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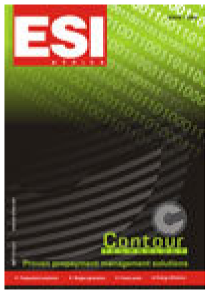

Biogas energy and sanitation provision in South Africa
By Greg Austin, Director, Biogas Technology Africa

Biogas is a low cost form of energy derived from renewable resources: animal dung and human waste. In developing countries such as China, India and Nepal, biogas has been used widely as a source of energy and as liquid fertiliser for soil enhancement, since the 1950s. A biogas digester, in which the biogas is produced, also provides an ideal on-site wet sanitation system.

In this article we look at how biogas is manufactured, consider the advantages of this form of appropriate technology, and examine the potential of the technology as an alternative energy supply for rural households and institutions such as schools. We also look at two biogas projects that have been piloted in the Ndwedwe District of KwaZulu-Natal, one at household level and the other at school level.

Biogas digesters and their functioning

Biodigesters are airtight containers in which water, animal wastes and/or faeces are acted upon by anaerobic bacteria. The three most common and successful designs are the fixed dome, the floating drum and the plastic covered ditch types. Biogas is formed by bacterial action on the plant or animal matter: the organic material is hydrolysed, from which organic acids are produced, leading to methane gas production. Biogas should not be confused with other forms of combustible gases produced from biomass e.g. producer gas or wood gas.

Biogas consists of methane (CH_4) 55-65% and carbon dioxide (CO_2) 35-45%, with the balance being made up of nitrogen (N_2), hydrogen (H_2) and hydrogen sulphide (H_2S). The second product is a digested effluent with between 60 and 80% reduction of the biological oxygen demand (BOD) compared with the input material. Biogas is about 20 percent lighter than air and has an ignition temperature in the range of 650 to 750º C. It is an odourless and colourless gas that burns with a blue flame similar to that of liquefied petroleum gas (LPG).

Factors affecting biogas production and the composition of biogas include the carbon/nitrogen ratio (optimum level is around 25 to 1), the pH (6.5 – 7), while the loading rate, temperature and retention time in the digester all also affect gas output. The optimum temperature is 36º C.

These factors are not mutually exclusive, but rather act in concert. Thus an increase in temperature will allow a shorter retention time or an increased loading rate. Typically, though, one might expect a range in biogas production of between 1,000 and 1,600 litres per 4,000 litres of digester volume per day. One thousand litres of biogas will provide a cooking time of 2 hours, or 1.5 kWh electrical output.

Advantages of biogas technology

Biogas is an important form of renewable energy, which can be used where organic waste is produced in appropriate quantities. It can make an important contribution to the protection and improvement of natural resources and environment. Slurry, a residue from the process, is a high-grade fertilizer which can replace expensive mineral fertilizers, in particular nitrogen. The technology also provides an efficient sanitary system, that enhances effective waste product disposal.

The use of biogas also enables women, especially in rural areas, to save time for productive agriculture, leisure and family care and welfare. It also improves the standard of living and can directly contribute to economic and social development of a country.

Recent case studies in South Africa

Two pilot biogas digesters have been installed in the Ndwedwe District outside Durban. One is a residential system with a volume of 9.5 m3 that was commissioned in November 2000. This digester takes input from a toilet and dung from three cows that are kraaled overnight. The digester generates in the region of 3 m3 of biogas each day, enough to cook for the family of eight. Of particular interest is the integration of the digester within the household, since all food and water wastes (viz. grey water) are directed through the biogas plant. It is a common misperception that access to water is a constraint on the application of biogas technology at the household level. Since each family uses water every day, this same water can easily be directed to the biogas digester. The levelised cost of this system is equal to the cost of LPG, without taking externalities or biogas benefits into account.

The second system is at a school with 1,000 learners. It is comprised of two 20 m3 digesters, each fed from an eight-toilet block. Additional gas is generated through the addition of cow dung through separate inlet chambers. This system produces around 16 m3 of biogas each day. The gas has dual end uses: cooking in the domestic science classroom by means of modified gas stoves, and running a modified 5 HP diesel engine which in turn drives a 2 kW AC generator. The biogas is sufficient to cook on four gas plates for eight hours per day, or to run the generator for eight hours each day. The diesel engine operates as a duel-fuel system, since the biogas replaces about 85% of the diesel that would otherwise be normally used. The unit energy costs over a 15-year lifecycle are lower than solar electrification, and can be markedly cheaper than grid power should the grid have to be extended to a particular end-use point. A biogas plant also does not suffer from the security risks faced by a solar installation.

Biogas technology's potential in SA

At the household level, extrapolating the data for rural KwaZulu-Natal to the rest of South Africa indicates conservatively that over 400,000 households could make use of the technology. This is based purely on those families with two or more cows, and without electricity.

Minister of education Kader Asmal told parliament in 2001 that 45% of schools in South Africa have no electricity, 27% lack clean water, 66% have inadequate sanitation, and 12% have no sanitation at all. These statistics have bearing on the over 16,000 rural schools in South Africa currently without power, many thousands of which will not get grid power in the foreseeable future.

