Biogas: global trends and exciting opportunities for South Africa

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The renewable IPP procurement programme aims to install 3725 MW of renewable power in line with the allocated renewable energy capacity in the IRP 2010 – 2030. Biogas is included in the program with an allocation of 12,5 MW. South Africa has been slow to install biogas plants and it is estimated that there are as few as 150 biogas digesters installed at present.

Biogas can be used to produce energy in the form of heat, combined heat and power (CHP) or as a vehicle fuel. One of the distinct advantages of a biogas plant as a renewable energy solution is its ability to be located anywhere a waste feedstock is available. This makes it particularly suitable for rural areas. As long as the plant is maintained and correctly supplied with feedstock, generation from biogas is not dependent on any external conditions. This makes it very suitable for generation to alleviate peaking power energy demand. There are a number of incentives available which make farm scale biogas plants a very attractive option for farms looking to reduce their carbon footprint and save on electricity bills. This paper explores the international trends in biogas usage with emphasis on combined heat and power (CHP) plants and the exciting potential they hold in rural and farm applications in South Africa.

Global trends in biogas use as a source of renewable energy

China

Internationally the use of biogas as an energy source is not new. The Chinese have been using biogas from agricultural and household waste for cooking since 1929 [2]. The last 30 years have seen the introduction of biogas to power plants supplying from 20 kW up to 600 kW. Large agricultural biogas plants are a more recent trend with only 3% of the biogas plants installed used for power generation. Notable biogas-to-power plants include a plant in Shandong province which utilises 500 t of chicken manure to generate 60 000 kWh of power daily, one in Meng Niu which treats manure from dairy cows to generate 18 000 kWh per day and a project in Beijing which digests manure and generates 38 000 kWh power per day [2].

Germany

Germany is one of the more prolific and successful implementers of biogas-to-power projects. Approximately 13% of all renewable power generated in Germany can be attributed to medium to large scale biogas plants. According to the German Biogas Association there were an estimated 7320 electricity producing biogas plants throughout Germany in 2011 with predicted growth to 7874 in 2013 [3]. Combined these plants have a capacity of 2997 MW (as measured in 2011).

A significant factor contributing to the successful implementation of these projects is support from the German government. The Renewable Energy Sources Act (EEG) of 2000 guarantees compensation for electricity produced by a renewable energy plant for 20 years [4].

Africa

While not as common as in Europe and Asia, domestic biogas digesters have been installed in South Africa and Kenya since the 1950s. The most widely used biogas model is that of household biogas digester using household and domestic animal waste. Most African countries show a low level of technology development with South Africa listed as having a high level [5]. It is estimated that there are as few as 150 biogas digesters in South Africa [6].

Biogas-to-power technology

There can be negative perceptions associated with the word "biogas" due to its connection to biofuels. A common concern is that the creation of biofuels will lead to higher food prices due to increased demand for crops used in the creation of biofuels. These concerns are not valid in the scenarios discussed in this paper as the biogas referred to is generated from waste products such as effluent from farm animals as well as domestic and landfill waste.

Agricultural biogas is produced by the anaerobic digestion of an organic feedstock, that may take the form of animal waste, domestic waste, crop "leftovers", or municipal solid waste [7]. Biogas can be used to produce energy in the form of heat, combined heat and power (CHP) or as a vehicle fuel. A common use internationally is as a source of heat for cooking and space heating purposes. This is particularly evident in countries with established natural gas networks where the use of gas for household cooking and heating is common.

In a biogas CHP installation the waste product (feedstock) is introduced as slurry into an anaerobic digester. This digester produces two products: biogas and digestate. The biogas is used to run a CHP plant consisting of a generator (usually a gas engine or micro-turbine), which generates electricity and a heat recovery plant. The efficiency of electricity generation is generally between 30% and 40% with efficiency of each plant influenced by the quality of the biogas, load and effective maintenance routines [8]. The heat recovery plant captures the waste heat in low temperature hot water (LTHW) or steam for heating purposes or utilises an absorption chiller to create chilled water for cooling uses. The choice and size of the installation depends largely on the quality of feedstock available as well as the available uses for waste heat and chilled water. An example of a use for waste heat in an agricultural context would be heating of hen houses or piggeries in winter. In installations where an abattoir or a processing plant is present the LTHW and chilled water can be used very effectively to enhance the efficiency of the process.

