Chapter 3

By-Country Reviews and Recommendations

March 2021

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Chapter 3

By-Country Reviews and Recommendations

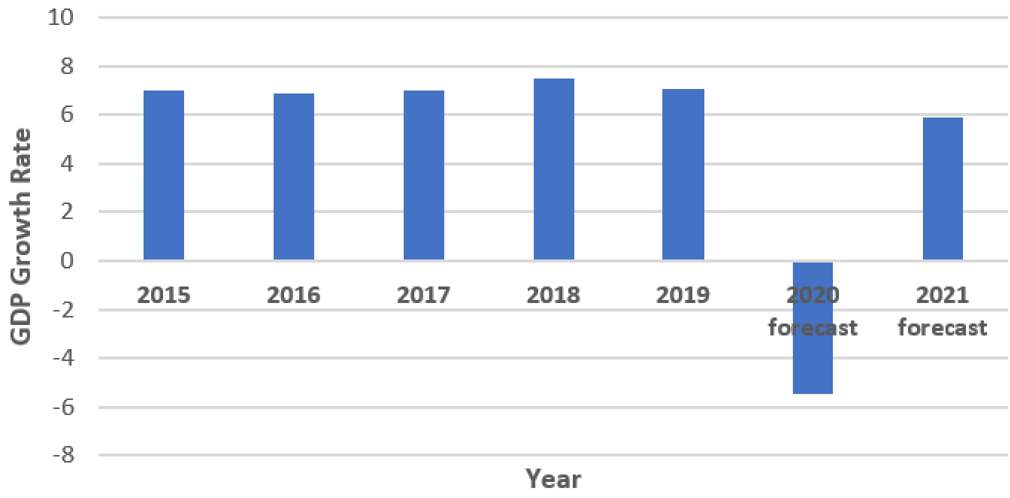
1. Cambodia

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



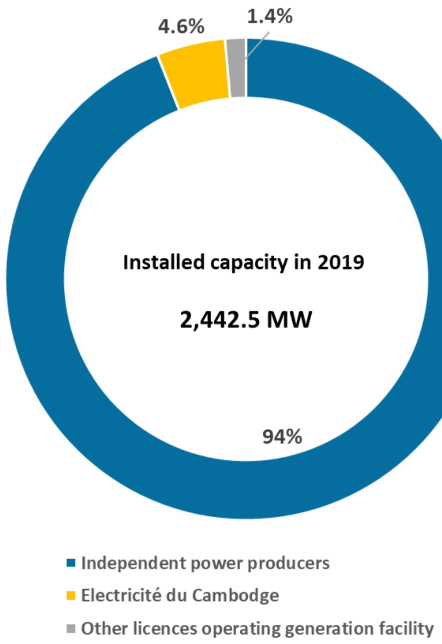
GDP: gross domestic product.
Source: ADB (2020).

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.

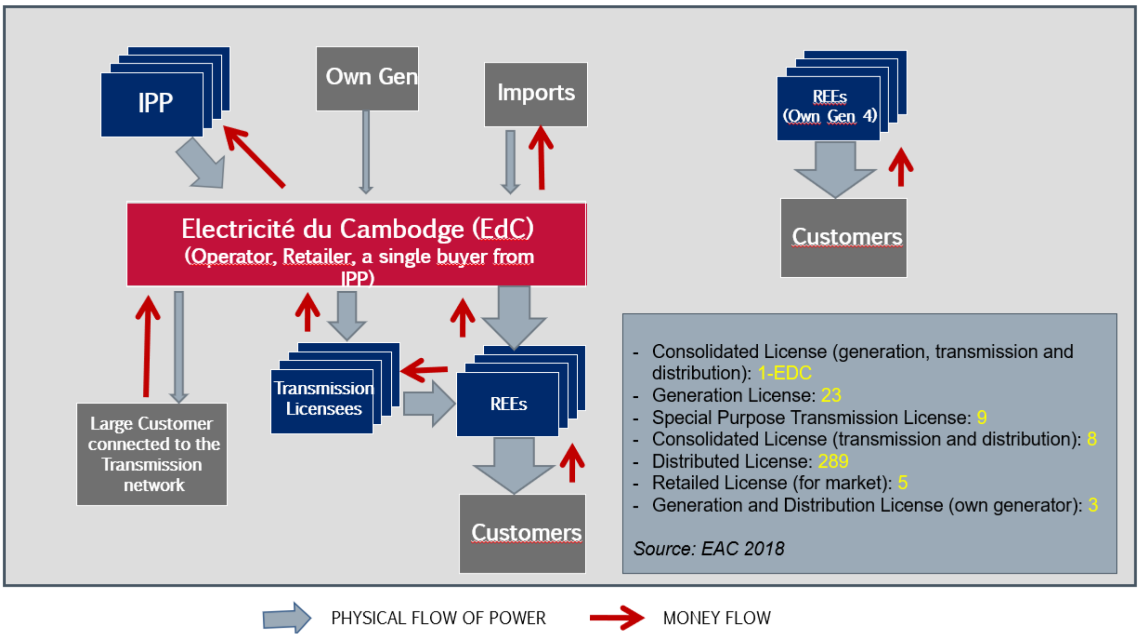
As of the end of 2019, the installed capacity of the IPPs accounted for 94% (Figure 3.1-2). The actual generated capacity reached 96%. Since growth is forecasted to continue except in 2020 when the COVID-19 pandemic affected the global economy, including that of Cambodia, the role of the IPPs in the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

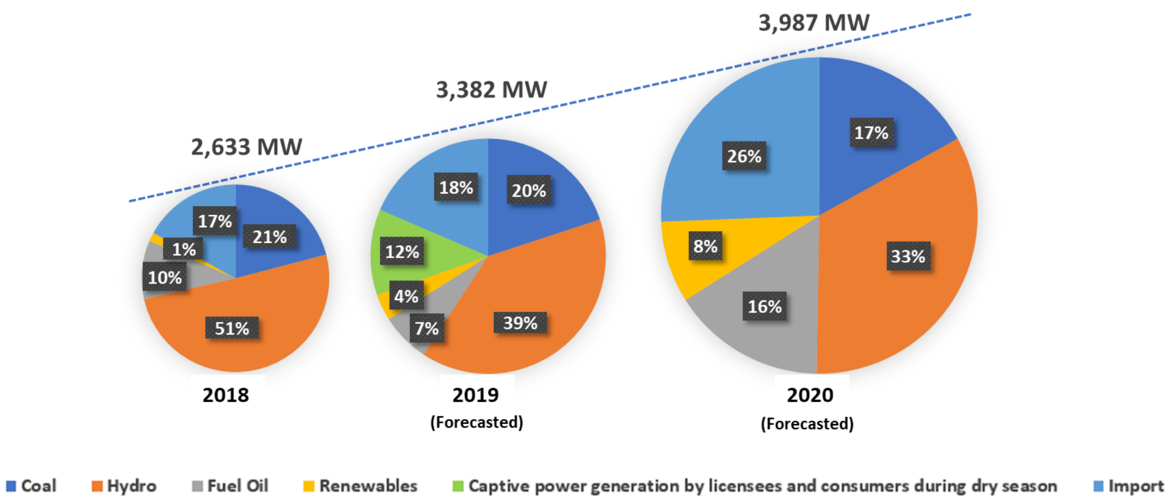


IPP = independent power producer, REE = rural electricity enterprise.
Source: Country presentation by Cambodia's representatives at the First WG Meeting (online) for the Phase II Study, 16 June 2020.

