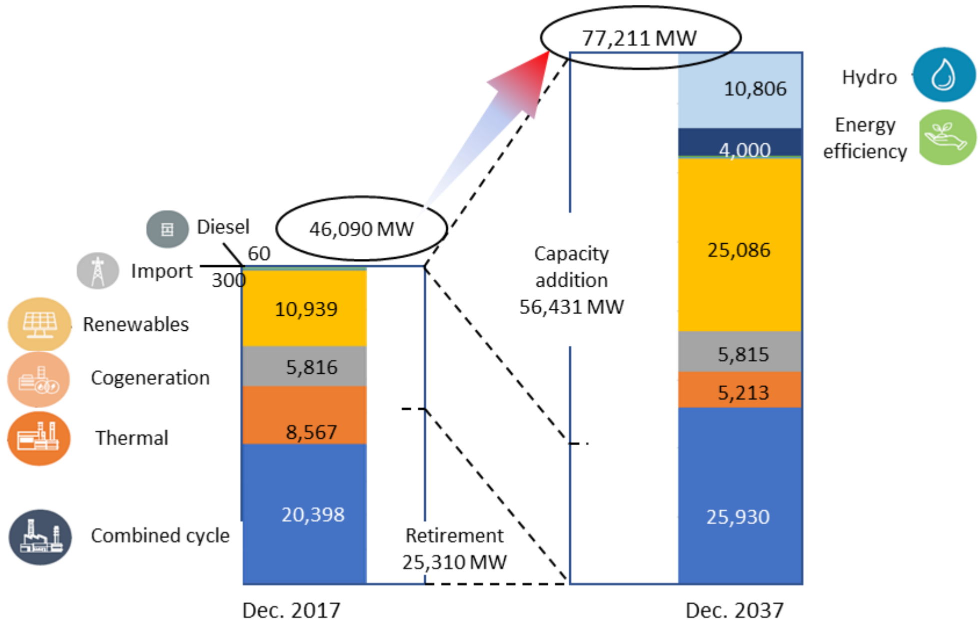
The CFB is relatively easy to use even if the fuel is biomass and can increase the cofiring rate. In PC-fired power generation, the current use is limited by the crushing equipment, so the cofiring rate is only a few percent. To increase the cofiring rate, it is necessary to appropriately modify the facility depending on the biomass type and the planned cofiring rate. The use of biomass in a new CFPP requires the planning of a power plant according to the area and scale. For small- and medium-scale power plants of 400 MW or less, we think that subcritical pressure CFB can be selected from biomass firing and cofiring depending on the region, grid connection, and available biomass type and amount. For large- and medium-scale power plants of 400 MW or more, grid connection is possible, and many options can be adopted. There is a plan to cofire a few percent of biomass as PC-fired power of USC to achieve high efficiency. In this case, torrefied biomass is used to increase the cofiring rate, but this rate will be about 20% or less. The CFB is used to increase the cofiring rate further and to diversify the types of biomass. The USC-type CFB has a proven track record and can be made highly efficient.

4. Thailand

4.1. Power development plan

According to the Power Development Plan, total power capacity will increase to 77,211 MW in 2037 from 46,090 MW in 2017. While 25 GW of relatively older and/or smaller plants will be retired, another 56 GW is expected for those newly commissioned. Its main energy source is the combined cycle and renewables.

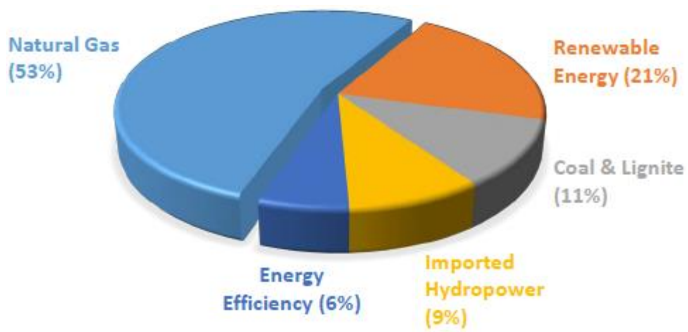
Figure 3.23. Power Development Plan (PDP 2018)



Source: WG presentation for the Study on Biomass and Coal Cofiring in the ASEAN Region, Electricity Generating Authority of Thailand (EGAT) (February 2019).

The Alternative Energy Development Plan focused on promoting energy production within the full potential of domestic renewable energy sources.

Figure 3.24. Target Energy Share in 2037 under the PDP and AEDP 2018



AEDP: Alternative Energy Development Plan, PDP = Power Development Plan (Thailand)
Source: WG presentation for the Study on Biomass and Coal Cofiring in the ASEAN Region (II), Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy (Thailand) June 2020).

AEDP 2018 aims to maintain the renewable energy target at 30% by 2037 by considering the following:

(1) Adding a 'Community-Based Power Plant for Local Economic Project' that involves 1,933 MW (biomass, biogas, and solar hybrid)
(2) Accelerating wind power purchasing by 2022 instead of 2037
(3) Adjusting the period of 'civil–state biomass power plant' COD (date of commissioning) to be 2022–2023

The revised PDP2018 is being considered and publicly heard by policymakers to achieve the above target. In the details, the community power plants, which use various types of biomass, biogas, and hybrid with other renewables such as solar, are planned to have the first quick-win projects of about 100–150 MW in 2020 for a total of 1,933 MW by 2024.

Regarding the thermal plant, the Electricity Generating Authority of Thailand (EGAT) will develop a 6.9 GW of eight gas-combined plants and a 0.6 GW of one coal-fired plant from 2020 to 2037. Further investigation of biomass and coal cofiring is to be considered for its technical adaptability.

4.2. Policy support for biomass utilisation

Thailand's Energy Policies under Disruptive Situation are expressed as '4D+E'– Digitalisation, Deregulation, Decarbonisation, Decentralisation, and Electrification (Table 3.9).

Table 3.9. Thailand's Energy Policies

Digitalisation	Enhance the transmission system to be a 'smart grid'
	Support the development of ESS to increase the stability of community and large power plants
	Becoming the ASEAN energy commercial centre
Deregulation	Originating the 'Sandbox' Project for energy innovation development
	Promote the 'energy start-up' concept
	Conduct flexibility of ENCON fund utilisation to promote the community's energy business
	Increase the opportunity for the public to purchase electricity ('prosumerism')
Decarbonisation	Promote the production and utilisation of electricity from solar to bioenergy
	Absorb and increase the value of agricultural products (such as palm oil) by using these as alternative fuels
Decentralisation	Promote P2P electricity trading by supporting electricity conveying through on-grid and off-grid systems
	Promote the installation of community power plants
	Proceed to map the community power plant network
	Support electricity balance in the southern area and the Eastern Economic Corridor
Electrification	Extend the EV network
	Promote the use of EV

ENCON = energy conservation, ESS = energy storage system, EV = electric vehicle, P2P = peer to peer.
Source: Adapted from the WG presentation for the Study on Biomass and Coal Cofiring in the ASEAN Region (II), DEDE (June 2020).

The Ministry of Energy (Thailand) launched the Community-Based Power Plant for Local Economic Project, which is renewable energy–distributed generation such as biomass, biogas, and solar hybrid systems. The principle and concept were approved by the National Energy Policy Council on 16 December 2019.[4] Its principles are listed as follows. Table 3.10 shows the newly introduced FIT incentives.

(1) Renewable energy type
  (a) Biomass
  (b) Biogas (wastewater)
  (c) Biogas (energy crop)
  (d) Solar hybrid with biomass and biogas (1–3) can add an energy storage system and can use a fossil fuel–only start-up plant
(2) Power purchase is FIT scheme and non-firm agreement
(3) Plant installed capacity does not exceed 10 MW
(4) The community must own 10%–40% shares of the power plant
(5) The revenue from the sale of electricity must be shared by the community fund (at least 0.25 ฿/kWh for biomass and biogas, 0.50 ฿/kWh for solar).

Table 3.10. Tariff Rate – Community Power Plant

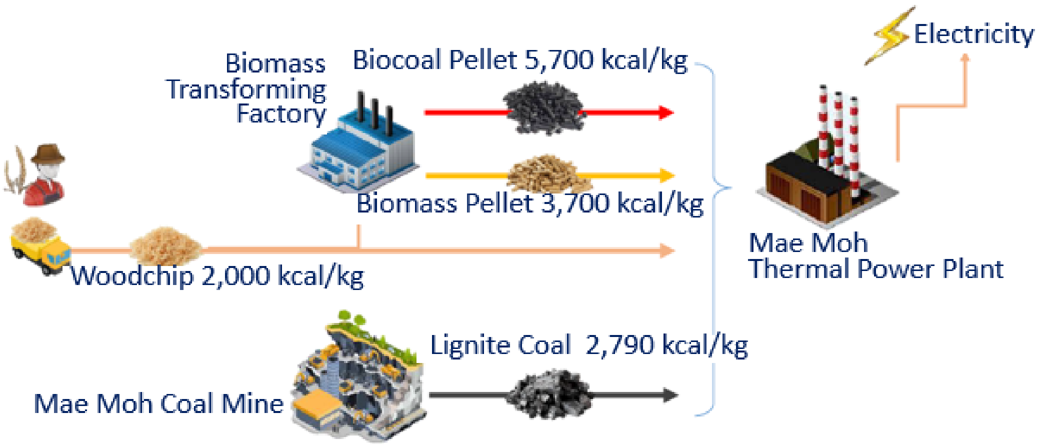
Type of Renewable Energy	FIT (฿/kWh)			Support Period	FIT Premium (฿/kWh)
	FIT_F	$FIT_{V(2019)}$	FIT	(Year)	Southern Border Provinces Area
1. Solar	2.90	-	2.90	20	0.50
2. Biomass					
- Installed capacity ≤3 MW	2.61	2.2382	4.8482	20	0.50
- Installed capacity > 3 MW	2.39	1.8736	4.2636	20	0.50
3. Biogas (wastewater/waste)	3.76	-	3.76	20	0.50
4. Biogas (100% energy crops)	2.79	2.5825	5.3725	20	0.50
4. Biogas + biogas (Waste) ≤25%	2.79	1.9369	4.7269	20	0.50

Notes: FIT_F = fixed electricity prices paid to renewable energy producers for each unit of energy produced and injected into the electricity grid. (Calculate from investment cost and fixed operations and maintenance (O&M).
$FIT_{V(2019)}$ = Electricity prices paid to renewable energy producers for each unit of energy produced and injected into the electricity grid, but there is an escalation rate every year (normally use core inflation rate, calculate from variable cost, fuel cost, variable O&M, etc.)
FIT Premium = Extra feed-in tariff for a short period to convince investors on the plant type and site.
Source: Working Group presentation for the Study on Biomass and Coal Co-combustion in the ASEAN Region (II), EGAT (June 2020).

