Pre-Feasibility Study on Anaerobic Digestion

Final Report

Submitted to:

Region of Durham

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Kelleher Environmental

in association with

ROBINS ENVIRONMENTAL

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Executive Summary

Anaerobic digestion (AD) is a biochemical conversion process that uses microbes (bacteria and other organisms) to break down organic material in the absence of oxygen. Under these conditions the AD process produces biogas (consisting mostly of methane) and digestate (which can be directly land applied or turned into compost). The benefit of AD technology is the ability to use the biogas to produce heat, steam, and electricity or upgrade the biogas to produce renewable natural gas (RNG) or other fuels. AD vendors use a wide variety of design approaches to meet client needs.

The Region of Durham engaged Kelleher Environmental (in association with Robins Environmental) to carry out a pre-feasibility study on anaerobic digestion (AD) for source separated organics (SSO) and other biodegradable materials produced in the Region. The objectives of the study were to address how AD could increase waste diversion and produce green energy. The study explored whether AD and related pre-processing technology could provide an opportunity to expand the list of materials accepted in the Green Bin program, including pet waste, diapers and sanitary products. The AD study specifically excluded leaf and yard waste which is not suitable for AD processing because of low biogas yields and is best processed in an open windrow composting system without energy recovery.

While AD technology is used to process residential SSO in many locations in Europe, to date, it has not been widely adopted in North America as the economics are not as attractive compared with the European market. Aggressive financial incentives (such as feed in tariff pricing for green, renewable energy, landfill surcharges and mandatory organics stabilization, etc.), have helped to drive AD in Europe. Similar incentives are not in place yet in North America and have hindered investment in AD.

The Ontario Power Authority introduced the Feed In Tariff (FIT) program for green energy produced from AD in 2009. The FIT improved the economics of AD by offering a price of 14.7 cents/kwhr for electricity produced by burning biogas. The FIT program is being re-designed in 2013 with a new approach to green energy projects.

The cost for enclosed aerobic composting has become more expensive over time due to stringent odour control requirements. As a result, AD has become more cost competitive over time as a means of processing SSO. This has caused an increased interest in AD projects. Consequently, many cities and communities across Canada and the US are currently exploring AD as an option for the processing of SSO and other organic materials.

The scenarios considered in the pre-feasibility study are:

Option 1: Maintain the current system for single-family SSO and implement AD technology to process additional materials from single-family homes, such as pet waste, diapers, and sanitary products.

Option 2: Replace the current system completely and process SSO, including additional materials deemed appropriate for addition to the Region's Green Bin Program, from single-family homes through AD technology.

Option 3: Maintain the current system for single-family SSO and implement AD technology to process SSO from multi-residential households.

Option 4: Maintain the current system for single-family SSO and implement AD technology to process multi-residential SSO and additional materials, such as pet waste, diapers and sanitary products from both single-family and multi-residential homes.

The diversion impacts and energy production associated with each option are summarized in the table below.

Option #	**Processing facility capacity requirements (tonnes per year)**	**GAP Diversion Impact**[1]	**Energy Impact (Electricity Generation From Biogas)**
Base Case – Continue with the current system that processes single-family organics only and do not implement AD or expand the list of accepted materials.	45,000 to 60,000 tonnes/year aerobic composting	Remains at 12%[2] - could increase to 16% over time as program matures	No energy benefit
Option 1 – Maintain the current system for single-family SSO and implement AD technology to process additional materials from single-family homes, such as pet waste, diapers, and sanitary products.	9,000 tonnes/year of pet waste to AD 6,000 tonnes/year of diapers and sanitary products to AD	Additional 0.75% for pet waste. 0.2%) for diapers and sanitary products	1 million kWhrs/year for pet waste Negligible for diapers.
Option 2 – Replace the current system completely and process SSO, including additional materials deemed appropriate for addition to the Region's Green Bin Program, from single-family homes through AD technology.	60,000 to 70,000 tonnes/year to AD	Additional 0.8% from pet waste. 0.2% for diapers and sanitary products	13.9 million kilowatt hours per year
Option 3 – Maintain the current system for single-family SSO and implement AD technology to process SSO from multi-residential households.	2,300 to 3,400 tonnes/year to AD	0.7% to 1%	0.7 million kilowatt hours per year but not viable as a stand alone option (tonnage too low)
Option 4 – Maintain the current system for single-family SSO and implement AD technology to process multi-residential SSO and additional materials, such as pet waste, diapers and sanitary products from both single-family and multi-residential homes.	18,000 to 19,000 tonnes/year to AD	2% of which 0.8% from pet waste, 0.2% from diapers and sanitary products and 1% from MF SSO (food waste)	3.5 million kilowatt hours per year

The research undertaken in this study concluded that diapers and sanitary products should not be added to the SSO program. These products contain very little biodegradable materials and will therefore not produce adequate biogas to justify the costs (as biogas and therefore energy can only be produced from biodegradable materials). Most of the collected material will end up in the residue stream and not be diverted (because it is plastic or other non-biodegradable material). Collection of these materials for processing in an AD facility will not contribute to residential waste diversion measured through the GAP process, and will create problems producing a clean finished compost (or from composting of digestate) because of potential plastic contamination. No community could be identified in North America that currently collects diaper and sanitary waste in a separate stream.

There may be an opportunity to incorporate pet waste into the SSO stream regardless of processing technology. There is some energy and compost value in the pet waste and it would contribute slightly to the Region's diversion rate. Subject to agreement of the processor, pet waste could also be introduced into the in-vessel aerobic composting system, as is done Niagara Region.

[1] The diversion rates are based on 2010 Datacall information in which total waste generation rate in 2010 was 229,629 tonnes. A 50% increase in waste to 2031 was assumed. The denominator for GAP residential diversion calculations is 358,000 tonnes.
[2] Based on 2010 Datacall information (2011 values are lower), 27,593 tonnes SSO divided by 229, 629 tonnes generated in 2010 – ignoring residues = 12%

An AD facility with a capacity of greater than 50,000 tonnes is the only option considered viable (Option 2). In Durham Region, this would require partnerships or all of the Region's SSO to be sent to an AD facility. The other options were not considered further as they do not provide sufficient material to justify AD processing.

Costing information from recent AD projects was used to develop approximate capital and operating costs for the AD facility size under consideration. The capital and operating costs are presented in the table below.

Cost Category	**Larger AD facility (60,000 to 70,000 tonnes/yr)**
Estimated Capital Costs of AD facility (excluding on-site composting and curing of digestate)	$45 million
Annual $/tonne capital for AD Facility (excluding on-site composting and curing of digestate which would be sent off site under contract)	$48 - $56
Annual $/tonne operating (excluding off site composting and curing)	$86
Annual $ per tonne of input for digestate composting and curing (amortized capital and operating costs together)	$25
Revenue from sale of compost – assume zero because absorbed into contracted cost for off site curing – could range up to $10 per tonne of input if revenues shared with Region	$0 - $10/tonne
Total Annual Cost/tonne of input before FIT Revenue	***$159-$167***
Electricity revenue $per tonne of input (based on pricing of 14.7 cents/kwhr[3])	$26
Total annual cost/tonne of input net of electricity revenue (@14.7 cents/kwhr)	***$133 - $141***

About 30-40% of the biogas produced at an AD facility is used internally to operate the AD facility. The remaining biogas can be used for other purposes. Opportunities available to generate revenue from biogas include: using it to generate steam (or heat), generating electricity; generating electricity and heat (co-generation), upgrading it to produce renewable natural gas (RNG) for injection directly into the natural gas pipeline (depending on the AD facility location), or converting it to vehicle fuel (CNG - compressed natural gas) or LNG (liquified natural gas). The economics of each of these options depend on the AD facility location, markets for the end product and the relative prices for different fuels and energy sources.

The future price for electricity to be offered by the OPA is not known at this time. If biogas generated electricity can be sold for a price similar to the 14.7 cents/kWhr offered under the recently cancelled FIT program, then the AD facility is likely economically comparable to composting.. Digestate can be applied directly to farmers fields to add nutrients and carbon structure to the soil, or it can be composted at an additional cost. Compost generated by the composting of digestate can generate some revenue, but this is generally not a significant amount and is generally kept by the composting contractor.

There are a number of potential funding and partnership opportunities available to the Region to help defray the capital and operating costs that would be incurred by the Region. These opportunities, as well as economic and technical risks should be explored further if the Region decides to move forward with an AD facility.

[3] The pricing of 14.7 cents/kwhr was offered by OPA under the recently re-designed FIT program. The FIT program now applies only to small projects of 500kW or less. OPA will continue to purchase electricity from renewable sources under a new, more community focused renewable energy program which will be based on open procurement and community needs. Should the new value for biogas generated electricity by lower than 14.7 cents/kwhr, then the economics of the AD facility would be less viable based on an electricity generation model, and renewable natural gas (RNG) production for vehicle fuel or injection into the natural gas pipeline might be a more attractive option.

The overall conclusions and recommendations resulting from this study are:

- AD facilities reach economies of scale, and become cost competitive at capacities of greater than 50,000 tonnes/year. Option 2, with a required AD facility capacity of 60,000 to 70,000 tonnes/year is considered the only viable option worth pursuing. There is sufficient SSO in the Region to consider AD if all SSO is processed in an AD facility.

- If the Region pursues an AD option where they own the AD facility, partnerships should be considered to augment the amount of material brought to the AD facility in order to reduce capital and operating costs.

Glossary of Terms

Aerobic Composting	Biological treatment of organic waste by bacteria that require oxygen to produce a stable end produce (compost) which can be used as a soil conditioner. Examples of aerobic composting include windrow composting, static pile composting, tunnel or in-vessel composting). By contrast, anaerobic (discussed below) means “out of the presence of oxygen”.
Anaerobic Digestion (AD)	The controlled biological conversion and treatment of organic material by bacteria and other microbes in the absence of oxygen. Oxygen is toxic to anaerobic bacteria and other micro-organisms (anaerobes). The AD process produces biogas (about 50-60% methane or natural gas, 40-45% carbon dioxide and traces of other gases), liquid effluent and a solid, partially stabilized organic material known as digestate which is generally sent for further aerobic composting to yield a stabilized product (compost).
Biodegradable (municipal) waste	This is a broader concept defined in the European Landfill Directive as any waste that is capable of undergoing anaerobic or aerobic decomposition, such as food and garden waste, and paper and paperboard.
Biofuel	Are liquid fuels derived from biomass. In the case of AD, the biogas generated is upgraded to form a biofuel (such as renewable natural gas)
Biogas	Gas formed during the anaerobic decomposition of organic material, mainly consisting of methane and carbon dioxide.
Biological Treatment	Involves the biological (aerobic or anaerobic) treatment of organic materials to stabilize the waste and/or create compost and/or create energy.
Certificate of Approval (CofA)	See Environmental Compliance Approval (ECA).
Compost	The relatively stable humus material that is produced from the aerobic decomposition or composting process in which bacteria in soil mixed with degradable organic materials break down the mixture into an organic soil amendment.
Contamination or Contaminant	Refers to any material in the organic stream that does not degrade during the aerobic composting or AD process, and which degrades the quality of the finished compost so that it can not be sold. Contaminants to organics processing include plastic, grit, metal, stones, etc.
Digestate	Solid organic material generated from the anaerobic digestion process. Becomes compost after the curing process.
Digestion	The biochemical decomposition of organic matter
Environmental Compliance Approval (ECA)	The ECA is a new instrument of environmental approval that replaces the Certificate of Approval (CofA). Existing CofA and their terms and conditions will continue to apply as if they were an ECA. An ECA is a license or permit issued by the Ministry of the Environment for the operation of a waste management site/facility or for the operation of a facility or component of a facility that emits regulated substances into the natural environment.
Energy From Waste (EFW)	EFW refers to projects and facilities that recover energy from waste, generally through a thermal conversion process.
Feedstock	The input material to be processed at an AD facility or waste management facility.
Generally Applied Principles (GAP)	A waste flow accounting system developed in Ontario to enable municipalities to accurately calculate and compare waste generation and diversion activities. Provides a directly comparable “apples-to-apples” waste generation and diversion tonnage and financial comparison system for municipalities.
Green Waste	The leaf and yard waste fraction of the municipal waste stream.
Greenfield	A site which has been previously undeveloped
Greenhouse Gas (GHG)	Gases (e.g. carbon dioxide and methane) generated naturally or as a result of human activity resulting in a warming of the Earth's atmosphere or greenhouse effect.
Greater Toronto Area (GTA)	An area in southern Ontario encompassing five regional municipalities including the Regions of Peel, Halton, Durham, York and Toronto.
LYW	Refers to the leaf and yard waste fraction of the municipal waste stream.

Mechanical Treatment	Involves the physical treatment of waste materials to recover recyclable materials and to prepare waste for further treatment or disposal
Ministry of the Environment (MOE) Ontario	The MOE monitors pollution and restoration trends in Ontario and uses that information to develop environmental laws, regulations, standards, policies, programs, and guidelines. The MOE works to provide cleaner air, land, and water for Ontarians
Mixed Municipal Waste	Includes all solid non - hazardous municipal waste. Solid waste that has not been sorted into specific categories (such as plastic, glass, yard trimmings, etc.)
Mixed Waste Processing	See Mechanical Biological Treatment (MBT)
Ontario Power Authority (OPA)	Established in 2004 as an independent, non-profit corporation responsible for assessing, forecasting and planning long term energy demand and capacity, procuring new supplies of electricity and achieving targets set for conservation and renewable energy. The OPA is licensed by the Ontario Energy Board and reports to the Ontario legislature through Ontario's Ministry of Energy
Reactor	Tank in which AD process takes place.
Renewable Natural Gas (RNG)	A biofuel derived from upgraded biogas (methane) that can be used as a substitute for natural gas
Residue	Amount of a waste remaining after a technological process has taken place; e.g., the sludge remaining after initial wastewater treatment, or unrecyclable/unprocessed materials remaining after being processed at a material recycling facility.
Source Separated Organics (SSO)	Organic waste that has been separated at the point of generation (household or establishment) resulting in minimal contamination and residue. This term tends to refer to kitchen food waste and non-recyclable paper waste and generally excludes leaf and yard waste, which is referred to separately as LYW (leaf and yard waste.
Stabilized Organic Material	Organic material that has converted to a form that resists any further change. Bacteria stabilize organic material and convert the material to gases and other more inert materials.

Acronyms

- AD – anaerobic digestion
- CNG – compressed natural gas
- IC&I – industrial, commercial and institutional
- LNG – liquid natural gas
- OMAFRA – Ontario Municipality of Agriculture, Food and Rural Affairs
- OMOE – Ontario Ministry of Environment
- RNG – Renewable Natural Gas
- SSO – Source Separated Organics

- DBB - design, bid, build
- EPC - Engineering, procurement & construction
- DBOM - Design, build, operate & maintain
- DFBO - Design, finance, build, operate
- DFBOO - Design, finance, build, own, operate
- DFBOOT - Design, finance, build, own, operate and transfer ownership to the Region at the end of an agreed period.
- WWTP – Waste Water Treatment Plant
- WPCP – Water Pollution Control Plant

1. Introduction

1.1 Background to Pre-Feasibility Study

Organics diversion has become a key waste diversion strategy in Durham Region and has helped the Region achieve over 50% diversion.

In 1999, less than 30% of the Region's waste was diverted from landfill and only 7% of Durham's diversion rate was attributed to the diversion of organic material, which amounted to 13,200 tonnes of leaf and yard waste (LYW). With the Region-wide introduction of the Green Bin program in 2006, the diversion rate significantly increased. In 2011, 22% of the total waste stream was diverted organic material, with approximately 26,900 tonnes (12 %) of Green Bin materials and approximately 23,700 tonnes (10%) of leaf and yard waste diverted.

