Final Report for the Study of Food-Based Inputs for Biogas Systems in Ontario

Prepared for:

Ontario Ministry of Agriculture, Food and Rural Affairs
1 Stone Road West
2nd Floor NE
Guelph, ON N1G 4Y2

May 9, 2008

Geomatrix

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EXECUTIVE SUMMARY

This study examined the types, quantity and characteristics of food processing industry residues and plate food waste that enters municipal solid waste that can be used for biogas production in Ontario, using anaerobic digestion. The study also estimated the biogas production potential of the residues and plate food waste and the equivalent electrical energy and natural gas energy of the biogas.

Based on information collected during the study, it is estimated that between 1.2 and 9.8 million wet tonnes of food processing residues and plate food waste are produced annually in Ontario. These residues have potential to produce between 106 and 1,393 GW-hr/yr of electrical energy (1.2 to 16.7 million GJ/yr of natural gas equivalence), assuming a biogas to electricity conversion efficiency of 30%.

Due to competition from other users of food processing industry residues it is estimated that between 40% and 60% of the residues will actually be available for biogas production. Based on 50% of the estimated 1.2 to 9.8 million tonnes of residues being available for biogas production, between 53.0 and 697 GW-hr/yr of biogas generated electrical power (0.64 to 8.4 million GJ/yr of natural gas equivalence) can be produced. At today's energy values ($0.11/kw-hr for electrical energy and $7.00/GJ for natural gas) the potential biogas energy has a value of between $5.8 million and $76.7 million as electrical energy and between $4.5 million and $58.8 million as natural gas.

The food processing residues considered for this project included any organic residues disposed of after primary and secondary processing of fruits, vegetables, grains, livestock and beverages. The residues also included wastewater generated by the food processing facilities. The plate food waste considered for this project included the food prepared for meals that is not eaten and thrown in the garbage. This included food wasted in homes, institutions, stores, and restaurants.

Energy crops such as corn silage that can be grown as an input for biogas production were not included in the study. Biomass such as forestry residues, brush from forest thinning and saw mill residues and manures from livestock production as well, were not included in the study.

Direct contact with a cross section of food processing industry facilities, food processing industry residue haulers and Ministry of Environment offices was made through mail and phone contact to collect information regarding food processing residues. Theoretical numbers were calculated using published loss/recovery and residue production factors combined with food processing data for Ontario. A literature search of food processing residue studies completed in Ontario and other jurisdictions was also conducted to obtain information to help predict and extrapolate food processing residue quantities produced in Ontario.

Obtaining information through direct contact was found to be difficult due to the reluctance of the industry to share data related to the production and disposal of food processing residues. Published information also noted that this reluctance of the food processing industry to share residue and production data is common in other jurisdictions. The literature search revealed that very few comprehensive food processing industry residue studies have been published.

Food processing industry wastewaters and wet residues have the highest likelihood of being available for biogas production. Many of the wet residues and wastewater residuals from treatment of food processing industry wastewaters are currently used as a nutrient source for agricultural crop production. Nutrients are conserved during anaerobic treatment, so these nutrients will still be available after the residues are used for biogas production, and the two uses do not compete with each other. Many of the higher value residues are used for livestock feed and biodiesel production. These competing industries may increase or decrease their demands for the residues depending on future energy costs and livestock production levels.

The meat, dairy, grain, fruit, vegetable and beverage industries all generate significant quantities of wastewater and wet food processing residues suitable for biogas production. These industries also produce a significant quantity of solid and semi solid wastes that are used in the animal feed industry. Animal feed production and biodiesel production will compete with biogas production for some of the food industry processing residues.

The relatively low solids content of the wastewaters generated in the food processing industry makes it uneconomical to haul these materials any distance and these materials will be best utilized in anaerobic systems located on site at the food processing facility or in close proximity to the residue source. There is an opportunity for farm based systems located relatively close to the food processing industries that generate wet residues to use the residues with manure to generate biogas.

Many of the fruit and vegetable processing residues are generated seasonally and difficult to store. These materials could produce biogas seasonally if the facility could make direct use of the biogas or export the biogas to the local natural gas grid. Seasonal operation of cogeneration systems would not be economically viable in most cases due to the high capital cost of the cogeneration system.

FINAL REPORT FOR THE STUDY OF FOOD BASED INPUTS FOR BIOGAS SYSTEMS IN ONTARIO

Ontario Ministry of Agriculture, Food and Rural Affairs

1.0 INTRODUCTION

The Province of Ontario faces challenges in meeting current and projected energy demand. The use of biogas systems is one of the green energy technologies being considered to help meet current and projected energy demand. In order to develop policies and programs to promote the implementation of existing biogas technologies and development of emerging biogas technologies, a clear understanding of the quantity, quality and the availability of feed stocks and the economic, environmental and social/community impacts of wide spread use of these feed stocks for green energy production, is required.

This project is a scan of readily available published food processing industry data, individual reports from companies, and engineering data for predicting food processing residues to provide an estimate of the quantities, characteristics and energy production potential of food processing industry residues. The results of this report can be used as a preliminary estimate in understanding the potential of the food processing industry to provide food based inputs for generating biogas using anaerobic systems.

The food processing industry is a sector of society that has potential to provide new or increased quantities of feed stock materials for green energy production that will enhance Ontario's bio-economy. The food and beverage processing industry generates annual revenues of nearly 32.5 billion dollars annually (Ontario Ministry of Economic Development and Trade 2005). The organic residues generated by this industry represent a significant potential source of green energy feed stocks for biogas systems. Environmental benefits beyond the production of green energy may also be realized from utilizing organic residues from the food processing industry. The potential of using residues as energy feed stocks may lower the cost of managing food processing residue streams. This in turn will improve the economic viability of the industry. Use of food processing industry residues as biogas system feed stocks also has the potential to reduce net greenhouse gas emissions.

This project has been commissioned to provide information about the quantities and value of the wide variety of organic residues generated by the food processing industry and households in Ontario. This information can support the development of policies and programs that will ensure that organic feed stocks from the food processing industry and municipal waste streams combined with emerging and existing green energy technologies are used effectively to contribute to the Ontario energy supply mix. The use of energy feed stocks from the food processing industry has the potential to improve the economic prosperity of Ontario.

2.0 DEVELOPMENT OF DATA REGARDING FOOD-BASED INPUTS AVAILABLE AS FEED STOCK FOR ONTARIO BIOGAS SYSTEMS

2.1 DATA COLLECTION

Information was obtained for food processing industry residues and discarded plate food that enters municipal solid waste. Green energy crops, manure, organic biomass and municipal solid waste were not part of the study.

A number of different types of information sources were used to establish the potential quantities of residues available from the Ontario food processing industry and the discarded food component of residential waste in Ontario. Information was successfully collected from the following sources for use in the report:

1. In house knowledge by Geomatrix staff regarding food processing industry residue volumes and residue characteristics.
2. Relevant food processing industry census data from the Ontario Ministry of Agriculture Food and Rural Affairs and from Statistics Canada.
3. Various Ontario food processing associations were contacted by phone to obtain data on waste quantities produced for the respective food industry represented by the association. A list of the associations contacted can be found in Appendix A
4. Waste haulers were contacted to obtain quantities of waste managed.
5. A literature search of data relevant to the quantities and characteristics of waste generated by different food processing industries. A bibliography of relevant data can be found in Section 7: Bibliography.

Several other sources of information were investigated but a limited amount of information was obtained. For example a questionnaire was sent to a cross section of 117 food processing industries. The response to the questionnaire was very limited and only 9 responses were obtained. Appendix B contains a list of the companies that received a questionnaire.

Calculations for determining the quantity of biogas and the energy value of the biogas were based on the following factors:

1. Biogas was assumed to have an average methane content of 65%.

2. Methane was assumed to have an energy value of 36.3 MJ/normal m^3.

3. Conversion of biogas energy to electrical energy was assumed to have an efficiency of 30%.

4. 1 kJ = 0.00027778 kW hr.

5. Ontario population used for all per capita calculations was 12,160,280 people. This is the 2006 Ontario population listed by Statistics Canada.

2.2 METHODS USED FOR ESTIMATING FOOD RESIDUE QUANTITIES GENERATED IN ONTARIO

Four methods were used to estimate the quantity of organic residues available from food processing industries in Ontario. The four methods include the following:

1. Use of Ontario food processing production data and standard loss/recovery factors.

2. Use of Cornell University web-based computer program for predicting food processing industry residues based on the number of employees in the industry.

3. Extrapolation from food processing industry residue studies completed in other jurisdictions.

4. Inventory of known residue volumes generated in Ontario.

2.2.1 Method 1 - Use of Ontario Food Processing Production Data and Standard Loss/Recovery Factors

Method 1 involved the use of residue production and loss/recovery factors combined with Ontario food industry production data. Table 2.1 provides a summary of the residue production and loss/ recovery factors that were obtained from published literature. The table also includes the Ontario food production numbers used in conjunction with the waste and loss/recovery factors to arrive at the quantity of food processing residues produced and the energy potentially available from them.

Residue production factors from a number of sources were used for the residue quantity calculations. The residue production factor represents the portion of the raw input material that ends up as a residue that is disposed of after producing a food product or a product that is further processed. The residue production factors were multiplied by Ontario production numbers that were available to arrive at a residue quantity. The Ontario production numbers represent the quantity of agricultural commodities such as grain, vegetables, fruit and livestock

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Table 2.1

Food Industry Residue Estimates Based on Data From Various Published Sources
Data is Summarized in Table 2.2

Food Industry Category (Based on terminology used in each information source)	Source of Residue Production Factor	Residue Production Factor Blank cells indicate that data was not found	Residue Production Factor Units	Production Data for Ontario	Production Units	Source of Production Data	Quantity Estimates Based on Residue Production Factors & Ontario Production Numbers Blank cells indicate that data was not found			Characteristics Blank cells indicate that data was not found				Source of Characteristics Information	Biogas Production Factor (assumes methane content of 65%) Blank cells indicate that data was not available	Biogas Production Factor Units	Source of Biogas Production Factor	Estimated Biogas Production m^3 (assumes methane content of 65%) Blank cells indicate that insufficient data was available to calculate
				Blank cells indicate that data was not found			WW COD or BOD tonnes/yr	Volume m^3/yr	Solids Weight tonnes/yr	TS Liquids - mg/L Solids - kg solids/kg wet weight	VS WW - mg/L Solids - kg VS solids/kg wet weight	COD mg/L	BOD mg/L					
Primary Processors																		
Red Meat - Beef																		
Red meat	Statistics Canada	0.0737	tonnes waste/tonne processed	791,635	beef animals with avg. carcass wt. of 372 kg. assumed 62% yield = avg. live wt. of 600 kg.	Statistics Canada 2006 Beef Cattle Table 24			35,018	0.36	0.29	2,500	2,000	TS from Biomass Inventory and Bioenergy Assessment	0.830	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	8,370,603
Red meat	Food Processing Handbook	10	m^3 WW/tonne product	791,635	beef animals with avg. carcass wt. of 372 kg. assumed 62% yield = avg. live wt. of 600 kg.	Statistics Canada 2006 Beef Cattle Table 24		2,944,882				2,500	2,000	Food Processing Handbook	0.830	m^3 biogas/kg COD @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	4,277,441
Red meat	Food Processing Handbook	440	kg waste /tonne of product	791,635	beef animals with avg. carcass wt. of 372 kg. assumed 62% yield = avg. live wt. of 600 kg.	Statistics Canada 2006 Beef Cattle Table 24			129,575	0.36	0.29	2,500	2,000	TS from Biomass Inventory and Bioenergy Assessment	0.830	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	30,973,564
Slaughtering	WP 2 Technical Potential for Polygeneration in the Food processing Industry	30	kg WW COD/tonne carcass weight	791,635	beef animals with avg. carcass wt. of 372 kg. assumed 62% yield = avg. live wt. of 600 kg.	Statistics Canada 2006 Beef Cattle Table 24	8,835						1,126	Waste Management Course Notes by Norbert Schmidtke	0.830	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	5,132,930
Slaughter house	Waste Management Course Notes by Norbert Schmidtke	6.0	kg WW BOD/tonne live weight	791,635	beef animals with avg. carcass wt. of 372 kg. assumed 62% yield = avg. live wt. of 600 kg.	Statistics Canada 2006 Beef Cattle Table 24	2,850						1,126	Waste Management Course Notes by Norbert Schmidtke	0.830	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	2,483,676
Packing house	Waste Management Course Notes by Norbert Schmidtke	6.28	kg WW BOD/tonne live weight	791,635	beef animals with avg. carcass wt. of 372 kg. assumed 62% yield = avg. live wt. of 600 kg.	Statistics Canada 2006 Beef Cattle Table 24	2,983						675	Waste Management Course Notes by Norbert Schmidtke	0.830	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	2,599,581
Slaughtering - beef	Central Pollution Control Board News Letter	275	kg solid waste/tonne of live weight	791,635	beef animals with avg. carcass wt. of 372 kg. assumed 62% yield = avg. live wt. of 600 kg.	Statistics Canada 2006 Beef Cattle Table 24			130,620	0.36	0.29			TS from Biomass Inventory and Bioenergy Assessment	0.830	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	31,223
Pre-processing	WP 2 Technical Potential for Polygeneration in the Food Processing Industry	100	kg solids/ tonne of carcass weight	791,635	beef animals with avg. carcass wt. of 372 kg. assumed 62% yield = avg. live wt. of 600 kg.	Statistics Canada 2006 Beef Cattle Table 24			29,449	0.36	0.29			TS from Biomass Inventory and Bioenergy Assessment	0.830	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	7,039,446
Cooking & canning	WP 2 Technical Potential for Polygeneration in the Food processing Industry	10	kg WW COD/tonne carcass weight	791,635	beef animals with avg. carcass wt. of 372 kg. assumed 62% yield = avg. live wt. of 600 kg.	Statistics Canada 2006 Beef Cattle Table 24	2,945								0.830	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	1,710,977
Beef meat processing	Biomass Inventory and Bioenergy Assessment	187	kg by-product materials/tonne of live weight	791,635	beef animals with avg. carcass wt. of 372 kg. assumed 62% yield = avg. live wt. of 600 kg.	Statistics Canada 2006 Beef Cattle Table 24			88,821	0.36	0.29	2,500	2,000	TS from Biomass Inventory and Bioenergy Assessment	0.830	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	21,231,879
Sheep & Goats																		
Slaughtering - goat/sheep	Central Pollution Control Board News Letter	170	kg solid waste/tonne of live weight	282,385	head of sheep, lambs & goats assume avg. wt of 55 kg. and 54% carcass yield = 29.7 kg carcass	OMAFRA Statistics - Red Meat Slaughter data 2007			2,640	0.36	0.29			TS from Biomass Inventory and Bioenergy Assessment	0.830	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	631,137
Pork																		
Pork	Statistics Canada	0.1663	tonnes waste/tonne processed	4,513,639	hog animals with avg. carcass wt. of 90.6 kg. assume 74% carcass yield = avg. live wt. of 122.4 kg.	Statistics Canada 2006 Hogs Table 27			91,901	0.36	0.29	3,015	2,000	TS from Biomass Inventory and Bioenergy Assessment	0.830	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	21,967,948
Slaughtering -pig	Central Pollution Control Board News Letter	40	kg solid waste/tonne of live weight	4,513,639	hog animals with avg. carcass wt. of 90.6 kg. assume 74% carcass yield = avg. live wt. of 122.4 kg.	Statistics Canada 2006 Hogs Table 27			22,099	0.36	0.29			TS from Biomass Inventory and Bioenergy Assessment	0.830	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	5,282,492
Swine meat processing	Biomass Inventory and Bioenergy Assessment	135	kg by-products/tonne of live weight	4,513,639	hog animals with avg. carcass wt. of 90.6 kg. assume 74% carcass yield = avg. live wt. of 122.4 kg.	Statistics Canada 2006 Hogs Table 27			74,583	0.36	0.29	3,015	2,000	TS from Biomass Inventory and Bioenergy Assessment	0.830	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	17,828,409
Poultry																		
Poultry	Food Processing Handbook	270	kg waste/tonne of prod.	330,398	tonnes	OMAFRA Statistics - Poultry and Egg Production 2004			89,207	0.37	0.30	597	317	TS from Biomass Inventory and Bioenergy Assessment	0.923	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	24,372,192
Broiler	Processing Wastes	22.2	kg WW BOD/1,000 animals	16,888,349	head	OMAFRA Statistics - 2007 White Meat Slaughter	375								0.923	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	363,355
Turkey	Processing Wastes	77.1	kg WW BOD/1,000 animals	148,730	head	OMAFRA Statistics - 2007 White Meat Slaughter	11			1,100	215	1,729	814	Water Use and Waste Discharge Patterns in a Turkey Processing Plant	0.923	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	11,113
Poultry processing	Waste Management Course Notes by Norbert Schmidtke	11.9	kg WW BOD/1,000 birds processed	16,888,349	head	OMAFRA Statistics - 2007 White Meat Slaughter	201								0.923	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	194,771
Poultry	Production Yield Analysis in Food Processing	300	kg waste/tonne of prod.	330,398	tonnes	OMAFRA Statistics - Poultry and Egg Production 2004			99,119	0.37	0.30			TS from Biomass Inventory and Bioenergy Assessment	0.923	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	27,080,213
Poultry Meat Processing	Biomass Inventory and Bioenergy Assessment	193	kg of waste/tonne of broiler live weight	330,398	tonnes	OMAFRA Statistics - Poultry and Egg Production 2004			63,767	0.37	0.30			TS from Biomass Inventory and Bioenergy Assessment	0.923	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	17,421,604
Poultry Feathers	Biomass Inventory and Bioenergy Assessment	0.09	kg/kg of live broiler weight	330,398	tonnes	OMAFRA Statistics - Poultry and Egg Production 2004			29,736	0.921	0.74			TS from Biomass Inventory and Bioenergy Assessment	0.923	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	20,222,332

