CHAPTER III
EXPERIMENTAL

3.1 Materials and Equipment

3.1.1 Equipment

- Desktop computer: Pentium IV, RAM 1 GB, Window XP, and Microsoft Office 2007

3.1.2 Software

- SimaPro version 7.1

3.2 Methodology

3.2.1 Goal and Scope Definition

a. Study and review the background of biofuel production from algae (macroalgae and microalgae) including their environmental impact through LCA technique.

b. Specify objectives and scope of the study.

The goal of this study is to perform a life cycle assessment (LCA) of biodiesel production from microalgae in Thailand in order to evaluate the energy efficiency and environmental impact of microalgae-based biodiesel. The energy efficiency is expressed in terms of Net Energy Ratio (NER) while Global Warming Potential (GWP) is a key factor to demonstrate the environmental impact. Additionally, comparison between microalgae-based biodiesel and conventional diesel or other types of biodiesel is necessary to provide suggestion for improving the energy efficiency and environmental performance of this kind of biodiesel.

c. Define system boundary of the study and make assumptions based on the objectives and scope.

The system boundary used in this study covers all processes in the entire life cycle of the production of biodiesel from microalgae including four

distinct stages: cultivation, harvesting, oil extraction, and transesterification as shown in Fig. 3.1.

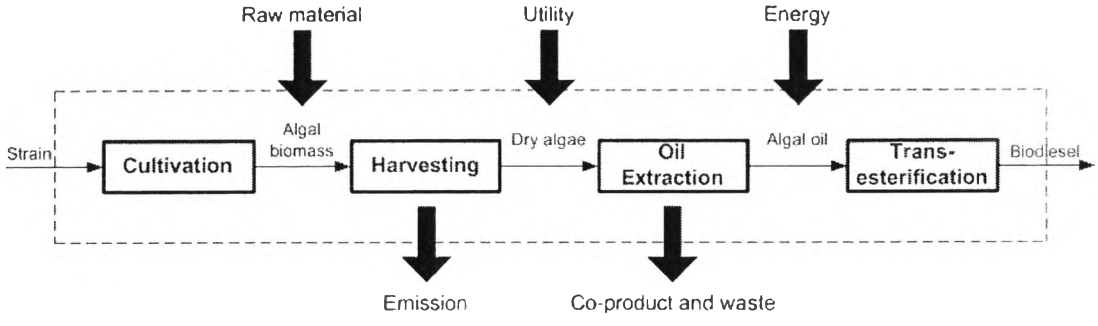

Figure 3.1 System boundary of biodiesel production process from microalgae.

d. Identify functional unit of the study.

In life cycle assessment (LCA), the functional unit provides a reference to which the inputs and outputs are related. Since biodiesel has a similar combustion characteristic with conventional diesel, the functional unit for this LCA study is 1 MJ of energy from microalgal biodiesel. This justifies a direct and fair comparison of microalgae- based biofuel to other fuels based on their calorific value.

3.2.2 Inventory Analysis (LCI)

a. Collect both numerical and qualitative data for all activities based on the system boundary concerning the followings:

- Raw material consumption
- Energy consumption
- Utility consumption
- Product and co-product generation
- Waste generation
- Emission to air, water, and soil

Since microalgae are not currently grown on a commercial scale for the production of biofuel in Thailand, data were collected from several sources. Some relevant data were extracted from literatures whereas data for

cultivation and harvesting stage were collected from Biochemical Engineering laboratory in Department of Chemical Engineering, Faculty of Engineering at Chulalongkorn University.

b. Quantify the flow of material and energy as well as environmental load attributable to each stage of product's life cycle based on the functional unit.

The result of the inventory analysis is the inventory table which is a list of all inputs and outputs per functional unit.

3.2.3 Impact Assessment (LCIA)

a. Compute energy demand and environmental impact potentials based on the LCI results by compiling data in the LCA commercial program named SimaPro version 7.1 with the following methods:

- Cumulative Energy Demand
- CML 2 baseline 2000

b. Analyze the overall process in both energy and environmental aspects which are energy efficiency and environmental impact, respectively.

Energy efficiency is expressed in terms of Net Energy Ratio (NER defined as a ratio of energy output to energy input). The energy output comes from the heating value of microalgae-based biodiesel. The energy input is the energy consumption throughout the microalgae-to-biodiesel production. The energy consumption includes both direct and indirect energy requirement to the process. Various environmental impact categories are evaluated, focusing on global warming potential (GWP as kg CO_2 equivalent).

3.2.4 Interpretation and Reporting

a. Compare the results with the NER and GWP of conventional diesel and biodiesel from other resources such as palm methyl ester, jatropha methyl ester, etc.

b. Evaluate opportunities to reduce energy, material inputs, or environmental impacts for each stage of the product's life cycle.

c. Provide conclusions and recommendations consistent with the goal and scope of the study.