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The Biogas Industry

Introduction

When cows graze a range they defecate in the fields and the passage of the herd's hooves grind the spoil into the earth where bacteria digest it. Bacterial digestion results in outgassing of carbon dioxide and methane, with nutrients returning to the soil to feed the next season's grass. The growth of the grass reabsorbs the carbon dioxide from the atmosphere so the only net production of climate warming gasses is the production of methane. Methane has 80 times the greenhouse gas effect of carbon dioxide so this production is significant.

Free ranging cattle requires lots of space. More typically today the animals are kept on feedlots and the forage is brought to them. Rather than spreading over a vast acreage, droppings pile up creating various health hazards. Droppings can either be washed away into septic lagoons, or, if water is in short supply, scraped up by small tractors.

The Biogas industry is about bringing this natural process of decomposition under industrial control and optimizing it for economic and climate benefits.

Engineering

The field of biogas production is much wider than animal sewage treatment. Any organic material can provide the feed stock. In addition to animal waste one may consider plant waste (stubble) left in fields when the harvest is complete, waste from lumber mills, purpose grown fuel crops, residue from sugar mills, and municipal solid and liquid waste. This material can be exposed to bacterial digestion either indoors or outdoors. Outdoors septic ponds may be covered to recover evolved gasses. Municipal landfills may be provided with collector pipes to capture gasses evolved deep in the center of the dump.

Indoors vast concrete fermentation tanks can be constructed. The common output in all cases is a stream of gas known as biogas. Its principal constituents will be methane and carbon dioxide, with the methane percentage generally between 50%

and 70%. Depending on feed stock composition and fermentation conditions there will be greater or lesser traces of hydrogen sulfide. Hydrogen sulfide is corrosive in the presence of water and toxic in sufficient concentration. It also has an objectionable odor.

Biogas itself may be burned on site to produce heat and power. Alternately it can be subjected to further processing. Typically hydrogen sulfide is scrubbed from the product stream. There are a number of methods by which this may be done, with selection depending on cost structure and desired degree of scrubbing. Some methods result in potentially valuable by product being created, such as gypsum and elemental sulfur. Next the carbon dioxide and methane are separated. The entire cycle is carbon neutral so the carbon dioxide may be vented or captured. At this point the product is methane. It may be piped into existing natural gas distribution systems. Alternately the methane may be converted to hydrogen and carbon dioxide, for instance by reacting the methane with high temperature steam in the presence of a catalyst. The hydrogen may be taken as the primary output or it may be further reacted to produce ammonia.

Various controls should be exercised over this process. The strain of bacteria should be controlled and the fermentation conditions optimized for the desired biogas production with minimum of undesired by product. The biogas should be monitored for potential carcinogens, heavy metal contamination and organic pollutants. Particularly this is the case where the ultimate utilization is distribution through natural gas pipelines and thus potential entry into residential kitchens. In general, however, biogas is a pretty clean product and monitoring is all that is needed, Further cleaning of the gas usually is not.

Besides gas production, solid waste known as digestate is produced. After cleaning and testing this by product may be sold as fertilizer.

Our description of the process implicitly describes a substantial industrial plant. Actually the process may be carried out on any scale. Two cows will produce about 50 pounds of waste per day. Fermented in a home digestor enough biogas is produced to provide several hours of cooking gas for a farmhouse. This is particularly suitable for rural “off grid” homes. However it requires a steady waste stream in this application. Somewhat larger digestors may operate on a communal scale, processing crop residue and municipal waste stream. Finally the large industrial plant is suitable to metropolitan waste streams, intense livestock operations and regional agricultural waste.

Economics

The economics of such plants is interesting. The waste stream is either free or the facility may derive revenue from accepting a waste stream which is otherwise costly to dispose of. There are capital costs associated to the fermentation facility. There are operating expense for monitoring, control, gas scrubbing maintenance and daily cycle. In general these costs are not high. The principal output is biogas or methane. By products may include sulfur compounds and digestate fertilizer.

