#### The Development of Small Fabricated Geomembrane Biogas Covers

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# ABSTRACT

Biogas collection and use from industrial and agricultural sources is a rapidly growing use for fabricated geomembrane floating covers. Most successful biogas collection projects in recent years have been on larger projects where the scale of the project allows for significant research and design expenditures. The need exists for a less expensive biogas collection solution for smaller farms. While State and National agencies work to develop protocols for using the biogas collected from small farms the development of biogas collection covers that meet the requirements of small agricultural projects has not kept pace.

This paper presents the current state of the development of covers for small confined animal feeding operations (CAFOs) with an emphasis on manure slurry storage applications. The problems with providing a cover for slurry storage will be outlined and the areas requiring solutions will be identified. An innovative design for prefabricated manure slurry storage biogas collection covers will be presented. The testing that went into the development of this new patent-pending cover design will be reviewed.

Current biogas collection cover designs are not well matched to the small agricultural livestock producer. Small livestock producers have little capital available to design or purchase covers and current biogas cover designs are not matched to existing manure management practices. This paper presents the issues surrounding biogas collection for small livestock operations and an innovative fabricated geomembrane biogas collection cover that addresses these issues.

#### Introduction

The harvesting and use of biogas from agricultural sources has been expanding rapidly in the past 5 years. Programs such as carbon credits, green electricity subsidies, and other incentives have contributed to this expansion. To date typical biogas collection projects have focused on large agricultural or industrial producers who have professional operators on site. This paper presents an option for small to mid-sized biogas collection covers that can be economically used by smaller operators. This new cover design is intended for use on small to mid-sized farms and is designed to fit with the operations of the typical small operator.

## Background

Confined animal feeding operations (CAFOs) are typically the type of facility that would have a manure handling system that would be suitable for biogas collection. In a CAFO manure is collected from the animal pens and stored in one or more ponds (or tanks). These ponds are periodically pumped out and the manure is applied to local land as fertilizer. Typical CAFOs with manure holding and treatment ponds/tanks include dairy, swine, beef and occasionally poultry. There are two types of manure storage; slurry storage and anaerobic digesters.

## **Types of Containments**

Anaerobic digesters are engineered systems where manure or other contaminated water sources are treated prior to release or re-use. There are two distinct types of anaerobic digesters; a tank-type and a pond-type. Tank anaerobic digesters are fed a controlled stream of waste at a constant level and temperature. The waste is usually mixed in the digester and the system is optimized for water treatment. Tank digesters have a high initial cost and usually require skilled staff to maintain and operate. Pond anaerobic digesters are operated at a constant level and are usually prefaced by a solids separator. The water in a pond-type digester is of a low volatile solids content (often less than 5%) and the emphasis is on water treatment. Pond-type anaerobic digesters tend to be large and are usually installed where skilled operators are available to run the system. Often an anaerobic treatment system is installed to improve water treatment time or efficiency; however, newer systems are being installed with biogas production as the main focus.

Slurry storage is a manure handling system that stores high-solids liquid manure in tanks or ponds. There is usually no treatment associated with this method; the slurry is simply stored for later re-use. Periodically (typically once per year) the slurry is agitated to re-suspend the solids and then pumped out for application to local fields. This practice recovers the fertilizer value of the manure for other farming operations. In slurry storage the liquid levels of the pond/tank fluctuate throughout the year and there is no operator input to monitor systems. This paper presents a new floating biogas cover design to address the requirements of slurry storage in ponds.

#### **Biogas Uses and Examples**

There are five general uses for biogas collection covers. These five elements may be used individually or in combination. Here is an explanation and example of each of these uses. **Odor Control** – Although not a way to use biogas the simple act of placing a cover suppresses the movement of biogas into the atmosphere and dramatically reduces odors. Research has shown that an impermeable cover can reduce odors by up to 95% (Nicolai et al., 2004 and Bicudo et al., 2004) in slurry storage ponds. The amount is not 100% because of the requirement to periodically remove the cover to agitate and pump out the manure.



Figure 1: Slurry storage cover for odor control. This swine manure cover is pulled back each year for pump out.

**Heat** – Biogas can be burned directly or augmented with natural gas to produce heat. Boilers can usually be adapted to burn biogas. In cold climates biogas produced in the summer can be stored under the cover until needed in the winter. Treatment of the biogas before burning may be required depending on the boiler.



Figure 2: This cover is at a meat packing plant. Stored biogas is lifting the cover up to 4 meters off the surface of the liquid. The biogas is used to directly fire boilers.

**Electricity** – Biogas can be used in specially adapted engines and gas turbines to generate electricity. Lean burn engines are widely available for biogas use. Typically some treatment of the gas is needed to remove moisture and hydrogen sulfide to protect the engine. Electricity incentives in many jurisdictions are promoting this type of use except in California where any combustion of biogas in an engine will not meet air emission standards.



Figure 3: This gas turbine at a food processing plant uses biogas to make electricity.

**Utility Gas** – The newest use for biogas is to clean the gas for use by the local gas utility. It takes a number of steps to clean biogas to utility standards and requires a large system with skilled operators.



Figure 4: This biogas treatment plant upgrades the gas produced by a 2 hectare (5 acre) anaerobic pond to utility quality. This system produces 4,000 cubic meters (140,000 cubic ft) of clean natural gas a day.

**Carbon Credits** – Methane as a greenhouse gas is 21 times more powerful at warming the atmosphere than  $CO_2$  over a 100-year period (US EPA 2006). Destroying methane by burning or other use can substantially reduce its harmful effects. Credits are available in some jurisdictions if it can be shown that methane has been destroyed. The two issues with carbon credits are that the current cost for credits in the US is very low and secondly, that credits can only be applied to existing sources of methane production.