In 2008, Durham Regional Council set a target of 70% diversion.

The Region retained the services of Golder Associates Ltd in 2009 to identify and recommend suitable policies and programs to help reach its 70% diversion goal. The Golder Associated Ltd. report identified potential options to increase organics diversion by expanding the Region's Green Bin program to multi-residential households and composting pet waste.

In addition to increasing diversion, the Region is also interested in exploring opportunities associated with green energy projects. Staff were directed by Regional Council in 2011 to conduct a strategic assessment/pre-feasibility study of the options available to utilize anaerobic digestion (AD) technology to produce useful green energy, while allowing for the diversion of compostable materials with known health and safety issues (e.g. pet waste).

1.2 Pre-Feasibility Study Objectives

This study focus is on residential SSO. Options to address residual waste were not part of the study's objectives and, therefore, were not assessed. The study objectives were to:

- Carry out an assessment and pre-feasibility study of the different options that could utilize AD technology to divert residential waste and produce green energy;
- Identify the extent to which each AD option could produce useful energy;
- Assess the diversion impacts of using AD technology to divert organic materials not currently accepted within the Region's SSO system;
- Identify high level costs for a potential AD facility in the Region of Durham;
- Identify the risks associated with an AD facility and
- Recommend next steps

1.3 Report Structure

The report is presented in the following sections:

- Section 2 – provides a brief overview of Durham Region's current SSO diversion program.
- Section 3 – introduces the four options explored in the study and summarizes the research resources employed for the study and to develop capacity estimates.
- Section 4 – presents estimated quantities of organic material generated under each option to the year 2031.
- Section 5 - discusses opportunities to process additional organic materials (diapers, sanitary products, pet waste, deadstock, biosolids, IC&I food waste).
- Section 6- provides a review of the AD process and the status of AD for municipal SSO processing in North America and Europe.
- Section 7 – describes the technologies typically employed to pre-treat SSO and other materials before they enter the AD process.
- Section 8 – explains the different design features of AD technology and identifies some AD vendors
- Section 9 – presents the estimated capital and operating costs associated with two sizes of AD facilities which could be considered by Region of Durham.
- Section 10 – discusses funding opportunities for a new AD facility in Region of Durham.
- Section 11 – presents legislative and permitting requirements for an AD facility in Region of Durham.
- Section 12 – discusses siting considerations for an AD facility.
- Section 13 – explores public and private partnership considerations for an AD facility.
- Section 14 – discusses risks associated with collecting new materials and building/operating an AD facility.
- Section 15 – provides conclusions and recommendations to the study.

2. Existing Region of Durham Organic Waste Management System

2.1 Introduction

The Regional Municipality of Durham is comprised of eight area municipalities including the Cities of Pickering and Oshawa, the Towns of Whitby and Ajax, the Municipality of Clarington and the Townships of Scugog, Brock and Uxbridge. The Region is responsible for providing waste collection, disposal and processing services, including source separated organics (SSO) collection through the Green Bin program to all area municipalities (with the exception of the Town of Whitby and the City of Oshawa, which provide their own garbage and SSO collection services).

This section describes the existing SSO service in the Region.

2.2 Source Separated Organics (SSO) Accepted in the Region's Green Bin Program

SSO refers to organic waste that has been separated at the point of generation (household or establishment) resulting in minimal contamination and residue. In Durham Region, this term refers to kitchen food waste and non-recyclable paper waste and excludes leaf and yard waste, which is collected separately as leaf and yard waste (LYW). In Durham Region, SSO is collected in the Green Bin Program. For the remainder of the report, the term SSO refers to material collected in the Region's Green Bin Program.

Currently, SSO collection is provided to all single family households within Durham Region boundaries. The SSO program accepts the following materials:

- All food waste (fruits, vegetables, table scraps, meat, shellfish, fish products, dairy products, egg shells, pasta, bread, cereal, coffee grounds, filters, tea bags;
- Paper fibre (soiled paper towels, tissues, paper plates and cups, soiled paper food packaging: fast food paper packaging, ice cream boxes, muffin paper, flour and sugar bags);
- Other organic waste (household plants, including soil, bedding from pet cages, pet food).

Diapers, sanitary products, coffee cups, kitty litter and pet waste are not currently accepted in the program.

Residents using liners and/or bags are to use ASTM D6400 certified compostable plastic bags/liners, paper bags/liners, or newsprint. Plastic film bags, oxy-degradable bags, plastic food packaging, and polystyrene packaging are not accepted in Durham's Green Bin Program.

2.3 Existing SSO Collection and Processing Program

Durham Region contracts out the collection of SSO materials to Miller Waste as part of its overall collection contract. The SSO is collected on a weekly basis from the curb using 46 litre specially designed green bin containers. In the case of Oshawa and Whitby, municipal staff provide weekly curbside SSO collection services to single family households.

The SSO materials collected by Miller Waste are delivered directly to the Miller Waste composting facility located in Pickering. SSO materials collected in Oshawa and Whitby are loaded into a 40 cubic yard bin at a privately owned transfer station before being delivered to the Miller Waste composting facility in Pickering.

The Region has contracted SSO processing to Miller Waste since 2006. The contract ends in 2016. The SSO materials are composted at Miller's enclosed composting facility located in Pickering using aerobic in-vessel Ebara technology. The facility has been operating at capacity since the launch of the SSO program. After processing, the material is sent to Miller's outdoor site in Clarington for additional composting and curing.

In 2009, the Region entered into a five year contract with All-Treat Farms to provide additional processing capacity for SSO. There is an option to renew the contract for two additional one year periods, such that the contract would also expire in 2016. All-Treat Farms operates an outdoor composting facility located in Arthur, Ontario using the Gore™ Cover System.

The finished compost is sold wholesale or commercially, by the contractors, at no financial benefit to the Region. As part of the contract, the Region receives up to 500 tonnes of finished compost annually at no cost to the Region for use at its Compost Giveaway events.

3. Approach and AD Options

3.1 Introduction

The research workplan for the AD pre-feasibility study involved a number of components:

- Review of the background information provided by the Region;
- Completion of a literature search (reports, internet, websites and journals);
- Interviews with selected communities and AD vendors with planned or existing AD systems;
- Development of AD processing options;
- Development of diversion, energy production and cost estimates for the AD processing options;
- Evaluation of the processing options and analysis of the data associated with the processing options; and
- Documentation of the analysis in the Pre-Feasibility Study Report.

This section describes the approach used in the Pre-Feasibility Study, as well as the AD design options evaluated in the study report.

3.2 Information Sources Used in the Pre-Feasibility Study

The following background information was provided to the Kelleher Environmental team by Regional Staff:

- The Long-term Waste Management Plan;
- Golder Associates Ltd. 70% Waste Diversion Study;
- Annual Joint Solid Waste Management Servicing and Financing Study 2011 – Detailed Report (2011-J-22)
- Durham Region 2010 and 2011 WDO Municipal Datacall Submission Forms
- Durham Region Waste Audit Data from May 6, 2011

A literature search was conducted to provide information on a number of topics relevant to the study including:

- Status of AD projects in North America and AD technology vendors involved;
- Suitability of AD for processing a wide variety of materials, and the strengths and weaknesses of different AD technologies in processing designs;
- Viability of including pet waste in an SSO program and processing pet waste using AD technology;
- Viability of including diapers and sanitary products in an SSO program and processing these materials using AD technology;
- Capital and operating cost information associated with AD projects in North America.

The literature search was augmented with personal communications with key contacts in the following fields:

- Municipalities with planned or existing AD projects (e.g. Toronto, ON; Seattle, WA; Surrey, BC; Portland, OR);
- AD vendors operating in North America, specifically in Ontario and British Columbia (e.g. Harvest Power, Yield Energy, CCI);

- Government staff involved in regulatory and policy development impacting AD use in Ontario (e.g. OMAFRA, MOE, OPA);
- Government staff and experts involved with management of different sources of organic waste (e.g. deadstock, agricultural waste, biosolids and SSO from industrial, commercial and institutional (IC&I) sites);
- AD & biogas related associations and experts (e.g. Biogas Association, Renewable Waste Association);
- Waste management associations and experts (e.g. OWMA, Miller Waste, GENIVAR).

The following documents were used in developing the AD facility design capacity requirements for different options:

- The *Growth Plan Implementation Study: Growing Durham Phase 1 and 2. May 27, 2008* by Urban Strategies Inc. was used in developing population growth projections on which waste quantities and AD system capacities were developed;
- Waste audit information provided by Durham Region Staff was augmented with relevant waste audit information generated within the GTA including:
  - Durham Region 2005 Four Season Single Family Waste Audits,
  - Town of Whitby 2007 Post Diversion Residual Garbage Waste Audit,
  - Durham Region 2011 Large Blue Box Container Study Waste Audit,
  - Halton Region 2007 Four Seasonal Single Family Waste Audits,
  - Toronto 2010 Two Season Single Family Waste Audits,
  - Richmond Hill 2010 One Season Single Family Waste Audit,
  - Toronto 2011 Four Season Multi Residential Waste Audit,
  - North York 2007 One Season Multi Residential Waste Audit,
  - Halton Region 2011 One Season Multi Residential Waste Audit, and
  - Hamilton 2010 one season Multi Residential Waste Audit.

3.3 AD Facility Processing Options

The Region of Durham is interested in assessing the viability of collecting pet waste, diapers and sanitary products, and SSO from multi-residential households in the Green Bin program for a number of reasons:

- To achieve higher waste diversion, as measured by the GAP process;
- To produce energy from these materials, if possible (using AD technology); and
- To address the public interest in managing pet waste in a more environmentally sustainable manner.

Four AD Options which could achieve these objectives were developed for the study and are summarized below:

Option 1: Maintain the current system for single-family SSO and implement AD technology to process additional material from single-family homes, such as pet waste, diapers and sanitary products.

Option 2: Replace the current system completely and process SSO, including additional materials deemed appropriate for addition to the Region's Green Bin Program, from single-family homes through AD technology.

Option 3: Maintain the current system for single-family SSO and implement AD technology to process SSO from multi-residential households.

Option 4: Maintain the current system for single-family SSO and implement AD technology to process multi-residential SSO and additional materials, such as pet waste, diapers and sanitary products from both single-family and multi-residential homes.

The base case (no changes to the current SSO program) is provided as background data, but is not included in the detailed evaluation of the options.

3.4 Population Projections Used For AD Facility Sizing Estimates

It is common practice to design most processing facilities with a capacity sufficient to meet needs for a 20-year horizon. The AD facility capacity estimates presented in Section 4 are based on a 20 year design requirement from 2011 to 2031. The year 2011 is chosen as the first year for which the most current waste generation estimates are available for the Region. Please note that all calculations for 2011 use the actual population and household numbers that were reported. Estimates for future years are based on the projections in Table 1.

Table 1: Durham Household and Population Demographics and Projections 2011-2031[4]

Year	Region of Durham Population	Region of Durham Single Family Households	Region of Durham Multi-Residential Households	Region of Durham Total Households
2011	617,888	193,145	28,080	**221,225**
2016	698,920	222,225	31,215	**253,440**
2021	774,721	252,103	35,052	**287,155**
2026	853,462	279,060	39,309	**318,369**
2031	918,205	302,156	43,678	**345,834**

To measure capacity requirements, quantities of SSO, pet waste, diapers and sanitary products are projected to the year 2031. To estimate the amounts that will be produced during the planning horizon for the AD facilities, household projections were obtained from the *Growth Plan Implementation Study: Growing Durham Phase 1 and 2. May 27, 2008* prepared by Urban Strategies Inc. for the Region of

[4] Growth Plan Implementation Study: Growing Durham Phase 1 and 2. May 27, 2008 by Urban Strategies Inc.

Durham Planning Department. The household projections are presented in Table 1. The total number of households in Durham Region was calculated by adding single family, multi (duplex or row-house), and other housing categories presented in the study. Multi-residential households were defined as buildings with greater than 6 units.

4.AD Processing Options Sizing and Capacity Estimates

4.1 Introduction

This section presents estimates of AD facility sizing (processing capacity) which would be required for the different AD options listed in Section 3.

In addition, this section provides estimates of other potential feedstocks to the AD facility, along with a conclusion regarding the suitability of each feedstock for planning purposes. The calculations presented throughout are intended to be capacity processing estimates only. The values include residue and should not be used to calculate the diversion impact of collecting these materials. Please see section 5 for a discussion of diversion impacts of various materials.

4.2 SSO Quantities For The Base Case

Table 2 presents the tonnes of SSO reported in the Region of Durham 2010 and 2011 Municipal Datacall administered by Waste Diversion Ontario.

Table 2: SSO Diversion in Durham Region Reported in WDO Datacall GAP, 2010 and 2011[5]

	2010	2011
Single Family Households Served	185,024	188,649
Total SSO Captured (curbside only)	27,593	26,865
Kg of SSO collected per household per year	149	142

The rate of SSO collection for the single-family households was 149 and 142 kg/household/year in 2010 and 2011, respectively. A range of estimates for future SSO quantities were developed using two rates (kg/household/year):

- 150 kg/household/year (similar to current Durham performance) and
- 200 kg/household/year to allow for increased collection over time through education, curbside policies which encourage greater participation and/or potential inclusion of additional materials to the Green Bin program. This number is based on the performance of Green Bin programs in other communities in Ontario which use similar sized green bins (46 litres) to Durham. Halton Region accepts the same type of materials in its green bin as does Durham Region, and diverted 178[6] kg/household of SSO in 2011. York Region collected 205[7] kg/household, in 2011 in their Green Bin program; however, they accept a wider range of materials in their green bin programs, including diapers, plastic bags, pet waste and sanitary waste.

Table 3 shows that SSO tonnages could range from approximately 45,000 to 60,000 tonnes per year (rounded values) by 2031, the design year used for the project.

[5] 2010 & 2011 GAP Analysis in Region of Durham Municipal Datacall
[6] WDO Datacall reports, calculated from the Tonnage Report and the Green Bin Program reports.
[7] Region of York Annual Waste Diversion Report

Table 3: Base Case - Estimated SSO Processing Capacity Required By 2031

Year	Single Family Household Projections	Single Family SSO (tonnes) at 150kg/hh/year	Single Family SSO (tonnes) at 200 kg/hh/year
2016	222,230	33,330	44,450
2021	252,100	37,820	50,420
2026	279,060	41,860	55,810
2031	302,160	45,320	60,430

The Region has processing contracts in place for less than 40,000 of SSO until 2016. Regardless of whether or not the Region chooses to move forward with an AD processing system, the Region will need to secure additional SSO processing capacity.

4.3 Estimated Quantities for Option 1

Option 1 involves collecting SSO, pet waste, diapers and sanitary products from single family households. The SSO (the existing list of materials in the Green Bin program) is processed at an aerobic composting facility. The pet waste, diapers and sanitary products are processed at an AD facility.

The amounts of SSO for this option are the same as for the Base Case, and range from 45,000 to 60,000 tonnes/year.

The amount of pet waste, diapers and sanitary products generated by single family households was estimated using waste audit data from Region of Durham. The detailed calculations and research are presented in Appendix A to this report. Table 4 summarizes the estimated amount of pet waste, diaper and sanitary waste generated and captured in a collection program. City of Toronto is the only program that measures capture rates for pet waste and diapers/sanitary products in its SSO program, reporting the capture rates of 87% for pet waste and 60% for diapers and sanitary products. These capture rates were used to develop the estimates for Region of Durham.

