LIFE CYCLE ASSESSMENT OF DOMESTIC BIOGAS SYSTEMS

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Degree of Master of Science in Sustainable Process Development

Department of Chemical and Process Engineering

University of Moratuwa
Sri Lanka

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Thesis submitted in partial fulfilment of the requirements for the degree Master of Science in Sustainable Process Development

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Abstract

Different sizes of biogas systems were analysed using Life Cycle Assessment (LCA) in order to find the effectiveness of biogas system as a renewable energy source for domestic use. As a pre requisite for the LCA, sample survey was carried out in order to find out the existing situation of biogas units installed in Sri Lanka. This survey covered a total of 167 biogas units in the country. According to the survey 143 (86%) are domestic units with a capacity less or equal than 20 m^3 while 27 (16%) of the above sample was not functioning at the time of this survey. A detailed LCA was carried out in two different phases in order to determine the environmental impacts in life cycle of Chinese fixed dome type biogas systems and to calculate the Energy Pay-Back Time (EPBT). In Life Cycle Energy Assessment, Embedded Energy Values (EEV) have been evaluated from the quantity of building materials used in construction of different sizes of biogas plants and the energy payback period have been evaluated for individual biogas plants using EEV and biogas energy production. Similar to the energy calculation, CO_2 emissions from each capacity of biogas units were also calculated. Although there are negative impacts from CO_2 emissions in the construction stage, there is a reduction of CO_2 emissions in the biogas consumption stage due to the replacement of fossil fuels with biogas. While the LPG / kerosene replacement reduces the CO_2 emissions, firewood replacement reduces the amount of particulate matters emitted to the environment. So this will contribute towards a reduction in climate change impact, giving the plant an overall positive impact on climate change.

Although EEV and CO_2 emission per 1 m^3 capacity of the biogas plant reduces with the increase of the size of the plant, there is no linear relationship between them. Therefore an equation was derived to calculate the EPBT ($y = 0.0006x^2 - 0.008x + 0.590$, where x is the capacity of the biogas plant).So it is obvious that construction of higher capacity plant is more energy efficient than a smaller capacity one and also the environmental effects can be minimized. However due to different reasons always the optimum solution is not the construction of a larger unit. So initially the situation should be carefully studied and then only one should construct the largest unit feasible for that application.

Keywords: Life Cycle Assessment (LCA), Embedded Energy Value (EEV), Energy Pay-Back Time (EPBT), CO_2 emissions, Biogas

D**edication**

This thesis is dedicated to my beloved **PARENTS** and **HUSBAND**

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List of Abbreviations

Abbreviation	Description
ABR	Anaerobic baffled reactors
ADB	Asian Development Bank
AF	Anaerobic filters
ARTI	Appropriate Rural Technology Institute
BOQ	Bill of Quantities
BORDA	Bremen. Overseas Research and Development Agency
CAMARTEC	Centre for Agriculture Mechanization and Rural Technology
CDM	Clean Development Mechanism
EEV	Embedded Energy Value
EPBT	Energy Pay-Back Time
GHG	Green House Gas
HRT	Hydraulic retention time
ICE	Inventory of Carbon Energy
ISO	International Standard Organization
ITDG	Intermediate Technology Development Group
KVIC	Khadi and Village Industries Commission
LCA	Life Cycle Assessment
LCEA	Life Cycle Energy Assessment
LCI	Life Cycle Inventory
LPG	Liquefied Petroleum Gas
LPG	Liquid petroleum Gas
MSW	Municipal Solid Waste
NCRE	Non-Conventional Renewable Energy
NERDC	National Engineering Research and Development Centre
NGO	Non-Governmental Organization
SLSEA	Sri Lanka Sustainable Energy Authority
SLSI	Sri Lanka Standard Institution
SRT	Sludge Retention Time
UASB	Upflow Anaerobic Sludge Blanket
UNEP	United Nations Environment Programme

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