# Agricultural Bioenergy Conference Report

for the

## 5th Annual Growing the Margins and 3rd Annual Farm and Food Biogas Conference

June 30, 2011


Prepared by:

Agrienergy Producers' Association of Ontario

Queen's University

Warren Mabee, PhD
Susan Wood, PhD
Lisa Cockburn, PhD Candidate
Trista Wood, MA Candidate

# Executive Summary

The Agrienergy Producers Association of Ontario (APAO) has partnered with Queen's University to deliver this report, summarizing the 5th Annual Growing the Margins and the 3rd Annual Farm and Food Biogas Conference. These meetings, held jointly between February 28 and March 1 2011, welcomed over 300 attendees, 50 exhibitors, and 60 presenters to the conference centre in London, Ontario.

The following report provides highlights from each of the plenary and parallel sessions in these meetings summarizing the challenges and opportunities facing the agricultural bioenergy sector as identified by speakers at these events as well as selected interview subjects, with emphasis on biogas-to-energy pathways. The report is intended to serve as a record of the presentations and discussions in each session based on notes taken by members of the research team present at each session. The purpose of this work is to accelerate the pace of innovation in this sector, and to facilitate the adoption of new technologies and management approaches within the Ontario agricultural industry.

Funding for this project was provided by Growing Forward, a federal, provincial, territorial initiative.

APAO has a mandate to develop biogas to its full potential as a clean, green energy source for Ontario and grow Ontario's biogas industry in the new sustainable energy economy. Queen's University is an educational and research institution with expertise in the areas of agricultural bioenergy and bio-foods.

## List of Abbreviations

AD – anaerobic digestion
CHP – combined heat and power
FIT – feed-in tariff
GHG – greenhouse gases
LDS – local distribution system
OPG – Ontario Power Generation
OPA – Ontario Power Authority
OMAFRA – Ontario Ministry of Agriculture, Food and Rural Affairs

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## Growing the Margins/Canadian Farm and food Biogas Conference

The 5th Annual Growing the Margins Conference and 3rd Annual Canadian Farm and Food Biogas Conference and Exhibition, held jointly between February 28 and March 1 2011, welcomed over 300 attendees, 50 exhibitors, and 60 presenters to the conference centre in London, Ontario. This document summarizes the lessons taken from this conference.

The opening plenary included talks from Elizabeth McDonald (Canadian Solar Industry Association), Don Jones (Agrienergy Producers Association of Ontario) and Don McCabe (Ontario Federation of Agriculture). The dominant message from this session was that Ontario is leading the way in the green energy field. Other provinces are watching to see what we do right or wrong - leading one to ask about how Ontario might work with other provinces to move this energy initiative forward. An important issue to address is the restructuring and decentralization of the energy industry, and the role of the government in picking 'winners and losers' when it comes to power. One message that could be taken from this session is the feeling that localized power does not seem to be prominent in the Ministry of Energy's plan, which is a concern particularly in relation to biogas-to-energy options.

A second plenary welcomed Karen Farbridge (Mayor of the City of Guelph), Bryan Goulden (Union Gas), and Colin Anderson (CEO of the Ontario Power Authority). The role of local government in promoting renewable energy was explored. While the City of Guelph has a target of 50% per capita reduction in energy use, and 60% less GHG per capita, the City does not see itself as being in the energy business, and sees their role in approvals and leadership facilitation in partnership with the private sector. At a regional scale, development of renewable energy was discussed; an issue with Ontario's Feed-in Tariff program is that it focuses on electricity, and not on developing other energy commodities such as gas in the form of biomethane injected into the gas pipeline. Broadening the scope of green energy in Ontario is encouraged. This led into a discussion of the OPA's agenda for the coming year, during which up to 4,000 MW of new power generation is expected. It was suggested that the vast majority of microFIT (small renewable electricity) projects will be connected, although some localized connection issues were acknowledged, and a backlog in applications for new projects exists. There were also questions about the potential role of heat and nutrients associated with biogas production, setting the stage for much of the discussion that followed throughout the conference.

The following sections provide a summary of the concurrent sessions for both conferences.

## 5th Annual Growing the Margins Conference

### Update on Solar Market Landscape (G1A)

This session featured Barry Buchanan (Electrical Safety Authority), Patricia Lightburn (Ontario Power Authority), and John Fuerth (Hydro One). The discussion covered the existing FIT and microFIT programs and suggested that a third program, the CFIT, will be introduced to accommodate projects by commercial aggregators. A key issue in the Ontario power landscape is system constraints; there are physical limits to how many connections can be made, and because of rapid uptake these limits are quickly being reached. This means that even capacity allocation exempt projects must now be screened for system upgrade requirements. Another concern is attrition rates, as the application barriers are minimal – it costs nothing to apply. A new rule requires confirmation from their local distribution company (LDC) before the OPA gives a conditional offer; this means that it will take longer to get a conditional offer, but increases certainty of ultimate success. The regulations around electrical connections are guided by Ontario law and must meet the Ontario electrical safety code. Some requirements are specific to the LDCs; the high degree of variability in available technology has caused challenges to standardizing the installation techniques and rules. This was an unexpected element of the FIT program because there was a general assumption that it would be fairly simple and a cookie cutter approach. The program will likely be reviewed in 2011.

While this session focused on solar projects, the discussion highlighted delays in the FIT and microFIT process. It was recommended that all projects be submitted as quickly as possible to deal with this problem. It was pointed out that biogas projects tend to be located in rural areas where there are no connection capabilities. Unfortunately, some have already been constructed and are ready to go on line; each applicant who was refused has received information about the specific connection issue. MicroFIT projects that were submitted last summer (pre-July) have been provided an extension until May 2011, but now some face further delay because of the connection issues. These will be connected but there is no guarantee when, so some people have made the investment and have no recourse but must rely on their LDC to figure out when. If there is still no connection availability after the 1 year extension has passed, it is unclear what will happen next.

### *Purpose Grown Biomass Crops – Opportunities, Innovations, Barriers (G1B)*

This session featured Donna Speranzini (Ontario Ministry of Agriculture, Food and Rural Affairs), Aung Oo (Bioindustrial Innovation Centre in Sarnia), and Naresh Thevathasan (University of Guelph). The session explored the use of biomass crops as a means of offsetting high energy prices in various operations. It is estimated that energy crops in Ontario could supply 8.75 Mt of biomass annually using ~ 15% total agricultural land (includes conversion of hay land and use of less productive land), and that corn stover and cereal straw could add an additional 4.5 Mt. The utilization of perennials such as miscanthus, switchgrass and willow as part of the long-term rotation could improve the soil and overall yields. Mixed energy crops minimize the risk of unsteady biomass supply, and native perennial grasses, such as tall grass prairie, can also be included in the fuel mix. The supply chain needs to be further developed, with third party harvesting organizations included and biomass supply contracts secured ~4 years in advance. Intercropping systems are shown to enhance soil organic C and biomass yields in a trial using willow clones, and winter drying reduced moisture content from 52% to 10%, bringing it to levels suitable for end-use processing. It appears that a close correlation exists between belowground root biomass, litter fall and biomass yield.

### *Operating Your Solar System Efficiently (G2A)*

Speakers in this session included Terrence Sauvé (Ontario Ministry of Agriculture, Food and Rural Affairs), Jaret HenHoeffer (Penguin Power) and Steve Ray (Essex Power Corporation, LaSalle, Ontario). This session explored ways of increasing the efficiency of solar systems but some of the lessons learned apply to a number of renewable energy technologies. Some solutions are technical: for instance, installing tracking systems, optimizing site and placement considerations, and choosing newer technologies can all provide major benefits. As with other sectors, the ground-mount solar sector is becoming more pragmatic as farmers realize individual projects have a life span and there are many hurdles along the way. Actual long-term downtime/operational issues centre on panel maintenance, inverters, and trackers. The same panel may make $2 some days, $50 others; variation is particularly pronounced over different months. There are reports of theft and vandalism, which are particularly of concern in remote locations; the importance of having good insurance for all projects was underscored. One issue that was emphasized was the impact of company evolution - when investing in new renewable energy technologies, will the company still be there in five years, or can parts be fixed by regular electricians or other tradespeople? Questions were also asked about the evolution of new technologies, but the consensus seemed to be that commercially established companies are going to continue to use traditional techs until new options are proven.

### *Biomass Crop and Processing Residues (G2B)*

Hilla Kludze (University of Guelph), John Mann (University of Guelph), and Nick Ruzich (University of Western Ontario and CENNATEK Bioanalytical Services Inc.) discussed the use of biomass crop and processing residues. Earlier Canadian studies have indicated that the cool and humid ecoregion of Ontario are characterized by higher soil organic carbon (SOC) decomposition rates, implying that more residual C input is needed to maintain certain SOC levels in Ontario soils. In terms of energy crops, the current focus in southern Ontario has been on *Panicum* (switchgrass), *Miscanthus* (miscanthus), *Populus* (poplar) and *Salix* (willow), which can be grown with minimal fertilizer inputs. Preliminary results indicate yield is influenced by planting dates; poplar, switchgrass, and the native mix all survived the establishment year while miscanthus and willow both had very low survival rates and were replanted the following year. Some specialty crops, such as Jerusalem Artichoke, have also been explored with positive results. The need for additional carbon input through effective rotation systems and the use of supplementary C inputs (including fertilizer applications, or potentially solids from anaerobic digestion) is shown to be very crucial. The University of Guelph has developed a five- step approach that allows for the estimation of removable residue under any type of cropping system in Ontario.

