

# **Update of the Agricultural Biogas Industry in Canada**

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**October 25, 2010**



**Natural Resources  
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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
$\leq 100$ kW	19.5¢/kWh
$> 100$ kW $\leq 250$ kW	18.5¢/kWh
$\leq 500$ kW	16.0¢/kWh
$>500$ kW $\leq 10$ 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 m<sup>3</sup> 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 m<sup>3</sup> 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 m<sup>3</sup>) and one secondary digester (1527 m<sup>3</sup>)
  - 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 m<sup>3</sup>) and one secondary digester (1200 m<sup>3</sup>)
  - 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 m<sup>3</sup>/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 (900m<sup>3</sup>) treating hog manure
  - System loading: 100 m<sup>3</sup>/day
  - Biogas produced: 1,600 m<sup>3</sup>/day
  - Biogas used for electricity (120 kW<sub>e</sub>) and heat production (630 kW<sub>t</sub>)
  - 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 ( $\sim 7$  ¢/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 m<sup>3</sup> 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 m<sup>3</sup> 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 m<sup>3</sup> fully mixed digesters
  - \$2 million project
  - Mesophilic operation (37°C)
  - Potential co-digestion with slaughterhouse waste
  - System loading of 88m<sup>3</sup>/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](http://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<sub>eq</sub>
  - Phase 2: 1.6 MW<sub>eq</sub>
  - 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 CH<sub>4</sub> and NH<sub>3</sub> 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

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**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)
  - CH<sub>4</sub> 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

<b>Digester System Performance</b>	<b>Environmental Impacts</b>
Biogas production & CH <sub>4</sub> concentration	Volatile fatty acids (VFAs) and Odours
Electricity & heat production	<i>E.coli</i>
Organic Matter: COD, Volatile Solids	<i>Salmonella</i>
Nutrients: NH <sub>4</sub> <sup>+</sup> , Organic-N, o-PO <sub>4</sub> <sup>3-</sup> , 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 : $\text{NH}_4^+$ , $\text{NO}_3^-$ , $\text{o-PO}_4^{3-}$ , TP, Organic-N	$\text{NH}_3$ & $\text{N}_2\text{O}$
<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 CH<sub>4</sub> Emissions from Digestion System and  
NH<sub>3</sub> Emissions following Land Application of Digested Manure

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**Researchers:** Tom Flesch, Ph.D.

Ray Desjardins, Ph.D.



Agriculture and  
Agri-Food Canada

Agriculture et  
Agroalimentaire Canada

# Project Overview

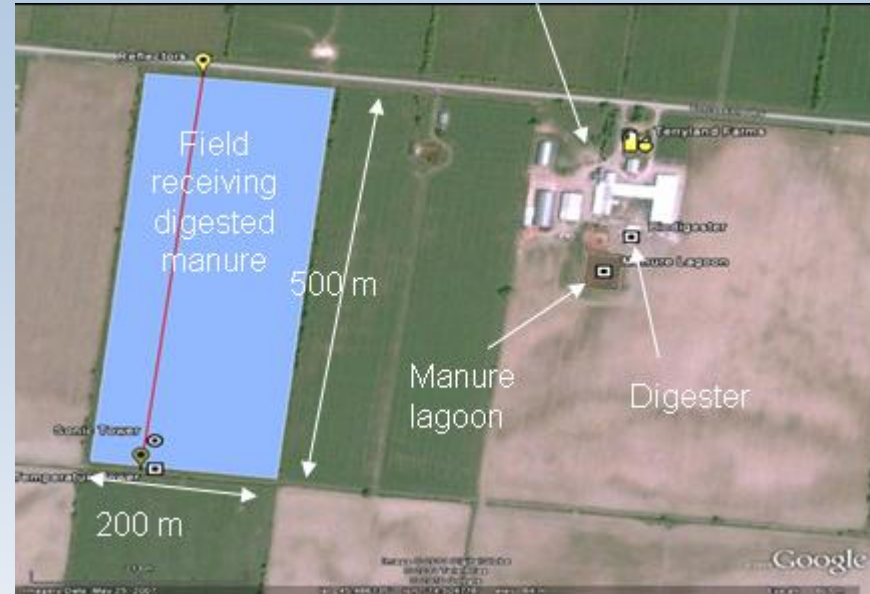
- Anaerobic Digesters:
  - Quantify CH<sub>4</sub> fugitive emissions from the whole biodigestion system
- Land Application Trials:
  - Measurements of NH<sub>3</sub> emissions following land application of digested manure

# Quantifying Fugitive CH<sub>4</sub> 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<sub>4</sub> emissions.
- Minimizing fugitive emissions can maximize energy production, while minimizing environmental impacts.
- Quantifying fugitive CH<sub>4</sub> emissions is difficult – commonly assumed:
  - 15% of total CH<sub>4</sub> 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 $\text{NH}_3$ Emissions from Land Application of Digested Dairy Manure



- Increased concentration of  $\text{NH}_4^+$ -N in digested manure can lead to increased  $\text{NH}_3$  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<sub>4</sub> and NH<sub>3</sub> emissions from farms with biodigesters.
- Recommendations to improve on-farm management of raw and digested manure that minimize methane emissions.
- Improve efficiency of CH<sub>4</sub> 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

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**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 CH<sub>4</sub> emissions from uncovered digestate storage reservoirs will be estimated.
- Conducted in conjunction with a University of Guelph study to investigate emissions of CH<sub>4</sub> and N<sub>2</sub>O from farms with biodigesters.