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							WW COD or BOD tonnes/yr	Volume m^3/yr	Solids Weight tonnes/yr	TS Liquids - mg/L Solids - kg solids/kg wet weight	VS WW - mg/L Solids - kg VS solids/kg wet weight	COD mg/L	BOD mg/L					
Fish																		
Fish	Waste Treatment in the Food Processing Industry	25	kg WW BOD/tonne of product	18,145	tonnes	Phil Dick OMAFRA	272		181,450	1,500	1200	1,950	1,020	Estimate	0.830	m^3 biogas/kg VS @ 65 % methane	Estimate	237,201
Fish canning	Waste Management Course Notes by Norbert Schmidtke	7.9	kg WW BOD/tonne of product									696	343	Waste Management Course Notes by Norbert Schmidtke				
Rendering																		
Yellow grease and animal carcasses	Final Report Biodiesel Feedstock Availability in Ontario	12,000	tonnes/yr	12,000	tonnes	Final Report Biodiesel Feedstock Availability in Ontario			12,000	0.47	0.38			Estimate	0.830	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	3,744,960
Condemned hogs	Estimating and Addressing America's Food Losses	0.20	% of animals sent for slaughter	4,513,639	hog animals with avg. carcass wt. of 90.6 kg. assume 74% carcass yield = avg. live wt. of 122.4 kg.	Statistics Canada 2006 Hogs Table 27			1,105	0.36	0.29			TS from Biomass Inventory and Bioenergy Assessment	0.830	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	264,125
Condemned calves	Estimating and Addressing America's Food Losses	1.7	% of animals sent for slaughter												0.830	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	
Chickens	Estimating and Addressing America's Food Losses	0.40	% of animals sent for slaughter	16,888,349	head	OMAFRA Statistics - 2007 White Meat Slaughter			8,269	0.37	0.30			TS from Biomass Inventory and Bioenergy Assessment	0.923	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	2,259,030
Turkeys	Estimating and Addressing America's Food Losses	0.40	% of animals sent for slaughter	148,730	head	OMAFRA Statistics - 2007 White Meat Slaughter			73	0.37	0.30			TS from Biomass Inventory and Bioenergy Assessment	0.923	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	19,895
Yellow grease	Biomass Inventory and Bioenergy Assessment	3.04	kg/capita/yr.	12,160,282	Population	OMAFRA Statistics - Statistical Summary of Ontario Agriculture - 2001 Census			36,967	0.90	0.72			TS from Biomass Inventory and Bioenergy Assessment	0.538	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	14,319,637
Brown grease	Biomass Inventory and Bioenergy Assessment	3.37	kg/capita/yr.	12,160,282	Population	OMAFRA Statistics - Statistical Summary of Ontario Agriculture - 2001 Census			40,980	0.90	0.72			TS from Biomass Inventory and Bioenergy Assessment	0.538	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	15,874,071
Yellow Grease	Final Report Biodiesel Feedstock Availability in Ontario	6	L/person/year	12,160,282	Population	OMAFRA Statistics - Statistical Summary of Ontario Agriculture - 2001 Census		72,962		0.90	0.72			TS from Biomass Inventory and Bioenergy Assessment	0.538	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	25,436,197
Trap Grease	Final Report Biodiesel Feedstock Availability in Ontario	5.9	kg/person/yr	12,160,282	Population	OMAFRA Statistics - Statistical Summary of Ontario Agriculture - 2001 Census			71,746	0.50	0.40			TS from The Elorin Bioenergy Feasibility Study	0.538	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	15,439,667
Dairy																		
Milk & milk products	Food Processing Handbook	1.5	m^3 WW/tonne product	445,693	tonnes of dairy products	OMAFRA Statistics - Production of Specified dairy Products 2006		668,540			3,150	4,500	2,190	Food Processing Handbook	0.352	m^3 biogas/kg COD @ 65 % methane	Food Processing Residues in California: Resources Assessment and Potential for Power Generation	1,058,967
Milk & milk products	Waste Management Course Notes by Norbert Schmidtke	3.21	kg WW BOD/tonne of product	445,693	tonnes of dairy products	OMAFRA Statistics - Production of Specified dairy Products 2006	1,431					4,000	2,190	Waste Treatment in the Food Processing Industry	0.352	m^3 biogas/kg COD @ 65 % methane	Food Processing Residues in California: Resources Assessment and Potential for Power Generation	503,597
Cheese whey	Biomass Inventory and Bioenergy Assessment	9	m^3 whey/m^3 milk processed into cheese	111,593	tonnes of cheese	OMAFRA Statistics - Production of Specified dairy Products 2006		1,004,337		65,000	52,000	1,135	696	TS from Biomass Inventory and Bioenergy Assessment	0.477	m^3 biogas/kg VS @ 65 % methane	Biomass Inventory and Bioenergy Assessment - Washington State 2005	24,911,575
Cheese	Food Processing Handbook	3	m^3 WW/tonne product	111,593	tonnes of cheese	OMAFRA Statistics - Production of Specified Dairy Products 2006		334,779		1,200	200	2,000	10,400	Food Processing Handbook	0.352	m^3 biogas/kg COD @ 65 % methane	Food Processing Residues in California: Resources Assessment and Potential for Power Generation	235,684
Cheese	Waste Management Course Notes by Norbert Schmidtke	10.3	kg WW BOD/tonne of product	111,593	tonnes of cheese	OMAFRA Statistics - Production of Specified Dairy Products 2006	1,149			1,200	200	15,200	10,400	Animal Agriculture and Food Processing Wastes IX	0.352	m^3 biogas/kg COD @ 65 % methane	Food Processing Residues in California: Resources Assessment and Potential for Power Generation	404,592
Skim milk	Food Processing Handbook	0.07	m^3 WW/m^3 product	854,703	m^3 skim milk	OMAFRA Statistics - Sales of Fluid Milk 2006		59,829				700		Food Processing Handbook	0.352	m^3 biogas/kg COD @ 65 % methane	Food Processing Residues in California: Resources Assessment and Potential for Power Generation	14,742
Ice cream	Food Processing Handbook	0.08	m^3 WW/m^3 product	109,277	m^3 ice cream	OMAFRA Statistics - Production of Specified Dairy Products 2006		8,742				4,500	500	Food Processing Handbook	0.352	m^3 biogas/kg COD @ 65 % methane	Food Processing Residues in California: Resources Assessment and Potential for Power Generation	13,848
Butter	Waste Management Course Notes by Norbert Schmidtke	20.9	kg WW BOD/tonne of product	23,710	tonnes butter	OMAFRA Statistics - Production of Specified Dairy Products 2006	496			1,720		1,746	1,000	Waste Management Course Notes by Norbert Schmidtke	0.352	m^3 biogas/kg COD @ 65 % methane	Food Processing Residues in California: Resources Assessment and Potential for Power Generation	174,430
Grains for Oils																		
Soybean	Final Report Biodiesel Feedstock Availability in Ontario	0.808	tonne waste/tonne processed	2,000,000	tonnes	Phil Dick OMAFRA			1,616	0.8	0.64			Estimate	0.528	m^3 biogas/kg BOD	Estimate	1,034,240
Canola	Final Report Biodiesel Feedstock Availability in Ontario	0.58	tonne waste/tonne processed	50,000	tonnes	Phil Dick OMAFRA			29.0	0.8	0.64			Estimate	0.528	m^3 biogas/kg BOD	Estimate	18,560
Corn	Final Report Biodiesel Feedstock Availability in Ontario	0.96	tonne waste/tonne processed															
Oil production	Calculated from Data in "Waste Management and Utilization in Food Production Processing" Textbook	0.623	m^3 ww/tonne processed	2,050,000	tonnes	Phil Dick OMAFRA		1,277,150			2,686		2,820	Calculated from Data in "Waste Management and Utilization in Food Production Processing" Textbook	0.352	m^3 biogas/kg BOD	Food Processing Residues in California: Resources Assessment and Potential for Power Generation	1,207,381

Table 2.1

Food Industry Residue Estimates Based on Data From Various Published Sources
Data is Summarized in Table 2.2

Food Industry Category (Based on terminology used in each information source)	Source of Residue Production Factor	Residue Production Factor Blank cells indicate that data was not found	Residue Production Factor Units	Production Data for Ontario Blank cells indicate that data was not found	Production Units	Source of Production Data	Quantity Estimates Based on Residue Production Factors & Ontario Production Numbers Blank cells indicate that data was not found			Characteristics Blank cells indicate that data was not found				Source of Characteristics Information	Biogas Production Factor (assumes methane content of 65%) Blank cells indicate that data was not available	Biogas Production Factor Units	Source of Biogas Production Factor	Estimated Biogas Production m^3 (assumes methane content of 65%) Blank cells indicate that insufficient data was available to calculate
							WW COD or BOD tonnes/yr	Volume m^3/yr	Solids Weight tonnes/yr	TS Liquids - mg/L Solids - kg solids/kg wet weight	VS WW - mg/L Solids - kg VS solids/kg wet weight	COD mg/L	BOD mg/L					
Oil production	Calculated from Data in "Waste Management and Utilization in Food Production Processing" Textbook	0.522	m^3 ww/tonne processed	2,050,000	tonnes	Phil Dick OMAFRA		1,070,100			2,686		2,820	Calculated from Data in "Waste Management and Utilization in Food Production Processing" Textbook	0.352	m^3 biogas/kg BOD	Food Processing Residues in California: Resources Assessment and Potential for Power Generation	1,011,642
Crude oil processing from seed	WP 2 Technical Potential for Polygeneration in the Food processing Industry	0.55	kg WW COD/tonne seed processed	2,050,000	tonnes	Phil Dick OMAFRA	1,128	486,875			1,622	2,317		Calculated from data in WP2 Technical Potential for Polygeneration in the Food Processing Industry	0.352	m^3 biogas/kg COD	Food Processing Residues in California: Resources Assessment and Potential for Power Generation	277,816
Oil refining	Waste Management Course Notes by Norbert Schmidtke	12.9	kg WW BOD/tonne of oil refined									365	224	Waste Management Course Notes by Norbert Schmidtke				
Fruits																		
Fruits	Statistics Canada	0.0507	tonnes waste/tonne processed	371.686	tonnes	Statistics Canada			18.9	0.16	0.13	3,500		TS from Biomass Inventory and Bioenergy Assessment	0.440	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	1,062
Fruits	Processing Wastes	0.266	tonnes of waste/tonne processed	371.686	tonnes	Statistics Canada			98.9	0.16	0.13	3,500		TS from Biomass Inventory and Bioenergy Assessment	0.440	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	5,568
Apples	WP 2 Technical Potential for Polygeneration in the Food processing Industry	90	kg solid waste/tonne of product	1	kg/capita processed	OMAFRA Statistics -Per Capita Disappearance of Selected Fruits and Vegetables - 2006			1,094	0.16	0.13			TS from Biomass Inventory and Bioenergy Assessment	0.440	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	61,638
Apples to Apple sauce	Estimating and Addressing America's Food Losses	200	kg solid waste/ tonne apples processed	0.5	kg/capita processed	OMAFRA Statistics -Per Capita Disappearance of Selected Fruits and Vegetables - 2006			1,216	0.53	0.42			TS from Biomass Inventory and Bioenergy Assessment	0.440	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	226,862
Peaches	WP 2 Technical Potential for Polygeneration in the Food processing Industry	180	kg solid waste/tonne of product	0.98	kg/capita processed	OMAFRA Statistics -Per Capita Disappearance of Selected Fruits and Vegetables - 2006			2,145	0.16	0.13			TS from Biomass Inventory and Bioenergy Assessment	0.440	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	120,811
Strawberries	WP 2 Technical Potential for Polygeneration in the Food processing Industry	60	kg solid waste/tonne of product	0.62	kg/capita processed	OMAFRA Statistics -Per Capita Disappearance of Selected Fruits and Vegetables - 2006			452	0.16	0.13			TS from Biomass Inventory and Bioenergy Assessment	0.440	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	25,477
Canning fruits	Waste Management Course Notes by Norbert Schmidtke	12.5	kg WW BOD/tonne of product	2.6	kg/capita processed	OMAFRA Statistics -Per Capita Disappearance of Selected Fruits and Vegetables - 2006	395						553	Waste Management Course Notes by Norbert Schmidtke	0.440	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	182,587
Vegetables																		
Vegetable processing (corn, peas, carrots)	Biomass Inventory and Bioenergy Assessment	130	kg waste/tonne of raw vegetables	4.21	kg/capita processed	OMAFRA Statistics -Per Capita Disappearance of Selected Fruits and Vegetables - 2006			6,655	0.10	0.08	3,500		TS from Biomass Inventory and Bioenergy Assessment	0.642	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	341,817
Vegetables	Processing Wastes	0.266	tonnes waste/tonne processed	12.3	kg/capita processed	OMAFRA Statistics -Per Capita Disappearance of Selected Fruits and Vegetables - 2006			39,786	0.45	0.36	3,500		TS from The Elorin Bioenergy Feasibility Study	0.642	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	9,195,343
Vegetables	Statistics Canada	0.1638	tonnes waste/tonne processed	1690.406	tonnes	Statistics Canada			277	0.45	0.36	3,500		TS from The Elorin Bioenergy Feasibility Study	0.642	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	63,996
Vegetables	Food Processing Handbook	17.5	m^3 WW/tonne product	12.3	kg/capita processed	OMAFRA Statistics -Per Capita Disappearance of Selected Fruits and Vegetables - 2006		2,617,501				3,500		Food Processing Handbook	0.642	m^3 biogas/kg COD	Biomass Inventory and Bioenergy Assessment - Washington State 2005	5,881,524
Kale	Food Processing Handbook	16	kg total solids/tonne production							4,000								
Spinach	Food Processing Handbook	20	kg total solids/tonne production							5,000								
Mustard Greens	Food Processing Handbook	16	kg total solids/tonne production							4,000								
Turnip Greens	Food Processing Handbook	15	kg total solids/tonne production							3,750								
Potatoes - processed	Food Processing Handbook	66	kg total solids/tonne production	66.36	kg/capita processed assumes processed consumption = to fresh consumption	OMAFRA Statistics -Per Capita Disappearance of Selected Fruits and Vegetables - 2006			53,259	0.19	0.15	6,450	4,100	TS from Biomass Inventory and Assessment	0.642	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	5,197,238
Potatoes - processed	Waste Treatment in the Food Processing Industry	29.5	kg ww COD/tonne processed	66.36	kg/capita processed assumes processed consumption = to fresh consumption	OMAFRA Statistics -Per Capita Disappearance of Selected Fruits and Vegetables - 2006	23,805			7,794	7,420	6,450	4,100	Waste Treatment in the Food Processing Industry	0.642	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	10,698,062
Potatoes - harvested	Biomass Inventory and Bioenergy Assessment	100	kg cull/tonne of production	226,867	tonnes	OMAFRA Statistics - Area, Production and farm value of Potatoes 2007			22,687	0.19	0.15	6,450	4,100	TS from Biomass Inventory and Assessment	0.642	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	2,213,859
Potatoes - processed	Biomass Inventory and Bioenergy Assessment	37	kg potato solids/tonne processed	226,867	tonnes	OMAFRA Statistics - Area, Production and farm value of Potatoes 2007			8,394	0.19	0.15	6,450	4,100	TS from Biomass Inventory and Assessment	0.642	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	819,128
Peppers (caustic peeling)	Food Processing Handbook	65	kg total solids/tonne production							3,250								
Tomatoes (caustic peeling)	Food Processing Handbook	14	kg total solids/tonne production	12.3	kg/capita processed	OMAFRA Statistics -Per Capita Disappearance of Selected Fruits and Vegetables - 2006			2,094	0.10	0.08			TS from Biomass Inventory and Assessment	0.642	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	107,548
Corn	Phil Dick OMAFRA	260	kg husk & silk/tonne processed	1.3	kg/capita processed	OMAFRA Statistics -Per Capita Disappearance of Selected Fruits and Vegetables - 2006			4,110	0.202	0.16			Estimate	0.642	m^3 biogas/kg VS	Estimate	426,419
Corn	WP 2 Technical Potential for Polygeneration in the Food processing Industry	40	kg solid waste/tonne of product	1.3	kg/capita processed	OMAFRA Statistics -Per Capita Disappearance of Selected Fruits and Vegetables - 2006			632	0.202	0.16			TS from The Elorin Bioenergy Feasibility Study	0.642	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	65,603
Broccoli	WP 2 Technical Potential for Polygeneration in the Food processing Industry	200	kg solid waste/tonne of product															

