In Searching of Biomass Resource for Gasification in Indonesia

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Abstract
Biomass is one of the promising resource for self-sustaining energy development in Indonesia. With its location in tropical region and as islands country, Biomass, with its abundant diversity, grows very well in Indonesia. On the contrary, knowledge of our biomass resource still has limitation. In order to harvest energy through biomass, first we have to know its calorific values as basis for energy transformation. In the previous paper, Kaliandra wood had been research as newly proposed biomass resource and its combustion properties had been identified. In this research, Kaliandra wood, Albasia wood and Coconut shell chip are gasified and identified its gas properties using Gas Chromathographer method. Thus, this resulted synthetic gas of several biomass resources are tested in a gas engine so as to know its capability to deliver energy. As the result, Coconut Shell chip has the highest gas calorific value of 26.827, 36 kCal/kg of Net Heating Value. Kaliandra wood and Albasia wood chip gives gas calorific value of 3632,09 kCal/kg and 4267,36 kCal/kg of Net Heating Value. The contain of Hydrogen (H2) of coconut shell also comes out with the highest among others which correlates with its high gas calorific value. The H2 and CO contain of coconut shell are 93.39 %mol and 1,24 %mol. The contain of H2 in Albasia wood is 12,49 %mol with CO contain 13,01 %mol. It is interesting that the contain of H2 and CO in Kaliandra wood is 21,41% mol and 9,89%mol, it is in the middle between coconut shell and albasia wood. Simulation of its energy price in form of electricity using gasification technology reveals the Levelised Cost of Electricity (LCOE) of 19,49.cent USD/kWh for gasification using coconut shell, 23,6 cent USD/kWh for gasification using albasia wood and 21,98 cent USD/kWh for gasification using Kaliandra wood.

Keywords: gasification; levelised cost of electricity; gas properties, biomass, electricity energy

Introduction

In the last decade, Indonesia, a country which consist of islands, had been striving to find better solutions for energy demand especially in those remote islands scattered through out the country. Traditional way by depending on Diesel Engine to generate power proved to be high cost and not environmental friendly. There is a growing desire of both government and the society to make use of renewable energy. Government had launched an ambitious plan to make use 23 % of green and renewable energy of its energy mix posture by the the year 2025, which now the number is only around 8%. Among the promising renewable energy to be developed is the biomass energy, which has long been known as Indonesia's traditional product; such as rice, sugar cane, palm oil, etc.

Biomass is planned to be able to fulfill the idea of an independent energy island, which aim to make a continuous self sustain energy in one remote island in the nation. The most common biomass in Indonesia are coconut shell, palm kernel shell and jungle wood chip (kayu hutan). Nowadays, Albasia wood is more and more popular because people are planting this trees in order to gain commercial value by selling it to pulp and plywood industries. Rice husk and sugar cane are also available in Indonesia but the number is not significant since Indonesia's farmer characteristic is planting on small land so usually they use their rice husk for their own needs and for sugar cane usually the sugar factory use it as boiler fuel.

Biomass resources as mentioned above, are used mainly as fuel in direct combustion application either for heat purpose or as power generation. Palm kernel shell and jungle wood chip are the most common biomass use for power generation. In power generation direct combustion method usually applied for medium to large scale power electricity generation, whereas for small scale power generation is not suitable to apply direct combustion method. In this research, gasification is proposed to small scale power generation, but in order to do this, first we must know and identified the syngas properties of the biomass. Unfortunately, research in syngas properties of biomass is still limited.

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In this research, Coconut Shell, Albasia wood and Kaliandra wood is selected as pilot project to be gasified in small scale gasification reactor so as to know its syngas properties. Later on the identified properties could be used for the development of small scale gasification unit in remote island of Indonesia. By knowing its gas properties, hopefully a more efficient gasification reactor could be developed and thus increases the power generation performance. In pilot project, we also connect the gasification reactor with a gas engine and generator, so that it could also deliver electricity that could be simulated its energy price.