### *Carbon Trading I (G2E)*

Josh Lamont (Atlantic Dairy and Forage Institute), Charles Lalonde (CJ Agren Consulting Inc., Guelph, Ontario) and Fatima Abdulrasul (Ontario Ministry of Environment) discussed the impacts of carbon trading on bioenergy projects. Because the dairy industry is not a regulated greenhouse gas (GHG) emitter, farms can generate GHG offset credits and will not be expected to buy credits if GHG emissions increase in the future. On-farm emissions are dependent on management of barn and feeding, and handling of manure. One case study found the potential for significant income (>$7,000 per year) based on a low carbon price of $15/tonne. The Ontario government recently indicated it would proceed to implement a regulated offset program as a tool that supports the development of a low carbon economy for Ontario. Anaerobic digestion carbon credits belong to the OPA, as pursuant to Feed-in Tariff contracts, but there are strong concerns that a variety of green energy contacts pass on risks to producers and the revenue share is inadequate; there is need for an agriculture-friendly option as a negotiation tool. An opportunity may lie in pooling carbon credits from several farms, which can create sufficient volume and keep the benefits within the agricultural sector. A business model for a prospective aggregator entity is being explored; this type of organization would trade offsets, address farm contracts and record infrastructure through partnerships, direct scientific priorities to support agriculture's interest and encourage commodity based approaches for Carbon Footprint determination that will identify areas for future carbon reduction.

### *Looking to Future Solar and Wind Systems (G3A)*

This session featured Mathias Leon (University of Guelph) and Lori Gallaugher (Ag Energy Co-operative Ltd.), and discussed the future of some renewable energy technologies. Interesting new opportunities include a solar-biomass hybrid air heating system with thermal storage, being designed for greenhouse applications. Such an opportunity could provide a reliable and economic alternative to fossil fuel-fired air heaters. A study on such a system reveals promising thermal performance in 45-50$^0$C range, and the ability to supply hot air at 55$^0$C & 80 $m^3$/h continuously during day & night, at both sunny/partially cloudy and fully overcast/rainy weather conditions. Such combinations may eventually be combined with flexible thin-layer solar panels, which is lightweight, durable, can be rolled for easy installation; challenges remain with efficiency, but such systems would have the advantage of easy deployment on existing structures.

### *Biomass Conversion Technologies (G3B)*

Idris Sule (University of Guelph) and Mohammad Rahbari (CENNATEK Bioanalytical) discussed development in biomass conversion technologies. One approach that is being explored is torrefaction, which provides advantages for storage and transportation as well as increased energy density by producing a solid fuel with lower moisture content, hydrophobic properties, and reduced smoking. Experiments using rice husk, sawdust, peanut husk, banagrass and water hyacinth show that original water content of biomass feedstock has a significant impact on the length of time and energy input of torrefaction process. Recovery of nutrients from various agricultural residues and purpose-grown crops was also considered; these include alkali metals, alkaline earth metals, silica and chlorine, the presence of which adversely impact reactors, furnaces, heat exchanger, turbines, and emission control devices. Technologies such as the electrostatic extraction of silica through corona charging or induction were discussed, as was industrial leaching of nutrients through immersion or spraying/pouring and recovery through reverse osmosis or chemical precipitation. Nutrient recovery technologies may be a significant opportunity in many types of bioenergy production, including anaerobic digestion, as the value of these nutrients can help drive the economics of conversion.

### *Carbon Trading II (G3E)*

In this session, Mahendran Navaratnasamy (Alberta Agriculture and Rural Development), Susantha Jayasundara (University of Guelph), and Morgan McDonald (Offsetters, Vancouver, British Columbia) discussed issues around carbon trading. The amount of bio-energy that may be produced using manure and agricultural residues is estimated to be 21-39 PJ in Alberta, or approximately 50% of the total energy demand by the agricultural industry in the province. The impact of anaerobic digestion (AD) technology may reduce annual $CH_4$ emissions from manure management by as much as 81%, based on an analysis done in Ontario. Close to 4% of volatile solids that are currently managed as liquid slurry in the dairy cattle sector could be managed using AD systems with biogas recovery. If AD technology were extended to all dairy farms with 363+ animals per farm, a potential reduction of 42% of the total annual $CH_4$ emissions from dairy manure management could be expected in Ontario. Carbon taxes, such as those implemented in British Columbia, remains a relatively small premium on the cost of energy and our use of energy is fairly inelastic – we need to buy it no matter the price. Interestingly, the carbon tax can be stacked with other carbon market instruments. In combination, these can put real pressure on companies to incentivize energy conservation, fuel switching, uptake of renewables, and changes in facility design and operation.

### *Business Considerations for Solar Systems (G4A)*

Kris Taylor (Essex Power Corporation, LaSalle, Ontario), Albert Schoeley (KPMG LLP, Waterloo, Ontario) and Use Baker (Ontario Mutual Insurance Association) discussed business consideration in developing renewable energy technologies. A number of factors significantly alter the perceived return of investments, including rates of asset depreciation, taxation rates, and insurance. Each of these areas must be considered in developing renewable energy projects, and it is important to understand how these differences work. Taxation rates for renewable energy projects, including solar systems as well as anaerobic digesters, are different than those applied to farm income. In addition, Capital Cost allowances, ownership, and the role of renewable power on residential properties must be considered. The specific risks to each project must be clearly identified in advance, as these will affect the overall rates and the time required for an appropriate insurance policy to be developed.

### *Biomass Markets – Small and Large (G4B)*

Hilla Kludze (University of Guelph), Harold Rudy (Ontario Soil and Crop Improvement Association), and Richard Painchaud (Innovente Inc.) discussed small and large biomass markets. Developing these markets starts with developing feedstocks; the University of Guelph suggests that miscanthus, switchgrass, and sorghum look best for cropping, with miscanthus being best for combustion, and sorghum best for versatility. Miscanthus as a C4 perennial offers good growth rates after the first year, receiving an extra month of sunlight interception and having good winter standability. Switchgrass is currently the most planted; because it is native to Ontario it involves no technology change. Yields were switchgrass are reported as between 10-13 dry tonnes/hectare, compared to miscanthus at 7-15 dry t/ha, and native grasses at 5-10 dry t/ha. Most of the current biomass projects are in southern Ontario. New technologies and approaches, such as the 'biodrying' system being developed by Innovente, may provide new avenues to increased efficiency and economy. The Innovente process, which combines anaerobic digestion with biodrying and combined heat and power production, can handle 50,000 tonnes/year organic waste, provide 4.6 MW of electric (or 40,000 MWh/yr), 10 MW heat, and 7,000 tonnes/yr of fertilizer (N-P-K) at a cost of about $25 million per plant.

### *Beyond MicroFIT – Farm based Solar Systems (G5A)*

Dan McDonald (Ontario Ministry of Agriculture, Food, and Rural Affairs), Rolf Maurer (Arntjen Solar NA Inc.), and Thomas Boehn (Solarzentrum Ostschweiz Ltd., Switzerland) discussed the development of larger solar power projects on farm, both on buildings and in fields. While many rooftops on rural buildings provide large, unobstructed surface areas for solar PV installations, some rural landowners are uneasy about making significant investments on the rooftops of these buildings because eligibility and regulations are unclear. Issues include shading, how to utilize back slopes, and how to set up systems with access points to allow for cleaning and maintenance. In fields, there are methods to minimize the crop land foot print of the project (such as planting crops between the panels or installing the panels in fence row or laneway lines). Minimizing capital cost while optimizing performance of the system is necessary to achieve adequate financial returns for these projects.

### *Biomass Markets for Large Projects (G5B)*

Chris Young (Ontario Power Generation), Lovleen Bassan (Ontario Power Generation) and Helma Geerts (Ontario Ministry of Agriculture, Food and Rural Affairs) and Kaji Kado (PPD Technologies Inc.) focused on biomass markets for large renewable energy projects. Ontario's Long Term Energy Plan includes phasing out coal-fired electricity generation, maintaining nuclear power at 50% of capacity, and increasing hydro and renewables (particularly wind) under an increased conservation program. To meet this plan, OPG is currently looking for agricultural and woody biomass partners, but seems to be downplaying the role of smaller projects (including biogas). Commercial agricultural biomass could be used for extensive combustion-to-electricity capacity; a working group is currently active in developing business plans, recommendations of appropriate crops, analyses of the supply chain, and OPG needs. A key issue is not just the production of biomass, but the heterogeneity of this feedstock and the logistics involved in transport and storage - for example, GM has used biomaterials to make autobody parts but could never get a uniform quality of biomass, which killed the project. Use of biogas as a 'processed form' of biomass may help to meet some of these challenges - a biogas industry allows methane gas sales, electric sales, local hot water/heat sales. Policy issues and high investment risks need to be worked out to address market uncertainty, production variability, and viable lifecycle analyses; essentially, we do not know enough yet to know we are making the right decisions.

### *Community Energy (G5E)*

The Partnerships Grant Program application workshop provided step by step instructions on how to apply for up to $200,000 in early stage development grants for biogas and other renewable energy projects. One on one meetings with potential proponents followed, led by Evan Ferrari & Laura Tozer (Program Managers with the Community Energy Partnerships Program).

### *Monitoring and Trouble Shooting (G6A)*

Steve Ray (Essex Energy Corporation, LaSalle, Ontario), Adam Webb (Sentinal Solar Systems, Woodbridge, Ontario) and Steve Clarke (Ontario Ministry of Agriculture, Food and Rural Affairs, Kemptville, Ontario) talked about monitoring and trouble-shooting issues around renewable energy projects, particularly solar projects. Specific issues addressed include the monitoring of small systems; many solar owners have opted out of monitoring, either because their provider did not offer it, or because a 'do-it-yourself' installation was chosen. Recurring issues of concern to operators, particularly those without monitoring services, include high line voltage, weather, and panel and connector concerns. The evolution of technology - such as new inverter development for solar projects - may take cost out of the system and save installers and proponents money, but the rapid state of development emphasizes the need for highly trained personnel who are aware of the current state of technology and who can ensure that installations are carried out correctly. Increasingly, standards (such as those available for solar panels) allow proponents to compare different technologies by properties, improving the potential for optimal technology selection.

