LIFE CYCLE ASSESSMENT OF BIODIESEL IN HONG KONG

*Ya Hong Dong, S. Thomas Ng**

The University of Hong Kong, Hong Kong
*Corresponding author: tstng@hku.hk

1. INTRODUCTION: Biodiesel is an environmental-friendly alternative of petroleum diesel. Biomasses, such as soy bean, rape seed, sunflower, palm oil, are usually the sources of biodiesel [1]. It is believed that biodiesel is a carbon-neutral solution, since the combustion of biodiesel generates the same amount of greenhouse gases (GHGs) as those which have been absorbed by plants [2]. Petroleum diesel, produced from fossil fuel that stocks carbon for millions of years, is generally not recyclable. In Hong Kong, biodiesel is made from a multi-feedstock that includes waste cooling oil, grease waste, palm fatty acid and animal fat. About 100,000 tons of low carbon fuel is manufactured in the biodiesel factory and this can lead to 3.6% of GHG reduction in Hong Kong [3]. In this study, a life cycle assessment (LCA) is carried out to evaluate the environmental performance of biodiesel in Hong Kong. The inventory is established based on the material and energy consumed in a local biodiesel factory. Results of biodiesel are further compared with petroleum diesel.

2. LIFE CYCLE INVENTORY: The LCA model considers the 'cradle-to-grave' processes, including raw material extraction, in-plant manufacturing, transportation, waste treatment, combustion in engines, etc. In order to analyze the environmental impacts of biodiesel before combustion, 'cradle-to-delivery' processes are studied as well to exclude fuel combustion. The manufacturing process flow chart of the biodiesel plant in Hong Kong is given in Figure 1. The inventory data are mainly acquired from the Project Profile [4]. The Ecoinvent database [5] is adopted to provide the background data of environmental impacts of the processes. The functional unit of biodiesel is 1 kilogram (kg) of biodiesel produced in the Hong Kong plant. As shown in Figure 1, the plant generates three products: biodiesel, glycerin and bioheating oil. The allocation percentages of the three products are proportional to their weights. When establishing the model, it is assumed that carbon dioxide is captured by the biomass, so that carbon sink is calculated to close the carbon balance. No environmental burden is accounted in the waste oil feedstock. Besides, infrastructure is not considered in the model. Figure 1. Manufacturing process of a biodiesel plant in Hong Kong (Adapted from [4])

3. LIFE CYCLE IMPACT ASSESSMENT: The impact assessment is carried out using 'ReCiPe' [6] and the results are computed in SimaPro 7. It is found that the carbon emissions to produce 1 kg of biodiesel is 0.32 kg. By considering the carbon sink to biomass, the net carbon balance is -2.2 kg, indicating that the carbon emitted to produce biodiesel is less than the carbon captured in the biomass. The results show that the carbon emission is 33.2% originated from material manufacturing and 47.6% due to in-plant processes. The LCA model also considers other impact categories of ozone depletion, human toxicity, particulate matter formation, eutrophication, ecotoxicity, metal depletion, etc.

4. COMPARISON WITH PETROLEUM DIESEL: The environmental impact of biodiesel is further compared with the impact of petroleum diesel. It is found that biodiesel performs much better than petroleum diesel in most impact categories, except agriculture land occupation. The endpoint score of biodiesel is -0.069 (combustion excluded), indicating that by considering the processes from 'cradle-to-delivery', biodiesel has positive environmental impact and can considerably reduce the carbon emissions as compared with petroleum diesel. If the combustion process is included (i.e. 'cradle-to-grave'), the environmental impact of biodiesel is much less than that of petroleum diesel. Single score of biodiesel becomes 0.16, which is much less than

0.53 of petroleum diesel. This indicates that the environmental impact of biodiesel is only about 30% of petroleum diesel.

5. CONCLUSIONS: Environmental impacts of biodiesel produced in the biodiesel plant in Hong Kong were studied using LCA. The impact assessment results were compared to petroleum diesel. The results indicated that petroleum diesel can lead to about three-fold of environmental influence of biodiesel when 'cradle-to-grave' life cycle processes are considered.

References

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