Gasification Method

Biomass energy is defined as any solid, liquid or gaseous fuel or electric power which comes from organic material like plants, plant waste/residue from industrial process, commercial or urban/municipal waste or agricultural crops and forest residue. Gas resulted from biomass is called Synthetic Gas or Syn Gas. In order to extract Syngas through biomass, a Gasification Reactor is needed to transform biomass from its solid phase into its gaseous phase. Gasification is a partial oxidation reaction to convert fuel from its solid or liquid phase into a gas fuel, which called syngas. The resulted syngas is then use as fuel and burn to harvest power. It is called partial oxidation because the transform reaction happens in minimum oxygen condition.

Gasification reactor consist of 2 major type that commonly used, which are the fixed bed reactor and the fluidized bed reactor. The most common used for a small scale reactor is the fixed bed reactor which is more efficient. There are 3 kinds of fixed bed gasification reactor, which are updraft, downdraft and cross draft reactor. The three are differentiated by the air flow that goes into the reactor chamber. Downdraft reactor has air flow to the center of the chamber where the oxidation happens, while updraft reactor has air flow from the bottom of the chamber, as in figure 1. The cross draft reactor has air flow from upper side of the chamber. The latter reactor is rarely used in biomass gasification due to its complex construction.

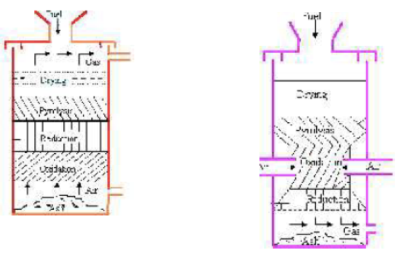

Figure 1. Upperdraft & Downdraft Reactor

In this research, we make used of the down draft gasification reactor. A set of gasification reactor with gas engine connected is prepared as a real pilot test bed apparatus to generate electricity from biomass. Steel tubes as media apparatus to collect syngas as gasification product are prepared, as well the plastic vacuum bag as a back up of media apparatus to collect syngas product. As the fuel burn in the reactor chamber, its solid phase starting to change phase from solid to gaseous form, then the resulted syngas product is captured into the steel tube and vacuum bag. The arrangement of the gasification system is shown in the picture bellow, a valve, located at the yellow tube as in the picture, in the connecting pipe between reactor and gas engine is used to connect with tube and bag so as to collect the resulted syngas product.

Figure 1. Gasification Set-up

Testing Facility

Down draft gasification reactor connected with a gas engine is installed and set up in a workshop so as to make real simulation of gasification process up to the power generation. The reactor is made by a local manufacture maximizing the down draft design including its filtering and separating tube. The engine is brought from overseas with capacity of 250 kW, it is solely a dedicated gas engine for a rural area usage. The engine and the reactor is connected through a pipe with an inspection tube in the middle. In the inspection tube, a safety valve is attached and a gas outlet valve also attached. The resulted syngas produce is then collected using a plastic bag and a tube through the gas outlet valve.

There is dummy load installed after the generator that couples to the engine. The dummy load absorb the electric power generated with a meter installed so as to

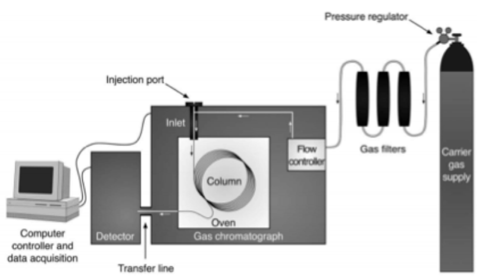

Figure 2. Gas Chromatography

calculate the kWh produce. A rated 250 kW of generator is place together as a set in front of the engine. Therefore, the kinetic energy comes from the engine rotation is used to rotated the generator and produce electric power. The arrangement is set so that we could simulate the amount of fuel inserted to the reactor and the amount of energy come out from the generator.