### *Bioproducts and Biofuels (G6B)*

This session featured Leon Hinger (Highmark Renewables Research), Rob Nicol (University of Guelph) and Lloyd Helferty (Biochar Ontario), who focused on bioproducts and biofuels development. An integrated biorefinery approach can deliver multiple benefits - for example, a case study in Alberta produces 40 million litres per year of wheat-based ethanol, as well as 5 MWe biogas from 36,000 head of beef cattle fed on mixed grasses and grains. In this case study, the avoidance of coal-fired electricity, production of urea, land spreading of digestate, and substitution of natural gas, a total reduction of 83,800 $CO_2e$ / year was achieved. A second case study, exploring ethanol production in the Midwestern US producing 200 MLPY corn and 17 MWe of biogas, achieved reductions of 381,700 $CO_2e$ / year. One potential coproduct of biorefining, biochar, is a climate mitigation tool as it sequesters solid carbon in a form that can remain stable in the soil for thousands of years, allowing farmers and land holders to potentially gain carbon credits while improving soil quality. Challenges include tight margins, volatile competition for commodities, cost of ASTM quality control testing for retail (particularly for biogas and biodiesel), and the US blender's credit (not available in Canada). Solutions include extending the value chain, expanding the Federal government's ecoEnergy program, and developing carbon credits.

## *3rd Annual Canadian Farm and Food Biogas Conference*

### *Lower Cost Methane Recovery (B1C)*

William Jewell (Cornell University), Benjamin Strehler (CH-Four Biogas Inc.), and Theirry Ribeiro (Lasalle Polytechnique Institute, France) explored low-cost methane recovery systems. An opportunity is small-scale farm-based biogas projects (i.e. farms with 100 or fewer milking cows). The Rural Management Act caps off-farm substrates for bioreactors at 25% of total feedstocks, which is a major regulatory barrier to small scale operations that require closer to 50% additional inputs. Currently, production becomes viable at 250 kW (milking 300+ cows to provide enough manure). One opportunity to handle this problem is the use of biomass feedstocks in addition to manure and other residues. A four year study was conducted comparing various stains of reed canary grass with switchgrass and wild grass in terms of biodegradability and kinetics. Nutrient and water requirements, changes in storage over 4 years, and potential energy were measured. Reed canary grass and switchgrass were close in efficiency though switchgrass requires more management; the conversion efficiency of reed canary grass was higher than expected but slow, with a long retention time required. No apparent biodegradability change was found after 4 years of storage. One important factor was that, while moisture content didn't affect digestibility, dry grass requires much more water (10 times water to feed ratio). Challenges include storage of biomass, different digestion rates, and different retention times. It may be possible to deal with these challenges through specific technological applications, such as microware pre-treatment which can increase organic matter accessibility and improve degradability (bringing digestion rates and retention rates in line for different feedstocks). A test case found that more methane is produced in less time, but that the energy balance is unfavourable under these experimental conditions; this could potentially be improved by decreasing water volume and/or increasing sample mass. There is also a need to develop microwave equipment in order to optimize heating rate and to scale up to pre-industrial and industrial scales. The regulatory climate needs to be more flexible in order to encourage new technologies.

## *Innovations in Europe and Around the World (B1D)*

Nadeem Afghan (BIOFerm Energy Systems), Catie Lewis (entec Biogas USA), and Ben van Ree (Maple Reinders) reviewed some global innovation in biogas production. One innovation is the BIOFerm™ dry fermentation anaerobic digester, which can recover energy from organics that would otherwise be landfilled and produces a usable by-product, pre-process compost. The first North American facility will be built in Wisconsin with Oshkosh, using up to 8000 tonnes of agricultural waste and source-separated organics (SSO) (6000 tonnes to start) with an installed capacity will be 370 kW (the engine manufacturer is GE Jenbacher). A project in Benet, France has been developed to handle a variety of post-market waste (including waste alcohol, bakery waste, sewage sludge, food waste, yeast, pet food, etc. from grocery stores, other commercial generators, food processors, and grease traps). Preprocessing aims to produce a clean slurry material for the digester; food waste diversity is the most challenging part of a food waste-to-energy plant. Another project treats wastewater from an ice cream plant, which has very high fat content (36-42% fat based on COD). Fat is skimmed from the wastewater and then processed via the Compact BIOPAQ® AFR process, followed by desulfurization using THIOPAQ®, a biotechnological process that converts $H_2S$ to elemental sulphur. Desulfurization enables efficient reuse of biogas in engines and boilers by reducing corrosion, allows biogas to be upgraded to natural gas quality, and reduces $SO_2$ emission. The importance of matching wet vs. dry streams with appropriate feedstocks was discussed.

## *Managing Digestion (B2C)*

The issue of managing digestion was explored by Tom Ferencevic (Yield Energy), Victoria Hilborn (PlanET Biogas Solutions) and Torsten Fischer (Krieg & Fischer Ingenieure GmbH). New solutions such as simulation modelling, physical and chemical analysis of feedstock and in-situ digestate, are available to help avoid problems, particularly during the five stages of starting up a project, which include (1) initial fill, (2) heating, (3) initial feeding, (4) ramp-up to full feeding and (5) evaluation and response to technical difficulties. Specific advice for new projects include not starting construction until 100% of feedstocks are known, as well as alternative feedstock availability. Dairy manure is preferable at start-up because typical cow manure doesn't have the right organisms. The aim of a new plant is a full load in a preferably short period of time: cannot start too fast because biology will collapse and cannot start too slow because you will lose money. Most liability lies on the operator so it is important to ensure enough training. A standard start-up and commissioning approach in the Ontario biogas industry would help increase the success of AD facilities. There is a record of success in Ontario to build on: for example, there have been no explosions in Ontario, which might ultimately support the entry of more actors to this space, and perhaps lead the insurance sector to lower premiums.

## *Tying Municipal Organics to Biogas (B2D)*

Ross Slaughter (Genivar Consultants), Graeme Millen (CH-Four Biogas Inc.) and Trevor Nickel (Highmark Renewables Research) explored the concept of tying municipal organics to biogas. One small project, located in

Ontario, can manage 40 $m^3$ of dewatered septage per day plus about 5 $m^3$ of farm or other organic waste. Interestingly, while this plant originally looked to co-digesting waste and biomass, it was found that costs for corn stover would be too high. The project is about 100 kW, with expansion to 300 kW expected. The total project cost was $3.8 million and will receive 16 c/kWh (about $1.667 M provided by government under stimulus funds, so actual price is somewhat lower). Some broad benefits to the uptake of biogas-to-energy were discussed. One benefit is the ability to add new technologies on to existing or new projects; for instance, it's relatively easy to improve nutrient recovery associated with a pre-built AD plant. There is also synergy between the human capital required to manage municipal waste and to install and manage on-farm AD technologies. Feedstocks are the most critical aspect to the development of the project, and need to be quantified in every proposal. Barriers that need to be addressed include management of expectations, feedstock availability and suitability, and renewable energy approval (regulation and legislation). The Green Energy Act is seen as a barrier - although it was supposed to streamline the process, no biogas projects have been approved, and costs are high and unpredictable. An opportunity that exists with municipal wastes is the addition of tipping fees, which are not present with on-farm wastes.

### *Co-Digestion Substrates (B3C)*

The potential for co-digestion of different substrates in anaerobic reactors was discussed by Ashwani Kumar (Global Water and Energy, OVIVO), Doug Carruthers (Organic Resource Management), and Abdel Samie Felfel (George Morris Centre). Co-digestion is a clear opportunity for anaerobic digestion, but optimizing feed mixture development for full scale co-digestion projects is a challenging task which becomes more complex with stringent fertilizer and digestate treatment requirements. Economic evaluation of each of the feed substrates is necessary to determine the risks vs. gains in co-digestion. The mixture of substrates should remain approximately the same, with a little bit of room for variation. Separating trash or contaminants from waste streams can be carried out via technology (i.e. bioseparators) or via education - generators need to know that they are producing organic residuals, and not waste. Feedstock opportunities include expanding sources, expanding capacity, and feedstock optimization, while facing challenges of substrate characterization, collection and processing logistics. The existing FIT does not really support this approach, as it does not allow sufficient flexibility. Improvements in project planning, and OPA and the Ministry of Energy must get more involved with the workings of biogas. Waste management is very cost sensitive and it is easier to throw something out than to hire someone to use it, so substrates with higher energy value require a lower tip fee and vice versa. The estimated value of food waste in Canada is $27B annually. Right now, it is too easy and too cheap for processors to dump and policy supports farmers to overproduce.

### *Direct Pipeline Injection (B3D)*

Sean Mezei (Flotech Services), Scott Graham (FortisBC), and Drew Everett (Union Gas) talked about incorporating biogas directly into pipelines. Biogas upgrading, which is required to facilitate this type of use, involves enriching the methane component of biogas to make it interchangeable with natural gas: it costs from about $2.5/GJ for larger systems, and up to $10/GJ for small systems. There is a trade-off between cost and biogas purity but cost for a purer product will likely go down over time. Agricultural feedstocks are better for biogas production when pipelining is being considered, as industrial waste streams can contain sulphur compounds and other contaminants. There were questions about shale gas and the impact it might have on future pricing of natural gas, and whether this might reduce demand for biogas. In British Columbia, Terasen actually sees biomethane as a separate product and is trying to avoid linking it with natural gas costs. Union Gas is interested in enabling the injection of renewable natural gas from agricultural and municipal waste, as well as landfill sources, but cautions that there is a one-way flow through the gas grid, so adding new production to the line can only happen "upstream"; therefore there are limited locations where the addition can happen. Union Gas is working towards a renewable biomethane reference price - i.e. a premium price that can be put forward to the Ontario Energy Board. A key lesson is transparency: there is a need to show reference pricing and providing a means by which companies can see exactly what the offer is. Finally, there was speculation on the impact that OPG might have on natural gas availability and pricing, if the Nanticoke plant were shifted from coal to natural gas (instead of biomass). This is apparently being incorporated into planning, but the lessons do not seem to be communicated with the farms and municipalities that might be called upon to produce biogas.