The priority of biomass use is focused on the Community-Based Power Plant Project as a small and distributed generation. On the other hand, many modifications are required to cofire biomass with coal at the existing CFPPs (Figure 3.25). The Government of Thailand does not support coal biomass cofiring.

[4] https://www.greennetworkthailand.com/

Figure 3.25. Fuel Flow for Cofiring Study at Mae Moh Thermal Power Plant



Source: WG presentation for the Study on Biomass and Coal Cofiring in the ASEAN Region, EGAT (February 2019).

4.3. Current status of biomass power plants

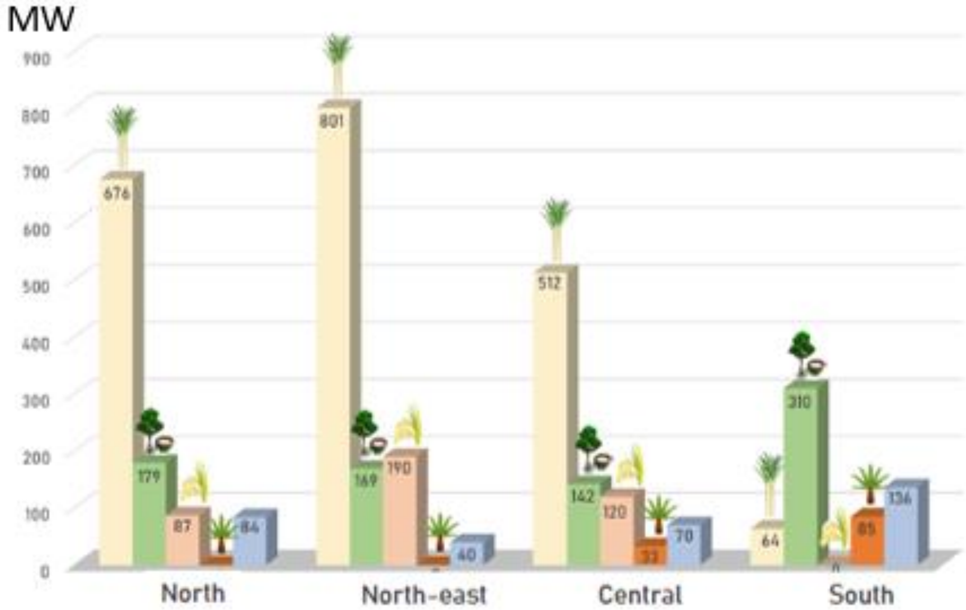
Table 3.11 and Figure 3.26 show the current situation of biomass utilisation in Thailand. Bagasse and leaves are the largest biomass source in Thailand. The total capacity of the domestic biomass power plant is 3,700 MW, out of which 2,052 MW is bagasse and leaves. Other major sources are rubberwood waste, rice husk, and palm cluster.

Table 3.11. Biomass Potential in Thailand

Biomass		Potential (Mt/y)	Biomass Power Plant (MW)
	Rice husk	1.38	400
	Bagasse and leaves	6.87	2,052
	Palm cluster	0.99	118
	Rubberwood waste	0.29	800
	Others		330

Source: WG presentation for the Study on Biomass and Coal Cofiring in the ASEAN Region, EGAT (February 2019).

Figure 3.26. Biomass Fuel Plant in Thailand



Source: WG presentation for the Study on Biomass and Coal Cofiring in the ASEAN Region, EGAT (February 2019).

In operation are 256 biomass power plants under a power purchase agreement (PPA). By 2017, 688 biomass (5,053 MW) projects requested a PPA, but 60% of the projects were cancelled for various reasons. The Community-Based Power Plant for Local Economic Project is to accelerate the implementation of such biomass projects.

Based on this new policy, 700 MW of electricity generated by the community-based power plants will be allowed to purchase and supply the national grid in 2020. Out of 700 MW, the 'quick-win project' must be a PPA in 2020, and electricity is supplied to the grid within 12 months after contract signing. Power purchased should be a maximum of 100 MW.

Table 3.12. shows examples of the community power plant project implemented by EGAT.

Table 3.12. EGAT's Pilot Project – Community Power Plant

Project		Location	Capacity	Biomass
	(1) Mae Jam Community Power Plant 	Mae Jam District, Chiang Mai Province	Biomass 3 MW	Corncobs, corn stalks, bamboos, fast-growing trees (Acacia)
	(2) Thap Sakae Community Power Plant 	Thap Sakae District, Prachuap Khiri Khan Province	Biogas Energy crop 3 MW	Napier grass and other energy crops

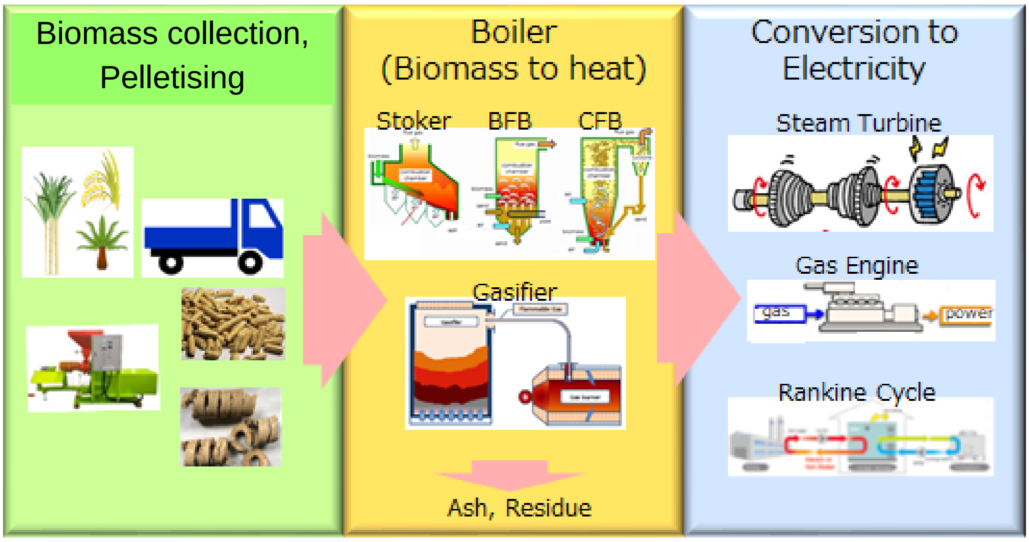
Source: WG presentation for the Study on Biomass and Coal Cofiring in the ASEAN Region (II), EGAT (June 2020).

4.4. Applicable biomass-to-energy technologies

During the online discussion in June 2020 of this study's WG members, JCOAL overviewed the applicable technologies for biomass and coal cofiring. It was suggested that a relatively larger CFPP, such as pulverised coal (PC) or CFB boiler, is advantageous for cofiring to mitigate its flue gas GHG. From the viewpoint of the total amount of GHG mitigation in a specific country, if the coal-fired plant is a mainstay of generation, cofiring is an effective measure. For example, in Japan's case, biomass cofiring is normally implemented by the major electric power companies. Biomass, which is mostly imported wood chip or pellet, is co-combusted in the existing USC boiler of 1,000 MW. Although its mixing ratio is 1% to 5%, the total volume of GHG mitigation is quite huge.

As described in Sections 4.2 and 4.3, the Thai government aims to utilise its domestic agricultural waste as biomass energy sources by adapting the concept of 'community power plant project', which needs smaller and distributed generation technologies. Figure 3.27 shows applicable technologies for biomass-to-energy in three portions: (i) biomass collection, (ii) biomass to heat conversion, and (iii) heat to power conversion. The technique must be properly selected for each portion. The technology chosen should consider the electricity demand of nearby communities, applicable biomass type, volume, seasonal variation, and the economics of equipment costs.

Figure 3.27 Applicable Technologies for Biomass to Energy



Source: Study Team.

- Biomass collection
  Biomass collection and supply to a community power plant are closely related to the volume of available agricultural waste, collected regularly in surrounding areas. Since biomass is bulky to handle in a combustion plant, pre-treatment to densify the biomass, such as pelletisation, is recommended.

- Biomass to heat conversion
  The boiler type also depends on the volume of biomass in the surrounding areas. If the biomass volume is large enough, a CFB boiler is most effective to be adapted for biomass combustion. On the other hand, if the biomass volume is limited, other types of boilers must be selected. The stoker type is one that can be adapted in such cases.

  The output from a boiler is not limited to 'steam'; in some cases, 'gas' is another type of conversion from biomass during heat decomposition. In such a case, the gasifier might be another option. The use of ash and/or residue will also be considered during the operation of the plant.

- Heat to power conversion
  The conventional type of power generation is a turbine-driven generator. If high-calorie gas is available during the combustion of biomass, a gas engine drives the generator. The Rankine cycle is another option to generate power from a small energy flow.

(1) Rice husk briquette

Rice husk is advantageous when used as biomass fuel because of its sufficient volume and collection efficiency as it can easily be densified. This report proposes the idea to make rice husk briquettes for the local community power plant. Figure 3.28 and Table 3.13 show a grind mill developed by Tromso Co., Ltd. This technology can make various shapes of briquettes, such as column shape, curl shape, and powder through different attachments. This grind mill briquette machine would provide additional benefits through on-site curl briquette production, as long as conventional trucks for transportation and a power source at the rice field are available. This advantage of portability can improve the flexibility of biomass fuel collection.

Figure 3.28. Grind Mill for Rice Husk Briquette

Source: WG presentation for the Study on Biomass and Coal Cofiring in the ASEAN Region (II), Tromso (June 2020).