Table 4 : Option 1 - Estimated Quantities of Pet Waste, Diapers and Sanitary Products Captured For AD Options Under Consideration

Year	Single Family Household Projections	Pet waste 35.2 kg/hh/yr (tonnes)	Diapers & sanitary 32.2 kg/hh/yr (tonnes)	Total Generated (tonnes per year)	Pet waste 87% capture rate (tonnes)	Diapers & sanitary 60% capture rate (tonnes)	Total Captured (tonnes per year)
2016	222,225	7822	7156	14978	6805	4293	11,099
2021	252,103	8874	8118	16992	7720	4871	12,591
2026	279,060	9823	8986	18809	8546	5391	13,937
2031	302,156	10636	9729	20365	9253	5838	15,091

On the basis of the information presented in Table 4, a rounded value of 6,000 tonnes of diaper/sanitary products and 9,000 tonnes of pet waste was used for option development.

4.4 Estimated Quantities For Option 2

Option 2 involves replacing the current aerobic composting system completely and collecting SSO along with pet waste, diapers and sanitary products if deemed appropriate for addition to the Region's Green Bin program, from single family households and processing all of this material in an AD facility. The amounts of SSO have previously been identified (in the Base Case) as ranging from 45,000 to 60,000 tonnes per year, depending on future capture rates.

The amounts of pet waste, diapers and sanitary products were estimated at a rounded value of 6,000 tonnes of diaper/sanitary products and 9,000 tonnes of pet waste.

Table 5 presents the range of estimates. For planning purposes, this option should be designed to process a rounded range of 60,000 to 70,000 tonnes/year by 2031.

Table 5: Option 2 Quantity Estimates - SSO, Pet, Diaper and Sanitary Products From Single Family Households

Year	Single Family HH	Single Family SSO (tonnes) at 150kg/hh/ year	Single Family SSO (tonnes) at 200 kg/hh/year	Pet waste 87% capture rate (tonnes)	Diapers & sanitary 60% capture rate (tonnes)	Total pet waste, diapers and sanitary captured (tonnes per year)	Total Tonnes per year Lower Range	Total Tonnes per year Upper Range
2016	222,225	33,334	44,445	6,805	4,293	11,099	44,433	55,544
2021	252,103	37,815	50,421	7,720	4,871	12,591	50,406	63,012
2026	279,060	41,859	55,812	8,546	5,391	13,937	55,796	69,749
2031	302,156	45,323	60,431	9,253	5,838	15,091	60,414	75,522

4.5 Estimated Quantities For Option 3

In Option 3, SSO is collected separately from multi-residential buildings in the Region and is processed at an AD facility. Given the relatively small number of multi-residential units in Durham, even in 20 years, and the low capture rate per household typically experienced in multi-residential buildings, this option produces a relatively small amount of material. The amounts projected for this option were estimated based on experience from existing multi-residential SSO programs in the Greater Toronto Area (GTA) and other Ontario municipalities.

Some Ontario communities have conducted waste audits on multi-residential buildings with Green Bin programs in place, with the following results:

- The City of Hamilton conducted a waste audit in 2010 which reported that on average the units were generating approximately 153 kg/unit/year of material suitable for the SSO program and captured about 20%[8], which equates to about 31 kg/unit /year
- The City of Toronto reports that multi-residential buildings participating in their SSO program divert on average 1 – 1.5 kg/unit/week[9] or 52 – 78 kg/unit/yr.

[8] Personal communication with City of Hamilton waste management staff
[9] Personal communication with Renee Dello, City of Toronto

- Halton Region conducted waste audits in four multi-residential buildings in 2011. The goal of the audit was to determine the success of four multi-residential buildings currently piloting the Green Cart organics program. As reported by staff, the four selected buildings have “better than average” participation rates in waste diversion programs and are considered “keener” buildings. The four buildings averaged 112 kg/unit/year SSO diversion through the Green Bin Program. The highest achieving building was reported to divert almost 170 kg/unit/year with the other three buildings averaging 93 kg/unit/year SSO diversion[10]. The 93kg/unit/year is considered a reasonable highest limit of the program for planning purposes in Region of Durham.

Table 6 shows a high variation in the reported SSO diversion rates for multi-residential buildings with a low value of 32 kg/unit/year and the highest at 93 kg/unit/year.

Table 6: SSO Diversion Rates for Multi-Residential Programs

	Toronto Low kg/unit/yr	Toronto High kg/unit/yr	Hamilton kg/unit/yr	Halton Pilot Average kg/unit/yr (3 buildings)
Annual green bin diversion	52	78	32	93

For the purposes of this study, a mid-range estimate of 52-78 kg/unit/year from multi-residential SSO programs in Ontario municipalities with large numbers of multi-residential units was used to estimate multi-residential diversion tonnages for Region of Durham. This leads to a rounded value of 2,300 to 3,400 tonnes per year for planning purposes. This is consistent with the values presented in the Implementation Plan and Business Case of A 70% Waste Diversion Strategy prepared for Durham Region by Golder Associates Ltd.

Table 7: Option 3 Quantity Estimates - SSO Diversion Estimates for Durham Region's Multi-Residential Sector

Year	Multi Residential Units	Tonnes/year from Multi-Residential Households			
		32kg/hh/y	52kg/hh/y	78kg/hh/y	93kg/hh/y
2016	31,215	999	1,623	2,435	2,903
2021	35,052	1,122	1,823	2,734	3,260
2026	39,309	1,258	2,044	3,066	3,656
2031	43,678	1,398	2,271	3,407	4,062

4.6 Estimated Quantities For Option 4

The Region could consider combining the SSO diverted from multi-residential buildings (Option 3) with the pet waste, diapers and sanitary products collected from single family households (Option 1). This approach would require an AD facility capacity of 17,400 to 18,500 tonnes per year in 2031, as shown in Table 8.

[10] Personal communication Region of Halton staff.

Table 8: Option 4 Quantity Estimates - Multi-Residential SSO Combined with Pet Waste, Diapers and Sanitary Products From Single Family Households

Year	Tonnes per year of Pet Waste, Diapers and Sanitary Products from Single Family Households	Tonnes per year at low multi-residential SSO (52 kg/unit/year)	Total Required AD Facility Processing Capacity (Tonnes/year)	High Multi-Residential SSO diversion (78 kg/unit/yr)	Total Required AD Facility Capacity (tonnes/year)
2016	11,099	1,623	12,722	2,435	13,534
2021	12,591	1,823	14,414	2,734	15,325
2026	13,937	2,044	15,981	3,066	17,003
2031	15,091	2,271	17,362	3,407	18,498

4.7 Conclusion

There is sufficient SSO in the Region to consider AD if all SSO is processed in an AD facility. AD facilities reach economies of scale, and become cost competitive with enclosed composting facilities at capacities of greater than 50,000 tonnes/year. Option 2, with a required AD facility capacity of 60,000 to 70,000 tonnes/year is considered the only viable option of those considered that would be worth pursuing.

5. Potential Input Materials and Feedstocks to AD Facility

5.1 Introduction

Durham has sufficient SSO from the residential stream (if all residential sources are included) to justify further exploration of AD for SSO from its residential Green Bin program without the need for other material. However, a larger AD facility could reach better economies of scale and result in lower costs to the Region. This section presents quantities available for materials that could potentially be added to the Green Bin program, as well as materials from outside sources that could be considered as feedstock to the AD facility. The appropriateness of adding these materials to the AD facility and their impact on diversion is also explored in this section.

5.2 GAP Diversion Rate and Residue Rates

It is important to understand how the addition of new materials will impact on residue rates from the AD operation and also on the residential GAP Diversion rate reported by the WDO annually.

AD and aerobic composting facilities can divert only the biodegradable portion of the material they process. If the material is not biodegradable, it cannot be diverted through AD or aerobic composting as it cannot be broken down biologically. A more detailed description of this process is presented in Section 6.

Non-biodegradable material (such as plastic) ends up in the residue stream from composting and AD, which is removed from either the front end pre-processing stage, or at the back end, typically following the compost process and prior to compost use or sale. Residue is not part of the material diverted and is sent for disposal.

Residue rates play an important role in calculating residential waste diversion rates in Ontario as the calculation procedure (using GAP – Generally Applied Principles) only counts residential waste diversion net of residue – any residue generated during a process (such as composting or AD) must be subtracted from the total tonnage of materials collected and sent to processing in order to get a net diverted tonnage. Only this net diverted tonnage counts in calculating the Region's overall residential diversion rate (GAP rate) as reported annually by the WDO Municipal Datacall.

This issue is particularly important when considering adding pet waste, diapers and sanitary products to the Region of Durham's SSO program as much of the content of these materials is not biodegradable. Whereas the urine and fecal material in these products is biodegradable, pet waste also contains clay, which is not biodegradable but may end up as an inert material in compost. Diapers are predominantly plastic and silicone except for urine and fecal material, etc.

The Region may also consider accepting materials from outside sources, (such as deadstock, IC&I organic waste and biosolids). These materials will have no impact on the GAP calculation of diersion rate as GAP strictly applies to residential waste only.

5.3 Diapers and Sanitary Products

This section addresses the potential addition of diapers (including adult incontinence products) and sanitary products to the Green Bin program. Very limited data was available to draw on (described and referenced in this section) to develop the estimates presented in this section, as this topic has not been researched or measured in the level of detail required to provide accurate estimates. Processing of diapers using AD is not common practice. Currently the Dufferin Digester in the City of Toronto is the only facility in North America that accepts diapers. Research conducted for this study did not find any AD facilities in Europe that process diapers. ,

A comprehensive waste audit conducted in Durham Region in 2005 concluded that households generated 32.2 kg of diapers and sanitary products annually. Approximately 60% of this total would expect to be captured in the Green Bin program (should these items be added), based on waste audit results from City of Toronto, which accepts diapers and sanitary waste in its Green Bin program. This capture rate was applied to the generation rate to estimate what amount of diaper and sanitary waste that could realistically be collected through Durham's Green Bin program. As calculated from the data provided in Table 4, the Region could expect to collect 19.3kg/household/year of diapers and sanitary waste.

A key question is what amount of the 19.3kg/household/year collected would actually be diverted. The answer to this question depends on the amount of biodegradable material in diapers and sanitary products. Most non-biodegradable material will end up in residue (from pre-processing or post-processing) and will not be diverted.

The composition of disposable diapers has evolved over the years. Diapers in the 1990's consisted of high amounts of paper fibre used as an absorbent. These diapers were very compostable because of the high paper content. Some of the paper material in diapers has since been replaced by an inorganic super absorbent polymer (SAP) that cannot be broken down in the composting or AD process because it is an in-organic material which is not biodegradable.

Over time, the paper fibre component of incontinence and sanitary products has also decreased.[11] Waste audits typically report diapers and other sanitary products as one item. For the purpose of calculations in this report, the composition of incontinence products is assumed to be the same as the composition of diapers, as no research could be found to indicate that their composition was different.

Research reports indicate that a typical unused diaper contains 35% organic material by weight in the form of cellulose (fibrous) pulp. However, the composition changes significantly when the diaper is used. By weight, a used diaper has only 12% organic material in the form of fecal matter (5%) and cellulose (fibrous) pulp (7%). Urine is the heaviest portion of a used diaper, and it is absorbed by the SAP. Urine is made up of 95% water with 5% of trace chemicals including 9.5g/l of urea, which is a nitrogen based compound[12]. Most of the urine would likely end up in the liquid in the digester as long as it can be liberated from the SAP. The extent to which the urine portion of the diaper can be digested in the AD process is not known, but research on composting of diapers has determined that 88% of a diaper by weight must be removed as residue and disposed of.[13] Pre-treatment to remove residue from diapers and sanitary products is discussed in Section 7.

Based on the composition of diapers and sanitary products obtained from limited data on existing programs and limited available research, as little as an estimated 12% of the diaper and sanitary products contain biodegradable material, and can therefore be broken down in an AD facility. If 19.3kg/household/year is collected, and 12% of the collected material is diverted, then only 2.3kg/household/year of the collected material would actually be diverted. As calculated in section 4.3, a

[11] Sustainability Report: Baby diapers and incontinence products. 2007. Prepared by The Absorbent Hygiene Products Manufacturers Committee of EDANA

[12] http://chemistry.about.com/od/biochemistry/f/What-Is-The-Chemical-Composition-Of-Urine.htm

[13] Joan Colon et. Al. Possibilities of Composting Disposable Diapers with Municipal Solid Wastes. April 2010. Waste Management & Research

rounded value of 6,000 tonnes of diapers and sanitary waste is expected to be collected, but only 720 tonnes of that waste would be diverted, which represents a 0.2 per cent additional diversion.

5.4 Pet Waste

In Durham Region, residents are asked to dispose of pet waste as garbage. Pet waste typically refers to dog droppings and kitty litter combined.

The breakdown of pet waste between dog droppings and kitty litter is not known as no studies were identified through the study research that analyzed the break-down of pet waste at that level of detail. The only information that could be found was a qualitative observation from Toronto staff that about 70 per cent of the pet litter that is processed at the Dufferin anaerobic digester consists of kitty litter[14].

The potential quantity of pet waste that could be collected by adding pet waste to the Green Bin is presented in Table 4. The values were estimated using the following sources:

- A generation rate of 35.2 kg/household/year of pet waste was identified through a Durham waste audit;
- A Toronto waste audit measured 87% of pet waste captured in its Green Bin program.
- The 87% capture rate was applied to the 35.2kg/household/year generation rate to estimate what amount of pet waste could realistically be collected through Durham's Green Bin program.

The amount actually diverted would depend on the amount of the pet waste which would end up in the residue. The dog dropping steam is relatively pure with only the plastic bag as a contaminant. Niagara Region currently accepts this material in their Green Bin program, but asks residents to use a compostable bag to collect the droppings. Most of kitty litter is clay, which is inert and does not biodegrade. Depending on the system, it may be removed in the pre-processing stage as residue, but more likely it ends up in the finished compost. As calculated in section 4.3, the Region could expect to collect about 9,000 tonnes of pet waste, but only 2,700 tonnes of that waste would be diverted (assuming the kitty litter portion is removed as it is not biodegradable). This would represent a 0.7 per cent additional diversion.

5.5 Conclusion On Diversion of Pet Waste, Diapers and Sanitary Products

The Region could expect to collect 9,000 tonnes of pet waste and 6,000 tonnes of diaper and sanitary products waste as per Table 4 of Section 4.3. The amount of collected waste that is actually diverted depends on its biodegradability. While more of the pet litter is biodegradable compared with diapers and sanitary products, not all of the pet waste can be processed effectively into compost and/or biogas end product since much of it consists of kitty litter (by weight) which is made up of a range of biodegradable and non-biodegradable materials such as clay which may or may not be diverted.

Table 9 shows the diversion potential of including pet waste and/or diapers and sanitary products in the Region's SSO program, assuming that only the biodegradable portion of these items is diverted, and basing calculations on a total residential generation of about 382,366 tonnes in 2031:

- Adding pet waste would divert an additional 0.7% of the residential waste stream and
- Adding diapers and sanitary waste would add 0.2% to diversion of the residential waste stream.

[14] Personal communication with Brian Van Opstal, City of Toronto

Table 9: Estimated Diversion Achieved from Diversion of Pet Waste and Diaper/Sanitary Waste

Option and Capacity	Total Available (Tonnes)	Total Biodegradable (Tonnes)	% Diversion (based on 2031 Residential Waste Generation of 358,000 tonnes/year)[15]
Pet Waste	9,000	2,700	0.7%
Diaper and Sanitary Waste	6,000	720	0.2%
Total	15,000	3,420	0.9%

It is not recommended that the Region pursue the collection of diapers and sanitary waste as much of the material is not biodegradable. A larger proportion of pet waste is biodegradable, so the Region could explore the addition of pet waste for future organics processing contracts, regardless of whether or not AD technology is chosen. The Region may consider excluding kitty litter from the collection of pet wastes, as this is the portion of pet waste that is not biodegrable. Should the Region wish to pursue adding pet waste to the Green Bin, field testing on likely diversion is recommended.

