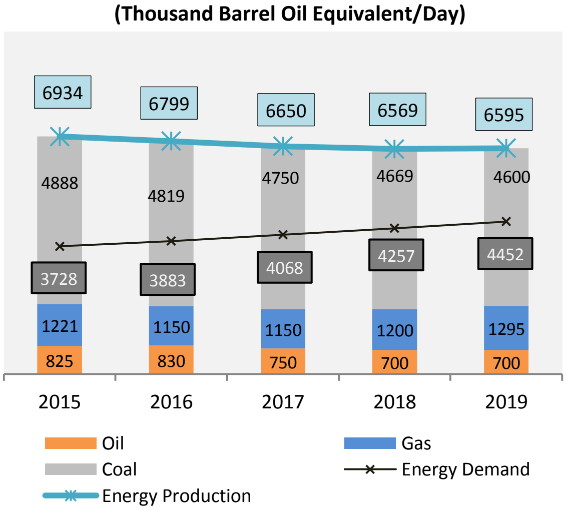
Reaching The Energy Mix Target Through Bioenergy

A. Introduction

The consumption of energy in Indonesia, currently is still depended on the use of fossil base. In other side, the production and discovery of new reserves of fossil base are not aligned with the growth of Indonesia's economy, which basically will trigger higher needs in the future.

Figure 1. Supply vs Demand of Fossil Base (Thousand Barrel Oil Equivalent/Day)



Source : Ministry of Energy and Mineral Resources (MEMR)

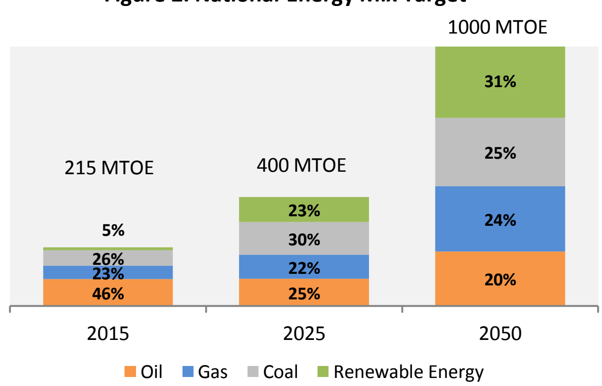
From the figure above, as we can see if the coal productions are excluded from the total productions of fossil base, the trade-off between total supply and demand are deficit. Such condition are mainly driven by three main reasons:

1) National demand > supply of oil, imports are needed.
2) Real demand > domestic gas supply, exports of gas are decreasing.
3) Production of coal > domestic demand.

Other problem will occur as a side effect of high demand fossil base is the rise of subsidy. For sure, this condition will suffer the government budget.

To overcome those problems, Government of Indonesia (GoI) continues to promote new and renewable resources by setting a target to reach 23 percent by 2025. This target is in line with Indonesia commitment to reduce greenhouse gas emissions which was set during the COP 21 conference 2015 in Paris, France.

Figure 2. National Energy Mix Target



Source : Ministry of Energy and Mineral Resources (MEMR)

The target that has been set by GoI is also supported by the potential of renewable energy resources which considerably untapped:

Figure 3. Energy Diversification Target

Resources	Potential	Resources	Potential
Geothermal	30 GW	Solar	533 GW
Bioenergy	33 GW	Wind	114 GW
Hydro	75 GW	Tidal	18 GW

Source: Global Green Growth Institute, Pushing the Envelope on Renewable Energy, 2016

Given the conditions, GoI has set focuses to increase energy diversification through renewable energy development ranging from geothermal, bioenergy, hydro, solar, wind, tidal and also biofuel production.

Figure 4. Energy Diversification Target

Indicator	2015	2016	2017	2018	2019
Geothermal*	1.439	1.713	1.976	2.610	3.195
Bioenergy*	1.892	2.069	2.292	2.559	2.872
Hydro & Mini Hydro*	8.342	9.252	9.592	10.082	10.622
Solar*	76,9	92,1	118,6	180	260,3
Wind/Hybrid *	5,8	11,5	19,8	30,8	47,0
Tidal*	-	-	-	-	1
Biofuel**	4,07	6,48	6,71	6,96	7,21

*In Megawatt (MW) Source : Ministry of Energy and Mineral Resources (MEMR)
**In Million Tons

Source : Ministry of Energy and Mineral Resources (MEMR)

By diversifying energy through several resources, the greenhouse gas emissions is expected to be reduced effectively from 14,71 million tons in 2015 to 28,48 million tons by in 2019.

Figure 5. Energy Efficiency and Emission Reduction Target

Indicator	2015	2016	2017	2018	2019
Energy Intensity*	482,2	477,3	472,6	467,8	463,2
CO2 Emission Reduction**	14,71	16,79	20,60	23,57	28,48

*Equivalent to Oil Barrel/Billion Rupiah
**Million Tons

Source : Ministry of Energy and Mineral Resources (MEMR)

When developing renewable energy, the competitiveness of technologies is a crucial factor in determining the extent to which they are developed and deployed purely on their own commercial merits, and therefore, the extent to which support may be required to enable society to meet many of its goals, such as mitigating climate change, reducing pollution and improving energy security. For a long time, some forms of renewable energy have offered competitive and cost effective means to generate electricity and heat, and to fuel transport. As a means of producing electricity, hydropower is foremost among competitive technologies. It has long been the largest source of renewable energy supply and currently provides about one sixth of the world's power supply. Bioenergy-based and geothermal power plants have also been deployed on a commercial basis in several markets. When cheap feed stocks are available, bioenergy is also competitive in some industrial applications, such as cement or food and beverages, and in the production of biofuels. For example, in Brazil, sugarcane based hydrous ethanol has been able to compete directly with conventional oil-based fuels over the past decade.[1]