A key economic issue is utilization. Steady waste streams lead to full utilization. Seasonal or varying waste stream lead to variable utilization with longer payback times on capital. Agricultural waste is an example of a seasonal feed stock.

There is some expertise involved in optimally controlling these plants. But for the most part they are low tech operations constructed from local building materials. If well constructed, operational lives measured in decades result.

Social Benefits

Biogas plants have several social benefits beyond the purely economic benefits.

Home sized units attached to rural farmhouses can supply a clean safe cooking fuel which displaces locally gathered firewood which is time consuming to collect and whose combustion can create smoky unhealthy interiors. Communal size units can similarly provide power to off grid rural communities. These gains are greatest in developing countries where a rural electrification grid may be absent.

Combustion of biogas converts methane to carbon dioxide with very substantial reduction in green house warming effect. Carbon dioxide released in biogas processing and use is ultimately of atmospheric origin and thus carbon neutral on a full cycle basis.

Conversion to biogas is an effective disposal method for many organic waste streams. Other disposal methods, e.g. ordinary landfill burial, ultimately result in methane outgassing. In addition biogas conversion is a sustainable waste disposal method whereas landfills eventually fill up and may even catch fire.

Conversion to biogas is a far healthier disposal method for agricultural stubble than burning. Burning produces huge amounts of air pollution, including heavy particulate fractions. For instance New Delhi, a capital city of 15 million people, rejoices in the most toxic air on the planet in the winter months when stubble burning blankets the Gangeatic plain in nasty mix of photochemical smog and particulate pollution.

Deployment

Similar to solar panels, biogas has an industrial scale and a consumer scale deployment. The industrial scale has been pioneered by forward thinking municipalities in the developed world whose primary motivation is avoiding burial under superabundant waste streams. In the developing world most waste streams are agricultural and exhibit a seasonality less conducive to large cap plant investment. Consumer and communal deployments are more feasible, but may require external financing support given the limited access to capital in the developing word.

The Case For Socially Responsible Investing

Socially responsible investing is a process of evaluating potential investments on both a conventional risk-reward basis and on an evaluation of social benefits and detriments of the investment activity. Generally socially responsible investing chooses to fund projects with high net beneficial impact and a risk-reward profile reasonable close to commercial terms.

Biogas projects are strong candidates for socially responsible investing. Their risk reward profile is that of typical utility or municipal infrastructure projects. Most of cost is capital cost and it is recovered incrementally over a long service life. Direct competition to the biogas facility is generally absent as these tend to be local monopolies. Indirect competition comes from other sources of methane or propane. But biogas will usually be cost competitive due to no or negative feedstock prices and low stable operating costs. This is a superior price picture as compared to natural gas and propane, saddled as they are with volatile market prices at source and higher transportation costs. Operating risks of large scale facilities are generally very well controlled. Residential units may require costly maintenance and supervision services however. But on balance biogas facilities can justify capital pricing typical of utility projects.

From the perspective of social impact, biogas production has a number of beneficial features

1. reduction in methane emissions
2. reduction in air, soil and water pollution
3. use of digestate fertilizer supports sustainable agricultural practice
4. efficient disposal of waste streams

   In the case of rural domestic or communal units there is in addition

5. displacing use of firewood
6. improved self-sufficiency

Social detriments of biogas plants are modest. They can be smelly if hydrogen sulfide is not adequately scrubbed.

Market Potential

The global biogas market is currently estimated to be 140 billion dollars and growing 4.5% per year. About half the installed base is located in Europe at present. Growth is expected to accelerate as the benefits of this technology become better understood. In particular growth in Asia is expected to be strong. Currently the US has 2,000 biogas plants representing $37 billion in investment. That works out to one plant per 165,0000 people and a per plant cost of $18 million. By contrast, Germany has 10,000 active plants. The per capita figure is one plant per 9000 people. Thus even in a well developed economy like the US there is considerable remaining growth potential. In fact, it is estimated that as many as 17,000 suitable development projects exist in the US alone.

Summary

With many strong features, biogas is likely to remain a bright spot in utility investment for many years. It also has strong appeal for practitioners of socially responsible investment.