5.6 Management of Deadstock From Region of Durham

This section explores the suitability of processing deadstock at an AD facility should the Region require additional tonnage to meet economies of scale. The section also identifies whether or not there is a need within the agricultural community for this service.

Discussions with the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) staff in Guelph, Ontario confirm that relatively small amounts of deadstock are produced in the Region of Durham. Estimates of annual deadstock production in the Province of Ontario are about 33,800 tonnes in total. Of this amount about 55% is collected and 45% is managed on-farm[16]. Pro-rating these amounts to Durham based on population (about 4.2% of the Provincial total), the total amount of deadstock produced in Durham is likely to be in the order of 730 tonnes of collected deadstock and 600 tonnes of deadstock managed on-farm[17].

Deadstock that cannot be managed on-farm is typically sent to rendering plants, such as Rothsay Concentrates (Maple Leaf Foods) in Listowel or Sanimax in Quebec. Deadstock in Durham Region is collected by one service provider based out of Lindsay, Ontario. These collection and processing options are deemed sufficient to manage the demand from the agricultural community in Durham Region and therefore there is not currently a need for additional processing capacity to serve the needs of the agricultural community in Durham.

Should additional processing capacity for deadstock be required, it is unlikely that AD would be chosen to process this material. Deadstock is categorized as either ruminants (cattle, sheep, goats, horses) or other (pigs and chickens). After the BSE (Bovine Spongiform Encephalopathy or Mad Cow Disease) crisis several years ago, very strict temperature related requirements were imposed on the management of ruminant deadstock to control and eliminate BSE from the Canadian food chain. Ruminants may contain specified risk material (SRM), which are animal tissues where BSE may concentrate. SRM must be handled in accordance with strict procedures set out by the federal legislation and monitored by the

[15] based on 2010 GAP total residential waste of 229,629 tonnes, households increasing by 50% by 2031 and assuming waste generation will be approximately 358,000 tonnes in 203

[16] Personal communication Kevin Joynes, Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) June, 2012

[17] Kelleher Environmental estimate based on discussions with OMAFRA staff

Canadian Food Inspection Agency (CFIA). All deadstock in Ontario must be processed by facilities approved by Reg 105/09 under the Food Safety and Quality Act, 2001.

Deadstock with SRM needs to be processed through thermal hydrolysis at 800 degrees Celsius to meet the regulations and ensure that BSE is destroyed. The highest temperatures reached in AD or composting are less than 100 degrees Celsius, therefore neither technology is suitable for handling deadstock from ruminants. A thermal hydrolysis unit could be added to an AD facility; however, this would result in a large capital cost for a relatively small amount of material. In addition, deadstock may also require additional grinding equipment and therefore increased cost to be processed through AD technology.

There is also a risk that if the digestate material is to be composted following processing, the material may not meet the compost quality guidelines for unrestricted use, which would decrease its value.

Additionally, the inclusion of deadstock as a feedstock material in a Durham owned facility would not help the Region in attaining it's 70% diversion goal. Deadstock is not included as part of the GAP diversion calculation.

Given that a need for processing capacity for deadstock was not identified, the addition of deadstock will not increase the Regions waste diversion rate, and the additional regulatory approvals, equipment and costs that would be required to manage the deadstock, it is not considered a suitable feedstock for the AD facility.

5.7 SSO From Industrial, Commercial and Institutional (IC&I) Facilities and Regional Agencies, Boards, Commissions and Departments (ABC&D's)

Waste composition studies carried out for a number of communities by Kelleher Environmental have indicated that about 28% of IC&I waste is food waste[18]. This indicates that up to an estimated 65,000 tonnes/year of IC&I food waste is generated by businesses and institutions in Durham[19]. Most of this food waste is from dispersed sources like restaurants, hotels, hospitals and food processing facilities throughout the region. The tonnage from IC&I and ABC&D's accepted at a Durham owned AD facility would not help the Region in reaching their 70% diversion goals. Under the GAP rules for calculating diversion, IC&I and ABC&D tonnage is not considered, as GAP only includes residential waste.

SSO from the IC&I and ABC & D's waste stream is amenable to processing in an AD facility. Some materials produced by the IC&I sector , such as FOG – fats, oils and greases and food or beverage processing, are an advantage to the AD process in that they can increase energy production. However, accepting IC&I materials adds to the complexity of operation of the AD facility. Additional challenges include:

- getting the generators to separate the food waste from the residual waste
- collecting the separated food waste in a cost effective way
- securing IC&I food waste as a feedstock
- providing a cost advantage over disposal for IC&I and ABC&D generators

At this point in time, it is not considered feasible for Durham Region to pursue food waste feedstock originating from the IC&I and ABC&D sectors. It is recommended that if the Region decides to proceed with an AD facility, it should be designed to meet the need for residential SSO, but include provisions in

[18] City of Ottawa IC&I Waste Diversion Strategy (2007); City of Calgary ICI Waste Diversion Study (2010)
[19] 28% of 6 million tonnes of non-residential waste disposed in Ontario (Statistics Canada 2010),pro-rated by Durham population as a % of Ontario.

the approval to accept SSO from IC&I and ABC&D sources should capacity be available. This may be of benefit during the early years of operation when the design capacity of the facility has not yet been matched by available tonnage.

5.8 Biosolids From Regional Water Pollution Control Facilities

Biosolids are a by-product from the treatment of wastewater from sanitary sewers and are produced at nine water pollution control facilities in the Region.

The volumes of biosolids managed by Durham Region annually are summarized in Appendix B. As the tables show, most biosolids are first digested at the local water pollution control plant (WPCP) and are then incinerated at Duffin Creek, which also has its own AD facility. Some biosolids are processed in local AD facilities, with landspreading of the digested biosolids.

Given that biosolids are already managed sufficiently by existing AD facilities at each facility (and aerobic digestion at small facilities), there is not currently a need for processing capacity of biosolids in an AD facility designed to process SSO.

Locations with facilities which handle biosolids offer promising AD facility siting partnership opportunities as some of the material handling equipment (gas storage, wastewater treatment, etc) could be shared thus reducing the cost of the AD facility.

Under the new Compost Guideline, the Region's current Green Bin program produces Category AA compost that can be used without restrictions or approvals. If the Region introduces biosolids to the AD process and then chooses to aerobically compost the digestate to produce compost, the Region could not produce Category AA compost. With a maximum of 25 per cent total feedstock being biosolids, the Region could produce Category A compost, which includes specific labeling requirements, including maximum application rates. Biosolids also do not contribute to diversion.

Since there is not currently a need for processing capacity of biosolids, biosolids do not count towards diversion and the introduction of biosolids could limit the end use of the digestate, it is not recommended that the Region accept biosolids at a potential AD facility. It is however recommended that should the Region build an AD facility, they consider siting the location near a WPCP to take advantage of similar material handling equipment. Siting considerations are discussed more fully in section 12.

5.9 Summary and Conclusions Regarding Adding New Materials

The following conclusions were drawn regarding addition of new materials to the AD facility:

- Addition diapers and sanitary products to the Green Bin would result in a low additional diversion rate (about 0.2%) because of the limited biodegradability of these materials. It is not recommended to include these items as part of the Region's SSO program.
- Pet waste may be considered for inclusion in the SSO program; however, the Region may choose to exclude the kitty litter portion as is not biodegradable depending on the vendors processing limitations. Should the Region wish to pursue diversion of these materials, additional composition and biodegradability tests and research should be carried out to firm up estimates of diversion potential;
- Management of deadstock is already well serviced in the Region of Durham therefore there is no immediate need to consider this source for the AD facility;

- AD is not a suitable technology for the management of deadstock which requires high temperature technologies, deadstock would not contribute to the Region's diversion goals and there is no immediate need within Durham Region for deadstock processing capacity;
- Biosolids are not recommended for inclusion because they are already managed at a number of AD facilities at wastewater treatment facilities, biosolids would not contribute to the Region's diversion goals and biosolids could limit the end use of the digestate;
- There is a significant amount of food waste generated by the IC&I sector in the Region; however, this material would not contribute to the Region's diversion goals and could result in additional costs for source separation and collection.

6. Introduction To The AD Process

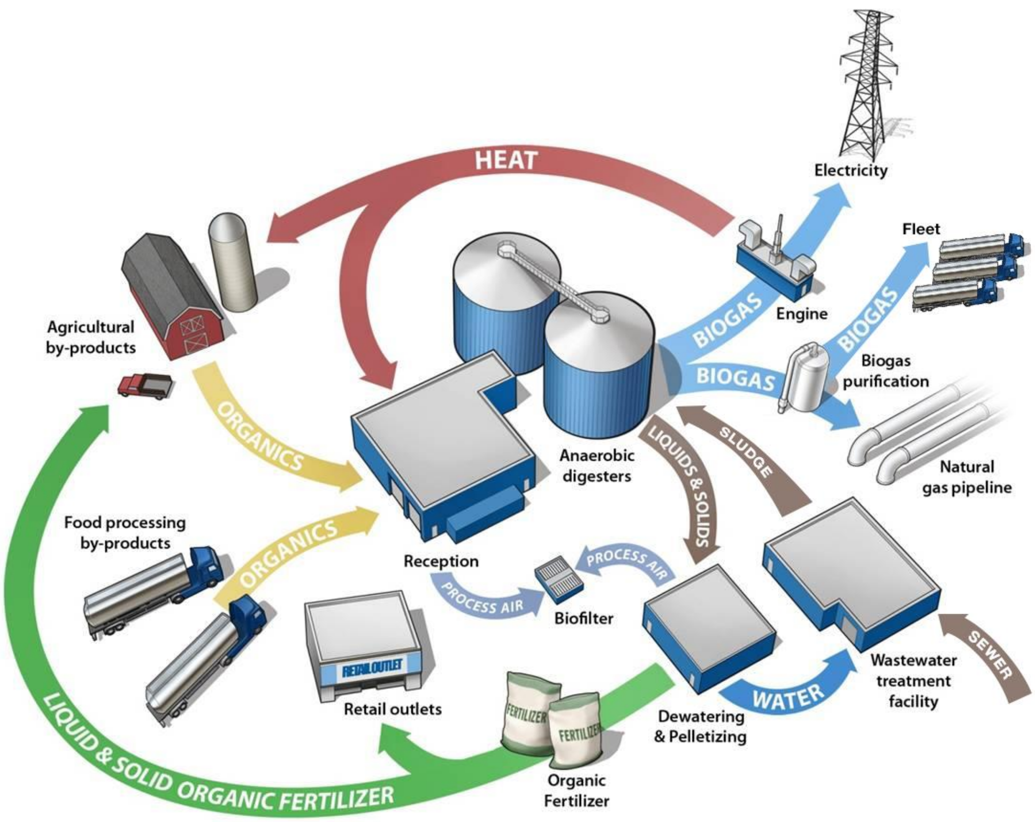
6.1 Introduction

Section 4 identified the capacity estimates that would be directed to AD processing in the four options evaluated in this study. This section describes the AD process and where it has been used or is under consideration/construction in Canada and the US.

6.2 Description Of The AD Process

AD, a biochemical conversion technology, is a naturally occurring biological process that uses microbes (bacteria and other micro-organisms) to break down organic material in the absence of oxygen. The digestion of SSO takes place in a special reactor, or enclosed chamber, where critical environmental conditions such as moisture content, temperature and pH levels can be controlled to maximize biogas generation and SSO decomposition rates.

Figure 1: Simple Schematic of AD Process[20]



[20] http://www.biogas-info.co.uk/index.php/ad-basics.html

AD produces biogas, which consists of mostly methane (which is renewable natural gas, typically ranging from 55% to 70%, depending on the process) and carbon dioxide (CO_2). One benefit of AD is that it is a net generator of energy. The energy which is not required for in-plant operations can be sold off-site in the form of heat, steam, electricity, natural gas or vehicle fuel. Figure 1 presents a simple schematic of the AD process.

6.3 AD of SSO in Canada

The use of AD technology to treat municipal SSO has been slow to penetrate the North American market, mostly because of high costs compared to aerobic composting. The North American market currently has only one commercially operating AD facility that processes municipal SSO, located at the City of Toronto Dufferin Transfer Station (the Dufferin Digester). A second City of Toronto AD facility is being commissioned and will be in full operation in 2013.

Municipal and private sector AD developments which process municipal SSO in Canada include:

- The City of Toronto Dufferin Digester uses BTA wet technology and has a throughput capacity of 25,000 tons/year of SSO from the Toronto Green Bin program. The facility will be expanded to a capacity of 55,000 tonnes per year in 2016 (two years after the Disco AD facility has been operational);
- The City of Toronto is constructing a second AD facility at its Disco Transfer Station with a capacity of 75,000 tonnes/year. The facility will be in operation in January 2014 and is being commissioned in 2013;
- Fraser Richmond Soil and Fibre opened an AD facility for commercial SSO in lower mainland British Columbia in September, 2013;
- The City of Surrey, British Columbia has announced a clean energy demonstration project featuring an AD facility to be operational by 2015. The RFP for the facility was released in 2013. The biogas from the facility will be used to fuel the collection truck fleet which uses natural gas with the new collection contract in 2013.
- Harvest Power opened an AD facility in London, Ontario in fall, 2013;
- Bio-en Power Inc will open an AD facility with a capacity of 70,000 tonnes/year in Elmira, Ontario in January, 2014. The facility will produce 2.85MW of electricity and received a FIT contract from the Ontario Power Authority. The facility is approved to accept residential Green Bin materials;
- The Province of Quebec has announced a landfill ban on organics by 2020 with support for a "bio-methanization" (or AD) program to convert SSO to vehicle fuel and de-carbonize municipal fleets. Montréal's *Municipal Waste Management Master Plan* has announced the planned construction of two AD centres, two aerobic composting centres and a pilot centre for the pre-treatment of organic waste[21]. In total, 12 AD facilities are in the planning states in Quebec.

Table 10 summarizes key municipal AD developments in Canada at this time.

[21] Over the next five years, more than 500,000 housing units will be targeted, enabling the treatment of 230,000 tons of organic matter.

Table 10: Status of Municipal and Private Sector AD Facility Development For Processing of Municipal SSO in Canada, 2012

Community	Status	Capacity	Expected Year of Completion
City of Toronto, ON	Increasing Dufferin AD facility capacity and building a new AD facility at Disco Transfer station Using BTA technology	Dufferin facility - 55,000 t/y Disco facility - 75,000 t/y process food waste, pet waste, sanitary waste, non recyclable paper (with a capacity of up to 90,000t/y)	Dufferin - second digester and secondary containment structure for two digesters under construction Disco - 2013
Fraser Richmond Soil and Fibre (owned by Harvest Power), BC (private sector initiative)	Funding received for an AD facility using High Solid AD Technology (Harvest Power)	27,000 t/y process food waste and yard waste 1 MW high-solids digester	Opened fall, 2013
City of Surrey, BC	Early stages – working towards sending out a tender and selecting a vendor	Tender for vendor fall 2013. Biogas will be used to fuel truck fleet which converted to natural gas with new collection contract	2014
Earth Renew, Delta, BC	Starting construction fall 2012	60,000 t/y Process commercial and restaurant food waste	2013
Harvest Energy Garden, London, ON (private sector initiative)		70,000 t/y Process food manufacturing and farm waste	Opened fall, 2013
Bio-En Power Inc	Construction complete. Commissioning underway	70,000t/y of organics. Approved to take Green Bin materials	Opening January 2014
Montreal	Under discussion	Two AD facilities, each 60,000t/year	Construction prior to provincial landfill ban in 2020
Quebec City, PQ	Under discussion	One AD facility, 85,000 t/year	Construction prior to provincial landfill ban in 2020
Province of Quebec	In planning stages	9 digesters in communities across Quebec, including Riviere Du Loup, St. Hyacinthe and others.	Construction prior to provincial landfill ban in 2020

6.4 AD of SSO in the United States

In the United States, processing SSO using AD experienced a flurry of activity in the early 1980s. Several pilot projects were conducted in Pompano Beach, Florida; Walt Disney World, Florida; and University of Berkley, California[22] In all three cases the SSO was co-digested with wastewater biosolids. Between 2004 and 2007 a number of large communities in the United States pursued AD. These communities entered into agreements to process SSO using AD, or entered into negotiations with AD suppliers or had undertaken feasibility studies examining AD among a range of other “Conversion” technologies. The status of these efforts is summarized in Table 11. The table illustrates the slow progress or lack of success for most of these efforts.

