Update of the Agricultural Biogas Industry in Canada

October 25, 2010
Biogas Industry in Canada

- Biogas industry in Canada is growing:
  - Currently 20 farm digesters are operating across the country, with 13 in Ontario and 5 in Alberta alone.
  - By 2012 there will be 28 farm based digesters operating in Ontario.
- Trend in Canada is to use waste residues as co-substrates with manure, with less emphasis on co-digesting manure with energy crops.
- Provincial and federal governments are committed to fostering adoption of farm based biogas plants
  - Example: Feed-In-Tariff program (Ontario) offers guaranteed pricing for renewable electricity production.
- Revenues from manure digesters are not the only considerations and environmental benefits associated with anaerobic digestion of manure need to be assessed.
Ontario

- Province with most advanced anaerobic digestion industry
- Feed-In-Tariff Program – First in North America
  - Guaranteed, stable, competitive prices for renewable energy projects under 20-year contracts
  - Prices cover capital, operating and maintenance costs and allow for reasonable rate of return on investment

<table>
<thead>
<tr>
<th>Generator Size</th>
<th>Price</th>
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<tbody>
<tr>
<td>≤ 100 kW</td>
<td>19.5¢/kWh</td>
</tr>
<tr>
<td>&gt; 100 kW ≤ 250 kW</td>
<td>18.5¢/kWh</td>
</tr>
<tr>
<td>≤ 500 kW</td>
<td>16.0¢/kWh</td>
</tr>
<tr>
<td>&gt; 500 kW ≤ 10 MW</td>
<td>14.7¢/kWh</td>
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Ontario

- Ontario Biogas Systems Financial Assistance Program (OBSFAP) delivered by the Ontario Ministry of Agriculture, Food and Rural Affairs:
  - Financial grants for design and construction of biogas systems - $11.2 million program
  - Program was setup to kick-start biogas industry in Ontario
  - Projects funded:
    - Construction of 24 biogas plants
    - 48 feasibility studies
Manure Digester - Ontario

- Fepro Farms (Cobden, ON)
  - 290 dairy cows (165 lactating, 85 heifers, 40 calves)
  - Mesophilic (40°C) continuously mixed system
  - Operating since 2003
  - As of 2007, co-digestion of dairy manure with waste grease
  - In 2009 expanded electrical generation from 65 kW to 500 kW
  - Electricity production sold to grid under FIT program
  - Heat production used to heat digester, 2 homes, machine shop and milking parlour
  - Digestate is land applied
Manure Digester - Ontario

- **Terryland Farms (St-Eugene, ON)**
  - 230 dairy cows (150 lactating)
  - Mesophilic (40°C) continuously mixed system
  - CH-Four Biogas system
  - $600,000 system
  - Operating since fall 2007
  - Co-digestion of dairy manure with waste grease
  - 360 kW electricity generation
  - Electricity production sold to grid under FIT program
  - Heat production used to heat digester, home, greenhouse milking parlour and to dry silage
  - Digestate is land applied
Manure Digester - Ontario

- Pinehedge Farms (St-Eugene, ON)
  - 95 dairy cows (70 lactating)
  - Mesophilic (40°C) continuously mixed system
  - CH-Four Biogas system
  - $350,000 system
  - Operating since 2008
  - Co-digestion of dairy manure with limited amounts of waste grease
  - 100 kW electricity generation
  - Electricity production to be sold to grid
  - Heat production used to heat digester and for on-site organic yoghurt and kefir production
  - Digestate is land applied
Manure Digester - Ontario

- Ledgecroft Farms (Seeley’s Bay, ON)
  - 500 dairy cows (225 lactating)
  - Mesophilic continuously mixed system
  - PlanET Biogas Solutions system
  - Operating since 2008
  - Co-digestion of dairy manure and waste grease
  - 500 kW electricity generation
  - Electricity production sold to grid under FIT program
  - Heat production used to heat digester and used on the farm
  - Digestate is land applied
Manure Digester - Ontario

- Donnandale Farms (Stirling, ON)
  - 650 dairy cows (300 lactating)
  - Mesophilic continuously mixed system
  - Plant built by Powerbase Energy Systems Inc.
  - Operating since 2009
  - Co-digestion of dairy manure and waste grease
  - 500 kW electricity generation
  - Electricity production to be sold to grid under FIT program
  - Heat production used to heat digester, home and barn
  - Digestate solids are separated and used for animal bedding and liquid portion is land applied
Manure Digester - Ontario