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Food Industry Category (Based on terminology used in each information source)	Source of Residue Production Factor	Residue Production Factor Blank cells indicate that data was not found	Residue Production Factor Units	Production Data for Ontario	Production Units	Source of Production Data	Quantity Estimates Based on Residue Production Factors & Ontario Production Numbers Blank cells indicate that data was not found			Characteristics Blank cells indicate that data was not found				Source of Characteristics Information	Biogas Production Factor (assumes methane content of 65%) Blank cells indicate that data was not available	Biogas Production Factor Units	Source of Biogas Production Factor	Estimated Biogas Production m^3 (assumes methane content of 65%) Blank cells indicate that insufficient data was available to calculate
				Blank cells indicate that data was not found			WW COD or BOD tonnes/yr	Volume m^3/yr	Solids Weight tonnes/yr	TS Liquids - mg/L Solids - kg solids/kg wet weight	VS WW - mg/L Solids - kg VS solids/kg wet weight	COD mg/L	BOD mg/L					
Carrots	WP 2 Technical Potential for Polygeneration in the Food processing Industry	200	kg solid waste/tonne of product	1.15	kg/capita processed	OMAFRA Statistics -Per Capita Disappearance of Selected Fruits and Vegetables - 2006			2,797	0.45	0.36			TS from The Elorin Bioenergy Feasibility Study	0.642	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	646,411
Peas	WP 2 Technical Potential for Polygeneration in the Food processing Industry	40	kg solid waste/tonne of product	1.76	kg/capita processed	OMAFRA Statistics -Per Capita Disappearance of Selected Fruits and Vegetables - 2006			856	0.45	0.36			TS from The Elorin Bioenergy Feasibility Study	0.642	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	197,858
Potatoes	WP 2 Technical Potential for Polygeneration in the Food processing Industry	40	kg solid waste/tonne of product	66.36	kg/capita processed assumes processed consumption = to fresh consumption	OMAFRA Statistics -Per Capita Disappearance of Selected Fruits and Vegetables - 2006			32,278	0.19	0.15			TS from Biomass Inventory and Assessment	0.642	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	3,149,841
All Vegetables	WP 2 Technical Potential for Polygeneration in the Food processing Industry	130	kg solid waste/tonne of product	12.3	kg/capita processed	OMAFRA Statistics -Per Capita Disappearance of Selected Fruits and Vegetables - 2006			19,444	0.45	0.36	3,500		TS from The Elorin Bioenergy Feasibility Study	0.642	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	4,493,965
Vegetables	WP 2 Technical Potential for Polygeneration in the Food processing Industry	250	kg vegetable waste/tonne of product	12.3	kg/capita processed	OMAFRA Statistics -Per Capita Disappearance of Selected Fruits and Vegetables - 2006			37,393	0.45	0.36	3,500		TS from The Elorin Bioenergy Feasibility Study	0.642	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	8,642,239
Canning vegetables	Waste Management Course Notes by Norbert Schmidtke	12.5	kg WW BOD/tonne of product	12.3	kg/capita processed	OMAFRA Statistics -Per Capita Disappearance of Selected Fruits and Vegetables - 2006	1,870						553	Waste Management Course Notes by Norbert Schmidtke	0.642	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	1,260,327
French fries	Production Yield Analysis in Food Processing	450	kg waste/tonne of production															
Eggs																		
Eggs	Statistics Canada	0.0216	tonnes waste/tonne processed	227,407,000	dozen assumes 0.805 kg/dozen & 50% processed	OMAFRA Statistics - Ontario Egg Production and Value 2006			3,961	0.10	0.08			Estimate	0.503	m^3 biogas/kg VS	Food Processing Residues in California: Resources Assessment and Potential for Power Generation	159,379
Eggs	Food Processing Handbook	111	kg total solids/tonne production	227,407,000	dozen assumes 0.805 kg/dozen & 50% processed	OMAFRA Statistics - Ontario Egg Production and Value 2006			20,320	0.10	0.08			Estimate	0.503	m^3 biogas/kg VS	Food Processing Residues in California: Resources Assessment and Potential for Power Generation	817,675
Secondary Processors																		
Bakery																		
Bakery	WP 2 Technical Potential for Polygeneration in the Food processing Industry	1.9	kg COD/tonne of bread	1,200,000	tonnes of bakery products/yr	Bakery Association of Canada 2005	2,280	276,000							0.830	m^3 biogas/kg BOD	Biomass Inventory and Bioenergy Assessment - Washington State 2005	1,324,680
Meat																		
Chicken nuggets	Manufacture of Food Products and beverages #46	0.408	kg WW BOD/1,000 chicken nuggets															
Cereal																		
Cereal	Statistics Canada	0.0189	tonnes waste/tonne production	2,657,540	tonnes	Statistics Canada			50,107	0.90	0.72			Estimate	0.503	m^3 biogas/kg VS	Food Processing Residues in California: Resources Assessment and Potential for Power Generation	18,146,784
Cereal	WP 2 Technical Potential for Polygeneration in the Food processing Industry	250	kg grain solids/tonne grain milled	1,725,000	tonnes dry milled grain	Phil Dick OMAFRA			431,250	0.90	0.72			Estimate	0.503	m^3 biogas/kg VS	Food Processing Residues in California: Resources Assessment and Potential for Power Generation	156,181,500
Cereal	WP 2 Technical Potential for Polygeneration in the Food processing Industry	21.8	Nm^3 biogas from processing waste/tonne of cereal	1,725,000	tonnes dry milled grain	Phil Dick OMAFRA									0.503	m^3 biogas/kg VS	Food Processing Residues in California: Resources Assessment and Potential for Power Generation	37,605,000
Corn processing	WP 2 Technical Potential for Polygeneration in the Food processing Industry	1.52	Nm^3 biogas from processing waste/tonne of corn processed	2,800,000	tonnes corn for wet milling /yr	Phil Dick OMAFRA									0.503	m^3 biogas/kg VS	Food Processing Residues in California: Resources Assessment and Potential for Power Generation	4,256,000
Beverages																		
Brewing	WP 2 Technical Potential for Polygeneration in the Food processing Industry	23	kg spent grains/hL of beer									500	593	Waste Management Course Notes by Norbert Schmidtke				
Brewing	WP 2 Technical Potential for Polygeneration in the Food processing Industry	0.3	Nm^3 biogas from ww/hL beer									500	593	Waste Management Course Notes by Norbert Schmidtke				
Brewing	Food Processing Handbook	4	m^3 of wastewater/m^3 of product									2,105	593	Food Processing Handbook	0.352	m^3 biogas/kg COD	Food Processing Residues in California: Resources Assessment and Potential for Power Generation	
Juice	WP 2 Technical Potential for Polygeneration in the Food processing Industry	1.125	Nm^3 biogas from ww/hL juice	11.8	litres per capita - includes apple juice, grape juice and tomato juice and assumes all Ontario production	OMAFRA Statistics -Per Capita Disappearance of Selected Fruits and Vegetables - 2006									1.125	Nm^3 biogas from ww/hL juice	WP 2 Technical Potential for Polygeneration in the Food processing Industry	1,614,277
Apple pomace	Biomass Inventory and Bioenergy Assessment	86	kg pomace/tonne of apples processed							0.63	0.50			TS from Biomass Inventory and Assessment	0.351	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	
Grape pomace	Biomass Inventory and Bioenergy Assessment	100	kg pomace/tonne of grapes pressed	5,000	tonnes grape pomace/yr	Phil Dick, OMAFRA			5,000	0.625	0.50			TS from Biomass Inventory and Assessment	0.388	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	970,000
Berry pomace	Biomass Inventory and Bioenergy Assessment	60	kg pomace/tonne of grapes pressed							0.625	0.50			TS from Biomass Inventory and Assessment	0.402	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	

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Food Industry Residue Estimates Based on Data From Various Published Sources
Data is Summarized in Table 2.2

Food Industry Category (Based on terminology used in each information source)	Source of Residue Production Factor	Residue Production Factor (Blank cells indicate that data was not found)	Residue Production Factor Units	Production Data for Ontario (Blank cells indicate that data was not found)	Production Units	Source of Production Data	Quantity Estimates Based on Residue Production Factors & Ontario Production Numbers (Blank cells indicate that data was not found): WW COD or BOD tonnes/yr	Volume m^3/yr	Solids Weight tonnes/yr	Characteristics (Blank cells indicate that data was not found): TS Liquids - mg/L Solids - kg solids/kg wet weight	VS WW - mg/L Solids - kg VS solids/kg wet weight	COD mg/L	BOD mg/L	Source of Characteristics Information	Biogas Production Factor (assumes methane content of 65%) Blank cells indicate that data was not available	Biogas Production Factor Units	Source of Biogas Production Factor	Estimated Biogas Production m^3 (assumes methane content of 65%) Blank cells indicate that insufficient data was available to calculate
Fruit pomace - other	Biomass Inventory and Bioenergy Assessment	170	kg pomace/tonne of grapes pressed							0.63	0.50			TS from Biomass Inventory and Assessment	0.440	m^3 biogas/kg VS	Biomass Inventory and Bioenergy Assessment - Washington State 2005	
Distilleries	WP 2 Technical Potential for Polygeneration in the Food processing Industry	0.28	Nm3 biogas from ww/L pure alcohol									200	3,429	Waste Management Course Notes by Norbert Schmidtke				
Soft drinks	Waste Management Course Notes by Norbert Schmidtke	2.5	kg WW BOD/tonne of product									2,000	1,732	Waste Management Course Notes by Norbert Schmidtke				
Sugar																		
Sugar beet processing	WP 2 Technical Potential for Polygeneration in the Food processing Industry	890	kg solid waste/tonne of beets processed									300	450	Waste Treatment in the Food Processing Industry				
Sugar beet processing	Waste Management Course Notes by Norbert Schmidtke	20	kg WW BOD/tonne of product	3,866	tonnes of sugar production waste primarily in WW	Phil Dick, OMAFRA	3,866					300	450	Waste Treatment in the Food Processing Industry	0.830	m^3 biogas/kg BOD	Biomass Inventory and Bioenergy Assessment - Washington State 2005	3,369,219
Sugar beet processing	Production Yield Analysis in Food Processing	850	kg solid waste/tonne of beets processed									300	450	Waste Treatment in the Food Processing Industry				
Sugar beet processing culls	Phil Dick OMAFRA	100	kg solid waste /tonne of sugar beet production	35,000	tonnes of sugar beet production/yr	Phil Dick, OMAFRA			3,500	0.8	0.64			Estimate	0.830	m^3 biogas/kg BOD	Biomass Inventory and Bioenergy Assessment - Washington State 2005	1,859,200
Confectionary																		
Confectionary										0.10	0.08	5,100	91	TS from The Elorin Bioenergy Feasibility Study	0.503	m^3 biogas/kg VS	Food Processing Residues in California: Resources Assessment and Potential for Power Generation	
Chocolate Confectionary												9,500		Food Processing Handbook				
Food Ingredients																		
Starch & Glucose	Waste Management Course Notes by Norbert Schmidtke	13.4	kg WW BOD/tonne of product									661	406	Waste Management Course Notes by Norbert Schmidtke				
Pet Food												300	600	Waste Treatment in the Food Processing Industry				
Prepared Foods																		
Municipal Solid Waste																		
Municipal Solid Waste	Food and Processing Residues in California: Resources Assessment and Potential for Power Generation	0.73	tonnes per capita/yr	12,160,282	Population	OMAFRA Statistics - Statistical Summary of Ontario Agriculture - 2001 Census			8,877,006						178.5	m^3/tonne of waste	Biogas Energy Potential in Alberta - Alberta Agriculture and Food	1,584,545,546
Municipal solid waste	Netherland Environmental Assessment Agency - Waste CRF Sector 6	0.62	tonnes per capita/yr	12,160,282	Population	OMAFRA Statistics - Statistical Summary of Ontario Agriculture - 2001 Census			7,539,375						178.5	m^3/tonne of waste	Biogas Energy Potential in Alberta - Alberta Agriculture and Food	1,345,778,409
Food Waste																		
Commercial Food Waste	Measuring Generation of Food Residuals	250	kg food/tonne of commercial waste															
Food waste generation	Organics: Food Residuals Commodity Profile	0.29	kg/capita/day	12,160,282	Population	OMAFRA Statistics - Statistical Summary of Ontario Agriculture - 2001 Census			1,287,166		0.206			Treatment of Biodegradable Kitchen Waste by Anaerobic Digestion	0.185	m^3 biogas/kg VS	Treatment of Biodegradable Kitchen Waste by Anaerobic Digestion	49,053,891
Food waste generation	Food Waste	0.59	kg/capita/day	12,160,282	Population	OMAFRA Statistics - Statistical Summary of Ontario Agriculture - 2001 Census			2,618,717		0.206			Treatment of Biodegradable Kitchen Waste by Anaerobic Digestion	0.185	m^3 biogas/kg VS	Treatment of Biodegradable Kitchen Waste by Anaerobic Digestion	99,799,295
Food waste generation	Half of US Food Goes to Waste - Food Production Daily	140	kg/tonne of food purchased								0.206			Treatment of Biodegradable Kitchen Waste by Anaerobic Digestion	0.185	m^3 biogas/kg VS	Treatment of Biodegradable Kitchen Waste by Anaerobic Digestion	
Food Service	Food Losses in Food Service Institutions Examples from Sweden	200	kg/tonne of food served								0.206			Treatment of Biodegradable Kitchen Waste by Anaerobic Digestion	0.185	m^3 biogas/kg VS	Treatment of Biodegradable Kitchen Waste by Anaerobic Digestion	
Food Plate Losses	Food Losses in Food Service Institutions Examples from Sweden	260	kg food waste/tonne of food purchased											Treatment of Biodegradable Kitchen Waste by Anaerobic Digestion	0.185	m^3 biogas/kg VS	Treatment of Biodegradable Kitchen Waste by Anaerobic Digestion	

produced and processed in Ontario under each food industry category. A combination of published data and engineering estimates were used to determine the residue characteristics and biogas production factors that were used for the calculations. The biogas production volume was calculated by multiplying the residue quantity times the volatile solids content times the biogas production factor, which is based on volatile solids. The biogas production factor represents the cubic meters of biogas at standard conditions that is produced by 1 kg of volatile solids present in the residue. The biogas volume was converted to an energy value by multiplying the volume times the methane content of the biogas times the energy value of the biogas. Factors used for the methane content and energy value of biogas are provided in Section 2.1.

Municipal solid waste was not included as part of the residue quantities. However the plate food waste component of municipal solid waste was used in the study. The total municipal solid waste quantity is shown in Table 2.1 to illustrate that food plate waste represents a significant portion of municipal solid waste. It was calculated to represent between 23.6 and 35.3% of the total municipal solid waste stream.

Table 2.2 summarizes the data listed in Table 2.1, and provides a low and high estimate of the quantities of waste, biogas potential and equivalent electrical energy potential for the major food industry sectors generating residues. The quantity of discarded food that enters municipal solid waste is also provided in Table 2.2. The table includes the estimated biogas production potential of this material and the electrical energy that can be producing from the biogas.

Multiple sources of data were used to calculate the residue volumes and the biogas production in the different food processing industries listed in Table 2.1. For categories of food industry residues for which more than one estimate was calculated, the low and high values were used in Table 2.2. For food processing residue categories with only one estimate, the residue was only included in the high estimate column. In some food industry categories several different residue streams are listed, and in these cases the residue streams were added to arrive at a total industry number.

