Appendices

Appendix A

Biomass and Coal Co-Combustion in ASEAN Region (II)

ERIA-Japan Coal Energy Center (JCOAL) Working Group Meeting
22 December 2020, MS Team Platform

Phase one study findings show that Indonesia has biomass co-firing and firing potential of around 32,654 MWe and the Philippines around 4,449.54 MWe. The advantages and spillover effects of biomass co-firing include (1) CO_2 reduction using carbon-neutral biomass co-firing; (2) reduction of disposed waste by utilising domestically available agricultural waste; (3) biomass co-firing or firing can be used in a variety of boilers, including circulating fluidised bed (CFB) boilers, small pulverised boilers, and ultra-supercritical (USC); (4) biomass co-firing may help improve plant economics because the fuel is locally available, and procurement is efficient; (5) the seasonality of biomass supply would be compensated by coal, and the coal/biomass ratio would be optimised with seasonal variation; and (6) local people would be employed in the labour-intensive process of biomass co-firing, which includes collection, selection, and torrefaction or pellet manufacture as needed.

The phase one study's recommendations include (1) government authorisation to use biomass as renewable energy in each country's energy development plan; (2) tariffs and other financial incentives for biomass co-combustion; (3) development of a biomass collection scheme, regional government support for jobs related to biomass waste collection; and (4) regional and international collaboration.

For Indonesia '50MW CFB with domestic coal' was chosen as an appropriate option, whereas '50MW CFB with imported coal' was identified as an appropriate option for the Philippines. For Thailand, it was determined that co-firing in a mine-mouth subcritical/biomass gasification/small-scale gas engines, as foreseen in the government's study, would be the optimal solution. The case study using Levelized Cost of Electricity (LCOE) to determine the economic viability of biomass and coal co-firing concluded that biomass and coal co-firing are not economically viable under existing tariff conditions and in the absence of additional relevant incentives. It is advised that governments implement the appropriate incentives, such as a feed-in tariff or other forms of support, to identify necessary measures that are compatible with the Association of Southeast Asian Nation's (ASEAN) individual member states and guidelines for biomass usage with a focus on co-firing through best practices, in order to create an ideal policy framework. Additional consideration will be given to developing country-specific recommendations about optimal plant capacity, technology selection, biomass firing and/or co-firing, and appropriate incentives.

The phase two study is expected to produce guidelines for the appropriate policy framework for ASEAN to support biomass utilisation, with a particular emphasis on co-firing, and strategies for introducing, implementing, and disseminating co-firing best practices on a country-by-country basis. The applicable technology, policy approaches, and anticipated challenges to be handled will be identified, along with their associated advantages and disadvantages. Extra attention will be taken to ensure the recommended by-country strategies are clear and suitable for prompt implementation by the target member state(s). Additionally, advice regarding the role of co-firing in tackling the forthcoming issue of grid instability as a result of the widespread use of renewable energy.

For the second phase of the study, suitable biomass energy methods such as woody biomass (wood chips, torrefied fuel); agricultural waste (pellets, chips); refuse-derived fuel (RDF); waste tires; gasification (gasified biomass, methane fermentation); and liquefaction (biodiesel, bioethanol, pyrolysis oil) will be investigated. These materials would be used in biomass power applications such as co-firing with coal (on a large scale/≦1,000 MW, and the mixed rate would be no more than 20%; on a medium scale/≦200 MW, the mixed rate would be no more than 50%); co-firing in CFBs with coal or biomass alone (on a medium scale/≦200 MW); and CHP (small scale of gas engines, gas combustion, fuel cell, binary cycle). Choose the optimal plan depending on the kind and quantity of biomass, the capacity of the power generation facility, and the type and capacity of the grid.

In Cambodia, the electricity rate increased from 86% in 2017 to 92.68% in 2019. The installed capacity and demand are expected to expand from roughly 2,200 MW in 2018 to approximately 5,500 MW in 2030 as a result of planned thermal and hydro expansion. Cambodia's national commitment to climate change action in the energy sector includes the following: (1) grid-connected renewable energy generation (solar energy, hydropower, biomass, and biogas), as well as decentralised renewable energy generation connected to the grid; (2) off-grid electricity generation such as solar home systems and hydro (pico, mini, hydro); and (3) promoting energy efficiency amongst end users, which can save 1,800 Gg CO_2eq (16%) by 2030. Priority initiatives in the industrial sector include increasing the use of renewable energy and implementing energy efficiency measures in garment factories, rice mills, and brick kilns, which can result in a 727 Gg CO_2eq (7%) reduction in 2030 compared to the baseline. Priority actions in the transportation sector include promoting mass public transportation and improving vehicle operation and maintenance through motor vehicle inspection and eco-driving, as well as increased use of hybrid cars, electric vehicles, and bicycles, which can save 390 Gg CO_2eq (3%) in 2030 compared to the baseline. In the other sectors, priority actions include (1) promoting energy efficiency in buildings and more efficient cookstoves, (2) reducing waste-related emissions through the use of biodigesters and water filters, and (3) utilising renewable energy for irrigation and solar lamps, which can result in a reduction of 155 Gg CO_2eq (1%)

in 2030 compared to the baseline. All four sectors will save a total of 3,100 (2%) Gg CO_2eq in 2030 as compared to the baseline.

