Development of a Biogas Plant for the Kumasi Abattoir

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Abstract

Biogas Technology in Ghana is relatively underdeveloped and has been limited to donor-funded projects in communal areas and health institutions. In most cases the projects have been abandoned for lack of sustained funding, poor maintenance and management. Where there is any technical utilization of the technology, these have been limited to the production of Biogas for heating water and for cooking purposes with little or poor maintenance of the equipment used. A survey carried out by the authors indicated that in almost all cases there is an under-utilisation of the gas produced. The Ministry of Energy, whilst recognising the growing importance of renewable energy in meeting the policy objectives of securing future energy for strategic applications in addition to minimising the environmental impacts of energy supply, particularly in a country that has no known appreciable reserves of oil, it has not come out with a clear policy statement for the research, development and promotion of biogas technology. The present study focuses on the development of biogas technology for industrial application in the Kumasi Abattoir, through the use of the animal waste produced for the production of Biogas, namely for heat and electricity generation with the resultant effect of creating an economically viable and thereby sustained venture for the private sector.

1. Trends in Biogas Production in Ghana

Biogas technology is not well developed in Ghana as compared to Europe or Asia. The problems associated with the non-progressive nature of this technology stems from the fact that it is considered both by the educated as well as the illiterate Ghanaians as a source of energy for the rural poor. Government policies throughout the past decades totally ignore bio-energy including biogas technology as far as the energy sector is concerned. This apparent lack of interest on the part of the government has crippled the industry. However it is worth noting that for a developing country like Ghana without any known reserves of oil, striving to achieve middle-income status, particular attention should be focused on non-polluting sources of energy including biogas generation. Another important reason why Ghana should intensify work on research and development as well as the spread of the technology is that biogas production makes use of mostly unwanted and highly polluting waste such as slaughterhouse waste, organic municipal wastes including human excreta, livestock manure, industrial wastes, farm and water weeds, among others. Through this means cheap means for electricity and for the production of soil manure is created.

Of the existing biogas plants in Ghana almost all are operating under capacity if not broken down. Most of these plants are found in hospitals and second cycle educational institutions. Domestic plants are rare even though Ghana can boast of one community centred plant located in Appolonia near Accra, under the direct control of the Ministry of Energy.

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A careful study of biogas plants in Ghana reveal that most of them were implemented through international donor agencies such as the German Agency for Technical Cooperation (GTZ) involved in alleviating rural poverty. Some of the biogas plants visited during this study include the following:

- The Ejura Slaughterhouse at Ejura in the Ashanti Region
- The Holy Trinity Hospital at Nkawkaw in the Eastern Region
- The Saint Patrick Hospital at Akwatia in the Eastern Region
- The Appolonia Community Biogas plant in the Greater Accra Region
- The Accra Psychiatric Hospital

In addition to the above plants, there are several small scale projects found mostly in secondary schools, tertiary institutions, most of which are not functioning currently.

2. The Kumasi Abattoir

Generally all abattoir waste is organic and had very high Biochemical Oxygen Demand (BOD), which indicates the presence of excess organic carbon. The BOD content of slaughterhouse waste is estimated as 1000 – 4000 mg/l. This renders them very bad pollutants especially in water bodies but very good source of energy.

The waste produced by the Kumasi Abattoir can be classified generally into two types; liquid and solid waste. With respect to the liquid waste 4,5 cubic metres of blood is produced per day together with 110 cubic metres of waste water generated through cleaning of the animals and the floors of the Abattoir. Kumasi Abattoir produces 20 tonnes of solid waste daily. This consists mainly of animal dung, rumen content, animal fat, bones, meat scrap, hooves and horns. This is sent to the to the landfill site.

Biogas technology, which is in the planning phase to be adopted at the Kumasi Abattoir Company Ltd, in Ghana, can be used as a fuel boiler to heat water to clean floors and also to scald the sheep and pigs. Presently, to singe the goats and sheep rubber tyres are burned and employed for the process, which is environmentally and hygienically an unacceptable practice. Instead of the current practice of disposing of the organic waste at the landfill site, an environmentally friendly alternative for the use of the waste has been found. The use of biogas will bring about a change in this practice. The prospects for the usage of a generator to utilise the biogas directly as electricity has been considered, and this can be supplied cheaper to the Abattoir.

Research carried out in the past 10 months by the Institute for Quality, Energy and Environmental Management (IQEEM) on behalf of Sabta Environmental Services Ltd, with students of the Chemical Engineering Department of the Kwame Nkrumah University of Science and Technology (KNUST) have amply demonstrated the technical and economic feasibility of the biogas project.