South African situation and advantages

South Africa has a very specific load profile. Peak energy demand hours are in the early morning between 07h00 and 10h00 and in the evening between 18h00 and 20h00. This is largely due to the fact that the majority of South African households utilise electricity for cooking and heating as opposed to gas which is used in many European countries and the United States. This means that our peak demand requirement does not match the period in which peak solar radiation gives the highest generation for solar energy. Wind energy profiles also do not fit in predictably with this demand profile.

One of the distinct advantages of a biogas plant is its ability to be located anywhere waste feedstock is available. This makes it particularly suitable for rural areas where farming is the main user of electricity. As long as the biodigester is supplied with a sufficient quantity of feedstock , power generation is not linked to any specific time periods and can be generated when

and where needed. The advantages for biogas CHP plants exceed the simple production of heat and power. The potential for the improvement of human well-being is significant. When installed in a rural community the electricity, heat, gas for cooking or a combination of these can lead to reduced levels of indoor smoke, better lighting and creation of employment for local people [5].

Implementation and future in South Africa

There is substantial opportunity for the production of biogas from agricultural activities. A biogas programme with piggeries and chicken farms is already in the implementation phase. The first farm went live in 2010 with the second following by mid 2013. It is estimated that a typical farm will be able to completely remove itself from the grid by utilising a third of its biogas production in the generation of electricity.

In the existing projects electricity is generated through combustion of the biogas in a micro-turbine. The choice of technology is suited to the farm scale projects due to small scale generation. Micro-turbines were chosen for a number of reasons. Gas engines have a poor step load capacity of approximately 10%. Micro-turbines operate at a higher frequency which is converted to grid frequency using a rectifier, battery and inverter. They are therefore able to handle step loads better than gas engines. The micro-turbines used also require no oil and as such require less maintenance. In an existing project, which is in the implementation phase, a waste stream from a piggery is processed in an anaerobic digester to produce a biogas stream. If the full available stream was processed it would provide 56 000 GJ per annum with the current output producing 14 000 GJ per annum in line with the farm's load requirements.

Multiple potential uses for the biogas stream were identified. The biogas stream can be used to produce electricity via combustion in a micro-turbine, with the option of using the waste heat for heating or cooling applications on the farm. Direction combustion of biogas could replace the LPG fuel in boilers. Clean-up and compression of the biogas would produce a compressed natural gas (CNG) product which is easily transported to sites within a 100 km radius that are able to use the gas effectively.

The chosen use of the biogas stream was power generation through a micro-turbine. Own generation will be run in parallel with the local utility grid. Two 65 kW Capstone micro-turbines will be installed to support the night time load as well as the majority of the day time load of the farm.

It is common that the electrical load of the farm is not large enough to use the entire biogas stream available. In cases where LTHW is not suitable due to long distances or high temperature requirements, the gas can be used directly in a boiler system at the point of heat consumption as an alternative to an electric boiler. In a situation where the farm has a significant number of vehicles the biogas can be cleaned, compressed and used to run vehicles which have been adapted to run on methane.

The scale of this project would not be suitable for inclusion in the current phase of the REIPPP programme as the projects in this phase are to be greater than 5 MW scale. The department of energy has indicated [1] that it intends to introduce a separate small projects IPP procurement programme. If this programme extends to small projects (100 kW to 1 MW) then there is very exciting potential for farm biogas projects to be able to alleviate some of South Africa's energy challenges.

Over and above this there are a number of mechanisms to encourage medium scale biogas projects. The Eskom Integrated Demand Management (IDM) offers an incentive for reduced consumption under their Standard Offer Programme (SOP). For every kWh generated by the biogas plant between 18h00 and 20h00 weekdays for the first three years of operation Eskom will contribute R1,20. This contributes significantly to reducing the capital cost of the plant. The IDC will provide a below prime loan for green technology investments [6]. Further tax benefits may be available in the near future. Energy savings will be further increased when the influence of the carbon tax (expected to be implemented in 2015) on the electricity price is realised.

Conclusion

Internationally it has been shown that biogas has significant potential as a renewable energy source. Germany produces approximately 3000 MW of power in biogas plants throughout the country. This shows that the technology is there and ready for South Africa to take advantage of. There are a number of incentives available which make farm scale biogas plants a very attractive option for farms looking to reduce their carbon footprint and save on electricity bills. Hopefully these factors will encourage a larger allocation for biogas plants in the next phase of the IPP renewables project.

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