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Potential of beef and biogas from integration of beef cattle-oil palm in Indonesia

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Abstract. Beef is a national strategic commodity and has high economic value. The consumption needs per capita of beef increase every year, so that it is fulfilled through imports. While domestic production has not been able to meet the meat needs of the Indonesian people to date. In addition to beef needs, Indonesia is also experiencing obstacles to meeting national energy needs. With an estimate of GDP growth reaching an average of 6.04% per year for the 2017–2050 period, it will further encourage an increase in Indonesia's energy needs in the future. The challenge of the world today is to develop renewable energy to overcome the minimum availability of fossil energy sources. To overcome this problem can be done by developing a bio-industrial farming system. One of them is the application of integration of beef **cattle-oil** palm. Based on the potential for oil palm area of 12.5 million ha, it can be used for the integration of beef cattle-oil palm. The integration of beef cattle-oil palm in Indonesia can produce as much as 2.7 million tons of beef and biogas as much as 172 million m^3 or equivalent to 103 million litres of kerosene per day.

1. Introduction

Beef is a national strategic commodity and has a high economic value in Indonesia, because beef is the second commodity after poultry (broiler chicken) as a source of animal protein with a contribution of 15.45% [1]. Based on data from the Indonesian Central Bureau of Statistics that the national beef demand for 2018 is 2.50 kg per capita per year and for 2019 it is 2.56 kg [2]. According to the Ministry of Agriculture, Indonesia's consumption of beef per capita in 2017 is 2.4 kg/year and is estimated to continue to increase to 3.02 kg/year in 2021 [1]. Although Indonesia's per capita consumption of beef is relatively low when compared to other Asean countries, Indonesia still relies on meat and cattle imports to meet domestic needs.

Since 2014 until 2018, domestic beef production has tended to increase. But the production capacity is not enough to meet beef consumption from the Indonesian people which also continues to increase significantly. Until 2018 Indonesia has not been self-sufficient in beef. The national beef cattle population since 2013–2017 has increased by 1.54% per year and in 2017 it is estimated that the beef cattle population in Indonesia will reach 16.60 million and production of 531.76 thousand tons [1]. The Ministry of Agriculture projects domestic beef production in 2019 to be 429,412 tons and production only meets 62.57% of the projected 2020 beef demand of 686,270 tons. Then the deficit for meat needs of 256,860 tons will be imported from imports [2].

The Indonesian government in previous years has launched various programs to achieve beef self-sufficiency. In 2007 the Directorate General of Animal Husbandry launched a Program to Accelerate Beef Self-Sufficiency Achievement (P2SDS) which was focused on 18 provinces in the center of beef cattle [3], but has not yet been achieved. Then in 2010, the 2014 Beef and Buffalo Self-Sufficiency Program (PSDSK) was launched, with the target in 2014 being achieved to become self-sufficiency in beef in Indonesia [4], but self-sufficiency has not been achieved and various programs to achieve self-sufficiency in beef continue next. On a strategic plan from the Ministry of Agriculture 2015–2019, one of its strategic goals is the achievement of self-sufficiency in meat [5]. And beef is included in the 7 main commodities in the program to achieve food self-sufficiency in 2017. Until 2018, beef self-sufficiency has not been achieved.

Indonesia is the country with the largest energy consumption in the Southeast Asia region, while the Asia Pacific region is in fifth place, brought by China, India, Japan and South Korea for primary energy consumption. The increase in Indonesia's energy needs in the future will be increasingly driven due to GDP growth which is expected to reach an average of 6.04% per year for the 2017–2050 period [6]. In addition, Indonesia's growing population has caused energy needs to increase. Based on the assumption of moderate GDP growth of 5.6% per year for the period 2015–2050 and population growth of 0.8% per year, it is estimated that Indonesia's final energy requirements will reach 238.8 MTOE (Million Tonnes Oil Equivalent) in 2025 for the BaU scenario (Bussinnes as Usual) [7]. Indonesia's final energy consumption (excluding firewood) in 2016 is still dominated by fuel oil by 47%. Energy consumption continues to increase, making the need for fossil fuels whose supplies are running low. The higher dependence on fossil energy to meet energy needs can be a problem in the future related to its inventory and the environmental impact it causes. For that we need alternative energy in the form of renewable energy. While currently third world countries are competing to develop the economy, namely in the form of industrialization. This situation causes the demand for fossil energy resources including non-renewable resources to increase [8]. Increasing world demand for fossil resources will cause environmental damage through greenhouse gas emissions that contribute greatly to global warming [9].