Figure 6. Key Concepts In Evaluating Renewable Energy Project

1. **Energy Competitiveness** is used in to indicate when renewables are profitable for investors without targeted support from the government or other outside sources (even where support is currently available), but including the cost of emissions when they are priced.
2. **Financial attractiveness** indicates when a project is profitable for an investor taking into account the impact of available support schemes, which may provide additional revenues or reduce costs.
3. **Cost effectiveness** is a familiar, well-defined concept. It refers to the assessment of the relative costs of meeting a set of defined objectives, whether, for example, a given form of renewables-based power generation is more or less costly than nuclear power or carbon capture and storage as a means of decarbonising power supply, enhancing energy security, improving air quality and contributing to economic growth; or how the cost of one renewable energy solution compares to another. Commercial investors will also discuss the cost effectiveness of different ways to earn a targeted financial return.[2]

1International Energy Agency, "World Energy Outlook, Part B, Special Focus on Renewable Energy" (2016): 444, www.iea.org/t&c. Access date: 16 October 2017

2International Energy Agency, "World Energy Outlook, Part B, Special Focus on Renewable Energy" (2016): 444 - 445, www.iea.org/t&c. Access date: 16 October 2017

During the evaluation stage, investors also need to mitigate some risks that might appear during the construction or operation period. Each of renewable energy projects have different typical risk issues and barriers. A study conducted by United Nations Environment Programme (UNEP) elaborates the most common risk appears associated to renewable projects :

Figure 7. Key Risks & Barriers Associated to RE Projects

RE Type	Key Risk Issues	Risk Management Considerations
Geothermal	• Drilling expense and associated risk (e.g. blow out). • Exploration risk (e.g. unexpected temperature and flow rate). • Critical component failures such as pump breakdowns. • Long lead times (e.g. planning permission).	• Limited experience of operators and certain aspects of technology in different locations. • Limited resource measurement data. • Planning approvals can be difficult. • 'Stimulation technology' is still unproven but can reduce exploration risk.
Large PV	• Component breakdowns (e.g. short circuits). • Weather damage. • Theft/vandalism.	• Performance guarantee available (e.g. up to 25 years). • Standard components, with easy substitution. • Maintenance can be neglected (especially in developing countries).
Solar Thermal	• Prototypical/technology risks as project size increases and combines with other • RETs e.g. solar towers	• Good operating history and loss record (since 1984). • Maintenance can be neglected (especially in developing countries).
Small Hydro	• Flooding. • Seasonal/annual resource variability. • Prolonged breakdowns due to offsite monitoring (long response time) and lack of spare parts.	• Long-term proven technology with low operational risks and maintenance expenses.
Wind Power	• Long lead times and up-front costs (e.g. planning permission and construction costs). • Critical component failures (e.g. gear train/ box, bearings, blades etc). • Wind resource variability. • Offshore cable laying.	• Make and model of turbines. • Manufacturing warranties from component suppliers. • Good wind resource data. • Loss control e.g. fire fighting can be difficult offshore due to height/location. • Development of best practice procedures.
Biomass Power	• Fuel supply availability/variability. • Resource price variability. • Environmental liabilities associated with fuel handling and storage.	• Long-term contracts can solve the resource problems. • Fuel handling costs. • Emission controls.
Biogas Power	• Resource risk (e.g. reduction of gas quantity and quality due to changes in organic feedstock). • Planning opposition associated with odour problems.	• Strict safety procedures are needed as are loss controls such as fire fighting equipment and services. • High rate of wear and tear.
Tidal/Wave Power	• Survivability in harsh marine environments (mooring systems etc). • Various designs and concepts but with no clear winner at present. • Prototypical/technology risks. • Small scale and long lead times.	• Mostly prototypical and technology demonstration projects. • Good resource measurement data.

Source: United Nations Environment Programe (UNEP), 2004. Financial Risk Management Instruments for Renewable Energy Projects - Summary Document, UNEP, Division of Technology, Industry and Economics.

B. Bioenergy

Indonesia which is overwhelmed with natural resources, are potential to become one of the biggest bioenergy producer in the world. One of potential could not be ignored is the availability of land to cultivate plants as a resource of bioenergy. The utilization includes the development of biomass, biogas, biofuel (biodiesel and bioethanol) as an energy alternative. This section elaborates the definition of bioenergy derivatives.

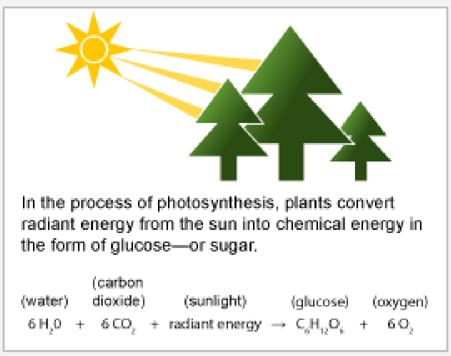
1. Biomass

By definition, biomass is organic material that comes from plants and animals, and it is a renewable source of energy. Biomass contains stored energy from the sun. Plants absorb the sun's energy in a process called photosynthesis.