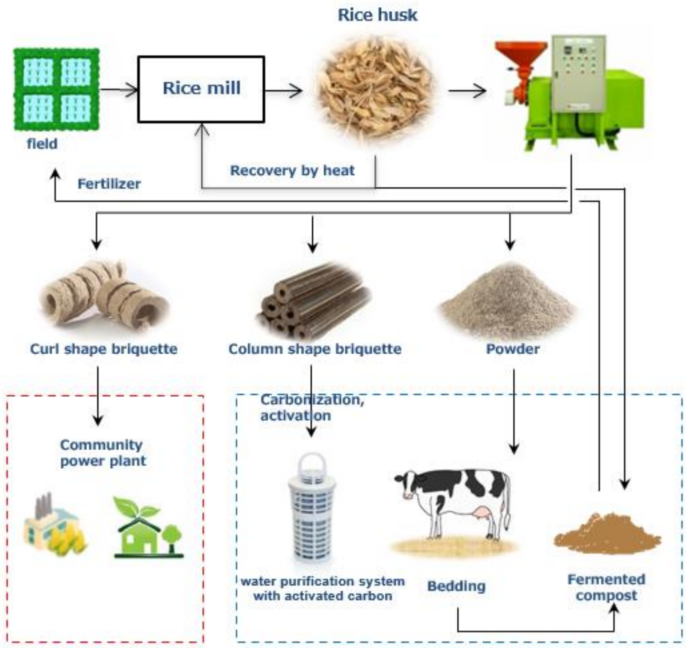
Table 3.13. Specifications of a Grind Mill

<table>
<tr><th>Item</th><th>Specification</th><th>Rice Husk Briquette</th></tr>
<tr><td>Processing capacity</td><td>Approx. 300 kg/h</td><td rowspan="6">
Curl shape</td></tr>
<tr><td>Dimension</td><td>2250 (W) x 1100 (D) x 1550 (H)</td></tr>
<tr><td>Weight</td><td>Approx. 985 kg</td></tr>
<tr><td>Power</td><td>AC200–400 V 3f 50–60 Hz</td></tr>
<tr><td>Motor</td><td>30 kW</td></tr>
<tr><td>Heater</td><td>None</td></tr>
</table>

Source: WG presentation for the Study on Biomass and Coal Co-combustion in the ASEAN Region (II), Tromso (June 2020).

Figure 3.29 shows an application of rice husk briquette technology for sustainable development of the local community, including the community power plant.

Figure 3.29. Application of Rice Husk Briquette for Sustainable Development



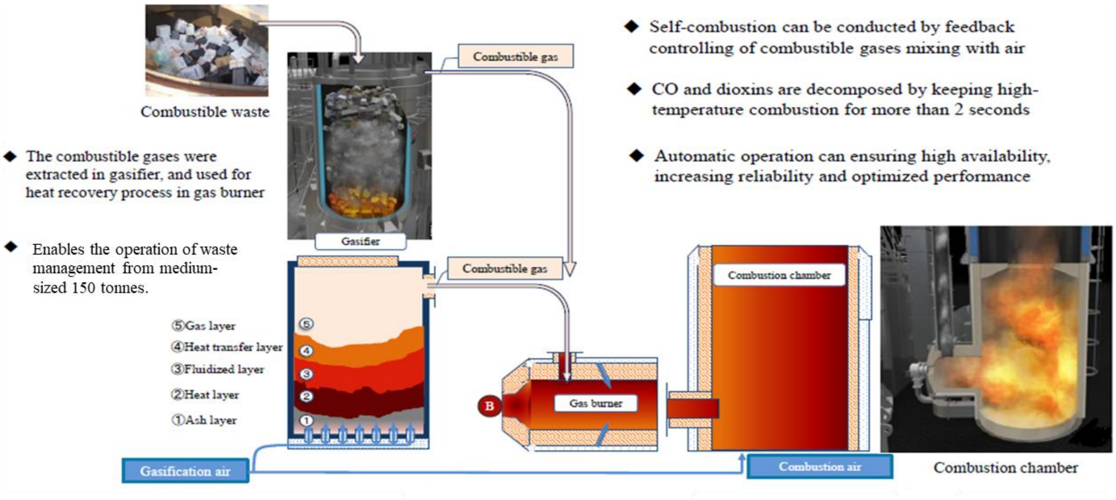
Source: Adapted from WG presentation for the Study on Biomass and Coal Co-combustion in the ASEAN Region (II), Tromso (June 2020).

This can provide biomass fuel to the community power plant and activated carbon for water purification and/or powder material for livestock bedding. These kinds of technology applications can potentially contribute and materialise the 'resource circulation community'.

(2) Waste treatment by gasifier

Figure 3.30 illustrates a waste treatment and energy recovery system by gasifier. This kind of batch-type gasifier has a simple structure and enough durability to decompose biomass.

Figure 3.30. Waste Treatment and Energy Recovery System, by Gasifier



Source: Adapted from WG presentation for the Study on Biomass and Coal Cofiring in the ASEAN Region (II), Kinsei Sangyo (June 2020).

If sufficient biomass is supplied from surrounding areas, the gasifier can be expanded to connect in parallel (Figure 3.4-8). Self-combustion can be conducted by feedback controlling of combustible gases mixing with air. CO and dioxins are decomposed through high-temperature combustion. Multiple integrated gasifiers enable continuous operation through the installation of a time-scheduled programme. Also, another potential in treating municipal waste in the same gasifier is if the capacity is large enough. There are several options to use flammable gas in the downstream of gasifiers. Combustion boiler and steam turbine are the most conventional way. A gas engine is another applicable option to convert heat to electricity.

(3) Organic Rankine Cycle (ORC) Technology

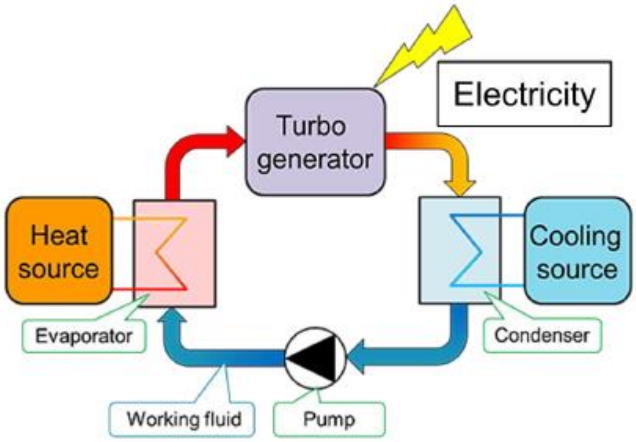
There might be some constraints in adapting high-efficiency turbines and generator facilities in a small-scale power plant concerning the technical aspects and investment. In these cases, ORC is sometimes applied to generate power. Its characteristics and features are as follows:

- Power generation at low-temperature heat source (70°C–150°C)
- Distributed power generation (20 kW–1,000 kW: Multiple operations)
- Low operating cost
- Low maintenance

A practical application of heat recovery is, for example, (i) waste heat from various industries such as genset, factory, incineration plant; and (ii) renewable heat source, such as geothermal, biomass, solar thermal.

Figure 3.31. shows the principles of ORC.

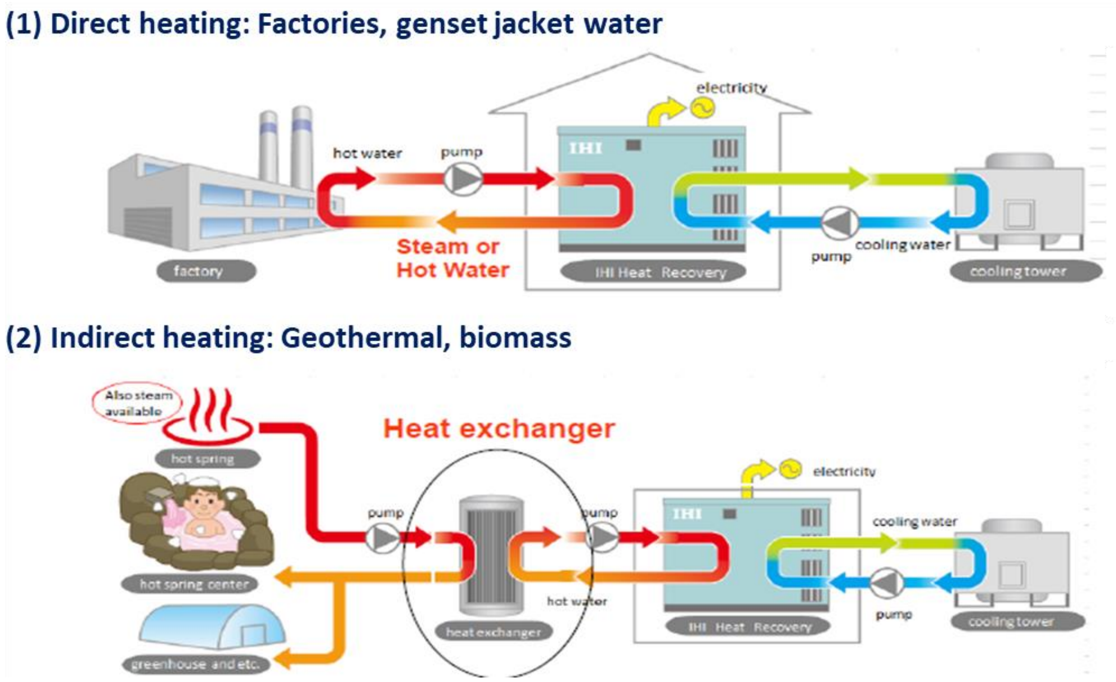
Figure 3.31. Principles of Organic Rankine Cycle



Source: WG presentation for the Study on Biomass and Coal Cofiring in the ASEAN Region (II), IHI (June 2020).

Electricity is generated in turbo generators by circulated heat exchanging fluid, heated up to enough energy from heat sources such as waste heat, steam, etc. An organic fluid of low-boiling-point material is typically used as heat exchanging fluid. This is the so-called binary generation system. Two types of applications are available: direct and indirect heating (Figure 3.32).

Figure 3.32. Direct and Indirect Conversion of Heat to Electricity



Source: Adapted from the WG presentation for the Study on Biomass and Coal Cofiring in the ASEAN Region (II), IHI (June 2020).

