Sector: Energy

Sub-Sector/Technology Option: Anaerobic digestion to produce biogas

Technology Application: Methane Recovery from livestock and biomass residue.

Introduction

Biogas, a gaseous mixture, is produced through the process of anaerobic digestion using a number of feedstock such as organic wastes, solid waste (landfill) and or waste water. Through fermentation, depending on the feedstock, the biogas mixture can consist of approximately 40-70% methane, 30-60% carbon dioxide, 0-1% hydrogen and 0-3% hydrogen sulfide (Jempa et al, 2006). Biogas can be produced at the household level and commercial and larger industrial scale for cooking, heating and electricity generation. Biogas applications can replace fossil fuel energy sources such as liquefied petroleum gas (LPG) (GEA, not dated).

The focus of this fact sheet is on the recovery of methane from the biogas produced during fermentation using organic waste such as manure as the feedstock. There is extensive access to manure which is generated as waste from livestock production in Guyana.

Livestock is categorized by the Ministry of Agriculture (MoA) to "*include dairy and beef cattle, swine, poultry, sheep, goats, wildlife and other livestock such as rabbits and bees"*, (Ministry of Agriculture, 2013). While this subsector contributes to Guyana's economy, according to the Ministry, livestock production over the period 2009-2010was below the capacity. Livestock production for poultry (for meat) fluctuated between 24,000,000 and 30,000,000 kilograms over the period 2009 – 2013. The production of cattle for beef stayed somewhat stable over this period, with a small decline in 2012 to 1,635,374 kilograms. According to the MoA(2013), the production of sheep for mutton showed small increases over the period 2009 – 2013 ranging from 95,017 kg to 129,391 kg and swine fluctuated with a steep decline over the period 2010– 2012 and a sharp increase to 571,962 kg in 2013. Annual production of milk remained relatively stable over the period 2009 – 2013 ranging from 26,800,000 liters (2010) to 46,483,931 liters (2013).

Digesters (bio-digesters) are typically set up to process manure from livestock (cattle, swine and poultry). Biodigesters capture and store methane for use as fuel in specially designated generators to generate electricity for lighting (using gas lamps) or fuel for cooking.

Technology Characteristics

Features	Biogas can be produced on a continuous basis or in batches (whereby digestion or fermentation occurs over several days at a time). The ideal process temperature for fermentation must be 35 degrees Celsius. Bio-digesters can be built at different sizes such as from 1 m^3 for a small household unit to about 10 m^3 at the farming scale and 1000 m^3 for larger operations[43]. Small household biogas digesters consists of (i) building the digester (ii) collecting the manure at a predetermined frequency (iii) storing and alternative use of the effluent (iv) collecting, handling, distribution and use of the gas. The digester can be constructed out of concrete, metal or a low-cost

[43] www.climatetechwiki.org/technology/biogas-cook

	polyethylene plastic currently promoted by the Guyana Energy Agency (GEA) (Jempa et al, 2006; GEA, not dated). The polyethylene bio-digester uses polyethylene plastic of different size and thickness and the digester is constructed as an enclosed, sealed tubular structure (plug flow design) (GEA, not dated).
Capital Investment Cost	The capital investment cost to build a simple polyethylene bio-digester with dimensions 25ft by 5ft is approximately GYD 120,000 (including labour) or USD 600 (GEA, not dated). According to the GEA, the gas captured from this system is equivalent to a 20-lb LPG gas cylinder consumed over a one month period and allows for installation payback in about three (3) years[44].
Operating Cost	The running cost for this system is limited to basic maintenance (value replacement every six (6) months) and labour, that is, the mixing and daily recharge of the manure to the digester.
Maturity	Bio-digesters are mature technology and have been in use world-wide, although its application is limited Guyana.
Country Specific Applicability	
Status of technology in country	Bio-digesters producing biogas through the process of anaerobic digestion is not new to Guyana. These systems were implemented as early as the 1980's when the then Guyana National Energy Authority jointly launched a biogas programme with the Latin American Energy Organisation (OLADE). Through this initiative seven (7) experimental bio-digesters were constructed and installed in Coverden and Linden. Over the years these systems became non-functional. Additionally, the Institute of Private Enterprise Development (IPED),through the implementing of the Integrated Farming Model project, facilitated the installation of twenty-six (26) bio-digesters across the country. These bio-digesters used manure from swine and cattle as the feedstock to produce biogas. GEA installed an additional two bio-digesters in 2012 with support from the UNDP and then Office of the Prime Minister.
Market potential	There is potential to expand technology application to smaller communities with limited access to fuel for cooking building on the experience and lessons of its application across the country.
Scale of application and time horizon	Small scale in the medium term.
Institutional and Organisational requirements	The institutional and organizational requirements for the installation of bio-digesters falls under the authority of the Ministry of Agriculture, Guyana Energy Agency, Environmental Protection Agency and local government body of the community or Region. Additionally, the Guyana Livestock Development Authority (GLDA) was established in 2010 with the main aim to sustainably develop the industry and to drive 'self-sufficiency' in meat and meat products for export. The GLDA manages pasture lands at Mon-Repos and Leonora with the potential to allow for methane capture.
Operation and maintenance	Institutional capacity building is a critical component for the application of this technology at the local (community) scale. This is necessary to allow for periodic maintenance of the components of the polyethylene bio-digester such