[22] SRI International. October 1992. Data Summary of Municipal Solid Waste Management Alternatives; Volume 1: Report Text. Prepared for National Renewable Energy Laboratory, Colorado.

Table 11: Status of AD Projects in US Communities Which Investigated AD In The mid 2000's

Community	Mid 2000 status	2012 status
City of Los Angeles, California	In 2007 entered into agreement with CR&R and Arrow Ecology, United States to construct an AD plant to process 150 tpd (55,000 tonnes/year) of green waste	Los Angeles announced in March 2012 that the agreement had been cancelled due to difficulties experienced in Australia with the Arrow Ecology AD technology
City of Lancaster, California	Were in negotiations with BioConverter to construct an AD plant to process 200 tonnes/day (52,000tonnes/year) of green waste in spring, 2012. The project did not proceed	In February 2012, the City entered into an agreement with Organic Energy Corporation/Ecolution to develop a recycling and AD facility
City of Seattle, Washington	Evaluated 26 food waste AD technologies to determine the feasibility of implementing a facility capable of processing up to 50,000 tonnes/year of food waste	Release of food waste processing RFP in March 2012. Entered into an agreement with PacifiClean Environmental to process SSO at an AD facility to be constructed and operational in 2014
Santa Barbara County, California	AD was one of a number of conversion technologies evaluated to process municipal solid waste	Negotiations underway for a consortium of companies to construct a facility for operation in 2016

Since this time, a number of new commercial scale AD projects have been initiated in the United States, again in some stage of agreement, planning or study. None are actually constructed as this writing (April, 2013). See Table 12 for details.

Table 12: Anaerobic Digestion Projects in the United States Targeting SSO

United States	Proponent	Target Operational Date
City of Columbia, SC	W2E Organic Power using Biogas GW (Germany)	2013
City of San Jose, CA	Zero Waste Energy using Kompoferm (Germany)	2014
City of Portland, OR	Columbia Biogas using Farmatic (Germany)	2013

6.5 AD of SSO in Europe

Europe is generally considered to be the international leader in AD technology for processing of SSO. Virtually all examples of AD facilities treating residential SSO are located in Europe, primarily in northern European countries such as Denmark, Belgium, France, Germany and Switzerland. There were an estimated 200 AD facilities operating in European countries in 2010[23] as shown in Table 13.

[23] Luc De Baere & Bruno Mattheeuws. February 2010. Anaerobic Digestion of MSW in Europe. Biocycle, Vol. 51 p.24

Table 13: Installed Capacity Of AD Facilities Processing SSO And Municipal Solid Waste in 2010[24]

Country	Total AD capacity (tonnes/year)	Average AD Facility Capacity (tonnes/year)	Number of AD Facilities By Country
AT (Austria)	84,500	12,071	7
BE (Belgium)	173,700	34,740	5
DE (Germany)	1,732,805	23,104	75
DK (Denmark)	31,000	40,500	1
ES (Spain)	1,495,000	59,563	25
FI (Finland)	15,000	15,000	1
FR (France)	862,000	66,308	13
IT (Italy)	397,500	36,136	11
LU (Luxemburg)	23,000	11,500	2
MT (Malta)	45,000	45,000	1
NL (Netherlands)	476,500	59,563	8
PL (Poland)	52,000	13,000	4
PT (Portugal)	85,000	21,250	4
SE (Sweden)	40,000	10,000	4
UK (United Kingdom)	202,500	40,500	5
Total	5,715,505		166

Germany is considered the leader in promoting and adopting AD technology as a renewable energy source. In 2010 AD facilities in Germany (many of which are farm digesters) produced 2,700 MW of electricity which provided power for approximately 4.3 million households. Biogas from AD facilities is reported to produce more electricity in Germany than solar and wind power combined[25].

Various policies in the EU have encouraged the development of AD at a faster rate than in Canada and the US, including feed in tariffs, landfill taxes/surcharges and regulations prohibiting unprocessed organic waste to be disposed in landfills.

AD is also being driven by landfill taxes and other policies in the United Kingdom but at a slower rate. Currently, there are 44 commercial scale AD facilities in the UK that process food waste from commercial/industrial and municipal sources with a processing capacity of around 3.7 million tonnes per year[26].

6.6 AD Feedstock Characteristics

Materials sent to AD are typically classified as low solid (or liquid waste), medium solids (or wet waste) and high solid (or dry waste). Examples of each are shown in Table 14.

[24] Source: Joint Research Centre, European Commission. October 11, 2011. Technical Report for End of Waste Criteria on biodegradable waste subject to biological treatment.

[25] Jennifer Green, Agrienergy Producers' Assocaition of Ontario. 2012. Ontario Biogas Outlook. Presented at the Canadian Farm and Food Biogas Conference and Meredith Sorensen, Harvest Power. January 31, 2012. Integrating Anaerobic Digestion Into Our Culture Part 2: Reality and the Future. In Renewable Energy World

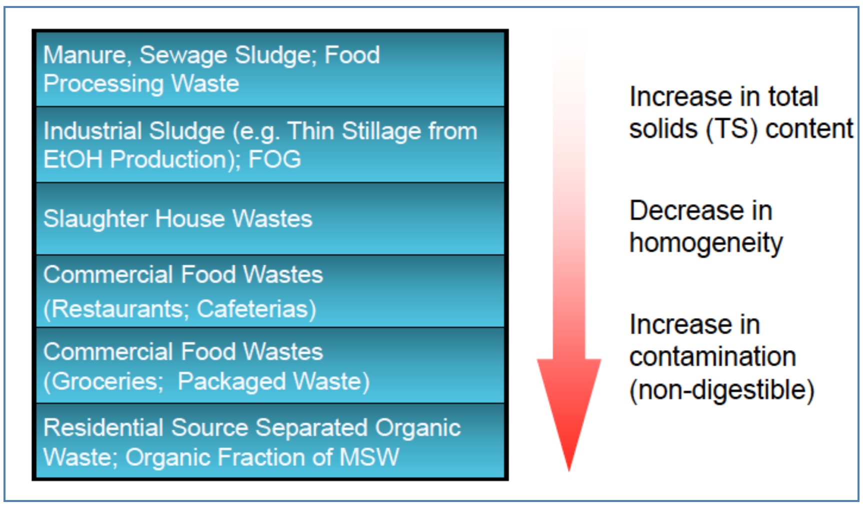
[26] AD infrastructure in the UK: September 2011 WRAP

Table 14: Total Solids Content Characteristics of Input Materials To AD Facilities[27]

Low Solids or Liquid Wastes	Medium Solids and Wet Wastes	High Solids or Dry Wastes
Spent Beverages	Food residuals	Slaughterhouse waste
Spent stillage from breweries	Fats, oils, grease (FOG)	SSO
Whey and cheese wastes	Biosolids	Leaf and yard waste (LYW)
Municipal wastewater	Dairy manure	Paper, cardboard, packaging
Commercial wastewater	Food processing waste	Food processing wastes
Industrial sludges	Used restaurant cooking oil	Agricultural residues

Figure 2 illustrates that as the total solids content increases (moving from low solid to high solid), the uniformity of the feedstock is reduced.

Figure 2: Properties of Input Materials For AD Facilities[28]



6.7 Outputs from the AD Process

AD converts SSO into three main products:

- digestate
- wastewater
- biogas

Digestate can either be directly land applied to add nutrients and carbon to soil structure, or it can be aerobically composted to produce finished compost which can be sold to landscaping and soil blending markets.

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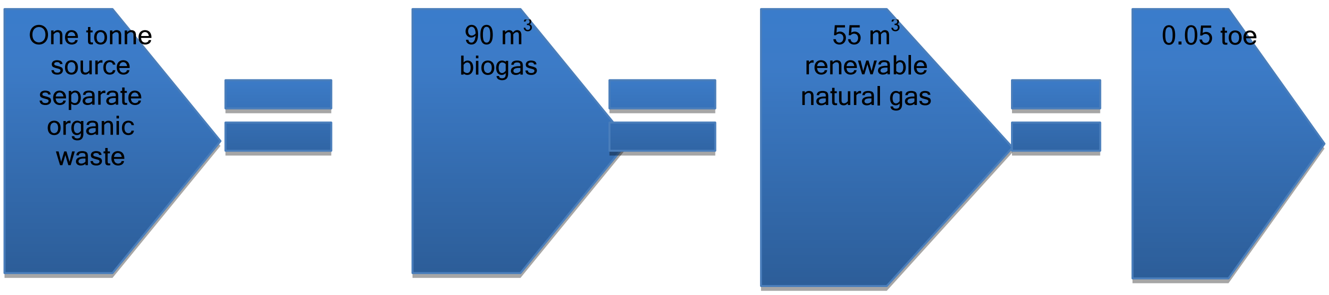
[27] Organic Recycling for Renewable Energy Generation. No date. Presented by Brian Duff at the BIA Workshop on Biomass Opportunities and Challenges in Indian Country

[28] Anaerobic Digestion of Solid Waste Technologies and Case Studies. Presentation by AECOM at the WIRMC - Green Bay, February 23-25 2011

The amount of wastewater generated by the AD process depends on the type of process employed and the vendor of the AD technology. Dry AD technology produces very little wastewater because the liquid produced from the dry AD process is re-circulated for process needs and to provide valuable inoculation. Wet AD technology relies on hydro-pulping at the beginning of the process which uses higher amounts of water and, therefore, creates higher amounts of wastewater. Wastewater treatment requirements depend on whether the wastewater is being discharged to a sewer or an open water body. Newer wet AD facilities have installed their own wastewater treatment plants on-site to ensure that any discharge is able to meet the sewer use by-laws before being released.

Biogas is primarily composed of methane (CH_4) generally ranging from 55-70% depending on the feedstock, carbon dioxide (CO_2) with small amounts of hydrogen sulfide (H_2S) and ammonia (NH_3) as well as trace amounts of hydrogen (H_2), nitrogen (N_2) oxygen (O_2) dust and siloxane. Typically, digester gas (biogas) is saturated with moisture.

The production of biogas through AD varies with the feedstock composition and the AD technology chosen. Published biogas production values vary. A recent European study states that one tonne of SSO typically produces about 90m³ of biogas (equivalent to 55 m³ of Renewable Natural Gas), and 0.05 tonne oil equivalent (toe)[29] .



About 30-40% of the biogas produced at an AD facility is used internally to operate the AD facility. Options for using the remaining biogas produced by AD include:

- Burn directly to generate heat or steam;
- Burn to generate electricity;
- Burn in a co-generation facility to generate both electric power and heat, using reciprocating engines, micro-turbines, gas turbines and fuel cells;
- Process the biogas and convert it to CNG (compressed natural gas) for use as a vehicle fuel or LNG (liquid natural gas) or
- Clean the biogas to natural gas quality to create renewable natural gas (RNG) and inject into the natural gas distribution system.

The level of pre-treatment and upgrading of biogas required depends on the end use chosen for the biogas. As the biogas is directed to more sophisticated end uses, and therefore more stringent upgrading requirements, more treatment is needed and the cost of biogas upgrading increases.

In the past, biogas was typically burned on-site for heat and sometimes heat and electricity generation in co-generation facilities. In the last few years, conversion of biogas to RNG (renewable natural gas) for use has a vehicle fuel (either compressed natural gas (CNG) or liquefied natural gas (LNG)) has become more popular for a number of reasons. Increased municipal interest in closed loop sustainability has led some municipalities to use the resulting bio-methane or bio-fuel in their waste collection truck fleet and transit bus fleets.

[29] 2011 Annual Statistical Report on the Contribution of Biomass to the Energy System in the EU27. June 2011. European Biomass Association (AEBIOM) pg 11

The primary constituent of natural gas is methane. In the last few years, utilities have become interested in upgrading biogas (by separating the CO_2 and trace components) to produce high-quality Renewable Natural Gas (RNG) for injection into natural gas pipelines or other uses. Whereas the upgrading requirements for this application are stringent and expensive, utilities need to work with biogas suppliers to meet their green energy targets, renewable portfolio standards and their carbon-neutral fuel goals. Should Durham proceed with the AD project, and the AD facility is located adjacent to the natural gas distribution pipeline system, there may be an opportunity for a partnership to use the biogas in the natural gas system. This option is dependent on the location of the AD facility and the interest of the local utility in green and renewable sources of natural gas.

The Region may have a partnership opportunity to use the biogas in the natural gas system. This option is dependent on the location of the AD facility and the interest of the local utility in green and renewable sources of natural gas.

Durham could initiate discussions with their current contractors and fleet managers to assess the level of interest in fuelling trucks with renewable natural gas produced from biogas. The City of Surrey in British Columbia has recently awarded a ten year collection contract which required natural gas powered vehicles.

7. Pre-Treatment of AD Feedstock

7.1 Introduction

The objective of pre-treatment technologies is to make the SSO suitable for digestion and to remove any materials that might hamper digestion. Pre-treatment accomplishes three objectives:

- removing contaminants, such as plastic bags, metals, and stones;
- reducing the size of the feedstock to make AD more effective and
- blending and preparing the feedstock prior to entering the AD process.

The type and level of pre-treatment required at the beginning of the process depends on the type of feedstock to be processed. Material that contains fewer contaminants requires less pre-treatment, which typically lowers the overall cost of the system.

As the level of contamination increases, so does the complexity of the pre-treatment step. Contaminants found in residential SSO may include stones, sand, grit, bones, shells, glass fragments, metal fragments, etc. A clean stream does not require as much pretreatment and is more compatible with a dry AD system, whereas a wet system is often utilized with a more contaminated feedstock as there are better wet pretreatment options available to capture contaminants such as plastics (associated with some pet waste and diapers).

This section describes the technologies that would be used to pre-treat SSO, pet waste, diaper and sanitary waste before they are sent to the AD unit for digestion.

7.2 Pre-Treatment of SSO (Current Durham List of Materials)

The material collected in Durham's Green Bin program is a suitable feedstock for processing at an AD facility, but some pre-treatment is required to reduce the size of the material and remove contaminants (e.g. metals, stones, plastics Pre-treatment for contaminant removal with the current list of materials collected in Durham Region would require a relatively simple front end pre-treatment system, as the program does not intentionally accept materials, such as plastic bags, that must be removed prior to processing. Figure 3 illustrates what the SSO material entering the AD system would look like. Pre-treatment may involve the use of a sieve, Trommel screen, chopper, magnet and/or other device to remove contaminants.

Figure 3: SSO Material with Current List of Acceptable

Case Study - University of Wisconsin in Oshkosh, Wisconsin:

The University of Wisconsin in Oshkosh, Wisconsin has installed a dry AD facility at its campus which has been processing pre-consumer food waste, agricultural animal bedding and city yard waste since fall 2011. Figure 3 shows the incoming feedstock, which contains no plastic or other contaminants. The facility processes approximately 8,000 tons (7,300 tonnes) annually. The dry AD technology uses a batch system in which the organic waste is stacked in one of two chambers, with a retention time of 28 days.