The challenge of the world today is to develop renewable energy to overcome the minimum availability of fossil energy sources. The development of new and renewable energy is also a special concern for Indonesia. Indonesia's energy needs continue to increase each year with an average growth of 7 percent per year and 94 percent still depend on fossil energy [10]. On the other hand, Indonesia has been a net importer of fuel oil since 2004 and a third in 2016 is met through imports [11]. If the energy needs dominated by oil fuels continue to increase without any changes in the pattern of energy use, then Indonesia's sustainability and energy security will be disrupted.

One of Indonesia's energy development priorities is the use of maximum renewable energy by taking into account the economic level. This is Indonesia's commitment in developing the role of new renewable energy [12]. This commitment encourages Indonesia to immediately look for other sources that are new and renewable energy sources for energy needs, especially domestic needs that are increasing, to achieve national energy independence and security [13].

Bioenergy as one of the new renewable energy sources is one of the focuses for the development of new renewable energy in Indonesia. Bioenergy is energy produced through biomass which is derived from living materials biologically and waste from animals [14]. Bioenergy is fulfilled through natural resources in the form of plants and animals that are converted into energy. Bioenergy is produced through a conversion process to produce energy in the form of heat, biopower, and biofuel. There are four factors that drive the development of the bioenergy sector. First, bioenergy is seen as one solution to overcome energy security problems [15]. National oil production will decline until 2025. The situation is a threat to national energy security. Indonesia carried out increasingly high oil imports starting in 2007 and is expected to continue to increase until 2025 [16]. In this case, alternative energy in the form of bioenergy as renewable energy is one of the solutions to reduce imports and overcome the threat of energy security [17]. Second, motivation to utilize clean energy. Bioenergy is still seen as a more environmentally friendly energy than fossil energy because this energy is produced by natural production activities. Where carbon emissions produced by bioenergy combustion can be reabsorbed into the carbon cycle system of agricultural activities [8]. Third, it becomes an instrument to control prices, especially agricultural commodities [18]. Fourth, one solution is to encourage the local, regional and national economy through agricultural development. Indonesia has a lot of agricultural resources as bioenergy raw material.

2. Materials and methods

This research was conducted using the literature study method. This method is carried out by searching various written sources, whether in the form of books, archives, magazines, articles and journals, or documents that are relevant to the topics of beef and biogas potentials from the integration of cattle with oil palm. Information obtained from the study of literature, then used to explain a theory to solve a problem by strengthening the arguments that exist from the literature. Literature study techniques are also used to express various theories that are relevant to the subject matter of the study being discussed and used as a reference in discussion. In this study the literature materials used were news papers, research journals, articles in publications, magazines, reports from various competent institutions, and proceedings of the results of the seminar

3. Results and discussion

3.1. Integration of beef cattle-oil palm

The problem of national beef needs and energy needs through bioenergy must be resolved to achieve self-sufficiency in beef and energy through local resources and wisdom. One way that can be done is by developing a bio-industry farming system. The Ministry of Agriculture has established the 2013–2045 Agricultural Development Master Strategy through the development of sustainable agriculture-bio-industry [19].

Indonesia is the largest oil palm plantation country in the world. The area of oil palm plantations in Indonesia in 2016 was 11.26 million hectares and is expected to be 12.30 million hectares in 2017 [20]. Based on data from the Directorate General of Plantations at the Ministry of Agriculture, the total area of Indonesian oil palm plantations in 2018 reached 14.03 million ha [21]. In the palm oil industry to produce CPO, a by-product is obtained which can be used as feed raw material for cattle. The source of cattle feed comes from oil palm frondand midribs, grass that grows around oil palm plantations, and CPO production waste, namely oil palm kernel cake and sludge [22]. With such a large plantation area, there is a large potential that can be used as feed raw material for cattle farms. By looking at this potential, the development of a bio-industry farming system in Indonesia is one of which is the development of beef cattle-oil palm integration.