## *“Show & Tell” Session on Engine Technologies*

Gerhard Klammer (MWM Canada Inc.), Jan Buijk (European Power Systems), and Aaron Tasin (Capstone Turbine) provided some demonstrations of new engine technologies. The boom in the biomass fermentation segment in Europe has greatly increased the knowledge of biogas operation both qualitatively and quantitatively – especially in regard to critical factors. Harmful substances in biogas – sulphur compounds, silicone compounds high moisture content influence the engine, maintenance and operating costs, the gas supply, the exhaust system and the availability of the engine. Engines are operating at three Ontario based biogas plants. Recent technology developments bring gas engine based CHP technology to a new level of operating experience with the first high efficiency gas engine CHP systems now being introduced into the Canadian market. A new technology, the microturbine, has emerged on the biogas market that simplifies installation and daily operation. Benefits range from no need for $H_2S$ cleaning and simple electrical integration, to once a year scheduled maintenance with no oil changes.

## *Economics and Operations (B4C)*

Robert Anderson (University of Guelph), Donald Hilborn and Chris Duke (Ontario Ministry of Agriculture, Food and Rural Affairs) and Jonathan Cheszes (Navigant Consulting) explored some of the challenges associated with economics and operations of biogas-to-energy projects. The Ontario Agricultural AD Calculator, a tool for assessing the economic feasibility of biogas facilities on Ontario farms, has been developed to help farmers assess expected quantifiable benefits and costs associated with construction and operation of these projects. The variables with the top 3 most significant effect on return on investment were price of sold power, price of system (capital cost) and electrical efficiency. Costs of material input (on farm or tipping fees) ranked fourth and project lifespan fifth or lower. Transportation costs did not rank very high. Spreadsheet predicts current practices should not include energy crops, should blend off-farm materials, and systems >100kW will be most viable. The Ontario FIT program can provide farms with return on expenditures (ROE) of greater than 20% when considering all contract provisions and outperforming base case assumptions.

## *Urban Sourced Organics for Biogas Systems (B4D)*

David Sanscartier (University of Toronto/ University of Saskatchewan), Rolfe Philip (Yield Energy) and Michael Brown (Bio-Methatech) explored the use of urban-sourced organics in biogas systems. In one case study, it was assumed that AD replaces landfill systems, and that coal and natural gas are used for electricity (pre- and post-2014). The estimated net GHG reduction associated with replacing landfill with AD technology could be as high as 860 kg $CO_2$-equivalent/t organic waste, and there is a large improvement in Internal Rate of Return as the scale of facility is moved from 2.3 MW (50,000 t HSSOW) to 7 MW (200,000 t HSSOW). It is estimated that there is about 6.6 million tonnes of residential and commercial waste available in Canada per year. Because restaurant feedstocks can have up to 15% contaminants, it’s important to plan for the impacts that these contaminants can have, including decreased volume for processing and ultimately reactor shutdown. The solution is to know your feedstock, which can help define solutions ahead of time in a proper planning process. A project in the city of Saint-Hyacinthe (just north of Montreal) was showcased, which is using anaerobic digestion technologies to deal with sewage sludge, a project that will eventually include additional process steps and capacity to accommodate both residential brown bag and local food producer waste streams, with the majority of product being upgraded and injected into the natural gas grid.

## *Case Studies (B5C)*

Presentations on specific case studies were given by Elise Villeneuve (Bio-Terre Systems), Jean-Claude Corbeil (Valbio Canada) and Kevin Shiell (New Brunswick Community College). The first of these case studies was built on a farm with 725 dairy cows by a company (Revolution Energy Solutions LLC) which designs, owns and operates projects on privately held farms. The system takes manure directly, with no concentration or mixing of feedstocks required within the process, except at start-up. The second case study, by Valbio Canada, uses phased AD technology for better control and higher pathogen destruction, as well as greater reactor productivity. This case study highlights the need to stick with a robust design, and do a feasibility study in advance; attempts to lower costs led to long and costly delays in this project. The feasibility of 100 kW projects was discussed, and the value of digestate as a fertilizer which can be used to replenish phosphorus and potash in soils was emphasized - the project is seeing increases of 100% in the value of hay on land that is being treated with the digestate, reducing costs for protein by half, which in turn increases feasibility. The final case study presented is Atlantic Canada's first on-farm biogas plant, which has been installed on a dairy farm which has about 100 milking cows, in partnership with McCain Foods in Grand Falls NB. McCain provides food waste (pizza crusts, French fries, and potato peels), avoiding landfill costs of about $300,000 per year. In this project, as in others, the digestate is used as a liquid fertilizer. Future projects attached to this study include adding a hydrolysis tank (working with Novozymes, which would be potentially the first Novozymes biogas project in North America). This process is currently only viable because of the tipping fees from McCain for food waste - particularly given the absence of FIT incentives.

## *Community / Co-op and Large Biogas Systems (B5D)*

The role of community or cooperative programs for large biogas systems was explored by John Stephenson (FVB Energy Inc.), John Hawke (Angus Power), Daniel Bida (ReGenerate Biogas), and Ron Cocking (Toromont CAT Power Systems). Combined heat and power, supported through district energy systems, is seen as a bridge to renewable energy because it addresses the economic challenges of biomass to energy conversion technologies; heat sales are key, and an ambient temperature of 21°C can be supplied from a waste product. Denmark now has well-thought out policy initiatives to support expansion of CHP. A community biogas system is being installed at the Toronto Zoo, which is shifting from composting to a 500 kW biogas project that will process strictly zoo waste (mostly manure) and food waste. The original plan, which would run multiple pipes to carry waste heat back to zoo structures, encountered problems; the project is now using excess heat to warm a greenhouse to grow bamboo. This project will reinvest any profits, doubling the intake from the waste food supplier; if additional funds remain, they will support start-up of other community biogas initiatives. The solid digestate will be marketed, but liquid will be sold directly to local farmers. It is estimated that 80% of carbon credits generated will go to the government. Obstacles to expanding community-based power systems include the high likelihood of remote siting, as many landfills are located a long way from the end user, as well as connection cost and the type of incentive offered. This last point has been demonstrated by the absence of biomass/biogas representation in the latest FIT announcements.

## *Fitting into Smart Grid (B6C)*

Jennifer Green (Agrienergy Producers Association of Ontario), Chris Ferguson (Carbon Control Systems Inc.), and Benjamin Strehler (CH-Four Biogas) discussed the integration of biogas-to-energy options into the smart grid. It is important to examine projects seeking grid connections to analyze barriers. It is emphasized that farm power = manure plus house waste + anaerobic waste = electricity, digestate and heat. The experiences to date for biogas developers have demonstrated that a plug and play approach to support renewable energy developments is not yet available in Ontario. Key policy barriers include the need for long term power contract, faster environmental approvals, and a more equitable FIT rate. Technical barriers include operations and maintenance, fuel reliability, geography, and grid connections. Connection challenges involve the location of the biogas production facility, which needs to be located next to fuel source in rural settings, so connections in rural areas are further down the road and generally are connecting to the lowest-quality, poorest part of the grid system. Utility feeders are designed to distribute electricity, not connect generators, adding complexity. Single phase lines are predominant in rural areas, which limits biogas plant capacity to 100 kW (long distances make it cheaper to run a single line, but quality is poor). Small farms on average have 50 -70 cows, and the FIT requires feedstock for biogas to come mostly from manure which limits size. It was emphasized that costs for substrates are changing and increasing – what was once free now has a price tag, and the transport cost remains a significant component.

## *Management and Business Practices (B6D)*

This session featured Patrick Ley (Miller Thomson LLP CleanTech Group), Johan Veldhuis (Landmark Projecten B.V., Hengelo (Ov.), Netherlands), and John Hawkes (Angus Power). Good management includes knowing your neighbours, and developing good lines of communications about expansion plans. It was emphasized that in litigation, being right doesn't matter - take things seriously and deal with concerns promptly and genuinely. If a farmer is taken to the Farming and Food Production Protection Act (FFPPA) due to odour, noise, etc., and wins their case, it is unlikely that the neighbour can still sue them for nuisance, as this step has transformed the activity into a normal farming practice. Projects require (a) technical feasibility and (b) financial support. There are a few reasons that biogas hasn't moved as quickly as other technologies - solar and wind are simpler technologies with very predictable costs, and the FIT incentive in Ontario is substantial relative to the cost of each. One of the key elements is a guaranteed feedstock for an extended period (i.e. 20 years), which is unlikely unless the ecosystem is completely closed - i.e., unless the farmer owns the land and can reasonably guarantee the production levels over that period. The Ontario Power Authority seems to have a bias against biogas - the fact that power outputs are relatively low on a per installation basis doesn't seem to work well within the OPA system.

## *Summary*

The 5th Annual Growing the Margins Conference and 3rd Annual Canadian Farm and Food Biogas Conference and Exhibition of 2011 showcased a number of interesting speakers and topics directly related to biogas-to-energy pathways. This report has summarized the presentations and discussions and therein captured the current challenges and opportunities facing the agricultural bioenergy sector. In having documented the status of the sector in this manner, it is anticipated that greater discussion and dialogue can continue to accelerate the pace of innovation in this sector, and to facilitate the adoption of new technologies and management approaches within the Ontario agricultural industry.

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## *Appendix A: The Future of Biogas-to-Energy in Ontario*

When organic material breaks down in an oxygen-free environment — a process called anaerobic digestion — it produces a mix of methane and carbon dioxide called biogas, as well as a nutrient-rich slurry. That biogas, in turn, can be burned as a fuel in a boiler or furnace, used to run a generator to create electricity and heat, or cleaned and concentrated for use as a natural gas replacement. In Canada, manure is generally the primary feedstock in farm-based systems, but many other materials can be digested, including energy crops, food industry products and by-products, and organic wastes from municipalities. The quality and characteristics of feedstock used in the production of biogas can be an issue - recent reports have observed significant variation in the amount and quality of gas production associated with different feedstocks, both in energy crops and in the manure associated with different livestock feeds (Amon et al. 2007). There are other, potentially controversial feedstocks for anaerobic digestion. Gilroyed (2010) examined the use of anaerobic digestion to handle specified risk materials (SRM) including diseased livestock tissues and other elements of meat and bone meal which might otherwise be used as feed for livestock. This study indicated that the use of SRM as a co-feed for anaerobic digestion (at 25% of feed) could increase methane production by over 160%, offering a means of deriving economic value from the disposal of SRM.