Figure 4: Feedstock To AD Facility in Oshkosh, Wisconsin[30]

7.3 Pre-Treatment Requirements For SSO Including Pet Waste, Diapers and Sanitary Products

Figure 5: Green Bin Materials With Plastics, Pet Waste, Diapers and Sanitary Products

SSO programs that accept diapers and sanitary products and permit the use of plastic liner bags require more extensive pre-treatment to remove the plastic contaminants before AD processing. Figure 5 shows an SSO stream containing plastic bags.

German BTA wet AD technology is the only AD technology currently operating in Ontario that processes municipal organic waste. The feedstock material, which includes pet waste, diapers and sanitary waste, and plastic bags is first sent to a hydropulper tank where water is added to the mixture to create a slurry. The slurry is then mixed using an agitator (similar to an old fashioned top loading washing machine). The mixing helps to separate the plastic (e.g. plastic bags, light plastic pieces, other light pieces, diapers) from the SSO. The plastic rises to the top of the slurry and is skimmed off, while the heavy materials (glass, metal, rocks) fall to the bottom of the tank and are removed. The slurry is then transferred to a hydro-cyclone, which removes the small grit, sand, stones, before the slurry enters the AD process.

Some pre-processing technologies associated with AD may be used to remove the non-digestable portion of a diaper. Currently the Dufferin Digester in the City of Toronto is the only facility that accepts diapers. Communications with staff managing the processing operations at the Toronto Dufferin AD facility indicate that typical light fractions that float off the top of the hydro pulping process (mostly plastic) include diapers.[31] As discussed in Section 5.3, a very minimal amount of the biodegradable part of the diaper (e.g. the feces and some pulp fibre) actually becomes part of the mixture that is digested. Most of the diaper along with other light factions (floating materials such as plastic bags, polystyrene, etc) are skimmed off the top of the hydro-pulper pre-treatment unit and are treated as a residual waste, requiring disposal.

[30] Dry Fermentation Anaerobic Digestion: UW-Oshkosh. June 20, 2012 Anaerobic Digestion for Organic Wastes, Albany, New York
[31] Communications with Derek Sawyer, Processing Operations, City of Toronto, July 3, 2012

7.4 Pre-Treatment Options for Wet versus Dry AD Technology

Traditionally (although the market is constantly changing) not all AD vendors handled feedstocks highly contaminated with plastic. In the past, it was generally believed that dry AD technologies were more suited to processing feedstocks with minimal contamination, such as the material collected in Durham Region's Green Bins and wet systems include pre-treatment steps which can remove a higher level of contaminants, particularly plastics (such as plastic bags, and other plastic components of the waste) before the AD facility. However, the range of pre-treatment systems and AD technologies now available on the market makes this generalization less accurate as some vendors may allow some contaminants to go through the AD processing step and remove the contaminants later in the process.

AD vendors now provide a wide range of pre-treatment systems which allow both dry and wet AD systems to process a wide range of feedstocks. Vendors will propose different pre-treatment approaches that best meet their own AD technology needs for processing the materials the Region requires to be processed.

7.5 Summary and Conclusions

The requirements for pre-treatment processes and technologies will depend on the list of materials sent to the AD facility and also the AD facility design approach chosen (specifically wet vs dry) discussed in Section 8. AD vendors typically put a whole package together for a client when they establish client needs. The package will include the pre-treatment technologies which best suit the AD design and the feedstock. It is premature at this stage of the process to prescribe what the pre-treatment elements should be.

8. AD Process Design Elements And AD Technology Vendors

8.1 Introduction

There are many permutations and combinations of AD system designs. AD systems can be classified according to whether they are:

- Wet or dry;
- Single or two stage;
- Mesophilic (25-45°C) or thermophilic (50-60°C); and
- Continuous flow, plug flow or batch.

This section describes the different design approaches used. The advantages and disadvantages of each AD approach with respect to the processing the materials under consideration by the Region and the range of proposed facility capacities are also described below.

8.2 Wet And Dry AD System Designs

A wet or dry AD facility design refers to the moisture content inside the digester. A dry AD system has minimal moisture content, and is often referred to as a high solid system (over 15% dry matter in the digester). A wet AD facility design has a high moisture content, and is often referred to as a low solid system (5%-15% dry matter in the digester).

Wet AD System Description

A "wet" AD system is designed to process a dilute organic slurry with 5% -15% total solids (85% to 95% moisture content). The slurry fed to the digesters has the consistency of soup. This wet slurry is created by adding approximately 1m^3 of water to each tonne of incoming SSO and other organic materials[32]. The wet AD system is useful for creating a consistency which allows pre-treatment systems to remove large amounts of plastic from incoming material. Based on the water requirements, a small AD system processing 16,000-20,000 tonnes of feedstock annually would need an estimated 16,000 to 20,000 m^3 (16 to 20 million litres) of water for the process annually and a larger AD system processing 60,000 to 70,000 tonnes of feedstock annually would need 60,000 to 70,000 m^3 (60 to 70 million litres) of water for the process annually.

The City of Toronto chose a wet (BTA - German) system design for the Dufferin Digester, as this AD system design provided the flexibility to permit plastic bags, pet waste, diapers and sanitary products to be added to Toronto's Green Bin program. The pre-treatment system includes a hydro-pulper which allows plastic to float to the top of the water tank with other light material and to be removed ahead of the AD tank. City of Toronto staff travelled to Germany to observe successful removal of plastic in BTA facilities in Germany prior to choosing the design for Toronto. The new Disco Digester uses the same design.

[32] The Dufferin facility is managing to reduce the amount of water added from 1m3/tonne (originally) to more like 0.5 m^3/tonne.

Dry AD System Description

Dry AD systems use considerably less water than wet AD systems; they mix approximately 0.3m^3 of water to each tonne of incoming material (10 cu ft of water per ton) to produce an organic slurry of 20-45% total solids content (55 % to 80% moisture content). Because of the requirement to heat smaller amounts of water, and for less dewatering after digestion, dry AD system designs have lower energy requirements for in-plant needs than wet AD system designs. This in turn leads to more energy available to sell outside of the AD facility.

Traditionally, dry AD systems were better suited to SSO that has no or low plastic content. European countries do not tolerate high plastic contamination in their SSO stream, which enables them to effectively use dry AD technology. Dry AD designs have increased in popularity in Europe in the past decade, with almost two thirds of new AD facilities using dry AD technology.[33] As discussed in section 7.4, improved pre-treatment technology may allow dry systems to accept a wider range of materials.

Risks, benefits and trade-offs between wet and dry AD facility designs are presented in Table 15.

Table 15: Risks, Benefits and Trade Offs Between Wed and Dry AD System Designs

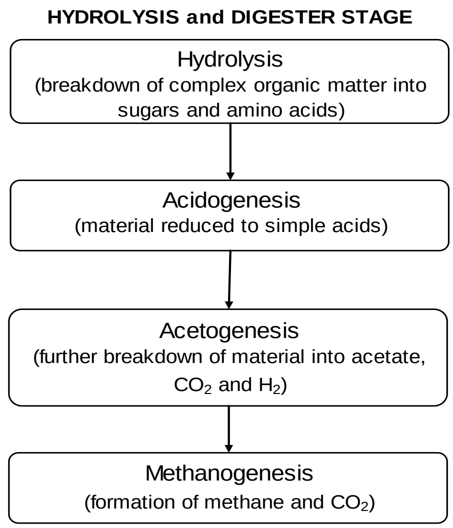
Dry AD Systems	Wet AD Systems
Risks • Can generally not handle high plastic content in incoming waste unless very specialized pre-treatment technologies are added • There are no dry AD systems operating on SSO in North America. • There are differences in feedstocks between Europe (where dry systems are well established) and N.A.	**Risks** • Higher water requirements • Higher energy needs to heat and pump water, therefore less energy for export which lowers revenues to offset costs • Higher energy needs to dewater digester contents therefore less energy for export which lowers revenues to offset costs • Some concern about loss of volatile solids and potentially lower gas yields which reduces revenues
Benefits • Fewer energy requirements • More energy available for export • Handle high solid SSO	**Benefits** • Can remove plastic from incoming waste stream • More suited for co-digestion with animal manures or biosolids

8.3 Single Stage And Two-Stage AD System Designs

As shown in Figure 6, there are four main processes that occur in anaerobic digestion. AD Systems can be designed to carry out these processes in a single stage for simplicitiy or in multiple stages to maximize breakdown. The single stage AD system is simpler and cheaper, the two stage AD system generates more biogas but requires additional reactors and handling systems. In Europe, about 90 percent of the installed AD capacity is single-stage systems and about 10 percent is two-stage systems.[34]

[33] Luc De Baere and Bruno Mattheeuws. Anaerobic Digestion of MSW in Europe. February 2010. Biocycle
[34] Current Anaerobic Digestion Technologies Used for Treatment of Municipal Organic Solid Waste. March 2008. Prepared for the California Integrated Waste Management Board.

Figure 6: Anaerobic Digestion Process Schematic[35]



Single Stage AD System Designs

In a single stage reactor, all four processes (hydrolysis, acidogensis, acetogensis and methanogensis) are completed in the same tank, Single-stage AD facilities are generally simple to design, build, and operate, and are consequently, less expensive. European plants that process residential SSO are mostly single stage systems. The predominance of one-stage systems is due to the technology's relatively simple design compared to two stage or multi-stage systems, less frequent technical failures and lower capital costs[36].

Two Stage AD Facility Designs

Two stage AD systems have been used for processing bio-solids in wastewater treatment plants for over 50 years, to optimize the environment for "acid forming" and "methane forming" bacteria. In a two stage reactor, the two key stages of digestion, hydrolysis and methogensis, take place in separate tanks. The key advantage of a two stage AD process is that the different processes can occur under optimal pH conditions in separate tanks. The theory behind two-stage processes is that optimizing each process will lead to higher gas yield and breakdown of organic matter. However, experience to date with AD facilities processing SSO is that the additional costs of the extra tankage cannot be justified in terms of the higher biogas yield, therefore some companies who experimented with two stage systems in the past prefer one stage AD systems.

The risks and benefits of one stage vs two stage AD systems are shown in Table 16.

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[35] Source: Ostrem, Karena. May 2004. Greening Waste: Anaerobic Digestion for Treating the Organic Fraction of Municipal Solid Wastes. Columbia University.

[36] Vandevivere. P. et. Al. 1999. Types of Anaerobic Digesters for Solid Wastes.

Table 16: Risks and Benefits of One Stage vs Two Stage AD System Designs

One Stage AD Systems	Two Stage AD Systems
Risks • Conditions for two stages are not optimized • May lead to somewhat lower biogas yields	**Risks** • Higher cost • More technical complexity • Less successful operational experience
Benefits • Lower capital cost • Easier to operate • Less technical failures	**Benefits** • Potentially higher gas yields • More breakdown of biodegradable material under optimal conditions

8.4 Thermophilic And Mesophilic AD System Designs

Two operating temperature ranges (mesophilic or thermophilic) are typically used in AD system designs. These different operating parameters have implications for odours and energy generation.

Mesophilic AD Facility Design
A mesophilic AD process operates within a temperature range of 30°C to 35°C (86°F to 95°F), and at an optimal temperature of about 35°C (95°F). The advantage of the mesophilic process is that the bacteria are more robust and more adaptable to changing environmental conditions[37]. The bacteria, however, require a longer retention time (time in the digester to break down the organic material) than the thermophilic system.

Thermophilic AD System Design
A thermophilic AD reactor operates at an optimal temperature of about 55°C (130°F) and must be maintained at a temperature ranging from 50°C to 65°C (122°F to 140°F) for most effective performance[38]. The main advantage associated with a thermophilic AD design is that higher temperatures can yield a superior rate of biogas production in a shorter period of time.

The risks and benefits of mesophilic vs thermophilic AD designs are shown in Table 17.

Table 17: Risks and Benefits of Mesophilic vs Thermophilic AD System Designs

Mesophilic AD Systems	Themophilic AD Systems
Risks • Longer retention time • Results in larger AD reactors • Potentially less gas yield	**Risks** • Potentially less stable for microbes (bacteria) • More potential for technical failures • Potentially higher odour problems
Benefits • Easier to operate • Less heating requirement • Conditions more stable for microbes (bacteria)	**Benefits** • Potentially higher gas yields • Shorter retention time • Sanitizes pathogen-bearing feedstocks

[37] Ostrem, Karena. May 2004. Greening Waste: Anaerobic Digestion for Treating the Organic Fraction of Municipal Solid Wastes. Columbia University.
[38] Ibid

8.5 Continuous Flow And Batch AD System Designs

There are two ways in which the feedstock moves through the AD process – continuous flow and batch flow, described below.

Continuous Flow AD Designs

In a continuous flow AD system, the SSO and other organic material is constantly or regularly fed into the digester and the material moves through the digester by either being pushed by the force of the new feed or by mechanically being moved forward to provide room for new feedstock (continuous flow). Unlike batch-type AD designs, continuous flow AD facilities produce biogas without the interruption of loading material and unloading the digested material. If properly designed and operated a continuous flow AD system will produce a steady and predictable supply of usable biogas.

Batch AD System Designs

In batch AD system designs the AD tank (or reactor) is loaded (or stacked) and sealed until the contents are digested and the AD process is complete. Batch AD facilities are simple to design and modular in nature so that the AD facility is easy to expand by adding more units or modules. Multiple batch digesters can be used to overcome peaks and troughs in biogas production by staggering changeover times. Handling of the digestate (the solid digested material in the batch AD unit when digestion is complete) requires extra safety precautions. Risks include explosions, fires or asphyxiation of employees due to buildup of biogas, which is predominantly methane which is highly toxic. Mitigation against these risks is possible through a well-designed health and safety protocol.

The risks and benefits of continuous flow AD vs batch AD systems are shown in Table 18.

Table 18: Risks and Benefits of Continuous vs Batch AD Designs

Continuous Flow AD Systems	Batch AD Systems
Risks • More difficult to expand operations • Risk if the environment is not properly controlled that the bacteria will be destroyed requiring new microbes (bacteria) to be added and conditions to be made stable again for their survival	**Risks** • Potential for biogas build-up in container and explosions (can mitigate with good operational systems) • Down time while removing processed digestate and loading new feedstock although this can be mitigated by using more than one module and alternating down times.
Benefits • No down time as feedstock is continuously added • Potentially higher gas yield • May be better suited for large-scale operations	**Benefits** • Simpler design (less complicated piping) • Easier to expand by adding extra modules • Resulting high solid content digestate requires minimal post de-watering processing

8.6 Selected AD System Vendors

Over the last decade, the AD industry has experienced significant changes in the number of players in the market. In the early 2000's fewer than 15 companies were involved in the AD market. Today, the list includes over 100 companies already in the AD market or trying to break into the AD market.[39]

AD Vendors Established in the 1980's and 1990's

In the early 2000's a handful of well-established European based companies dominated the SSO AD market, with the leaders shown in Table 19. Most of these companies were established in the 1980's and have been in the AD market for over 30 years. These companies have a strong record of success throughout Europe in constructing and operating AD facilities which process SSO. Further description of these companies is provided in Appendix A.

