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Review

Second generation bioethanol potential from selected Malaysia's biodiversity biomasses: A review

H.B. Aditiya [a,b,*], W.T. Chong [a], T.M.I. Mahlia [b], A.H. Sebayang [a], M.A. Berawi [c], Hadi Nur [d]

[a] Department of Mechanical Engineering, Faculty of Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia
[b] Department of Mechanical Engineering, Universiti Tenaga Nasional, 43000 Kajang, Selangor, Malaysia
[c] Department of Civil Engineering, Faculty of Engineering, Universitas Indonesia, Kampus UI, Depok, Indonesia
[d] Centre for Sustainable Nanomaterials, Ibnu Sina Institute for Scientific and Industrial Research, Universiti Teknologi Malaysia, Johor Bahru, Malaysia

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ABSTRACT

Rising global temperature, worsening air quality and drastic declining of fossil fuel reserve are the inevitable phenomena from the disorganized energy management. Bioethanol is believed to clear out the effects as being an energy-derivable product sourced from renewable organic sources. Second generation bioethanol interests many researches from its unique source of inedible biomass, and this paper presents the potential of several selected biomasses from Malaysia case. As one of countries with rich biodiversity, Malaysia holds enormous potential in second generation bioethanol production from its various agricultural and forestry biomasses, which are the source of lignocellulosic and starch compounds. This paper reviews potentials of biomasses and potential ethanol yield from oil palm, paddy (rice), pineapple, banana and durian, as the common agricultural waste in the country but uncommon to be served as bioethanol feedstock, by calculating the theoretical conversion of cellulose, hemicellulose and starch components of the biomasses into bioethanol. Moreover, the potential of the biomasses as feedstock are discussed based on several reported works.

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1. Introduction

Malaysia provides the possible limitless options of renewable energy resources. Located in the tropical climate, all-year sunshine is one blessing that Malaysia owns. The solar energy could be

* Corresponding author at: Department of Mechanical Engineering, Faculty of Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia.
E-mail addresses: aditharjon@siswa.um.edu.my (H.B. Aditiya), chong_wentong@um.edu.my (W.T. Chong), indra@uniten.edu.my (T.M.I. Mahlia).

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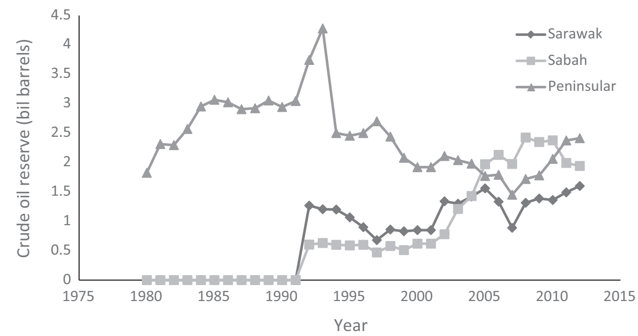

Fig. 1. Malaysia's crude oil reserve by region (Commission, 2011b).

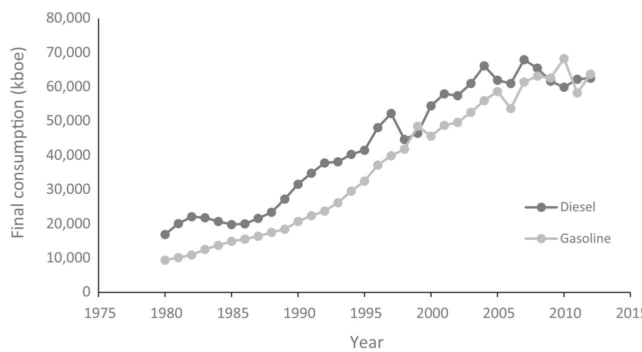

Fig. 2. Malaysia's fuel consumption (Commission, 2011a).

transferred into living and non-living things that made them eventually possible to be transformed into energy resources after many years, for instance, petroleum, coal, natural gas, etc. Technologies over time were developed, which made them further processed and refined into our reachable applications of energy, namely, electricity, fuels, etc.