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).

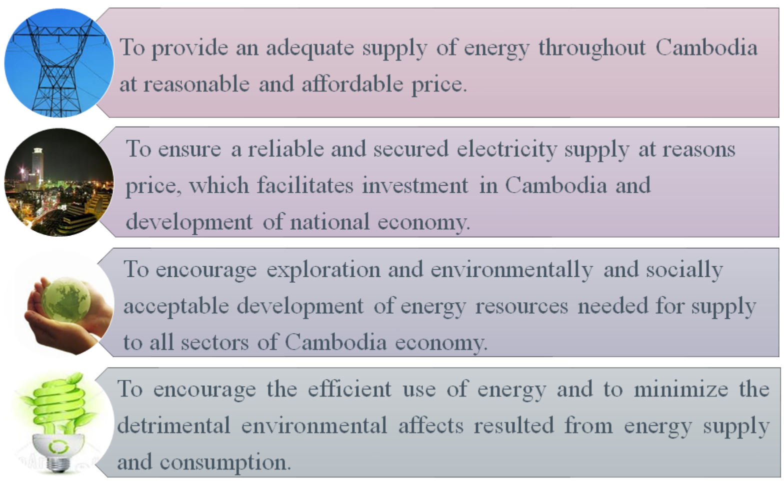
Figure 3.4. Power Growth, by Fuel, 2018–2020



Source: EAC (2019).

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

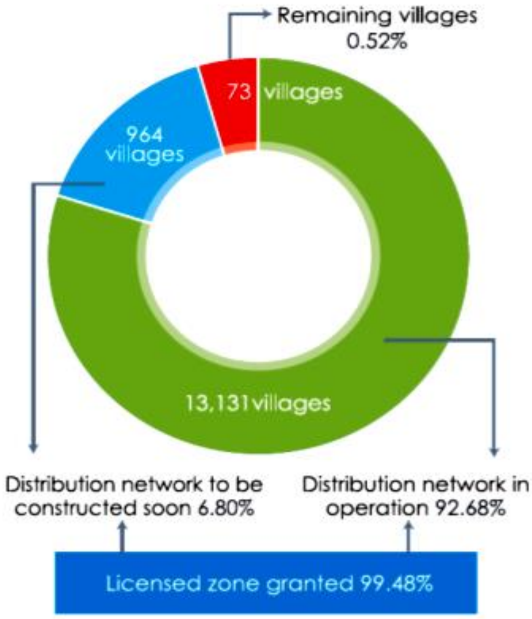
Figure 3.5. Four Pillars of Cambodia's National Energy Policy



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



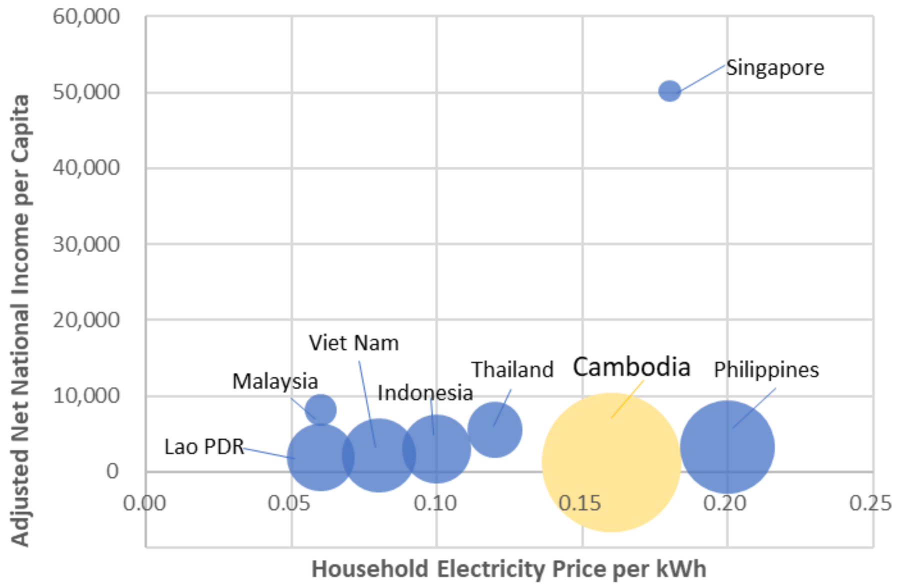
Source: Country presentation by Cambodia's representatives at the First WG Meeting (online) for the Phase II Study, 16 June 2020.

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.

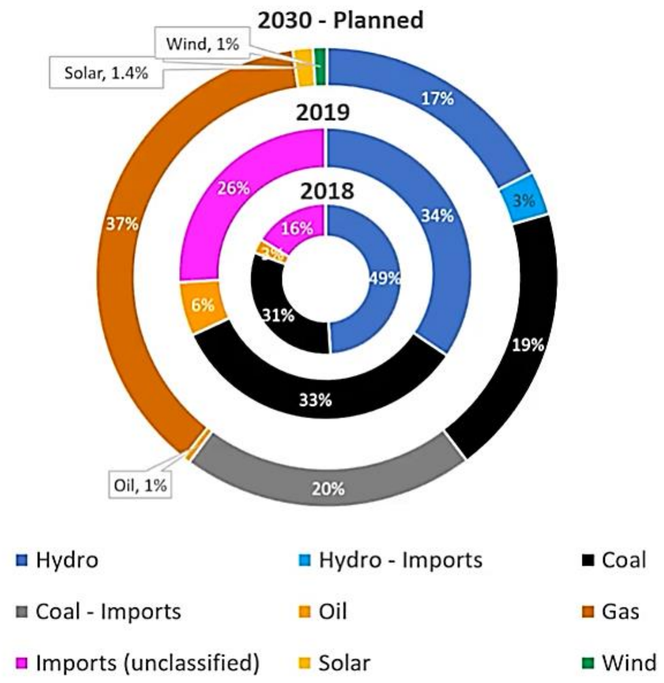
Table 3.1. Mitigation Actions in Key Sectors: Aggregate Reduction by 2030

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

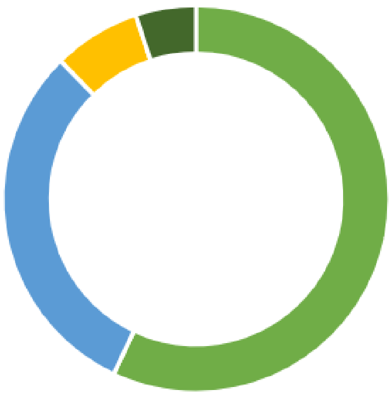
Source: Adapted from MME (2020).

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.