There are a number of different reactor designs available, and advances in computerized control and sensor technology has greatly increased the ability of small farms to utilize this technology (see Karmakar et al. 2007). Although this paper does not describe different pathways, there are many resources available both online and in the literature that describe these approaches and the construction techniques associated with different projects (see OMAFRA 2011a, Nazir 1991).

While anaerobic digestion is widely used in Asia and parts of Europe, Canada has lagged behind until recently, with a number of projects coming on line in recent years. Currently, there are about 20 farm digesters operating across the country, with 13 known installations in Ontario and another 14-15 projects underway at the time of writing (IEA Bioenergy Task 37 2011). As stated, there is less emphasis on energy crops or co-digestion in Canada, with most projects focused on manure management. The provincial Ministry of Agriculture, Food and Affairs (OMAFRA) has stressed that revenues from manure digesters are not the only considerations and environmental benefits associated with anaerobic digestion of manure need to be assessed. This theme was strongly echoed at the Conference in March 2011.

There are significant differences in the anaerobic digestion industry between provinces. The lack of clear economic drivers means that the industry is growing slowly. Many suggest that some form of environmental credits – a price on carbon, or credits for specific greenhouse gas emissions – is needed as an economic driver for the industry. The nature of the provincial/federal split in responsibilities means that there is no comprehensive strategy for biogas in Canada, but rather a series of individual strategies set province by province, leaving farmers in different jurisdictions to organize among themselves to lobby or advocate. Recent reports suggest that the limitations in electricity uptake have brought renewed attention to upgrading biogas for integration into the natural gas grid (IEA Bioenergy Task 37 2011).

In an analysis of potential policies to support biogas production in Nova Scotia, it was found that green energy credits would provide the highest financial returns, compared to cost-sharing or low-interest loans (Brown et al. 2007). To date, however, few jurisdictions in Canada have provided significant support mechanisms. Ontario’s funding has largely flowed through two mechanisms: initially, funding was made available through the introduction of a Renewable Energy Standard Offer Program (2006), and more recently through the Feed-In Tariff (FIT) program under the new Green Energy and Green Economy Act (2009). Ontario's FIT program offers guaranteed prices for green electricity generation, for eligible projects across a wide range of technologies (including biogas-to-electricity) that pass quantitative tests related to the cost and availability of transmission capacity (Ontario Power Authority 2011). There are four broad categories based on fuel type: bioenergy, including biomass, biogas and landfill gas; solar; hydropower; and wind power. Tariffs range from 10 to 20 ¢/kWh for bioenergy; 44–80¢ for solar; 12–13¢ for hydropower; and 14–19¢ for wind powered facilities (Yatchewa and

Bailiauskas 2011). Tariffs were originally designed based on a targeted 11% rate of return. As of August 13, 2010, on-farm biogas benefits from FIT rates of 19.5 ¢/kWh (projects <100 kW) to 18.5 ¢/kWh (>100 kW). Other biogas projects (i.e. carried out by municipalities or by industry) are offered slightly lower rates of 16.0 ¢/kWh (≤ 500 kW), 14.7 ¢/kWh (more than 500 kW but less than 10 MW), or 10.0 ¢/kWh (>10 MW). Landfill gas-to-electricity projects qualify for rates of 11.1 ¢/kWh (≤ 10 MW) or 10 ¢/kWh (> 10 MW) (Ontario Power Authority 2011). Biogas projects of less than 10 kW qualify for the microFIT program, which offers 16.0 ¢/kWh for all projects in this size range. The offered prices are designed to provide a reasonable rate of return based on projected project costs, assuming a 20-year contract term and that 20% of the contract price escalates at CPI for all technologies. It has been suggested that, unless the cost of various renewables (particularly solar) drop dramatically, the FIT program may not be politically sustainable (Yatchewa and Bailiauskas 2011), and the upcoming election (scheduled for October 2011) may serve as a test for this policy.

In addition to the Feed-In Tariff program under the Green Energy and Green Economy Act, Ontario provides a Biogas Systems Financial Assistance Program which is delivered by the Ontario Ministry of Agriculture (OMAFRA 2011b). This program ran from 2008-2010 and provided financial grants for design and construction of biogas systems (total investment - $11.2 million), designed to kick-start the biogas industry in Ontario. It has funded up to 27 biogas plants (with some plants still under construction or in planning phases), and 48 feasibility studies. Other potential funding sources include the Canada-Ontario Farm Stewardship Program and the Agriculture Flexibility Fund (OMAFRA 2011b).

While the production of electricity may be seen as the primary output of a biogas operation, it has been noted that other benefits - including non-economic factors - are also important. These benefits include the mitigation of greenhouse gases (particularly methane), cost savings in manure management, improving the nutrient content of processed manure (suitable for spreading on fields) , odour and pathogen reduction and waste diversion from landfills. Taken together, these benefits can significantly impact the economics of a biogas operation; if the value of this benefit is taken at $15,000 annually for a small- to mid-size farm, the total economic return for a biogas installation shifts from negative to positive (Yiridoe et al. 2009). Some valuation of the additional benefits of biogas production is already being explored - for example, Solomie et al. (2010) suggest that the digestate associated with anaerobic digestion should be considered a green fertilizer, providing a lucrative source of potential revenue and perhaps lessening the environmental burden of long distance transportation.

## *Strengths*

Operation and Maintenance

Biogas is a versatile product that has the ability to deliver a diversity of products beyond electricity: heat, bio-sourced natural gas (biomethane) and nutrients (bioproducts). Among the many benefits associated with biogas production via anaerobic digestion are the ability to increase the availability of nutrients by creating a solid or liquid digestate that performs similarly to commercial fertilizer, use of solid materials for animal bedding, the capacity to reduce manure odour and pathogens , the potential to increase revenue through the sale of renewable electricity and/or the collection of tipping fees from off-farm material (OMAFRA 2011b).

Technology

There are a number of technological innovations improving ability for digesters to efficiently process waste streams of varying purities and heterogeneities. Partnerships and synergies between different feedstocks and waste streams are being developed. A new technology, the microturbine, simplifies installation and daily operation. Benefits include simple electrical integration and maintenance and no need for $H_2S$ cleaning. Another promising innovation is torrefaction of biomass, as it offers advantages in cost per BTU, transportation, and storage.

Feedstocks and Sustainability

Biogas infrastructure, while primarily used to handle solid and liquid wastes from livestock production, has other applications. In parts of Europe, for example, biogas production from silage – biomass harvested and digested without the application of water, manure, or slurry – is being explored. A recent study compared conventional anaerobic digestion of biomass crops with a modified process that utilizes hydro-thermal treatment of ensiled biomass, and found that this type of approach may increase energy efficiency, but leads to slightly higher greenhouse gas emissions (Bühle et al. 2011). Interestingly, the same study indicated that both bioenergy systems caused higher emissions compared to the fossil-based reference systems, when the impacts of acidification and eutrophication are included (Bühle et al. 2011). Another study compared biogas production from two feedstocks, straw and ley, and showed that ley could reduce greenhouse gas emissions by 35% over a fossil reference system, compared to a 9% reduction associated with straw (Kimming 2011). Massé et al. (2010) looked at the use of switchgrass for methane production, finding that 25% more methane could be produced via a two-cut strategy, and suggesting that switchgrass might be a useful crop for biogas production in the future.

Use of biogas as a 'processed form' of biomass may help to meet some of the challenges associated with biomass production, particularly the heterogeneity of different biomass feedstocks and the logistics involved in transport and storage. Upgraded biogas can be pipelined, stored and used in the existing natural gas infrastructure. Agricultural feedstocks are better for biogas production when pipelining is being considered, as industrial waste streams can contain sulphur compounds and other contaminants. While results of these studies are promising, it would seem that biogas from livestock wastes will remain the dominant form of production, at least in the foreseeable future. Biogas from wastes (agricultural or otherwise) has the additional advantage of minimizing the cropland footprint of the project, something that is a challenge to overcome for solar projects (where solutions such as planting crops between the panels or installing the panels in fence rows or laneway lines are being explored).

Policy and Regulatory Issues

Although there is certainly much room for improvement, there is a feeling that Ontario is doing comparatively well, and the biogas industry is much stronger here than in some other regions. Ontario is leading the way on green energy in Canada, and other provinces are watching to see what we do right or wrong. There are a number of biogas plants of various sizes already in operation across the province, supplying a total of 96 MW of biomass power to the grid. Feed-in-Tariff (FIT) and microFIT programs are in place and running, while most other provinces have no FIT in place yet. While it can be easy to focus on what is missing or needs to change, it is helpful to remember there are other places in North America that say Ontario is an innovator in biogas and the place to be.

## *Weaknesses*

Operation and Maintenance

Biogas-to-energy works best when both electricity and heat can be captured from the project. Obstacles to expanding combined heat and power systems include the high likelihood of remote siting, as most farms and landfills are located a long way from the end user, as well as connection cost and the type of incentive offered. This last point has been demonstrated by the absence of biomass/biogas representation in the recently announced FIT contracts (Feb. 24, 2011). A key issue in the Ontario power landscape is system constraints; there are physical limits to how many connections can be made, and because of rapid uptake these limits are quickly being reached. This means that even capacity allocation exempt projects must now be screened for system upgrade requirements.

Connection challenges revolve mainly around the location of the biogas production facility, which needs to be located next to fuel source in rural settings; connections in rural areas are further down the road and generally are connecting to the lowest-quality, poorest part of the grid system. One concern that was highlighted in our interviews was the impression that wind and solar projects are getting grid connection priority over biogas; this needs to be explored, clarified, and (if necessary) rectified. It cannot be denied that there is a very strong wind and solar lobby in the Province, with a very high install base, but there are deficiencies associated with these systems (primarily intermittency). Biogas needs to formulate a concise response to move the industry agenda forward in a more coordinated way.