4.5. Policy recommendations

Resource circulation, waste-to-energy, and financial support under bilateral cooperation should be considered to materialise each community power plant project and achieve the target of the community power plant policy.

Biomass and coal cofiring in existing CFPPs is another measure to utilise a large volume of domestic biomass.

(1) Resource circulation

By-products of community power plants should be used for the sustainable development of the community. One example is shown in Figure 3.4-7. Discharged ash can be used as feed material for cement and/or block production. If there is no problem with the quality and composition of the ash, the ash can be applied as fertiliser and/or soil conditioner. The overall optimisation of the use of by-products might be the way to realise a carbon-neutral or carbon-minus community and improve the community's economy.

(2) Waste-to-energy, municipal waste treatment

Simultaneous feeding of municipal waste with biomass in a combustion chamber is a measure to address municipal waste issues. In this option, flue gas treatment, such as de-SOx, de-NOx, and SPM filtering facilities, is essential.

(3) Financial support under bilateral cooperation

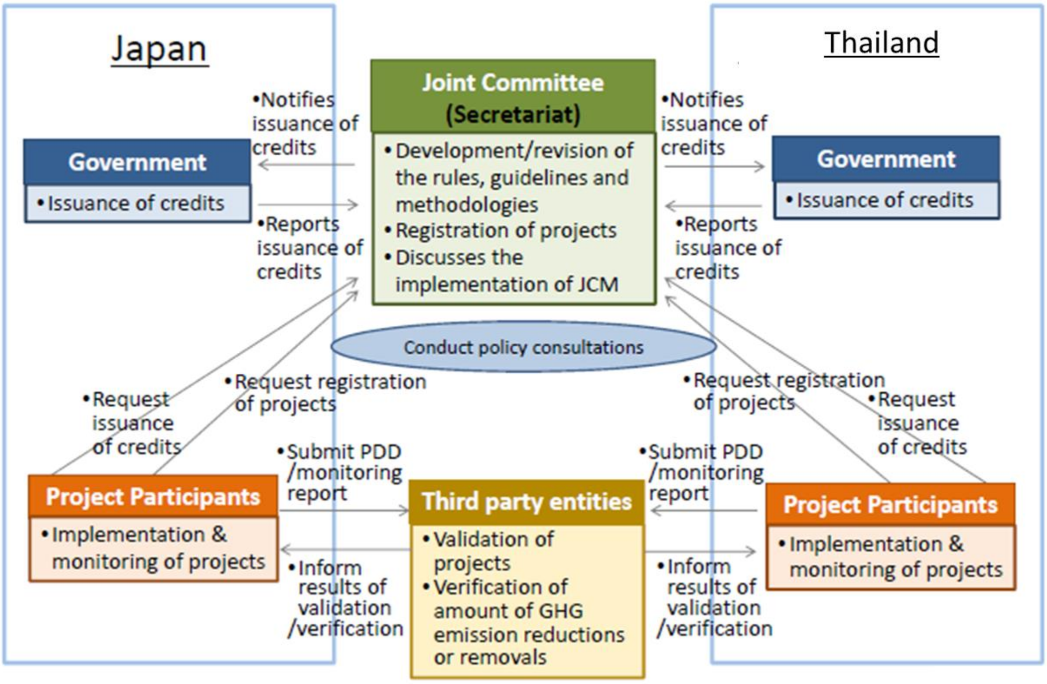
The plant facility's financial support is a critical item to materialise the community power plant project.

The Joint Crediting Mechanism (JCM) (Figure 3.33) is to facilitate the diffusion of leading low-carbon technologies, products, systems, services, and infrastructure as well as the implementation of mitigation actions and contribution to the sustainable development of developing countries.

This also contributes to the ultimate objective of the United Nations Framework Convention on Climate Change by facilitating global actions for GHG emission reductions or removals. Thailand and Japan signed a bilateral document that introduced the JCM on 19 November 2015.[5] Many projects are ongoing in Thailand's industry sector regarding solar power, energy recovery, and other energy-saving fields. The biomass power plant is thought to be consistent with the JCM concept.

[5] https://www.jcm.go.jp/th-jp.

Figure 3.33. Scheme of the Joint Crediting Mechanism (JCM)



GHG = greenhouse gas, PDD = project design document.

Source: MOFA (n.d.), https://www.mofa.go.jp/ic/ch/page1we_000105.html.

(4) Biomass and coal cofiring in existing CFPPs

Biomass and coal cofiring in existing CFPPs should be considered in terms of energy security, flexibility, and maximum use of existing infrastructures, not only domestic biomass utilisation. In this regard, further studies on essential technology and investment for biomass and coal cofiring are recommended.

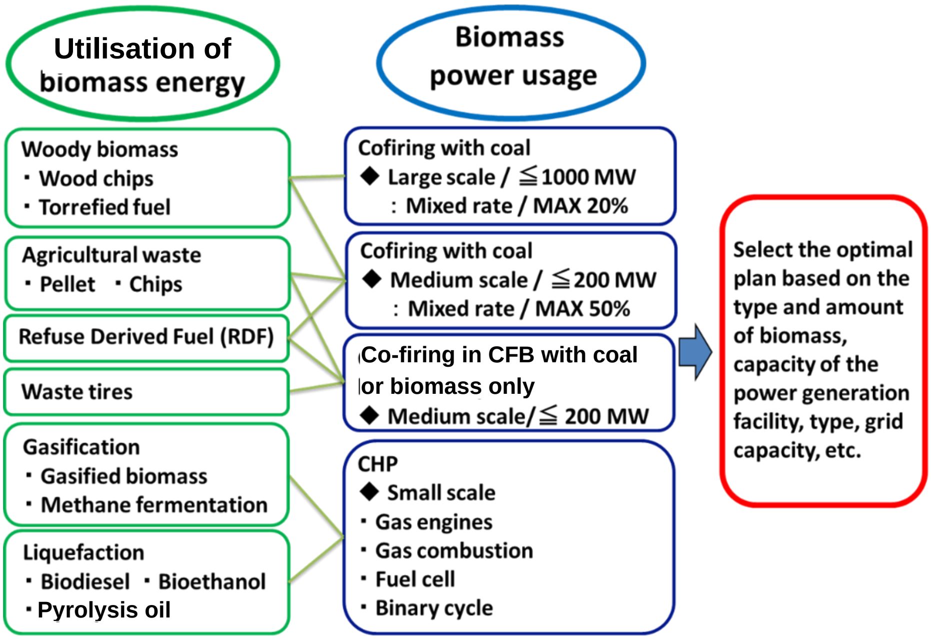
Chapter 4

Recommendations for the ASEAN Region

1. Available Technologies and Technical Solutions

It is always important for an energy project, regardless of scale, to identify a choice – or choices, if available – of technologies and technical solutions most suitable to the given conditions of the project. In this regard, we would like to overview the available technologies and technical solutions that applicable to the AMS (Figure 4.1).

Figure 4.1. Available Technologies and Technical Solutions for ASEAN Member States



CFB = circulating fluidised bed, CHP = combined heat and power.
Source: Study Team.

Biomass energy can be used either directly or through processing, such as liquefaction and gasification. Direct use includes the use of wood chips and woody biomass as a torrefaction or semi-carbonised fuel. Agricultural wastes are available for direct use or in the form of pellets or chips. Waste tires are a well-known fuel called tire-derived fuel. The use of derived gases, such as biomass gasification and methane fermentation, is also proven. The other option is liquefied biomass, such as biodiesel or bioethanol.

A biomass project developer should identify the optimal combination of technology, equipment, and capacity considering demand, grid capacity in case of grid-connected, and the available type and volume of biomass.

On biomass utilisation in the power sector, one of the most practical options is cofiring with coal at a pulverised CFPP. The technically proven and viable cofiring ratio is 20% for large scale (600–1,000 MW) and 30%–50% for medium scale (200–<600 MW).

Pulverisation is not required in the case of CFB, and dedicated biomass firing will be available in addition to the choice of cofiring with coal. The scale of CFB units is generally smaller, with most commercially operating units being 200 MW or so. However, recent technology development has enabled proven USC-level high-efficiency and environmentally compliant 550 MW CFB units.

There are also technologies combined with heat utilisation such as gas engine combined heat and power (CHP), gasification gas combustion CHP, fuel cell CHP, and binary power generation CHP for units smaller than 5 MW.

2. Available Technologies and Technical Solutions: By-Country Recommendations

Chapter 3 discussed the by-country situation of the four target AMS in pursuit of biomass utilisation possibilities through biomass cofiring or dedicated biomass firing.

Below is a summary of the by-country recommendations.

2.1. Cambodia

The Government of Cambodia sees that the country has high potential in wood biomass by fuel tree planting, considering that agricultural biomass utilisation is mostly established and no more surplus for power generation is expected. The following are the advantages of wood biomass for power generation compared to agricultural biomass clarified by the government.

- Planned and stable fuelwood supply is possible in the case of tree planting.
- Even in the case of cultivation of energy trees, the fuel cost holds only a small fraction of total electricity generation cost (11% in the case of 13 kWh monthly electricity consumption per household). Using agricultural residues does not reduce the cost dramatically.
- The purchasing cost of cultivated trees is not high (about $20/t). Using agricultural residue could be more expensive when transportation cost occurs.
- Woody biomass is generally the best fuel for gasification.

Wood biomass utilisation, often criticised for possibly leading to deforestation, will be more sustainable if such tree plantation is combined with low-value wood as a by-product of a traditional timber harvest. An appropriate regulatory framework by the government for overall forest management, not limited to tree planning, and market development should be established, and well-organised management by the developer and/or the concerned community should be ensured.

a) Conduct a basic study to identify the availability of wood biomass resources in terms of amount, areas, and prices. Collaboration with forestry experts shall be crucial, since the study must consider sustainable tree planting and wood biomass utilisation.

b) Following the basic study, conduct a model study for biomass collection and procurement with the community and community-based organisations' roles in mind.

c) Biomass technologies are to be also studied in close cooperation with biomass power–related technology specialists.

d) Literature study complemented with some interviews to identify financing schemes for dedicated biomass firing would be helpful.

e) In parallel with the previous studies, the government is expected to make policy efforts to consider and set up incentives for biomass cofiring in existing and incoming CFPPs. Wood biomass cofiring has been implemented in many countries, including Japan. Thus, no major studies may be required to recommend power plant producers for biomass cofiring.

f) Based on the outcomes of the studies in (a), (b), (c), a model project on dedicated biomass firing well connected to the community and community-based organisations is to be planned and implemented.