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[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

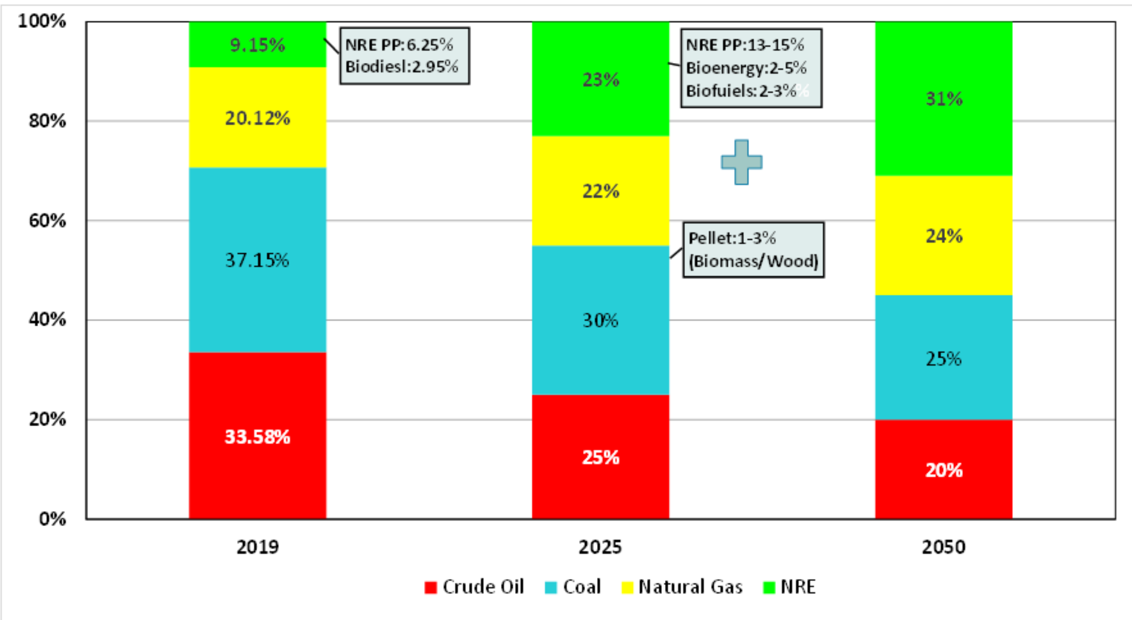
Indonesia is endowed with fossil fuel resources such as crude oil, natural gas, and coal, and uses these fossil resources as main energy sources. In 2019, fossil energy accounted for 90.85% (coal = 37.15%, oil = 33.58%, and gas = 20.12%) of energy mix.

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.

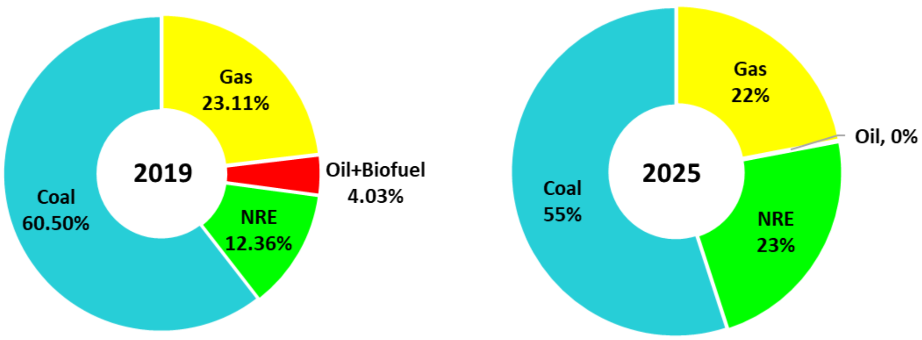
Source: Country presentation by the Indonesia's representative at the First WG Meeting for the Phase II Study, 16 June 2020.

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.

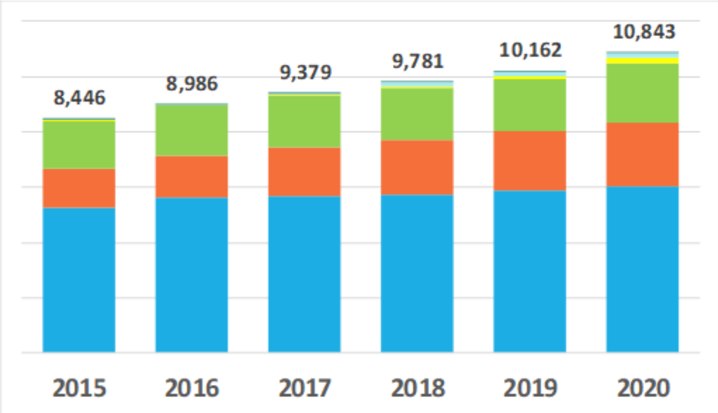
Figure 3.11. Power Generation Energy Mix



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.

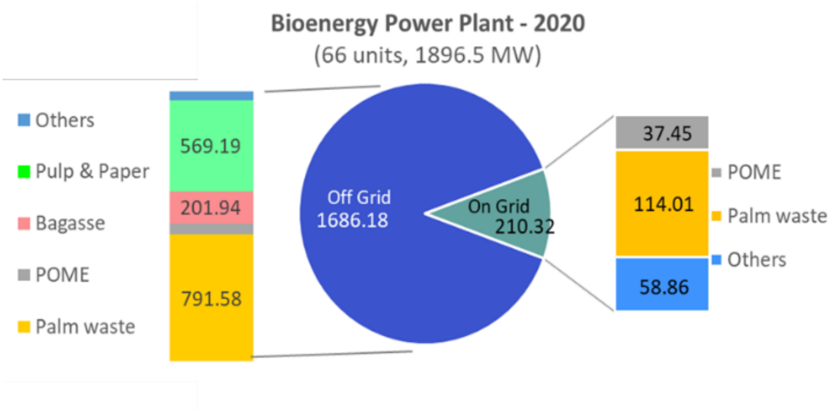
Source: Country presentation by Indonesia's representative at the First WG Meeting for the Phase I Study, 6 February 2019.

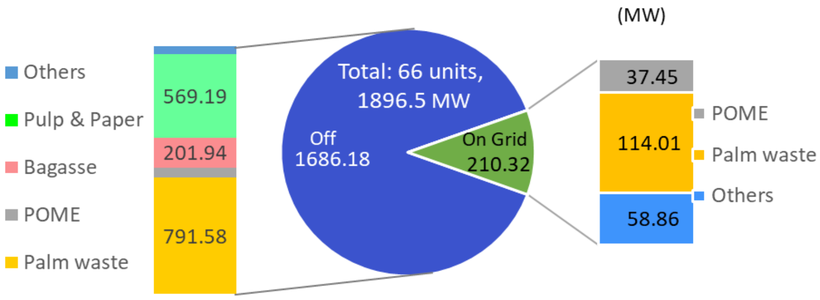
Bioenergy power generation in 2020 is 1,896.5 MW for 66 units (Figure 3.2-4). The details are as follows.

- 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.