The management of the Kumasi Abattoir has also expressed its preparedness to subcontract the Biogas production to a private company to supply its heating and electrical energy requirements at a cost less than what they are presently paying for LPG gas and electricity from the Electricity Corporation of Ghana (ECG). There is a ready market for the Biogas and the electricity to be generated therefrom to be sold directly to the Kumasi Abattoir. The demand is great and by our estimation everything that will be generated will be sold to the Abattoir. In the event of surplus biogas or energy being produced, these can be sold to nearby industrial establishments, since the Abattoir is located in an industrial area. By this means an eco-
nomically viable and sustainable arrangement is created for the Abattoir as well as for the subcontracted company

On successful completion, the project will create jobs for 20 people in Kumasi. Besides, the project can be replicated in the other major Abattoirs mentioned earlier in the country. In that case one could reckon with about 200 jobs in Kumasi and Tamale and Accra. Besides the recent introduction of a modern solid waste management system in the Tamale Municipality, Sabta Environmental Services is currently working in the area of dislodging and disposal of liquid waste. This waste, together with the Abattoir waste could be mobilised for Biogas project in the two metropolitan cities.

3. Benefits of Anaerobic Digestion Technology

According to the Warmer Campaign, the aim of modern waste management is to avoid the creation of waste wherever possible. The following options are therefore recommended for adoption:

- Re-use unavoidable waste.
- Reprocess those wastes which cannot be used in their current form, provided there is a stable demand for the end product.
- Convert to energy those wastes which are not suitable for material recovery.
- Dispose of those wastes which remain in the least environmentally damaging way possible.

Organic waste has the potential of causing significant pollution through atmospheric methane, polluted groundwater and the spread of water related diseases. Anaerobic digestion – this a form of digestion by various forms of bacteria in the absence of oxygen – can provide a range of benefits in addition to the valuable renewable energy from the biogas, such as;

- Less greenhouse gas emission
- Cheap and environmentally sound waste recycling
- Reduced nuisance from odours and flies
- Improved soil quality by recycling the organic matter as humus, thus preserving fragile top soils
- Sanitization of the compost, reducing the spread of soil-borne pathogens and weeds.
- The following organisms are destroyed in biogas plants: Typhoid, paratyphoid, cholera and dysentery bacteria (in one or two weeks), hookworm and bilharzias (in three weeks). However, tapeworm and roundworm die completely only after drying of the fermented slurry in the sun.

The application of the technology results in the reduction of the use of fossil fuels hence a reduction in CO₂ and CH₄, the latter being the second most important greenhouse gas contributing with 20 % to the effect while CO₂ is responsible for 62 %. Methane also has 25 times higher global warming potential compared with Carbon Dioxide in a time horizon of 100 years.
4. Design Parameters and Process Description of the Biogas Plant

4.1 Design Parameters of the Biogas Plant

The metabolic activity involved in microbiological methanation is dependent on the following factors:
- Dry matter
- Substrate temperature
- Available nutrients
- Retention time (flow-through time)
- Ph level
- Nitrogen inhibition and C/N ratio
- Substrate solid content and agitation
- Inhibitory factors
- Digestion loading rate

4.2 Process Description for biogas production

The process for the biogas production as seen in the process flow diagram (Figure 1) is as follows:

1. Biomass is received from the Abattoir in skips and emptied into a feed collector. Animal waste (sheep, goat and pig waste as well as cow dung) which have been freed from stoned, polythene bags and other impurities are brought in from the animal shed and emptied into the feed collector
2. At the start of the process, waste water from the abattoir is used in mixing the feed. The waste water is pumped into the mixer and the biomass added and thoroughly mixed to form a homogenous mixture.
3. The mixture is fed into the digester and left to undergo anaerobic digestion for 20 days during which biogas is formed and the pathogens in the organic waste killed
4. The biogas is sent to the gas holder via pipes for storage till use.
5. The slurry goes to the slurry storage tank
6. The slurry is pumped to a gravity filter press where 95% of liquid is removed and pumped into the liquid digestate tank holder. Part of the liquid is sold as liquid fertilizer and part is recycled into the mixer. The solid digestate is processed, packaged and sold to farmers.
7. A double chamber fuel generator which operates on diesel and gas is used to generate electricity which is used to power the plant and the excess sold to the abattoir
8. To make efficient use of heat being generated from the generator, the hot flue gases are channelled through a heat exchanger and used for singeing and other purposes at the Abattoir.

5. Conclusions

The preliminary results of the research point clearly to the fact that the management of the organic waste of the Kumasi Abattoir can be organised in an environmental sustainable manner and at the same time generate profit for the operating private company as well as creating the basis for an economically more efficient management of the Abattoir.

In terms of the environment, the thousands of litres of methane which would have been released into the atmosphere to worsen the greenhouse global warming effect is checked. Also benefits using the biofertil-
iser from the digestion for plants cultivation have a record in other parts of the world to have excellent yields.

Economic analysis with respect to the discounted cash flow rate of return, net present value and the rate of Investment and pay back period have all yielded positive results, proving the economic viability and sustainability of the project.

Bibliography

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