When biomass is burned, the chemical energy in biomass is released as heat. Biomass can be burned directly or converted to liquid biofuels or biogas that can be burned as fuels. Examples of biomass and their uses for energy:

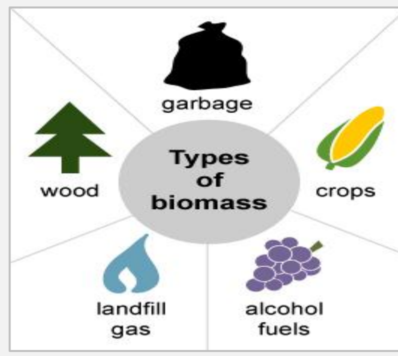
- Wood and wood processing wastes—burned to heat buildings, to produce process heat in industry, and to generate electricity.
- Agricultural crops and waste materials—burned as a fuel or converted to liquid biofuels.
- Food, yard, and wood waste in garbage—burned to generate electricity in power plants or converted to biogas in landfills.
- Animal manure and human sewage—converted to biogas, which can be burned as a fuel.[3]

Figure 8. Photosynthesis



Source: Adapted from www.eia.gov/ (public domain)

Figure 9. Type of biomass



Source: Adapted from www.eia.gov/ (public domain)

Technology and location are imperative aspects to be considered when developing biomass power plant. Each type of biomass has it own characteristics and will determine which technology will be used. The technology also should be commercially proven and match with the capacity that is run in the financial projection. There are various choices of technology. Some of them are well developed and financially feasible as used by the palm oil mill. Two technologies commonly used are [4] :

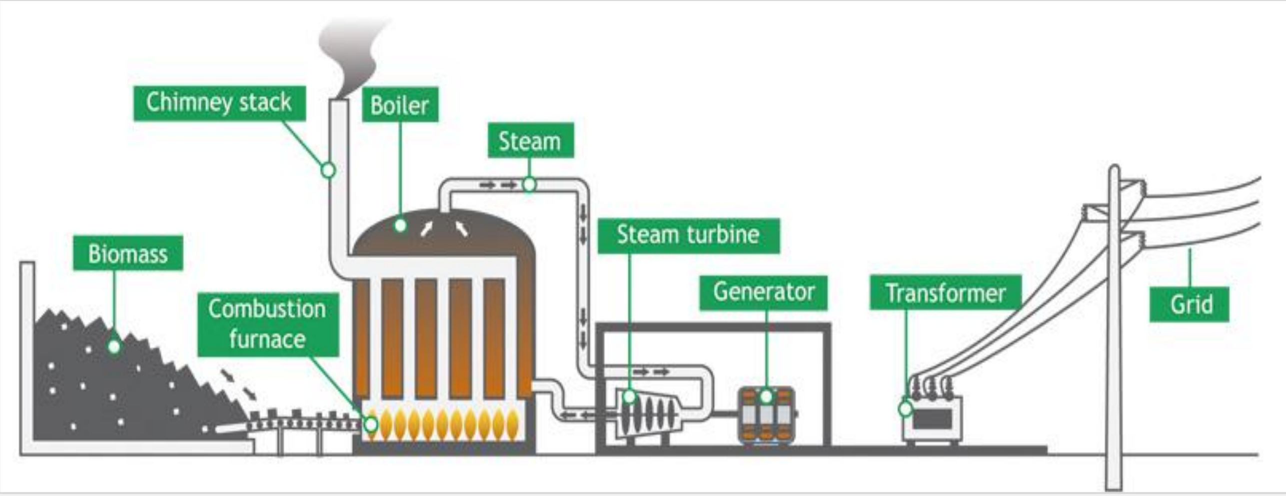
1) Direct-fired

The technology are mature and commercially available. Direct-fired method is the oldest method that has been used to generate power from biomass. The solid waste directly fired in the boiler. Combustion is the easiest way to extract energy from bio-mass and convert it into electricity in final stage. During combustion the chemical energy of bio fuel are converting into the heat and pressure of steam in heat exchanger. After them, the steam drives turbine which is connected with generator by a shaft.

[3]Independent Statistics & Analysis U.S Energy Information Administration, Biomass explained, https://www.eia.gov/energyexplained/?page=biomass_home. Access date: 18 October 2017

[4]The Energy and Resources Institute (TERI), Biomass Gasifier for Thermal and Power applications, http://www.teriin.org/technology/biomass-gasifier. Access date: 18 October 2017

Figure 10. Biomass Direct-Fired Technology Flow



Source: http://www.gse.it (Public Domain)

2) Gasification

Unlike the direct-fired method, biomass gasification is a process of converting solid biomass fuel into a gaseous combustible gas (called producer gas) through a sequence of thermo-chemical reactions. Gasification is made up for five discrete thermal processes: *Drying*, *Pyrolysis*, *Combustion*, *Cracking*, and *Reduction*. Following are the explanation of the processes[5]:

a) Drying

Drying is what removes the moisture in the biomass before it enters Pyrolysis. All the moisture needs to be (or will be) removed from the fuel before any above 100°C processes happen.

b) Pyrolysis

Pyrolysis is the application of heat to raw biomass, in an absence of air, so as to break it down Into charcoal and various tar gasses and liquids. It is essentially the process of charring.