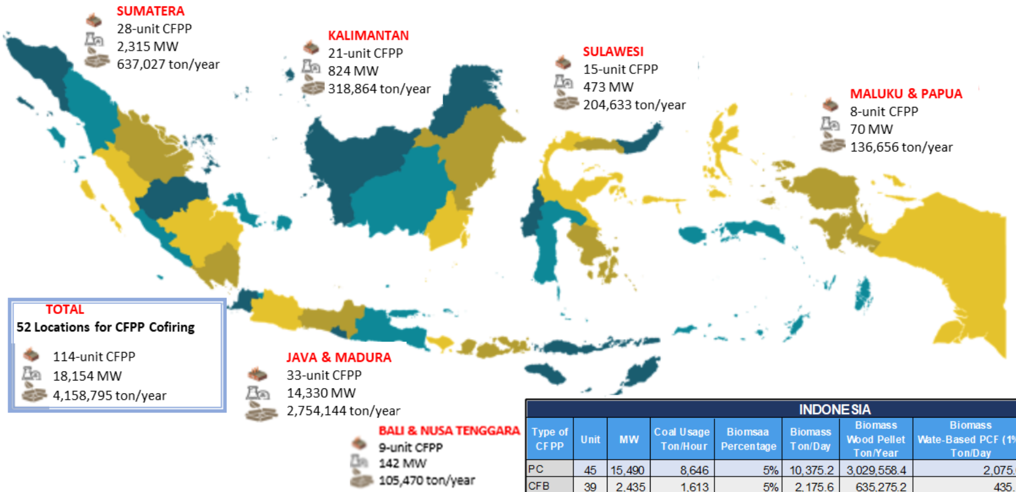
Table 3.7. Biomass Cofiring Tests on Existing CFPPs by PLN

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.

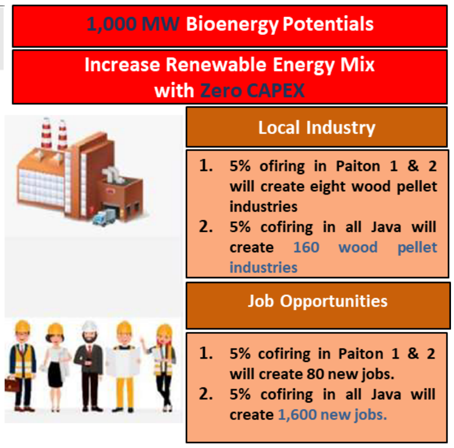
(b) Application of the benefits of biomass cofiring

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

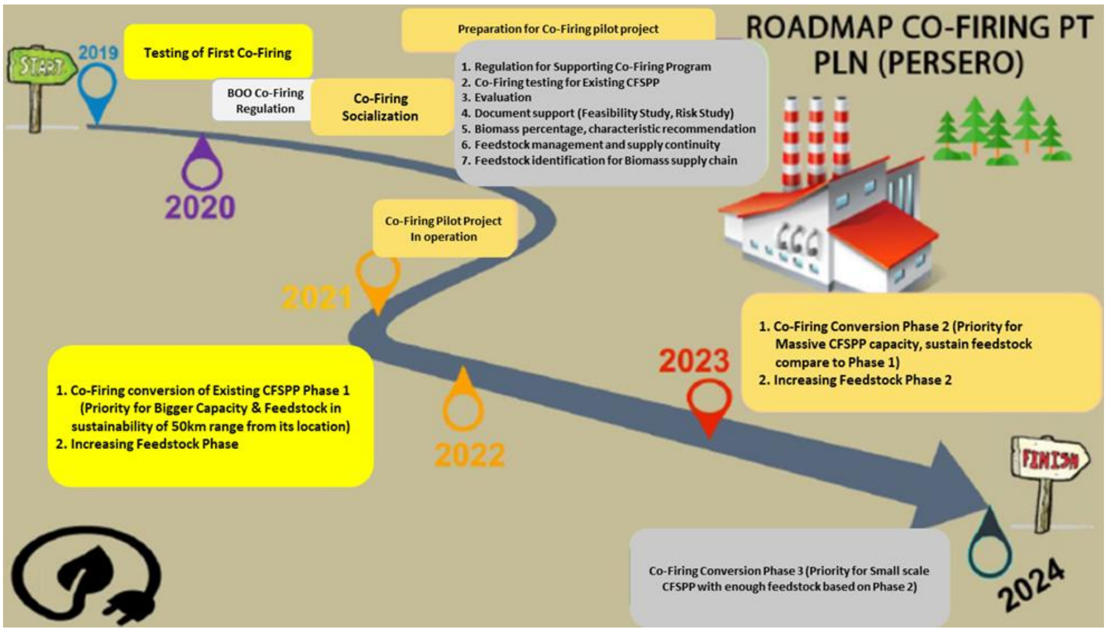


Source: Kanam (2020).

(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.

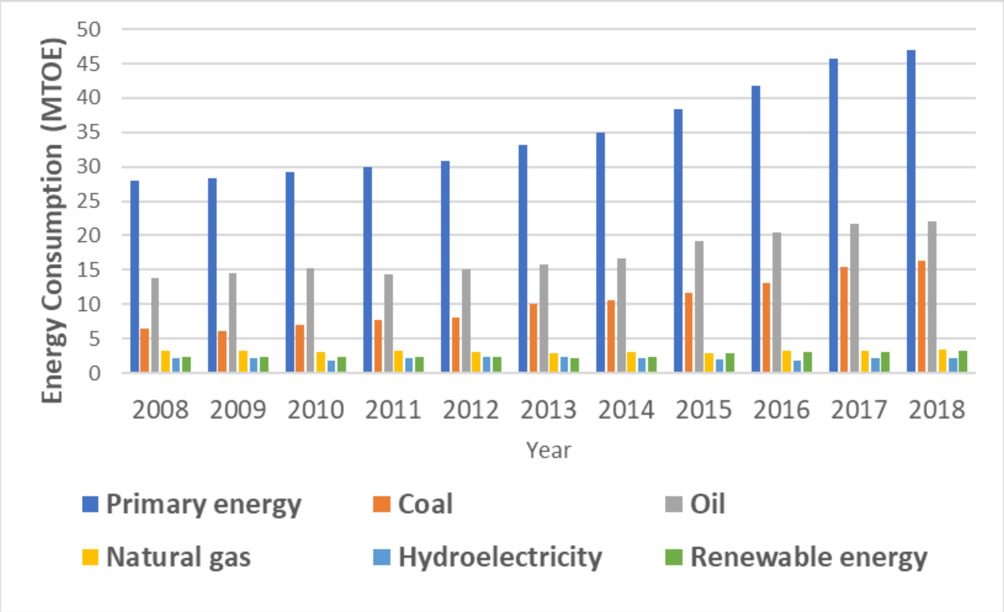
3. Philippines

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.