2.2. Indonesia

The government of Indonesia continues policy efforts to increase the contribution of renewable energy in the energy mix. In the power sector, the government, in close cooperation with the PLN, is taking various measures, amongst others, tests for promotion, and disseminates biomass use to enhance the national efforts to commit to the Paris Agreement. In this context, we would like to highlight the following two recommendations:

- Biomass power, by providing options for village electrification through the sales of off-grid captive power to the PLN or direct supply of such off-grid biomass power to the local area, would be conducive to the government's acceleration plan of electrifying 2,500 villages with over 10 million people.
- While ample amounts of corn and coconut wastes are available throughout the year, small-scale farmers might have barriers in procurement, i.e. collecting and transporting them to the power plant. In this context, a cooperative would play a key role in assisting local farmers. Further, a special purpose association involving such farmers, business owners, and related organisations would be more functional in managing biomass throughout the procurement value chain, i.e. for collection, transportation, and supply.

Working with a cooperative or a cooperative association would result in benefits like tax exemption, which will improve the project's economy. This, together with the related jobs created, will enhance the local economy as well.

2.3. Philippines

- Coal-fired power will continue to play an important role, but it is essential to control the increase in CO_2 emissions.
- The use of biomass in coal-fired power generation facilities is being implemented in many countries. In addition to cofiring biomass with PC-fired boilers and CFBs are CFBs

dedicated to biomass combustion. Fossil fuel consumption has been reduced for biomass use. Since biomass is carbon neutral, it is advantageous in terms of CO_2 reduction in power generation facilities.

- Biomass with coal-fired power can also be used with existing coal-fired power. In PC-fired boilers, the cofiring rate is generally limited to a few percent because the amount of biomass used is limited by the crusher's capacity. On the other hand, in CFB, since restrictions are few due to the crushing device, the cofiring rate can increase and the biomass can be exclusively burned. To increase the biomass cofiring rate in the existing CFPP, it is necessary to appropriately modify the equipment according to the type of biomass and the planned cofiring rate.
- The use of biomass in a new CFPP necessitates the planning of a power plant according to the site area and facility scale. For small and midsized power generation facilities of 400 MW or less, a CFB with subcritical pressure can be selected according to the installation area, the presence or absence of grid connection, and the type and amount of available biomass.
- For relatively large-scale power generation facilities of 400 MW or more, grid connections are used, and there are many options. It is also possible to cofire biomass as a USC-PC-fired power generation facility to make it highly efficient. In this case, torrefied biomass is used to increase the cofiring rate, but the cofiring rate is 20% or less. USC-type CFBs have a proven track record and can improve efficiency.

2.4. Thailand

By-products throughout the community power plant should be used for the sustainable development of the community. Discharged ash can be utilised as feed material for cement, block production. The overall optimisation of by-products use might be the way to realise a carbon-neutral or carbon-minus community and improve the community economy.

The simultaneous feed of municipal waste with biomass in a combustion chamber is a measure to address municipal waste issues. In this option, flue gas treatment such as de-SOx, de-NOx, and SPM filtering facilities, is essential.

Financial support of the plant facility is a critical item to materialise the community power plant project. The JCM is to facilitate the diffusion of leading low-carbon technologies, products, systems, services, and infrastructure as well as the implementation of mitigation actions and contribution to the sustainable development of developing countries. The biomass power plant is thought to be consistent with the concept of the JCM.

Biomass cofiring in existing CFPPs should be considered in terms of energy security, flexibility, and maximum utilisation of existing infrastructures, not only domestic biomass utilisation. In this regard, further studies on essential technology and investment for biomass cofiring is recommended.

3. Policy Recommendations for ASEAN

3.1. Benefits of biomass cofiring at coal-fired power plants

Coal is an affordable, available, and reliable fuel for power generation; yet, it is also the largest emitter of all fuels. Biomass, as a renewable and carbon-neutral generation source, is advantageous as it contributes to the reduction of CO_2 emission.

ASEAN is expected to undergo energy transition, where massive introduction of renewables is expected., Achieving grid flexibilisation is crucial in making a dynamic shift to introduce renewables energy on a massive scale in ASEAN since renewables energy is inherently variable and intermittent. Such massive introduction may cause system fluctuation if no measures are taken. In this context, coal and biomass have similar advantages in their competency in flexible operation that is crucial in enabling successful energy transition. Coal is excellent in supply reliability but is a large CO_2 emitter. Biomass is carbon-neutral, but its supply is seasonal. So, both are complementary and would make a good combination. This complementary relation between coal and biomass is a key to understanding biomass cofiring.

3.2. Benefits of dedicated biomass firing

Thanks to policy efforts in the past decades, a few AMS have achieved 100% electrification, and others are supposed to follow. However, those following the AMS seem to be struggling to achieve a few percent more towards full electrification. In this connection, dedicated biomass firing would be a suitable option for rural electrification and social development as it is small scale, labour intensive. It is also less costly, procurement is ensured by indigenous fuel utilisation, less intermittent (only seasonal), and options are available for both off-grid and on-grid generation.

3.3. Envisaged policy initiatives to facilitate biomass utilisation in the power sector of the AMS

ASEAN and respective AMS are expected to initiate the following as part of their facilitation programmes for biomass use:

(1) Survey and evaluate biomass resources to ensure that relevant policy implementation and actions go in the right direction.

(2) Ensure networking and association with all stakeholders and organisations that would support and/or facilitate or benefit from programmes and projects with biomass power.

(3) Conduct a comprehensive model study on biomass power generation technology and finance, and supporting schemes, such as organisational set-up and increased job opportunities, given the importance of implementing local electrification and rural development programmes combined with a biomass firing project.

(4) Deliberate and consider economic incentives to implement such programmes and projects. Incentives are essential, especially at the initial stage of introduction.

(5) Forge measures to promote biomass collection, such as creating regional bases and promoting related employment, for which formulation of a new cooperative association or leveraging existing cooperatives would be a key.

(6) Formulate a platform involving both in-region and external experts to discuss relevant technical, policy, and financial issues to further facilitate biomass utilisation and learning opportunities from international cooperation projects and collaboration activities.

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Appendixes

Appendix 1: The First Working Group (WG) Meeting

Attendance List

Country	Institution	Member(s)
Cambodia	Ministry of Mines and Energy (MME)	Mr. PHAN Bunthoeun, Deputy Director, Department of Thermal and Combustion Energy
	Electricity Authority of Cambodia (EAC)	Mr. CHHUN Ratana, Chief, Regulation and Licensees Section
	Electricite Du Cambodge (EDC)	Mr. BOU Dolla, Deputy Chief, Thermal and Solar Division
Indonesia	Ministry of Energy and Mineral Resources (MEMR)	Ms. Elis Heviati, Deputy Director for Investment and Cooperation of Bioenergy Directorate of Bio Energy Director General for New Energy, Renewable Energy and Energy Conservation
	PT. PLN (Persero)	Mr. Agung Wibowo Engineer, System Planning Division, PT. PLN (Persero)
Philippines	Department of Energy (DOE)	Ms. Ruby B. De Guzman, Chief Science Research Specialist, Biomass Energy Management Division, Renewable Energy Management Bureau (REMB)
		Mr. Jensen M. Alvarez Senior Science Research Specialist, Biomass Energy Management Division Renewable Energy Management Bureau Department of Energy
	Meralco Powergen Corporation	Litz M. Manuel-Santana, Vice President for External Affairs
Thailand	Ministry of Energy	Dr. Yaowateera Achawangkul, Mechanical Engineer, Senior Professional Level, Department of Alternative Energy Development and Efficiency (DEDE)
		Dr. Weerawat Chantanakome, Special Counselor on International Affairs (as an advisor)
	Electricity Generating Authority of Thailand (EGAT)	Mr. Chawit Chongwilaiwan, Head, Renewable Energy and Power Plant Survey and Potential Appraisal Section, Renewable Energy Planning and Feasibility Study Department Power Plant Development Planning Division
		Mr. Prasit Chantong, Engineer, Renewable Energy Project Cost and Project Appraisal Section, Power Plant Development Planning Division

Organization	Participants
Economic Research Institute for ASEAN and East Asia (ERIA)	Dr. Han Phoumin, Senior Energy Economist
Japan Coal Energy Center (JCOAL)	Mr. Osamu Tsukamoto, President (as an observer)
	Mr. Masamichi Hashiguchi, Senior Executive Director/Secretary General
	Mr. Toshiyuki Oda, Director, International Collaboration Department
	Dr. Kazuyuki Murakami, Principal Deputy Director, International Collaboration Department
	Ms. Toshiko Fujita, Principal Deputy Director, International Collaboration Department
	Mr. Yasuo Otaka, Deputy Director, Resources Development
	Mr. Masahiro Ozawa, Chief Engineer, International Collaboration Department
	Ms. Yamada, Fumiko, Assistant Director, International Collaboration Department
IHI Corporation	Dr. Toshiro Fujimori, Technology & Intelligence Integration and Industrial Systems & General-Purpose Machine Business Area Technical Supervisor
KINSEI SANGYO Co.,Ltd.	Dr. Keiichi Kaneko, Managing Director /General Manager of Development & Overseas Department
	Mr. Taotiang Phatthakon, Engineer, R&D Department
Tromso Co., Ltd.	Mr. Yuichi Yanaka, Staff, Sales / Technical

Minutes of the First WG Meeting

The master of ceremonies (MC) announced the start of the meeting and called on Dr Han Phoumin, Energy Economist, ERIA; Dr Weerawat Chantanakome, Special Advisor, Ministry of Energy, Thailand; and Mr Osamu Tsukamoto, President of JCOAL.

- Address by Dr Han Phoumin, Senior Energy Economist, ERIA

First of all, I would like to greet a very good afternoon the two other speakers of the opening session and all the distinguished WG members; those who have been continuously contributing from the phase 1 study to this phase 2 study; and those who have joined us for the phase 2 study.