Syngas produced as the result of gasification process is analyzed in a standard laboratory in order to identify its calorific value and its properties. Up to now there is only limited knowledge of syngas properties especially those that come from an original Indonesia plant. Using a standard recognized laboratory and a good gasification set-up, syngas properties of Kaliandra wood, Albasia wood and Coconut shell chip are to identified. The method to analyzed gas properties use gas chromatographer The lab for analyzing syngas produced is the LEMIGAS Lab under Research and Development Agency of the Ministry of Energy and Mineral Resources, which is a well known and reputable laboratory that used to analyzed any kind of gas that exist on earth.

Gas Capturing & Identification

The resulted syngas produced is captured and collected after the reactor is turned on by burning the biomass fuel inserted to the reactor. In order to be able to produce syngas, the biomass fuel must be burnt in pyrolysis condition. The pyrolysis condition is stated between 300 – 500 ^{o}C. The syngas is then produced under the minimum oxygen condition so that the chemical reaction of the combustion transform fuel into CO and H2. If the biomass fuel is burn with abundant oxygen, then the chemical reaction transforms the fuel into CO2 and H2O. The latter one is not desired in the syngas production because CO2 and H2O do not contain energy.

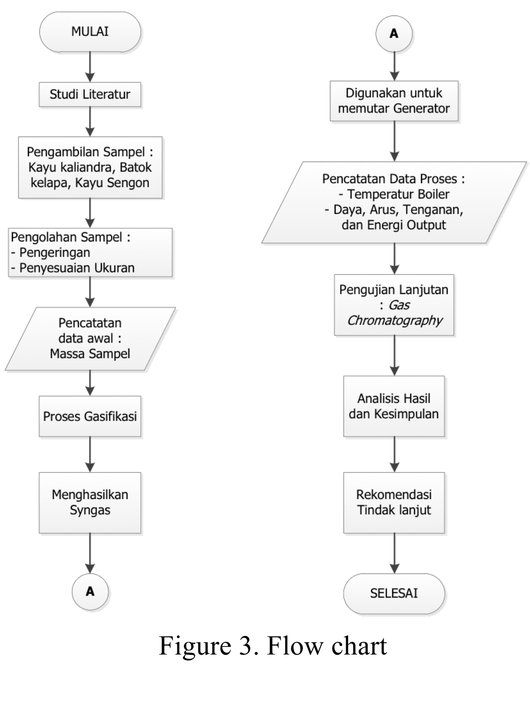

Figure 3. Flow chart

The method to conduct this research follows the flow chart above, in figure 3. In the flow chart, the biomass fuel that want to be identified its properties where prepared. It consists of the Kaliandra wood chip, Albasia wood chip and the last is the Coconut shell chip. The chip is then dry-up in open air so as to reduce the moisture content of the biomass, because gasification reactor allows around 10% moisture content. After preparation of the biomass is completed, combustion of the biomass fuel in reactor is conducted step-by-step. First the biomass is ignited with kerosene inside reactor and let the flame to turn on with all the reactor hole is open so as to bring oxygen. After the biomass fuel started to burn, all the reactor hole is then closed and let the gasification process occurred with limited or minimal oxygen content.

Whenever the reactor is already full with syngas, it is then the syngas started to flow and fill the pipe connecting reactor and gas engine. Syngas produced is cleaned by a set of filtering apparatus in several tube next to reactor chamber. Filtering process uses also water to catch tar produced in gasification process. The tube in the middle of connecting pipe between reactor chamber and gas engine, has an outlet valve to check whether the syngas production has already reach its cleanliness. The cleanliness parameter of syngas could be evaluated by setting flame at the outlet valve to identified the flame form. If the flame form is blue, then the syngas is ready to transfer it into the gas engine.

Resulted syngas is collected and capture in a stainless tube and a vacuum plastic bag in order to identified its properties, especially its calorific property. A standard Gas Chromatographer in LEMIGAS laboratory is used to detect syngas composition of the inserted biomass. A Chromatographer make use of synchronous particle detection method to detect and identified the composition of syngas. It is a chemical analysis instrument for separating chemical and make identification. The carrier floe rate and inlet pressure in a chromatographer is calculated using Poiseuille's equation The equation can be described as follow:

$$\Delta p = \frac{8\mu LQ}{\pi R^4}$$

where:
Δp is the pressure difference between the two ends,
L is the length of pipe,
μ is the dynamic viscosity,
Q is the volumetric flow rate,
R is the pipe radius,
A is the cross section of pipe.