Integration of beef cattle-oil palm, hereinafter referred to as Integration of beef cattle-oil palm, is the integration of plantation business with the cultivation of beef cattle on oil palm plantation land. The integration of beef cattle-oil palm business is carried out to be able to utilize the oil palm plantation's by-products and cow manure as fertilizer, bio urine, and biogas and other benefits [23]. Integration activities have long been carried out in Indonesia. Since 2003, the Ministry of Agriculture has encouraged people to implement the integration of beef cattle-oil palm. The centers of integration activities in Indonesia are in North Sumatra, Riau, Jambi, South Sumatra, Central Kalimantan, South Kalimantan and areas that have extensive oil palm plantations in Indonesia.

3.2. Potential of beef from integration beef cattle-oil palm

Forages that grow on oil palm plantations are natural forages, so changes in the composition of forage botanists are strongly influenced by environmental conditions such as soil fertility, water availability, and shade from oil palm or light canopy. Plant species that grow under oil palm with different age proportions are also different. Forage crops in oil palm plantations are usually dominated by ferns, puzzles, legumes, shrub plants, and reeds [24]. In young oil palm, forage crops are very diverse and in greater numbers. Conversely the higher the age, the less the type of forage and less plants. This happens because young oil palm, the size of trees and midribs is still small so that sunlight that hits the land between oil palm plants is still free. In Samboja Subdistrict, Kutai Kartanegara Regency, East Kalimantan Province, at 3 years old oil palm plantations were dominated by Paspalum conjugatum (45.54%), followed by Mikania micrantha (9.93%), and Ottochloa nodosa (7.89%), while in the 6 year old oil palm plantation it was dominated by Ottochloa nodosa (33.89%), followed by Melastoma malabatrichum (28.23%) and Paspalum urvillei (8.37%) [25]. For oil palm heads aged 1–2 years the cover crop production can reach 5.5–9.5 tons of dry matter/ha. per year, 5–10 years old 10.479 tons/ha.year, and 10–20 years old 14,827 tons/ha.year [24]

Oil palm midribs and fronds a result of harvesting activities can be used as cattle feed. Oil palm plantations that have a spacing of 9 mx 9 m are assumed to have 138 trees and each tree produces 22 midribs per year. In the midribs, it is assumed that there are 0.5 kg of leaves, so that from one ha of oil palm plantations the fronds are produced as much as 1,518 kg/ha.year [26]. Assuming an average midrib weight of 7 kg, 21.252 tons/ha are obtained per year. The cattle feed potential of fronds and midribs of oil palm plants is 0.7 tons of dry matter/ha.year and 5.2 tons of dry matter/ha.year [27], 2008) midribs and fronds can be used as cattle substitutes for grass as source of forage, because it has a fairly high crude fiber with high lignin levels, namely 17.4% and 27.6% [28]. In its use, size reduction is needed to increase consumption and palatability.

Processing of crude palm oil (CPO) and palm kernel oil (PKO) produces palm oil kernel cake (PKC) and palm oil sludge (PS) [29]. PKC is the by-product of processing PKO, while PS is the by-product of processing CPO. In processing FFB in the factory, 23% CPO and 10% PKO were obtained, with 24% oil palm empty fruit bunches by-products, 21% palm fiber, 8% core skin, 2.5% PKC, and 10% PS. Each processing of 1000 kg of fresh fruit bunches (FFB) can be obtained as much as 250 kg of oil palm and by-products of 294 kg of palm sludge, 35 kg of palm kernel cake, and 180 kg of fiber feeling [28]. If it is assumed that every one hectare of oil palm can produce 15 tons/ha.year, then every year 525 kg BIS/year and 4,410 kg solid/year are produced. The potential of cattle feed from oil palm processing byproducts in the form of BIS and oil palm sludge is 0.5 tons of dry matter/ha.year and 1.1 tons of dry matter/ha.year [27].