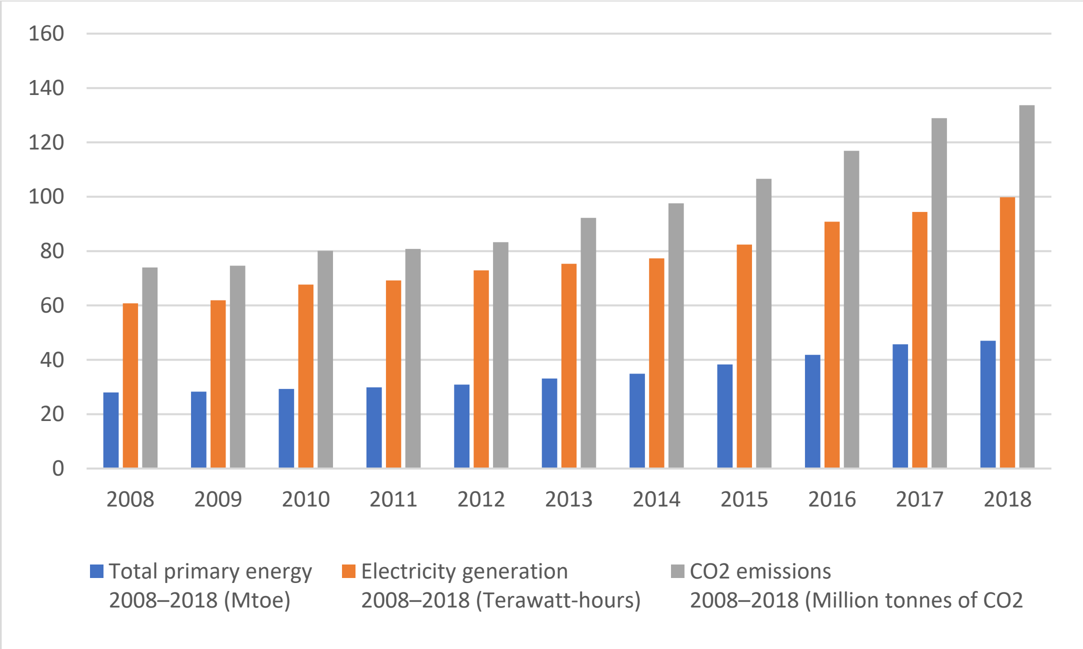
Of this, renewable energy was 1.3 times, while coal increased 2.5 times or more. As a result, CO_2 emissions were 1.8 times or more, more than the increase in primary energy.

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

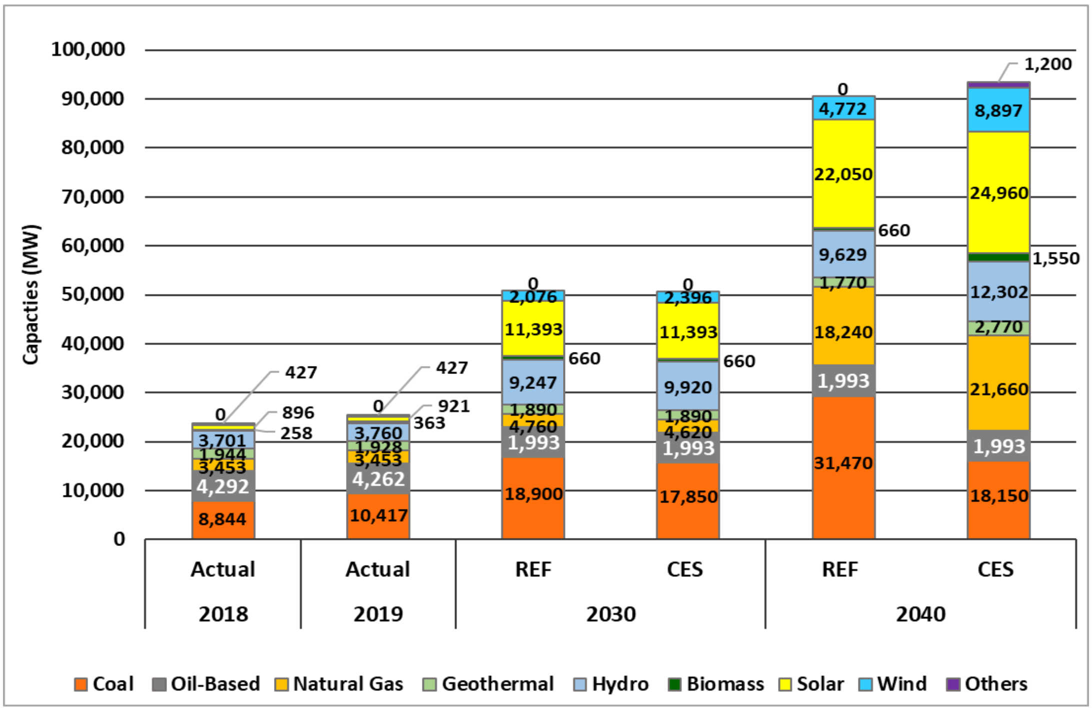
The Philippine government is currently soliciting opinions on the Philippine Energy Plan 2018–2040'. This energy plan shows two scenarios: the Reference Scenario (REF) and the Clean Energy Scenario (CES).

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.

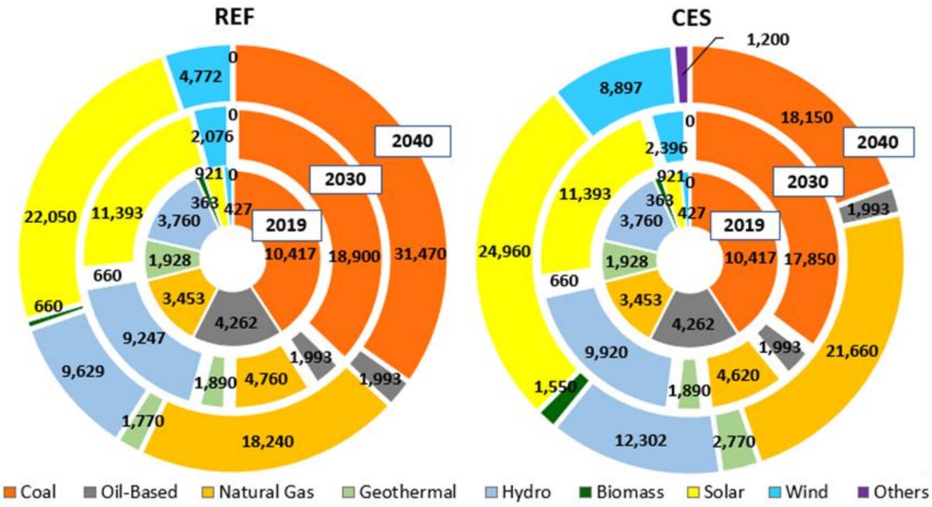
Figure 3.20. Total Installed Capacities by 2040, by Fuel (MW)



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).