• Clearydale Farms (Spencerville, ON)
  – 300 dairy cows (150 lactating)
  – $1.4 million project
  – Mesophilic (40°C) system
  – Plant built by Powerbase Energy Systems Inc.
  – Operating since spring 2010
  – Co-digestion of manure with waste grease and organic grocery refuse
  – 500 kW electricity generation
  – Electricity production sold to grid under FIT program
  – Heat production used for home, outdoor swimming pool and workshop
  – Digestate is land applied
Manure Digester - Ontario

- Delft Blue Veal Inc. (Cambridge, ON)
  - 2700 veal calves
  - $2.5 million project
  - Mesophilic (40°C) system
  - PlanET Biogas Solutions system
  - Operating since spring 2010
  - Co-digestion of manure with waste grease and some organic grocery refuse
  - 500 kW electricity generation
  - Electricity production sold to grid under FIT program
  - Heat production used at the farm
  - Digestate is land applied
Manure Digester - Ontario

- Stanton Brothers Ltd. (Ilderton, ON)
  - 2000 dairy cows
  - $4.1 million project
  - Eight 115 m³ digesters (vertical induced blanket reactors)
  - Mesophilic (37°C) system
  - System designed by Andigen LC and built by Dairy Lane Systems
  - Operating since 2008
  - Co-digestion of manure with waste grease
  - 300 kW electricity generation and will be expanding to 1.3 MW
  - Electricity production sold to grid under FIT program
  - Heat production used to heat digester and barn
  - Digestate solids are separated and used as animal bedding and liquid is land applied
Manure Digester - Ontario

• Clovermead Farms (Alma, ON)
  – 375 dairy cows (160 lactating)
  – Mesophilic (37°C) system
  – Operating since spring 2010
  – Co-digestion of dairy manure, off-farm poultry manure and off-farm waste
  – Up to 500 kW electricity generation capacity (currently running at 250 kW)
  – Electricity production sold to grid under FIT program
  – Heat production used to heat digester and barn
  – Digestate is land applied
Manure Digester - Ontario

- Kirchmeier Farms (St-Isidore, ON)
  - 200 dairy cows
  - CH-Four Biogas system
  - 1500 m³ digester
  - Mesophilic (37°C) system
  - Operating since spring 2010
  - Co-digestion of dairy manure, waste grease and biomass waste
  - 500 kW electricity generation
  - Electricity production to be sold to grid under FIT program
  - Heat production used to heat digester and barn
  - Digestate is land applied
Digester - Ontario

- Vandermeer Greenhouses (Niagara-on-the-Lake, ON)
  - PlanET Biogas system
  - One primary digester (1527 m³) and one secondary digester (1527 m³)
  - Mesophilic (37°C) system
  - Operating since 2008
  - Co-digestion of grape pomace with some poultry manure and greenhouse clippings
  - 335 kW electricity generation
  - Electricity production sold to grid under FIT program
  - Heat production used in greenhouse
  - Solid fraction of digesate is separated and re-used in greenhouse
Bayview Flowers (Jordan Station, ON)
- PlanET Biogas system
- One primary digester (1200 m$^3$) and one secondary digester (1200 m$^3$)
- Mesophilic (37°C) system
- Operating since 2007
- Co-digestion of greenhouse clippings, dairy manure, off-spec dog kibble, corn silage and some grape pomace
- 250 kW electricity generation
- Electricity and heat used in greenhouse, with surplus electricity sold to grid under FIT program
- Digesate is land applied
Pelee Hydroponics (Leamington, ON)
- Owned and designed by Seacliff Energy Inc.
- $6.5 million system
- Two-stage digestion system
- Mesophilic (37°C) system
- Operating since early 2010
- Co-digestion of waste greenhouse vines and waste from food processors, with a small amount of manure
- Phase 1: 1.6 MW electricity generation
- Phase 2: 3.2 MW electricity generation (planned for 2012)
- Electricity production sold to grid under FIT program
- Heat production used in 6.5 acre tomatoe greenhouse
- Digesate is separated into solid and liquid fractions that will be sold as fertilizers, where the liquid fraction may be re-used in hydroponics system
Manure Digester – Manitoba (MB)