Cambodia is pursuing the use of wood biomass through tree planting and sustainable forest management. The following is the government's position on this: (1) With tree planting, a planned and stable supply of fuel wood is possible; (2) Even with energy tree cultivation, fuel costs are a small fraction of total electricity generation costs (11% in the case of 13 kWh monthly electricity consumption per household); (3) Using agricultural residues does not significantly reduce costs; (4) The purchasing cost of cultivated trees is low (about $20/t); (5) Using agricultural residue could be more expensive when transportation cost occurs; and (6) In general, woody biomass is the ideal fuel for gasification. Additionally, a proposed plan of action includes the following: 1) Conduct a baseline research to determine the availability of wood biomass resources in terms of quantity, area, and price. Collaboration with forestry experts is critical, as the study must consider sustainable tree planting and wood biomass utilisation; 2) Following the basic study, conduct a model study for biomass collection and procurement, keeping in mind the roles of the community and community-based organisations; 3) Biomass technologies must also be studied in close collaboration with biomass power technology specialists; 4) Literature review supplemented with interviews with biomass power technology specialists; 5) In addition to the aforementioned studies, the government is anticipated to make policy efforts toward examining and establishing incentives for biomass co-firing at existing and future coal-fired power plants; and 6) Based on the findings of the studies in 1), 2), and 3), a model project of dedicated biomass firing well-connected to the community and community-based organisations is to be planned and implemented.

In Indonesia, fossil fuels will continue to be the primary source of energy until 2050; however, reserves of fossil fuels have depleted and output of oil and natural gas has stagnated. Indonesia initiated an energy policy that advocates for increased use of new renewable energy (NRE) sources with the goal of diversifying energy sources and reducing reliance on fossil fuels in order to mitigate climate change. NRE's proportion of the economy will expand to 23% in 2025 and 31% in 2050. Finally, NRE will account for the largest share of the energy mix in 2050. In the power generation sector, coal-fired power plants will continue to dominate in the future, while the share of electricity generated by renewable energy sources will climb from 13% in 2019 to 23% in 2025.

Additionally, the country has an extensive biomass potential of approximately 32,655MWe. Palm oil, which includes palm oil mill effluent (POME), palm kernel shell (PKS), and empty fruit bunch (EFB), is Indonesia's primary source. Around 66 biomass power plants (including municipal solid waste) have been installed, totalling 1,896.5 MW in capacity. In the palm oil, sugar, pulp, and paper industries, the majority of biomass energy generation occurs off-grid.

EFB was chosen as the appropriate biomass crop for Indonesia, while rice husk was chosen for the Philippines. The international market for woody biomass has already been established, and it is quite expensive. Woody biomass is excluded from this study due to deforestation and the cost of electricity. The efficiency of the unit diminishes as the amount of biomass cofired increases. The findings for Case 1 and Case 2 indicate that their economic viability is currently unfeasible without the appropriate incentives. In comparison to ordinary coal combustion for power generation, co-firing agricultural waste and coal on CFBC boilers will significantly contribute to CO_2 mitigation.

According to PLN's Co-firing Roadmap, the company began co-firing trial tests in 2019 and will continue through 2024. PLN conducted biomass co-firing testing on six existing CFPPs with varied compositions and found excellent results. The total generation capacity of biomass co-firing on PLN's CFPP in Indonesia is 18,154 MW, with roughly 4 million tonnes of biomass consumed annually. The benefits of biomass co-firing include increased waste utilisation, increased renewable energy generation, and CO_2 emission reduction. Additionally, biomass co-firing will spur economic development and employment creation in the region. The overall capacity of the proposed coal-fired power plants (CFPP) on Jawa-Madura-Bali (JAMALI) Grid for 5% co-firing with biomass is 10,00MW, which is estimated to result in the establishment of 160 mills and 1,600 new jobs. Numerous technologies for biomass utilisation have previously been implemented in Indonesia. The technology that is relevant to biomass is scale-dependent. It is critical to understand the characteristics of biomass before using it, such as grindability, contained corrosive components, and moisture content.

Indonesia's government is increasing the share of renewable energy in the country's energy mix, including the power generation sector. The government has issued a number of directives and rules that are believed to adequately fulfil the power sector's requirements. Additionally, the government has developed a strategic plan and is advocating support for biomass expansion. As indicated previously, the Indonesian government is implementing numerous efforts to promote and disseminate utilisation of biomass, and the development of biomass-based power generation is moving apace.

Japan Coal Energy Center (JCOAL) made two recommendations: 1) Improve rural electrification and effective use of off-grid power, in which biomass power would enable village electrification via off-grid captive power sales to PLN or direct supply of such off-grid biomass power to the local area; and 2) Collecting biomass waste for power plants. Local farmers, business owners, and allied groups formed a cooperative association to manage the collecting and transportation of biomass in the region, thereby increasing the efficiency of biomass delivery.