The gas sample from each biomass fuel, the kaliandra wood chip, the albasia wood chip and coconut shell chip, is brought to the lab and analyzed using the method.

The knowledge of this properties would eventually open a better understanding of design of gasification reactor. The design would be better to adapt the majority available Indonesian biomass, such as: Kaliandra, Albasia Wood and Coconut Shell.

Gas Properties

Gas evolution due to heat is called pyrolysis process, that progressively transform biomass solids into gas, volatile and char. After a series of syngas extraction from the outlet valve as a result of gasification in the reactor using Kaliandra, Albasia wood chip and Coconut Shell chip, the produced syngas in its tube or bag is brought to the lab to analyzed. A gas chromatographer is used to identified the syngas properties. The syngas properties mainly would consist of the gas that contain energy which is essential as fuel and the gas that do not contain energy which could not be used as fuel. The gas that contain energy usually would be Hydrogen (H2) and Carbon Monoxide (CO). These main gas as fuel together with non fuel gas such as Carbon Dioxide (CO2), Nitrogen (N2) and others will form the syngas properties that eventually will become the identity of the syngas of a particular biomass used.

The standard test for gas chromatographer would be based on ASTM code number ASTM D3612 : 2002 dan GPA 2179 : 2002. The result of syngas properties of Kaliandra wood chip is shown in table 5 bellow.

Komposisi	Satuan	Temperatur° C				Metode
		380	440	500	650	
Nitrogen		40.51	43.33	33.92	29.87	
Karbondioksida	% mol	21.70	20.88	26.52	16.58	ASTM D 3612:2002
Hidrogen		6.45	5.39	7.68	16.43	
Karbonmonoksida		16.10	15.21	21.72	30.31	
Oksigen		10.09	10.60	4.19	3.72	
Metana		4.07	3.64	4.73	2.55	
Etana		0.30	0.26	0.40	0.12	
Etilena		0.53	0.47	0.52	0.30	
Acetilen		0.07	0.07	0.05	0.03	
Propana		0.05	0.05	0.08	0.01	
Propilena		0.13	0.11	0.19	0.08	
Iso Butana		nil	nil	nil	nil	
N-Butana		nil	nil	nil	nil	
Iso Pentana		nil	nil	nil	nil	
N-Pentana		nil	nil	nil	nil	
Heksana Plus		nil	nil	nil	nil	
Relative Density		1.0274	1.0347	1.0327	0.9064	
Gross Heating Value (GHV)	(BTU/FT^3)	132.7237	119.9638	164.7916	185.5878	
Net Heating Value (NHV)	(BTU/FT^3)	124.0588	112.4153	154.5696	174.1049	
Gross Heating Value (GHV)	kCal/kg	3245.3757	2792.9010	3903.7232	6656.4769	GPA 2172:2009
Net Heating Value (NHV)	kCal/kg	2843.8026	2453.7400	3427.3704	5803.4649	
Average Gross Heating Value (avg GHV)	kCal/kg	4149.6192				
Average Net Heating Value (avg NHV)	kCal/kg	3632.0945				

Table 5. Kaliandra Wood Chip Syngas Analysis

The result of syngas properties of Albasia wood chip could be seen in Table 6 below.

