

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

A biorefinery model for the production of bioethanol, lactic acid (LA) and biosuccinic acid (BSA) from sugarcane and cassava was evaluated the performance by means of the life cycle assessment (LCA) approach in both environmental and economic aspects. The life cycle environmental impact assessment (LCIA) used were global warming potential (GWP), acidification potential (AP), eutrophication potential (EP), and energy resources. Five scenarios were created by varying ratios of feedstocks (sugarcane and cassava) and products (BSA and LA). The results indicated that increasing sugarcane consumption led to better performance in GWP, AP, EP, and energy resources. This was due to the high amount of avoided steam and electricity generated from bagasse although cassava residues (pulp and rhizome) were fully utilized. Increasing BSA production led to better AP and EP but worse performance in GWP and energy resources since LA process consumed higher steam, sulfuric acid, and CSL. In the other hand, much higher electricity consumption in BSA process could cause worse GWP and energy resources. However, environmental impacts and profit were combined to be eco-efficiency parameters ($\text{Eco-efficiency}_{\text{GWP}}$, $\text{Eco-efficiency}_{\text{AP}}$, $\text{Eco-efficiency}_{\text{EP}}$, and $\text{Eco-efficiency}_{\text{Energy resources}}$) in order to assess both environmental and economic aspects. Among all scenarios studied, Scenario 5, with highest sugarcane usage and BSA production, was shown to be the most suitable scenario since the substantial profit yielded from BSA production would significantly help the biorefinery gain higher eco-efficiency in all characterizations.

5.2 Recommendations

Although the biorefinery model could be successfully assessed, several recommendations could be offered as follows:

5.2.1 Suggestions for Improvement of Inventory Data

Although the LCI data were retrieved from related literature and references, it might not be good enough for real situation. Therefore, the reliable LCI should be obtained from the company. The LCI data which should be more corrected are that of BSA, LA, cassava pulp biogas production, and soil emissions.

The LCI of BSA process was calculated under some assumptions in this study. Since BSA plant will be finished soon in Thailand by PTTMCC, the data should be sought more easily. The source of LA data in this study is not commercial plant, so the LCI data should be also corrected. The data of cassava pulp biogas production was not complete due to the lack of electricity and chemicals consumption. In Thailand, there is the pulp biogas production; new data should be obtained from the real plant. From Brazil journal, soil emissions significantly affect environmental impacts. The calculation of soil emissions should be conducted in order to complete more transparent LCA.

Furthermore, the prices of many products were obtained from several years due to the deficiency of data. This can cause the different results. So, the prices should be get from the recent year or close period.

5.2.2 Suggestions for Improvement of Environmental Performance

In Thailand, Mitr Phol, famous cane and sugar company, applies ploughing up and over cane trash to naturally degraded and avoid GHG from burning trash. The benefit from natural fertilizer is that can decrease avoided chemical fertilizer. How much equivalent fertilizer provided from cane trash should be achieved to avoid environmental impacts. Furthermore, changing vinasse production from slop in sugarcane ethanol conversion process 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

Although CO₂ from fermentation is neglected as biogenic carbon, the number of CO₂ generated should be captured to produce other value products such as dried ice, liquid carbon dioxide etc. Therefore, LCI of carbon capture should be achieved and applied. Though cassava pulp biogas was used to provide electricity in

this study, it can also be converted to ethanol or sugar. Alternative way from cassava pulp can be obtained to compare with. In some plants, vinasse can be given as free product since the price is very low. Moreover, the very high volume led to hard transportation; the most farmers do not buy. In order to sell the vinasse as alternative value product, vinasse dryer should be equipped.

5.2.4 Suggestions for Improvement of Sensitivity Analysis

Since BSA and LA prices could significantly impact to the results. So, the data in the prices are very important. The range of BSA and LA prices in the recent and incoming year should be obtained to make the different results to compare with. This sensitivity analysis can recheck if the results are different.