Anaerobic Digestion – A Feel Good Strategy or a Sustainable Manure Management Solution? **January 2008**

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Evaluating whether anaerobic digestion is a sustainable manure management solution requires requires reflection on the history of anaerobic digestion, a look over the fence to see what our neighbors on the planet are doing, and some simple science.

When I was completing my Ph.D. work in the microbiology and biochemistry of manure and soils in the late 1980s, a retiring professor made an important observation, "Every 25-30 years, we renew an old idea and somehow think its new or better, the next generation likes to think itself smarter than the last one" How does this relate to anaerobic digestion technologies?

> The objectives of anaerobic digestion are to reduce greenhouse gas emissions and to produce "green" energy.

Let's consider anaerobic digestion in the Netherlands, where there is intensive livestock production similar to our conditions in the Fraser Valley. In an article entitled "Biogas in Europe, a General Overview" prepared in 2001, Holm-Nielsen and Seadi, observed that around the year 1980 more than 30 farm-scale biogas plants were installed in the Netherlands. They summarize the situation in 2001 by saying "The high operation costs and low fertilizer value of the digested manure led to today's situation when most of the plants are no longer in operation. No new plants were built since then." I visited several anaerobic digestion facilities in the late 1980s in Ontario, none of them were operating, again because of the high cost of operation. The factsheet published by the Ontario Ministry of Agriculture, Food and Rural Affairs (Agdex 720/400) reads "Manure-based anaerobic digesters built in Ontario in the 1980s failed due to poor economic returns or operational difficulties. However, new technologies and control systems have seen a new deployment of agri-food anaerobic digesters."

How is the situation different now than in the 1980s? Yes, we have new companies marketing "new" technologies, but the microbiology of the process is still exactly the same. Anaerobic digestion is still a two stage microbial process, where acid formers break down the organic matter into organic acids, and the methanogenic bacteria produce methane. And, yes the methanogenic bacteria are just as sensitive to process changes as they were in the 1980s. And the methane gas produced is still very dirty and corrosive, and the conversion efficiency of methane to electricity is still 30-35%.

So, what is different? There are two significant differences, the first being the potential to reduce greenhouse gas emissions from agriculture, and the second being the increased value of "green energy" These two changes over the years prompted me to get interested in anaerobic digestion once again – so we built a "silver bullet", a small prototype anaerobic digester in 2003 on farm in Abbotsford. This research was funded in part by the Greenhouse Gas Initiative program funded by the Canadian government and administered through the Abbotsford Soil Conservation Association.

> We have to understand why a lot of digesters built in the 1980s are standing idle.

The potential of anaerobic digestion to reduce greenhouse gas emissions is about reducing methane emission. We achieved the methane productions that were predicted based on the

science of methane emission. So why didn't we continue with this? We stopped this program because anaerobic digestion did not address the environmental concerns with manure management in the Fraser Valley – these concerns are that too many nutrients in manure that are applied on our small landbase. Anaerobic digestion does nothing to change either the volume of manure produced, or the amount of nutrients in the manure. We recognized that government programs and incentives will change the economics of the process, making it more financially lucrative, but we still need to deal with the managing our manure in an environmentally sustainable manner. If the government programs end because the voters decide its no longer a priority, we may have some anaerobic digesters standing idle – just like in the 1980s.

Anaerobic digestion doesn't solve the farmers' main problem – too much manure and too many nutrients

So, what about the potential of anaerobic digestion to reduce greenhouse gases? Do our farms really produce that much methane? Dairy farms produce some methane, while poultry farms don't produce any. On the dairy farms, most of the methane actually comes from the stomachs of our dairy cows, not the manure. Studies by Agriculture and Agri-Food Canada in Ottawa in 1997 showed that 500 L per day of methane were emitted from each dairy cow. What about the manure? Agriculture and Agri-Food Canada did its own measurements of methane emission from dairy cattle manure in 1997 in the Fraser Valley. We showed that methane emission during the winter months (when most of the manure is stored) amounts to less than 2% of the carbon in the manure, while methane emission during the summer months can be as high as 25% of the carbon in the manure. Many dairy farms utilize their manure for fertilizer during the summer, hence don't accumulate the manure to produce much methane. Poultry farms don't produce methane because the birds don't produce methane, nor is methane produced during storage of manures because methane emission from solid poultry manure is negligible.