The power generation facilities in the Philippines by the end of 2019 is 25,531 MW and it is expected increase in 2030 around 50,919 MW which is almost two times in 2040 around 90,584 MW under reference scenario. In the Philippines small to medium-sized power plants and coal-fired power plants are of the subcritical type 400 MW, and CFB 200 MW.

The Philippine Department of Energy made requests at its December 2019 meeting with JCOAL, including the installation of a bigger capacity CFB boiler and the continuation of coal-fired power generation through the use of high-efficiency, low-emission carbon capture technology. Biomass power generation capacity is expected to reach 1,550 MW by CES in 2040, representing less than 2% of overall power generation capacity. Co-firing biomass is advantageous in terms of CO_2 reduction, as it is carbon-neutral.

Thailand's power development plan projects that overall capacity will expand to 77,211MW in 2037, up from 46,090 MW in 2017. While 25 GW of plants that are somewhat older and/or smaller will be retired, another 56 GW will be commissioned. Its primary sources of energy are combined cycle and renewables. Additionally, policy support for biomass utilisation, dubbed '4D+E,' is available (Digitalisation, Deregulation, Decarbonisation, Decentralisation, and Electrification).

In 2020, a total of 700 MW of electricity generated by community-based power plants will be permitted for purchase and sale to the national grid under this new policy. Out of the 700 MW, a 'Quick Win Project' must be contracted by 2020 and must begin supplying electricity to the grid within 12 months of contract signing. Purchase of up to 100 MW of power is permitted. Mae Jam (Biomass 3 MW) in Chiang Mai Province and Thap Sakae (Biogas Energy Crop 3 MW) in Prachuap Khiri Khan Province are two of the community power plant projects of the Electricity Generating Authority of Thailand (EGAT).

Recommendations for Thailand include resource circulation to promote community sustainability, the use of municipal waste as biomass to manage municipal waste challenges, and financial assistance through bilateral collaboration.

ASEAN is predicted to undergo an energy transition, with a large increase in renewable energy. When introducing renewable energy on a large scale in ASEAN, grid flexibility is critical, as renewable energy is inherently unpredictable and intermittent. If no countermeasures are adopted, such a big introduction may result in systemic fluctuation. Additionally, coal and biomass share similar advantages in terms of their ability to operate in a flexible manner, which is critical for enabling a successful energy transition. Coal is highly reliable in terms of supply but is a significant CO_2 emitter, whereas biomass is carbon neutral but has a seasonal supply; so, both are complementary and would make an ideal combination. This complementary relationship between coal and biomass is critical for understanding biomass co-firing; Dedicated biomass firing would be an appropriate option for rural electrification and social development due to its small scale, labour-intensive but less expensive nature, and guaranteed procurement through indigenous fuel utilisation; Envisaged policy initiatives to facilitate biomass utilisation in the power sector of the ASEAN Member States.

Appendix B

Biomass Production and Supply Chain in Indonesia

ERIA-Indonesian Biomass Energy Society (IBES) Working Group Meeting

Ir Djoko Winarno, MM, IPU, AER – Chairman

14 January 2021, MS Team Platform

The Indonesian Biomass Energy Society (IBES) was declared on September 2021 with a vision to become a leading professional organisation in the development of biomass energy to support the national energy security and economy in a sustainable manner. The objectives of IBES are (1) increasing public energy access through renewable energy that can promote economic growth and environmental protection, aligning with the philosophy of pro-growth, pro-job, pro-poor, pro-environment; (2) improve the utilisation of biofuels and biomass as a source of electricity; (3) initiate the energy forest development program with government involving the community in assuring raw material availability and biomass production.

The roles and contribution of forest plants are (1) local need for diesel power plants, with its fuel converted into biomass; (2) more than 2 million people rely on biomass for cooking and heating; (3) the availability of energy from fossil fuels is limited, while forest land still quite extensive (2,245,364.00 hectares of the industrial plantaion forest (Hutan Tanaman Industry or HTI in Indonesian language) reserved and the community plantation forest (Hutan Tanaman Rakyat or HTR in Indonesian language) has 702,519.73 hectares reserved).

Additionally, the potential for crop forest development invokes the following: (1) forest area is 70% of total land area, (2) 74.44 million hectares (62.57%) of production forest, (3) permits have not been imposed on an area of 36.99 million hectares, of which 10.06 million hectares have been reserved for HT, (4) the area of HP is 28.99 million hectares, HPT is 28.41 million hectares, HPK is 18.04 million hectares, (5) plantation forest area is 5 million hectares and wood production is 21 million m^3/year.

Indonesia has a total of 32,656 MW biomass power plant and waste potential including HTI/E area, specifically Sumatra (15,588 MW); Java, Bali, Madura (9,215 MW); Kalimantan (5,062 MW); Sulawesi (1.937 MW); Nusa Tenggara (636 MW); Papua (151 MW); and Maluku (67 MW). The total area of potential energy plantation forest (HTE) is 1,292,766 hectares, with 32 total business units committed to developing energy and bioenergy plantation forests. PLN is currently preparing the new biomass power plant. In addition, biomass pellets from waste and forest products are also used as co-firing at the coal-fired power plant. Pellets from waste can generate 2,900–3,400 Cal/gr and pellets from wood can generate 3,300–4,000 Cal/gr.

