LIFE CYCLE ASSESSMENT ON ELECTRICITY GENERATION FROM PALM OIL MILL EFFLUENT

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To my beloved mother and father

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ABSTRACT

Nowadays, the world is dealing with a crisis between the limits of nature and the ambitions of mankind. The climate change issue that been mentioned globally is caused by uncontrollable greenhouse gases emissions from anthropogenic activities. This life cycle assessment study on electricity generation from palm oil mill effluent is important to measure the impacts from the activities to the environment because palm oil effluent is harmful to environment due to high BOD and COD content. Along the process of anaerobic digestion and electricity generation through biogas CHP, a lot of energy (electricity, heat, steam), raw materials and water been used to get a complete product. So, these inputs will contribute to the many categories of environmental impacts. Then, a life cycle assessment is required to perform an impact assessment for this process. The functional unit is production of 1 MWh of electricity produced. This study was modeled by using openLCA Software to develop with addition of Ecoinvent 2.2 Database to reveal the impact of the processes involves towards environment as well as to compare their impact with electricity generation from fossil fuel alternatives. From the study done, it proves that cogenerating electricity from biogas produced by anaerobic digestion by using palm oil mill effluent can lead to significant reduction in most impacts compared to fossil fuel alternatives. This study also includes sensitivity analysis of feedstock used and type of digestate storage.

ABSTRAK

Pada masa kini, dunia berhadapan dengan krisis antara had alam semulajadi dan pembangunan dunia. Isu perubahan iklim yang terjadi di seluruh dunia yang diakibatkan oleh pelepasan gas rumah hijau yang tidak terkawal daripada aktiviti aktiviti antropogenik. Kajian penilaian kitar hayat mengenai penjanaan elektrik dari pembuangan sisa kilang minyak sawit adalah penting untuk mengukur kesan aktiviti yang terlibat terhadap alam sekitar kerana sisa pembuangan minyak kepala sawit berbahaya kepada alam sekitar disebabkan oleh kandungan BOD dan COD yang tinggi. Sepanjang proses pencernaan anaerobik dan penjanaan elektrik melalui biogas, banyak tenaga (elektrik, haba, stim), bahan mentah dan air digunakan sepanjang proses berjalan. Oleh itu, penggunaain tenaga tenaga ini akan menyumbang kepada pelbagai kategori kesan alam sekitar. Di dalam kajian ini, semua model yang dibuat berdasarkan penghasilkan 1 MWh tenaga elektrik yang dihasilkan. Kajian ini dimodelkan dengan menggunakan OpenLCA dan pangkalan data Ecoinvent 2.2 untuk mengkaji kesan proses yang terlibat terhadap alam sekitar serta membandingkan kesannya dengan penjanaan elektrik dari alternatif bahan api fosil. Kajian yang dilakukan membuktikan bahawa penghasilan elektrik dari biogas yang dihasilkan oleh pencernaan anaerobik dengan menggunakan sisa buangan kilang minyak sawit boleh menyebabkan pengurangan yang ketara dalam kebanyakan kesan berbanding alternatif bahan bakar fosil. Kajian ini juga merangkumi analisis sensitiviti jenis sisa yang digunakan dan jenis penyimpanan pencernaan.

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LIST OF ABBREVIATION

ADP	-	Abiotic Depletion Potential
AP	-	Acidification Potential
EP	-	Eutrophication Potential
FAETP	-	Freash Water Aquatic Ecotoxicity Potential
GWP	-	Global Warming Potential
HTP	-	Human Toxicity Potential
MAETP	-	Marine Aquatic Eco Toxicity Potential
ODP	-	Ozone Depletion Potential
POCP	-	Photochemical Oxidant Creation Potential
TETP	-	Terresterial Eco Toxicity Potential
DCB	-	Dichlorobenzene
CFC	-	Cholorofluorocarbon
LCA	-	Life Cycle Assessment
LCI	-	Life Cycle Inventory
LCIA	-	Life Cycle Impact Assessment
SO_2	-	Sulphur Dioxide
PO_4	-	Phosphate
C_2H_4	-	Ethene