c) Combustion

Combustion is the only net exothermic process of the Five Processes of Gasification; ultimately, all of the heat that drives drying, pyrolysis, and reduction comes either directly from combustion, or is recovered indirectly from combustion by heat exchange processes in a gasifier. Combustion can be fueled by either the tar gasses or char from Pyrolysis.

d) Cracking

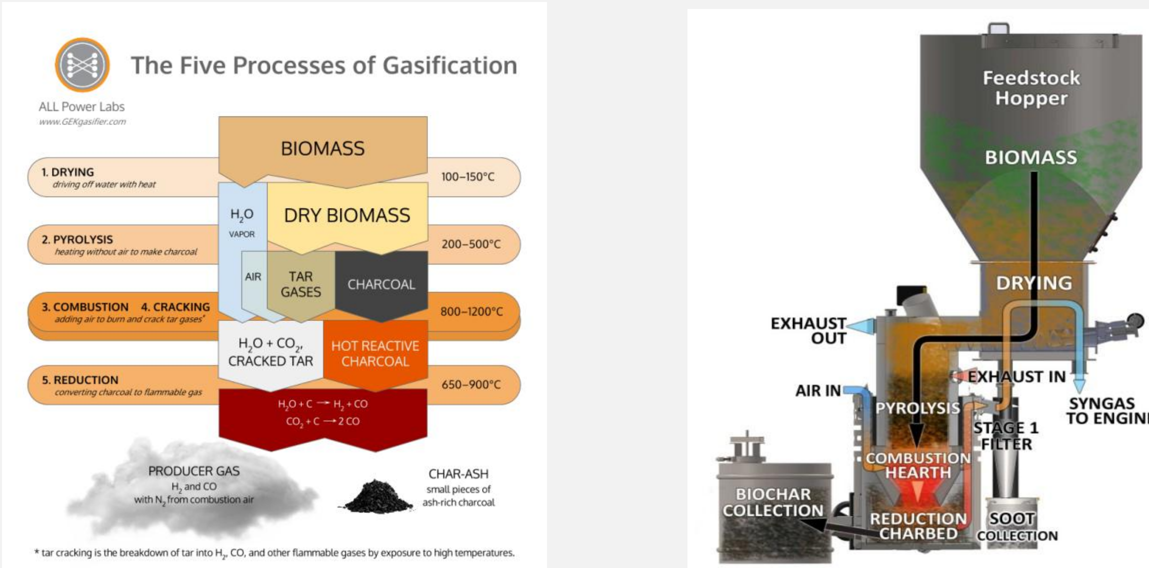
Cracking is the process of breaking down large complex molecules such as tar into lighter gases by exposure to heat. This process is crucial for the production of clean gas that is compatible with an internal combustion engine because tar gases condense into sticky tar that will rapidly foul the valves of an engine.

e) Reduction

Reduction is the process stripping of oxygen atoms off combustion products of hydrocarbon (HC) molecules, so as to return the molecules to forms that can burn again. Reduction is the direct reverse process of combustion.

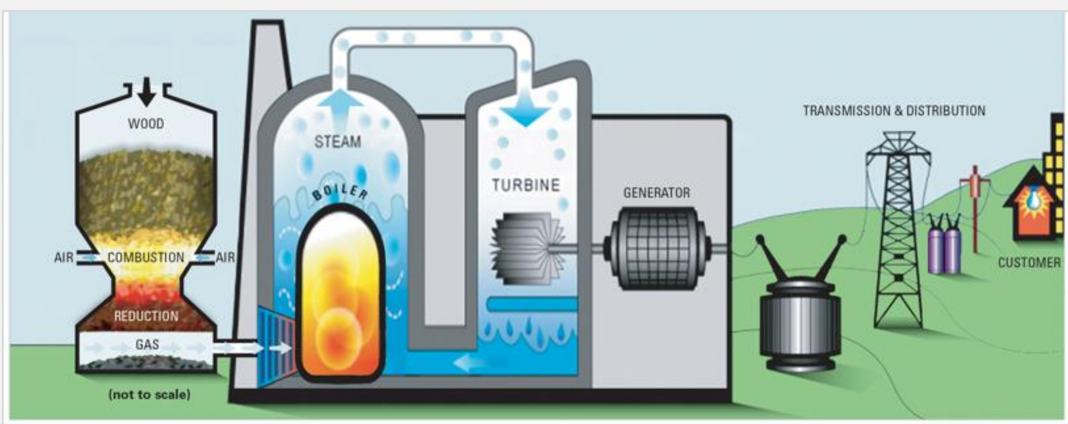
[5] All Power Labs, Gasification explained, http://www.allpowerlabs.com/gasification-explained. Access date: 27 October 2017

Figure 11. Processes of Gasification



Source: http://www.allpowerlabs.com/gasification-explained (Public Domain)

Figure 12. Biomass Gasification Technology Flow



Source: http://www.rainharvest.co.za (Public Domain)

Regardless on the technology that is used for the plant, biomass has been existed before people started talking about renewable energy. This long term use has proven that biomass brings a lot of benefit. Here are 4 of some advantages that make biomass energy a perfect alternative to fossil fuels:

1) **Renewable Form of Energy**

Biomass energy is considered a renewable form of energy because the organic materials used to produce it are never ending.