- Cook Feeders (Teulon, MB)
  - 18,000 hogs/yr
  - Designed by Bio-Terre Systems Inc.
  - Psychrophilic (20-25°C) plug-flow in-ground digester system
  - Operating since 2005
  - 2 digester system
  - System capacity is 13,000 m³/yr
  - Biogas used to heat digester and excess is flared
  - Digestate is land applied
Manure Digester – Manitoba (MB)

- Riverbend Colony (Carberry, MB)
  - 1500 hogs/yr
  - Mesophilic-thermophilic system
  - Operating since 2007
  - Biogas used to produce electricity for colony
  - A Vertical Shear Enhanced Process (VSEP) filter system used to clean digestate
  - Digestate is land applied
Manure Digester – Manitoba (MB)

• The following digester was approved for funding by Manitoba government but I can’t find information on the system:
  – Topeka Farms (Grunthal, MB)
    • 5500 hog operation
    • Thermophilic digestion
Manure Digester – Manitoba (MB)

- University of Manitoba (Glenlea, MB)
  - Pilot-scale digesters housed in greenhouse
  - Used for studies assessing the co-digestion of hog manure with other substrates
  - Several research projects have been conducted with University of Manitoba professors and industry
**Saskatchewan (SK)**

- **Cudsworth Pork Investors Group (Cudsworth, SK)**
  - 35,000 hogs/year
  - Mesophilic digester (900m$^3$) treating hog manure
  - System loading: 100 m$^3$/day
  - Biogas produced: 1,600 m$^3$/day
  - Biogas used for electricity (120 kW$_e$) and heat production (630 kW$_t$)
  - Nutrient separation technology to produce a variety of end products from digestate
  - May be temporarily stopped
Alberta (AB)

• Great electrical grid due to extensive rural oil development
• Large feedlots with large volumes of manure
• BioEnergy Producer Credit Program
  – Energy base price (~7 ¢/kWh) + 6 ¢/kWh (for <3 MW)
  – Available for both electric or thermal energy
• Focus is using establishing GHG credit with provincial government
Alberta (AB)

- 2 operating farm digesters
- 1 farm digester currently being rebuilt
- 3 operating covered lagoons at food processors
  - Replacing natural gas in boilers
- 4 proposed farm biodigester projects (beef and pork)
- 1 under construction, Andigen system
  - Ranch – at regional composting site – onsite energy use
  - Focus on GHG credits
- 3 proposed regional digester projects

- Focus: odour and waste management, GHG credits
Manure Digester – Alberta (AB)

• Highland Feeders (Vegreville, AB)
  – Partners with Highmark Renewables and Integrated Manure Utilization System (IMUS)
  – 6000 cattle in feedlot
  – Two 1800 m³ fully mixed digesters
  – $6.8 million project
  – Thermophilic operation (55°C)
  – 1 MW system
  – Only digesting cattle manure
  – Digestate sold as fertilizer
  – Verified GHG credits, to be registered with Alberta Government
    • Estimate 8000 tonnes/year
    • Alberta government sets floor price of $15/tonne
  – To expand to 2.5 MW production:
    • Manure will be from 30,000 cattle
    • Two 7000 m³ digesters
    • $11 million project
    • Co-digestion: Manure + corn stillage + other co-substrates
    • Biogas to fuel ethanol production and dry distillers grains (at future corn ethanol plant)
Manure Digester – Alberta (AB)

- Iron Creek Hutterite Colony (Viking, AB)
  - Partners with BioGem Power Systems
  - 1200 hogs
  - Three 1000 m³ fully mixed digesters
  - $2 million project
  - Mesophilic operation (37°C)
  - Potential co-digestion with slaughterhouse waste
  - System loading of 88m³/day
  - Plant generates 350 kW of electrical energy and 770 kW of thermal energy (>3,000,000 kWh/yr of electricity)
  - Digesterate goes through solid/liquid separation
    - Solids are land applied
    - Liquid re-used as process and wash waters
  - System being re-commissioned and may not be currently operational
Alberta (AB)

