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Scenarios for bioethanol production in Indonesia: How can we meet mandatory blending targets?

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ABSTRACT

This study investigates the potential of bioethanol production and fossil fuel substitution using sugarcane feedstock in Indonesia. Current production practices, government biofuel policies (esp. mandatory blending targets), and sugar self-sufficiency are simulated to project the total potential of fuel ethanol and land requirements in the timeframe between 2015 and 2025. At present conditions, 450 million liters bioethanol can be annually produced in Indonesia using sugarcane molasses, a low-value co-product. This gives only a marginal contribution equivalent to 1% of the total gasoline consumption in 2015. The study examines the ethanol production potential after domestic sugar self-sufficiency is achieved by 2020. In 2015, 0.71 Mha land were required for sugarcane cultivation in order to meet a 2% blend mandate i.e. 0.68 billion liters (BL) ethanol using only cane-molasses. Juice ethanol is needed to meet the blending targets set for 2020 (i.e., 4.45 BL ethanol) and 2025 (i.e., 11.48 BL ethanol). This translates into sugarcane feedstock obtained from 1.60 Mha to 2.76 Mha land, respectively. The study also evaluates how improved resource efficiency can be achieved, exploring the bioelectricity production potential from sugarcane biomass, improvements in yields, and modernization of sugarcane mills. The results highlight how the use of established technologies and production methods can help develop agro-industries in the sugar ethanol segment of Indonesia.

1. Introduction

Biofuels have received increased attention in Indonesia since 2006 after the promulgation of a national energy policy (presidential regulation no. 5/2006) aimed at diversifying the country's energy mix. This includes a 5% minimum share of biofuel in the total national energy consumption by 2025 [1–3]. Alleviation of poverty and unemployment, socioeconomic development, fossil fuel substitution, and diversification of energy sources motivate the efforts being made through Indonesian biofuel policies. The Government of Indonesia (GOI) has first enacted biofuel blending mandates in 2008 and, since then, targets have been revised several times for blends in transportation, industry and electricity sectors until 2025. Still the share of biofuels in the primary energy supply mix of Indonesia was negligible in 2014 [4]. In 2015, the government issued a new policy (presidential regulation no. 12/2015) on mandatory biofuels targets aimed at increased but differentiated biofuel blending by fuel and sector. When it comes to transport, fuel ethanol blending should fulfil 2% by 2015, 5% by 2016, 10% by 2020, and 20% by 2025 of the total gasoline fuel consumption [5].

Despite the new regulations, there is no road map defining how the bioethanol blending targets will be achieved in the transport sector. Although the country started producing molasses-bioethanol in 2007, the production was interrupted in 2010 due to economic and political reasons. The shortcomings in production and use of bioethanol stand in contrast with the increasing role of biodiesel which contributed 5.7% of the total diesel consumption in the transportation sector in 2013 [5]. It should be noted that bioethanol producers have installed molasses based ethanol plants with 339 million liters' capacity in 2010, which corresponds to a share of 6% (in volumetric terms) of the total biofuel installed capacity in the country [6]. Lack of economic competitiveness in the sugarcane agro-industrial sector, low yields, gasoline fuel subsidies, and volatile international prices of petroleum have hindered domestic production and use of bioethanol in Indonesia [7,8]. In 2013, the country allocated IDR 200 trillion (US$ 18 billion) on fuel subsidy, which is equivalent to 17% of the total government expenditures [9], but gasoline fuel subsidies were abolished in early 2015 [10]. The removal of the fossil fuel subsidies, implementation of

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the blending mandates, together with appropriate pricing could help to make sugarcane agro-industries competitive, while simultaneously produce sugar, ethanol, and bioelectricity in Indonesia. Indonesia imported 32.7 million tonnes of oil in 2014 [11], which equated to large government expenditures. The country is also one of the largest importers of sugar in the world [12]. In this context, it is important to examine how domestic sugarcane-ethanol agro-industries can help meet the demand for sugar and bioethanol.

The objective of this paper is to investigate conditions for sugarcane-based bioethanol production for meeting bioethanol blending targets and sugar self-sufficiency in Indonesia. The conditions for bioethanol production are closely intertwined with the production of sugar and, therefore, both are considered. What is the potential for sugar and bioethanol production at present, and what needs to be done to achieve the targets set for sugar self-sufficiency and bioethanol blend in gasoline? Can we possibly go beyond present bioethanol targets? In addition to biofuel mandates between 2015 and 2025 and land availability for sugarcane cultivation, we consider the development of domestic sugar demand. We investigate different scenarios developed for simulating alternative options for meeting sugar self-sufficiency and bioethanol blending mandates. Fuel ethanol is produced either from molasses and/or juice ethanol depending on the availability of feedstock for sugar production. The scope of this study is limited to sugarcane for sugar, ethanol, and bioelectricity production using first generation technologies. We do not consider ethanol production from other feedstock nor second generation (2G) ethanol derived from sugarcane biomass and other agricultural residues.

