The Potential Energy of Oklahoma Hogs: Methane beyond Thunderdome.

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The Mel Gibson movie, *Mad Max Beyond Thunderdome*, opened in Ames, Iowa on a Friday evening back in 1985. I sat in the dark theater with my friend and fellow Agricultural Engineering Graduate Student.*Beyond Thunderdome* was the third in a series starring Gibson as Mad Max, the post-apocalyptic “road warrior”.In the first movie, they killed his wife and child. In the second movie, they killed his dog. At the start of the third, they stole his car … so Max is really mad. He follows his stolen vehicle to Barter Town, a mini Las Vegas in the middle of the Australian desert, run by a woman named “Auntie”, played by Tina Turner. In the course of trying to recover his vehicle, Max runs afoul of Auntie and is sentenced to work down in the dungeon where Barter Town receives its power.The town is powered by an old steam locomotive turned electrical generator, which is heated by methane gas.As Mel faces the fifty-or-so pigs that supply the methane, only two people in the audience laugh. These two are the Agricultural Engineering Graduate Students working on a waste to energy project producing methane from cattle feedlot manure.

The idea of using pig manure to produce energy isn’t absurd … Put swine waste in an airtight container, heat it above 68^{o}F, and the anaerobic bacteria present in the manure will produce flammable biogas like nobody’s business. The problem is running an entire town on 50 pigs worth of manure.

Let’s do the math.

In 2008, attendees of the South-Central Sungrant Biofuels Conference calculated the total heat value of swine manure produced by hogs in Oklahoma to be 6 Trillion (That's 12 zeros behind the 6) Btus per year.

Using energy units commonly used in electricity, 6 Trillion Btu's is roughly 200 Billion KW hours. So why don't we just burn pig manure and collect that energy?

This brings us to the first problem of pig power.

Swine manure contains lots of water. Feces, straight from the pig, is 90% water. And, since swine manure flows easily as a liquid, we add more water to manure to move it around. By the time swine manure leaves a pull-plug building, it is more than 99% water. Drying the waste down to a point it will burn uses more energy than we are able to produce by burning.

Wet manure is not a problem with anaerobic digestion. In fact, adding water is usually the first step towards creating an anaerobic environment. Work done in the Biosystems Engineering Laboratory at Oklahoma State University shows that 20% of energy stored in organic matter of dilute swine manure is convertible to methane. Methane potential is essentially natural gas, and is the flammable component of biogas. Using the 20% conversion of organic matter to methane means that hogs in Oklahoma can produce 1.2 Trillion Btus of energy per year.

This brings us to the second problem.

Hog farms are spread out across the countryside. Drying biogas, removing Carbon dioxide and Sulfides, and pressurizing the clean, dry methane to inject into natural gas pipelines also uses more energy than is available in the biogas.So, we are probably going to use energy from biogas on-farm.

One way to use on-farm is to convert biogas to electricity just like they did in Barter Town, and use the heat left over from burning biogas to warm the digester. The most we can hope for is to have 30% conversion of biogas to electricity.

So the potential of hog manure in Oklahoma is down to 360,000 Btu's or 100 Million KWh per year. That sounds like a lot of energy, but if you consider that the per capita use of electricity in Oklahoma is 15,000 Kwh per year, 100 million KWh is enough power for about 7,000 people. Now you know why we laughed. All the hogs in Oklahoma would not provide the electrical needs of a town the size of Guymon.

So, 50 hogs aren't going to power Tina Turner's little Las Vegas in Australian desert. But spread that 100 Million KWh per year over 300 or 400 farms, and you can do a lot of work. A 10,000 head finisher farm will produce enough biogas to run a 150 KW generator 24-7.

How do we convert wet hog manure to biogas?

There are a number of digester systems out there.

Complete mix digester: manure flushed out of building is placed in an air-tight container, heated, and stirred. The main drawback of complete mix digesters is we need to hold the material for 30 days in order to reliably produce biogas. Given the sheer volume of liquid produced with pit-recharge systems, the reactor needs to be as large as a lagoon.

Which brings up the second system …

Covered lagoon: an impermeable cover is placed on top of existing anaerobic lagoon, collecting biogas. Covered lagoons work fine, but gas production goes down in winter when you can make the best use wasted heat from the engine generator. And, as with the existing lagoon systems, most of the fertilizer nutrients are left, unused, in the bottom of the lagoon.

If you consider that 75% of all fossil fuel used in growing corn went in the manufacturing fertilizer, this is a terrible waste of energy. So, let's try to capture more nutrients in a smaller vessel.

Fixed Film Digester: anaerobic bacteria are grown on media placed in an airtight container. The methane forming bacteria stay in place, and organic liquids flow past them. A fixed film digester works with swine waste, and we can use a much smaller reactor compared to complete mix digester, but we may need to separate solids to keep media from plugging. About half of the potential gas is lost if we do not digest the suspended solids in swine manure.

This leads us to a system we are working on at OSU.

Anaerobic Sequencing Batch Reactor (ASBR): Flushed manure is heated and mixed in an airtight vessel; at least once a day, the mixer is turned off, solids are allowed to settle, and liquid is decanted off the top. We are constantly accumulating solids in the digester. The methane forming bacteria stay with the solids. Every now and then we need to remove some solids, but these solids contain nutrients. ASBRs also have the advantage of being relatively small, so they can be added to existing lagoons systems – lowering the organic loading on the lagoon and increasing the amount of fertilizer nutrients captured by the farm.

We are starting-up a farm-scale ASBR at the OSU Swine Research and Education Center. In the coming months we will be collecting data on the performance of the system.