2.2.2 Results for Method 1 - Use of Ontario Food Processing Production Data and Standard Loss/Recovery Factors

Table 2.2 summarizes the residue quantities and energy potential calculated using loss/recovery factors. Based on the published data available, a low estimate of food processing industry residues produced in Ontario was calculated to be 4.9 million wet tonnes/yr and a high estimate

Table 2.2
Summary of Selected High and Low Food Industry Residue Estimates and Energy Potential Based on Published Data Provided in Table 2.1

Food Industry Category	Low Estimate from Data in Table 2.1 for Wastewaters			Low Estimate from Data in Table 2.1 for Solid Residues			High Estimate from Data in Table 2.1 for Wastewaters			High Estimate from Data in Table 2.1 for Solid Residues		
	Wastewater Quantity m^3	Biogas Potential from Wastewater m^3 @ 65% methane	Equivalent Electrical Energy 30% Conversion Efficiency GW-hrs/yr	Solid Residue Quantity tonnes	Biogas Potential from Solid Waste m^3 @ 65% methane	Equivalent Electrical Energy 30% Conversion Efficiency GW-hrs/yr	Wastewater Quantity m^3	Biogas Potential from Wastewater m^3 @ 65% methane	Equivalent Electrical Energy 30% Conversion Efficiency GW-hrs/yr	Solid Residue Quantity tonnes	Biogas Potential from Solid Waste m^3 @ 65% methane	Equivalent Electrical Energy 30% Conversion Efficiency GW-hrs/yr
Beef	1,789,800	2,483,676	4.88	35,018	8,370,603	16.46	3,534,000	5,132,930	10.09	129,575	30,973,564	60.92
Sheep & Goats										2,640	631,137	1.24
Pork				22,099	5,282,492	10.39				91,901	21,967,948	43.20
Poultry	6,600	11,113	0.02	63,767	17,421,604	34.26	225,000	363,355	0.71	99,119	27,080,213	53.26
Fish							181,450	237,201	0.47			
Rendering				124,726	35,058,698	68.95				195,134	59,292,984	116.61
Dairy	477,000	503,597	0.99				668,540	1,058,967	2.08			
Grains - Oil Processing	1,070,100	1,517,463	2.98				1,277,150	1,811,072	3.56	1,645	1,052,800	2.07
Grains - Cereal				50,107	18,146,784	35.69				431,250	156,181,500	307.16
Fruits				18.9	1,062	0.002				98.9	5,568	0.01
Vegetables				6,655	341,817	0.672				39,786	9,195,343	18.08
Bakery							276,000	1,324,680	2.61			
Beverages							na	1,514,678	2.98			
Sugar							na	3,369,219	6.63	3,500	1,859,200	3.66
Plate Food Waste (includes plate food waste in MSW and plate food waste currently diverted from MSW)				1,287,166	49,053,891	96.473				2,618,717	99,799,295	196.27
Totals	3,343,500	4,515,849	8.88	1,589,557	133,676,951	262.900	6,162,140	14,812,102	29.13	3,613,366	408,039,552	802.484

Summary of Data

Estimated Level	Quantity (liquid & solids) wet tonnes/yr	Biogas Potential from Wastewater & Solid Waste m^3 @ 65% methane	Biogas Energy Value (65% methane) GJ	Equivalent Electrical Energy 30% Conversion Efficiency GW-hrs/yr
Low Estimate Totals for Wastewater and Solid Residues	**4,933,057**	**138,192,800**	**3,260,659**	**272**
High Estimate Totals for Wastewater and Solid Residues	**9,775,506**	**422,851,654**	**9,977,185**	**831**

Note: Blank cells indicate that insufficient data was available to estimate residue quantities.

was calculated to be 9.8 million wet tonnes/yr. The biogas energy production potential from food processing residues was calculated to range between 272 GW-hr/year and 831 GW-hr/year (3.3 to 10.0 million GJ/yr of natural gas equivalence).

The residue estimates based on published residue production and loss/recovery factors does not include all food processing industry residues because some of the food production and loss recovery factors were not available. The quantities of these residues that will actually be available for biogas production will vary between 0 and 100% based on the availability factors discussed in Section 6.0. Although the estimate does not identify all residues, the high estimate (9.8 million wet tonnes) is likely still higher than the actual quantity of residue that will ultimately be available for biogas production. Competition from other users of residues, particularly residues used by the animal feed industry will limit the quantities available for biogas production.

2.2.3 Method 2 – Use of Cornell University Web-Based Computer Program for Predicting Food Processing Industry Residues Based on the Number of Employees in the Industry

This method uses a computer decision making program called "Turning Waste into Energy" that calculates the quantities of residue for a specific set of food processing industries, based on the number of employees working in each food processing industry. These residue production factors were developed by Cornell University as part of a decision making computer tool that allows a person to quantify the availability of food processing residues from a particular facility, based on the number of employees. The Cornell computer tool and information regarding the development of the tool can be found at http://wastetoenergy.bee.cornell.edu/default.htm.

2.2.4 Results for Method 2 - Use of Cornell University Web-Based Computer Program for Predicting Food Processing Industry Residues Based on the Number of Employees in the Industry

Table 2.3 summarizes the information obtained from the Cornell computer program. The table provides a summary of the residue production factors available from Cornell based on the number of employees working in the particular food processing industry in Ontario. The table also includes the estimated biogas production for each residue type and the total biogas energy potential from the grouping of industries covered by the residue factors. The table includes an estimate of the quantity of prepared table food that is not eaten and ends up in the garbage in Ontario based on published per capita quantities. The prepared table food that ends up in the garbage is referred to as plate food waste in this report.

Table 2.3
Summary of Ontario Food Industry Residue Estimates Based on Number of Employees in Each Food Sector

Food Industry Category	Number of Industry Employees in Ontario (OMAFRA Statistics - Principal Manufacturing Statistics by Food, Beverage and Tobacco Industries - Ontario 2005)	Residue Production Factor (From Cornell University Food Processing Residue Estimator Software Program "Turning Waste Into Energy") tonnes/employee/yr	Production Factor Units	Residue Quantity Estimate for Ontario tonnes	Estimated Volatile Solids Content of Residue (from Table 2.1 of this report) kg VS solids/kg wet waste	Biogas Production Factor (from Table 2.1 of this report) m^3 biogas/kg VS	Estimated Biogas Quantity (assumes 65% methane) m^3/yr	Potential Biogas Energy MJ	Equivalent Electrical Energy Assuming 30% Electrical Conversion Efficiency GW-hrs/yr
Bakery (Sugar and confectionary employees included)	30,100	0.460	tonne/employee/yr	13,832	0.36	0.830	4,133,097	97,520,416	8.127
Dairy	8,600	3.545	tonne/employee/yr	30,491	0.0032	0.352	34,345	810,369	0.0675
Fruit	3,550	2.608	tonne/employee/yr	9,259	0.13	0.44	529,617	12,496,323	1.0414
Meat (animal food manufacturing employees added)	30,200	0.010	tonne/employee/yr	288	0.29	0.83	69,387	1,637,192	0.1364
Vegetables	3,550	0.236	tonne/employee/yr	839	0.36	0.642	193,931	4,575,795	0.3813
Supermarkets	198,600	1.364	tonne/employee/yr	270,818	0.206	0.185	10,320,881	243,521,185	20.2934
Restaurants	308200	1.364	tonne/employee/yr	420,273	0.206	0.185	16,016,594	377,911,527	31.4926
Totals (Ontario)	582,800	1.280	tonne/employee/yr	745,801			31,297,852	738,472,806	61.539
Household Plate Food Waste - Calculated from Low Estimate in Table 2.2	Household plate food waste was included in this estimate, even though the Cornell model does not account for it, so that the other methods of estimating food processing residues that include plate food waste can be compared. Plate food waste represents a significant quantity of organic waste. Data for high and low quantities was available and included to provide the reader with information regarding the variability in published quantity estimates.			596,075	0.206	0.185	22,716,422	535,993,970	44.666
Household Plate Food Waste - Calculated from High Estimate from Table 2.2	Household plate food waste was included in this estimate, even though the Cornell model does not account for it, so that the other methods of estimating food processing residues that include plate food waste can be compared. Plate food waste represents a significant quantity of organic waste. Data for high and low quantities was available and included to provide the reader with information regarding the variability in published quantity estimates.			1,927,626	0.206	0.185	73,461,830	1,733,331,887	144.444
Total including low estimate of household plate food waste				1,341,876			54,014,273	1,274,466,777	106.206
Total including high estimate of household plate food waste				2,673,427			104,759,682	2,471,804,693	205.984

Data was collected and presented in Tables 2.1 and 2.2 with respect to the quantity of food prepared for meals that is not eaten (plate food waste) and ends up in MSW. The plate food waste component of MSW comes from three main categories which include, households, restaurants and stores and institutions. Plate food waste from households that ends up in the garbage is not a direct category in the Cornell model, however, the model does provide estimates of plate food waste that ends up in municipal garbage that is generated by stores, restaurants and institutions. The quantity of plate food waste that stores and restaurants throw in the garbage was subtracted from the estimate of total plate food waste in MSW listed in Table 2.2. The remaining quantity of plate food waste is the fraction that comes from households. The plate food waste that originates from households is included under a separate category in Table 2.3. It is assumed that this fraction of plate food waste can be diverted from land fill and used for biogas production, even though the Cornell model does not account for this fraction of plate food waste.

Based on the Cornell model output and the calculated high and low estimates of divertible household plate food waste calculated using Method 1, it is estimated that between 1.3 million wet tonnes and 2.7 million wet tonnes of food processing industry residues and household food waste are produced in Ontario. The food processing residues and plate food waste estimated to be generated by Ontario using the Cornell program will generate between 106 and 206 GW-hr/yr of electrical energy (1.3 to 2.5 million GJ/yr of natural gas equivalence).

2.2.5 Method 3 – Extrapolation from Food Processing Industry Residue Studies Completed in Other Jurisdictions

The third method that was used to estimate the food processing industry residues available in Ontario was to look at three other residue studies that have been completed and compare the population base of each of the jurisdictions to Ontario's population base, and ratio the quantities of residue based on the differences in the populations. The three studies include a study completed for Washington State USA, a study Completed for California USA and a study completed in Denmark. The Washington State study titled "Biomass Inventory and Bioenergy Assessment – An Evaluation of Organic Material Resources for Bioenergy Production in Washington State" can be found at http://www.ecy.wa.gov/biblio/0507047.html. The California Study titled "Food Processing Residues in California: Resource Assessment and Potential for Power Generation" can be purchased from the American Society of Agricultural Engineers. The Denmark information was included in a presentation titled "Biogas for a Sustainable Clean Environment" which can be obtained by contacting Jens Bo Holm-Nielsen by email at jhn@aue.auc.dk.

2.2.5.1 Results - Extrapolation Using Washington State Food Processing Residue Study

Table 2.4 lists the quantities of residues generated in a food processing industry residue study completed for the State of Washington USA in 2005, along with the population base in the respective study area. The table also provides the population of Ontario and the population ratio between Ontario and the respective study area. Based on extrapolation using the population ratio between Ontario and Washington state, it was estimated that 5.8 million wet tonnes of combined food processing residues and plate food waste are generated in Ontario. If the total quantity of food processing industry residue and plate food waste predicted by this method were used for biogas production, approximately 1,393 GW-hr/yr of electrical energy (16.7 million GJ/yr of natural gas equivalence) could be produced. Based on the Washington State data 58.3 m^3 of biogas is generated per capita from food processing and plate food waste.

Washington State is listed as having a food and agriculture industry that generates $34 billion in revenue (Washington State Department of Agriculture 2006) annually. This is comparable to Ontario that has a food processing industry that generates $32.5 billion in revenue annually (Ontario Ministry of Economic Development and Trade 2005). There is however a significant difference in the population base. Ontario has a population of 12,160,282 compared to Washington State with a population of 6,287,759. The distribution of primary processors to secondary processors is also significantly different. Washington State has a food processing industry comprised of approximately 75% primary processors (P. Dick 2008). Ontario has a food processing industry comprised of approximately 25% primary processors. The higher percentage of primary processors in Washington state accounts for the higher quantities of food processing industry residues compared to other jurisdictions examined.

2.2.5.2 Results - Extrapolation Using California State Food Processing Residue Study

Table 2.5 summarizes a food processing industry residue study completed in 2005 for the state of California USA. The table provides the population of California and the population of Ontario along with the population ratio used to extrapolate an estimate of the quantity of food processing residue produced in Ontario. Based on the population ratio between Ontario and the state of California, the quantity of food processing residue produced is estimated to be 2.0 million wet tonnes/yr. The electrical energy production potential of this residue was calculated to be 441 GW-hr/yr (5.3 million GJ/yr natural gas equivalence).

There is a significant difference in the population base between Ontario and California. Ontario has a population of 12,160,282 compared to California State with a population of 36,457,549. The distribution of primary processors to secondary processors is also somewhat different.

Table 2.4
Food Industry Residue Data from Washington State Residue Study and Estimation of Ontario Production Values

Food Industry Category	Quantity Dry tons (from Washington State Residue Study 2005) dry tons	Total Solids (from Washington State Residue Study 2005) %	Quantity (Calculated from Washington State data) wet tonnes	Biogas Energy @ 65% Methane (calculated from electrical energy potential provided in Washington State Residue Study) GJ	Electrical Energy Potential (30% conversion efficiency) (from Washington State Residue Study 2005) GW-hr/yr
Dairy					
Cheese whey	44,255	6.5	618,951	461,636	38.47
Fruit					
Cull Apples	41,039	16	233,176	314,877	26.24
Cull Fruit	8,934	16	50,761	86,039	7.17
Apple Pommace	27794	63	40,107	213,238	17.77
Grape Pommace	19254	62.5	28,006	163,319	13.61
Berry Pommace	1938	62.5	2,819	17,040	1.42
Fruit Pommace	11,865	63	17,121	114,239	9.52
Meat					
Poultry meat	5,479	37	13,462	98,879	8.24
Beef meat	35,842	36	90,510	561,236	46.77
Pork Meat	280	36	707	4,320	0.36
Yellow grease	18486	90	18,673	204,238	17.02
Brown grease	20528	90	20,735	226,798	18.9
Poultry Feathers	7,932	92.1	7,829	57,000	4.75
Animal mortalities	5,857	36	14,790	91,679	7.64
Fish waste	7,995	36	20,189	46,920	3.91
Shell fish waste	3,674	36	9,278	27,840	2.32
Vegetables					
Cull Onions	2,322	10	21,109	31,200	2.6
Cull Potatoes	91,412	19	437,378	1,310,510	109.21
Asparagus Butts	667	8	7,580	5,160	0.43
Asparagus trimmings	120	8	1,364	0	

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Table 2.4
Food Industry Residue Data from Washington State Residue Study and Estimation of Ontario Production Values

Food Industry Category	Quantity Dry tons (from Washington State Residue Study 2005) dry tons	Total Solids (from Washington State Residue Study 2005) %	Quantity (Calculated from Washington State data) wet tonnes	Biogas Energy @ 65% Methane (calculated from electrical energy potential provided in Washington State Residue Study) GJ	Electrical Energy Potential (30% conversion efficiency) (from Washington State Residue Study 2005) GW-hr/yr
Vegetables	14,744	10	134,036	206,878	17.24
Potato Solids	19177	19	91,756	164,879	13.74
Food Waste (includes food waste in MSW and food waste currently diverted)	246,011	20	1,118,232	4,235,366	352.95
Totals	**635,605**		**2,998,570**	**8,643,291**	**720**
Summary of Extrapolated Data for Ontario					
	Quantity dry tons		**Quantity wet tonnes**	**Biogas Energy @ 65% Methane GJ**	**Electrical Energy Potential GW-hr/yr**
Ontario Values Extrapolated Based on Washington State Per Capita Values	1,229,235		5,799,118	16,715,789	1,393

Washington State Population (2005) Source - Infoplease US Population Statistics	6,287,759
Ontario Population (2006) Statistics Canada 2006 Census	12,160,282
Population ratio	1.93

Table 2.5
Data from 2005 Food Industry Residue Study in California and Estimation of Ontario Production Values

Food Industry Category	Quantity from California Residue Study 2005 Gross Weight dry tonnes	Quantity of Wet Residue Estimated by this Study Based on Estimation of Solids Content of Each Class of Residue tonnes	Fraction Considered Available for AD %	Available Dry Fraction tonnes	Quantity of Wet Residue Available Estimated by this Study Based on Estimation of Solids Content of Each Class of Residue tonnes	Potential Biogas Energy @ 65% Methane GJ	Electrical Energy Potential (assume 30% conversion efficiency) GW-hr/yr
Food Processing	207,703	2,077,030	65	135,007	1,350,070	1,271,990	106
Meat Processing	65,304	181,400	70	45,713	126,980	431,997	36
Grain and Fiber Processing	454,170	534,318	80	363,336	427,454	4,847,961	404
Food Waste in MSW	1,676,650	6,706,600	50	838,325	3,353,300	7,919,937	660
Food Waste Diverted from Landfill	295,879	1,183,516	50	147,940	591,758	1,391,989	116
Totals	2,699,706	10,682,864	0.567	1,530,320	5,849,562	15,863,873	1,322
Summary of Extrapolated Data for Ontario							
	Quantity Gross Weight dry tonnes	**Quantity wet tonnes**	**Fraction Considered Available for AD %**	**Available Dry Fraction %**	**Quantity of Wet Residue Available tonnes**	**Potential Biogas Energy @ 65% Methane GJ**	**Electrical Energy Potential GW-hr/yr**
Ontario Values Extrapolated Based on California State Per Capita Values	900,477	3,563,230	0.567	510,433	1,951,100	5,291,337	441

California Population (2006) US Census Board Estimate	36,457,549
Ontario Population (2006) Statistics Canada 2006 census	12,160,282
Population Ratio	0.334

California State has a food processing industry comprised of approximately 50% primary processors (P. Dick 2008). Ontario has a food processing industry comprised of approximately 25% primary processors. The higher percentage of primary processors in California State will result in a higher per capita residue generation than would typically be expected in Ontario, but is likely in the same order of magnitude.