Technology

There are several drawbacks to anaerobic digestion and biogas production that have been identified. Some are technical: for example, there is a risk of odours if feedstocks are not managed properly, and involve complex biological, mechanical and electrical systems that require specialized knowledge and training (OMAFRA 2011b). There are some concerns about plant safety, in terms of design and construction, and whether there is sufficient regulation. But biogas in Ontario has a good track record, with no explosions.

Utility feeders are designed to distribute electricity, not connect generators, adding complexity. Complexity with distribution connection, quality, operations and reliability and higher than anticipated compliance costs also negatively impact project viability.

Feedstocks and Sustainability

A commonly identified weakness is the impression that biogas is not significant in terms of potential energy provision. A recent analysis suggested that small farms (dairy with at least 33 animals, beef with at least 78 animals) can operate economically attractive biogas systems (White et al. 2011). Ontario farm demographics suggest that about 9000 farms meet these criteria, and would be capable of producing about 120 MWe of renewable energy for the Ontario electrical grid; a single wind farm in Eastern Ontario can provide almost 200 MWe and receives similar financial incentives to the biogas option. To counter this, there is a need to continue to develop potential synergies between waste streams, expanding beyond the agricultural sector to work with municipalities and commercial industries. However, the Nutrient Management Act caps off-farm substrates for anaerobic digesters at 25% of total feedstocks, which is a major regulatory barrier to small scale operations that require closer to 50% additional inputs. Currently, production becomes viable at 250 kW (milking 300+ cows to provide enough manure), leaving smaller farms out; indeed, the Ontario Agricultural AD Calculator currently emphasizes the need to blend off-farm materials for smaller installations. Until new options like biomass are proven, commercially established companies are going to continue to give preference to traditional technologies.

Particularly related to co-digestion and the use of residuals is the challenges of substrate characterization, collection and processing, which are not yet off-the-shelf or easily deployable. More research and clarity is needed on digestates from various waste streams and what can be done with them. New projects should not be started until 100% of feedstocks are known, as well as alternative feedstock availability. Lack of preparedness on the side of new projects lowers the success rate of the industry and discourages new entrants. One important factor related to co-digestion of manure and biomass is that, while moisture content does not affect digestibility, dry grass requires much more water (10 times water to feed ratio), and will incur additional expenditures such as the storage of biomass, and the cost of managing different digestion rates and retention times. Concern was also expressed about how to regulate offsite organics going onto farms, in case of contamination. In the private sector the company has to put up a bond to clean up the site, but in the agricultural sector that is not the case. There needs to be mechanisms in place to ensure that waste is well managed and not simply used for profit (tipping fees) without generating biogas.

Policy and Regulatory Issues

A number of policy issues and factors contributing to high investment risks need to be worked out to address market uncertainty, production variability, and viable lifecycle analyses. Taxation rates for renewable energy projects, including anaerobic digesters, are different than those applied to farm income, and these differences are not always clearly understood by proponents. Because it costs nothing to apply, there is also concern among regulatory bodies about attrition rates, a weakness that could be addressed from within the industry.

The current policy situation in Ontario focuses strictly on electricity, and does not provide much flexibility (this is particularly a threat to biomethane development, discussed below). For example, batteries are not yet permitted, because of the potential to store energy from the grid and sell it back at a higher rate.

## *Opportunities*

Operation and Maintenance

The climate for agricultural energy is favourable: farms are willing to risk their own dollars to research and innovate, companies are willing to develop the industry and the market for green energy is there.

The weaknesses of solar can become an opportunity for biogas. For example, there is a high level of uncertainty associated with solar power, including unexplained variance due to panel/inverter efficiencies, tracking technology, parasitic load and climatic uncertainty. Consequently, solar must be paired with back-up generation, which OPG currently sees as a role for repowered coal units. However, the opportunity is here for biogas to step in and fill this role. Nuclear refurbishments will also need back-up generation because of reliability issues. In fact, at this time of increased global nuclear anxiety, biogas is poised as an important factor when looking at alternatives to nuclear. A great deal of electricity is wasted as line-loss pushing electricity from nuclear out to local communities. De-centralized power production makes sense because feeding the grid in many places with biogas-to-energy would greatly reduce this line-loss.

The best use for biogas (heat generation, power/CHP generation, or upgrading to biomethane) depends on a number of factors, including economics, incentives, public policy, technical risk, environmental and location-specific issues. As the highest value pathway for biogas, there is a real opportunity for farmers in the development of a biomethane industry. The energetic efficiency of biomethane is very high (95%), much more efficient than biogas-to-electricity, which is about 35% to 40% (with the balance as heat and losses). The market for off-takers is likely to develop in the next 12-24 months and prices of biomethane are still being determined; this includes the value of the 'green', renewable component of the gas. The crucial question is, what price will be set? Union Gas and Enbridge are working towards developing a renewable biomethane reference price, i.e. a premium price that can be put forward to the Ontario Energy Board. The utilities will file in the spring or early summer for regulatory approval, and the answer from the Ontario Energy Board is expected by the end of the year. There is a clear opportunity here to ensure that the price is set at the right level to provide the necessary market incentive to help biogas grow, but it must be acted upon quickly. Marketing biomethane as a separate green product can avoid linking it too closely to natural gas pricing. The most successful policy to drive biomethane development in Europe has been the feed-in tariff (e.g. Germany), but only when it is 'aimed' at biomethane and/or CHP, and not simply electricity; renewable fuel standards can also work well, as in Sweden. There is already a significant market demand, and as natural gas prices are likely to rise while biomethane remains steady or drops, future benefits might be great.

Enriching the methane component of biogas to make it interchangeable with natural gas in pipelines costs about $2.5/GJ for larger systems, and up to $10/GJ for small systems. There is a trade-off between cost and biogas purity but cost for a purer product will likely go down over time. Since enrichment costs are significantly higher for smaller systems, it may make sense to encourage biogas-to-electricity for small-scale plants and biogas-to-gas for larger operations.

Technology

There are many opportunities for biogas use, including methane gas sales, electricity sales, district heating/CHP and other local hot water or heat sales, and alternatives such as using biogas as fuel in trucks, tractors or other vehicles.

Several presenters at the conference commented on the value of digestates as a fertilizer source, a conviction that is supported by research (i.e. Solomie et al. 2010). Nutrient recovery technologies may be a significant opportunity in many types of bioenergy production, include anaerobic digestion, as the value of these nutrients can help drive the economics of conversion. The value of digestate as a fertilizer that can be used to replenish phosphorus and potash in soils, which in turn increases the economic feasibility of the project, is emphasized in many examples; in one case an increase of 100% in the value of hay grown on land with digestate was reported, reducing costs for protein by half.

Dry fermentation anaerobic digesters can recover energy from organics that would otherwise be landfilled while producing usable pre-process compost. Despite much innovation, there are difficulties with the technology for digesting heterogeneous materials; pre-processing is used to produce a clean and consistent slurry material for the digester. New technologies such as microware pre-treatment can increase organic matter accessibility and improve degradability, and increase accessibility of biomass for co-digestion. Food waste diversity and variability is the most challenging part of a food waste-to-energy plant. According to one interview respondent, "there is a real need for someone to come up with a source-separated organic digester". A North American case study uses up to 8,000 tonnes of agricultural waste and source-separated organics (SSO) with an installed capacity of 370 kW. The Innovente process, which combines anaerobic digestion with biodrying and combined heat and power production, can handle 50,000 tonnes/year organic waste, provide 4.6 MW of electric (or 40,000 MWh/yr), 10 MW heat, and 7,000 tonnes/yr of fertilizer (N-P-K) at a cost of about $25 million per plant.

Biogas can also be combined with other biofuel types. A case study in Alberta produces 40 million litres per year of wheat-based ethanol, as well as 5 MWe biogas, from 36,000 head of beef cattle fed on mixed grasses and grains. Other potential co-products such as biochar may be produced in these systems; biochar is a climate mitigation tool as it sequesters solid carbon in a form that can remain stable in the soil for thousands of years, allowing farmers and land holders to potentially gain carbon credits while improving soil quality. Desulfurization enables efficient reuse of biogas in engines and boilers by reducing corrosion, allows biogas to be upgraded to natural gas quality, and reduces $SO_2$ emission. An interesting new opportunity combines a solar-biomass hybrid air heating system with thermal storage, designed for greenhouse applications. Another new technology is the addition of a hydrolysis tank to an anaerobic digester, which allows further decomposition and potential digestion of various feedstocks; Novozymes is reportedly working in this area.

<u>Feedstocks and Sustainability</u>

> *"I think that part of the future of biogas is connecting it with industry and municipalities that have organics to dispose of. I think that we have a lot of organics that municipalities are composting now that really should be going to the digesters."*

Feedstock opportunities include expanding sources, expanding capacity, and feedstock optimization. Very promising is the use of anaerobic digestion to recycle organic residuals. It is estimated that there is about 6.6 million tonnes of residential and commercial waste available in Canada per year. Much that is currently composted could be turned into biogas, thus capturing and recycling the energy value as well as the material nutrient value. Tipping fees from municipal or food processing wastes are a significant – in some cases game-changing – source of revenue for anaerobic digestion facilities. There are synergies between the human capital required to manage municipal waste and to install and manage on-farm AD technologies, and if these can be captured and exploited, it would accelerate the deployment of new AD projects (and potentially bring on-farm and municipal projects more closely into alignment). Separating trash or contaminants from waste streams can be achieved via technology (i.e. bioseparators) or via education of organic residual generators.

