CHAPTER I
INTRODUCTION

Nowadays, there are two main global issues: energy crisis and environmental problem. Due to fossil fuel depletion and considerable increasing in energy demand as a result of population growth and industrial development, energy crisis has occurred. It has been reported that world proved reserves of oil and natural gas are expected to last within 45 and 60 years, respectively (British Petroleum, 2010). As a result, crude oil price has increased continuously during the past decades. Another issue is the environmental problems, especially global warming which is the main concern of the world at this moment. The combustion of an enormous amount of fossil fuel has increased carbon dioxide (CO_2) level in the atmosphere, which is a major greenhouse gas (GHG) that causes global warming. The emission also consists of other air contaminants including CO, NOx, SOx, particulate matter, and volatile organic compound. This can lead to climate change and environmental degradation problems in long-term period. Therefore, many researchers have tried to find an alternative energy source which is sustainable and economically feasible in order to solve both global issues. There are many alternative energy sources, for example, biofuel, biomass, solar, wind, tide, geothermal, hydrogen, etc. However, in Thailand where there are abundant agriculture and biomass resources, energy and/or fuel derived from biomass and agricultural residues have high potential for fossil fuel substitution and greenhouse gas mitigation.

Biofuel has been considered renewable energy since CO_2 generated can be fixed in the atmosphere via photosynthesis. The combustion of biofuel derived from biomass has no impact on the CO_2 balance in the atmosphere since the CO_2 emitted from the combustion is offset by the CO_2 fixed by photosynthesis. The process is often referred to as "Carbon Neutral" process. First generation biofuel is biofuel that is made from sugar, starch, vegetable oil, or animal fat using conventional technology. As a result of mass production of the first generation biofuel, its ability to achieve the target of petroleum substitution tends to be limited due to the competition with food crop for land use. The rising of food price is also due to the

increase in the production of biofuel. Therefore, the use of the first generation biofuel as a sustainable alternative to fossil fuel is questionable.

Second generation biofuel is biofuel that is made from non-food crops using advanced technology. It refers largely to lignocellulosic material including cereal straw, forest residue, bagasse, and purpose-grown energy crop such as vegetative grass and short rotation forest. In addition, the organic fraction of municipal solid waste can also be used as feedstock for the second generation biofuel. Therefore, many problems and concerns associated with the first generation biofuel can be addressed by biofuel manufactured from non-food crop feedstock which is abundant and not expensive. Although the pilot plants and demonstration facilities are being developed, the production of the second generation biofuel suffers with cost effectiveness due to technological barrier and feedstock collection network. Therefore, it is still not commercial at the present.

Biofuel produced from algae is considered the third generation biofuel and sometimes called oilgae. Among biomass, algae (macroalgae and microalgae) usually have much higher photosynthetic efficiency than others. In fact, algae are the highest yielding feedstock for biofuel as shown in Table 1.1. Therefore, producing biofuel from fast growing and high yield algae may be the only way to produce enough fuel in order to substitute of current petroleum usage. Currently many research works have been conducted to investigate the utilization of microalgae as an energy feedstock, with the applications being developed for the production of biodiesel, bioethanol, biogas, and biohydrogen. In Thailand, several institutions have already started to investigate the production of biofuel from microalgae. Although these studies have been restricted to lab and pilot scale, all results show potential of the microalgae system.

However, there is no study in Thailand on life cycle energy and environmental evaluation of the microalgae system for biofuel production. Thus, at this stage it is very important to assess biofuel production from microalgae in energy and environmental aspects throughout its life cycle. The aim of this study is to employ life cycle assessment (LCA) technique based on ISO 14040 series to evaluate the biofuel production from microalgae in terms of energy efficiency (net energy ratio or NER) and environmental impact (global warming potential or GWP).

Table 1.1 Comparison of average oil yield from microalgae with that from other feedstocks (Riesing, 2009)

Feedstock	**Yield (gallons of oil per acre per year)**
Corn	18
Soybean	48
Safflower	83
Sunflower	102
Rapeseed	127
Oil palm	635
Microalgae	5,000-15,000