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Resources, policy, and research activities of biofuel in Indonesia: A review

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ABSTRACT

Fossil fuels as the main energy source of every country now predicted will be ended no more than 40 years. Therefore, alternative fuel such as biofuel has been developed by many countries including Indonesia. Indonesia as one of the highest populated country and has wide areas of agriculture, forest and crop field is potential to be the highest biofuel production in the world. However, after one decade since the Government of Indonesia launched the energy Policy in 2006, appears to be interesting that the biofuels progress in Indonesia seen not well developed. One of the basic weaknesses is the program only applied to the specific area with a high biofuel resource by central government without support by local government. Furthermore, the target of biofuel programs seems to be very high or too ambitious, while the condition of the people still very traditional which can be seen from the lifestyle and their energy consumption. This paper provides in detail a review of several topics related to resource, energy consumption, policy and the research and development activities of biofuel in Indonesia. As a discussion, some recommendation provided to encourage the biofuel development in the near future.

1. Introduction

The dependence situation of many countries in the world on fossil fuel delivers at least three serious conditions specifically (1) depleting fossil fuel stock, (Salvi and Panwar, 2012; Jayed et al., 2011; Kumar et al., 2012; Tariq et al., 2012) (2) increasing of fossil fuel price due to the high demand rate averaged 1.8% from 2005 to 2035, Atabani et al. (2012) and (3) greenhouse gas pollution especially CO2 due to the burning process of fossil fuel. Based on these matters, several ideas occurred to develop and utilize the renewable energy resources. Nowadays there are many energy resources to replace fossil fuel, namely fuel cells, geo-thermal, ocean power, solar power, wind power, coal, nuclear, gas fusions and biofuel (Abbaszaadeh et al., 2012; Shahid and Jamal, 2011; Vibhanshu et al., 2014). Among these alternative energy resources, biofuel is high potentially appropriate to solve the energy problems due to it has many advantages (Kumar et al., 2012; Abbaszaadeh et al., 2012; Demirbas, 2009; Kelkar et al., 2013; Jain et al., 2015).

The advantages of biofuel besides it can be renewed, it also environmentally friendly, (Ong et al., 2011; Atadashi et al., 2010, 2012) very degradable, has high potential to eliminate greenhouse effect, Arbab et al. (2013) and the raw material stock is abundant. The biofuel can be obtained simply such as crop plant cultivation and raising animal livestock (Atadashi et al., 2010; Nasir et al., 2013; Zarling et al., 2004; Hoekman et al., 2012; A et al., 2013; Tyagi et al., 2010; Mythili et al., 2014). Biofuel is different from the other type of alternative energy such as battery energy that complicated and expensive, coal that has billion ton dangerous carbon and non-renewable resource, natural gas that need a high capital, geothermal that not so simple and very expensive, and solar energy even though it is free but need expensive cost. Biomass (biofuel resource) is the only one renewable energy source that have a big potential to replace fossil fuels in many types (Harsono and Subronto, 2013). Meanwhile, the other energy sources such as solar, wind, water, geothermal, and nuclear energy will be easy only if converted to electric energy types.

As an agricultural country, Indonesia has a very big opportunity to utilize the new and renewable energy source from biomass. Agriculture product such as corn, bean, cassava, sugar cane, coconut, and oil palms (Costa et al., 2013) that have been known and used in order to fulfill the food supply of humans began to

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be considered as an alternative fuel. In developed countries such as the United States, the utilize of corn for biofuels growing very fast, Zarling et al. (2004) even in Brazil, the Brazilian Government decided to introduce a National Biodiesel Program, initially by replacing 2% of current diesel oil consumption, implemented to reach 5% in 2013 (Costa et al., 2013). The vegetable oils from castor and palm are as the main inputs of the biodiesel. These opportunities are opening when the international market demand for biofuels over the past few years has also increased sharply.

Indonesia, since 2005, started with huge plantations of Jatropha curcas as biodiesel source since this particular oil is non-edible and potential to be converted to biodiesel (Jayed et al., 2011). Furthermore, since 2006 the Indonesian government has released an energy mix policy which is the implementation of a mixture of energy sources utilizing local resources (renewable energy) besides fossil fuel energy (Jupesta, 2010) and in the same year the biodiesel 5% began to be marketed in Indonesia. During one decade of 2005–2015, the research and development of biodiesel in Indonesia have ups and downs. However, after one decade since the Government of Indonesia launched the energy Policy on 2006, the biofuel development in Indonesia appears to be not well developed. One of the basic weaknesses is perhaps the program only applied to the specific area with high biofuel resource managed by central government without support by the local government. Furthermore, the target of biofuel programs is too high or too ambitious, while the condition of the people still very traditional which can be seen from the lifestyle and energy consumption. Then, the comprehensive information related to biofuel research and development in Indonesia cannot be found easily. Therefore, this paper presents a review of resources, policy, and research activities of biofuel in Indonesia. The information about biofuel, energy resource, energy consumption policy and research activities in Indonesia will be covered in this paper based on good quality literature source and trusted references.