Another opportunity that could help address the problem of limited waste streams, or limits on the amount of off-farm feedstock permitted, is the use of biomass feedstocks as co-digestates with manure. Mixed energy crops minimize the risk of unsteady biomass supply. Winter drying reduced moisture content from 52% to 10%, bringing it to levels suitable for end-use processing at minimal cost. While bioenergy crops are seen as a real opportunity, the need for additional carbon input through effective rotation systems and the use of supplementary carbon inputs (including fertilizer applications, or potentially solids from anaerobic digestion) is shown to be crucial. Sustainability is a major concern with biomass crops. Intercropping systems have been found to enhance soil organic carbon and biomass yields in a trial using willow clones. The University of Guelph has developed a five-step approach that allows for the estimation of removable residue under any type of cropping system in Ontario. Possibly this can be linked to the application of solids from anaerobic digestion to determine optimal combinations of bioenergy cropping and biogas production.

Policy and Regulatory Issues

Ontario's Long-Term Energy Plan is to eliminate coal-fired generation by 2014. OPG is currently looking for agricultural and woody biomass partners. Electrical efficiency and system price were ranked 3rd and 2nd (respectively) by the Ontario Agricultural AD calculator. Finding ways to improve efficiency should be viewed as an opportunity.

In terms of developing the use of waste feedstocks, there are indications of support from municipalities: at the conference, the mayors of Guelph and London were in attendance and expressed interest in biogas projects. The Mayor of London emphasized his understanding and support for technologies that can support the rural economy, which in turn are critical to the economy of the towns and cities in southwestern Ontario; in Guelph, the city wants to develop landfill gas, biomethane and CHP by 2031. The Green Energy Act and FIT have made these goals realistic for community initiatives. There are also opportunities for strong rural-municipal connections, working with the local community food movement to address cross-boundary energy flow.

The Ontario government recently indicated it would proceed to implement a regulated offset program as a tool that supports the development of a low carbon economy for Ontario. However, anaerobic digestion carbon credits currently belong to the OPA pursuant to the Feed-in-Tariff contracts. There are strong concerns that revenue sharing does not adequately reflect the risks that green energy contracts pass on to producers; there is need for an agriculture-friendly option as a negotiation tool. Allowing the agricultural sector to keep carbon credits rather than the government getting them could be an elegant way to stimulate the biogas industry. If farmers directly received these credits and were allowed to monetize them through something like the California Climate Action Registry or the Alberta Carbon Offset Market, this would reduce the need for government subsidies or incentives, as the carbon credits for methane would be so valuable and biogas producers would directly receive the market benefit. To make this happen, the right policy framework must be established. Pooling carbon credits from several farms could create sufficient volume to be able to sell credits, but it is important that benefits stay in agriculture, not move to other sectors of the economy. A business model for a prospective producer-aggregator is being explored; this entity would trade offsets, address farm contracts and recording infrastructure through partnerships, direct scientific priorities to support agriculture's interest, and encourage commodity based approaches for Carbon Footprint determination to identify areas for future carbon reduction. A related opportunity might be to stack carbon taxes with incentives for manure management. Biogas production could provide approximately 50% of the total energy demand by the agricultural industry while reducing annual $CH_4$ emissions from manure management by as much as 81%, and volatile solids by 4%. If AD technology were extended to all dairy farms with 363+ animals per farm, a potential reduction of 42% of the total annual $CH_4$ emissions from dairy manure management could be expected in Ontario, with similar numbers to be expected in other provinces.

## *Threats*

Operation and Maintenance

Key barriers that need to be addressed are approvals and grid connection. The current processes are too complicated, expensive, take too long and involve too much uncertainty. That there were no biogas projects in the most recent round of FIT announcements is a serious threat to the viability of new projects, as every project that fails due to miscommunication or lack of transparency around each step of the process becomes an argument against future projects.

> *"The whole connection process is a nightmare as soon as Hydro One is involved. Some believe that Hydro One has been commissioned to ensure that there are no connections to the grid."*

The Ontario Power Authority seems to have a bias against biogas; the fact that power outputs are relatively low on a per installation basis does not work well within the OPA system.  Rural connection issues must be addressed: a straightforward, efficient and reliable system to connect to the grid is desperately needed.

Regarding biomethane, the natural gas distribution system in Ontario is poorly developed, which represents a serious constraint when looking to feed biogas into a natural gas pipeline. There are discussions happening with gas companies now about how to put gas into the pipeline. However, connection issues may be even greater than those being faced in the electricity grid, because of the one-way flow of natural gas pipelines, which means connection can occur upstream only, and pressure becomes an issue. The biogas industry is going to have to develop relationships with the natural gas companies for bi-lateral negotiations on pricing and grid access. Furthermore, natural gas prices are very low and are projected to remain low for the next 20 to 40 years, as shale gas could put a downward pressure on natural gas prices. Biomethane producers must be able to compete with suppliers of natural gas, balancing low enough customer rates with prices high enough to encourage investment. Large producing projects (economics of scale) will help.

Despite the major regulatory barriers that must be overcome, many feel the predominant barrier will be economics. Another issue that was emphasized at the conference was the impact of company evolution. When investing in new renewable energy technologies, will the company still be there in five years, or can parts be fixed by regular electricians or other tradespeople?

Technology

Operation and control can be complex: the right mix of feedstock material and the right temperature range to maximize digestion must be achieved while avoiding problems like plugging, crusting and foaming. Care must be taken in designing and managing biogas systems to deal with the moisture, sulphur compounds and other minor gases found in biogas.

Feedstocks and Sustainability

There are concerns about the tipping fee market, as waste management is very cost sensitive and it is usually easier to throw something out than to hire someone to use it. The estimated value of food waste in Canada is $27B annually. Right now, it is too easy and too cheap for processors in Canada to dump waste; in Europe it is expensive to dump food waste and this stimulates the market to turn that waste into a resource. Substrates with higher energy value must be identified and given higher tipping fees at landfills and lower at waste-to-energy plants. FIT may not be a good fit for operations focussed on digestion of organic residuals as it is not flexible enough to deal with the different circumstances surrounding waste. Waste diversity is also a significant challenge in utilizing food residuals in a waste-to-energy plant. Understanding substrate composition and ensuring a reliable supply are crucial to success. It is important to educate organic waste generators that rather than waste, they are producing feedstock (of value and part of a continuing commodity cycle).

Policy and Regulatory Issues

Key policy barriers include the need for long-term power contracts and a streamlined environmental approval process. There is a general consensus that the Feed-in Tariff is the best way to promote biogas-to-electricity, as it is directly linked to actual production and efficiency. However, as discussed in the previous section, this may not be the case when using off-farm residuals. There are a number of reasons that biogas hasn't moved as quickly as other technologies. Solar and wind are simpler technologies with very predictable costs, and the FIT incentive is substantial relative to the cost of these technologies. However, a FIT program directly aimed at gas-to-grid is needed, as the current structure of FIT encourages power generation rather than commodity-based production such as biomethane. Regarding whether the Feed-in Tariff rate for biogas-to-energy is currently set at the right level, opinions are mixed. It may be high enough, although perhaps not as overly-generous as those for solar and wind were. That it may not be high enough is evidenced by the low number of biogas projects currently underway in Ontario. It is difficult at this rate to create profitable projects, and requires extracting additional value to cope with increasing construction costs and competition for material. It has been suggested that an increase in the FIT rate for on-farm biogas of <=100 kW (~25 cents per kWh to level the playing field with 250 kW), coupled with a reduction on the limitation regarding off-farm inputs, would make the program more equitable. Larger scale projects will likely proceed regardless. FIT contracts may need reworking to better address the realities of biogas production.

Since anaerobic digesters are still new to Ontario, steps such as securing a building permit or insurance may take longer than expected. The Renewable Energy Approval (REA) process needs to be streamlined, with clear timelines, deliverables, and opportunities for community involvement. It is currently too expensive and complex when off-farm substrates are involved. The Nutrient Management Act allowance of 25% off-farm substrates is a major regulatory barrier to small scale (under 250kW) biogas operations, which would require closer to 50%. The Green Energy Act is also seen as a barrier by industry; although it was meant to streamline the process, no biogas projects have been approved, and costs are high and unpredictable.

Over-regulation is a threat that must be managed if the AD-to-biogas sector is to grow in Canada. Challenges include meeting the emerging Canadian biomethane quality standards which in some respects are the toughest in the world. Permitting under the Ministry of Energy is a major stumbling block. Complex fertilizer and digestate treatment requirements also must be navigated. Optimizing feed mixture development for full-scale co-digestion projects is a challenging task which becomes more complex when the proponent needs to deal with stringent fertilizer and digestate treatment requirements.

There is concern about municipalities being on board with CHP. There is a lot of negative discourse around the word "incinerator"; people are much more likely to support CHP from wastewater. For example, in Prince George, the district generator system was pushed out of the downtown core. There are questions about what the tolerance of residents will be, to bringing biomass into cities and towns. The best approach may be to import tough regulations from the EU, which is well ahead (~30 years) in terms of CHP.

The upcoming provincial election, and the views towards renewable energy of the incoming government, is also a potential threat.

## *Discussion*

The biogas industry is at a cross-roads; it is not where it should be by this point in its development. Overall, circumstances are favourable for biogas, particularly from wastes and residuals, as people are looking for sustainable long-term alternatives to fossil fuels. The demand for green power is there and the opportunities are great, but barriers are preventing biogas from meeting this potential. In a classic chicken and egg dilemma, there needs to be a better infrastructure in order to encourage development and demand more favourable policies, but there needs to be a large enough industry to mandate that infrastructure. A standard start-up and commissioning approach for AD facilities would help increase the success of the Ontario biogas industry. There is also a feeling that within the next 2-3 years the biogas industry needs to reach a point where companies are comfortable with the technologies and processes they are using, with a cookie-cutter system in place for how to build systems at lower cost. Considering the number of companies currently operating in Ontario and the capacity of the construction and engineering industries, a goal of 10 new 250-750 kW systems per year, with a few larger (1-4 MW) in development and supplemented with the development of smaller systems, is realistic. Progress should be measured by both the number of facilities and their performance: how many kWh they are actually generating. Growth of between 10 and 50 new systems producing a total of 5-15MW per year would provide the industry with the security and momentum it needs. There are currently 96 MW of biomass power connected to the grid across the province. The participation and interest are there, but the pressing unresolved question seems to be whether or not the grid can handle it.

