CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

In this study, the life cycle environmental impact assessment was performed in order to evaluate the performance of CBG produced from pig manure liquids and napier grass feedstock. To suggest the improvement of the CBG production to be more environmental friendly, the entire life cycle of CBG was analyzed in both energy and environmental aspect. The LCA software, SimaPro 7.1, was employed to analyze data gathered from CBG production plant at Chiangmai province, Thailand and from the literature. For the life cycle energy analysis, the Eco-indicator 95 method was use to analyze the overall process in the energy aspect. Whereas the energy output of 1 MJ of CBG, the NER value for CBG system was 4.50. This energy analysis result showed that the NER value was higher than one, implying a net energy gain from this CBG production process. Major energy consumption was found to come from the biogas upgrading stage, accounted for 66.79% of total energy input. It mainly came from the power consumption. For the environmental aspect, the GWP of CBG was analyzed based on the LCI results by CML 2 baseline 2000 method. The results indicated that the biogas production process had the highest GWP impact, accounted for 55.81% of total GWP. GHG emissions of CBG production process mainly came from high methane loss and the energy consumption. Compared with conventional fuels, the GWP of CBG was higher than those of fossil-based CNG and gasohol 95 for the WTT phase. On the contrary, the comparative result of GWP in TTW phase was reversed. When combining WTT and TTW phase, the GWP of CBG WTW phase was shown to be better than those of the conventional fuels. It also can be seen from the comparative result that the CBG product in this study is competitive with CBG products from different upgrading technologies. Furthermore, the results showed that 0.1 percent of total GWP of CBG production system was from the LUC effect. It is nevertheless clear that the displacement of forestry by agricultural activity is significant from a GHG perspective.

5.2 Recommendations

As the life cycle assessment was successfully conducted for CBG systems, several recommendations could be offered as follows:

5.2.1 Suggestion for Improvement of Inventory Data

Some of the inventory data were extracted from literature so it may be not good enough for the real case. In order to get better results, the inventory data should be gathered from the plant. For the calculation of GHG emissions from LUC, this study made use of international standard values since there are not enough local values to use in this study. When it has more information within Thailand country, the results of future studies may be more accuracy and more reliability.

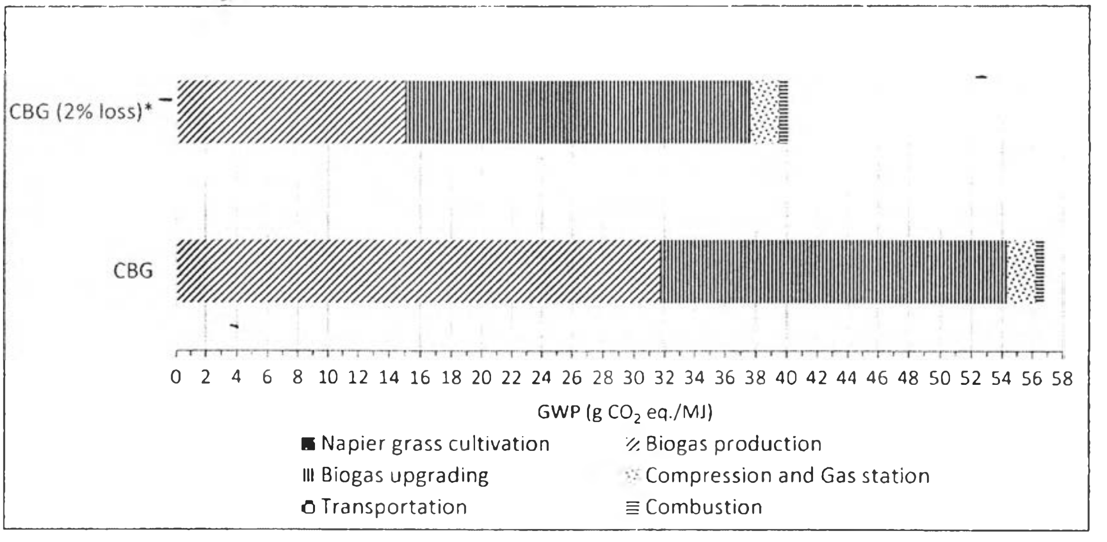
5.2.2 Suggestions for Improvement of CBG Production System

The biogas production process can be improved and developed to be more efficient by grinding the solid in pig manure liquids. As a result of the grinding, the onset of methane production began sooner, and the digestion process was more stable than when the solid in pig manure liquids was simply crushed. However, any benefits that might be gained, such as an increased rate of biogas production and consequent reduction in hydraulic retention time, would need to be weighed against the increased energy required to grind the manure (Krich *et al.*, 2005).

From the results of this study, the significant factor which affected to GWP value of CBG production was methane losses. Methane losses occurred in the biogas production and upgrading process. For the upgrading process, it can be seen that the imperfection of membrane separation constituted a conflict between high methane purity in the upgraded gas and high methane yield. The purity of the upgraded gas can be improved by increasing the size or number of membrane modules, but a larger amount of methane will permeate through the membranes and is therefore lost. Methane losses can be partly prevented by recirculation of a part of the permeated CO_2-enriched gas (Allegue and Hinge, 2012).

In the CBG production system of this study, two main stages which had the highest GWP are biogas production process and biogas upgrading process.

The interesting choice to reduce GWP of CBG production is to improve the methane leakage prevention system to prevent CH_4 leakage from biogas production process to be less than 2% of CH_4 in raw biogas. The GWP impact can be reduced significantly as shown in Figure 5.1.



Note: *2% CH_4 loss from biogas production process

Figure 5.1 Potential reduction of GWP associated with improvement of the methane leakage prevention system of biogas production process.

When the methane leakage from biogas production process is controlled to be 2%, GWP value will be decreased from 56.76 g CO_2 eq./MJ CBG to 40.07 g CO_2 eq./MJ CBG.