CHAPTER I
INTRODUCTION

At present, the world is facing many serious challenges. One of the important challenges is an energy crisis. The human population growing rapidly will drive demand supported by rising economic aspirations of developing countries, lead to heavily used of natural resources and energy. The main resource of energy used is fossil-based resources that are predicted to decrease in the near future, opposed to the growing energy demand. The world shortage of crude oil resources causes rising crude oil price inescapably. In order to reduce the strong dependence on fossil fuels, alternative production chains are imperative (Theis and Tomkin, 2012). It is increasingly accepted that there is no single solution to these problems and mixed actions are needed, including changes in behavior, changes in vehicle technologies, enlargement of public transport and introduction of innovative fuels and technologies.

The other challenge is environmental problems. Most of conventional plastics being used are derived from petroleum-based. It does not degrade naturally. As a result, this has led to increasing environmental problems in waste management as well as global warming the world is facing. Bioplastic has been proposed as an alternative way to solve the environmental problems. Some bioplastics can be degradable biologically by microorganisms in the natural environment. Many types of bioplastic have been developed for their potential as a substitute for conventional plastics in various applications. Polylactic acid (PLA) is prepared from lactic acid and is one of the most promising products for packaging application. Polyhydroxy alkanoate (PHA) are naturally produced by micro-organisms from various carbon substrates as a carbon or energy source. They are used in packaging films; mainly in bags, containers and paper coatings. Polybutylene succinate (PBS) is an example of bioplastics which can be obtained from petroleum-based or bio-based resources. It is commonly used in plastic film such as mulch film in agricultural industry. These bioplastics are already used in commercial applications.

Nowadays, people begin to recognize the opportunity to replace fossil resources by biomass. Biomass refers to renewable carbon-based raw materials that are synthesized by plants via the photosynthetic process. This process can convert atmospheric carbon dioxide and water into sugars. Then, the sugars are used by plants to synthesize the complex materials that are commonly named biomass. Biomass can be converted into useful biofuels, clean biochemicals, and valuable biomaterials via various technologies.

Biorefinery is a facility that integrates biomass conversion processes and equipments to convert biomass resources (e.g., cassava, sugarcane, wood, palm, etc.) into basic products like starch, sugar, cellulose and oil. These basic products can be transformed to value added products such as fuels, chemicals, materials and energy. This concept is analogous to today's petroleum refinery which produces multiple fuels, chemicals, materials and energy from petroleum (Cherubini and Jungmeier, 2009; Cherubini, 2010). Biorefinery complex provides high-cost products from low-cost feedstocks due to the potential use of resources and minimize wastes, consequently maximizing benefits and profitability (King *et al.*, 2010). Using biomass instead of petroleum for producing bio-products can reduce both energy and environmental problems.

Since Thailand has abundance in natural biomass resources and agricultural raw materials especially sugarcane and cassava. The average yield of sugarcane and cassava in 2012 are 97.97 and 24.78 million ton respectively (Bank of Thailand, 2012). Thailand ranked as the world's second leading sugar exporter after Brazil which is the outstanding sugarcane producer. Moreover, Thailand is known as one of the world's largest cassava producer and exporter (Silalertruksa and Gheewala, 2010). There are great potentials of feedstocks for biorefinery to produce various bio-products. Currently, there are commercial production of biofuels and biochemicals in Thailand. The government is providing a series of incentives to stimulate ethanol production and consumption, including, excise tax exemption for ethanol producers selling ethanol in Thailand, subsidies using the State Oil Fund to reduce the selling price of gasohol, and more advantageous excise tax reduction for car manufactures of vehicles running on E85 (Gheewala *et al.*, 2011). Biopolymers are receiving much attention in the emerging topic of green chemistry since they can be made from renewable resources or will degrade easily later in nature or under industrial conditions. At present, Thailand has lactic acid (LA) production plant which belongs to Purac of the Netherland. Purac has started up a modern low-cost lactic acid plant near Rayong in Thailand (Groot and Borén, 2010). There has been discussion about possibility of having biorefinery complex in the future to obtain benefits from co-production. For example, meeting process energy requirements with electricity and steam cogenerated from process residues.

This study aim to evaluate energy and environmental impacts associated with the production of biofuel (bioethanol) and biopolymer (polylactic acid, PLA) from possible model biorefinery in Thailand. Sugarcane and cassava roots were chosen as feedstocks for the proposed of biorefinery. The scope of the research covers inventory data collection (raw materials, chemicals, energy, utilities and emissions) for the production of bioethanol and PLA based on cradle-to-gate approach. Secondary data sources from existing bioethanol and PLA plants and current researches were used for life cycle analysis (LCA) based on ISO 14040 series framework. The biorefinery model was created while the performance was evaluated in several aspects such as fuel and biopolymer production, raw materials consumption, and profit generation for five scenarios. The results were analyzed by using commercial LCA software, SimaPro 7.1, with Eco-Indicator 95 and CML 2 baseline 2000 methods to identify the environmental burdens in terms of global warming impact (GWP), acidification potential (AP), eutrophication potential (EP), and energy consumption. Finally, Eco-efficiency parameters were developed to combine both economic and ecology aspects and used to find the optimal scenario. Suggestions for the development of future biorefinery in Thailand and improvements towards sustainability were also included.