This is the first meeting of phase 2 of the ERIA study, which is about a very important theme; that is, biomass–coal cofiring. JCOAL has been commissioned to conduct this important research project which, I think, will benefit ASEAN and the entire region of East Asia. We are aware that cofiring, particularly of coal and biomass, will be extremely important in the future of ASEAN. The actual cofiring practices hopefully will be successfully implemented and will bring about a significant reduction of greenhouse gas (GHG) emissions.

In this meeting, we will make efforts to highlight how the region will continue to work together to mitigate GHG emissions.

The phase I study was already conducted and the outcome was reported, which was well accepted. Now we are to find out the modality of technologies and policy support. The target is cofiring biomass and coal, whether with existing coal power plants or with incoming power plants. So, I hope that this study, from every point of view, will be successful in addressing, through policy recommendations, the issue of CO_2 emissions in the future. It is also anticipated to identify and accelerate the potential of biomass utilisation in the region. With this, I also welcome and thank all of you in the region, whose names are to be tied to this study. I believe that the study will be very successful. With that, I conclude my welcome remarks.

Since Dr Weerawat was not yet in the meeting, the MC suggested that Mr Tsukamoto, President of JCOAL, deliver his remarks first, to which Dr Phoumin agreed.

- Address by Mr Osamu Tsukamoto, President of JCOAL

Good afternoon. I would like to express my sincere gratitude to all of you participating in today’s meeting. JCOAL has been commissioned to undertake the second phase of ERIA’s research on the cofiring of biomass and coal. The results of the findings of the first study in 2019 indicated that the energy situation, the biomass resource, and the introduction of renewable energy are different from one country to the other. Today we will share useful information and exchange opinions to identify the recommendations for the by-country optimal models of cofiring of biomass and coal. Such cofiring is expected to contribute to reducing CO_2 emissions, improve energy security in each country, and provide local people with job and business opportunities. Lastly, I would like to again express my sincere respect and gratitude to the ERIA Secretariat for their decision to continuously engage in such important topics. My appreciation is also for the representatives from the four relevant ASEAN Member States (AMS) that have been cooperating with us and for the specialists from Japanese companies who will later share with us excellent technology information that would enable implementation of projects. Thank you.

The MC explained the agenda, to which another session on biomass cofiring–related technologies was added for three brief presentations by representatives of Japanese companies that are active in ASEAN region.

This was followed by the self-introduction of the WG members and representatives of Japanese companies.

The MC introduced Dr Weerawat Chantanakome, Counselor and Senior Policy Advisor to the Ministry of Energy, Thailand.

- Address by Dr Weerawat Chantanakome, Special Counselor on International Affairs, Ministry of Energy, Thailand

Good afternoon, everyone. On behalf of Thailand, I am pleased to welcome all of you and all of my old friends to this very important meeting on biomass and coal cofiring in ASEAN that has come at the right time. Especially during the post-COVID time, we need something like a new normal. I hope everyone always stays safe and healthy. With that, just to remind you, at the last ASEAN Ministers on Energy Meeting (AMEM), the issue of the rising demand for coal towards 2040 was discussed, amongst others. At the same time, the current amount of unused biomass is so huge. So, the combination of coal and biomass is an issue that perhaps can be addressed at the same time. Also, during such activities, you can also address climate change and the reduction of emissions. With that, I think phase 1 had a very successful outcome, right? From that successful outcome, we go further in phase 2 by pursuing the way forward and actions to be taken since it is time to act and facilitate cofiring with the model that you propose. Thus, I think the combination of coal and biomass depends not only on the type and volume of biomass but also on suitable technology.

I would also like to remind you that the last AMEM meeting in September 2019 confirmed that, in ASEAN, electricity demand will go up, possibly triple, towards 2040. The share of coal in power generation may also rise to 50%. Just one thing to mention, even if nothing happens. And then, renewable energy and electricity generation will increase threefold at the same time towards 2040. With that, the action that you may like to do today is to show the region, through the phase 2 study, how you will go for the guidelines on the optimal policy framework for ASEAN on the utilisation of cofiring. Also, we would like to gear up ASEAN, including Thailand, to go for the strategy on how proceed with implementation. Not only that. I think that at the end of the day, we need the recommendation and policy interpretation of the role of cofiring to address the situation where a huge amount of regional biomass is produced and unused. We would like to know how these two energy fields can go together for us to move forward to address energy security and reduce CO_2 emissions at the same time. With that, I appreciate the opportunity that ERIA and JCOAL provided. I hope the meeting will be very successful today. Thank you.

The MC requested the three parties and company representatives to introduce themselves.

Finally, the MC introduced the JCOAL representatives: Mr Osamu Tsukamoto, President; Mr Masamichi Hashiguchi, Senior Executive Director/Secretary General; Mr. Toshiyuki Oda, Director of International Collaboration; Ms. Toshiko Fujita, Principal Deputy Director, International Collaboration; and the members of the Study Team – Dr. Murakami, Mr. Ozawa, and Ms. Yamada.

Presentation by Cambodia: Slide 010

<Q&A >

Ms Yamada, JCOAL Study Team: I am undertaking the part in the JCOAL Study Team to identify the optimal technology and policy measures for Cambodia.

I know that the imported coal you refer to is of a very high rank, that is, bituminous. I wonder why bituminous coal is imported from Indonesia while it is of high quality but is not economically supported. Other countries import even cheaper and lower-ranked coals from Indonesia.

Mr Bou Dolla: The quality of domestic coal is not satisfactory in terms of gross calorific value (GCV). It can be as low as 1,000 kCal/kg, which may not satisfy the standards of the Ministry of the Environment and Ministry of Mines and Energy. We use imported coal from Indonesia that is even more than 6,000 kCal/kg, compared to domestic coal quality, which is very low.

Ms Yamada: I have another question about the list of biomass power plants in your presentation. It is a bit different from the one provided by the WG under phase 1. Many of them are no longer in operation anymore. Why are these biomass power plants not in operation anymore? Is it only because of economic reasons, or are there no incentives? Please give us information on why that is happening.

Mr Phan Bunthoeun: For biomass power generation, we used firewood to cook and produce electricity; that is over. Now, we have biomass power plants. However, biomass, as we see in the case of bagasse, has seasonality, so there are some difficulties in that context.

The MC asked Dr Phoumin to comment.

Dr. Phoumin: Thank you for the presentation of Cambodia members represented by Mr Phan Bunthoeun. I would like to know if the operating factor, the load factors from the biomass power plant, operate only during the dry season. At least biomass power plants must start the feedstock's supply chain to increase their operation rate so that the capital can be returned. In that case, I am not sure why because Yamada-san is asking whether the biomass plants stopped operations because of seasonal fluctuation of the feedstock supply or other reasons. If it is feedstock, I think it will be very important to understand the supply chain of biomass – whether not only bagasse can be used because biomass is hugely available from other sources. In that case, I think Cambodia may need to study the supply chain more. I am not sure if that is correct or not. However, from an economic point of view, I think we need to understand well how to ensure that the power plant is operating at the optimum level to ensure that returns can be expected. Just my comment, by the way. Thank you.

Mr Phan Bunthoeun: The biomass power plants in Cambodia produce electricity primarily for their use, and the remaining power is sold to the Electricité du Cambodge (EdC). It is not for the EdC only. So, they produce power during the dry season, and they use it for their use and sell the remaining to the EdC.

Mr Bou Dolla: Let me clarify a little. As I said, we are not very sure about the power plant in Kratie (no. 5 in the list) – whether it can produce more. But power plant no. 1 produces power even during the rainy season though production is unlike the coal power plant. Thank you.

Presentation by Indonesia: Slide 020

<Q&A >

Dr Murakami: I understand you have already conducted tests on cofiring in existing power plants. Just one point: I would like to know the current situation of the development of biomass pelletisation: what pelletisation technology is available in Indonesia? I refer to the list of power plants that includes those with biomass or waste pellets. Who handles the pelletisation?

Dr Murakami: Kaliandra. Who is doing this pelletisation?

Ms. Elis Heviati: PT PLN and its subsidiary have conducted seven successful trials of biomass cofiring at existing coal-fired power plants (CFPPs). One of the trials, which used waste-based pellets, is located in Jeranjang CFPP, Lombok, West Nusa Tenggara. In this trial, PT Indonesia Power – a subsidiary of PT PLN – collaborates with the local government. For the trial, the waste-based pellets were taken from Klungkung Bali, where a community-based pellet facility was developed. However, in the future, an Refuse Derived Fuel (RDF) facility will be built in Kebon Kongok Landfill to supply the waste-based pellets for cofiring needs at the Jeranjang Power Plan. The plan is currently under discussion between related parties with support funding from the Ministry of Public Works and Housing.

Ms Yamada: When we did the phase 1 study, I heard from you that there were no clear incentives about biomass cofiring in the existing power plants. My impression is, in a relatively short period since then, Indonesia has undergone so much development about it. I wonder how IP (Indonesia Power) and other stakeholders came in to be engaged in the projects: whether incentives were already in place or they were ordered by the government.

Ms. Elis Heviati: There have been many discussions about incentives. Those are still under discussion, so we started the pilot programme with the PT PLN first. I hope incentives are coming, which depends on how well the pilot project with the PLN goes.

The MC thanked the members of Indonesia and requested the Philippine representatives to present.

Presentation by the Philippines: Slide 030

<Q&A >

The MC thanked the two representatives from the Department of Energy (DOE) and asked the other Philippine representative, Ms Litz M. Manuel-Santana of MERALCO PowerGen, to speak for comments or supplementary explanation from the viewpoint of one of the major companies in the private sector.

Ms Litz M. Manuel-Santana: I would like to inform the team members that MERALCO PowerGen is currently doing projects mostly on renewables, solar, and wind projects. We have not gone into biomass yet, and our bigger projects are on coal. We have started operations of Ventura Power Unlimited, which is a super-critical cofired power plant in Quezon Province of the Philippines. In September 2019, we started another cofired power plant along the east coast of Quezon. This is a 1,200-MW power plant also using super-critical technology.

Ms Yamada: Now I would like to open the floor for questions about the DOE presentation and company or business activities of MERALCO PowerGen.