[44] This is based on the average cost of GYD 3,600 (USD 18) per 20-lb LPG gas (GEA, not dated).

	as replacing the "pot-scrub" inside the PVC "T" every six (6) months and fixing leakage and cracks in pipes.
Scale/size of beneficiary group	The technology is intended to target mainly farming communities but also is applicable to the Guyana Livestock Development Authority pastures at Mon-Repos and Leonora, and larger livestock production farmers.
Acceptability to local stakeholders	This technology is acceptable to stakeholders since it was implemented since the 1980's.
Endorsement by experts	This technology is accepted and endorsed by local and international experts.
Barriers and Disadvantages	▪ Though well established in Guyana, this technology is not yet at scale due to small livestock population – the production in this sub-sector is under capacity. ▪ Reduction in organic manure available for small scale agriculture and farming and by extension reduction in soil fertility. ▪ Accumulation of pathogens (worms, protozoa and bacteria such as salmonella) in the digester. ▪ The composition of manure and by extension the quantity of methane produced by the system is impacted by the feed consumed by the animal. For example, an animal feeding only on grass will produce lower nitrogen content manure. ▪ Liquid sludge could become an environmental issue if not properly handled and escapes into surrounding water bodies. ▪ Inadequate handling and operating conditions of the digester could affect the volume of gas produce daily. ▪ Using crop residues for feedstock will result in longer standing time for decomposition due to its fibrous content and larger particle sizes when compared with manure feedstock. ▪ Switching to biogas for cooking may not be easy. According to the IEA (2006; 2008), with increase income, households could eventually use multiple fuels at a time to improve on their energy security instead of depending only on one (1) source of fuel. ▪ On the other hand, the lack of awareness and benefits of sustainable fuel sources can act as barriers to prevent deployment and acceptance of the technology. ▪ General lack of interest in the technology. This may be due to the daily/manual work involved in gathering the manure and feeding the digester.
Mitigation Benefits	
Greenhouse gases abatement potential	A small scale household bio-digester reduces between 3 and 5tCO2 equivalent per year[45]. However, biogas can be considered a clean and greenhouse gas neutral source of energy and referred to "green gas"[46]but requires 'cleaning' to remove the other gases in the mix and increase the methane content.

[45] www.climatetechwiki.org/technology/biogas-cook

[46] This reference to "green gas" is made when the biogas goes through a further step after production to 'clean' the biogas and upgrade it to a level comparable with natural gas (green gas). The cleaning of the biogas requires the

Potential Development Benefits: Economic, Social, Environmental	
Economic Benefits	▪ Increases security of energy supply since the feedstock can be obtained locally. ▪ Reduces the quantity of imported petroleum-based products and annual national expenditure. ▪ Provides additional opportunity for diversification in the agriculture sector. ▪ Additional jobs created to support the construction, operation and maintenance of small digesters.
Social Benefits	▪ Provides a sustainable alternative for households in farming communities instead of dependence on fuel wood. ▪ Reduces respiratory infections as a result of reduce exposure to smoke.
Environmental Benefits	▪ Reduces the volume of manure and the amount of pollutants released directly into the immediate environment and atmosphere. ▪ The organic content of waste materials is reduced by 30-50%. ▪ The use of the sludge or effluent from the bio-digesters to be used as fertilizers on farms to grow vegetables. ▪ Contributes to climate mitigation through the avoidance of methane released into the atmosphere. ▪ The methane produced can be stored at ambient temperature. ▪ The feedstock used and the resultant product does not attract pests and vermin. ▪ Provides an alternative to the use of imported petroleum-based products.

References:

1. Guyana Energy Agency (GEA) (not dated): Bio-digester information and construction Manual for small farmers
2. Guyana Energy Agency, (2014): Strategic Plan 2014 – 2018
3. International Energy Agency (IEA), (2006): Energy Technology Perspectives – Scenario and Strategies to 2050 in support of the G-8 Plan of Action.
4. International Energy Agency (IEA), (2008): Energy Technology Perspectives – Scenarios and Strategies to 2050. International Energy Agency.
5. Jepma, C.J. and Nakicenovic, N. (2006): Sustainable Development and the role of Gas.
6. Ministry of Agriculture (2013): A National Strategy for Agriculture in Guyana 2013 – 2020
7. National Hog Farmer, (2011): Weighing the Pros and Cons of Methane Digesters. http://nationalhogfarmer.com/environmental-stewardship/manure-management/0310-weighting-methane-digesters
8. www.climatetechwiki.org

removal of hydrogen sulfide, ammonia and hydrocarbons and increasing the methane content by removing the carbon dioxide.