Komposisi	Satuan	Temperatur °C	Metode
		504	
Nitrogen		36.91	
Karbondioksida	% mol	31.40	ASTM D 3612:2002
Hidrogen		12.49	
Karbonmonoksida		13.01	
Oksigen		3.00	
Metana		2.51	
Etana		0.12	
Etilena		0.46	
Acetilen		0.02	
Propana		0.01	
Propilena		0.06	
Iso Butana		nil	
N-Butana		nil	
Iso Pentana		nil	
N-Pentana		nil	
Heksana Plus		nil	
Relative Density		1.0228	
Gross Heating Value (GHV)	(BTU/FT^3)	119.1829	
Net Heating Value (NHV)	(BTU/FT^3)	109.5841	GPA 2172:2009
Gross Heating Value (GHV)	kCal/kg	4961.9465	
Net Heating Value (NHV)	kCal/kg	4267.3581	

Table 6. Albasia Wood Chip Syngas Analysis

And the result of syngas properties of Coconut Shell chip is shown in table 7.

Komposisi	Satuan	Temperatur° C	Metode
		504	
Nitrogen		1.88	
Karbondioksida	% mol	2.52	GPA 2261:2013
Hidrogen		93.39	
Karbonmonoksida		1.43	
Oksigen		0.46	
Metana		0.33	
Etana		nil	
Etilena		nil	
Acetilen		nil	
Propana		nil	
Propilena		nil	
Iso Butana		nil	
N-Butana		nil	
Iso Pentana		nil	
N-Pentana		nil	
Heksana Plus		nil	
Relative Density		0.1421	
Gross Heating Value (GHV)	(BTU/FT^3)	310.6749	
Net Heating Value (NHV)	(BTU/FT^3)	263.3960	GPA 2172:2009
Gross Heating Value (GHV)	(kCal/kg)	31737.6855	
Net Heating Value (NHV)	(kCal/kg)	26827.3585	

Table 7. Coconut Shell Syngas Analysis

There are four main gas in the produced syngas: Nitrogen (N2), Carbon dioxide (CO2), Hydrogen (H2) and Carbon Monoxide (CO). Energy content of syngas lies in the amount of Hydrogen and Carbon Monoxide. In Kaliandra syngas, the content of CO and H2 (46,45%) almost equal to CO2 and N2 (46,74%). In Albasia syngas, the content of CO2 and N2 is higher than the content of CO and H2. And the content of CO and H2 in Coconut Shell is 94 % compare with the content of CO2 and N2 with only 4,3%. Coconut Shell has the highest Net Heating Value of 26827,35 kCal/kg. Kaliandra syngas has 3632,09 kCal/kg and Albasia wood chip 4267,35 kCal/kg of Net Heating Value.

LCOE Calculation

Gasification is relatively new compare with direct combustion. In gasification, the goal is to produce syngas, which is the result of partial oxygen combustion so that the syngas produced still contain energy, which later on used as fuel to generate electricity. The energy content in syngas define the price of electricity whenever its converted. Usually the energy content comes as a result of proximate and ultimate test of solid material in lab. Calculation based on produced syngas in a pilot project that collected in a tube or vessel rarely to be done. Thus this research proposed a calculation of electricity price based on real pilot project result of produced syngas.

In order to be able to conduct calculation of price electricity of the produced syngas, first it is imperative to define all assumption needed. The Least Cost of Electricity (LCOE) method is a method based on financial project modelling principle. To make use of syngas as fuel, the gasification reactor is coupled with

Project Capacity (MW)	0.50
Capital Cost ($/kW)	$1,800
Fixed O&M ($/kW)	$0.0781
Variable O&M ($/MWh)	$0.0001
Fuel Cost ($/kWh)	$0.0296
Engine Efficiency (%)	40
Availability Factor	85%
Capacity Factor	90%

Figure 5. Financial Model Assumption

gas engine. Gas engine is still ideal to generate small electricity for an isolated area. Therefore, the assumption set is based on gas engine generation for a small local remote area in Indonesia, comprise of around hundreds of people. The assumption is shown in figure 5 above.

