CHAPTER I
INTRODUCTION

In recent years, there has been increasing concern in industrial sectors of the need to improve environmental performance of the production process and products in terms of resources utilization and impacts to human and environment. This has driven engineers to develop the process design that is not only economical but also environmentally friendly. In this aspect, life cycle assessment (LCA) is an effective tool for identifying and quantifying potential environmental impacts throughout the life cycle of the product or process. It can be used in conjunction with an economic tool to evaluate the process design and create improvement options in order to arrive at the best design among various alternatives. Although there are several commercial LCA software but there is still need to develop a simple LCA software that can be integrated with process design tools in order to retrieve data and models from the processes directly.

In our research group, first version of our own LCA software has been developed, LCSoft, and it is needed to be refined further (Piyarak, 2012). In order to improve LCA software and extend the application range, a large amount of data is required for the implementation of an LCA, especially life cycle inventory (LCI) data which specifies inputs and outputs of the product in the system. Therefore, more LCI data is required and the data should be systematically manipulated to become a transparent, flexible to user assumptions. This system information authorizes expansion of the database, robust and fast for LCA calculation. In fact, emissions from the process given by LCI data compose of hundreds of released substances. In order to assess environmental impacts from the released substances, the specific characterization factors (CFs) of the substances are necessary. For many substances, CF may not be available. Every effort made for developing property prediction models for the prediction of properties (CF) of the complex chemicals. For this purpose, one part of this work has been published within the study of "Estimation of Environment-Related Properties of Chemicals for Design of Sustainable Processes: Development of Group-Contribution^{+} (GC^{+}) Property Models and Uncertainty Analysis" for characterization factors estimation (Hukkerikar *et al,* 2012). LCA

software together with other process design tools are widely used for process synthesis. Therefore, several approaches such as economic feasibility, process sustainability, and process safety are important and included as the objective of the process optimization. SustainPro developed in Department of Chemical and Biochemical Engineering, Technical University of Denmark (Carvalho *et al.*, 2008) and it is first of all a tool to perform sustainability analysis of a process as it provides targets for improvement in order to make the process more profitable, safer, and more sustainable regarded to the sustainability metrics. Environmental performances obtained from LCA and the sustainability metrics are used to find the improvement options. In fact, after process flowsheet has been improved, economic analysis is performed. ECON developed for processing cost analysis, including calculating equipment cost, capital cost, utility cost, operating cost (Saengwirun, 2011). Therefore, these tools should be integrated and directly linked with the simulation results for a quick screening of alternatives for multi-criteria process evaluation.

The purposes of this work are to enrich LCSoft with specially developed models including (1) LCI knowledge management, and (2) group contribution^{+} method $(GC)^{-}$ for the estimation of more accurate environmental factors, and to integrate it with economic analysis software, ECON, and sustainable process design software, SustainPro. Finally, the upgraded LCSoft is tested with a bioethanol production process using cassava rhizome (Mangnimit, 2013) and also compared with commercial LCA software, SimaPro. LCSoft and with its integrated tools can help the product-process developer to obtain sustainable designs more efficiently.