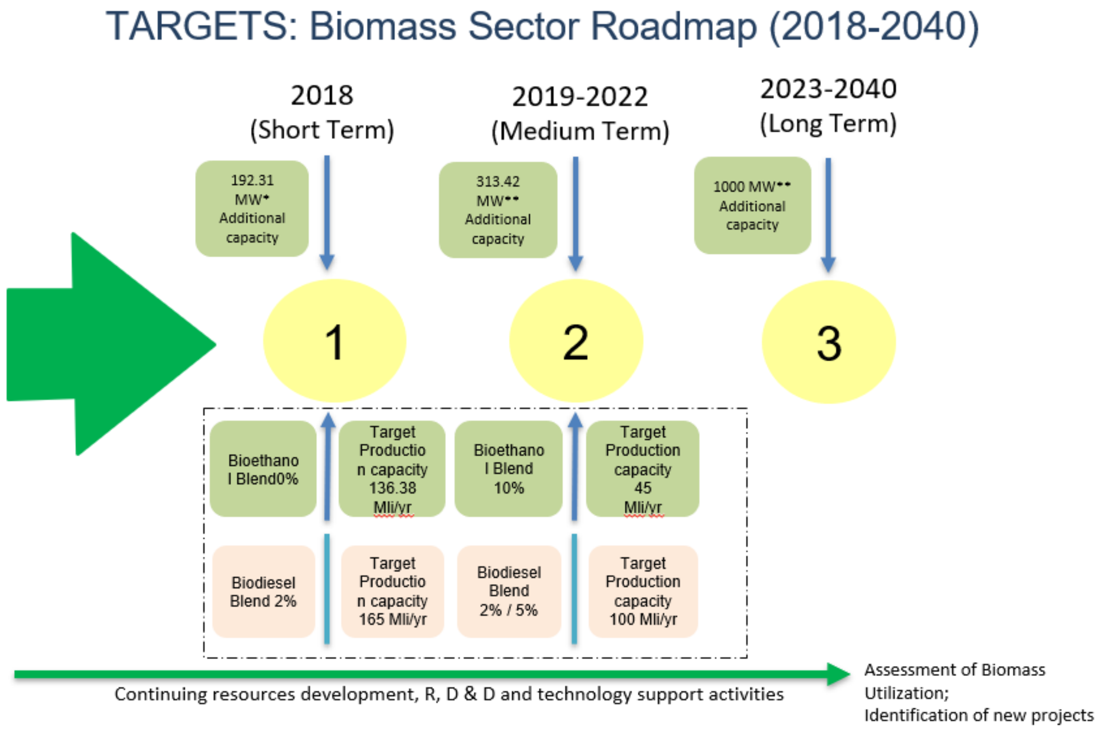
3.3. Biomass potential and biomass power plant

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.

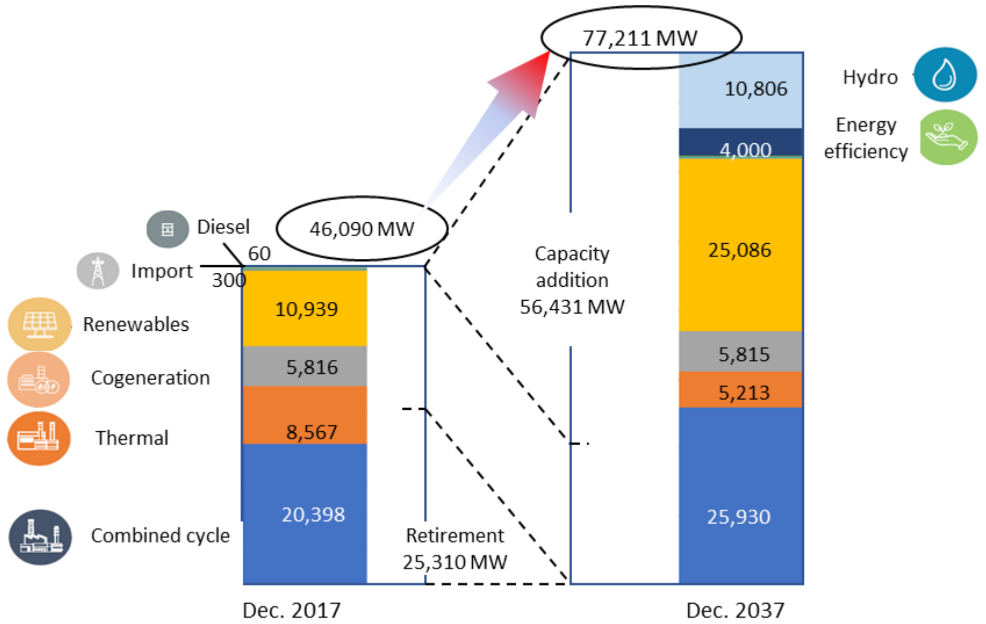
The CFB is relatively easy to use even if the fuel is biomass and can increase the cofiring rate. In PC-fired power generation, the current use is limited by the crushing equipment, so the cofiring rate is only a few percent. To increase the cofiring rate, it is necessary to appropriately modify the 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.

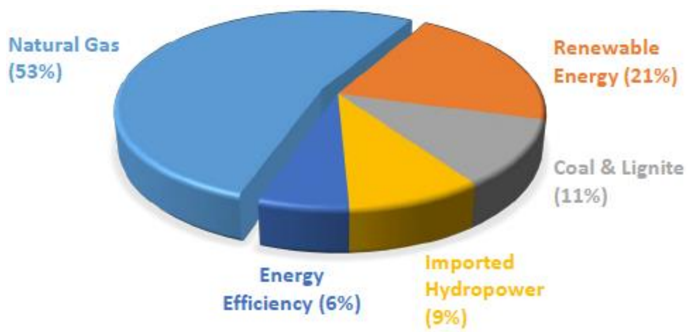
Figure 3.23. Power Development Plan (PDP 2018)



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

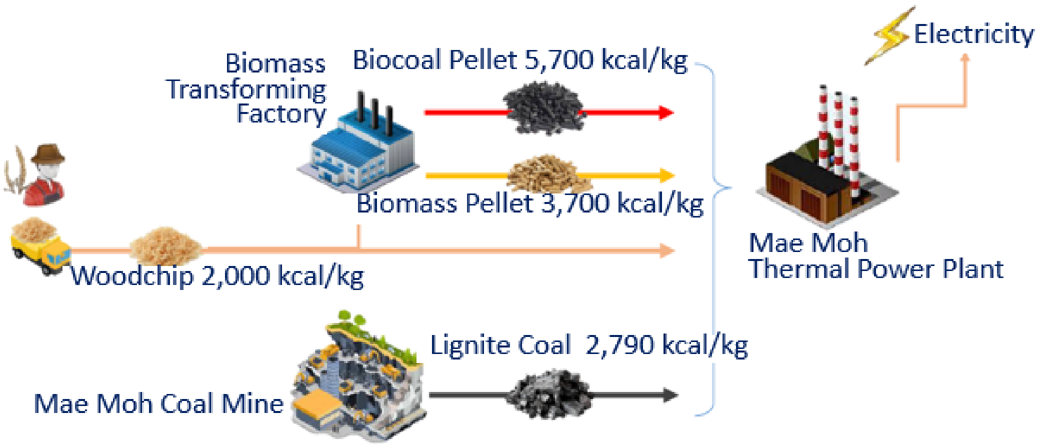
Type of Renewable Energy	FIT (฿/kWh)			Support Period	FIT Premium (฿/kWh)
	FIT_F	$FIT_{V(2019)}$	FIT	(Year)	Southern Border Provinces Area
1. Solar	2.90	-	2.90	20	0.50
2. Biomass					
- Installed capacity ≤3 MW	2.61	2.2382	4.8482	20	0.50
- Installed capacity > 3 MW	2.39	1.8736	4.2636	20	0.50
3. Biogas (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

