

Update of the Agricultural Biogas Industry in Canada

October 25, 2010



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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

Generator Size	Price
≤ 100 kW	19.5¢/kWh
> 100 kW ≤ 250 kW	18.5¢/kWh
≤ 500 kW	16.0¢/kWh
>500 kW ≤ 10 MW	14.7¢/kWh

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



Cobden, ON



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



St-Eugene, ON



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



St-Eugene, ON

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



Seeley's Bay, ON



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



Stirling, ON



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



Spencerville, ON



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



Cambridge, ON



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



St-Isidore, ON

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



Niagara-on-the-Lake, ON



Digester - Ontario

- Bayview Flowers (Jordan Station, ON)
 - PlanET Biogas system
 - One primary digester (1200 m³) and one secondary digester (1200 m³)
 - 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



Jordan Station, ON



Digester - Ontario

- Pelee Hydroponics (Leamington, ON)
 - Owned and designed by Seaclyff 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



Leamington, ON



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



Teulon, MB



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



Carberry, MB



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



Glenlea, MB



Saskatchewan (SK)

- Cudsworth Pork Investors Group (Cudsworth, SK)
 - Partnership includes Clear-Green Environmental, SaskPower Corp., Ag-West Biotech Inc. and Canadian Cement Association.
 - 35,000 hogs/year
 - Mesophilic digester (900m³) treating hog manure
 - System loading: 100 m³/day
 - Biogas produced: 1,600 m³/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



Cudsworth, SK



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)



Vegreville, AB



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)
 - Digestate 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



Viking, AB

Alberta (AB)

- Not sure if you want to discuss this one as it is still in the conceptual stage
- Biorefinex www.Biorefinex.com
- 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



Abbotsford, BC



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)

Studies Assessing Environmental Impacts from Anaerobic Digesters

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 CH₄ and NH₃ 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.



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de GUELPH
CAMPUS d'ALFRED

Project Overview

- Anaerobic Digesters:
 - Monitoring of 3 on-farm anaerobic digesters
 - Evaluate use of co-substrates for enhanced biogas production (pilot & full scales)
 - CH₄ 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

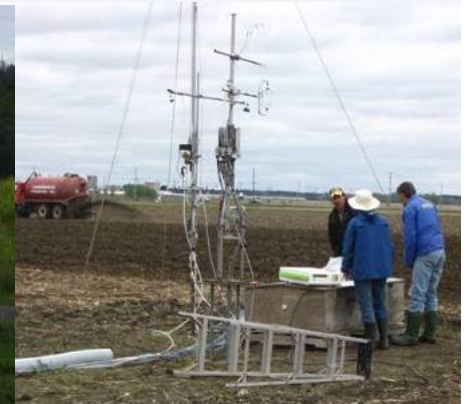
Monitoring Parameters

Digester System Performance	Environmental Impacts
Biogas production & CH ₄ concentration	Volatile fatty acids (VFAs) and Odours
Electricity & heat production	<i>E.coli</i>
Organic Matter: COD, Volatile Solids	<i>Salmonella</i>
Nutrients: NH ₄ ⁺ , Organic-N, o-PO ₄ ³⁻ , TP	<i>C.perfringens</i>
pH, IA/TA ratio (FOS/TAC)	Enterococci

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**

Groundwater and Soil Samples	Air Measurements
Nutrients : NH_4^+ , NO_3^- , o-PO_4^{3-} , TP, Organic-N	NH_3 & N_2O
<i>E.coli</i>	Plant Samples
<i>Salmonella</i>	Plant Yield
<i>C.perfringens</i>	Total-N
Enterococci	Total-P



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.

Agriculture and Agri-food Canada (AAFC)

Measurement of Fugitive CH₄ Emissions from Digestion System and
NH₃ Emissions following Land Application of Digested Manure

Researchers: Tom Flesch, Ph.D.

Ray Desjardins, Ph.D.



Agriculture and
Agri-Food Canada

Agriculture et
Agroalimentaire Canada

Project Overview

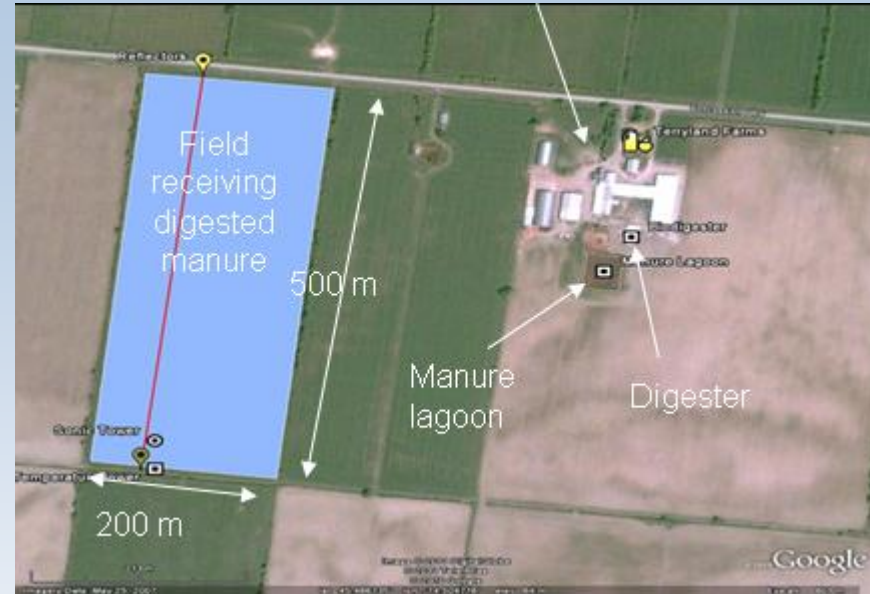
- Anaerobic Digesters:
 - Quantify CH₄ fugitive emissions from the whole biodigestion system
- Land Application Trials:
 - Measurements of NH₃ emissions following land application of digested manure

Quantifying Fugitive CH₄ Emissions from Digesters

- Anaerobic digesters reduce GHG emissions & generate clean energy.
- GHG reductions depend on many factors (design, feedstock, etc.), including quantity of fugitive CH₄ emissions.
- Minimizing fugitive emissions can maximize energy production, while minimizing environmental impacts.
- Quantifying fugitive CH₄ emissions is difficult – commonly assumed:
 - 15% of total CH₄ 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 CH₄ and NH₃ emissions from farms with biodigesters.
- Recommendations to improve on-farm management of raw and digested manure that minimize methane emissions.
- Improve efficiency of CH₄ 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.

