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Biogas from Organic Waste - A Case Study

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Abstract

This paper presents a case study to investigate the potential for upgrade of a bio-waste treatment plant. The paper also discusses development potentials in order to optimize the plant for maximum energy and environmental benefits. Data gathered over two consecutive years about the production of biogas, energy and bio-rest were considered and mass balance analysis of inputs and outputs of the plant were carried out. An estimate of the energy and environmental impact of the plant were carried out, and it was observed that the plant had significant environmental benefits. However, the study demonstrates, through material balance analysis of the plant's operation, that the amount of produced methane and hence, generated electricity can be further increased by optimising the operation of the plant.

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Keywords: Biogas, organic waste, anaerobic digestion (AD), municipal solid waste (MSW), biomethanation

1. Introduction

The cost and security of energy and emissions of greenhouse gases (GHG) and other pollutants from the existing means of energy production are two main problems that have led to many technological developments in alternative energy sources. Using biomass to produce energy is one such alternative that has recently become attractive worldwide as a clean and sustainable source of energy. Another problem is effective disposal of Municipal Solid Waste (MSW), because the biodegradable part of MSW leads to unrestrained emissions of methane when dumped untreated. However, due to rapid urbanisation, landfill sites are becoming scarce and stringent legislations are in force, particularly restricting disposition of degradable waste in landfills.

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Nomenclature

GHG	greenhouse gases
MSW	municipal solid waste
AD	anaerobic digestion
ABP	animal by-products
LPG	liquid petroleum gas
WWS	waste water sludge
NMOC	non-methane organic compounds
LHV	lower heating value
THP	thermal hydrolysis process

It is recognised that biodegradable waste can be feedstock to produce useful energy, leading to waste minimisation at the same time. Therefore, waste treatment plants to produce biofuel and electricity are common in many countries.
Anaerobic digestion (AD) of MSW has advanced in Europe due to European regulatory pressures on waste disposal (EU landfill directive 2008). In July 2009, total ban on landfills was decreed in Norway. In addition, there has been increased focus on the implementation of Animal By-Products (ABP); regulation (ABPR EC 1774/2002), which resulted in building many waste treatment plants around Europe. This paper studies an AD biogas plant from Norway to investigate its development potential. The operation of the plant was monitored over a period of two years and data on production of biogas, energy and bio-rest was gathered. An energy and environmental balance were performed and parameters for optimization of the plant were discussed.

2. Anaerobic Digestion- Bio-Waste Treatment Technology

Anaerobic digestion (AD) is one of the preferred technologies for treating organic municipal solid waste (MSW) for the production of biogas and methane, which can be used as alternative fuel to liquid petroleum gas (LPG) and natural gas. The residue, after completion of the AD process, is a stabilized organic material that can be applied directly on agricultural land (without any maturing) as a bio-fertilizer, and thereby can replace artificial/mineral fertilizers and offer the possibility for recycling of nutrients (nitrogen and phosphorus). Thus, AD of bio waste combines the energy production with environmental benefits.
Digester design criteria and performance of AD process attracted te attention of many researches. For example, Igoni et. al. [1] investigated the designs of anaerobic digesters for producing biogas from municipal solid-waste and analysed the effects of various parameters such as temperature control, pH, C/N ratio, moisture content, waste particles and effects of mixing on biogas product characteristics. Zhang et. al. [2] compared the digestion efficiency of source segregated domestic waste and the mechanically recovered fraction of MSW. They concluded that higher percentage of biodegradability, leading to higher energy potential, can be achieved if the organic fraction of MSW is segregated at the source.
Banks et. al. [3] monitored the performance of an anaerobic digester receiving domestic food waste over a period of 426 days and showed that for each tonne of input material the potential recoverable energy was 405 kWh. Volatlie substance added with a methane content of around 62%. They observed high ammonia concentration in the digester, which could have been due to high nitrogen from the volatlie fatty acids in the food waste. In another study, Banks et. al. [4] monitored the bio-cycle anaerobic digester in South Shropshire, UK over a period of 14 months and again found that the source-segregated waste was readily biodegradable and produced a biogas with 60% methane. The process had a very favourable energy balance with around 400 kWh of energy recoverable from each tonne of waste processed. Those studies offer guidelines for the expected yield of biogas from the treatment of municipal solid waste.

3. Plant Specifications

The plant considered in this study is located in Nord Trøndelag County in central Norway. It's actual "waste-zone" covers an area of 98200 km2, with a population of 230000 inhabitants. Three organic substrates are treated in the plant: organic household waste, sludge from wastewater and a minor part of ensilage waste from fish farms.