2) **Carbon Neutral**

According to research, only carbon emitted to the environment from biomass fuels is the amount that was absorbed by plants in the course of their life cycle. In the process of replenishing the used plant materials, the new ones that spring up absorb equal quantity of carbon, hence, developing neutrality that witnesses no new carbon generated. This aspect renders biomass uniquely clean.

3) Widely Available

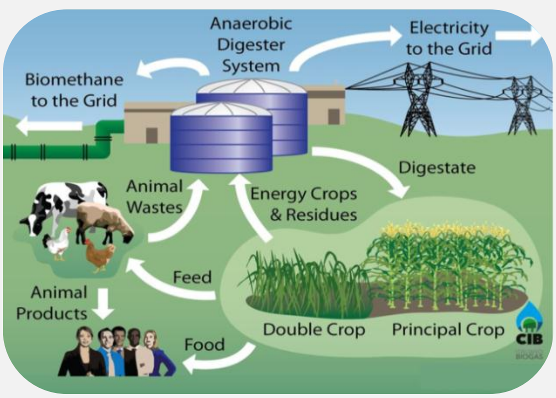
Biomass is a source that can be found easily. This certainty is one of the main benefits of biomass. Many energy experts agree that when when the economic and environmental character combined, biomass will be on the top of choice of alternative energy.

4) Cheaper Compared to Fossil Fuels

Producing biomass energy does not involve high investment cost . On the other hand, fossil fuels production involves high upfront capital costs ranging from drilling, construction gas pipelines, etc[6] .

2. Biogas

Figure 13. Biogas to Electricity Illustration



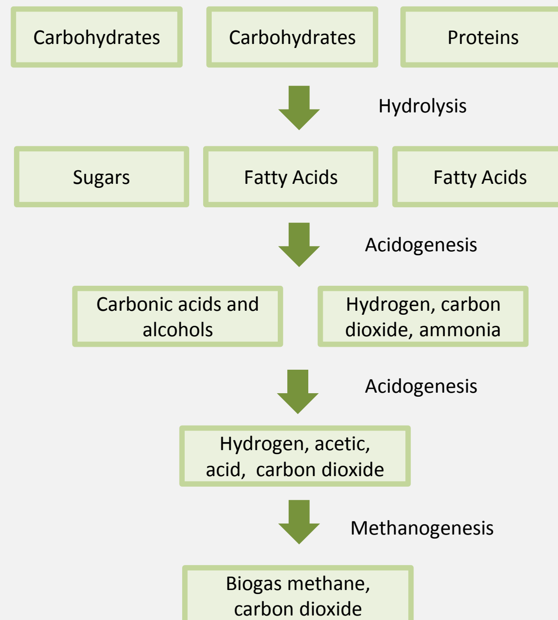
Source: https://www.ecofys.com/

Biogas is a gas that is formed by anaerobic microorganisms. These microbes feed off carbohydrates and fats, producing methane and carbon dioxides as metabolic waste products. This gas can be harnessed by man as a source of sustainable energy.

The composition of biogas depending upon the origin. Primarily, Biogas consist of methane and carbon dioxide and may also contain small amounts of nitrogen or hydrogen. The relative composition percentages of methane are commonly influence by the ratio of carbohydrates, proteins, and fats in the feedstock, and also the dilution factor in the digester. The production of biogas consists of four steps, (1) hydrolysis, (2) acidification, (3) acetic acid formation, (4) methane formation.

The process of biogas production is illustrated in the following chart:

Figure 14. Biogas Production Process



Source: https://www.clarke-energy.com/

Anaerobic digestion brings few benefits. The advantages of biogas utilization can be seen in the following table:

Figure 15.
Benefit of Anaerobic Digestion

Energy Aspects	• Increase the capacity production of clean energy • Contribute to national energy mix target • Provide stable supply of energy
Social Aspects	• Create new jobs opportunity in villages • Increase revenue through biogas utilization
Environment Aspects	• Brings benefit to environment • Reduce water pollution • Reduce emission of methane

5 Conserve Energy Future, What is Biomass? https://www.conserve-energy-future.com/. Access date: 30 October 2017

6 Clarke Energy, What is Biogas, https://www.clarke-energy.com/biogas/. Access date: 27 October 2017

During developing biogas power plant project, developer should also assess and recognized. Each type of risk should be allocated to the party best equipped to manage it. For a typical biogas project, the critical risks include:

Figure 16.
Risks of Biogas Plant[7]

Type of Risk	Description	Mitigation
Feedstock supply	A biogas-to-energy project is unlikely to succeed if the long-term fuel supply is unpredictable or the fuel quality is uncertain.	The project developer needs a long-term contract with a feedstock supplier and should avoid situations that would allow the supplier to entertain competing offers from other feedstock users.
Revenue	Short-term purchase agreements or buy as-needed contracts are generally not considered financeable unless a strong guarantor agrees to repay the loan regardless whether the electricity can be sold.	A suitable contract typically includes a mandatory purchase (take-or-pay) obligation: The energy buyer cannot default on a purchase for any reason, including, for example, a malfunction of a transmission line or other facility within the buyer's control that stops the flow of power.
Technology	Not all generating technologies are designed, manufactured, and serviced equally. It is incumbent on the project owner to select prime movers, generators and ancillary equipment with an eye toward a track record of performance in similar applications.	As part of due diligence, a project owner should ask all prospective equipment suppliers to offer references and data on successful projects of similar size and type operating on similar fuel. The technology provider should have both the ability and willingness to provide a performance guarantee for a term that is agreeable to the lender.
Operations	Improper maintenance or poor operating practices can lead to unplanned downtime that puts project financial results in jeopardy.	Complete operations and maintenance agreement with the equipment supplier that covers all planned service at an annual fixed cost.
Construction	The engineering, procurement and construction (EPC) phase of a biogas project requires an experienced contractor and proven equipment and component suppliers. Critical guarantees of milestones, such as project completion date, net kilowatt power output and the fuel heat rate based on local fuel parameters, need to be secured up front.	In addition, the project owner needs to have enough equity in reserve to cover a cost overrun and still complete the project. lenders require a lump sum EPC contract that provides a complete "wrap" of the construction of the project. Payment and performance bonds (or comparable standby letters of credit) may also be required by lenders.