Optimal plant size is a key question. Forecasts using the Ontario Agricultural AD Calculator indicate current practices should not include energy crops, should blend off-farm materials, and that systems >100kW will be most viable. It is easier to find investors for larger projects with a high rate of return (scalability). However, single phase lines are predominant in rural areas and this limits biogas plant capacity to 100 kW (long distances make it cheaper to run a single line, but the power quality is poor). It is better to produce electricity from waste feedstocks on site to reduce transportation costs and carbon footprint, but this in turn raises questions around grid connection and scalability issues. The use of CHP increases efficiency greatly and is required under the German FIT program. CHP is an innovation that needs to be further encouraged in Ontario.

Although there is still some feeling that front-end incentives such as guaranteed loans have a place in helping companies finance their facilities from the pilot/demonstration scale up to full-scale, the general message coming from the interviews is that the role of incentives should be limited. Specifically, incentives have an important role in encouraging innovations, particularly to promote environmental benefits, efficiency, and GHG reductions. For example, incentives should be used to encourage using certain substrates like food waste diverted from landfilling, or utilizing process heat from the generator. A problem several respondents identified with grants or other start-up incentives is that they simply reduce capital costs and disappear quickly without contributing to the long-term growth and sustainability of the industry. Transferring the benefit of carbon credits directly to farmers and operators is a potential solution.

Rather than incentives, the primary focus needs to be on infrastructure development and access – removing barriers – as the drive toward biogas is already there. That there is much opportunity but also many threats may be another reason why start-up incentives are not the answer. Besides the grid access and regulatory issues already discussed, education at the construction and manufacturing level is needed to enable local industry development as most equipment manufacturing currently occurs in Europe or the US. Also, developing policies and programs to encourage local support and to link agriculture with partners at the community level will facilitate the development of more sustainable local models. More municipal interest in biogas production will help achieve industry sustainability; as it currently stands, some of the existing companies will not survive. Increased collaboration and cooperation with local communities and waste producers is needed.

**On the Horizon:**

1. Hydro One is embarking on an Advanced Distribution System project to design, test, install, and prove smart grid technology and determine better ways to integrate distribution generators of various size and complexity into the distribution system.

2. OPA will conduct a 2 year review of FIT and microFIT this year, which will address issues of price, cost, connection constraints, prioritize transmission and upgrades. Although heat and nutrients are not currently assessed as part of the environmental attributes of anaerobic digestion, they should be.

3. Results from the OPG and OMAFRA project on the feasibility of a commercial agricultural biomass industry for combustion energy in Ontario are expected over the next year or two, which will include business plans, recommendations of appropriate crops, supply chain, and OPG needs.

4. Gas utilities will file this spring or early summer for regulatory approval setting a biomethane reference price, and the answer from the Ontario Energy Board is expected by the end of the year

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## Appendix B: Additional Resources

### Government of Ontario

- Ontario Power Authority
  - FIT (Feed-in Tariff): http://fit.powerauthority.on.ca, Email: fit@powerauthority.on.ca
  - microFIT – http://microfit.powerauthority.on.ca, Email: microfit@powerauthority.on.ca
- saveONenergy: www.saveonenergy.ca
  - Conservation programs for home and business designed to make it easier to manage your electricity use and educate about the benefits of the energy-saving measures and incentives offered by these conservation programs.
- Ontario Ministry of Energy Renewable Energy Facilitation Office: www.mei.gov.on.ca/en/energy/renewable
  - For questions regarding getting started with renewable energy, renewable energy approvals and permitting.
  - Email: REFO@ontario.ca
  - Phone: 1-877-440-REFO (7336)
- Ontario's Long-Term Energy Plan: http://www.mei.gov.on.ca/en/energy/
- OMAFRA - Project to Commercialize Agricultural Biomass for Combustion Energy: http://www.omafra.gov.on.ca/english/engineer/biomass/index.htm
  - Research projects across the province
  - Funding opportunities for communities, entrepreneurs and researchers
  - Steering Committee documents
  - Inventory of Research Projects

### Research and Reports

- BioIndustrial Innovation Centre: Complete reports (including Assessment of Agricultural Residuals as a Biomass Fuel, Energy Crops Options For Ontario Power Generation): http://www.bicsarnia.ca/reports.html
- George Morris Centre: http://www.georgemorris.org/GMC/Home.aspx
- Biochar Ontario: www.biocharontario.ca
- http://groups.google.com/group/biochar-ontario
- Canadian Biochar Initiative: www.biochar.ca
- International Biochar Initiative: www.biochar-international.org

### Private Sector Innovations

- BIOFerm™ Energy Systems: www.biofermenergy.com/us
- CH-four Biogas: http://www.chfour.ca/
- entec Biogas USA: http://www.entecbiogasusa.com/index.html
- Maple Reinders: http://www.maple.ca/
- Paques: http://www.paques.nl/en/home
- Ecotricity Guelph Inc.: http://www.guelphhydroinc.com/ecotricity.html
- Yield Energy Inc.: http://www.yieldenergy.com/
- PlanET Biogas Solutions: http://www.planet-biogas.ca/
- Krieg & Fischer Ingenieure GmbH: http://www.kriegfischer.de/
- Genivar Consultants: http://www.genivar.com/en/Pages/default.aspx
- Highmark Renewables Research: http://www.highmark.ca/
- Global Water and Energy, OVIVO: http://www.ovivowater.com/
- Organic Resource Management: http://www.ormi.com/ormi/
- Flotech Services
- FortisBC: http://www.fortisbc.com/Pages/default.aspx
- Union Gas: http://www.uniongas.com/
- Innovente Inc.: http://www.innovente.ca/

- MWM Canada Inc.: http://www.mwm.net/modules/home/index.php?lang=en
- European Power Systems: http://www.europeanpowersystems.eu.com/
- Capstone Turbine: http://www.capstoneturbine.com/
- Bio-Methatech: http://bio-methatech.com/
- Bio-Terre Systems: http://www.bioterre.com/
- Valbio Canada: http://www.valbio.ca/en.html
- FVB Energy Inc.: http://www.fvbenergy.com/
- ReGenerate Biogas: http://www.regeneratebiogas.com/
- Angus Power: http://www.hhangus.com/anguspower.html
- Toromont CAT Power Systems: http://www.toromontcat.com/powersystems/
- Carbon Control Systems Inc.: http://ccs-agrikomp.ca/
- Miller Thomson LLP CleanTech Group: http://www.millerthomson.com/en/our-services/cleantech
- Landmark Projecten: http://www.landmarkprojecten.nl/

### *Carbon Credits*

- Carbon Credits and the State of Play of North American Carbon – Government of Alberta: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/cl11179

### *Solar*

- www.esasafe.com: provide info about installation of solar and specific guidelines for installations, as well as installation specific diagrams for contractors
- Checking specific technology – recommend "gosolar California" website which assess inverter efficiency for most panels out there and lists all the monitoring of companies as well as any relevant safety recalls www.gosolarcalifornia.ca.gov
- RetScreen Calculator: www.RETScreen.net
- Canadian Solar Resource Map (web tool) - https://glfc.cfsnet.nfis.org/mapserver/pv/index_e.php

## *Appendix C: Survey Questions*

General information
Name:
Organization/company:
Job title:
Way in which your work is linked to biogas production in Ontario:
Currently a member of APAO?:

The Agrienergy Producers Association of Ontario (APAO) has been organized to facilitate the transition to a sustainable energy economy in Ontario through the development and support of community-based sustainable energy initiatives. A number of renewable energy technologies are being promoted in Ontario. Biogas-based power has been recognized as an off-the-shelf technical solution that can increase production of renewable energy and help address issues of waste management in the agricultural sector.

1. In your opinion, is the Feed-in Tariff currently available for biogas-to-electricity set at the appropriate level? (Currently, 19.5 c/kWh in installations under 100 kW, and 18.5 c/kWh for installations between 100-250 kW).

2. Is a Feed-in Tariff the appropriate policy mechanism to promote biogas-to-energy in the agricultural sector? Is there opportunity for development of a mechanism to enable biogas-to-gas grid

3. Can you suggest other incentives which might be useful in promoting biogas-to-energy in the agricultural sector?

4. What is a successful rate of uptake for biogas-to-energy technology - is there a target we should set, and how should it be measured?

5. Should incentives for biogas-to-energy take into account the initial type of technology being used? Should incentives be made available for future adaptation and upgrades?

6. Should incentives be calculated based on environmental, social, or economic performance? What other factors should be included in the calculation?

7. Are there any other regulatory challenges that need to be overcome to allow biogas-to-energy to succeed in Ontario?

8. Are there any upcoming opportunities that the biogas-to-energy sector might take advantage of?

9. What is the greatest threat to the adoption of biogas-to-energy technologies?

10. Do you have any other comments about what we have discussed?

## *Appendix D: Sample recruitment letter*

Dear sir/madam,

You are invited to participate in research being conducted under the supervision of Dr. Warren Mabee, Assistant Professor - Queen's University, on behalf of the Agrienergy Producers Association of Ontario (APAO). Your email address was acquired from online biographies or contact information, and/or your business card distribution.

This project is entitled: Supporting increased uptake of biogas-to-electricity technologies in Ontario. The objective of this research is to investigate the interaction between the policies and incentives currently offered or needed to support the biogas-to-electricity sector in the Province, and to increase the uptake of appropriate technologies. Strengths, weaknesses, opportunities, and threats in this interaction will be identified and analyzed. The time requirement for your participation is no more than 30 minutes in which you will be interviewed on the subject matter. Your role is outlined further in the attached letter of information and consent.

Your response is requested whether you wish to participate or decline. Should you wish to participate further emails will be exchanged to set up an interview date, time and place. Thank you for your consideration.

Regards,

Dr. Warren Mabee
Assistant Professor,
School of Policy Studies and Department of Geography
Queen's University
Kingston, Ontario, Canada K7L 3N6
(613) 533-6000 ext. 77092