Indonesia, as an agrarian country, has the capacity to produce ethanol. In Indonesia, the raw materials that are widely used are straw rice, corn stover, sago baggase, sugarcane baggase, and empty fruit bunch. The total potential of cellulosic ethanol from those raw materials is approximately 34.6 billion litres. Indonesia also has a large biomass resource. Biomass-based ethanol production could produce 34 billion litres per year. Biomass ethanol production technology is currently in its infancy; hence, the cost of biomass ethanol production is still very high. In order for Indonesia to have effective biorefinery technology and efficient biomass ethanol production at the price level of gasoline-95 in 5 years' time, it is required nationally to conduct focused research.

According to the International Renewable Energy Agency (IRENA), bioenergy must be a significant part of our energy mix by the year 2050. Renewable energy and energy efficiency are capable of reducing emissions by 90%. Modern bioenergy use must increase from 4% of the energy mix in 2017 to 16% by 2050 as part of this shift. In addition, bioenergy must play a core role in industry and transport. In the industrial sector, biomass was used at a rate of around 9% in 2017. The percentage of biomass utilisation in 2050 Planned Energy Scenario (PES) and 2050 Transforming Energy Scenario (TES) is predicted to climb to 16% and 28%, respectively. Biomass use in the transportation sector is 3% in 2017, but is expected to rise to 10% in 2050 PES and 17% in 2050 TES.

In Southeast Asia, bioenergy is expected to become the largest energy source in the total energy mix, over 40% of total primary energy supply (TPES) in 2050 under TES. The potential for sustainable biomass is estimated to be in Indonesia, Malaysia, the Philippines, Thailand, and Viet Nam. The study revealed that by reducing waste and improving efficiency, biomass might contribute significantly to the energy mix while also freeing up space for other purposes, such as agricultural and forestry residues, reduced food waste, and sustainable timber extraction. In addition, biomass from all aspects of the oil palm industry is widely used as sources of renewable energy.

The first step is mapping bioenergy pathways in Indonesia. There are four demonstrable pathways that have potential to provide over 60% of the contestable energy mix in industry and transport by 2050. Bioenergy pathways provide an approach for quantifying available sources and potential technical routes through which they can be supplied. Out of the available primary bioenergy sources, over 40% on a petajoule (PJ) basis can be used as substitute for fossil fuel by 2050. The first pathway is direct combustion for industrial heat rising; the second pathway is direct combustion in CHP for raising steam and power generation; the third pathway is anaerobic digestion; and the fourth is refining and blending. Although there are huge bioenergy resources in Southeast Asia, a realistic view on the security of supply must recognise constraints from several key factors. The increase in collected feedstock over time is due to increasing plantation owner and farmer awareness, improvements in logistics management in the collection, stockpile management, processing and delivery, and improvements in technology.

The second step is quantifying bioenergy economics in Indonesia. A cost and benefit analysis shows significant economic benefits through developing bioenergy projects by 2050, with the benefits including avoided environmental costs and creation of resilient jobs. Total economic benefits are $55 billion, total avoided environmental costs $45 billion, and total contribution to economy from resilient jobs creation is $12 billion.

The third step is developing a bioenergy transformational roadmap in Indonesia. To unlock the significant economic benefits by 2050, key challenges around political, economic, social, technical, environmental, legal, and financing (PESTEL&F) dimensions were identified as well as short-, medium-, and long-term interventions which can tackle these challenges. The key challenges are lack of preferential regulatory framework, constraints of efficiency and replaceability, and low security of revenue.

Appendix C

Second Generation Bioethanol in Indonesia: Prospect and Challenges

ERIA-Indonesian Spirits and Ethanol Association (ASENDO) Working Group Meeting

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29 January 2021, MS Team Platform

There are two types of bioethanol namely 1st Generation-ethanol and 2nd Generation-ethanol. The feedstocks of 1st G-ethanol include sugar-containing materials such as sugarcane juice, cane molasses, sweet sorghum juice, and starch-containing materials such as cassava (dry or fresh) as well as corn. Additionally, technology for producing 1st G-ethanol is very well established in Indonesia. Only six of the approximately 12 enterprises that are members of ASENDO, Indonesia's ethanol association, are operational. Molindo Raya Industrial, PT in Malang, East Java, is the largest ethanol producer, producing 80,000 kL ethanol per year. Only one non-ASENDO firm has existed that generated 50,000 kL of ethanol each year. However, the production cost of 1st G-ethanol is higher compared to 2nd G-ethanol. Furthermore, the price of ethanol is about double the price of gasoline-88 because the price of molasses is very high. Consequently, biofuel programmes cannot be implemented.