[7]Szymanski, Devine, and Lee. Managing Risks, Reaping Rewards through Biogas Applications, Caterpillar : 2013

3. Biofuel

Biofuel in general is the fuel of biomass (material derived from plants and animals). Every biofuel product is produced differently. For example ethanol is produced by fermentation of corn or sugarcane, while biodiesel is produced by destroying animal or plant fats in the presence of methanol. Crude Palm Oil through the transesterification process, which chemically reacts with alcohols such as methanol or ethanol to produce biodiesel.

There are two main types of biofuel feedstock: the one that can be consumed and can not be consumed. Human food products such as sugar, starch, or vegetable oil are made into biofuels through a methods called transesterification. Biofuel, also can be produced from non-food crops, agricultural waste and residues that can not be consumed by humans using advanced technologies such as hydrocracking. In this process the raw materials are broken down in the presence of hydrogen in the production of biofuels. Raw materials such as palm oil can be used to produce biofuels through conventional and advanced methods depending on the circumstances. In this section mainly will elaborate two types of biofuels: Bioethanol and Biodiesel.

a) Bioethanol

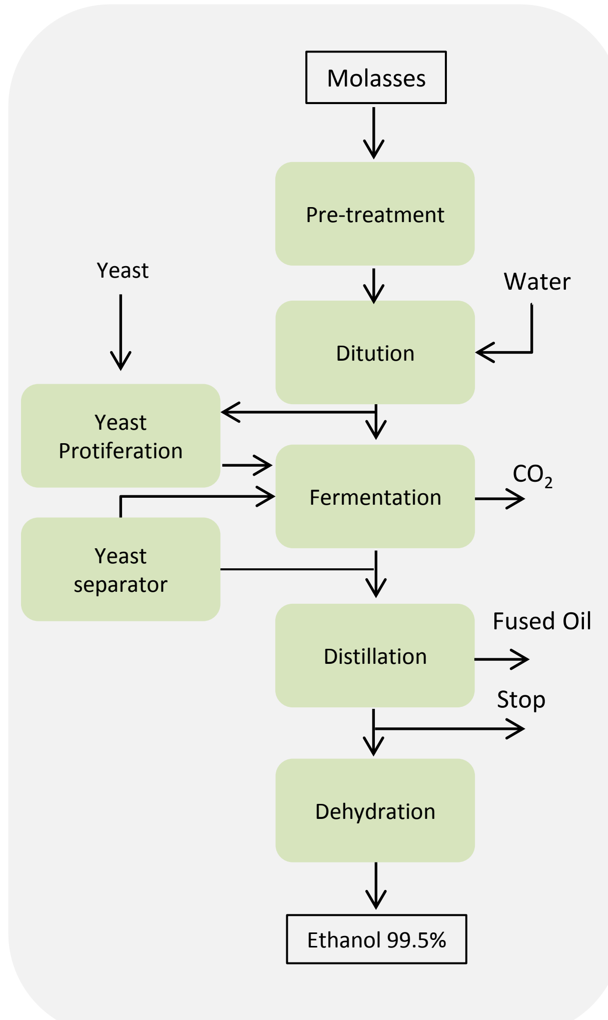
Bioethanol fuel is mainly produced by the sugar fermentation process, although it can also be manufactured by the chemical process of reacting ethylene with steam.

The main sources of sugar required to produce ethanol come from fuel or energy crops. These crops are grown specifically for energy use and include corn, maize and wheat crops, waste straw, willow and popular trees, sawdust, reed canary grass, cord grasses, and sorghum plants. There is also ongoing research and development into the use of municipal solid wastes to produce ethanol fuel.

Ethanol or ethyl alcohol (C2H5OH) is a clear colour less liquid, it is biodegradable, low in toxicity and causes little environmental pollution if spilt. Ethanol burns to produce carbon dioxide and water. Ethanol is a high octane fuel and has replaced lead as an octane enhancer in petrol. By blending ethanol with gasoline we can also oxygenate the fuel mixture so it burns more completely and reduces polluting emissions.[8]

The production of bioethanol is basically consist of 3 main processes of fermentation, distillation, and dehydration. Prior to fermentation process, some crops require hydrolysis of carbohydrates. The process of biogas production is illustrated in the following chart:

Figure 17.
Processes of Biethanol from Molasses



Beside bioethanol, another type of biofuel that is used as a diversification strategy of national energy mix is biodiesel. In the next section, will be elaborated the definition of biodiesel and its potential in Indonesia.