Mr Masahiro Ozawa: Thank you. My name is Ozawa, engaging in the research work for the Philippines under this study. I have one question. I learned recently from the Philippine media ecobusiness.com that 'The Philippines considers the power sector future without new coal'. It was in ecobusiness.com and the Philippine news. They reported that the country's Congressional Committee on Climate Change approved House Resolution 761, calling for a climate energy response, which includes not permitting any new coal plants. This is very big news, I think. Does it mean a policy change?

Ms Ruby B. De Guzman: The news article emanated from the Philippine Congressional Committee on Climate Change, which approved this resolution. They are yet to invite us to comment on this proposed House resolution.

So, we have not yet been invited by the Philippine Congress because it just adjourned its regular session and will resume in July. So, there have been calls that no permits will be issued to incoming or new coal plants that will be proposed or will apply.

But as I mentioned earlier, the DOE stands with its position that it is technology neutral. That all types of technologies – be they coal, natural gas, renewables – are all welcome, provided they would provide efficient, reliable, and the least-cost options and flexibility in our power system.

So, basically, in the Philippines, coal is the fuel for all our baseload plants. Our coal-fired plants are baseload and provide the basic generation for the country's energy demand. But we are still waiting to be called or invited to this hearing. When the Philippine Congress or any committee of the Philippine Congress approves a House resolution, all concerned government agencies are invited to provide comments before this resolution is passed into law.

Ms Yamada: Cofiring. Is that categorised under this? Is that also eligible for these fiscal and non-fiscal incentives? Or some of them are not applicable? Or none of them are applicable?

Ms Ruby B. De Guzman: The Renewable Energy (RE) Law encourages hybrid systems. It is a combination of conventional and renewable energy systems. But cofiring is different from hybrid systems. If this cofiring of coal with biomass will be allowed, it may not qualify for incentives under the RE law. It may be treated as a conventional power facility.

The MC thanked the Philippine members and asked the Thai members to proceed with their presentation.

Presentation by Ministry of Energy, Thailand: Slides 040 and 041

<Q&A >

The MC thanked the presenters from the Department of Alternative Energy Development and Efficiency, Ministry of Energy (DEDE) and the Electricity Generating Authority of Thailand (EGAT) and announced that the floor is open for questions and comments.

Dr Weerawat Chantanakome: Thank you very much. You know, I think the process went very smoothly. I hope we can get the solution today. Anyway, ladies and gentlemen, I think we will have to put this on the table until the very end, but let me give some comments about the 'hybrid' that one of the members referred to.

So, what we are doing right now is on hybrid. What kind of hybrid is not an issue. As you know, all kinds of biomass and all other fossil fuels and renewables apply. I think that before we act, we must identify the advantages and disadvantages, including the environmental benefits and impacts.

On the environmental benefits, for example, CO_2 emissions come from coal which, at the same time, provides the benefit of low cost. People do not talk about it officially anymore; however, they still use coal in their backyard. In Germany, people still use coal. Even though they advocate for renewable energy, they still use coal for security and affordability.

Before we move on, I will look into the differences at this moment. For example, when you combine biomass with coal in an existing CFPP, I think you can save on your budget, such as grid connection fees, which, in the case of starting afresh a biomass power plant are required.

That said, the existing system is originally for 100% coal. So, for cofiring with biomass, a technology that allows smooth cofiring of the two will be required. While biomass cofiring conducted in an existing CFPP and reduced CO_2 emissions look good in the eyes of anti-pollution people, what we should pay attention to is, the more you like to increase the portion of biomass, the more technical deliberation will be required. There will be another future option that the biomass portion becomes larger than that of coal. We cannot phase out coal, but we can reduce the amount we use.

My last point is that because we are concerned with policy, we believe we need to talk at the municipal level, so we will convince them to step forward for action. This is because people at the municipal level are always talking, but they take no action. The economic, operational, and environmental factors, apart from cost, need to be considered. But have them on a test-by-test basis. This is my view on your next step in terms of policy to promote this kind of hybrid into a reality. Thank you so much.

Ms Yamada: Thank you very much, Dr Weerawat. What Dr Weerawat has told us – the economic, operational, and environmental aspects of these forthcoming plans – is very important.

Thank you again, Dr. Weerawat, for providing important insights for us to incorporate in our report.

(Dr Weerawat Chantanakome left for another meeting.)

Dr Murakami: I have one question about the community power plant. What kind of technologies are adopted in the plant? I understand such power plants are smaller in scale.

Dr Yaowateera Achawangkul: Dr Murakami, the technology is for a community-based plant. Actually, the concept of the community power plant is not new; it has been there for more than 10 years before, but at the beginning we tried to do this more to skill up the capacity of people there. We tried to educate them that a power plant does not necessarily have to be on a large scale. Therefore, I think if we try to implement biomass power generation in the community, it is good for sustainability. If the people think that is complicated to operate at their end, they will give up the power plant operation. But we put out the maximum capacity of the community power plant at 10 MW. In Thailand, a lot of such power plants are using the system. The operation is going well. This is my comment.

Mr Chawit Chongwilaiwan: May I add my comments? May I share more? Biomass utilisation does not require too specific technical knowledge. And by using biomass power, Thailand's ecological condition is unspoiled. What the community has to do is to mix the fuel. The quality is maintained.

Presentation by the Team: Slide 050

The MC announced that questions on the team's presentation will be accepted after the presentations of the three technology companies: IHI Corporation, Kinsei Sangyo, and Tromso.

Presentation by private companies (files are not available in this transcription):

Dr Yaowateera Achawangkul: I have some comments on the Tromso presentation, about rice husk transformation. In Thailand, rice husk is used for other purposes; and obtaining a sufficient volume of rice husk may not be easy. Is it ok with your technology that we use other biomass forms that have the same properties as rice husk. something quite simple like sawdust?

Mr Yanaka, Tromso: Thank you for your questions. Well, we may mix it with other materials, like you said, sawdust and others (peanut shells, banana peels). Every organic material is available to be mixed with our machinery. However, the very important thing is moisture. It is important to be very dry. We have already implemented the solidification tests of sawdust. Then, we could succeed in solidifying 50% of sawdust and 50% of rice husk. It is possible to solidify and put on fire so you can use the fuel as usual.

Dr Yaowateera Achawangkul: Yes, thank you. I have another question about your system. Is there already an actual power plant where your technology has been applied?

Mr Yanaka, Tromso: We have a project in Viet Nam and have done a feasibility study on gasification generation plants. Now we are planning to conduct some projects, a city-to-city collaborative programme that focuses on the feasibility of the cofiring process. We are yet to have a generation plant in actual operation.

Ms Yamada: We already learned from the Cambodian delegates that some of the biomass power plants are not in operation. Some of them are just seasonally being operated. However, the Philippines uses bagasse and generates power throughout the year. I am wondering why bagasse is seasonal in Cambodia but is not seasonal in the Philippines? You do not have a similar climate, right? How about in Thailand? They don't have bagasse.

Dr Yaowateera Achawangkul: Yes, currently we have a total capacity of 2,000 MW for the bagasse-fired power plant in Thailand. We use it not only for power generation but also for co-generation. They have their own plant; they can supply the steam to the factory.

The MC thanked Dr Yao for the comments and asked Dr Murakami for some words before closing the meeting.

Dr Murakami: I would like to say a few words to close this First WG Meeting. First of all, I would like to thank all of you for joining this WG. Initially, we planned to have this WG meeting at the end of April in Bangkok. However, due to the COVID-19 pandemic, we were not able to make it and instead arranged this online meeting. As this is the first experience for JCOAL, tests arranged in connection with this WG meeting would not have been satisfactory. However, we are grateful that this WG meeting was very successfully conducted, thanks to the contributions of each WG member. We will continue further study with close communication with working members. We will work hard to make the technical proposal and policy recommendations for each country. We look forward to meeting with you again in late September 2020.

Appendix 2: The Second Working Group (WG) Meeting

Attendance List

Country	Institution	Member(s)
Indonesia	Ministry of Energy and Mineral Resources (MEMR)	Ms. Elis Heviati, Deputy Director for Investment and Cooperation of Bioenergy Directorate of Bio Energy Director General for New Energy, Renewable Energy and Energy Conservation
	PT. PLN (Persero)	Mr. Agung Wibowo System Planning Division, PT. PLN (Persero)
Philippines	Department of Energy (DOE)	Ms. Ruby B. De Guzman, Chief Science Research Specialist, Biomass Energy Management Division, Renewable Energy Management Bureau (REMB)
		Mr. Jensen M. Alvarez Senior Science Research Specialist, Biomass Energy Management Division Renewable Energy Management Bureau Department of Energy
	Meralco Powergen Corporation	Litz M. Manuel-Santana, Vice President for External Affairs
Thailand	Ministry of Energy	Dr. Yaowateera Achawangkul, Mechanical Engineer, Senior Professional Level, Department of Alternative Energy Development and Efficiency (DEDE)
		Dr. Weerawat Chantanakome, Special Counselor on International Affairs (as an advisor)
		Mr. Tananchai Mahattanchai, Senior Professional Geologist, Department of Mineral Fuels
	Electricity Generating Authority of Thailand (EGAT)	Mr. Chawit Chongwilaiwan, Head, Renewable Energy and Power Plant Survey and Potential Appraisal Section, Renewable Energy Planning and Feasibility Study Department Power Plant Development Planning Division
		Mr. Prasit Chantong, Engineer, Renewable Energy Project Cost and Project Appraisal Section, Power Plant Development Planning Division

Organization	Participants
Economic Research Institute for ASEAN and East Asia (ERIA)	Dr. Han Phoumin, Senior Energy Economist
Japan Coal Energy Center (JCOAL)	Mr. Osamu Tsukamoto, President (as an observer)
	Mr. Masamichi Hashiguchi, Senior Executive Director/Secretary General
	Mr. Toshiyuki Oda, Director, International Collaboration Department
	Dr. Kazuyuki Murakami, Principal Deputy Director, International Collaboration Department
	Mr. Yasuo Otaka, Deputy Director, Resources Development
	Mr. Masahiro Ozawa, Chief Engineer, International Collaboration Department
	Ms. Yamada, Fumiko, Assistant Director, International Collaboration Department

Minutes of the Second Working Group (WG) Meeting

Opening Session

- Address by Dr Han Phoumin, Senior Energy Economist, ERIA

  It is good that the study is in its final stage to provide suggestions for the policy direction on biomass cofiring in ASEAN, thanks to the cooperation of all WG members. The AMS will benefit from the proposals to obtain ideas on how to apply technology, what policy instruments would be desirable to facilitate biomass utilisation in the power sector, by which ASEAN will further progress in CO_2 emissions mitigation. I would say this study is, to some extent, the first to discuss and deliberate on biomass cofiring in ASEAN.

