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Bioenergy production in Central America: Integration of sweet sorghum into sugar mills

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ABSTRACT

This paper aims to evaluate the potential for electricity and ethanol production in Central America using sweet sorghum as an energy crop. Three scenarios were built to analyse sweet sorghum production in terms of the land where it can be cultivated: cropland, sugarcane land in fallow and land in continuous production (intercropping system). The land under permanent crops was not considered for this evaluation. We propose the integration of sweet sorghum into Central American sugar mills, by using the existing machinery to process it. The short growing period of sweet sorghum would allow the Combined Heat and Power (CHP) plants and distilleries to operate outside the sugarcane crushing season using sorghum bagasse and molasses as raw materials. This production could be performed 1 month before, and 1 month after the sugarcane season.

Results indicate that by growing sweet sorghum on 5% of Central America's cropland, sorghum could supply around 10% of region's electricity demand. Thus, Central America could increase its CHP share of electricity supply from 4.4% to 5.6%. The increase in renewable electricity production would allow countries such as Guatemala, Honduras and Nicaragua to reduce fossil fuel bills by USD$ 13, 10 and 20 million, respectively.

The ethanol produced from sweet sorghum during off-season can help to implement and maintain a sustainable ethanol program in the region that does not only depend on sugarcane. Sweet sorghum would allow distilleries to easily supply the ethanol required to implement an E5 or ED3 program. Central America could produce about 387 million liters of ethanol by growing sweet sorghum on 5% of its cropland. This ethanol production would help the region to reduce fossil fuel bills by USD$ 517 million by using ethanol–gasoline blends or USD$ 463 million by using ethanol–diesel blends.

Contents

1. Introduction

Fossil fuels provide about 35% of the total electricity supply in Central America, where about 78% of this energy comes from diesel and fuel oil generators [1]. This dependence on fossil fuels leaves the region in a vulnerable position in front of the rise of fuel prices and

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supply shocks. So far, biomass resources (sugarcane bagasse) provide about 4% of the total energy supply through CHP plants [2]. Currently in Central America, the main crop used to produce sugar, ethanol, process heat and power is sugarcane. The main advantages of sugarcane in relation to starchy feedstocks are that cane has fewer process stages and less energy requirements, which allow savings between 20 and 60% [3]. Nevertheless, sugarcane requires a long growing season and it can only be harvested once a year. Thus, limiting the production areas and cane crushing season. The shortage of sugarcane by-products such as bagasse and molasses during off-season is one of the major constraints of electricity and ethanol production in a sugar mill. Therefore, in recent years, the sugar industry has become interested in the use of supplemental feedstocks that would enable them to expand their operational season.

Among the feedstocks under study, special attention has been paid to the use of energy crops such as *Arundo donax*, energy cane (*Saccharum sponteneum*), *Eucalyptus camaldulensis*, gliricidia (*Gliricidia sepium*) and *Leucaena leucolephala* [4–6]. With the current technology available in the region, all the aforementioned crops can only be processed for electricity generation, except energy cane. Energy cane can be used for electricity and ethanol production.

It is well known that the land area available plays a critical role when it comes to energy production. Thus, it is important to focus on potential feedstocks available for conversion into multiple products. This is the case of sweet sorghum, which is considered a crop close to sugarcane and a viable alternative for ethanol production in some regions of the world [3]. Furthermore, sweet sorghum can be grown as a supplementary crop to sugarcane and processed using the existing machinery of sugar mills [7–9].

In Panamá, several projects have been carried out by the National Secretary of Science and Technology (SENACYT) to produce ethanol from sweet sorghum. SENACYT reported that higher yields can be obtained from sweet sorghum compared with sugarcane in a year cycle, yields up to 90 t_{stems}[1]/ha[2] and 17 000 l_{juice}/ha can be achieved for ethanol production [10,11]. Besides these attractive characteristics, SENACYT states that the greatest advantage of sweet sorghum is its status as non-food crop [12]. Such status gives sorghum a competitive advantage over other feedstocks as the production of energy from food crops is related to sustainability problems [13,14].

Considering that Central America has the machinery, factories and experience with the use of this type of crop (sugar crop) in large-scale production, sweet sorghum could be an attractive bioenergy feedstock for the region.