There is another, more powerful greenhouse gas that can be reduced by anaerobic digestion. This gas is nitrous oxide, or laughing gas, a gas that is 200 times more powerful than carbon dioxide. My previous research in Ontario in the late 1980s showed that there are significant nitrous oxide emissions from soil following manure application, and that these emissions are enhanced by the presence of readily available carbon. Research at the Pacific Agriculture Research Center in 1995 showed that storage of manure as a liquid resulted in no emissions of nitrous oxide, but that the emissions occurred following application of the manure to the soil. Our theory was that by removing the readily available carbon from the manure through anaerobic digestion, the nitrous oxide emissions from soil would be reduced, hence providing a further greenhouse gas reduction effect.

The second difference since the 1980s is the increased value of "green". In a presentation on anerobic digestion in Abbotsford in 2006, Don Hilborn mentioned that in Germany, there are now more than 2600 anaerobic digesters, simply because of a policy that pays the producers $ 0.22 per kwh. In contrast, here in BC, we pay $ 0.06 to $ 0.08 per kwh. Is the Canadian public going to support this kind of subsidy for anaerobic digestion, a technology that doesn't even address most of the environmental concerns with manure management?

What does the Sierra Club, a leading environmental advocacy organization have to say about this? A report entitled, Sierra Club Guidance: Methane Digesters and Concentrated Animal Feeding Operation (CAFO) Waste published in 2004 reads. "Most environmental damage caused by CAFOs, however, remains unabated. Excess nutrients which run off from waste lagoons or land-applied waste residuals suffocate the life out of our waters. The volume of solid waste remaining is not significantly diminished and requires proper disposal (Iowa State University et al. 2002). The solid waste is often land applied

Methane emission from animal manure is not very high.

Anaerobic digestion does not kill pathogens in manure, nor produce a marketable end product.

as "fertilizer" or "soil conditioner" but can pose problems because anaerobic digestion does not remove antibiotics and heavy metals passed by dosed swine and poultry. In addition, although pathogen numbers decrease, the decrease may be ephemeral as the pathogens regrow (Gibbs et al. 1997). Numerous studies have demonstrated that these toxic and pathogenic contaminants are entering the environment in substantial concentrations (Giger et al. 2003, Huang et al. 2001, Kolpin et al. 2002, Union of Concerned Scientists et al. 2002). Further, digesters pose a risk of explosion and create both nitrogenous and sulfurous gases which may be emitted. In sum, the potential for methane digesters to partially mitigate some of the extensive and pervasive damage caused by CAFOs does not justify the use of this technology as a basis to support the development of new CAFOs. Their conclusion was that "power from poop" should not be publicly funded because "A fuel that damages the environment is not "renewable". The anaerobic decomposition of CAFO manure, like the decomposition of garbage in landfills, and waste-burning incinerators, is symptomatic of inefficient waste treatment, treatment necessitated by inefficient, wasteful industries, practices, and processes."

What about the other benefits of anaerobic digestion that have been mentioned – benefits such as the destruction of pathogens and weed seeds, reduction in manure volume, increased value of the digested manure as a fertilizer, and the marketability of the separated solids from the process. As for the destruction of potential pathogens and weed seeds, scientists have accepted a minimum of 55 C for at least 3 days to destroy potential pathogens and weed seeds. Most anaerobic digesters operate at temperatures of 35-40 C, which is lower than the accepted temperature requirements for pathogen kill.

Is the volume of the manure really reduced? The volume reduction is cited by the Ontario Ministry of Agriculture, Food and Rural Affairs at 5%, which is hardly a reduction. Is the value of digested manure increased as a fertilizer? There have been studies from Europe in the 1980s that showed that more of the nitrogen is in the ammonium form, and therefore is more available to plants. The other observation was that the pH of the digested manure is higher, which means that the potential for ammonia loss to the atmosphere is also higher.