CHAPTER 1

INTRODUCTION

1.1 Research Background

In recent years, palm oil industry grown rapidly and keep growing over the year. Palm oil industry in Malaysia is one of the world's largest producers and exporter of crude palm oil and its derivatives products. In 2004, oil palm cultivation covers more than 3.79 million hectares of land and occupies 11% of the total land area and more than one third of the total cultivated area in Malaysia. By increasing the number of production of palm oil every year, the process of converting fresh fruit bunch (FFB) to crude palm oil (CPO), it concurrently will generate abundant of by-product such as palm oil mill effluent (POME) , empty fruit bunch (EFB), palm kernel shell (PKS) and mesocarp fibre. From these by-products, POME is the only by-product that has not been commercialized re-used by industry although 2.5 – 3.75 tonnes of POME will be generated for every tonne of CPO produced. However, there is a great potential for renewable energy project using POME since it produce methane gas which also can produce electricity

POME is still remain untapped and will be threat to the environment if directly discharged into watercourse. Due to its highly polluting properties with

average value of 25 000 mg/L biochemical oxygen demand (BOD) and 50 000 mg/L chemical oxygen demand (COD), the most cost effective technology is anaerobic treatment. By the end of anaerobic digestion, the end product that will form is basically methane and carbon dioxide. The utilization of biogas captured from POME becomes recent interest as the increasing price of natural gas and fossil fuel. The biogas captured from POME can be utilized as one of energy sources with upgrading them either to be electricity generation, vehicle fuel, heating, cooking gas or it can be distributed on the natural-gas grid.

With increasing of energy demand every year, utilization of biogas as electricity is relevant to replace the fossil-fuel based sources since Malaysia is the world leader in the production and supply of crude palm oil. It leads to the plantation of more palm oil trees, consequently processing more palm oil fresh fruit bunches and thus more palm oil waste which also called palm oil mill effluent, mesocarp and palm kernel shell. However, the process of capturing biogas and utilize it to generate electricity still will give some amount of environmental emission. There is several ways to determine it and one of the method is by using life cycle assessment.

Life Cycle Assessment (LCA) is currently the most common method of designing environmental friendly products and technologies and evaluating their impact on the environment (Mirjana et. al, 2013). This method governed by the international series of ISO 14000 standards, which also the reason why it is widely used in relation to other methods of designing for the environment. LCA helps to realize the extent of the impact of their products, processes, and other activities on the environment. The goal of LCA is not only to provide an answer to the question of how serious the harmful effect is, but also to enable strategic planning of future activities.

1.2 Problem Statement

Malaysia is one of the largest exporter and producer of crude palm oil and its derivatives. This industry is involving in 3 major sector which is agriculture (plantation), transport and industry (milling). It causes high environmental challenge to deal with along the process of CPO production. Production of CPO creates abundance of POME which will gives threat to environment if flow to waterways due to its high BOD and COD. One of the solutions to prevent POME produced from continuously harm environment is by utilizing it to be alternative sources of energy due to high organic compound exist in the POME. Since the energy need in Malaysia is relatively high and expected to increase from years to years and the existing fossil fuel is keep depleted, abundance POME produced can be feedstock to produce electricity in order to cater the energy demand that keep rising.

Although biogas captured is utilized as one of the energy sources such as electricity, it still has its own impact to environment. By adopting self regulated environmental tools such as ISO 14000, Life Cycle Assessment is one of the ways that can be done to monitor and deal with the environmental impact along the process run. This study will propose to conduct life cycle analysis on the electricity generationfrom biogas produced by anaerobic digestion as it is one of the way to monitor the impact exist towards environment along the process done.

1.3 Objective

The objective of this study is to conduct life cycle assessment on the electricity generation from palm oil mill effluent with several aims;

a. To evaluate the life cycle environmental impact of biogas utilization from palm oil mill effluent to generate electricity.

b. To compare the impact of the electricity generation from biogas system with electricity generation from fossil – fuel based alternatives.

1.4 Scope

The scope of this study includes;

a. Data Collection on every single stage involved in generating electricity from biogas based on scope boundary.

b. Performing Life Cycle Assessment on utilization of biogas to be converted to electricity by using openLCA software.

c. Comparing the environmental factor of electricity generation from POME with the conventional source.

1.5 Significance of Study

Process of POME generation starting from plantation of palm oil, transportation and milling might gives significant impact towards environment as well as process of converting biogas produced as energy sources. By this study with scope limited for electricity generation from palm oil mill effluent, it is important to do life cycle within the scope chosen due to following reason.

a. To reveal the actual impact for each activity occur along the process of generate electricity from biogas of palm oil mill effluent

b. Increase awareness that every activity done may harm environment with certain magnitude for each activities.

c. To identify the most highly impact of generate electricity from different sources.

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