Indonesia is an agricultural country; therefore, biomass, including 2nd G-ethanol, biomass ethanol, and cellulosic ethanol, is readily available. Potential feedstocks for biomass ethanol are sugarcane bagasse (480 million L/year), rice straw (19.44 billion L/year), corn stover (8.271 billion L/year), sago hampass (136 million L/year), and empty fruit bunch (EFB) from oil palm (6.283 billion L/year). This total of 34,610,000 kl/year constitutes more than enough to replace gasoline imports via the 'A20' programme. This programme was initiated by PERTAMINA as an effort to reduce gasoline imports. The government has issued regulations for the mandatory use of biofuels as a vehicle fuel mixture. In the Minister of Energy and Mineral Resources Regulation 12/2005, ethanol has been required as a gasoline fuel mixture since 2015. The implementation target continues to increase to 20% in 2025. The programme is to develop bio gasoline (A20) or 15% methanol gasoline and 5% ethanol.

From the feedstock availability point of view, it can be concluded that the prospect of 2nd G-ethanol in Indonesia is very encouraging. However, the challenges to realise the prospect remain. Even in the US, which is the world's number one ethanol producer, 14 years after the Energy Independence and Security Act was signed by President Bush in 2007, cellulosic ethanol production is still less than 4% of total ethanol production. The US ethanol production by feedstock type is from corn starch (94%), with the rest from corn/ sorghum/ cellulosic biomass/ waste (3.4%); corn/ sorghum (2.1%); cellulosic biomass (0.5%); and waste sugars/ alcohol/ starch (0.1%). Furthermore, according to the USDA-GAIN report, annual European Union production of cellulosic ethanol was estimated to be around 40 kt in 2017 down to 10 kt in 2018. In Brazil, total cellulosic ethanol production is estimated to be 25 million litres (or 20 kt) for 2018, representing an insignificant share of total ethanol production. In China, 2018 cellulosic ethanol production is forecast to stop at 20 million litres (or 16 kt) as its major cellulosic project appears idle.

To comprehend the challenges, knowledge of the 2nd G-ethanol stages is required. Four steps to produce 2nd G-ethanol are (1) biomass pre-treatment; (2) hydrolysis (enzymatic) of pre-treated biomass; (3) fermentation of hydrolysis products; and (4) distillation and dehydration. Biomass pre-treatment is to make cellulose and hemicellulose free from lignin so that cellulolytic enzymes have access to contact and hydrolise cellulose to yield C6 (glucose) and xylanolytic enzymes can hydrolise hemicellulose to xylose (C5). This step should be done because feedstocks for 2nd G-ethanol cannot be fermented directly. Biomass pre-treatment technology is quite mature but is still being developed. Pre-treatment is very essential for enzymatic hydrolysis and graded according to multiple targets including degree of particle size reduction, fermentable sugar (C6/C5) recovery, inhibitor formation (e.g. fermentability), energy and water consumption, operating cost, as well as environmental footprint. The methods used for pre-treatment are alkaline, acid, ammonia, and steam explosion. Effective pre-treatment methods should have low capex, which can be accomplished by avoiding the use of costly materials (catalyst, solvents, reagents, and biomass) during pre-treatment and consequent neutralisation. Because pre-treatment uses a significant amount of energy in the ethanol process, it is critical to keep the energy demand low while preserving process performance. Inhibitors should be produced in small quantities. High pre-treatment severity can result in inefficient hemicellulose degradation and the formation of hazardous chemicals derived from sugar decomposition, which can affect the enzymatic hydrolysis and fermentation stages. The sugars content from the collective pre-treatment and enzymatic hydrolysis processes should be >10% to establish acceptable ethanol concentrations, manage recovery, and other downstream costs. Lignin should also be recoverable to be converted into important products to realise the biorefinery concept. At industrial scale, research and development is still needed to develop efficient and environmentally friendly biomass pre- treatment technology.

The second step, which is hydrolysis of pre-treated biomass is very important. Two enzymes used in this step are cellulolytic enzymes and xylanolytic enzymes. Cellulolytic will hydrolise cellulose into glucose and xylanolytic will hydrolise hemicellulose to use xylose (C5). In Indonesia, significant research effort is required to lower the contribution of enzymes to biofuel production costs. Due to the fundamental role of cellulolytic enzymes in 2nd G-ethanol production, Indonesia must develop its own technology.

Many literatures mentioned the cost of enzymes to produce one gallon of 2nd G-ethanol. The cost contribution of enzymes to the production of lignocellulosic ethanol varies widely in the literature, ranging from \$0.10/gal–\$0.40/gal. In addition, the cost of enzymes in the production of lignocellulosic biofuels is still a big challenge. Around the world, there are many studies conducted to minimise the cost of enzymes in the 2nd G-ethanol production.

China, India, and Brazil have a high number of publications in the development of Cellulolytic Enzymes Technology, most likely due to investments made on Cellulosic Bioethanol between 2015 and 2017. In order to efficiently produce 2^{nd} G-ethanol from a mixture of glucose and xylose at once, the development of special yeast strains through genetic engineering is a must. To summarise, a large amount of study is still required in Indonesia to reduce the contribution of enzymes to the expenses of biofuel production.