There has been mention that the remaining solids from the anaerobic digester can be separated and sold as a soil conditioner. This is one of the marketing features of anaerobic digesters. Experience is showing that these separated solids still require further processing such as composting in order to achieve any marketable value.

What are we learning from our neighbors on the planet? We learn that anaerobic digestion is not really viable on its own, even with government support, and significantly higher prices paid for energy than residents and industrial users are currently paying.

Producing "green" energy from manure through anaerobic digestion requires taxpayer's $.

Most of the successful digesters in Europe require other inputs such as corn silage or off-farm wastes. The concept of centralised biogas plants has been developed in Denmark since 1987. Nielsen and Seadi (Biogas in Europe, A General Overview 2001) reported that 20 plants were operating in Denmark, with capacities ranging from 50 to 500 tonnes biomass (feedstock per day). Approximately 80% manure, mainly as slurry, is co-digested with 20% organic wastes from abattoirs, other food industries and municipalities. In Austria, the authors found that

centralized plants with a wider range of suitable substrates are proven to be more economic than farm scale plants, but subsidies on the investment costs are necessary for both of them. Their conclusion was that the most commercial and technically mature anaerobic digestion systems are those designed for the digestion of animal manure, both on and off-farm and in some cases for co-digestion of animal manure and residues from slaughter houses, breweries and a wide range of other food-processing industries as well.

In Canada, a report from Ontario has concluded that on-farm anaerobic digestion systems smaller than 300 kilo-watts (farms with greater than 3,800 dairy cattle or 973,686 poultry) is not financially feasible with electricity prices at $ 0.14 per kwh or without off-farm inputs. Incorporating off-farm organic material at a rate of 25% improved financial feasibility by increasing biogas production and offering the potential for tipping fee revenue. (Mallon and Weersink, 2007. The Financial Feasibility of Anaerobic Digestion for Ontario's Livestock Industries. Working Paper, University of Guelph Department of Food, Agricultural and Resource Economics, Guelph, Ontario).

Even closer to home, local anaerobic digesters have found that financial viability is difficult without taking in off-farm wastes. This has raised new issues for the Environmental Departments, which now has to deal with increased nutrients coming onto farms that already have too many nutrients for their landbases.

What does this mean for us in the Fraser Valley? First, we do not have any farms large enough for a digester to be viable without taking off-farm wastes. This means that we may need to have a centralized digester which requires transport of the manure from the surrounding farms to the digester, then transport of the digestate back the farms. This additional cost has not been factored into the Ontario financial feasibility analysis. Secondly, we risk the application of more nutrients from off the farm on farms that already have are applying too many nutrients from their current manure management strategy.

What is my recommendation on anaerobic digestion of manure to our Canadian taxpayers? I have to concur with the Sierra Club's recommendations and the conclusions of many of my farmer friends in BC, that anaerobic digestion doesn't address environmental sustainability of manure management in the Fraser Valley. In order to make this economically viable, the taxpayers will be asked to participate in paying to build the digesters, the cost of moving the manure to and from the digester, and the environmental bill for cleaning up the damage from the excess nutrients from the off-farm inputs that are required to make this technology work.

As for the excitement of reducing greenhouse gas emissions, it is negligible from poultry manure, and minimal from dairy cattle manure. I have to conclude that the greatest potential for anaerobic digestion of liquid animal manures is the reduction of nitrous oxide, or laughing gas, a greenhouse gas that is 200 times more powerful than carbon dioxide. Then again, trying to look at life more holistically, do we really want to reduce laughing gas emissions when we read almost daily about the increased concerns about our mental health? Perhaps there is another market opportunity with manure….?

The greatest potential for anaerobic digestion may be the reduction of nitrous oxide (laughing gas), but then considering the economy and our mental health trends, perhaps not...

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