2. Biofuel as alternative of petroleum fuel

Biofuel can be determined as a fuel from organic resources including plants and animals. Biofuel has a specific characteristic that is renewable, whereas it can be produced by using raw material which can be grown or developed. There are a variety of biofuels potentially available, but the main biofuels being considered globally are biodiesel and bioethanol.

Bioethanol is a fuel produced from crops which have properties almost the same with gasoline. Bioethanol is a kind of alcohol produced from fermentation of glucose then continued with the distillation process. The distillation process can produce ethanol with 95% of purity, to be used as fuel (biofuel) the ethanol necessary to be purified until 99% or so called fuel grade ethanol. Bioethanol can be produced from a number of crops, including sugarcane, corn (maze), wheat and sugar beet. The raw material of bioethanol usually can be divided into 3 groups, i.e.

a. Glucose material, the glucose materials, including sugar cane, palm, sweet sorghum, grapes, coconut etc. (Dyartanti et al., 2015)
b. Starchy material, the starchy material, including corn, banana, cassava, sweet potato, etc. (Widodo et al., 2015a,b)
c. Lignocellulose material, the lignocellulose material, including woods, rice straw, seaweed, banana stem, tapioca solid waste etc. (Wahyuono et al., 2015; Puspawati et al., 2015).

There are many techniques and methods to produce bioethanol based on the raw materials that used, conventionally and also advanced method, while, the standard process always consists of fermentation, distillation, and dehydration (Jeon et al., 2014; Meinita et al., 2015; Triwahyuni et al., 2015b; Muryanto et al., 2015; Wahono et al., 2014)

Biodiesel is a fuel that appropriate for compression ignition (diesel) engine which is produced from biological resources such as fatty oils of vegetable or animal fat. The main component of biodiesel is an ester. Biodiesel is the fuel that can be produced from straight vegetable oils, edible and non-edible, recycled waste vegetable oils, and animal fat. The raw materials of biodiesel, which is developed, depend on the country resources. Indonesia has many resources for biodiesel such as coconut, palm, *Jatropha Curcas* etc. Biodiesel should have the same properties with diesel fuel for its chemical and physical properties. The detail of properties, production process, and the advantages or disadvantages of biodiesel compared to diesel fuel will not be explained here, it can be obtained from the reference (Hassan and Kalam, 2013)

3. Energy resource in Indonesia

The statistical data from ministry of Energy and Mineral Resources 2013 (Dewan Energi Nasional Republik Indonesia, 2014) shows that for unrenewable resources beside fossil fuel with potential stock, 3.85 billion barrels, the other huge energy resources in Indonesia are natural gas 150.7 TSCF and coal 28.97 billion Ton, then, followed by some renewable energy such as geothermal 28,910 MW and hydro resource 75,000 MW. Meanwhile, in the biomass sector for about 32,654 MW there are many potential energy from bio resources such as palm oil, crops, non-food crops, and livestock manure. For the other renewable energy resources such as solar 4.80 RWh/M2/day, wind 3–6 m/s, sea wave 49 GW and uranium 3000 MW. Fig. 1. Shows the detail of energy resource for oil and gas in Indonesia (Dewan Energi Nasional Republik Indonesia, 2014).

The energy resource from biomass in Indonesia can be discussed through several categories specifically forestry residue, agriculture residue, waste and crops.

3.1. Forestry residue

In 2014 the potential Bioenergy from forestry residue in Indonesia is approximately 271 MW. It was resulted from the annual wood production of seven big islands namely Sumatra, Kalimantan, Jawa–Madura–Bali, Nusa Tenggara, Sulawesi, Maluku, and Papua. The wood production activities are included replanting rubber wood, logging, sawn timber, plywood, and veneer.

3.2. Agriculture reserves

The total potential supply from agriculture residues in Indonesia is almost from rice, sugar and corn production annually approximately 123.4 million tonnes. The detail productions are rice 67.8 million tonnes, sugar cane 20.1 million tonnes, corn 3.8 million tonnes, palm oil 8.5 million tonnes, and coconut 3.1 million tonnes.

3.3. Wastes resource

Waste generation is defined as the waste produced by humans or livestock in everyday activities such as solid waste and manure (cattle dung). Source of biomass energy from waste generation is estimated approximately 94.84 million tons per year (except the recycle material). The specific data of municipal solid waste from 400 regencies and 98 cities are around 18 million tonnes and animal manure around 82.61 million tonnes.