Figure 5: Biogas is usually metered and then flared in order to obtain carbon credits. Photo courtesy of Advanced Burner Technologies.

# **Definition of Requirements**

The design of a biogas collection cover for small slurry storage ponds needs to meet a number of key design criteria. The basic criteria are that the cover material must be resistant to the manure in the pond, must be flexible enough to move up and down with liquid changes, and must be impermeable enough to retain the biogas. The other key design issues with a slurry storage pond are that the liquid level will change continuously over time and that the cover will need to be opened periodically for agitation and pump out.

Experience with previous cover types has shown us that attempting to remove a cover for agitation and pump out will damage a cover after only a few years. Typical low cost cover materials that have been used for slurry storage ponds are often damaged within the first three years of use.

The other key issue has been the change in liquid levels. In an anaerobic pond the cover is floated in place without slack. A grid of weights is placed to stabilize the cover from wind damage as biogas lifts the cover off the water. It has proved impractical to remove these cover weights for maintenance or repair. When sufficient slack is added to accommodate changes in liquid level the cover can lift much higher off the pond under biogas pressure and wind damage can easily result. Controlling the amount of slack in the cover while stabilizing the cover from wind damage and allowing liquid level changes is a key design parameter. The ability to remove the cover weights for future maintenance or repair is also seen as an advantageous feature.

Finally the design of the cover had to meet cost expectations from farm operators. Although the operators could reasonably expect to use the biogas for any of the main uses (including simple utility gas systems in developing countries) the cover had to be simple and inexpensive to install and operate. This led to the design of a fabricated geomembrane style cover that could be built in one piece for installations up to an acre in size. In many cases these covers will be suitable for self-installation by the farm operator.

# **Cover Design**

The basic cover design required solving the problem of attaching weights while allowing simplified assembly in the field. Typical floating covers have the weights welded to the cover during installation in an empty pond. Large biogas collection covers use field applied straps to hold grout-filed weight tubes on the surface of the floating cover. Both weight attachment methods required substantial field resources and were not suited to a slurry storage style pond. Our new cover design uses factory fabricated pockets that are filled with weight tubes at time of installation. The weight tubes are filled with liquid after cover installation and can be drained if needed for removal during maintenance or repair. The factory fabricated pockets can also be filled with floats if needed to control the slack in the pond.



Figure 6: Biogas collection cover section showing details of weight (ballast) tubes, gas collection piping, and anchor trench (Mills 2008, reprinted with permission).

Experience has shown that removal of grout-filled weight tubes on a biogas cover is very difficult. The new fabricated biogas cover design uses liquid filled tubes to provide ballast weight. The weight tubes are made from high strength reinforced PVC geomembrane material with ports installed at either end. The tubes are installed in the fabricated cover pockets prior to the cover being pulling into place on the pond. Once the cover is in place on the pond the weight tubes are filled with liquid. In most cases the liquid will be fresh water; however, a non-freezing liquid weight fluid is available for cold climates. The advantage of liquid filled weights is that the weight increases as the cover lifts off the surface of the liquid. Stress is reduced in the cover until the weight is actually needed.



Figure 7: Detail of fabricated weight tube.

The most important aspect of this new cover design is the ability of the cover to be removed for agitation and pump out. In order to accommodate this activity we looked at a number of options. The cover needed to remain in place as much as possible to limit damage. After exploring a number of designs we settled on using a special hatch section at one end of the pond. This hatch allows a section of cover to be removed for access to the manure. Agitation pumps can be lowered in to the manure for mixing and then pumps can remove the manure for field application. The design of the hatch can use either permeable or impermeable materials. The hatch material is made from a lightweight, inexpensively replaceable material. A small amount of gas seepage from the hatch area is not seen as significant. A concrete ramp is recommended under the hatch area so that agitators and other equipment do not damage the pond liner.



Figure 8: Section showing permeable hatch cover.

# **Prototyping and Testing**

In 2006 a prototype cover was constructed and installed on a local pond for testing. This prototype covered an area of 43 m x 91 m (140 ft x 300 ft) and used two different material types; each in half of the pond. Fabricated pockets were built into the cover and floats were placed in the pockets at the time of installation. This cover was intended to demonstrate the ease of installation, the placement of floats (or

weights) in the fabricated pockets, the ability to install the fabricated cover on a full pond, and the ability to deal with changes in water elevation over time. The pond chosen was a farm dugout with seasonal water level variations. Weight tubes were not placed in this prototype as this was not a biogas producing pond; however, the placement of preassembled float sections mirrored the weight tube installation.



Figure 9 and 10: Floats are preassembled into a sleeve and pulled through the fabricated pockets in the cover. Here is the before and after of a float installation.

After three years of study the test cover was taken off. From the standpoint of a biogas collection cover the use of the fabricated pockets worked well and the basic cover design accommodated changes in water levels without significant difficulty.

In 2009 a second test cover was installed on a small residential sewage lagoon to test the liquid filled weights. In this cover the weights were installed before cover deployment and then filled with clean water after installation.



Figure 11: Installation of the second test cover.

This second test cover went through the winter of 2009/2010 with extended periods of temperature below -15C. The top of the lagoon and the water filled weights were completely frozen however no damage or leakage was observed.

#### Conclusions

This paper has presented details of a new fabricated floating cover for biogas collection for slurry storage ponds. This cover has been developed through the use of experience and prototypes and is ready for general use. The design details of this cover are the subject of a pending patent application.

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