Low-cost housing developments also provide an opportunity. It is easy to visualise a peri-urban, or rural, housing development where sewer lines are fed directly to a biogas plant. By adding a purpose-built effluent purification plant (which derives its power from the biogas itself) to the digester's output means that clear water can be recycled to the toilets. In this way about 90% of the total black water is continuously recycled. Development of such a system is already at an advanced stage.

Other opportunities exist in the cattle and livestock industry, a market that is being increasingly tapped in Europe, USA and Australia. In South Africa, there is a potential energy output from dairy farms and beef cattle feedlots in the order of 3.9 GWh per year. A biogas energy plant also solves the dung disposal problem faced by these farms and feedlots.

There are rural and peri-urban orphanages and clinics that do not have any sanitation in place. For the former the biogas provides the opportunity for a self-feeding scheme; for the latter, the energy can be used for sterilisation.

Developing the technology

Of all the national biogas programs instituted to date, Nepal's probably has had the best results. It is therefore instructive to look at some of the reasons behind their successes. A well-proven and reliable fixed dome biogas plant design, and biogas appliances, have been introduced following several years of research and development of the technology. This was accompanied by a national survey to assess the potential of and demand for biogas in the country. Nationally, an ongoing program of promotion and awareness activities were carried out at different levels.

Financial and cost benefit analyses of the technology have been performed, resulting in continuous subsidies being provided through various banks. As with other technologies affordability remains the biggest barrier to wider biogas dissemination in rural areas, and it is felt that once a successful programme is under way that subsidies should give way to a purely market-driven industry.

Technical capacities were also properly examined, with resultant widespread local mason training. In addition, biogas plant construction is followed by quality control visits in order to ensure a high standard. Excellent user support has been gained by good organisational networking through, for example, biogas and slurry co-ordination committees. A slurry extension programme has been introduced, and an association of all biogas construction companies has been formed for the promotion and extension of biogas. These companies now number 39.

Finally, and most importantly, the technology has generated employment in rural areas, since all the construction companies use locally sourced labour. The industry has created 2,000 permanent mason jobs (with 500 entering it each year) and around 500 working in the biogas appliance industry.

From the South African perspective, we can learn from the Indian, Chinese and Nepalese programs, with offers already having been made of bilateral governmental assistance in setting up such a programme here. We have both the natural and human resources to develop the technology, and perhaps the recent move by government in meeting targets for renewables over the next 10 years will see us starting a national biogas dissemination programme in the not too distant future.

Based on a presentation at the CARENSA-SPARKNET-LAMNET joint workshop 2002.

Résumé

Le biogaz est une forme d'énergie à faible coût, dérivée de source d'énergie renouvelable : les excréments animaux et humains. Dans les pays en voie de développement comme la Chine, l'Inde et le Népal, le biogaz a largement été utilisé comme une source d'énergie et en tant que fertilisant liquide pour les champs depuis les années 50.

Le biogaz consiste de 55 à 65% de méthane (CH4) et de 35% à 45% de dioxyde de carbone (CO2), le reste est composé de nitrogène (N2), d'hydrogène (H2) et de sulphide d'hydrogène (H2S). C'est un gaz sans odeur ni couleur qui brûle avec une flamme bleue similaire à celle du gaz de pétrole liquéfié (GPL).

Deux digesteurs de biogaz au stade experimental ont été installés dans la région de Ndwedwe, près de Durban. L'un d'eux est un système résidentiel d'un volume de 9,5m? qui est alimenté par les toilettes et par les excréments de trois vaches gardées en enclos durant la nuit. Ce digesteur produit environ 3m? de biogaz par jour, assez pour cuisiner pour une famille de huit personnes. Il est particulièrement intéressant de considérer un digesteur au sein même du ménage car tous les déchets alimentaires et les eaux usées partent vers l'usine biogaz.

Le deuxième système se trouve dans une école de 1000 étudiants. Il comprend 2 digesteurs de 20 m?, chacun est alimenté par un bloc sanitaire de 8 toilettes. En supplément, du gaz est produit à partir d'excréments de vache alimentés dans la machine par un compartiment séparé. Ce système produit environ 16m? de biogaz par jour. Le gaz est utilisé de deux façons : pour les cours culinaires avec des fourneaux à gaz modifiés et pour faire marcher un générateur à courant alterné de 2kW. Le biogaz est suffisant pour faire marcher le générateur ou pour cuisiner sur quatre plaques chauffantes pendant huit heures par jour.

Sur une durée de vie de plus de 15 ans, le coût de cette machine productrice d'énergie est moins élevé que le coût de l'électrification solaire et certainement beaucoup moins cher que le réseau électrique s'il devait être étendu à un utilisateur isolé.

Le potentiel du biogaz est très important. En Afrique du Sud par exemple, quand les données du KwaZulu-Natal rural sont extrapolées par rapport au reste du pays, elles indiquent de manière conventionnelle que 400 000 ménages pourraient utiliser cette technologie. De plus, plus de 16 000 écoles rurales en Afrique du Sud n'ont pas d'électricité et beaucoup manquent d'eau courante ainsi que de sanitaires adéquates.

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