This paper focuses on determining the potential for electricity and ethanol production from sweet sorghum in Central America. This work proposes the production of sweet sorghum on land under temporary agricultural crops, temporary meadows for pasture or fallow land. The land under permanent crops was not considered for this evaluation to prevent competition with food production. This study does not propose a competition between sweet sorghum and sugarcane. The primary aim is to use equipment that is not used for sugarcane during off-season. This analysis was based on the reality of each country to assess the potential benefits and disadvantages of using sweet sorghum as an energy crop.

2. Central America profile

In 2010, Central America reached a petroleum products import bill of USD$ 9 321 million (96 million barrels), which represented an increase of 24% with respect to 2009 [15]. Most of the fuel consumption in the area is related to the transportation sector, which consumes approximately 62% of all petroleum products in the region [15]. In order to show Central America's dependency on petroleum fuels, a selection of indicators are presented in Fig. 1.

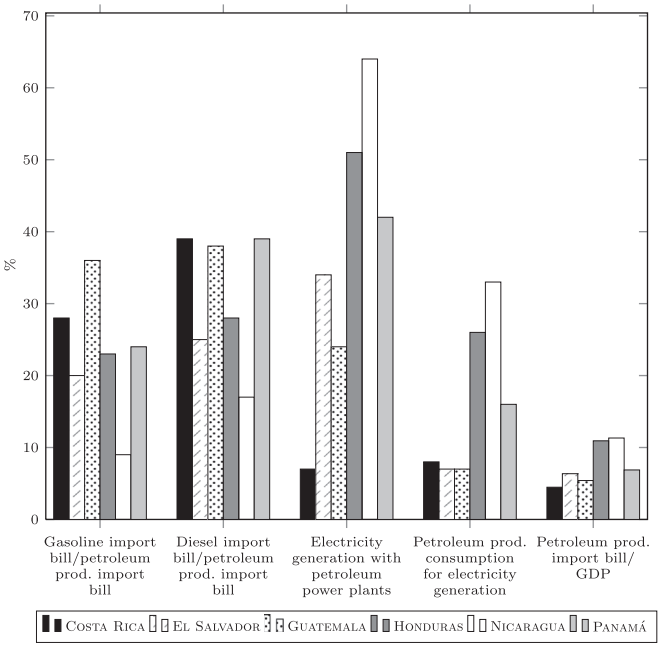

Fig. 1. Central America's dependency on petroleum products. Information was obtained from UN CEPAL SSeM [15,1].

With respect to gasoline and diesel consumption, the most vulnerable transportation sector in Central America belongs to Guatemala (Fig. 1). The gasoline and diesel imports of this country represent around 36% and 38% of petroleum products import bill, respectively. In contrast, Nicaragua is the less dependent on petroleum-based fuels for transportation purposes. This is due to the fact that the Nicaraguan motor vehicle fleet is the smallest in the Central American region [16].

The other major use of fuels in Central America is for electricity production. Honduras and Nicaragua show heavy dependence on petroleum fuels for electricity generation, more than 50% of their energy is produced by petroleum power plants. That is, plants that usually use fuel oil or a mixture of diesel fuel oil to generate electricity. At a regional level, Costa Rica seems to be in a better position, only 8% of petroleum derivatives are destined for electricity generation.

The petroleum products bill per unit of Gross Domestic Product (GDP) indicator shows the percentage of final goods and services produced that is used to pay petroleum products bills (Fig. 1). The countries that struggle more to pay bills are Honduras and Nicaragua, which spent around 10 and 11% of their GDP, respectively.

In order to have a healthy region with low dependence on petroleum-derived products, efforts have to be made to increase the use of renewable energy technologies and fuels. That is, encouraging electricity generation from renewable resources such as biomass and production of renewable fuels such as ethanol.

Currently, CHP plants in Central America have a total installed electricity capacity of 723.8 MW for a generation of 1 775.9 GWh [1]. Guatemala and Nicaragua account together for 68% of total installed capacity for a generation of 72% of regional production [1]. Most of the electricity production from CHP plants in Central America is provided by sugar mill cogeneration plants. However,

[1] Stems refers to the main body or stalk of a plant.
[2] ha: hectares.