2.2.5.3 Results - Extrapolation Using Data from Denmark

A study was completed in Denmark that developed a per capita industrial organic residue generation factor of 100 kg/capita. This factor was used to estimate the food processing industry residue quantity produced in Ontario. The factor was obtained from a presentation titled "Biogas for a Sustainable Clean Environment" prepared by Jens Bo Holm-Nielsen, AALBORG University, ESBJERG, Center of Biotechnology and Bioenergy. The email address for Jens Bo Holm-Nielson is jhn@aue.auc.dk and a general website address for the Center of Biotechnology and Bioenergy at the AALBORG University is www.acabs.dk.

The industrial organic residue factor may include more than just food processing industry organic residues but the bulk of organic residues produced by industry are typically from the food processing industry and the factor was used as an approximate estimate. Using the Denmark per capita industrial organic residue generation factor, it was estimated that 1.2 million wet tonnes of organic residue from the food processing industry will be produced in Ontario. Based on an estimated average dry matter content of 25%, volatile solids content of 80% of total solids and specific biogas production of 0.35 m^3 biogas (65% methane)/kg VS the potential for electrical energy from this residue was estimated to be 562 GW-hr/yr (6.7 million GJ/yr natural gas equivalence).

The use of the Denmark per capita value provides an estimate that can be considered an order of magnitude estimate of the quantity of food processing residues produced in Ontario. Denmark has a population of approximately 5,427,459 which is comparable to Washington State but has a per capita organic residue production rate that is significantly lower than Washington. The Washington state per capita residue generation rate was calculated to be 0.477 wet tonnes/capita and Denmark generates 0.100 wet tonnes/capita. This may be due to differences in the ratio of primary processing to secondary processing in the food industry as well as differences in culture and management.

2.2.6 Method 4 – Inventory of Known Residue Volumes Generated in Ontario

The fourth method used to estimate the quantity of food processing residue produced in Ontario, for biogas production, was to sum the known quantities of residues generated. These residues include residues generated by Geomatrix clients, residues collected by waste haulers and provided to Geomatrix, residues collected by waste haulers and reported by the MOE and residues reported by respondents to the questionnaire sent out to a cross section of food processing companies. The total quantity of residues identified can be considered the low end of the food processing residue quantities produced in Ontario. This is due to the reluctance of the food processing industry to share information regarding residue quantities and the desire for confidentiality in the waste hauling business to protect client base.

2.2.7 Results - Method 4 – Inventory of Known Residue Volumes Generated in Ontario

Table 2.6 provides a summary of the residue types, the quantities reported and the estimated biogas production. Known residue quantities generated yearly in Ontario totalled 364,373 wet tonnes. The potential electrical energy that can be produced from the known residues was calculated to be 47.7 GW-hr/yr (0.57 million GJ/yr of natural gas equivalence).

Based on the theoretical food processing residue estimates provided in Section 2.2.2 (4.9 to 9.8 million wet tonnes/yr), the food processing residues that were quantified through project activities (0.36 million wet tonnes) represents approximately 3.7% to 7.3% of the total estimated to be produced in Ontario.

The quantity of known residues identified in this study is very low compared to the total theoretical residue quantities estimated by other means. The estimate developed by this method, is an order of magnitude lower than quantities determined by other means in this study. The reluctance of the food processing industry to share information regarding food processing residue quantities and the desire for confidentiality in the waste hauling business make this method of estimating waste quantities difficult to use.

3.0 CURRENT ONTARIO FOOD PROCESSING RESIDUE MANAGEMENT APPROACH

Table 2.7 provides a summary of the current Ontario food processing residue management approach. The table includes the current opportunities for utilization of the residues and methods of disposal, current regulatory frame work that applies to the residues, management costs where available, other opportunities for utilizing the residues, seasonal nature of the

Table 2.6
Summary of Specific Ontario Residue Types Identified and Quantified Through Project Activities

Food Industry Category	Residue Description	Residue Quantity Identified Wet tonnes/yr	Estimated Total Solids %	Estimated Volatile Solids % of TS	Estimated Biogas Yield m^3/kg VS	Biogas Quantity m^3 @ 65% Methane	Biogas Energy Value MJ	Electrical Energy Potential GW-hr/yr (30% conversion efficiency) MJ-hrs/yr
Bakery								
Solids from wastewater treatment	Skimmed or settled solids from pre-treatment of wastewater to meet sewer use by-laws	2,809	3.0	80.0	0.830	55,955	1,320,545	110.0
Dairy								
Whey	Whey recovered from cheese making	30,220	6.5	80.0	0.477	749,577	17,690,014	1,474.2
DAF float	Skimmed solids from milk processing wastewater	3,095	5.8	80.0	0.477	68,501	1,616,624	134.7
Wastewater	Wastewater from facility and equipment clean up	66,000	1.2	80.0	0.477	302,227	7,132,562	594.4
Fruit								
Fruit pulp	Pulp from juice and wine production	280	63	80.0	0.351	49,533	1,168,982	97.4
Meat								
blood	Blood from livestock butchering	15,086	11.5	80	0.650	902,143	21,290,570	1,774.2
paunch manure	Stomach contents from livestock butchering	11,274	17.0	80	0.350	536,642	12,664,761	1,055.4
fat trimmings	Fat trimmings from meat cutting	970	36.0	80	0.830	231,869	5,472,104	456.0
Offal	Guts and unusable parts from animal butchering.	33,555	36.0	80	0.830	8,020,987	189,295,298	15,774.7
Settled solids	Solids settled from wastewater.	4,012	5.0	80	0.830	133,198	3,143,482	262.0
DAF float from poultry processing	Fatty solids removed from wastewater	7,938	10.5	80	0.780	520,098	12,274,307	1,022.9
WAS from poultry wastewater treatment	Waste activated sludge from aerobic treatment of wastewater.	20,192	5	80	0.350	254,419	6,004,293	500.4
Grease Trap waste	Grease from cleaning grease traps in restaurant and other food industries	234	50	80	0.538	50,357	1,188,420	99.0
DAF float from hog processing	Fatty solids removed from wastewater	9,620	12	80	0.780	720,346	17,000,156	1,416.7
Rendering Waste								
Grease fines	Grease fines left after rendering wastes.	762	57	80	1.00	347,472	8,200,339	683.4
Vegetable								
Food Ingredients								
Sweetener production	Waste from sweetener production	6	75	80	1.00	3,600	84,960	7.1
Grains - oil processing								
Grains - cereal processing								
Beverages								
Spent grains from beer/alcohol production	Spent grains after distilling.	141,093	17	80	0.570	10,937,529	258,125,693	21,510.6
Food Transport								
Tanker wash water	Wash water from cleaning bulk food tanker trucks.	17,227	3.5	80	0.78	376,238	8,879,209	739.9
Totals		364,373				24,260,691	572,552,319	47,713

Table 2.7
Current Ontario Food Processing Residue Management Approach

	Utilization	Destination/Disposal	Current Regulatory Frame work	Management Costs	Risks with Current Approach	Other Opportunities for Utilizing the Material	Seasonality	Material Upgrading Required for AD Use	Potential for Biogas Production Inhibition
Beef									
Wastewater		Pre-treatment and sewer discharge. Full treatment and direct discharge.	Municipal sewer use by-law for sewer discharge. OWRA for direct discharge.	$0.84/m^3$	Possibility of SRM escape to municipal treatment plant with sewer discharge.	Anaerobically treat for biogas production	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	
Recovered wastewater solids	Animal feed	Land application Rendering Land fill	MOE C of A for land application. Municipal by-laws for land fill disposal. CFIA regulations for use in feed.	$20-$75/tonne	SRM material entering land un-treated	High fat material such as DAF float for biodiesel.	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	High fat content may cause long chain fatty acid toxicity if fed at too high a rate.
Offal	Rendered for animal feed and other by-product recovery.	Rendering	MOE C of A CFIA feed regulations.	$50 - $65/tonne	Potential for pathogen transmission if not properly rendered.	Anaerobic digestion. Production of biodiesel from high fat materials.	Year round typically with some seasonal fluctuations	Requires maceration prior to digestion. May require heat treatment for pathogen destruction if digested. Require separation of high fat materials for biodiesel production.	High fat content may cause long chain fatty acid toxicity if fed at too high a rate.
SRM		Landfill Composting	MOE C of A.	$50-$120/tonne	Risk of SRM pathogen spread.	Anaerobic digestion	Year round typically with some seasonal fluctuations	Requires maceration prior to digestion. May require heat treatment for pathogen destruction if digested.	
Paunch manure	Nutrient and organic matter source for crop production.	Land application	MOE C of A	$20-$75/tonne	Pathogen application to land.	Anaerobic digestion.	Year round typically with some seasonal fluctuations	No pre-treatment required.	
Sheep & Goats									
Wastewater		Pre-treatment and sewer discharge. Full treatment and direct discharge.	Municipal sewer use by-law for sewer discharge. OWRA for direct discharge.	$0.84/m^3$	Minimal risk.	Anaerobically treat for biogas production	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	
Recovered wastewater solids	Animal feed. Nutrients and organic matter for crop production.	Land application Rendering Land fill	MOE C of A for land application. Municipal by-laws for land fill disposal. CFIA regulations for use in feed.	$20-$75/tonne	Pathogen spread to land and rendered products.	High fat material such as DAF float for biodiesel.	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	High fat content may cause long chain fatty acid toxicity if fed at too high a rate.

Table 2.7
Current Ontario Food Processing Residue Management Approach

	Utilization	Destination/Disposal	Current Regulatory Frame work	Management Costs	Risks with Current Approach	Other Opportunities for Utilizing the Material	Seasonality	Material Upgrading Required for AD Use	Potential for Biogas Production Inhibition
Offal	Rendered for animal feed and other by-product recovery.	Rendering	MOE C of A CFIA feed regulations.	$50 - $65/tonne	Potential for pathogen transmission if not properly rendered.	Anaerobic digestion. Production of biodiesel from high fat materials.	Year round typically with some seasonal fluctuations	Requires maceration prior to digestion. May require heat treatment for pathogen destruction if digested. Require separation of high fat materials for biodiesel production.	High fat content may cause long chain fatty acid toxicity if fed at too high a rate.
Paunch manure	Nutrient and organic matter source for crop production.	Land application	MOE C of A	$20-$75/tonne	Pathogen application to land.	Anaerobic digestion.	Year round typically with some seasonal fluctuations	No pre-treatment required.	
Pork									
Wastewater		Pre-treatment and sewer discharge. Full treatment and direct discharge.	Municipal sewer use by-law for sewer discharge. OWRA for direct discharge.	$0.84/m^3	Minimal risk.	Anaerobically treat for biogas production	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	
Recovered wastewater solids	Animal feed. Nutrients and organic matter for crop production.	Land application Rendering Land fill	MOE C of A for land application. Municipal by-laws for land fill disposal. CFIA regulations for use in feed.	$20-$75/tonne	Pathogen spread to land and rendered products.	High fat material such as DAF float for biodiesel.	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	High fat content may cause long chain fatty acid toxicity if fed at too high a rate.
Offal	Rendered for animal feed and other by-product recovery.	Rendering	MOE C of A CFIA feed regulations.	$50 - $65/tonne	Potential for pathogen transmission if not properly rendered.	Anaerobic digestion. Production of biodiesel from high fat materials.	Year round typically with some seasonal fluctuations	Requires maceration prior to digestion. May require heat treatment for pathogen destruction if digested. Require separation of high fat materials for biodiesel production.	High fat content may cause long chain fatty acid toxicity if fed at too high a rate.
Paunch manure	Nutrient and organic matter source for crop production.	Land application	MOE C of A	$20-$75/tonne	Pathogen application to land.	Anaerobic digestion.	Year round typically with some seasonal fluctuations	May require heat treatment for pathogen destruction if digested.	
Fish									
Wastewater		Pre-treatment and sewer discharge. Full treatment and direct discharge.	Municipal sewer use by-law for sewer discharge. OWRA for direct discharge.	$0.84/m^3	Minimal risk.	Anaerobically treat for biogas production	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	

Table 2.7
Current Ontario Food Processing Residue Management Approach

	Utilization	Destination/Disposal	Current Regulatory Frame work	Management Costs	Risks with Current Approach	Other Opportunities for Utilizing the Material	Seasonality	Material Upgrading Required for AD Use	Potential for Biogas Production Inhibition
Recovered wastewater solids	Animal feed. Nutrients and organic matter for crop production.	Land application Rendering Land fill	MOE C of A for land application. Municipal by-laws for land fill disposal. CFIA regulations for use in feed.	NA	Pathogen spread to land and rendered products.	High fat material such as DAF float for biodiesel.	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	High fat content may cause long chain fatty acid toxicity if fed at too high a rate.
Processing solids	Animal feed	Land application Rendering Land fill	MOE C of A for land application. Municipal by-laws for land fill disposal. CFIA regulations for use in feed.	NA	Pathogen spread to land and rendered products.	Anaerobic treatment.	Seasonal depending on fish species.	requires maceration prior to digestion. Can be frozen during production season to provide year round digestion supply.	High fat content may cause long chain fatty acid toxicity if fed at too high a rate.
Rendering									
Wastewater		Pre-treatment and sewer discharge. Full treatment and direct discharge.	Municipal sewer use by-law for sewer discharge. OWRA for direct discharge.	NA	Minimal risk.	Anaerobically treat for biogas production	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	
Recovered wastewater solids	Nutrients and organic matter for crop production.	Land application Land fill	MOE C of A for land application. Municipal by-laws for land fill disposal.	$20-$75/tonne	Pathogen application to land.	High fat material such as DAF float for biodiesel.	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	High fat content may cause long chain fatty acid toxicity if fed at too high a rate.
Processing solids		Land application Land fill	MOE C of A for land application. Municipal by-laws for land fill disposal.	$20-$75/tonne	Pathogen application to land.	Anaerobic treatment.	Seasonal depending on fish species.	requires maceration prior to digestion. Can be frozen during production season to provide year round digestion supply.	High fat content may cause long chain fatty acid toxicity if fed at too high a rate.
Dairy									
Wastewater		Pre-treatment and sewer discharge. Full treatment and direct discharge.	Municipal sewer use by-law for sewer discharge. OWRA for direct discharge.	NA	Minimal risk.	Anaerobically treat for biogas production	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	
Recovered wastewater solids	Animal feed. Nutrients and organic matter for crop production.	Land application Feed Land fill	MOE C of A for land application. Municipal by-laws for land fill disposal. CFIA regulations for use in feed.	$50-$75/tonne	Pathogen spread to land and livestock.	Anaerobically treat for biogas production.	Year round	Suitable as is for AD treatment. Solids would not have to be removed from wastewater for digestion.	High fat content may cause long chain fatty acid toxicity if fed at too high a rate.
Whey	Feed	Feed	CFIA regulations for animal feed	NA	Pathogen spread to livestock.	Anaerobic treatment. Ethanol production.	Year round.	Suitable as is for AD treatment	High fat content may cause long chain fatty acid toxicity if fed at too high a rate.