- Not sure if you want to discuss this one as it is still in the conceptual stage
- Prion destruction using thermal hydrolysis
- End product fed into biogas system
- Pilot plant to be built in Lacombe, AB
  - Co-digestion with agricultural and municipal organic wastes
British Columbia (BC)

- **BC Hydro and Fortis:**
  - 90% green generation resources
  - Natural gas is a dirty option in comparison
- **Will be introducing a FIT program shortly for alternative energy production**
- **BC Bio-Energy Strategy and Energy Plan strategies:**
  - Reduce GHG emissions
  - Invest in alternative energy technologies
- **Climate Action Charter:**
  - Municipalities committed to be carbon neutral by 2012
- **Terasen Gas** is the largest distributor of natural gas in BC and also develops alternative energy systems
  - Beginning to develop biogas from landfills and agricultural waste
  - Pilot projects include:
    - Catalyst Power in Abbotsford (BC) to produce biogas from farm waste
    - Salmon Arm Landfill in the Columbian Shuswap Regional District to capture and upgrade landfill gas into biomethane
Manure Digester – British Columbia (BC)

- Catalyst Power (Abbotsford, BC)
  - Plan-ET Biogas system
  - $4.5 million project
  - Mesophilic digestion (38°C)
  - Two primary digesters and one secondary digester
  - Start up summer 2010
  - Co-digestion of dairy and chicken manure with food processing wastes (e.g. FOG, DAF, potato waste)
  - Inputs: up to 350 t/day of manure and up to 40 t/day of food processing waste
  - Phase 1: 0.8 MW_{eq}
  - Phase 2: 1.6 MW_{eq}
  - Biogas upgraded to natural gas pipeline specifications and fed into local utility grid (Greenlane Biogas - water scrubbing technology)
  - Liquid digestate gets land applied while solid digestate goes for animal bedding
Trend in Canada

• Significant differences in anaerobic digestion industry between provinces.
• Lack of clear economic driver means industry is growing slowly.
• GHG credits needs to be part of economic driver for industry
• Energy policies are primarily a provincial responsibility, individual small industry/farmer groups, or individual farmers are essentially on their own to lobby/advocate
• Growing interest in biogas upgrading
  – Several hydro-electricity or electrical grid limitations exist which means there is a growing focus on upgrading (where natural gas exists in rural settings)
Several studies are being conducted to investigate environmental impacts associated with on-farm manure digesters:

- **University of Guelph**: Characterizing digestate quality and impacts to air, soil and groundwater quality from digestate storage and after land application.

- **Agriculture and Agri-food Canada (AAFC)**: Measurement of fugitive CH$_4$ and NH$_3$ emissions at the farm.

- **Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA)**: Collection of data to develop a GHG Offset Protocol.
University of Guelph

Air, Soil and Groundwater Quality Monitoring of Raw and Digested Manure from Storage Reservoirs and Land Application Trials

Researchers: Anna Crolla, M.A.Sc., P.Eng.
Chris Kinsley, M.Eng., P.Eng.
Claudia Wagner-Riddle, Ph.D.
Project Overview

• Anaerobic Digesters:
  – Monitoring of 3 on-farm anaerobic digesters
  – Evaluate use of co-substrates for enhanced biogas production (pilot & full scales)
  – CH$_4$ measurements from raw and digested manure storages

• Land Application Trials:
  – Land application trials for GHG measurements (AAFC)
  – Land application trials for fate of nutrients and pathogens in soil and water
### Anaerobic Digesters

1. Fepro Farms (dairy operation) – Cobden, Ontario
2. Terryland Farm (dairy operation) – St. Eugene, Ontario

### Monitoring Parameters

<table>
<thead>
<tr>
<th>Digester System Performance</th>
<th>Environmental Impacts</th>
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</thead>
<tbody>
<tr>
<td>Biogas production &amp; CH₄ concentration</td>
<td>Volatile fatty acids (VFAs) and Odours</td>
</tr>
<tr>
<td>Electricity &amp; heat production</td>
<td>E.coli</td>
</tr>
<tr>
<td>Organic Matter: COD, Volatile Solids</td>
<td>Salmonella</td>
</tr>
<tr>
<td>Nutrients: NH₄⁺, Organic-N, o-PO₄³⁻, TP</td>
<td>C.perfringens</td>
</tr>
<tr>
<td>pH, IA/TA ratio (FOS/TAC)</td>
<td>Enterococci</td>
</tr>
</tbody>
</table>
Land Application Trials

- University of Guelph at Alfred and AAFC at Ottawa – Monitoring of air, soil and water after land application of raw manure, digested manure and inorganic fertilizer.