Table 19: AD Vendors and Technology Designs

Technology	Number of Stages		Solid Content		Operating Temperature		Process Flow		Reactor Type	
	single	two	wet	dry	meso	thermo	continuous	batch	vertical	horizontal
Dranco	✔			✔		✔	✔		✔	
BTA	✔		✔		✔		✔		✔	
Strabag/Linde	✔		✔		✔		✔			✔
Strabag/Linde	✔			✔	✔	✔	✔			✔
Valorga	✔			✔	✔		✔		✔	
Kompogas	✔			✔		✔	✔			✔
Ros Roca	✔		✔	✔	✔	✔	✔		✔	

AD Vendors Established Since Year 2000

A number of companies have entered the AD market since the year 2000, many of which have been operating for only a decade or less, as shown in Table 20. These companies have secured agreements with municipalities recently to construct AD facilities in Canada and the US. These companies have a shorter, less established record in constructing and operating AD facilities processing SSO. Most of the newer AD companies have less than 10 facilities in operation throughout Europe. Further description of these companies is provided in Appendix A.

[39] Anaerobic Digestion Technology for Biomass Projects. June 2007. Juniper for Renewables East

Table 20: AD Vendors Established After Year 2000

Technology	Established	Headquarters	Facilities Processing SSO (2009)	North America experience
GICON	2006	Germany	n.a.	Under construction Fraser Richmond Soil & Fibre,BC Renovations under way, Energy Garden Facility, London, ON
BEKON	2002	Germany	16	Agreement reached Santa Barbara, CA
Kompoferm	n.a.	Germany	7	Agreement reached San Jose, CA
FITEC (represented by Yield Energy)	2001	Germany	7	Construction to begin fall 2012 for Renew Earth Facility, Delta BC
Farmatic (Biotech Energy)	2001	Austria	3	Final design stage Portland, OR
Biogas GW (Green Waste)	2008	Germany	<5	AD facility in Columbia, SC Under construction

*Biowaste includes residential and restaurant SSO

Table 21 details the system design of AD technologies being promoted in the North American municipal AD market.

Table 21: Design Features For More Recent AD Market Entrants

Technology	Number of Stages		Solid Content		Operating Temperature		Process Flow		Reactor Type	
	single	two	wet	dry	meso	thermo	continuous	batch	vertical	horizontal
GICON	✔			✔	✔			✔		✔
BEKON	✔			✔		✔		✔		✔
FITEC	✔		✔		✔		✔			✔
Farmatic		✔	✔			✔	✔		✔	
Kompoferm	✔			✔	✔			✔		✔
Biogas GW		✔		✔	✔		✔			✔

8.7 Summary and Conclusions

Many AD system designs are available in the marketplace. AD system designers (who assemble the AD facility components for vendors and suppliers) will choose between:

- Wet or dry AD;
- Single or two stage AD;
- Thermophilic or mesophilic AD;
- Continuous, plug flow or batch AD.

The design decisions would need to be combined with pre-treatment decisions (discussed in Section 7) to create an overall AD design which would best meets the needs of the Region of Durham once the type of materials to be processed is decided (e.g. whether the current SSO material, or the current SSO with pet waste, diapers and sanitary products are chosen).

The Region should not prescribe or limit the design options at the pre-feasibility stage of the assessment. AD vendors may provide customized approaches to AD and pre-treatment options.

The differences between different AD design approaches are not relevant to the AD decision to be made, as the Region will set out performance specifications that AD vendors will need to meet, and vendors will pick the combination of technologies and approaches which they feel will work best for the feedstock to be treated. For example, a dry AD vendor could put a wet pre-processing system on the front end of their system.

Understanding risks and benefits is important background, but this information should not be used in making a procurement decision (either by dictating requirements in an RFP and/or in the evaluation of proposals). In Canada and the US, there has only been one vendor (CCI/BTA – wet AD) which has constructed AD facilities to date. Dry AD vendors have often not responded to RFPs, but have recently expressed a strong interest in entering the Ontario marketplace.

The Region will need to clearly define the feedstock preferences and level of tolerance for residue in an RFP and let the vendors design a system which they believe best meets the needs of Durham.

9. Cost Estimates

9.1 Introduction

Many of the early European AD facilities were built with processing capacity in the 10,000 tonne/year range, but the size of facilities constructed has increased over time to reach better economies of scale. AD facilities reach economies of scale, and become cost competitive with enclosed composting facilities at capacities of greater than 50,000 tonnes/year. The tonnage of SSO materials available for processing under each of the four options for Durham Region (excluding baseline) is estimated in Section 4. Option 2, with a required AD facility capacity of 60,000 to 70,000 tonnes/year is considered the only viable option of those considered that would be worth pursuing.

This section presents capital and operating cost estimates for an AD facility with a processing capacity of 60,000 – 70,000 tonnes per year.

9.2 AD Facility Capital Costs

Capital costs for an AD facility processing 60,000 to 70,000 tonnes/year were based on available information on reported capital costs of AD facilities under construction in Canada and the US. Table 22 presents the available data and converts the information to a capital cost value expressed as $ per tonne of annual constructed capacity. The table ranks the accuracy of the cost using a ranking system of low, medium and high, based on the level of completion of the AD project. Those AD projects under construction are considered to provide more accurate capital costs at this point in time. Only those capital costs considered most accurate (ranked high) were used in estimating the average capital cost per tonne of capacity.

Table 22: Capital Cost per Tonne of Annual Capacity For AD Facilities

Project	Annual Capacity of Facility	Estimated Capital Costs[1]	(A) Average cost per tonne for all projects	(B) Ranking of Accuracy of Cost[2]	(C) Average cost per tonne for high rank
	Tonnes /Year	$	$/tonne	Low * Med ** High ***	
City of Toronto	75,000	50,000,000	$667	***	$670
City of Surrey	80,000	30,000,000	$375	*	
Partners in Project Green	50,000	20,000,000	$400	*	
City of Columbia	48,000	23,000,000	$479	***	$480
City of Portland	91,000	55,000,000	$604	***	$610
City of San Jose	73,000	23,000,000	$315	**	
Weighted average $/tonne					**$600**

(1) Canadian and US dollar treated on par
(2) Rank is based on the extent to which the project is under construction or in the planning stages

A capital cost value of $600 per tonne of annual capacity is considered appropriate for application to Durham. It is based on information for those projects where costs were considered of reasonable accuracy for planning purposes. The capital cost of an AD facility to process 60,000 – 70,000 tonnes per year is estimated at $45 million. This capital cost does not include land acquisition and/or remediation. The additional capital cost for on-site aerobic composting and curing facilities would be $15 million for a 60,000 to 70,000 tonne/year AD facility. The costs for on-site aerobic composting and curing are discussed in more detail in Section 9.4.

Amortized costs of capital were estimated assuming the municipal cost of borrowing rate of 4.5% over 20 year facility life (amortization factor of 0.075). Using this approach every $1 million of capital has an annual cost of $75,000. Capital costs and amortized capital costs are summarized in Table 23.

Table 23: Capital Costs For \AD Facility Processing 60,000 to 70,000 tonnes/year

Cost Category	AD facility (60,000 to 70,000 tonnes/yr)
Estimated Capital Costs	$45 million
Capital Costs of Composting and Curing On Site	$15 million
Total Capital Cost with on-site curing	$60 million
Amortized Capital Costs ($/year) with on-site composting and curing	$4.5 million/year
Amortized Capital Costs ($/year) without on-site composting and curing (curing is carried out at an off-site facility for a tip fee per tonne)	$3.375 million/year

9.3 AD Facility Operating & Maintenance Costs

Reported annual operating costs for European SSO AD facilities and for Toronto's Dufferin and Disco AD facilities range from a low of $105/tonne/year to a high of $229/tonne/year, as shown in Table 24. Operating costs include labor, maintenance, materials, testing, insurance, overheads, and training costs. In some cases disposal of residue is included or identified; in other cases digestate curing is included or excluded as shown in the table.

Table 24: Reported Annual Operating and Maintenance Costs for AD Facilities Processing SSO

Location	AD capacity (tonnes/year)	Annual operating costs ($/tonne Can)	Notes
European	10,000	$155 - $229	Cost in € dollars €125 - €185 does not include disposal cost for residuals
European	20,000	$125 - $170	Cost in € dollars €100 - €135 does not include disposal cost for residuals
European[40]	30,000	$105 - $136	Cost in € dollars €85 - €110 does not include disposal cost for residuals
Toronto Dufferin AD Facility[41]	25,000	$139 + $24 per incoming tonne for curing Total $163/tonne	$112 contracted operating cost + $27 for hydro and residue disposal Digestate curing is $59/tonne of <u>digestate</u> which is 30% to 40% of incoming tonnes
Toronto Disco AD Facility[42]	75,000	$85 + disposal and $24/incoming tonne for curing	$84.99 is the contracted price with $97.40 for the first 55,000 tonnes and $42.23 for the remaining tonnes. Disposal extra.

[40] Anaerobic Digestion of Organic Solid Waste at WWTPs. 22-24 Sept. 2009. Presentation at PORS by AECOM
[41] Anaerobic Digestion Outlook for MSW Streams. August 2007 written by M. Kelleher for BioCycle,
[42] Authority to Negotiate and Enter into an Agreement with AECOM Canada Ltd. to Design, Build, Commission and Operate a New SSO Processing Facility at Disco Transfer Station. January 18, 2010. Staff report to Public Works and Infrastructure Committee

These processing costs were used to estimate operating costs for a Durham AD facility at: $5.1 to $6 million/year to process 60,000 to 70,000 tonne/year. These costs do not cover aerobic composting and final curing of the digestate which is addressed separately in Section 9.4 which follows.

9.4 Digestate Composting and Curing Costs

AD systems produce a solid material referred to as digestate, which requires further processing to convert it into a finished compost which can be used or sold. The process is generally referred to as curing, finishing or stabilization, and involves aerobic composting either in enclosed facilities or open windrow composting sites.

Digestate from the AD facility could be direct land applied without composting during certain times of year. However, for the remainder of the year, it would need to be composted to stabilize the digestate (and significantly reduce its odour). Composting is generally used to stabilize digestate and reduce its moisture content - this makes it easier to store and distribute at a later date.

It is generally current practice for the digestate processing to be carried out at an open windrow aerobic composting facility. However, industry experts now suggest that digestate may need some time in a high rate aerobic composting system (e.g. enclosed or in-vessel composting facility) followed by low rate composting or curing (e.g. outdoor windrow composting), rather than just windrow composting and curing of the digestate which is current practice. The high rate composting achieved in enclosed or in-vessel aerobic composting facilities achieves higher temperatures to destroy more pathogens that may remain in the digestate, and the curing that occurs outside on outdoor windrow composting pads helps to finish the conversion of the material into a finished compost[43].

The amount of digestate produced by an AD facility is typically about 30% to 40% of the incoming tonnage to the AD facility. An AD facility processing 60,000 to 70,000 tonnes/year could expect to produce 18,000 to 28,000 tonnes/year of digestate.

Table 25 identifies the estimated cost to aerobically compost and cure the digestate generated at the end of the AD process using a value of $80/tonne to reflect a process which involve some high rate aerobic composting in enclosed or in-vessel composting facilities followed by open windrow curing on outdoor open windrow composting pads. This is somewhat higher than the price of $59/tonne in the most recently renewed Toronto contract to process leaf and yard waste and digestate due to the extra step to send the digestate through a high rate composting process first. The composting report prepared by UEM for Kawartha Lakes indicates a cost of $45-$65 for open outdoor aerobic windrow composting.

Table 25: Estimated Costs to Compost and Cure Digestate From Region of Durham AD Facilities

Region of Durham AD Facility Annual Capacity (tonnes/year)	30% digestate generation (tonnes/year)	40% digestate generation (tonnes/year)	Digestate Curing Cost (30% at $80/tonne)	Digestate Curing Cost (40% at $80/tonne
60,000 t/y	18,000	24,000	$1,440,000	$1,920,000
70,000 t/y	21,000	28,000	$1,680,000	$2,240,000

43 Personal communication Brian Oke, Genivar

9.5 Revenues From Biogas and Compost

Revenues From Biogas

AD facilities produce biogas, which can be sold in a number of different formats, depending on the location of the AD facility (not yet identified). Options are:

- Burn the biogas with minimal clean-up to produce steam. The biogas is burned to heat water and generate steam with the resulting steam used at a host facility (e.g. for process heating loads or facility heating). This option is viable if a local “steam host” referring to a steam customer is available adjacent to or a short distance from the AD facility, as the steam needs to be delivered by pipeline to the customer. This is typically a manufacturing facility with a large steam load, or possibly a hospital or other institution with a large heat requirement.
- Upgrade the biogas to remove CO_2 and other contaminants, and burn it in an engine to product electricity. Until recently, the electricity could be sold into the Ontario electricity grid. The Ontario Power Authority operated a FIT (feed in tariff) program which paid an average rate of $0.148 / kWh[44] for electricity generated by biogas facilities which had FIT contracts. The FIT program was cancelled in June, 2013, and will be replaced by a large renewable energy procurement process whereby renewable energy projects will be awarded through a competitive process. The new program will be strongly linked to community energy plans and renewable electricity generation will only be located in areas of the Province where a need has been identified. The details of the new procurement process are not known at the time of writing (November, 2013), and the future price to be paid for electricity from biogas is not known at this time.
- Upgrade the biogas to a level where it can produce compressed natural gas (CNG) for use as a vehicle fuel. This option only makes sense if a fueling station can be established near truck routes and trucks which can run on natural gas are added to the fleet. The use of natural gas or renewable natural gas (RNG) to fuel municipal fleets such as buses or waste collection vehicles has gained popularity recently as the price of natural gas is significantly lower than that of diesel. Recent studies have shown that over the lifetime of a collection truck (about 7 years) the initial up front incremental costs of a CHG truck (about $80,000) can be offset by fuel savings as long as certain tax benefits continue to be given to natural gas but not diesel. The City of Surrey in British Columbia required vehicles to use natural gas for fuel in its most recent waste collection tender. The City of Winnipeg has also changed their fleet over to CNG, and Simcoe County as also moved to natural gas for its collection vehicles in the new contract.
- Upgrade the biogas to a level where it can be classified as a renewable natural gas (RNG) and can be injected into the natural gas pipeline and be sold as natural gas to customers. The quality of the RNG will need to meet stringent pipeline specifications before it can be injected into the natural gas pipeline grid. This option is only viable if there is a natural gas pipeline at the AD site. This option was being pursued by City of Toronto and Enbridge in 2009 but was abandoned when the price of natural gas fell. However, Enbridge and Union Gas continue to explore this option and asked the Ontario Energy Board to consider an application to increase the amount of RNG in the Ontario natural gas supply at an additional cost to consumers. The application was rejected[45], but the companies continue to explore the concept.
- The future of the carbon credit market is somewhat uncertain at this time as no firm trading rules have been established for Canada. Carbon offset sales are currently priced in the $5 - $12/ tonne of carbon emissions. Quebec passed legislation to enable it to establish a cap and trade system for carbon emissions and has explored setting up a cap and trade system with California. Ontario, British Columbia and Manitoba have shown interest in a cap and trade system but nothing has materialized to date. British Columbia has instituted a carbon tax. No actions have been taken at the Federal level to pursue a cap and trade system.

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[44] http://fit.powerauthority.on.ca/sites/default/files/page/FIT-mFITPriceScheduleV2.0.pdf
[45] Ontario Energy Board Interim Decision and Order EB 2011-0242 and EB – 2011-0283, dated 12th July, 2012

Given that the location of the AD facility is not known at this time, the end market to which biogas or biogas products will be sold is not known. Revenues were estimated based on the FIT rate for electricity generation using the biogas from the AD process. A business case would help to confirm the electricity revenues required to make an AD project comparable to other end market options. .

The City of Toronto is embarking on a comprehensive business case study from mid-2013 to early 2014 to evaluate all of the options for use of the biogas from the Dufferin and Disco AD facilities, as well as the landfill gas from the Green Lane Landfill (which is also classified as biogas with similar revenue generating options). The Region of Durham should follow the results of the assessment closely as the study will evaluate all of the options listed above (steam/heat, electricity, co-generation, vehicle fuel, RNG) in detail.