Microbes such as Saccharomyces cerevisiae, S. uvarum, and Zimomonas mobilis are capable of fermenting glucose (C6) into ethanol, and the technique for doing so is well established. For the technological fermentative 2^{nd} G-ethanol from C5 and C6, sophisticated microbial genetic engineering methods are used. However, there still no research published in Indonesia. Several 2^{nd} G-ethanol plants are well established around the world such as GranBio in Brazil (construction start in 2014), Raizen in Piracicaba, Brazil (inaugurated in 2015), four plants in the US (two of them in Iowa, one in Kansas, one in Illinois), and one plant in Italy. However, in Indonesia, PERTAMINA will construct the 2^{nd} G-ethanol plant with a capacity of 25,000 tonne/year by 2025.

Appendix D

Introduction to RENOVA Energy and Biomass Project Development

ERIA-RENOVA Working Group Meeting

18 March 2021, MS Team Platform

The government has a clear target of carbon neutrality by 2050 and declared that low-efficiency coal power stations must be made obsolete by biomass in tandem with its deep relation with government policy on fossil fuels, particularly coal and non-renewables. RENOVA, Inc. was established in May 2020 and specialises in the development and operation of renewable energy facilities (solar, wind, biomass, and geothermal). Its mission is to create green and sustainable energy systems for a better world with the vision to become Asia's renewable energy leader. RENOVA focuses on biomass and offshore wind power while accelerating its overseas business. This strategy includes increasing its investment in biomass, and wind power, both offshore and onshore overseas, and further strengthening cost competitiveness to achieve long-term growth.

As of February 2021, existing and pipeline RENOVA projects account for approximately 1.8 GW of power. Specifically, around 350 MW of solar, around 400 MW of biomass, around 1,000 MW of wind, and geothermal are under development. RENOVA expects to commence construction on all disclosed biomass pipeline projects over the next 1–2 years. In Japan and abroad, RENOVA has 25 projects in operation, under construction, and under development.

Construction commenced as scheduled in December 2019 for the Omaezakikou Biomass Project (74.95 MW) and in March 2020 for the Ishinomaki Hibarino Biomass Project (74.95 MW). Both projects will commence operation in FY3/2024. Furthermore, one of the large-scale biomass project developments, the Tokushima-Tsuda Biomass Project (74.8 MW) reached financial completion on 25 February 2019. RENOVA was selected by the local consortium and led its development. The business development fee was received from the special purpose company (SPC) and one of the project's co-sponsors.

RENOVA has five dedicated biomass power projects in Kanda, Tokushima, Omaezaki, Sendai, and Ishinomaki, each generating 75 MW. In Tokushima, the process is on schedule and a commercial operation date is in the middle of 2023. In the nearby prefecture of Tohoku, a power project is beginning construction. By the of 2023, five units of dedicated biomass power station will start commercial operation. By that time, RENOVA would be one of the top companies in Japan in terms of total generation capacity by biomass. Total biomass fuel consumption by RENOVA will be about 1.5 million tonnes per year in wood chips and wood pellets. For the moment, most fuel is coming from overseas. Additionally, RENOVA has one existing biomass power station of 20 MW in Akita prefecture, which has operated since 2016. It has a good reputation on the quality of its construction. In addition, Akita power station also imports briquettes from Indonesia and Malaysia to maintain constant combustion, particularly in winter.

After the commencement of commercial operation, RENOVA pays the greatest attention to stable, continuous, and safe operation of whole biomass power plant. Electricity generation has a social responsibility, and is fundamental to supporting the energy infrastructure of Japan. Furthermore, amongst renewables, biomass can constitute an important electricity baseload.

The Ministry of Economy, Trade, and Industry (METI) of Japan has a famous guideline called Energy Mix 2030. By 2030, renewables would be between 22%–24% of total energy for power generation. According to the Reuter.com (2021), this percentage has been almost attained at this moment. Amongst renewables, biomass contributes 3.7%–4.5% of total energy. To achieve this capacity, about 2.5 million tonnes of biomass per year is necessary. Meanwhile, before the energy mix was announced by METI in 2016, the feed-in tariff was introduced in 2012. It accelerated the power industry to move toward renewables. Independent power producer (IPP) has developed dedicated biomass power projects and the power measures utility company has begun to co-fire coal and biomass. Nonetheless, Japan needs to leave out fossil fuels more seriously and more quickly. The driving force was the statement of the Prime Minister in 2020, which declared that Japan will be carbon-neutral by 2050. At the same time, the minister of METI announced low-efficiency coal-fired power stations must be phased out because coal is not welcome by international society. As most European counties already planned to abandon coal dependency, Japan must go in the same direction. It has become obvious that Japan needs to leave out coal dependency as quickly as possible.

The government has started the discussion for reconsidering, revising, updating its energy mix guideline. One of the potential scenarios is making renewables 50%–60% of the total share. Hydrogen and ammonia would be made 10% of total energy. The remained is given for nuclear and thermal power with carbon capture technology. Amongst renewables, the government emphasises that offshore wind power, both embedded and floating, should be encouraged. However, biomass is important as well. It is not always necessary to have a green biomass project, which normally takes several years to build. The existing facility can be utilised, although the city modification is necessary. Coal-fired power stations cannot become renewable power stations without sacrificing the oversupply facilities.