**Monitoring Parameters**

<table>
<thead>
<tr>
<th>Groundwater and Soil Samples</th>
<th>Air Measurements</th>
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<tbody>
<tr>
<td>Nutrients: NH$_4^+$, NO$_3^-$, o-PO$_4^{3-}$, TP, Organic-N</td>
<td>NH$_3$ &amp; N$_2$O</td>
</tr>
<tr>
<td>E.coli</td>
<td>Plant Samples</td>
</tr>
<tr>
<td>Salmonella</td>
<td>Plant Yield</td>
</tr>
<tr>
<td>C.perfringens</td>
<td>Total-N</td>
</tr>
<tr>
<td>Enterococci</td>
<td>Total-P</td>
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</table>
Research Study Outcomes

• Life Cycle Analysis (LCA) for the on-farm manure anaerobic digester technology (as part of a larger study lead by Dr. Wagner-Riddle).

• Recommendations for land application of digested manure that minimize nutrients & pathogens to surface and subsurface waters under varying agronomic conditions.

• Recommendations for mitigating GHG emissions from the land application of digested manure.
Measurement of Fugitive CH$_4$ Emissions from Digestion System and NH$_3$ Emissions following Land Application of Digested Manure

Researchers: Tom Flesch, Ph.D.
Ray Desjardins, Ph.D.
Project Overview

• Anaerobic Digesters:
  – Quantify CH$_4$ fugitive emissions from the whole biodigestion system

• Land Application Trials:
  – Measurements of NH$_3$ emissions following land application of digested manure
Quantifying Fugitive CH$_4$ Emissions from Digesters

- Anaerobic digesters reduce GHG emissions & generate clean energy.
- GHG reductions depend on many factors (design, feedstock, etc.), including quantity of fugitive CH$_4$ emissions.
- Minimizing fugitive emissions can maximize energy production, while minimizing environmental impacts.

Quantifying fugitive CH$_4$ emissions is difficult – commonly assumed:
- 15% of total CH$_4$ production (California Climate Action Registry)
- 15% of production (Clean Development Mechanism (CDM), 2005)
- 10% of production (Intergovernmental Panel on Climate Change (IPCC), 2006)
- 5% of production (US Environmental Protection Agency (USEPA) – for covered anaerobic lagoons)
Quantifying NH$_3$ Emissions from Land Application of Digested Dairy Manure

- Increased concentration of NH$_4^+$-N in digested manure can lead to increased NH$_3$ emissions during land application
- Land application trials using digested dairy manure are conducted at Terryland Farms
- Digested manure is spray broadcast in 8m wide bands and incorporated within 24 hours
- Digested manure is applied at 1x agronomic rate for nitrogen
Research Study Outcomes

- Quantify CH$_4$ and NH$_3$ emissions from farms with biodigesters.
- Recommendations to improve on-farm management of raw and digested manure that minimize methane emissions.
- Improve efficiency of CH$_4$ flaring.
- Recommendations for land application of digested manure that minimize ammonia emissions.
Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA)

Biogas System Greenhouse Gas Offset Protocol

Program Analyst: Chris Duke, Ph.D.
Researchers: Anna Crolla, M.A.Sc., P.Eng.
Chris Kinsley, M.Eng., P.Eng.
Claudia Wagner-Riddle, Ph.D.
Project Overview

• New project that began in Spring 2010 (2 year study).
• Outcomes will provide data required for the development of a Biogas Offset Protocol.
• Offset credits will represent a significant revenue stream for most biogas systems – leading to growth of the biogas sector.
• 10 on-farm digesters across Ontario will be monitored for digester performance; where raw feedstocks and digestate are fully characterized and methane yields determined.
• Potential CH₄ emissions from uncovered digestate storage reservoirs will be estimated.
• Conducted in conjunction with a University of Guelph study to investigate emissions of CH₄ and N₂O from farms with biodigesters.