8 Energy System Research Unit, what is Bioethanol, http://www.esru.strath.ac.uk/EandE/Web_sites/02-03/biofuels/what_bioethanol.htm. Access date : 7 December 2017

b) Biodiesel

Biodiesel can be produced from vegetable oil, animal oil/fats, tallow and waste cooking oil. It is very similar with fossil diesel. The main benefit of biodiesel can be described as carbon neutral. This means that the fuel produces no net output of carbon in the form of carbon dioxide (CO2). The process to convert above mentioned oils is called transesterification. It breaks down the molecules of vegetable oils into constituent molecules forming biodiesel as the main product and glycerin as the byproduct.

Figure 18. Biodiesel Cycle

Source : http://www.alternative-energy-news.info (Public domain)

Same as bioethanol, the uses of biodiesel in Indonesia has been developed for the recent years considering the limitation of fossil fuels. The uses of biodiesel is also included in national energy mix. Based on Ministry of Energy regulation No. 20/ 2014, blended biodiesel into diesel in several sectors will be targeted as follows:

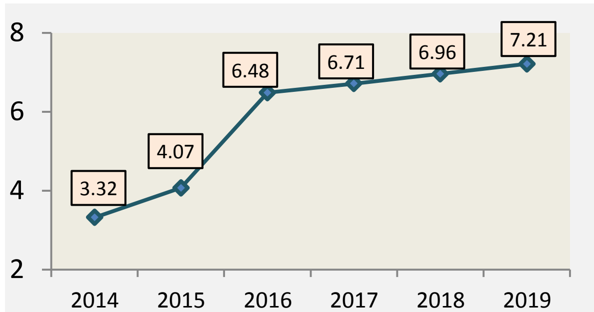
Figure 19.
Biodiesel Uses Target

Sectors	Jan'16	Jan'20	Jan'25
Micro, Fisheries, Agriculture, PSO	20%	30%	30%
Non PSO Transportation	20%	30%	30%
Commercial and Industry	20%	30%	30%
Power	30%	30%	30%

Source : Ministry of Energy and Mineral Resources (MEMR)

One of the forms of clean energy provision to the world is biodiesel. As the largest palm oil producer in the world, Indonesia should have the potentials to become one of the largest biodiesel producers. In addition to palm oil, the waste generated by the palm oil industry also has large potentials to be processed into energy source. Other potential industries for development of bio-energy include sugar industry for processing bioethanol and national electricity provision. Therefore, since the end of 2008, the Government through the Ministry of EMR has implemented mandatory biodiesel and bioethanol use gradually, especially in land transportation sector.[10]

Figure 20.
Bioenergy Production as Fuels (In KL)



Source : Renstra, Ministry of Energy and Mineral Resources (MEMR)

In Figure 20, it can be seen By 2019, expectedly the production of Bioenergy can reach 7,2 KL. This numbers is aligned with the total target of bioenergy utilization.

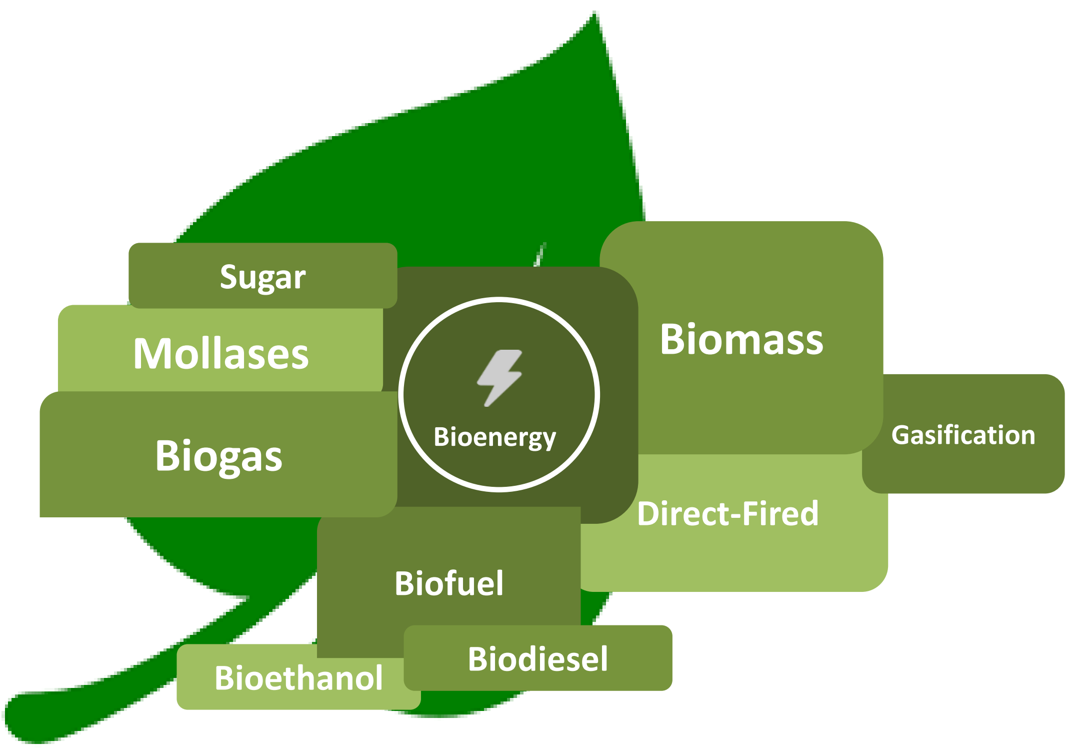
9 Energy System Research Unit, what is Biodiesel, www.esru.strath.ac.uk/EandE/Web_sites/02-03/biofuels/what_biodiesel.htm. Access date : 8 December 2017