Processing of Crude Oil palm (CPO) and Palm Kernel Oil (PKO) produces palm kernel cake and oil palm sludge. Palm kernel meal is the by-product of palm kernel oil (PKO) processing, while oil palm sludge is the by-product of CPO processing. In the processing of fresh fruit bunches in the factory, 23% CPO and 10% PKO were obtained, with a non-stick 24% by-product, 21% palm fiber, 8% core skin, 2.5% palm kernel cake, and 10% oil palm sludge. Each processing of 1000 kg of fresh fruit bunches can be obtained as much as 250 kg of CPO and by-products of 294 kg of PS, 35 kg of PKC, and 180 kg of fiber feeling [27]. If it is assumed that every one hectare of oil palm can produce 15 tons/year, then every year 525 kg PKC/year and 4,410 kg PS/year are produced. The potential of cattle feed from oil palm processing byproducts in the form of PKC anda PS is 0.5 tons of dry matter/ha.year and 1.1 tons of dry matter/ha.year [27].

PKC has a high crude fiber content, to increase its utilization, it can be done by fermentation. PS can be relied upon as a feed because it is cheap, abundant, sustainable, and until now it has not competed with human needs. The protein content of PS can be increased to 24.5% by fermentation with Aspergillus niger mold [30].

Based on data from the Central Statistics Agency that in 2017 the area of oil palm plantations in Indonesia is 12.30 million Ha, so the potential for cattle feed from biomass waste from the palm oil industry in Indonesia is presented in table 1.

Table 1. Potential for cattle feed from palm oil industry biomass.

Palm Oil Industry Biomass	Potential for cattle feed per Hectare (tons Dry Material/year)	Potential for cattle feed in Indonesia (ton Dry Material/year)
Oil Palm Midribs	5.2	63,960,000
Oil Palm Leaves	0.7	8,610,000
Oil Palm Kernel Cake	0.5	6,150,000
Oil Palm Sludge	1.1	13,530,000
Total	7.5	93,250,000

Source: Processed based on data from various sources.

Feed cattle from palm oil industry biomass can be made can be made by processing mixtures in certain compositions. The composition of cattle feed from the biomass of palm oil industry waste that was once carried out at the Oil Palm Research Center in Bukit Sentang, Langkat Regency is presented in table 2.

Table 2. Feed composition of cows from oil palm industry biomass waste.

No	Material	Percent (%)
A.	Feed for breeding	
1.	Chopped Oil palm Midribs and Frond	78
2	Oil Palm Kernel Cake	10.6
B.	Feed for Fattening	
1.	Chopped Oil palm Midribs and Frond	42
2.	Oil Palm Kernel Cake	30

Source: [31]

Cattle can be cultivated on old or harvested oil palm land, cattle can be fed from grasses that grow wildly under oil palm. The capacity of one hectare of oil palm is 2 cows [4]. With an area of oil palm plantations of 12.30 million ha, it can accommodate around 24.6 million head of cattle.

If it is assumed that the feed needs of a cow are 3% of the weight of an adult cow (250 kg/head), then the need for cattle feed is 7.5 kg/day or 2.7 tons/year. To be able to grow healthy, beef feed must consist of forage and protein. Oil palm midribs and frond can be used as a forage substitute for grass, while for protein sources, can be provided from PKC and PS. Details of the requirements for the composition of feed for one cow are presented in table 3.

Table 3. Needs of cattle feed composition from oil palm industry biomass for one cow per year (2.7 tons/head).

No	Material	Percent (%)	Number of Needs (Kg)
A	Feed for breeding		
1.	Chopped Oil palm Midribs and Fronds	78	2,101
2	Oil palm Kernel Cake	10.6	286
B.	Feed for Fattening		
1.	Chopped Oil palm Midribs and Fronds	42	1,134
2.	Oil palm Kernel Cake	30	810

With the potential of oil palm midribs and frond that exist, it can be used as feed for cattle breeding activities as many as 30 million head of cattle, while palm kernel cake as much as 21.5 million. For cattle fattening activities, the biomass potential of oil palm midribs and frond is able to feed 56 million head of cattle, while PKC is 7.6 million head of cattle.

The percentage of meat obtained from live cattle weight ranges from 50 percent [32]. By utilizing oil palm plantation land as a cattle grazing place, where cattle only consume weeds under oil palm plants, cattle can be cultivated as many as 24.6 million head of cattle. When converted into beef with the assumption that the cattle ranges from 250 kg, beef as much as 3.075 million tons of beef is obtained. Then by using oil palm midribs, oil palm leaves, and palm kernel cake as animal feed raw material for fattening activities, as many as 21.5 million head of cattle can be produced. When converted into beef, 2.7 million tons are obtained.