Regarding biomass fuel procurement, there are many long-term supply and purchase contracts already existing between overseas suppliers and Japan. Many of them supply biomass fuel to dedicated projects of the capacity between 50–110 MW. Some of them have already started operation. In fact, in the case of RENOVA, only one power plant in Akita is now in operation. One power plant in Kanda is under trial run, and power plants in Tokushima, Ishinomaki, and Sendai are under construction. The other, in Omaezaki, is still in the construction preparation stage. By 2023, RENOVA will have completed six dedicated biomass power projects.

As of March 2021, RENOVA currently purchases about 100,000 tonnes a year of wood pellet equivalent biomass. However, after all power plants commence operation in 2023, RENOVA's total biomass purchase will be about 1.7 million tonnes a year of wood pellet equivalent. In addition, existing coal-fired power stations now co-firing small percentage of biomass will increase their ratio. Fuel conversion from coal to biomass will come as well.

Regarding the total demand of biomass, from Energy Mix 2030, around 25 million tonnes a year is necessary. Future demand will change upward depending on the other energy behaviour. The most difficult part of biomass is availability uncertainty. Therefore, biomass should focus on sustainability, legality, and transparency of its feedstock. Further, life cycle assessment of GHGs needs to be managed. Sustainability certification from crude palm oil mills is needed for port delivery. Simultaneously, in the context of biomass, some NGOs claim that biomass could potentially harvest native trees, which destroys rainforests and ecosystems. Therefore, it is better to distinguish between good and bad biomass, which is agreed upon by everyone, including environmental NGOs.

Biomass needs to be proven internationally as sustainable, legal, and transparent. In terms of CO_2 emissions, biomass should prove that its entire trip to the power station produces fewer greenhouse gases than fossil fuels. In addition, black pellet and torrefaction biomass will have a certain market share in Japan in the future as well. Torrefaction of biomass will increase calorific value-up, have a better handling and stockpiling efficiency, be water-resistant, and have a better grind ability.

Appendix E

Automotive Contribution to Support Oil Reduction through Biofuel Utilisation

ERIA-Toyota Daihatsu Engineering & Manufacturing (TDEM) Working Group Meeting

Indra Chandra Setiawan

19 March 2021, MS Team Platform

In 2020, the Prime Minister of Japan, Yoshihide Suga, declared the country will be carbon-neutral by 2050. To accomplish this goal, it is critical to increase the efficiency of electricity generation and transportation. In automotives, this can be accomplished by focusing on vehicle design and technology, such as reducing air drag, reducing weight, and lowering rolling resistance. On the energy and powertrain mix for sustainable mobility, the short-term issues are connected to internal combustion engines, such as increased thermal efficiency and fuel diversity, while the medium-term challenges are related to electrification, such as batteries and infrastructure.

In Indonesia and Malaysia, higher-mixed biodiesel is extensively promoted, while Thailand's government considers E20 as the primary fuel and plans to phase out E85 through subsidy reductions. Thailand's government has announced the implementation of Euro 5 and Euro 6 emissions regulations in 2022 and 2023, respectively. Additionally, the Indonesian government intends to research B40 in advance of its adoption in 2021, while Malaysia's government intends to do research with the Japan Automobile Manufacturers Association (JAMA) in order to prepare for B30 implementation in 2021. JAMA proposed starting in April 2020, but the Malaysian Palm Oil Board (MPOB) wants to begin when JAMA discloses the results of B20 laboratory testing.

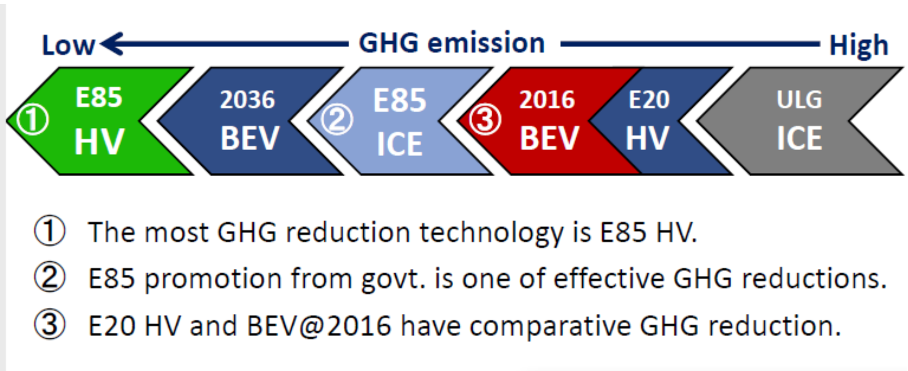
Indonesia is experiencing an oil consumption surplus, and the government has launched an 'Energy Mix' strategy to minimise oil consumption. According to National Energy General Plan (2018), renewable energy's proportion in Indonesia's energy mix will expand from 10% in 2018 to 23% in 2025 and 25% in 2030. According to 2018 data, 39% of total oil consumption in Indonesia comes from four wheels, including the energy mix, the oil consumption sector, transportation, and road transportation. Using the national energy mix target as a guide, the automotive sector should aim for a –20.8% reduction in oil consumption by 2030. To achieve the aim, comprehensive activities such as a Low Carbon Emission Vehicle(LCEV) or Battery Electric Vehicle (BEV) policy, compressed natural gas (CNG) vehicles, biodiesel, bioethanol, and vehicle replacement are implemented. To meet the oil consumption and CO_2 emission reduction targets, comprehensive actions are required to approach 'New Vehicle UIO (Units in Operation),' 'All UIO (Fuel Usage),' and 'Aged Vehicle UIO.' By implementing these efforts, it is conceivable to reduce oil consumption by 30.2% by 2030. This figure corresponds to the National Energy Mix Target. As a result, biofuels contribute significantly to Indonesia's oil reduction efforts.

