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# Optimum cost for ethanol production from cassava roots and cassava chips

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## Abstract

This study aimed to evaluate the optimal proportions of two forms of feedstocks such as cassava roots and chips to minimize total cost of 340,000 liter/day ethanol production capacity by solving a linear programming problem. The time period for the optimization problem was based on 12 months in a year. There were four studied case scenarios as follows: (i) base case for interchangeable ethanol production process from two different feedstocks; (ii) modified based case for non-interchangeable monthly production process (iii) no limitation of feedstock supply for demand of ethanol manufactured in non-interchangeable production process; and (iv) inventory cost reduction scenario without maintaining minimum inventory during the time period of sufficient feedstock supply. The optimal result showed that cassava roots were first selected for their availability and then cassava chips were selected to satisfy monthly demand of ethanol due to three-fold higher ethanol processing cost of cassava chips as feedstock. Amongst the first three cases with minimum inventory for each month, the case of unlimited feedstock supply (scenario iii) yielded the minimum total cost. However, the optimal total ethanol production cost of scenario (iv) without minimum inventory required during seasons of harvesting (November – April) and planting (May and October) was 5% lower than that of scenario (ii).

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## 1. Introduction

Thailand has been facing fuel crisis since the high quantity of crude oils were imported to use in economic growth, household and transportation. Nowadays, fuel production is not sufficient to domestic demand, which in turn the price of crude oil in the world market increased rapidly and is likely to rise steadily. Besides, there are also emissions of greenhouse gases in the atmosphere conditions affecting greatly to the economic system and the environment. Therefore, the development and research on new renewable energy sources are supported by Thai government, and "Ethanol" is considered as an interesting alternative energy.

Ethanol is a type of alcohol derived from plant fermentation to change starch from plant to sugar. Then, sugar will be converted to alcohol and purified to be 95% alcohol by distillation which can be used as fuel. Ethanol manufacturing to produce fuel in Thailand can be derived from various types of raw materials. As refer to many researches, one of the most suitable resources is cassava which has less economic impact on other production from cassava. Due to high availability of cassava forms for industrialization such as cassava chips, cassava pallets and starch, they can be used as feedstock for ethanol production.

Domestic ethanol production uses two forms of cassava as raw material such as cassava roots and chips. The use of different forms of cassava in ethanol manufacturing results in the difference of processing cost, storage method, storage loss, and percent of ethanol conversion. Moreover, the availability of feedstock and its cost also dynamically vary in each moth per year. Cassava roots price is about three-fold cheaper than cassava chips because cassava roots do not have raw material processing cost in converting from roots into chips. However, the yield of ethanol derived from cassava roots is about two-fold less than that from cassava chip and cassava roots maybe shortage in some seasons such as rainy season due to difficulty of maneuver a large truck in accessible cultivated area. Normally, the farmers plant cassava from November to April to make high yield of cassava in terms of ton per area. The quantity supplied of cassava roots varies seasonally. Moreover, fresh cassavas are not stored in Thailand due to their limit ageing, normally maximum of 2-3 days after harvest. For Cassava chips, they have high ethanol conversion percentage and can be stored for off-season use; however, their conditions for safe storage to avoid mold damage and fire risk.

Therefore, this study recognized the importance of the optimum feedstock choice for ethanol production using cassava roots and cassava chips in order to minimize ethanol total annual cost for cassava-based ethanol production.

## 2. Methodology

The methodology applied in this study can be divided into three major steps as shown in Fig.1. After the scope of study was defined and optimization model was formulated, all parameter values obtained from primary data collected by the government sectors and data reported by previous studies. Then the optimization problem was solved using GAMS/CPLEX (GAMS, 2009).
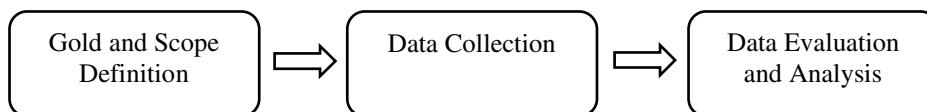


Fig. 1. Steps of methodology.