Petroleum production in Malaysia has a decreasing trend in the recent decade. Although the nature provides Malaysia with raw petroleum within the nation, Malaysia still far from petroleum sustainability in comparing with other countries' reservation. When Iraq, Iran and Saudi Arabia reserve 115, 138 and 260 billion barrels, Malaysia is only able to reserves approximately 5.5 billion barrels (Shafie et al., 2011). Additionally, the energy demand in transportation sector, as the biggest user of petroleum products, has been rising with the worrying trend. Along with industrial sector, Malaysia's transport sector seems still the most dependant on the fossil petroleum products, which mostly are diesel and gasoline. Malaysia's crude oil reserve has shown a very slow response throughout the past decades, as shown in Fig. 1 (Commission, 2011b). It seems that the Malaysia's oil stock would have a hard time to fulfil the trend of both diesel and gasoline consumption, as they have been constantly increasing throughout the decades (Fig. 2) (Commission, 2011a). Data released by United Nation Development Programme (2006) reported that transportation sector led the energy demand by sector in Malaysia for year 2000, 2005 and 2010 by 505.5, 661.3 and 911.7 petajoules respectively. Table 1 shows the breakdown of Malaysia's fuel consumption and its estimation on transport sector based on the vehicle types (DECP, 2006; Kennedy and Ahamad, 2007).

Despite the mentioned worrying facts, Malaysia still have many potentials to retract these drawbacks. Bioethanol is one answer for Malaysia as it holds the tropical biodiversity, which is the key to establish bioethanol production sustainably. Bioethanol could bring the practical benefits if to be implemented nationally in Malaysia. Brazil has been implementing bioethanol–gasoline blend since the 1930s (Rodrigues, 2000), and the implementation of the blending was mandatorily increased by 50% in 1943 (Kovarik, 2008). Malaysia, as a country that is relatively having the same geographic location and condition with Brazil, could potentially follow Brazil's path in utilizing its own agricultural resources to contribute in fulfilling the nation's energy demand. This suggestion is true since Malaysia's transportations are majorly operated by fossil gasoline than fossil diesel; as vehicles with spark-ignition engines are in the bigger proportion than the vehicles with compression-ignition engine (diesel engine). However, Malaysia's interest in biodiesel production and its performance is seemed greater in comparison with bioethanol studies, as reported by Ong et al. (2014a,b, 2013), Silitonga et al. (2011, 2013a,b).

Second generation bioethanol production captures the attention of many researchers and scientists in the optimism of better path of fuel sustainability. Crossing off the food-versus-fuel risk from the equation, second generation production utilizes the non-edible lignocellulosic and starchy materials from agricultural and forestry biomasses and it becomes one fascinating solution in the popular deteriorating fuel demand and environmental complications. From lignocellulosic material alone, Kim and Dale (2004) reported that the global ethanol production from this material can potentially produce about 442 billion litres, which is approximately 16 times greater compared to the current global production. Bioethanol production via this route is also expected to be economically preferable in the future for the observable reason of low feedstock cost. A study by Eijck et al. (2014) reported the overall production cost of second generation biofuels production. It is projected that in year 2020 the production costs $17-26/GJ of biofuel produced, while in another future decade, 2030, is estimated decreased to $14-23/GJ of biofuel produced. The authors also claimed that conversion optimization dominates the whole production costs, which covers 35–65%. In Malaysia, similar studies regarding various non-edible feedstock conversion but to produce biodiesel have been reported by Ong et al. (2014a,b,c), Silitonga et al. (2013b,c, 2014). However, it is rather rare to find study of which focusing on the potential of different Malaysian biomasses in second generation bioethanol production although Malaysia's agricultural biomass reserves are abundant: 85.5% from oil palm, 9.5% from municipal solid waste, 3.7% from wood industry, 0.7% from rice and 0.5% from sugarcane (Hassan and Shirai, 2003).

This study is aimed to emphasize the potential of second generation bioethanol in Malaysia from its various biomasses through theoretical conversion approach of their lignocellulosic and starch components to obtain potential yield of bioethanol production. In addition, this study is aimed to imply that the selected biomasses

Table 1
Estimation of fuel consumption based on vehicles type in Malaysia (DECP, 2006; Kennedy and Ahamad, 2007).

Vehicle type	Estimated vehicles number (thousands)				Annual fuel consumption in average (L/vehicle)
	2005	2010	2015	2020	
Domestic cars (run on diesel)	22.18	28.82	35.89	43.29	1500
Domestic cars (run on gasoline)	5837.74	7586.16	9447.80	11,396.56	1500
Large vehicles (busses and lorry, run on diesel)	695.13	975.64	1348.37	1843.99	5000 (for busses), 5700 (for goods vehicles)
Large vehicles (busses and lorry, run on gasoline)	243.88	343.83	477.10	654.84	