The simulation makes use of Levelised Cost of Energy (LCOE) method to calculate the energy price of the proposed Kaliandra, Albasia and Coconut Shell Biomass Power Plant based on gasification. LCOE is one of the most popular standard method in calculating electricity price and had been practiced by most of energy company in the world. The formula of LCOE method is shown in formula 1 below.

$$\text{LCOE} = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}} \qquad \text{……..(2)}$$

LCOE	: the average lifetime levelised cost of electricity generation
It	: investment expenditures in the year t
Mt	: operations and maintenance expenditures in the year t
Ft	: Fuel expenditures in the year t
Et	: Electricity generation in the year t
r	: discount rate
n	: life of the system

The basic principles of LCOE is measuring lifetime cost of the proposed power plant divided by energy production. In LCOE method, the total cost of the whole power plant and its operational over an assumed life time must be calculated in its present value. An advantage of using LCOE method is that it allows the comparison of different type of power plant by making use each power plant life time, project size, different capital cost, risk, return and capacities using also different type of fuel. Mostly the initial capital cost and capacity of power plant are two critical drivers. The result of LCOE is essential for an investor as one of critical information before deciding to proceed with the development of the utility. In Simulation, 1 USD currency exchange rate is set equal to IDR 13.500,-.

Capacity factor is percentage of power comes out from plant compare with installed power capacity, usually around 80 to 90 %. The price of Kaliandra, and Albasia wood chip and Coconut Shell is set to be same as market price. Albasia wood is already a market commodity as well as Coconut Shell, so it is not difficult to define its price. The Price of syngas of Kaliandra wood is calculated as table 8 bellow.

Syngas Kaliandra				
Uraian	**Konversi**			**Satuan**
Harga Kayu Kaliandra	1 kg	=	700	Rp
Efisiensi Gas Engine	40% Eff	=	2149.65	kCal/kWh
NHV Kaliandra syngas	average	=	3632.0945	kCal/kg
Kebutuhan syngas/kWh	average	=	0.591848592	kg/kWh
Harga Syngas Kaliandra/kWh	average	=	414.2940142	Rp/kWh

Table 8. Kaliandra Syngas Price

Next, the financial assumption including the interest or discount factor value is set as could be shown in table 9 bellow.

Financial/Economic Asumptions	
Fixed O&M Escalation	5%
Variable O&M Escalation	5%
US escalation	2.0%
Indonesian Inflation	5.0%
Indonesian Corporate Tax	30.0%
Kurs USD	IDR13,500
Economic Life (years)	20
Interest Rate	12%

Table 9. Financial Asumption

With the energy price of Kaliandra syngas is 414,29 Rp/kWh, or about 3,06 centUSD/kWh then the energy price of Kaliandra syngas is 2968 Rp/kWh or 21,98 centUSD/kWh as seen in table 10 bellow. The IRR value of Kaliandra Syngas gives around 17% with payback period of 7,5 years under condition that PLN as state government company buy the electricity using a market price not with regulated price as now set. The result for Albasia Syngas and Coconut Shell Syngas gives the value of electricity price of 3186 Rp/kWh or 23,60 centUSD/kWh and 2632 Rp/kWh or 19,49 centUSD/kWh. The result comes based on calculated syngas price of Albasia and Coconut Shell around 604 Rp/kWh and 120 Rp/kWh. It is interesting that although the price of coconut shell is the highest but the syngas price is the lowest due to the high content of energy in syngas. The Internal Rate of Return (IRR) simulated that by using coconut shell syngas give the highest IRR value of 17,89 % as shown in table 12.

LCOE (Rp/kWh)	2968
IRR (%)	17.33%
NPV (USD)	2,317,475,708
BCR	1.15
Payback Period (years)	7.5

Table 10. LCOE Result of Kaliandra Syngas

LCOE (Rp/kWh)	3186
IRR (%)	16.97%
NPV (USD)	2,206,781,196
BCR	1.148
Payback Period	7.5

Table 11. LCOE Result of Albasia Syngas

LCOE (Rp/kWh)	2632
IRR (%)	17.89%
NPV (USD)	2,488,642,269
BCR	1.167
Payback Period	7.5

Table 12. LCOE Result of Coconut Shell Syngas

From the result it is clear that a government intervention is needed in order to increase electricity ratio especially in the remote islands, because looking at PLN's selling price now is not possible for acquiring electricity from a renewable energy. Simulation shows that gas engine electricity power generation runs with Coconut Shell syngas gives the lowest electricity price, although Coconut Shell Price is the highest among other sources used in experiment. On the other hand, Albasia syngas gives the highest electricity price with Albasia woodchip price is among Kaliandra woodchip and Coconut Shell price.