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Table 2.7
Current Ontario Food Processing Residue Management Approach

	Utilization	Destination/Disposal	Current Regulatory Frame work	Management Costs	Risks with Current Approach	Other Opportunities for Utilizing the Material	Seasonality	Material Upgrading Required for AD Use	Potential for Biogas Production Inhibition
Grains - Oil Processing									
Wastewater		Pre-treatment and sewer discharge. Full treatment and direct discharge.	Municipal sewer use by-law for sewer discharge. OWRA for direct discharge.	NA	Minimal risk.	Anaerobically treat for biogas production. Ethanol production.	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	High fat content may cause long chain fatty acid toxicity if fed at too high a rate.
Solids	Feed	Feed	CFIA regulations for animal feed	NA	Minimal risk.	Anaerobically treat for biogas production. Ethanol production.	Year round typically with some seasonal fluctuations	May require moisture addition. May require particle size reduction.	High fat content may cause long chain fatty acid toxicity if fed at too high a rate.
Grains - Cereal									
Wastewater		Pre-treatment and sewer discharge. Full treatment and direct discharge.	Municipal sewer use by-law for sewer discharge. OWRA for direct discharge.	NA	Minimal risk.		Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	
Solids		Feed	CFIA regulations for feed.	NA	Minimal risk.	Anaerobically treat for biogas production. Ethanol production.		May require moisture addition. May require particle size reduction.	
Fruits									
Wastewater		Pre-treatment and sewer discharge. Full treatment and direct discharge.	Municipal sewer use by-law for sewer discharge. OWRA for direct discharge.	NA	Minimal risk.	Anaerobically treat for biogas production.	Seasonal for some fruits that do not store well such as strawberries. Year round for processing of fruits that store well such as apples.	Suitable as is for AD treatment	
Solid fruit waste from processing	Nutrient and organic matter source for crops. Feed		MOE C of A. CFIA feed regulations.	NA	Potential for pathogen spread to crops and livestock.	Anaerobically teat for biogas production. Ethanol production.	Seasonal for some fruits that do not store well such as strawberries. Year round for processing of fruits that store well such as apples.	May require some moisture addition. May require particle size reduction.	Caustic peeling process chemical may cause pH problems in digester.
Vegetables									
Wastewater		Pre-treatment and sewer discharge. Full treatment and direct discharge.	Municipal sewer use by-law for sewer discharge. OWRA for direct discharge.	$\$0.84/m^3$	Minimal risk.	Anaerobically treat for biogas production	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	

Table 2.7
Current Ontario Food Processing Residue Management Approach

	Utilization	Destination/Disposal	Current Regulatory Frame work	Management Costs	Risks with Current Approach	Other Opportunities for Utilizing the Material	Seasonality	Material Upgrading Required for AD Use	Potential for Biogas Production Inhibition
Solid vegetable waste from processing	Nutrient and organic matter source for crops. Feed		MOE C of A. CFIA feed regulations.	NA	Potential for pathogen spread to crops and livestock.	Anaerobically teat for biogas production. Ethanol production.	Seasonal for some vegetables that do not store well such as beans. Year round for processing of root crop vegetables that store well such as potatoes and carrots.	May require some moisture addition. May require particle size reduction.	Caustic peeling process chemical may cause pH problems in digester.
Bakery									
Wastewater		Pre-treatment and sewer discharge. Full treatment and direct discharge.	Municipal sewer use by-law for sewer discharge. OWRA for direct discharge.	NA	Minimal risk.	Anaerobically treat for biogas production..	Year round.	Suitable as is for AD treatment	High fat grease and oil content may cause long chain fatty acid toxicity if fed at too high a rate.
Processing solid waste	Nutrient and organic matter source for crops. Feed		MOE C of A. CFIA feed regulations.	NA	Minimal risk.	Anaerobically teat for biogas production. Ethanol production.	Year round.	May require some moisture addition. May require particle size reduction.	High fat grease and oil content may cause long chain fatty acid toxicity if fed at too high a rate.
Beverages									
Wastewater		Pre-treatment and sewer discharge. Full treatment and direct discharge.	Municipal sewer use by-law for sewer discharge. OWRA for direct discharge.	NA	Minimal risk.	Anaerobically treat for biogas production	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	
Solids recovered from wastewater	Nutrient and organic matter source for crops.	Land application.	MOE C of A.	NA	Minimal risk.	Anaerobically treat for biogas production	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	Suitable as is for AD treatment
Processing solids	Nutrient and organic matter source for crops.	Land application. Land fill. Composting	MOE C of A for land application. Municipal by-laws for land fill. MOE C of A for composting	NA	Potential for pathogen spread to crops.	Anaerobically treat for biogas production. Ethanol production.	May require moisture addition. May require particle size reduction.		
Sugar									
Wastewater		Pre-treatment and sewer discharge. Full treatment and direct discharge.	Municipal sewer use by-law for sewer discharge. OWRA for direct discharge.	NA	Minimal risk.	Anaerobically treat for biogas production	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	
Solids recovered from wastewater	Nutrient and organic matter source for crops.	Land application.	MOE C of A.	NA	Potential for pathogen spread to crops.	Anaerobically treat for biogas production	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	

Table 2.7
Current Ontario Food Processing Residue Management Approach

	Utilization	Destination/Disposal	Current Regulatory Frame work	Management Costs	Risks with Current Approach	Other Opportunities for Utilizing the Material	Seasonality	Material Upgrading Required for AD Use	Potential for Biogas Production Inhibition
Processing solids	Nutrient and organic matter source for crops. Feed	Land application Feed.	MOE C of A. CFIA feed regulations.	NA	Potential for pathogen spread to crops.	Anaerobically treat for biogas production. Ethanol production.	Year round typically with some seasonal fluctuations	may require moisture addition. May require particle size reduction.	
Condiments									
Wastewater		Pre-treatment and sewer discharge. Full treatment and direct discharge.	Municipal sewer use by-law for sewer discharge. OWRA for direct discharge.	NA	Minimal risk.	Anaerobically treat for biogas production	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	Manufacturing chemicals may be inhibitory to bacterial activity.
Solids recovered from wastewater	Nutrient and organic matter source for crops.	Land application.	MOE C of A.	NA	Minimal risk.	Anaerobically treat for biogas production	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	Manufacturing chemicals may be inhibitory to bacterial activity.
Confectionary									
Wastewater		Pre-treatment and sewer discharge. Full treatment and direct discharge.	Municipal sewer use by-law for sewer discharge. OWRA for direct discharge.	NA	Minimal risk.	Anaerobically treat for biogas production	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	
Solids recovered from wastewater	Nutrient and organic matter source for crops.	Land application.	MOE C of A.	NA	Minimal risk.	Anaerobically treat for biogas production	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	
Food Ingredients									
Wastewater		Pre-treatment and sewer discharge. Full treatment and direct discharge.	Municipal sewer use by-law for sewer discharge. OWRA for direct discharge.	NA	Minimal risk.	Anaerobically treat for biogas production	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	Manufacturing chemicals may be inhibitory to bacterial activity.
Solids recovered from wastewater	Nutrient and organic matter source for crops.	Land application.	MOE C of A.	NA	Minimal risk.	Anaerobically treat for biogas production	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	Manufacturing chemicals may be inhibitory to bacterial activity.
Prepared Foods									
Wastewater		Pre-treatment and sewer discharge. Full treatment and direct discharge.	Municipal sewer use by-law for sewer discharge. OWRA for direct discharge.	NA	Minimal risk.	Anaerobically treat for biogas production	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	Manufacturing chemicals may be inhibitory to bacterial activity.
Solids recovered from wastewater	Nutrient and organic matter source for crops.	Land application.	MOE C of A.	$20-$75/tonne	Minimal risk.	Anaerobically treat for biogas production	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	Manufacturing chemicals may be inhibitory to bacterial activity.

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Table 2.7
Current Ontario Food Processing Residue Management Approach

	Utilization	Destination/Disposal	Current Regulatory Frame work	Management Costs	Risks with Current Approach	Other Opportunities for Utilizing the Material	Seasonality	Material Upgrading Required for AD Use	Potential for Biogas Production Inhibition
Pet Foods									
Wastewater		Pre-treatment and sewer discharge. Full treatment and direct discharge.	Municipal sewer use by-law for sewer discharge. OWRA for direct discharge.	NA	Minimal risk.	Anaerobically treat for biogas production	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	High fat, grease and oil content may produce long chain fatty acid toxicity if fed at too high a rate.
Solids recovered from wastewater	Nutrient and organic matter source for crops.	Land application.	MOE C of A.	$20-$75/tonne	Potential for pathogen spread to land.	Anaerobically treat for biogas production	Year round typically with some seasonal fluctuations	Suitable as is for AD treatment	High fat, grease and oil content may produce long chain fatty acid toxicity if fed at too high a rate.
Processing solids	Nutrient and organic matter source for crops.	Land application. Land fill. Composting	MOE C of A for land application. Municipal by-laws for land application. MOE C of A for composting.	$20-$75/tonne	Potential for pathogen spread to land.	Anaerobically treat for biogas production	Year round.	May require particle size reduction.	High fat, grease and oil content may produce long chain fatty acid toxicity if fed at too high a rate.
Food Waste		Land Fill. Composting.	Municipal by-laws for disposal of food waste. Land fill by-laws. MOE C of A for composting.	$25-$120	Contamination from unknown sources. Spread of pathogens.	Anaerobic digestion. Production of ethanol.	Year round	Requires maceration and may require moisture addition depending on type and source. Will require removal of debris such as disposable plates and cutlery, cups and napkins and other foreign contaminants.	

NA - Data not available

residues, material up-grades required for AD use and possible inhibitions to biogas production due to characteristics of the residue.

Based on direct discussions with the food processing industry and the waste management industry there appears to be a significant amount of confidentiality with regards to residue volumes, disposal costs and processing production numbers for the various sectors of the food processing industry. This is not just an Ontario situation but a situation that has been identified in other jurisdictions as well, which limits obtaining first hand data. The disposal costs listed are general estimates based on in house knowledge and published data for other Canadian jurisdictions.

Ontario has a waste diversion program called "Waste Diversion Ontario (WDO). WDO is a non-crown corporation created under the Waste Diversion Act to develop, implement and operate waste diversion programs for a wide range of materials. The program however is currently geared to keeping Blue Box recyclables, used tires, electronic components and municipal hazardous solid waste out of landfills. At this point the program has not targeted food processing industry residues. Typically food processing industry residues that are not suitable for animal feed are land applied as a nutrient source for crop production and do not enter landfills. Land application is typically a lower cost alternative to land filling these materials. Since treatment of residues for biogas production conserves nutrients, residues currently land applied will theoretically be available for use in the production of biogas. Once the residues are treated for biogas production, the resulting digestate can still be land applied as a nutrient source.

A number of municipalities are trying to remove plate food waste generated by households, institutions and restaurants from municipal solid waste entering landfill sites. This residue stream in Ontario is estimated to range between 1.3 and 2.6 million tonnes annually (Table 2.1) with an electrical energy potential using biogas fuelled co-generation of between 96 and 196 GW-hr/yr (1.2 to 2.4 million GJ/yr of natural gas equivalence). The plate food waste that enters municipal solid waste represents between an estimated 23.6% and 35.3% of the total biogas production potential of the combined food processing industry residues and plate food waste in Ontario. The one major problem with diversion of plate food waste is the potential for contamination from other household, restaurant and institution wastes including packaging, and in some cases hazardous wastes such as batteries, cleaning chemicals and other similar materials.

Figure 1 shows a map of Ontario issued by OMFRA with the location of all of the food processing plants by category. The map shows a relatively high concentration of food processing industries in the greater Toronto area with some smaller pockets spread out across the province. In general, food processing industries are spread out across the southern half of the province with a few isolated facilities in the northern part. The wide geographic area in which food processors are located is a draw back for centralized processing of these materials for biogas production, due to the higher transportation costs.

The map can be used as a guide to identify areas that are a potential source of food processing industry residues. This information combined with information provided in Table 2.1 and Table 2.3 can be used to estimate the quantity of residues potentially available in a given area, once information about the production level and/or number of employees for facilities in the area is known.

4.0 COMPARISON OF FOOD PROCESSING SECTOR RESIDUE ESTIMATES BASED ON FOUR DIFFERENT METHODS OF ESTIMATION

The food processing industry in Ontario employs approximately 120,000 people in total and generates approximately 32.5 billion dollars in annual sales (Ontario Ministry of Economic Development and Trade 2005). The significance of the food processing industry in terms of sales does not provide a direct indication of the availability of food processing industry residues but it does provide an estimate of the significance of the industry in terms of production level and certainly substantiates that the food industry can be a significant source of organic material for generating biogas.

Table 2.8 summarizes the residue quantities and biogas production estimates developed using four different methods. The residue quantity estimates ranged from 1.2 million wet tonnes to 9.8 million wet tonnes. The biogas electrical energy potential from these residues ranged from 106 GW-hr/yr to 1,393 GW-hr/yr (1.2 to 16.7 GJ/yr of natural gas equivalence).

The residue estimates based on published residue production and loss/recovery factors does not include all residues because some residue factors and production data were unavailable. Although the estimate does not identify all residues, the high estimate (9.8 million wet tonnes) is likely higher than the actual quantity of residue that will ultimately be available for biogas production, due to competition from other users of residues. Residues such as offal from livestock butchering (excluding specified risk materials from beef cattle) that is used by the rendering industry for animal feed production as well as other grain processing by-products that

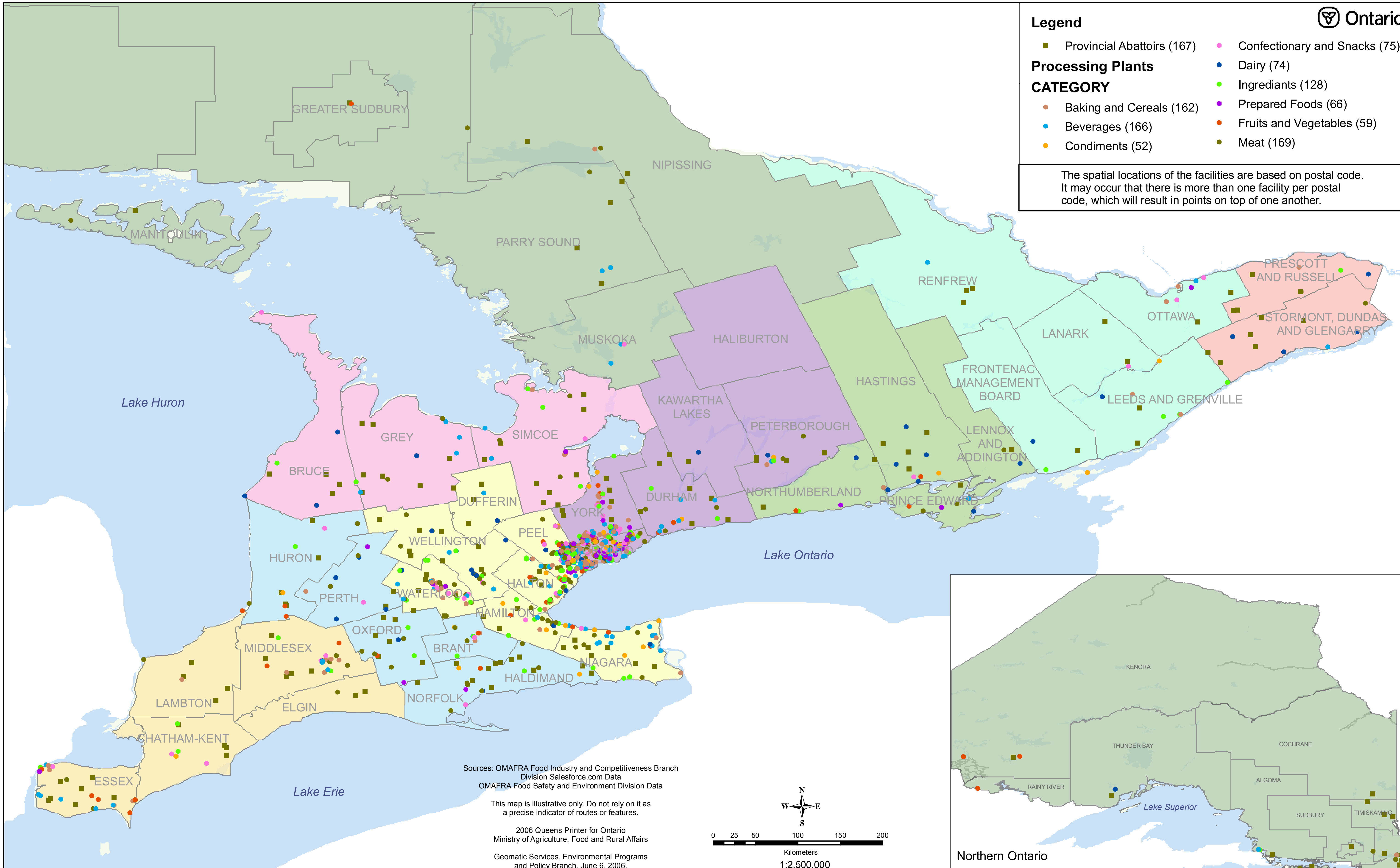

Figure 1
Map Identifying the Location of Food Processing Plants by Category in Ontario

Table 2.8
Summary of Food Processing Industry Residue Estimates

Source of Quantity Estimate	Estimated Residue Quantity wet tonnes	Biogas Quantity (@ 65% methane) m^3	Biogas Energy Potential GJ	Equivalent Electrical Energy 30% Conversion Efficiency GW-hrs/yr
Based on residue production and loss recovery factors - low estimates	4,933,057	138,192,800	3,260,659	272
Based on residue production and loss recovery factors - high estimates	9,775,506	422,851,654	9,977,185	831
Based on number of industry employees and residue factor per employee - low estimate	1,341,876	54,014,273	1,274,467	106
Based on number of industry employees and residue factor per employee - high estimate	2,673,427	104,759,682	2,471,805	206
Based on Washington State USA residue study	5,799,118	708,446,248	16,715,789	1,393
Based on California USA residue study	1,951,100	224,256,698	5,291,337	441
Based on Denmark residue study	1,216,028	285,903,327	6,745,889	562

are used for feed production may not be available for biogas production. Residues that are currently managed through land application will likely be available for biogas production because the nutrients are conserved during biogas production and the digestate generated by the process will be available for land application.