Globally, bioethanol dominates the renewable energy supply in the transport sector [13]. Sugarcane has contributed 32% of the total bioethanol produced and shall remain the main feedstock for ethanol production until 2025 [12]. In spite of low oil prices, global production of fuel ethanol increased by around 4% between 2014 and 2015 as government policies have been put in place in many countries to promote ethanol production through various subsidies and blending targets. The use of ethanol, as a transport fuel, contributes to reduce local air pollution, dependency on imported fossil oil and greenhouse emissions. In addition, the development of sugar-ethanol industries has provided a good starting point for the transition towards renewable fuels and promotion of agricultural development in many countries. In Brazil, the most successful example, sugarcane provides around 17% of the total domestic energy consumption [14]. In Guatemala, after meeting the domestic demand, the country exported 2.35 million tonnes of sugar (i.e. 75% of the total production during 2013/2014) [15]. Sugar-ethanol industries contributed 412 MW (i.e. 21% of the national grid) electricity generation and exported 272 million liters of fuel ethanol. Similarly, Thailand is a major producer of sugarcane molasses based bioethanol in Asia. The government has been promoting the production and use of ethanol in the transport sector through price incentives/subsidies and tax reductions for gasohol vehicles, i.e. cars using E20 and E85 blended fuels [16,17]. Ethanol biofuel industries have grown substantially in Thailand, with a 12% annual growth rate of gasohol consumption between 2009 and 2014 [18]. Thus efforts being made in Indonesia are well in line with developments in other countries with good conditions for sugarcane production.

The study is organized in five sections. Following this introduction containing the rationale of the study and research questions, Section 2 provides an overview of liquid fuel consumption and biofuel development in Indonesia and the context for sugarcane-based sugar and bioethanol production. Section 3 presents data sources and methodology used in the study. Different scenarios for land use, sugar self-sufficiency, and bioethanol mandates are described. In Section 4, results of the ethanol production potential are presented, followed by a discussion on sugar self-sufficiency, bioethanol blend mandates, and fuel versus food debates. The potential of bioelectricity production is also evaluated. Finally, concluding remarks are made in Section 5 with an emphasis on the main policy implications of the study.

2. Oil scarcity and biofuel development in Indonesia

The primary energy matrix of Indonesia is largely dominated by fossil fuels, viz. oil (33.9%), coal (25.4%), and natural gas (15%) adding up to 74.3%, while renewables including hydropower, geothermal, and biomass/biofuel only comprise 25.7% of the total [4], see Fig. 1. While oil consumption increased steadily since the seventies, production has lagged behind due to exhaustion of oil reserves. The country has been a net oil importer since 2003 [11]. In 2011, the transport sector consumed 52% of the oil used in the country [19].

The transport sector responded for around 27% of the total energy consumption in 2013. Out of the total domestic oil fuel sales, 30.5 BL (billion liters) was gasoline (97% for transport) and 22.4 BL was automobile diesel. Biodiesel blend contributed 10.93 BL. Note that the share of biodiesel in the blend was 5.7% in 2014 [5]. Fig. 2 shows the trend of transport fuel consumption, indicating rapid increase in the demand for gasoline and biodiesel in the transportation sector. There is an average 6.5% growth in gasoline consumption per year which comprised a 53.4% of the total transport fuel consumption (in energy equivalent units) in 2013 [4].

The vehicle fleets are increasing approximately 15% annually, being mainly composed of Otto-engine vehicles i.e., motorbikes and passenger cars in the last one decade (2004–2013). Therefore, gasoline demand is expected to continue increasing in the near future (see Section 3.3). The transport sector is one of the main sources of GHG emissions and local air pollution in urban centers [20–23]. In this context, it is of paramount importance for the government of Indonesia, to find alternative solutions to the transport sector. Nevertheless, in spite of the country's biofuel potential, the government's efforts to reduce fossil oil dependency, and some progress achieved lately in biodiesel production and blending, fuel ethanol production has not taken off.

As the country plans to meet sugar self-sufficiency within 5 years' time and, at the same time, has defined mandatory bioethanol targets, it is important to investigate the availability of land and potential to increase the production of sugar and ethanol. How can we meet the targets for sugar and bioethanol production simultaneously? This study analyses the potential of fuel ethanol

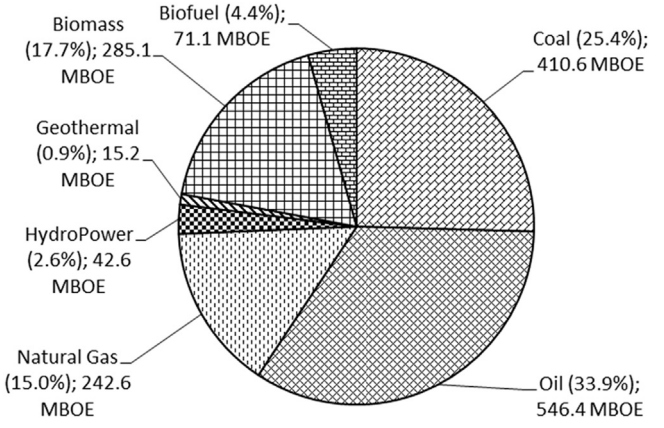

Fig. 1. Primary energy supply by sources (MBOE – million barrels of oil equivalent) in Indonesia, 2013 [4].