- Address by Dr Weerawat Chantanakome, Special Counselor on International Affairs, Ministry of Energy, Thailand

  I am happy to see the progress of the study, which will facilitate biomass utilisation in ASEAN's power sector. ASEAN will continuously utilise coal towards 2040 as it provides affordability and energy security. So, adding biomass utilisation through cofiring would be good in terms of having an option to reduce emissions to address climate change issues. I expect maximised benefits will be obtained through the study, which I believe would provide a platform and a springboard for the next step for the realisation of projects.

- Address by Mr Osamu Tsukamoto, President of JCOAL

  This study was conducted coincidentally during the COVID-19 pandemic. I suppose every single WG member, being in the position to formulate policy and policy instruments, must have been extra busy to address the social and economic change in the energy sector that the pandemic has caused. I would like to offer my utmost gratitude to all of you for the generous and dedicated contributions to this study under such severe circumstances.

  We believe we can furnish the report that will be conducive to the policy formulation of all four target countries, for which the Study Team and JCOAL are committed to make. In this regard, we very much appreciate your continued cooperation at this meeting and towards the finalisation of the report, without which we may not anticipate the successful completion of the study.

  I am aware that the AMS, like most emerging economies, will make a strong comeback in the power sector in 2021. Then we can ultimately achieve the shared goal of SDG7: 'ensure access to affordable, reliable, sustainable, and modern energy for all by 2030'. I hope the study outcomes will firmly contribute to a clean electricity supply in the AMS that will bolster steady and outstanding growth in the region.

Introduction of participants

The MC announced that the President of JCOAL has left, and the Senior Executive Director/Secretary General is attending on his behalf.

The MC introduced the WG members and announced that three members from Cambodia are not present and that one newly assigned Thai member, Mr Tananchai Mahattanchai, is present.

Mr Tananchai Mahattanchai, Senior Professional Geologist, Department of Mineral Fuels (DMF) of the Ministry of Energy, Thailand, greeted the WG members and expressed his appreciation for joining the WG as a member. He then provided information on the coal situation in Thailand, and introduced the mission and responsibilities of the DMF related to the promotion of coal image and support for the use of CCT for public and local community acceptance. He briefly highlighted some efforts related to coal, including the ASEAN Forum on Coal (AFOC) cooperation, local community engagement, and adoption of the Code of Practice for coal management for which public participation activities are being implemented. (A brief presentation by Mr Tananchai)

Presentation by the Team

The MC announced that the Philippines' subchapter would be discussed first as discussions on Cambodia would be conducted separately, and Indonesia members have not yet arrived.

Presentation by Mr Ozawa: Slides 36-44

- Ms Ruby B. De Guzman, Chief Science Research Specialist, Biomass Energy Management Division, Renewable Energy Management Bureau, DOE, Philippines

  We concur with the biomass sector roadmap, especially on the additional capacity from 2018 to 2040.

  As for 1,550 MW, the data on the installed capacity addition of biomass power in 2018–2040 is based on awarded contracts. It may sound rather small compared to the total power generation capacity of 93,482 MW. Our determination of this capacity is based on our awarded contracts as per the Renewable Energy (RE) Law, where the government, through the DOE, awards or issues operating contracts to biomass RE developers. If I may repeat part of the presentation, a proposed biomass project is evaluated primarily based on feedstock, i.e. feedstock supply, availability, and sustainability. So, the identified capacity of 1,550 MW is based on the projects awarded from 2018, so that is 192 MW. For the medium term of 313 MW, these are ongoing constructions. And for the long term, these are mainly based on the results of the biomass resource assessment conducted. It would mainly be composed of biomass feedstock using municipal solid waste. That is how we identified the total capacity addition of biomass power at 1,550 MW by 2040.

The Philippines has great potential for other biomass resources, but other renewables have yet to be developed only because of the coordinated arrangements required compared to, let say, solar that only requires land.

The energy policy of the Philippines is ‘technology neutral’. Whatever energy source that would provide affordability, accessibility, and environmental compliance, etc. would be considered. So, coal use for power generation will continue with the use of CCT; it is expected to remain at 27% by 2040.

- The House of Representatives (Congress) is now considering legislation on biomass energy utilisation through a proposed Biomass Energy Act. We are thinking of using the report, once finalised, as one of the reference documents the DOE would use for briefings of relevant parliamentary members, etc.

- Ms Litz M. Manuel-Santana, Vice President for External Affairs, MERALCO PowerGen Corporation (MGen), Philippines

  MGen through its subsidiary MGreen is planning to build 1,200 MW of renewable energy in the next 5 to 7 years.

Presentation by Mr Otaka: Slides 28–35

- Ms Elis Heviati, Deputy Director for Investment and Cooperation of Bioenergy, Directorate of Bio Energy, Director General for New Energy, Renewables Energy and Energy Conservation, Ministry of Energy and Mineral Resources, Indonesia

  The summary of Indonesia’s subchapter well reflected the Indonesian members’ presentation at the First WG Meeting. I have no further comments, but the PLN might like to say something as they are engaging in the pilot tests of biomass cofiring.

- Mr Agung Wibowo, Engineer, System Planning Division, PT PLN (Persero), Indonesia

  The tests are still ongoing. We are now working on the RUPTL (National Electricity Business Plan) 2020–2029, the publication of which has been delayed due to the COVID-19 pandemic. We have submitted the first draft recently to the ministry. We are making RUPTL 2020–2030 right now and hope it will be finalised by the end of October 2020 or so. The outcomes of the tests were detailed in the annual report of the PLN and its subsidiaries.

  Renewables are aimed to account for 23% for 2025–2029. So, whether biomass cofiring would go well does matter since its successful implementation means the share of renewables would be boosted.

Presentation by Dr Murakami: Slides 45–56

- Dr Yaowateera Achawangkul, Mechanical Engineer, Senior Professional Level, Department of Alternative Energy Development and Efficiency (DEDE)

  Mr Punmeechaow, the new Energy Minister of Thailand, assumed his position in July 2020. Hence, some policies would be amended or changed. The new minister suggests revising the target of the demonstration community power plant installed capacity from the initial 100 MW (quick-win project) to 150 MW. Since EGAT has the discretion about the Power Development Plan, I suggest that the team communicate with EGAT for further confirmation.

- Mr Tananchai Mahattanchai, Senior Professional Geologist, Department of Mineral Fuels, Ministry of Energy, Thailand

  I agree with Dr Yaowateera in the point that before establishing the support policy, we need to correct more data and information to make sure that the policy recommendations to be made are applicable and functional. Also, on behalf of the DMF, I appreciate the work done by the WG and welcome all support from ERIA, JCOAL, and the WG members to help advise on technology and fufil data acquiring. The DMF is exploring an opportunity to implement coal biomass cofiring to drive the achievement of the renewable target. Also, coal and biomass cofiring may result in more public and local community acceptance and help people to realise that coal is an affordable fuel energy with an environment-friendly appearance.

  Thailand is seeking assistance from ERIA and JCOAL to support the project related to the feasibility study of how Thailand will utilise and implement coal biomass cofiring.

- Dr Weerawat Chantanakome, Special Counselor on International Affairs, Ministry of Energy, Thailand

  This direction is really good. Biomass firing under the community power plant programme is one thing; it is good for community development and for ensuring electricity access. On the other hand, biomass cofiring in the CFPPs allows environmentally acceptable and clean coal utilisation and provides opportunities for the reduction of CO_2 emissions while facilitating public acceptance.

- Dr Han Phoumin, Senior Energy Economist, ERIA

  I am pleased to see this development of discussions. The team can further explore this point in the report.

The team clarified that this particular aspect of biomass cofiring is yet to be pursued in the subchapter of Thailand only because the team was aware that biomass firing through the community power plant programme was initiated by the government of Thailand. The team will incorporate the discussions led by the DMF, Ministry of Energy Thailand into the report and add recommendations on the way forward about biomass cofiring in Thailand, the proposal of which was well accepted by Thai members and ERIA.

Closing

Dr Weerawat expressed his appreciation that the study outcomes are concrete. He emphasised that ASEAN would use coal in this period of energy transition; and we have to make it a 'good transition period' by forging synergy of coal and biomass by co-utilising the two fuels.

Dr Phoumin referred to the importance of practical application of the study recommendations to the AMS and asked the WG members for a post-meeting feedback.

Dr Murakami, on behalf of JCOAL and the team, extended a vote of thanks to the dignitaries and experts who have been contributing through discussions at the meeting and providing advice and comments through email.

The MC announced the end of the meeting.

Appendix 3: Breakout session of the Second Working Group Meeting

Attendance List

<table>
<tr><th>Country</th><th>Institution</th><th>Member(s)</th></tr>
<tr><td rowspan="4">Cambodia</td><td rowspan="2">Ministry of Mines and Energy (MME)</td><td>Mr. Tiv Dara Rith, Vice Chief of Office
Department of Cooperation and ASEAN Affairs</td></tr>
<tr><td>Mr. PHAN Bunthoeun, Deputy Director, Department of Thermal and Combustion Energy</td></tr>
<tr><td>Electricity Authority of Cambodia (EAC)</td><td>Mr. CHHUN Ratana, Chief, Regulation and Licensees Section</td></tr>
<tr><td>Electricite Du Cambodge (EDC)</td><td>Mr. BOU Dolla, Deputy Chief, Thermal and Solar Division</td></tr>
<tr><th colspan="2">Organization</th><th>Participants</th></tr>
<tr><td colspan="2">Economic Research Institute for ASEAN and East Asia (ERIA)</td><td>Dr. Han Phoumin, Senior Energy Economist</td></tr>
<tr><td colspan="2" rowspan="4">Japan Coal Energy Center (JCOAL)</td><td>Dr. Kazuyuki Murakami, Principal Deputy Director, International Collaboration Department</td></tr>
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