The Washington State residue study predicts a significantly higher energy potential (1,393 GW-hr/yr, 16.7 million GJ of natural gas equivalence) from residues than the other methods used. This is likely because the Washington state food processing industry is comprised of approximately 75% primary processors that produce a higher ratio of residue to product than secondary processors. Ontario has approximately 25% primary processors and California has approximately 50% primary processors.

In terms of predicting biogas energy potential from food processing residue, 1,393 GW-hr/yr (16.7 million GJ/yr natural gas equivalence) is likely a high-end estimate and 106 GW-hr/yr (1.3 million GJ/yr natural gas equivalence) is a low estimate, with 400 – 500 GW-hr/yr (1.4 to 1.8 million GJ/yr of natural gas equivalence) being a value that can be achieved with a reasonable degree of confidence. This however assumes that it will be technically feasible to utilize food processing wastewaters as well as semi-solid and solid residues from the food processing industries and plate food waste from municipal solid waste for biogas production.

5.0 ECONOMIC SIGNIFICANCE OF UTILIZING FOOD PROCESSING INDUSTRY RESIDUES FOR BIOGAS PRODUCTION

There are several economic scenarios that could occur as the number of biogas systems continues to grow in Ontario. Predicting which scenario will dominate is a difficult task because of the number of unknowns that will affect biogas production economics. Factors that will affect the economic scenario that evolves include:

- Capital cost of anaerobic system
- Operating costs for anaerobic system
- Interest rates
- Market value of natural gas
- Market value of electricity
- Cost of fuel for transporting residues to digester
- Storage costs for digestate
- Costs for fuel to transport digestate to agricultural land

- Availability of land for utilizing digestate
- Availability of alternative uses for digestate
- Ability to economically process digestate into other value added products
- Tipping fees that the food industry can bear
- Demand for food processing residues for biogas production
- Demand for food processing residues for animal food production
- Value of food processing residues for animal food production
- Energy potential of residues

One economic scenario that could occur is that tipping fees for food processing residues remain constant as the demand from biogas systems continues to grow. If this were the case, biogas systems would receive tipping fees ranging from approximately $20/tonne to approximately $75.00/tonne, depending on the residue type and number of competing uses for the residues. If we assume a tipping fee midway between $20.00/tonne and $75.00/tonne ($47.50/tonne) and assume that approximately 50% of the high residue estimate in Table 2.2 is available (4.9 million wet tonnes of food processing residues; including wastewater) the biogas industry will receive approximately $233 million in tipping fees.

The other economic scenario that could occur is that as the demand for food processing residues increases, the tipping fees available will decline due to competition for the materials. In this scenario it is reasonable to expect at some point, biogas systems may actually have to pay for higher energy residues and receive no or minimal tipping fees for other residues. In this scenario the food processing industry will benefit from reduced residue management costs. If we assume that tipping fees reduce to zero, 4.9 million wet tonnes of food processing residues are used for biogas production and that current tipping fees average $47.50/tonne, this will represent a savings of approximately $233 million to the food processing industry.

One of the draw backs with the operation of centralized biogas systems is the transportation costs associated with delivering food processing residues to the facility. Many of the lower energy residues such as wastewater and high moisture content wastewater residuals will not have sufficient energy production potential to make it economical to haul these materials any significant distance. Unfortunately these residues are also the materials that have the least amount of competition from other uses and so have the highest degree of availability. The wastewaters and high moisture content residues are more suited to biogas production using smaller on site facilities. Typically wastewaters are partially treated on site and discharged to a municipal sewer system, or fully treated on site and the treated effluent discharged to a river or stream. Wastewater treatment residuals are typically land applied within a relatively short distance of the source, due to high transportation costs.

Using the residue quantity estimate of 4.9 million wet tonnes/yr derived earlier in this section, and an average biogas production factor of 43.3 m^3/wet tonnes (calculated from data in Table 2.2), and assuming conservative estimates of $0.11/kwh from the Renewable Energy Standard Offer Program (REOP) and $7/GJ for natural gas, the energy value derived from using food processing residues for biogas production is approximately $45.7 million for electricity and $34.9 million for natural gas equivalence. Heat recovery in cogeneration systems could increase the total energy value for systems generating electricity by 50%.

The hauling costs associated with management of digestate will have a significant influence on the economic scenario that evolves in Ontario as the use of food processing residues for biogas production increases. Typically the most economical means of digestate management is land application as a nutrient source for crop production. Many of the residues suited for biogas production are currently land applied and the farming community typically receives these materials at no cost. So it is unlikely that they will pay to receive digestate from biogas facilities. Therefore hauling costs associated with food processing residues may be twice as high, or more, than current hauling costs, because these materials will have to be hauled to a biogas system which may be further away than the land application site, and then the digestate hauled to crop land that can utilize the nutrients.

A more in depth discussion of the factors that will affect the availability of food processing residues for use as a feed stock for biogas production is provided in Section 7.0.

6.0 GAPS IN AVAILABLE DATA FOR FOOD- BASED INPUTS FOR ONTARIO BIOGAS SYSTEMS

There is a significant amount of literature published that predicts the quantities and characteristics of residue or wastewater that a variety of food processing plants will generate. Most of the published data was developed to assist with the design of treatment facilities for managing the various types of food residue. The quantities of residue or wastewater are predicted on the basis of the quantity of raw materials processed or the quantity of product produced.

One major data gap that was identified is product production data or raw material processing quantities for Ontario food processing facilities. A significant amount of economic data was found that provides information in dollars of production but limited amount of actual quantity data that could be correlated with residue production estimating factors.

It was found that the Ontario food processing industry considers residue production and residue management costs to be confidential information. This appears to be typical of other jurisdictions as well and was noted by the Cornell University working group involved with the development of the food processing industry residue prediction computer program for New York State.

In reviewing the literature available it was noted that there is no standard system of units used for reporting residue estimating factors. Some factors are provided on a volume basis, some on a weight basis some on the basis of organic strength (COD, BOD) or other physical properties (TS, TSS, VS, VSS), some on a dry weight basis and some on an as is basis. This makes it more difficult to use a standard method of predicting biogas quantities.

Based on the literature search completed, there have been very few comprehensive food residue studies completed to identify the potential for the food processing industry to provide feed stocks for the biogas industry. Three studies were found and used in this report. They include a study for the State of California USA, the State of Washington USA and Denmark.

Data on the number of food processing facilities that can actually use low grade heat from a co-gen system is not available and further investigation is required to determine this. There appears to be significant potential to install small scale biogas systems located on site at food processing industries to utilize wastewaters for biogas production. These systems would be most suited to facilities that can utilize the biogas directly in boilers on site or export the biogas to the natural gas grid. Most food processing facilities require high grade heat (steam) for their processes. Cogeneration systems operated on biogas typically generate low grade heat, which can not be used to replace steam heat. There may be some potential to use cogeneration heat to pre-heat boiler make up water for facilities that use direct steam injection in their processes. There may also be some opportunity to use low grade co-gen heat for large facilities that have a low condensate return temperature in the boiler system and require auxiliary heat to raise the condensate return temperature to an acceptable temperature before it is returned to the boiler.

This project had a 5 week duration and was intended to quantify food processing industry residues from readily available data. In order to complete a comprehensive study, a larger study would be required with sufficient resources to do on site analysis of representative facilities in each of the food processing industry sectors. This would provide an opportunity to obtain production and residue data that could be used to extrapolate residue quantities for each food processing industry sector. The acquired data would provide a more accurate estimate of the quantities, characteristics and availability of food processing residues for biogas production.

7.0 FACTORS THAT WILL AFFECT THE AVAILABILITY OF FOOD PROCESSING RESIDUES FOR USE AS A FEED STOCK FOR BIOGAS PRODUCTION

The availability of the different types of food processing residues as a feed stock for biogas production will be driven by a variety of factors. Theses factors include:

- demand for the residue by the different sectors that currently utilize the residue or potentially have the ability to utilize the residue
- location of the residue relative to potential users,
- transportation costs,
- costs for current treatment and disposal options
- costs for traditional and emerging forms of energy and
- the residue to energy conversion efficiency of anaerobic digestion, biodiesel and methanol.

The different sectors that can currently utilize food processing residue include the rendering and feed processing industry, agriculture which uses food processing residue as a nutrient and organic matter source for crop production and the energy production industry which can use food processing residue for biogas production, biodiesel production and ethanol production.

At the present time most food processors pay to have their residues removed or treated and disposed of. The residues are managed in a least cost fashion by the food processors and therefore the industry that can most economically utilize the residues, with the lowest tipping fee are the industries that end up securing the residues for their respective feed stock requirements.

7.1 COMPETITION FOR RESIDUE FOR OTHER FUEL PRODUCTION PROCESSES

Clean high-quality fats oils and grease are high energy inputs for biogas systems but will likely not be available for biogas due to competing uses. Ontario has a well established rendering industry that makes use of fats, oils and grease for the production of animal feed and other by-products. The tipping fees for these materials varies somewhat but $50/tonne is a good average cost for disposal by meat processing facilities. Biodiesel production technologies will typically yield between 0.8 and 0.9 tonnes of bio-diesel per tonne of grease processed. The density of biodiesel is approximately 0.88 tonnes/m^3. The energy value of biodiesel is approximately 37.8 GJ/tonne, so 1 tonne of grease will produce approximately 32.1 GJ of energy. On the other hand 387.4 m^3 of biogas at 65% methane, with an energy value of approximately 9.2 GJ is produced from 1 tonne of grease using anaerobic digestion as the conversion method. Based on a pure energy conversion efficiency, it would appear that the use of clean grease type materials (fats, oil and grease) will be more valuable for biodiesel production than biogas and will likely not be an available biogas feed stock. The residues from biodiesel production may be a potential feed stock for biogas production but no data was found to estimate the potential biogas production.

Dirty type fats, oil and grease such as DAF float with a high water content are a viable feed stock for biogas production because the presence of other organics and moisture are not a detriment to the anaerobic process which can use a wide range of organic materials for conversion to biogas.

7.2 ENERGY VALUE OF RESIDUES

Most food processing industries generate waste water which has a significant potential for generating biogas and is not well suited for use by other industry sectors. However this residue stream, because of the volume and lower energy value per unit volume than most solid residues from the food processing industry, is not suited for use in centralized facilities, and would require installation of smaller local facilities for producing biogas. Biogas production at localized sites could be used to offset natural gas use at the site, used as a fuel source for combined heat and electricity production at the site or the biogas could be sold to the local natural gas distribution company. The willingness of local natural gas distribution companies to purchase biogas from localized facilities and the availability of affordable biogas cleaning/ upgrading technology will affect the potential for individual food processors to install anaerobic systems. Due to the high cost of upgrading biogas to the quality required by natural gas distribution companies, this alternative will only be feasible for large biogas facilities.

7.3 RESIDUE CHARACTERISTICS

The use of anaerobic digestion for the production of biogas is well suited to wet residues that do not lend themselves to production of biodiesel or direct combustion. Moisture is required to optimize bacterial activity and is not a detriment to biogas production. Solid residues that result from crop residues during fruit and vegetable production as well as solids recovered from on site waste water treatment facilities at food processing plants are all wet residues well suited for biogas production. These residues however are traditionally recycled back onto agricultural land as a nutrient and carbon source for crop production. Use of these materials as a feed stock for biogas production will reduce the amount of organic matter available for recycling on agricultural land. However, since nutrients are conserved during anaerobic digestion, the quantity of nutrients available for crop production will remain the same if the digestion effluent is land applied.

7.4 SEASONAL NATURE OF RESIDUE AVAILABILITY

The ability to store food processing residues to equalize the quantity of feed stock material available through out the year may pose a problem for seasonal residues, residues that readily generate foul odours and residues that rapidly decompose. These types of residues may end up not being available simply because of the issues associated with storing them and the loss of organic matter due to decomposition during storage. In some cases biogas systems may be operated on a seasonal basis economically, if the biogas can be sold directly to the local natural gas distribution company. Systems operated seasonally will not generate sufficient biogas to support the capital and operating costs associated with biogas cogeneration of electricity seasonally.

7.5 TRANSPORTATION COSTS

The cost of fuel for transportation of food processing residues is another factor that may affect the availability of food processing residues for biogas production. Ontario has a large number of smaller food processing facilities spread out across the province that are too small to install an anaerobic treatment system for managing just the residues produced at their site. Therefore these residues will have to be transported to a centralized facility if they are to be utilized. As fuel costs continue to increase less and less residue from smaller facilities may be within a viable travel distance to an anaerobic digestion facility that can utilize the residues.

The economic travel distance will be directly related to the biogas production potential of the residue and tipping fee available. Table 2.9 shows the costs associated hauling semi-liquid type materials different distances in Eastern Ontario developed by Goodfellow Agricola Consultants Inc. (2007). The biogas energy potential $/m^3 or $/tonne and tipping fee must exceed transportation costs in order for the residue to be an economically viable material for a particular biogas production facility location.

Table 2.9
Hauling Costs for Semi-liquid Residues

Travel Distance	Load ($/m^3)	Per km ($/km)	Total Cost ($/m^3)
Over 5 km	$6.60	$0.075	$6.99
Over 10 km	$6.60	$0.055	$7.17
Over 15 km	$6.60	$0.035	$7.15
Over 25 km	$6.60	$0.015	$7.00
Over 50 km	$6.60	$0.015	$7.39
Over 500 km	$6.60	$0.015	$14.33

Goodfellow Agricola Consultants Inc. 2007

7.6 TIPPING FEES ASSOCIATED WITH RESIDUE MANAGEMENT

In many cases, use of food processing residues as a feed stock for biogas production is only viable if the anaerobic facility can collect a tipping fee for managing the food processing residue. As the number of anaerobic facilities increases in the province, the demand for feed stock materials will increase, and the tipping fees will gradually decline as competition for feed stocks increase. This could result in some installed facilities becoming un-economical to operate, as the number of biogas production facilities increase. An increase in revenue from biogas production facilities due to an increase in the value of biogas (general increase in energy costs) and the availability of green house gas emission credits could offset the economic impact of lower tipping fees.

As the cost for current methods of treatment and disposal of food processing residues increase, the potential for higher tipping fees increases, but again this can be off set by high demand in the biogas industry for the residues which will drive the tipping fees down.

7.7 SHIFTS IN FOOD PROCESSING INDUSTRY PRODUCTION

Shifts in the type and numbers of food processing industries operating in Ontario is another factor that can affect the availability of food processing residues for biogas production. With the global economy that exists more and more raw materials from Canada including Ontario are being exported to other countries for processing. As the global economy continues to evolve, Ontario could see a significant shift in the food processing industries that operate here. A reduction in Ontario crop processing will result in a decrease in food processing residues.

The potential for a shift in the food processing industry that actually increases the quantities of residue available is also possible. For example the elimination of specified risk material (SRM) from use in the animal feed industry has resulted in this material emerging as a residue that is available for producing biogas. Ontario is currently experiencing a decline in the demand for hogs and hence a decline in production. As a result the quantities of hog feed required have declined. This has reduced the demand for food processing residues that have traditionally been used for producing hog feed. Some of these materials are now potentially available for biogas production.

8.0 CONCLUSIONS

The quantities of food processing industry residues and plate food waste that are produced in Ontario were estimated to range between 1.2 million and 9.8 million wet tonnes/yr, based on available information for estimating the quantities. The biogas electrical energy that can be produced from the residues and plate food waste quantified in this study, assuming the total quantity is available, were calculated to range between 106 GW-hr/yr and 1,393 GW-hr/yr (1.3 to 16.7 million GJ/yr of natural gas equivalence). In reality all of the food processing residues and plate food waste will not be available. Competition from other users of food processing residues will reduce the quantities available for biogas production. Based on the California study data discussed earlier in this report and the competition for some food processing residues, it is estimated that between 40% and 60% of the residues and plate food waste will be available for biogas production.

The data set of actual residues available in Ontario is very limited. There appears to be a degree of confidentiality in the food industry regarding residue quantities as well as production quantities. Limited information was obtained from food processing residue hauler contacts, questionnaires sent to food industries, and direct phone contact during the timelines of this project. This is not a situation that is unique to Ontario and was identified in other jurisdictions as well. Lack of actual residue production data from the food processing industry in Ontario suggests that theoretical calculations based on residue factors and actual production data will likely yield the most accurate inventory of residues produced in Ontario.