Government support by providing Kaliandra, Albasia or Coconut land for silviculture cultivation is necessary in the remote island. By doing that, then the biomass power plant investment could assure its continuous operational activity. Creating an energy forest using silviculture method is one of good solution in electrifying small remote island of Indonesia. All tree of Kaliandra, Albasia and Coconut are renown for its adaptability and ability to be cultivated and grow in tropical country like Indonesia. Its calorific value also best option among other wood in Indonesia. Biomass power plant make use of gasification technology would be suitable for small remote island in Indonesia.

Conclusion

In the experiment Kaliandra wood chip, Albasia wood chip and Coconut Shell had been analyzed with regard its purpose to make use of them as fuel in gasification technology power electricity generation. All the three resources were selected because it is the most promising biomass resources in Indonesia in terms of its availability and affordability. Knowledge of syngas properties from an original biomass resources in Indonesia would give advantage in making progress in gasification implementation towards remote island of Indonesia. The simulation of energy price is calculated using Levelised Cost of Electricity method. The new proposed systems are believed to be able to give electricity to a remote island of Indonesia. In summary, findings of this study are as follows:

- Calorific value of Kaliandra syngas from the gas chromatographer test result is 3632,09 kCal/kg
- Calorific value of Albasia syngas from the gas chromatographer test result is 4267,35 kCal/kg
- Calorific value of Coconut Shell syngas from the gas chromatographer test result is 26827,35 kCal/kg
- CO and H2 content in Kaliandra syngas from the gas chromatographer test give value of 20,83% and 8,98%.
- CO and H2 content in Albasia syngas from the gas chromatographer test give value of 13,01% and 12,49%.
- CO and H2 content in Coconut Shell syngas from the gas chromatographer test give value of 1,43% and 93,39%.
- CO2 and N2 content in Kaliandra syngas from the result of Gas Chromatographer test give value of 21,42% and 36,90%.
- CO2 and N2 content in Albasia syngas from the result of Gas Chromatographer test give value of 31,40% and 36,91%.
- CO2 and N2 content in Coconut Shell syngas from the result of Gas Chromatographer test give value of 2,52% and 1,88%.

- Other content in Kaliandra Syngas as reveal from the chromatographer test are Oxigen, Methane, Ethane, Etilene, Acetilene, Propane
- Other content in Albasia Syngas as reveal from the chromatographer test are Oxigen, Methane and small fraction of Ethane, Etilene, Acetilene, Propane
- Other content in Coconut Shell Syngas as reveal from the chromatographer test are Methane : 0,46% & Oxigen : 0,33%
- The LCOE (Levelised Cost Of Electricity) value of electricity generation from gasification of Kaliandra Syngas is 2968 Rp/kWh or 21,98 cent USD/kWh
- The LCOE (Levelised Cost Of Electricity) value of electricity generation from gasification of Albasia Syngas is 3186 Rp/kWh or 23,60 cent USD/kWh
- The LCOE (Levelised Cost Of Electricity) value of electricity generation from gasification of Coconut Shell Syngas is 2632 Rp/kWh or 19,49 cent USD/kWh
- IRR and BCR value of Kaliandra syngas generation is 17,33% and 1,15
- IRR and BCR value of Albasia syngas generation is 16,97% and 1,14
- IRR and BCR value of Coconut Shell syngas generation is 17,89% and 1,16
- Government support is mandatory, in order to ensure feedstock availability, by providing land to grow the biomass resource around the vicinity of the site location.
- Government support to regulate special renewable energy tariff or tax flexibility for private producer is also necessary so as to invite more private capital to increase the electrification ratio, especially in remote island.

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