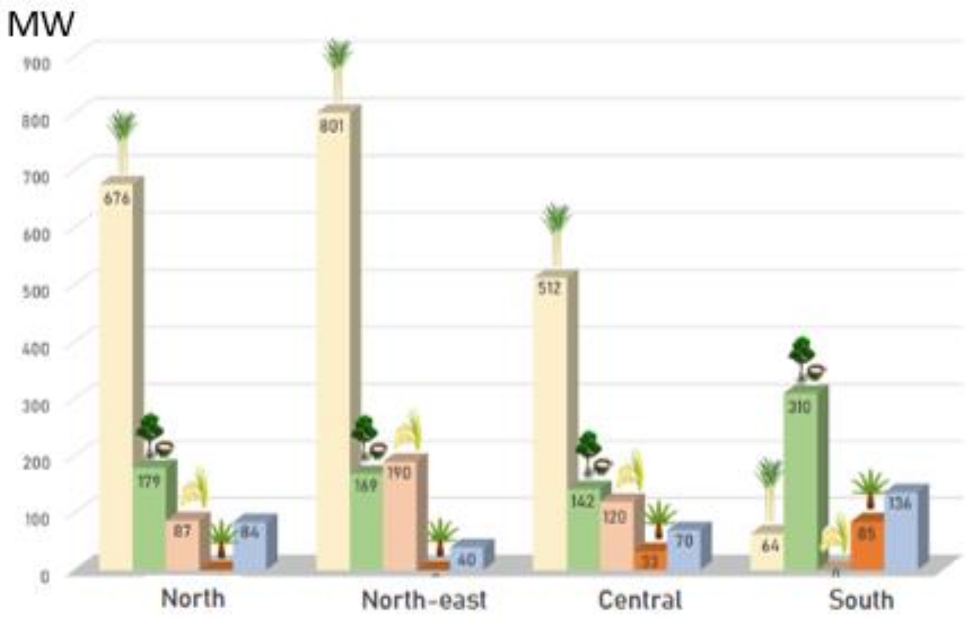
Table 3.11 and Figure 3.26 show the current situation of biomass utilisation in Thailand. Bagasse and leaves are the largest biomass source in Thailand. The total capacity of the domestic biomass power plant is 3,700 MW, out of which 2,052 MW is bagasse and leaves. Other major sources are rubberwood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

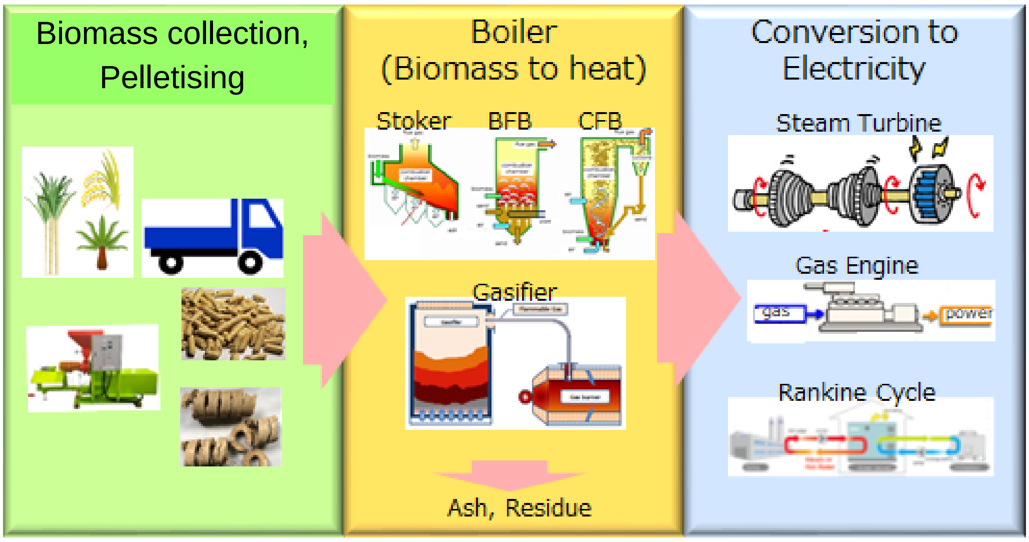
Source: WG presentation for the Study on Biomass and Coal Cofiring in the ASEAN Region (II), EGAT (June 2020).

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).

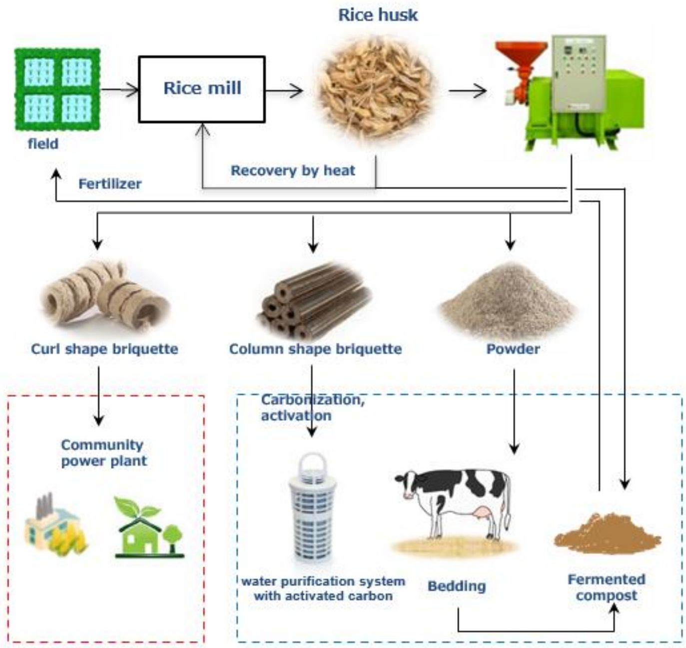
Table 3.13. Specifications of a Grind Mill

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

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



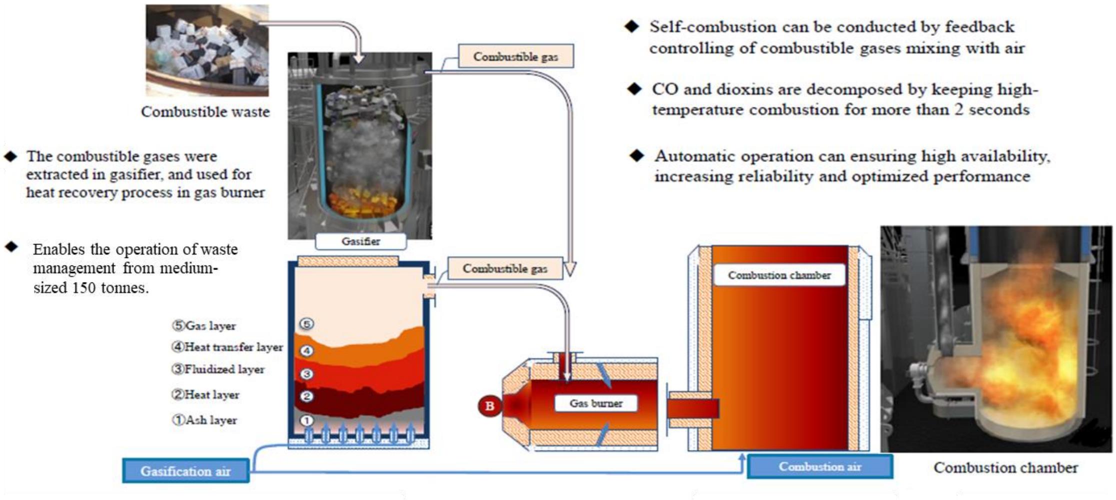
Source: Adapted from WG presentation for the Study on Biomass and Coal Co-combustion in the ASEAN Region (II), Tromso (June 2020).