Direct visits to a cross section of food processing industries should be considered if additional work is undertaken to increase the information available for food processing industry residue quantities and production data.

The likelihood of biogas systems being installed to make use of these residues is difficult to predict and will depend on the economics at each potential site.

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Appendix A

Ontario Food Processing Association Offices Contacted

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Alliance of Ontario Food Processors

Apple Marketers' Association of Ontario

Aquaculture Center

Association of Canadian Distillers

Association of Ontario Chicken Processors

Baking Association of Canada

Beef Improvement Ontario Inc.

Beef Information Centre

Breakfast Cereal Manufacturers of Canada

Brewers of Canada Association

Canadian Council of Grocery Distributors – Ontario Region

Canadian Dairy Network

Canadian Federation of Independent Grocers

Canadian Health Food Association

Canadian Meat Council

Canadian Mushroom Growers Association

Canadian Poultry and Egg Processors Council

Canadian Renewable Fuels Association

Canadian Restaurant and Foodservices Association

Canadian Snack Food Association

Canadian Spice Association

Canadian Sugar Institute

Confectionary Manufacturers Association of Canada

Flavour Manufacturers Association of Canada

Food and Consumer Products of Canada

Food Processors of Canada

Fruit Wines of Canada

Fruit Wines of Ontario

Further Poultry Processors Association of Canada

Gay Lea Foods Co-operative Ltd.

Ontario Agri Business Association

Ontario Dairy Council

Ontario Food Processors Association

Ontario Greenhouse Vegetable Growers

Ontario Independent Meat Processors

Ontario Pork Industry Council

Ontario Pork Producers' Marketing Board

Ontario Poultry Processes Association Turkey Committee

Pet Food Association of Canada

Poultry Industry Council

Appendix B

List of Companies that Received a Questionnaire

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List of Companies that Received a Questionnaire

Ms. Lori Agro
Agro's Foods Inc.,
381 Highway #8
Dundas ON L9H 5E1

Ms. Allison Kershaw
Apple Valley Juice Corporation,
P.O. Box 280
Clarksburg ON N0H 1J0

Mr. Jason Harris
Aromatics & Flavors Inc.,
125 Midwest Road
Scarborough ON M1P 3A6

Ms. Sandy Waliczek
Bacardi Canada Inc.,
1000 Steeles Avenue East
Brampton ON L6T 1A1

Mr. Keith Wallace
Black River Juice Company Limited,
3083 Universal Drive
Mississauga ON L4X 2E2

Mr. Monte Smith
United Canadian Malt Ltd.,
843 Park Street South
Peterborough ON K9J 3V1

Mr. Keith Taylor
Wrigley Canada Inc.,
1123 Leslie Street
Don Mills ON M3C 2K1

Mr. Joe Abate
Abate Rabbit Packers Ltd.,
R.R. No. 1
Arthur ON N0G 1A0

Mr. Curtis Krueger
Andres Wines Ltd.,
1249 Niagara Stone Road
Niagara-on-the-Lake ON
L0S 1J0

Ms. Tanya Vanderploeg
Associated Brands Inc.,
335 Judson Street
Toronto ON M8Z 1B2

Ms. Monica Desmond
Bartek Ingredients Inc.,
421 Seaman Street
Stoney Creek ON L8E 3J4

Ms. Grace Lallemand
Beetroot Delights,
72 Spruceside Crescent
Fonthill ON L0S 1E1

Mr. Roy Sespon
W.T. Lynch Foods Ltd.,
72 Railside Road
Toronto ON M3A 1A3

Mr. Bob Thomas
Thomas Canning (Maidstone) Ltd.,
R.R. No. 1
Maidstone ON N0R 1K0

Ms. Shenul Williams
Aki's Fine Foods Ltd.,
1885 Clements Road
Unit 250
Pickering ON L1W 3V4

Ms. Mary Hanna
Andrew Peller Limited,
697 South Service Road
Grimsby ON L3M 4E8

Mr. Raul Garcia
Arla Foods Inc.,
675 Rivermede Road
Concord ON L4K 2G9

Mr. James Brown
Bavarian Meat Products Ltd.,
699 Wallace Road
North Bay ON P1B 8G4

Mr. Azim Hosein
Belmont Meat Products Ltd.,
230 Signet Drive
Weston ON M9L 1V2

Mr. Stephan Krawec
Wing's Food Products,
50 Torlake Crescent
Toronto ON M8Z 1B8

Mr. Peter Deo
Brazcanco,
1260 Martingrove Road
Rexdale ON M9W 4X3

Mr. Doug Hoover
Bright Cheese House,
478 Industrial Avenue
P.O. Box 1665
Woodstock ON N4S 0A9

Mr. John Pound
Cardinal Meat Specialists Ltd.,
3160 Caravelle Drive
Mississauga ON L4V 1K9

Dr. John Paroschy
Chateau Des Charmes Wines Ltd.,
P.O. Box 280
St. Davids ON L0S 1P0

Mr. Gordon Fuller
Creemore Springs Brewey Ltd.,
139 Mill Street
P.O. Box 369
Creemore ON L0M 1G0

Mr. Rob Curik
DC Foods (2001) Inc.,
35 Northland Road
Waterloo ON N2V 1Y8

Mr. Angelo Di Santo
Dr. Oetker Ltd.,
2229 Drew Road
Mississauga ON L5S 1E5

Ms. Anna Sung
Enviro Mushroom Farm Inc.,
5200 Britannia Road West
R.R. No. 6
Milton ON L9T 2Y1

Mr. Sharif Sunderji
Breadsource Corporation,
1820 Ellesmere Road
Toronto ON M1H 2V5

Mr. Brent Brook
Cadbury Adams Canada Inc.,
277 Gladstone Avnue
Toronto ON M6J 3L9

Mr. David Hooper
Cave Spring Cellars Ltd.,
3836 Main Street
Jordan ON L0R 1S0

Mr. Lyndon Jones
Celtrade Canada Inc.,
2687 Slough Street
Mississauga ON L4T 1G2

Mr. John Warner
Crofters Food Ltd.,
7 Great North Road
Parry Sound ON P2A 2X8

Mr. Vasant Motwani
Delta Beverages Inc.,
21 Marycroft Avenue
Woodbridge ON L4L 5Y6

Ms. Kim Calmusa
Elmira Poultry Inc.,
605 Kumpf Drive
Waterloo ON N2V 1K8

Mr. Larry McCabe
European Quality Meats &
Sausages,
14 Westwyn Court
Brampton ON L6T 4T5

Mr. Mike Baumken
Brick Brewing Co. Ltd.,
181 King Street South
Waterloo ON N2J 1P7

Mr. Al Obma
Canadian Mist Distillers Ltd.,
202 MacDonald Road
Collingwood ON L9Y 4J2

Ms. Cathy Mistretta
Capo Foods Ltd.,
102 Meg Drive
London ON N6E 3T7

Mr. Adrian Carabajal
Cilento Wines Ltd.,
672 Chrislea Road
Woodbridge ON L4L 8K9

Mr. Randy Woods
Damon Industries (Canada) Ltd.,
225 Bradwick Drive
Unit 14
Concord ON L4K 1K7

Mr. Bruce Davis
Dare Foods Ltd.,
2481 Kingsway Drive
P.O. Box 1058
Kitchener ON N2G 4G4

Mr. Andy Brown
Dover Industries Ltd.,
140 King Street West
P.O. Box 3368
Cambridge ON N3H 4T3

Mr. Richard Pitman
Feature Foods International Ltd.,
15 Meteor Drive
Etobicoke ON M9W 1A3

Mr. Ken Duipuis
Ferndale Vineyards Inc.,
3026 8th Avenue
R.R. No. 1
Jordan ON L0R 1S0

Mr. Carlos Martins
Weston Bakeries Ltd.,
1425 The Queensway
Etobicoke ON M8Z 1T3

Mr. Brian Schmidt
Vineland Estates Winery Ltd.,
3620 Moyer Road
R.R. No. 1
Vineland ON L0R 2C0

Mr. Paul Cook
Flavorchem Inc.,
145 Dynamic Drive
Scarborough ON M1V 5L8

Mr. David Shram
Florentina Foods,
760 Supertest Road
Downsview ON M3J 2M5

Mr. Allen Lau
Food Directions Inc.,
8-120 Melford Drive
Scarborough ON M1B 2X5

Mr. Paul Reynolds
Summer Fresh Salads Inc.,
181 Sharer Road
Woodbridge ON L4L 8Z3

Mr. Hitesh Vyas
Sunny Crunch Foods Ltd.,
200 Shield Court
Markham ON L3R 9T5

Mr. Wayne Lemire
Strub's Pickles,
100 Roy Boulevard
Brantford ON N3R 7K2

Mr. Donovan Lazarus
Tiffany Gate Foods Corporation,
195 Steinway Boulevard
Toronto ON M9W 6H6

Mr. Robert Braini
Tasty Selections Inc.,
350 Creditstone Road
Unit 102
Concord ON L4K 3Z2

Mr. Brian Brown
Taylor & Grant Specialities Limitec
151 Weber Street South
Waterloo ON N2J 2A9

Mr. Earl Brubacher
Bio-En Power Inc.,
43 Arthur Street North
P.O. Box 130
Elmira ON N3B 3A2

Derlea Brand Foods Inc.,
953 Dillingham Road
Pickering ON L1W 1Z7

Furlani's Food Corporation,
1700 Aimco Boulevard
Mississauga ON L4W 1V1

Mr. Charlie Saldutto
G. Brandt Meat Packers Ltd.,
1878 Mattawa Avenue
Mississauga ON L4X 1K1

Gelda Scientific & Industrial,
6320 Northwest Drive
Mississauga ON L4V 1J7

Mr. Michel Lafortune
Golden Gate Margarine Michca Inc
2835 Circle
Oakville ON L6H 7H7

Mr. George Birimyi, Jr.
Grain Process Enterprises Ltd.,
115 Commander Blvd.
Scarborough ON M1S 3M7

Mr. John Smillie
Great Canadian Beam
Company Inc.,
26831 New Ontario Road
Ailsa Craig ON N0M 1A0

Mr. Peter Bulut, Jr.
Great Lakes Brewing Co. Inc.,
30 Queen Elizabeth Blvd.
Toronto ON M8Z 1L8

Mrs. Ping
Great Northern Smokehouses,
43 Mulock Avenue
Toronto ON M6N 3C3

Mr. Rudy Doerwald
Greaves Jams & Marmalades
Ltd.,
1 Walker Road
P.O. Box 26
Niagara-on-the-Lake ON
L0S 1J0

Mr. Bruce MacIntyre
Halton Flour Division of Dover Ind
62 Mill Street West
Acton ON L7J 1G4

Mr. Dave Maguire
Hayter's Turkey Products Inc.,
Highway 83
R.R. No. 2
Dashwood ON N0M 1N0

Mr. Peter Misner
Henry H. Misner Limited,
Harbour Street
P.O. Box 1540
Port Dover ON N0A 1N0

Ms. Christine Rohrbach
Hewitt's Dairy Ltd.,
128 King Street East
Hagersville ON N0A 1H0

Mr. Philippe Labre
Hilltech Canada Inc.,
249 Main Street East
Vankleek Hill ON K0B 1R0

Ms. Vaska Jovanovska
Horton Spice Mills Ltd.,
256 Steelcase Road West
Markham ON L3R 1B3

Mr. Rick Howson
Howson & Howson Limited,
23 Westmoreland Street
Blyth ON N0M 1H0

Mr. Sudhir Relan
J.J. Derma Meats,
61 Torlake Crescent
Etobicoke ON M8Z 1B4

Mr. Steve Wright
Jadee Meat Products Ltd.,
4710 Bartlett Road
P.O. Box 669
Beamsville ON L0R 1B0

Mr. Murray Johnston
Johnston's Cranberry Marsh,
1074 Cranberry Road
P.O. Box 24
Bala ON P0C 1A0

Dr. Joseph Porly
Joseph's Estate Wines Inc.,
1811 Niagara Stone Road
R.R. No. 3
Niagara-on-the-Lake ON L0S 1J0

Ms. Heidi Pazulla
Kasseler Food Products Inc.,
1031 Brevik Place
Mississauga ON L4W 3R7

Mr. Arezou Rahbari
Keybrand Foods Inc.,
1326 Victoria Street North
Kitchener ON N2B 3E2

Ms. Bella Kerr
Kingsville Fishermens Co. Ltd.,
P.O. Box 37
Kingsville ON N9Y 2E8

Mr. Peter Wloch
Kittling Ridge Winery,
297 South Service Road
Grimsby ON L3M 4E9

Mr. Don Chapman
Lakeview Vegetable Processors,
21413 Leslie Street
Queensville ON L0G 1R0

Mr. Jim Deluca
Macgregors Meat & Seafood Ltd.,
265 Garyray Drive
Toronto ON M9L 1P2

Mr. John Tavares
Malabar Super Spice Co. Ltd.,
459 Enfield Road
Burlington ON L7T 2X5

Mr. Martin deGroot
Mapleton Organic Dairy Inc.,
8548 Welling Road #7
R.R. No. 1
Moorefield ON N0G 2K0

Mr. Terry McCann
MLG Enterprises Ltd.,
425 Admiral Boulevard
Mississauga ON L5T 2N1

Mr. Henry Finaldi
Nation Wide Canning Ltd.,
324E County Road 34
P.O. Box 227
Cottam ON N0R 1B0

Mr. Chris Neal
Neal Brothers Foods,
6-160 Pennsylvania Avenue
Unit B
Concord ON L4K 4A9

Ms. Mary Lim
Nealanders International Inc.,
6980 Creditview Road
Mississauga ON L5N 8E2

Mr. Nolan Terry
Nestle Purina PetCare Canada,
2500 Royal Windsor Drive
Mississauga ON L5J 1K8

Mr. Jim Groves
Newly Weds Foods Co.,
450 Superior Boulevard
Missisauga ON L5T 2R9

Mr. Aidan Finn
Orange A Peel,
487 Book Road West
Ancaster ON L9G 3L1

Mr. Nino D'Aprile
Pasta D'aprile Pasta,
125 Anderson Avenue
Markham ON L6E 1A4

Mr. Arcady Krasmov
Pop-Ins Frozen Foods Ltd.,
852-860 Magnetic Drive
Downsview ON M3J 2C4

Mr. Dave Franks
Reid's Dairy Co. Ltd.,
222 Bell Boulevard
P.O. Box 997
Belleville ON K8N 5B6

Mr. Harry Bojrski
Ryding-Regency Meat Packers Ltd.,
70 Clen Scarlett Road
Toronto ON M4N 1P4

Mr. Robin Narayan
Sensient Flavors Canada,
7200 West Credit Avenue
Mississauga ON L5N 5N1

Mr. Dror Balshine
Sol Cuisine Inc.,
1-5715 Coopers Avenue
Mississauga ON L4Z 2C7

Trophy Foods Inc.,
71 Admiral Boulevard
Mississauga ON L5T 2T1

Mr. Peter Driedger
Otter Valley Foods Inc.,
95 Spruce Street
Tillsonburg ON N4G 5C4

Pelee Island Winery &
Vineyards Inc.,
455 Seacliff Drive
County Road 20

Mr. Brian Fiedler
R. Fiedler Meat Products Ltd.,
10 Grigg Drive
P.O. Box 400
Simcoe ON N3Y 4L4

Mr. Libman
Richmans Kosher Bakery,
4119 Bathurst Street
North York ON M3H 3P4

Mr. Damian Curran
Saxon Chocolates,
21 Colville Road
Toronto ON M6M 2Y2

Mr. Gulzan Dabass
Skjodt-Barrett Foods Inc.,
2395 Lucknow Drive
Mississauga ON L5S 1H9

Mr. John Curtis
St. Helen's Meat Packers Ltd.,
1-3 Glen Scarlett Road
Toronto ON M6N 1P5

Parrish & Heimbecker Ltd.,
69219 Victoria Drive
P.O. Box 10
Centralia ON N0M 1K0

Ms. Betty Renner
Pepsico Inc. - Frito Lay Canada,
700 - 55 Standish Court
Mississauga ON L5R 4B2

Ms. Anna Bucko
Redpath Sugars,
95 Queens Quay East
Toronto ON M5E 1A3

Mr. Alfredo Varalli
Roman Cheese Products Limited,
7770 Canadian Drive
Niagara Falls ON L2E 6S5

Mr. Alex Polsinello
Select Food Products Ltd.,
120 Sunrise Avenue
Toronto ON M4A 1B4

Mr. Ed Vanderbeek
Sleeman Breweries Ltd.,
551 Clair Road West
Guelph ON N1H 6H9

Trafalgar Brewing Company Ltd.,
1156 Speers Road
Oakville ON L6L 2X4