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Full chain energy analysis of fuel ethanol from cane molasses in Thailand

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Abstract

An analysis of energy performance and supply potential was performed to evaluate molasses utilization for fuel ethanol in Thailand. The Thai government recently has set up a production target of 1.925 million litres a day of sugar-based ethanol. The molasses-based ethanol (MoE) system involves three main segments: sugar cane cultivation, molasses generation, and ethanol conversion. Negative net energy value found for MoE is a consequence of not utilizing system co-products (e.g. stillage and cane trash) for energy. Taking into account only fossil fuel or petroleum inputs in the production cycle, the energy analysis provides results in favour of ethanol. A positive net energy of 5.95 MJ/L which corresponds to 39% energy gain shows that MoE is efficient as far as its potential to replace fossil fuels is concerned. Another encouraging result is that each MJ of petroleum inputs can produce 6.12 MJ of ethanol fuel. Regarding supply potential, if only the surplus molasses is utilized for ethanol, a shift of 8–10% sugar cane produce to fuel ethanol from its current use in sugar industry could be a probable solution.

Keywords: Molasses-based ethanol; Life cycle assessment; Net energy value; Energy ratio; Thailand

1. Introduction

After China and India, Thailand is considered another market for fuel ethanol in Asia. At present, the 10% ethanol in gasohol available at the Thai gas stations is mainly a fermentation product of molasses. According to [1], by 2008, 12 sugar-based ethanol plants with the total output of 1.925 million litres (ML) a day will come on stream in Thailand.

In line with rapid development of process technologies involved in ethanol production from biomass, evaluations of ethanol's advantages over gasoline through intensive life cycle assessment (LCA) studies have been conducted by groups of researchers throughout the world. Through LCA procedure, all exchanges of ethanol system with the environment and their potential impacts are examined. One instrument conventionally used to evaluate ethanol system's efficiency is net energy value which weighs energy output against energy input.

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However, most assessments conducted to date focus mainly on ethanol from starch-based feedstocks [2–6] whereas just a few are available to evaluate ethanol from sugar-based feedstocks, either directly as sugar cane [7] or indirectly, as the by-product from sugar industry, e.g. molasses [8]. Having high content of fermentable sugars, molasses is considered no less important than any other feedstocks in utilization for ethanol production, especially in tropical and sub-tropical regions where the climate favours cane growth [9].

The reason for conducting this analysis is to better understand the energy performance of ethanol from molasses in Thailand. Supply potential versus production target is also an important issue to be considered.

2. Methodology

2.1. Goal and scope definition

This paper aims to (1) present a full chain energy analysis of fuel ethanol from molasses in Thailand to evaluate whether the production and use of the fuel can help can help reduce fossil imports and (2) assess supply potentials of molasses for ethanol in the country based on the government target.

2.2. Molasses-based ethanol production cycle: System boundary and data sources

The system boundary of the MoE life cycle is shown in Fig. 1. Major operating units located inside this boundary are sugar cane farming, molasses generation, and ethanol conversion. Transportation is a component of all operating units. Also included is the production of various items which are energy or energy-related material inputs in sugar cane farming, e.g. fertilizers, herbicides, diesel fuel, and labour.

2.2.1. Sugar cane farming

Sugar cane crop rotation generally covers a two to five year period: one new planting followed by one to four ratoons. Steps involved at this stage include land preparation, planting, crop maintenance (fertilizing, weeding, watering), and harvesting. Background information on this sub-segment is available from [10–12]. Detailed information on fuel, labour and material inputs was reviewed and verified based on data collection in the central region of Thailand (CRTh), which is the largest sugar cane producing area of the country [13].

2.2.2. Sugar milling (molasses generation)

Around one year after new crop cultivation, cane stalks are cut and ready for sugar milling whereas the remaining parts, e.g. leaves and tops (termed cane trash) are either open burned or used for low-end applications. Sugar milling involves a series of process stages, e.g. crushing, clarification, boiling, seeding and centrifuging to extract sugar crystals from the cane. The process leaves behind two key co-products: one is a sticky black syrup termed molasses, the other, a straw-like residue termed bagasse. Sugar mills commonly burn bagasse to produce steam and electricity for their operation and export excess electricity to the grid.

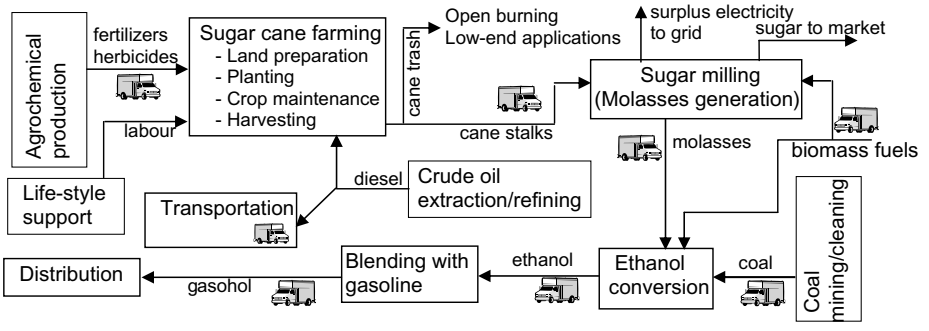

Fig. 1. Life cycle scheme for the studied system.