Toyota is actively participating in the B40 implementation process. Currently, B40 is being investigated and tested for precipitation and material compatibility. This is expected to be completed in March 2021.

Toyota Motor Corporation developed analysis on 'Well-to-Wheel (WTW)' in regard to greenhouse gas (GHG) reduction from automotive fuels. This concept analysis can be implemented at the fuel supply cycle and operation stage of vehicle cycle, combining 'Well-to-Tank (WTT)' (fuel supply cycle) and 'Tank-to-Wheel (TTW)' (vehicle cycle) concept. In the case of ethanol, utilising a higher blend will reduce total WTW GHG emissions due to carbon balance between higher WTT and lower TTW. E85, moreover, is good for reducing GHG emissions from automotive fuels.

Toyota identified types of vehicle technologies from high to low generation of emissions, i.e. Internal Combustion Engine (ICE), Hybrid Vehicle (HV), Plug-in Hybrid Electric Vehicle (PHEV), and Battery Electric Vehicle (BEV). ICE and HV generate emissions on TTW; meanwhile, PHEV and BEV do so on the WTT stage. In the ideal scenario, BEV could be improved by using renewable energy in electricity generation to reduce WTT GHG emission. In this case, Toyota identifies scenarios for each vehicle technology as depicted on following figure D.1.

Figure D.1. Summary of Well-to-Wheel Analysis



GHG = greenhouse gases, E85: = 85% bioethanol blended to gasoline fuel, E20 = 20% bioethanol blended to gasoline fuel, ICE= internal combustion engine vehicles, HV = electric hybrid vehicles, BEV = battery electric vehicles.
Source: Toyota's Workshop Presentation, 2021.

In Thailand, the transportation sector is critical in reducing CO_2 emissions. Around 25% of emissions originate from the transportation sector, 40% from the electricity sector, 27% from industry, and 8% from other sources. The country has committed to a 25% reduction in GHG emissions by 2030. Thailand has an E85 Policy to blend ethanol to gasoline, and the National Elective Vehicle policy committee announced the country's target to have 30% of plug-in electric vehicles (xEVs) (consisting of 15% plug-in hybrid electric vehicles (PHEVs), and 15% battery electric vehicles (BEVs)) in total production by 2030.

Collaboration amongst all stakeholders, including energy suppliers, governments, customers, and automobile manufacturers, is required to meet the challenges of environmental and energy efficiency.

Appendix F

Biomass Supply Chain and Its Business Opportunity in Indonesia

ERIA- The Institute of Energy Economics, Japan Working Group Meeting

11 May 2021, MS Team Platform

From upstream to downstream, the biomass supply chain includes biomass production, pre-treatment, feedstock storage, bioenergy conversion, and bioenergy consumption. Biodiesel and bioethanol can be produced from the first generation of biomass. Biomass from all facets of the palm oil industry, including Palm Oil Mill Effluent (POME), Empty Fruit Bunch (EFB), and old palm trunks, is frequently employed as a sustainable energy source. The manufacturing procedures for the second generation of bioethanol include biomass pre-treatment, hydrolysis of pre-treated biomass, fermentation of hydrolysis products, distillation, and dehydration.

The primary business potential for biomass energy generation is related with Independent Power Producers (IPPs) that are privately developed, financed, and sell electricity to PLN under a long-term (up to 30 years) Power Purchase Agreement (PPA). The largest prospects (in terms of value) exist for foreign enterprises in consulting and engineering studies, significant electro-mechanical equipment supply, and engineering, procurement, and construction management, particularly for projects with a capacity more than 10 MW. Due to the constant changes in regulatory treatment and permissions for renewable energy IPPs, most foreign businesses established offices in Indonesia to perform market research, develop strong relationships with PLN, and evaluate possible local business partners. Market value of biomass is estimated to be around $271.5 million in 2020–21, increasing to $378.0 million in 2022–25, with a foreign share of $227.3 million.

The challenges of biomass are: 1) the high cost of transporting biomass results in these powerplants being located near the feedstock source; 2) feedstock availability is a challenge in developing and financing biomass power projects. Banks look for a feedstock supply agreement equal to or longer than the tenor of the loan; 3) the feedstock agreement should have a cap on the annual escalation, since that cost cannot be passed through to PLN; 4) in terms of commercial biomass technology, the principal is combustion for steam. Due to the size of biomass boilers, the most economic size for a biomass steam power plant is 10 MW or larger.