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

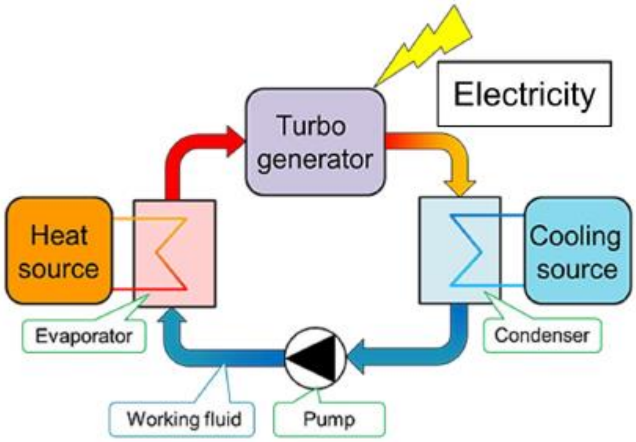
There might be some constraints in adapting high-efficiency turbines and generator facilities in a small-scale power plant concerning the technical aspects and investment. In these cases, ORC is sometimes applied to generate power. Its characteristics and features are as follows:

- 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.

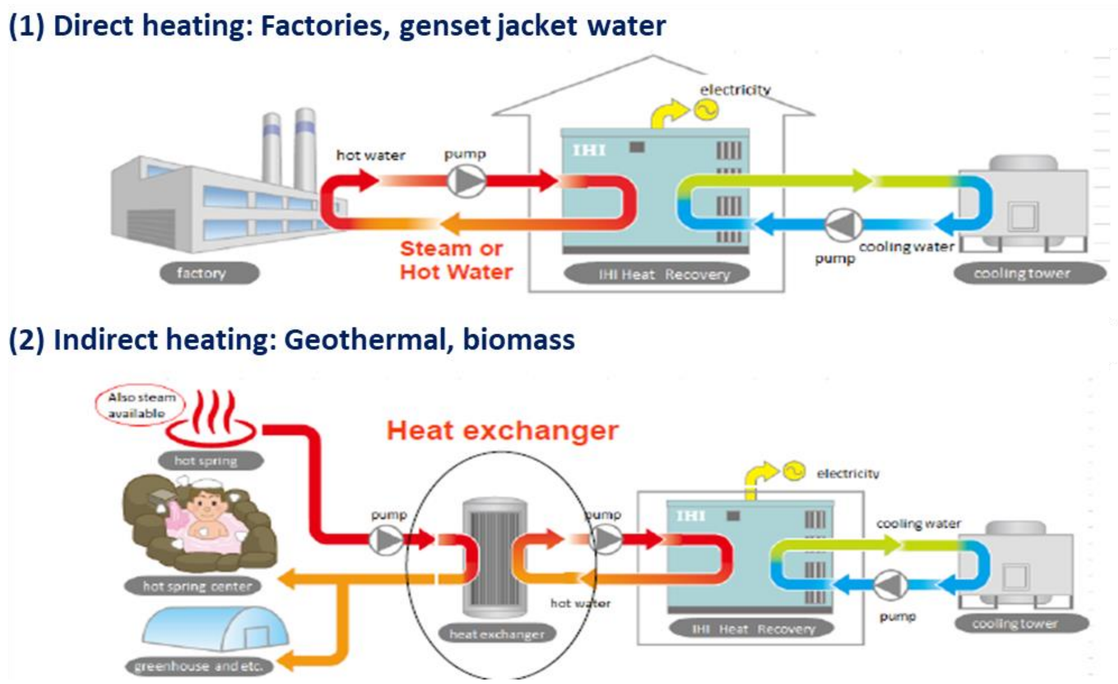
Figure 3.31. Principles of Organic Rankine Cycle



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

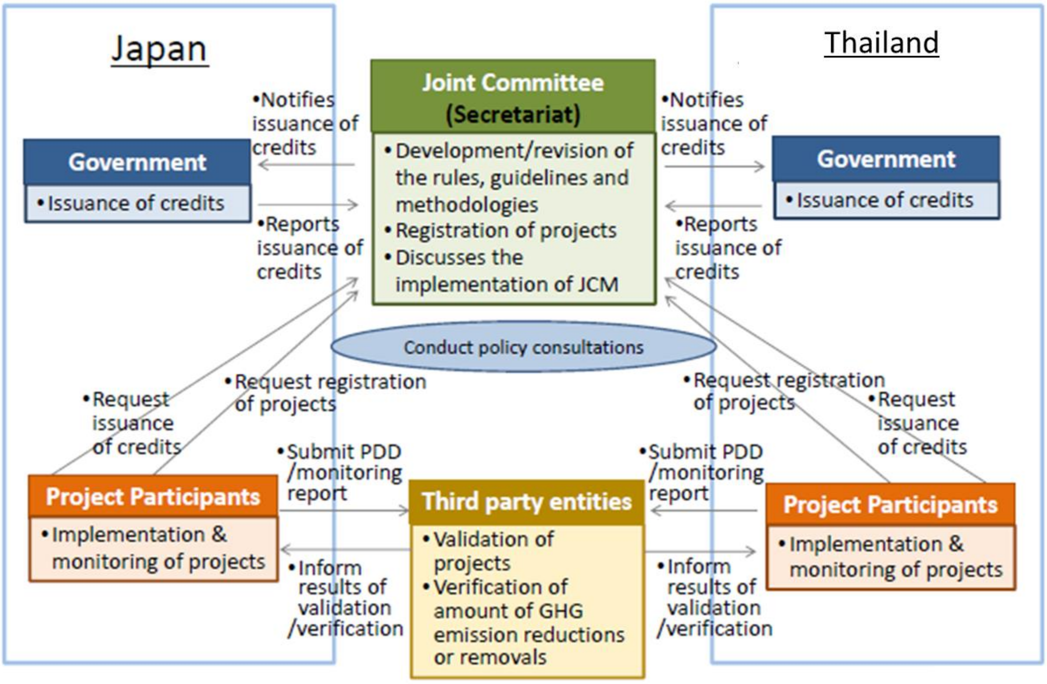
The plant facility's financial support is a critical item to materialise the community power plant project.

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.