CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

In this research, the bioethanol conversion process using a potential biomass material in Thailand, sugarcane molasses, was modeled by using the commercial simulator PRO/II. A systematic design methodology was applied through a sustainability analysis tool, SustainPro, for the analysis of indicators, and sustainability metrics. LCA technique was employed to evaluate the environmental impacts of the design using SimaPro 7.0 with the CML 2 baseline 2000. In order to develop the more sustainable process, sustainability analysis was used to generate new design alternatives. To determine the alternative design that is most efficient in both energy and environmental aspects, Life Cycle Assessment (LCA) was utilized to evaluate their environmental impacts.

After performing the calculations for sustainability metrics, the indicators were calculated and the results identified the open-paths with the highest potential for improvement. These were found to be water, glucose, and cellulose. Based on this, 4 new design alternatives were generated. In the first alternative, recycle of water and glucose were considered because they will reduce the raw material usage. Next, conversion of unconverted cellulose was considered in order to increase the value added. Then, alternative 2, 3, and 4 were created: combustion of unconverted cellulose, pyrolysis of unconverted cellulose to produce bio-oil, and HMF (hydroxymethyl furfural) production.

In terms of economic aspects, the sustainability metrics showed that the value added of alternative 1 (recycle of glucose and water) compared to the other process alternatives. In terms of environmental aspects, the results obtained from LCA showed that alternative 2 has the lowest greenhouse gas (GHG) emission. In contrast, alternative 4 was found to release the highest amount of GHG, which is a consequence of high emission of GHG in the manufacturing process. When compromising the two effects (economic value added and environmental impact), the alternative 2 has been shown to be the best alternative.

Based on the results, several recommendations can be offered:

1. As an economic result, recycle of raw material should be considered for ethanol production process. But in practice, it is difficult to do this because the contaminants in the recycle streams may have high negative effect on the ethanol production, for example, inhibition of enzyme may be caused.

2. Production of bio-oil from biomass is very interesting because of their potential use and value. In order to make this process more efficient, it should be integrated with the sugarcane production, which provides bagasses as waste. Note, however, it is a potential lignocellulosic material feed stock.

3. Same as bio-oil production, lignocellulosic material can create hydroxymethyl furfural (HMF) which is an important intermediate in the chemical industries. To improve the process more sustainable, HMF production also should integrated with the sugarcane production.

4. According to the results, making recycle stream (alternative 1) separate from utilization of unconverted cellulose (alternative 2, 3, and 4). In order to increase efficiency for improvement, they should mix in the same process.

5. In economic analysis part, the capital cost and investment should be included in the economic analysis in order to be able to calculate Return On Investment (ROI) which is defined as ratio of profit to investment and Payback period to measure the length of time necessary for the total return to equal the capital investment.