CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

In this study, the life cycle environmental impact assessment (LCIA) was performed in order to evaluate the performance of a biorefinery model in Thailand in both environment and economic aspects by using five scenarios created by varying ratio of raw materials (sugarcane and cassava) and ratio of products (ethanol and PLA). The environmental performance was evaluated in terms of global warming potential (GWP), acidification potential (AP), eutrophication potential (EP), and energy consumption while profit generated was used for the economic aspect. The results indicated that the biorefinery showed better performance in both GWP and energy resources with increasing sugarcane usage. This was due to the use of bagasse and biogas as sources of fuel to generate electricity and steam by using high efficiency cogeneration process in the biorefinery. In contrast, increasing sugarcane usage led to higher molasses based ethanol production. This production was causing higher EP because of waste water from the production. Moreover, increasing PLA production led to higher GWP and energy resources impacts because of high electricity and steam usage in the bioplastic production process. Furthermore, the use of sulfuric acid in PLA production causes higher AP impact. In order to identify the best scenario, four Eco-efficiency parameters (Eco-efficiency$_{GWP}$, Eco-efficiancy$_{AP}$, Eco-efficiancy$_{EP}$, and Eco-efficiency$_{Energy\ resources}$) were developed in order to combine both environmental and economic aspects by using normalized values based on average profit gained and average impact associated. The results showed that S4 was the best scenario as it has highest values in several Eco-efficiency parameters. This study showed that the biorefinery performance in both environment and economic could be improved by integrating efficient feedstocks utilization and production of desired products with by-products utilization and waste minimization. The PLA resin enhances the profitability, the ethanol helps meet the national energy needs, and the power production reduces costs and avoids GHG emissions. However, PLA resin production process should be improved because it consumes a lot of energy and releases a lot of emissions.

5.2 Recommendations

Although the life cycle environmental impact assessment was successfully conducted for biorefinery performance, several recommendations could be offered as follows:

5.2.1 Suggestions for Improvement of Inventory Data

The inventory data were extracted from literature; it may be not good enough for real case. In order to get good results should seek information from the company.

As the inventory data from Wim J. Groot & Tobias Borén (2010) were used as the secondary data for the production of PLA resin of PURAC (Thailand). In their study, several assumptions and estimations were made in order for the research team to be able to have enough data to assess the environmental impact as planned. This may be improved if more complete and transparent data could be achieved.

5.2.2 Suggestions for Improvement of Environmental Performance

From the results, it can be seen that GWP and energy resources impacts mainly comes from the PLA resin production. This process should be improved and developed to reduce the impacts more than this by making conversion processes more efficient, designing with flexibility in mind, maximizing the exploitation of energy from feedstock and developing a set of conversion capabilities that are independent of particular fuels, chemicals and materials. The other bioplastics such as polyhydroxyalkanoates (PHA) and polybutylene succinate (PBS) are alternative due to they are also the market demand. We have used data that utilization of biomass (bagasse and biogas) to generate electricity help to reduce GWP significantly. However, increasing use of renewable energy by changing vinasse production from slop in sugarcane ethanol conversion processes to biogas production could help further reduce GWP and energy resources impacts. Developing biogas system and can be more produced biogas from waste water is interesting choice to reduce GWP and energy resources impacts.

5.2.3 Suggestions for Improvement of Profit Generated

From life cycle inventory of cassava starch production process, it can be observed that the process has high volume cassava pulp which is low value by-product from the process. Cassava pulp has high starch composition which can be transformed into sugar. This sugar can be used to produce high value product such as ethanol and PLA. Thus, the utilization of by-product can raise the profit.