10 Jurnal Energi, Kementerian Energi dan Sumber Daya Mineral , 2nd Edition 2016

B. Conclusion

After understanding the definition of Bioenergy, the derivative and its potential in Indonesia, following are several conclusion in regards to the target of energy mix plan:

1. Dependency of fossil base energy should be reduced significantly as the supply are lower than its demand.
2. Government of Indonesia has set a focus to reach 23 percent of national energy mix by 2025. The development is ranging from geothermal, bioenergy, Hydro, solar and wind.
3. Bioenergy in Indonesia has potential up to 33 GW through the development of Biogas and Biomass plant.
4. Key concepts to develop renewable energy is to evaluate the energy competitiveness, financial attractiveness and cost effectiveness.
5. There are two types of biomass technology that commonly used: 1) Direct –fired; 2) Gasification.
6. The most typical risk that appear is biogas plant is usually comes from its feedstock supply. Long-term contract with supplier can be applied to mitigate this kind of risk.
7. Biodiesel can be produced from vegetable oil, animal oil/fats, tallow and waste cooking oil. As the largest palm oil producer in the world, Indonesia should have the potentials to become one of the largest biodiesel producers. In addition to palm oil, the waste generated by the palm oil industry also has large potentials to be processed into energy source.



Appendix 1
Bioenergy Potential Per Province (In MW)

No	Province	Biomass/ Biofuel	Biogas	Total
1	Riau	4157.4	37.7	4195.1
2	East Java	2851.3	569.6	3420.9
3	North Sumatera	2796.1	115.5	2911.6
4	West Java	1979.8	574.3	2554.1
5	Central Java	1884.1	348.4	2232.5
6	Sumatera Selatan	2061.4	71.2	2132.6
7	Jambi	1821	18.9	1839.9
8	Kalimantan Tengah	1486.7	12.2	1498.9
9	Lampung	1407.6	84.5	1492.1
10	West Kalimantan	1279.3	28.9	1308.2
11	South kalimantan	1266.3	23.6	1289.9
12	Aceh	1136.6	37.7	1174.3
13	East/North kalimantan	946.6	17.7	964.3
14	South Sulawesi	890.3	69.1	959.4
15	West Sumatera	923.1	34.7	957.8
16	Bengkulu	633	11.8	644.8
17	Banten	346.5	118.6	465.1
18	West Nusa Tenggara	341.3	52.8	394.1
19	Central Sulawesi	307.4	19.5	326.9
20	East Nusa Tenggara	192.5	48	240.5
21	DI Yogyakarta	183.1	41.1	224.2
22	Bangka Belitung	217.7	5.4	223.1
23	West Sulawesi	197.8	8.1	205.9
24	Bali	146.9	44.7	191.6
25	North Sulawesi	150.2	13.8	164
26	South East Sulawesi	132.8	17.7	150.5
27	Gorontalo	119.1	11.5	130.6
28	DKI Jakarta	0.5	126.1	126.6
29	Papua	81.4	15.1	96.5
30	West Papua	50.8	4.1	54.9
31	North Maluku	27.5	7	34.5
32	Maluku	23.6	9	32.6
33	Riau Islands	11.6	4.3	15.9
		30,051	**2,603**	**32,654**

Ministry of Mineral Resources, Directorate General EBTKE. Buku Statistik EBTKE : 2016

Appendix 2
Biomass Plant On Grid (In MW) Per 2015

No	Company	COD	Biomass Type	Contract (MW)
1	PT Riau Prima Energy	2001	Palm Waste	10
2	PT Growth Sumatra 1	2006	Palm Waste	9
3	PT Listrindo Kencana	2006	Palm Waste	5
4	PT Indah Kiat Pulp & Paper	2006	Palm Waste	3
5	PT Belitung Energy	2010	Palm Waste	7
6	PT Growth Sumatra 2	2010	Palm Waste	10
7	PT Growth Asia	2011	Palm Waste	10
8	PT Navigat Organic	2011	MSW	12
9	PT Navigat Organic	2012	MSW	2
10	PT Growth Asia	2012	Palm Waste	10
11	PT Navigat Organic	2013	MSW	2
12	PT Austindo ANE	2014	POME	1.2
13	PT PLN	2014	Corn	0.4
14	PT Rimba Palma	2014	Palm Waste	10
15	PT Victorindo	2015	Palm Waste	3
16	PT Harkat Sejahtera	2015	Palm Waste	10
17	PT Sumber Organik	2015	MSW	1.6
18	PT Meskom Agro Sarimas	2015	Palm Waste	10
19	PT Maju Aneka Sawit	2015	POME	1
20	Sukajadi Sawit	2015	POME	2.4
	Total			**119.6**

No	Location	Biomass Type	Capacity (Mw)
1	Sumatera	Palm Industry	335
		POME	9
		Sugar Cane	66
		Pulp	955
2	Kalimantan	Palm Industry	91
3	Jawa - Bali	Palm Industry	2
		Sugar Cane	142
		Municipal Waste	-
4	Sulawesi	Palm Industry	11
		Sugar Cane	11
5	Papua	Palm Industry	4
	Total		**1626**

Ministry of Mineral Resources, Directorate General EBTKE. Buku Statistik EBTKE : 2016