3.3. Biogas potential from beef cattle-oil palm integration

The pattern of integration of beef cattle-oil palm can be carried out in the form of intensive, semi-intensive, and extensive [4]. The integration of beef cattle-oil palm which can utilize cow dung to produce biogas is intensive and semi intensive pattern activities. With this pattern cow dung can be collected, because cattle are cultivated in cages throughout the day in intensive patterns, while semi-intensive patterns of cows are anchored at night until noon. Some examples of those who have carried out cattle integration activities that have utilized cattle manure to be processed into biogas are the Medan Oil Palm Research Center in Medan on Bukit sentang since 2009 [33], Sulung Ranch at the Oil palm Plantation PT. Citra Borneo Indah in Waringin Barat City, Central Kalimantan Province [34], and Karya Lestari Farmers Group in Pelalawan Regency, Riau Province. This integration activity is often referred to as integrating "cattle, oil palm and energy" activities. This integration activity can produce several products, namely: Oil palm fruit, livestock feed made from waste palm oil industry, cattle, biogas, oil palm sludge, solid organic fertilizer, and liquid organic fertilizer.

If it is assumed that the integration activities carried out are intensive patterns and use cattle feed from the waste of the oil palm industry, then it can be cultivated as many as 21.5 million head of cattle. One cattle every day can produce as much as 20 kg of dirt [35–36]. If it is assumed that a cattle produces 20 kg of manure/day, then with as many as 21.5 million cattle will be obtained every day 430 million kg.

The principle of making biogas is the decomposition of organic materials anaerobically (closed from free air) or the degradation process of bio materials. This process is to produce gas which is mostly in the form of methane gas (which has flammability) and carbon dioxide, this gas is called biogas. Biogas is included in the category of renewable energy and is a prospective source of energy to be developed as a substitute for energy from fossil fuels. The anaerobic decomposition process is aided by a number of microorganisms, especially methane bacteria. A good temperature for the fermentation process is 30–55 °C, where at this temperature microorganisms are able to optimally reorganize organic matter [37]. The result of reforming organic matter by bacteria is methane gas.

The main building of a biogas installation is a Digester that serves to accommodate methane gas as a result of reforming organic matter by bacteria. Mixture of cow dung with water until mud is formed with a ratio of 1:1 inserted in the digester. The filling requires a large amount of cow manure until the digester is full. The first gas produced is produced on day 1 to 8 because CO_2 is formed and this must be removed. Whereas on the 10 th day to the 14 th day methane gas (CH_4) will be produced, while the CO_2 begins to decline. In CH_4 54% composition and 27% CO_2, the biogas will light up and on day 14 the gas formed can be used to light a fire on a gas stove or other needs.

Organic material from cattle dung as much as 1 kg can produce biogas as much as 40 liters [38–39]. Integration of beef cattle-oil palm that use palm oil industry waste as feed, can accommodate 21.5 million heads of cattle. Every day can produce 430 million kg of cattle dung every day. So that the potential of Biogas that can be produced is 172 million m^3 every day.

The benefits of biogas energy are producing methane gas as a substitute for fuel, especially kerosene and can be used for cooking. On a large scale, biogas can be used as an electric energy generator. In addition, the biogas production process will produce residual manure that can be directly used as organic fertilizer in crops/agricultural cultivation. And more importantly is reducing dependence on the use of petroleum fuels which Biogas has a high energy content that is not inferior to the energy content of fossil fuels. The calorific value of 1 cubic meter of biogas is equivalent to 0.6–0.8 liters of kerosene. To produce 1 Kwh of electricity it takes 0.62–1 cubic meter of biogas which is equivalent to 0.52 liters of diesel oil. Therefore biogas is very suitable to replace kerosene, LPG and other fossil fuels [40]. If the potential of biogas is converted into kerosene, it will be 103 million liters of kerosene every day.

6. Conclusion

The integration of beef cattle-oil palm in Indonesia can produce as much as 2.7 million tons of beef and biogas as much as 172 million m^3 or equivalent to 103 million liters of kerosene per day.

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