Compost and Digestate Revenues

Compost can typically be sold for $10/tonne. An AD facility which processes 60,000 to 70,000 tonnes/year of SSO might produce 30% to 40% digestate (18,000 to 28,000 tonnes) per year. When this digestate is sent to composting, there are additional loses in weight due to moisture loss and biological degradation as well as the removal of additional residues to improve the quality of compost, therefore about 75% of the incoming tonnage to curing results in finished compost. On this basis, about 12,000 to 21,000 tonnes of finished compost would be produced from the AD digestate. If the Region owned and operated and marketed the compost, they could potentially generate $120,000 to $210,000 in revenue. However, if the digestate is composted off-site by a private sector composting facility, the private sector operator typically takes over the marketing of the compost and keeps the revenue. The price quoted for digestate curing would take revenues generated into account.

The option of directly land applying digestate is only viable during certain times of year permitted through the Nutrient Management Act. For the rest of the year, the digestate would need to be composted to turn it into a material which is easier to store and handle. No revenues are assumed for this scenario.

9.6 Summary of Estimated Capital and Operating Costs For Region of Durham AD Facility Options

Table 26 summarizes the estimated capital and operating costs for an AD facility with off-site composting and curing of digestate, and includes potential revenues from a FIT contract (no carbon credit revenues) for a facility processing 60,000 to 70,000 tonnes/year: The table breaks out key components of the AD facility estimated annual costs which will need to be confirmed to a greater degree through a business case.

Table 26: Total Estimated Capital and Operating Costs For Region of Durham AD Facility Option

Cost Category	Larger AD facility (60,000 to 70,000 tonnes/yr)
Estimated Capital Costs of AD facility	$45 million
Amortized Capital Costs ($/year) (at $75,000/year per $1 million capital)	$3.375 million/year
Estimated Operating Costs	$5.1 to $6 million
Estimated Digestate Composting and Curing Costs (at $80/tonne of digestate, which is 30% to 40% of incoming tonnage to AD)	$1.9 to 2.2 million/year
Total Annual Costs (with off-site composting and curing)	**$10.8 to $11.6 million**
Electric Power Generation For FIT contract	*13.7 million KWhrs/year*
Ontario FIT contract revenues at 14.7 cents/KWhr	*$2,013,400*
Annual $/tonne capital	$48 - $56
Annual $/tonne operating (excluding off site composting and curing)	$86
Annual $/tonne of input for digestate composting and curing	$25
Revenue from sale of compost (retained by composting contractor)	$0
FIT revenue $/tonne input	$26
Total annual cost/tonne of input before FIT Revenue	**$159-167**
Total annual cost/tonne of input net of FIT Revenue	**$133 - $141**

9.7 Conclusions

The cost assessment presented in this section illustrates the importance of securing revenues of at least 14.7 cents/kWhr if electricity is produced by the AD facility. This rate used to be available for all biogas projects through the FIT program. The program was modified in summer, 2013 to only apply to small projects (under 500kW). Should the Durham AD facility pursue electricity as a use of the biogas, revenues from OPA will be established in the future through a procurement process and are not known at this time.

An AD facility (60,000 to 70,000 tonne/year capacity) is comparable financially to an enclosed or in-vessel aerobic composting costs, which range from $95 - $130/tonne or more at this time in Ontario.

A business case analysis should be undertaken to evaluate the AD option compared to the current aerobic composting option.

10 Funding Opportunities

There are several funding opportunities that could be explored by Durham Region to secure financial funds for the capital costs of an AD facility.

10.1 Private Funding Opportunities

The *Canadian Council for Public Private Partnerships* identifies public/private partnerships for a wide range of municipal projects. There may be a number of companies interested in the Durham AD opportunity to gain control of the biogas produced.

The Region of Waterloo, Ontario has partnered with a local energy company to produce electricity from landfill gas. The Waterloo, Ontario Landfill gas facility is a design, construction, ownership, operation and maintenance project between Waterloo Region and Toromont Energy. In this public/private arrangement the Region supplies the landfill gas with Toromont, designing, building, operating, maintaining and financing the $7.5 million power plant. Toromont pays the Region a royalty for the landfill gas based on electricity revenues.[46] Reports state that "The project would not have been financially possible without a parallel agreement between Toromont Energy and the local utility, Ontario Power Generation, for the sale of electricity and associated emission reduction credits. The project was developed before Ontario FIT contracts were available and is not part of the FIT program, but was part of an earlier program with the federal government where greenhouse gas credits were purchased through the PERT (pilot Emission Reduction Trading) program. The project helps Ontario Power meet its own corporate greenhouse gas emissions targets and satisfy green power marketing initiatives in Canada."[47]

The Durham AD facility would produce smaller amounts of biogas than a landfill, so that the same partnership opportunities may not be viable. These could be explored as part of a feasibility or business case study.

10.2 Energy Utilities

Various partnerships have been explored between energy utilities and AD developers. These partnerships generally involve use of the biogas as a power source, for heat/steam, or heat and electricity (co-generation) as renewable natural gas (RNG).

The City of Toronto and Enwave (formerly the Toronto District Heating Corporation) explored a partnership in the early 2000's when natural gas prices were high and Enwave wanted to explore AD of Toronto SSO as a potential method to stabilize the cost of the gas needed for their district heating operation. At the time, the economics of the project were not favourable, and the project could not produce sufficient biogas to meet Enwave needs.

In 2009, the City of Toronto planned to use the natural gas pipeline distribution system to "wheel" RNG (renewable natural gas, which is "cleaned up" biogas) from the Dufferin Anaerobic Digestion Facility site to a fuelling station for garbage trucks. In June 2010, the City of Toronto Council endorsed a proposal for City staff to engage Enbridge Gas Distribution Inc. in owning, operating and supplying a RNG system out of the Dufferin Anaerobic Digestion Facility site which would upgrade biogas from the AD facility for injection into Enbridge's natural gas distribution pipeline system.[48] However, interest in the project

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[46] Power Projects – Waterloo Landfill. Toromont Energy Group at http://www.toromontenergy.com
[47] Power Projects – Waterloo Landfill. Toromont Energy Group at http://www.toromontenergy.com
[48] Report PW33.13, "Authority to Enter into a Biogas Pilot Project Agreement with Enbridge Gas Distribution Inc. to Supply, Install, Own and Operate a Biomethane System (BMS) at the Dufferin Waste Management Facility. June 8 and 9, 2010 Public Works and Infrastructure Committee

evaporated when the price of natural gas fell substantially.

Partnerships with energy utilities are a good way to ensure that the energy produced from biogas has a secure end market. Energy companies generally have the expertise required for some of the highly technical aspects of biogas utilization projects.

10.3 Public Private Partnerships (P3) Canada Fund

The *Public Private Partnerships Fund (P3) Canada* is a Federal Crown Corporation established to support the development of public-private partnerships and to facilitate the development of public infrastructure projects in the Canadian P3 market. To be eligible for a P3 Canada Fund investment, the infrastructure project must be procured, and supported by a province, territory, municipality or First Nation (i.e., a public authority).

The purpose of the $1.25 billion P3 fund was to attract investments from the private sector, with the added benefit of increasing knowledge and expertise in alternative financing for infrastructure projects.

In a public-private partnership (P3), a government enters into a contract with a company or companies that may take on responsibility for one of the following partnership arrangements:

- design and build (DB),
- design-build and finance (DBF),
- design-build-finance, operate and maintain (DBFOM).

The proponent (which must be a province, territory, municipality or First Nation (i.e., a public authority, but can also be a private sector company with public sector partners[49]) must apply to PPP Canada and may qualify for up to 25 percent funding of the project's eligible capital costs.

Sudbury's Biosolids Management Facility is a $30-$40 million project which secured $11 million under the P3s Design, Build, Finance, Operate and Maintain (DBFOM) model.

P3 Canada funding includes a Solid Waste Management Infrastructure category which includes the following eligible project categories:

Solid waste diversion projects:

- Recycling
- Composting
- Anaerobic digestion

Solid waste disposal projects:

- Thermal processes, including gasification
- Landfill gas recovery

York Region has applied to the P3 Canada Fund to help pay for a planned organic waste processing facility. A previous organics processing procurement process (with Dufferin County) was abandoned and the project was not constructed because of high quoted costs (above the allocated project budget) received in response to the bid documents. York Region will undertake a new proposal process for organics processing capacity in 2013.[50]

[49] Information for Applicants, Round 5 www.p3canada.ca
[50] Processing delays. York Region seeks funding partners on its organic waste program. March 29, 2012. YorkRegion.com

The P3 funding is introduced in Phases. Round Five was announced in April 2013 with a particular focus on transportation, water/wastewater, solid waste disposal and brownfield re-development. The closing date deadline for Round Five submissions is 14th June, 2013[51] which is too soon for the AD project. However, other rounds of P3 Canada Fund opportunities are expected.

To assist Round Five applicants in preparing their submissions to the P3 Canada Fund, PPP Canada has developed an Application Guide which provides detailed information of the Fund's eligibility and evaluation process and detailed instructions on how to prepare a submission. In addition, PPP Canada has created a P3 Business Case Development Guide which outlines the necessary steps to the development of a comprehensive and robust P3 business case. Project sponsors whose applications are retained for further analysis will be required to follow this guide in preparing their Business Case for submission to PPP Canada.

Region of Durham staff should contact P3 Canada at this early stage in the project and assess if there is any merit to submitting an application for Round Five.

10.4 Building Canada Fund

The $8.8 billion *Building Canada Fund* was established under the 2007 *Building Canada Plan* to fund projects from 2007 to 2014. Given that the AD facility is unlikely to be constructed by that date, there is some uncertainty as to whether the current tranche of funds will be available, or whether the program will be extended.

The current Building Canada Fund has two funding components including the Major Infrastructure Component which targets larger, strategic projects of national and regional significance.

The Major Infrastructure components funds projects related to:

- drinking water;
- wastewater;
- public transit;
- the core National Highway System; and
- green energy.

The fund will cover a maximum contribution of 50% to any single project. The Region of Durham AD facility would qualify as a green energy project.

10.5 Infrastructure Ontario

In 2006 the *Ontario Strategic Infrastructure Financing Authority (OSIFA)* amalgamated into Ontario Infrastructure Projects Corporation to streamline infrastructural renewal with the OSIFA loan program.

Infrastructure Ontario (IO) uses the term Alternative Financing and Procurement (AFP) to identify its process for partnering with the private sector to deliver infrastructure projects. Infrastructure Ontario will assist projects in the range of $50 million to $300 million, or more, by bringing together public and private sector organizations, conduct a procurement process to select a private-sector consortium and ensuring the public interest is upheld throughout the life of the project.

[51] www.p3canada.ca

10.6 Federation of Canadian Municipalities

The Federation of Canadian Municipalities supports green energy and other sustainable municipal projects through two funds:

- Green Municipal Investment Fund (GMIF) is designed to provide financial support for environmental projects, such as those associated with integrate community energy solutions, and projects must demonstrate an improvement in energy efficiency or environmental performance and
- The Green Municipal Enabling Fund (GMEF) provides support for municipalities interested in doing feasibility studies to assess the technical, environmental and/or economic feasibility of innovative municipal projects.

In 2013-2014, the FCE will approve $45 million in loans and $5 million in grants for capital projects in the energy, transportation, waste and water sectors through its competitive selection process.

10.7 Borealis Infrastructure

Borealis Infrastructure, a division of OMERS (*Ontario Municipal Employees Retirement System)* invests in public infrastructure in the following categories:

- energy (generation, transmission and distribution networks),
- transportation (transportation gateways, rail corridors, ports and airports)
- institutional facilities (hospitals, long-term care facilities and schools), and
- government-regulated services (laboratory diagnostic services, satellite and other communications networks and land registry services).

Borealis acts as the infrastructure investment arm of OMERS, with approximately C$55.1 billion in net investment assets.[1] Borealis investments in the energy sector include:

- Bruce Power;
- Enwave (Toronto District Heating Corporation;
- Enersource (Mississauga) and others

Borealis Infrastructure was established in the late 1990s, with a mandate to invest in infrastructure as a separate asset class. As of end of 2011 Borealis had approximately C$9 billion invested in 20+ investments that have a total enterprise value of approximately C$50 billion.

Borealis Infrastructure was a joint owner of Enwave Energy Corporation (formerly Toronto District Heating Corporation) for a number of years. On 2nd October, 2012 Borealis announced that it has entered into an agreement to sell its 57% stake in Enwave Energy Corporation to a corporation indirectly owned by a partnership sponsored by Brookfield Asset Management.

Borealis targets investments in large-scale, world-class infrastructure opportunities with enterprise values in excess of $1 billion. For this reason, they are unlikely to be interested in a project of the scale of the Durham AD facility. However, they should be contacted when the business case is complete.

10.8 Summary, Conclusions and Recommendations

There are a number of opportunities to approach funders for financing or support for the Durham AD facility. It is recommended that Region of Durham staff approach each of these funders to discuss the AD project and assess which applications should be submitted at this early stage, and how early stage applications would be addressed by the funder or partner.

Funding opportunities listed in this section should all be explored when the AD project concept is further advanced. Funders will generally only commit to a project when the capacity, capital cost and timing is known. It is also preferable in most funding applications if the location is confirmed.

11. Legislative and Permitting Requirements

11.1 Introduction

This section discusses the permitting and approvals which may be required for a greenfield AD facility in the Region of Durham.

Obtaining approval for an AD facility is somewhat different than obtaining approval for a composting facility. AD includes an energy and gas handling component, which require additional approvals.

Environmental approvals for AD facilities include:

- Renewable Energy Approval - REA (O. Reg 359/09 under the Environmental Protection Act)
- Environmental Compliance Approval (ECA) under Part V and Regulation 347 of the EPA (Environmental Protection Act)
- Approval under the Ontario Water Resources Act (OWRA) for sewage works. and storm water management plan and
- General municipal and gas handling approvals.

Each approval is discussed in this section.

11.2 Renewable Energy Approval (REA)

The *Green Energy Act* introduced the *Renewable Energy Approval (REA)* in September, 2009, for all renewable energy systems participating in the OPA Feed In Tariff (FIT) program. As discussed in Section 9.5, the FIT program for large renewable energy projects (> 500kw) was cancelled in June, 2013. Renewable energy projects have a separate Environmental Approval process.

The REA is similar to the Certificate of Approval process which has been replaced by the ECA discussed in Section 11.3. However, the REA requires additional screening for cultural heritage, natural areas, aboriginal consultations, etc.

Under the *Electricity Act (1998)* a "renewable energy generation facility" is a facility that generates electricity from a renewable energy source. A renewable energy source is defined as an energy source that is renewed by natural processes and includes wind, water, biomass, biogas, biofuel and other renewable energy sources. AD falls into this category as it produces biogas.

A REA approval is required for an AD facility if it:

- produces electricity from biogas or renewable natural gas (RNG – upgraded and cleaned up biogas);
- produces electricity using permitted biomass;
- 90% or more of the electricity produced from a renewable energy source, if the name plate capacity is < 500kw; 95% of the electricity produced is from a renewable source for capacity > 500kw;

AD facility approvals are classified as on-farm (Class 1 and 2) and off-farm (Class 3). The Durham AD facility would be a Class 3 (off farm) AD facility. Permitted feedstock includes:

- **Biomass** is defined in Regulation 160 under the Electricity Act as "organic matter that is derived from a plant or animal"
- **Source separated organics (SSO)** is defined as "organic waste that has been separated from other waste under a program operated by and for a municipality";
- **Farm material** is defined as "organic matter other than biomass that is derived from a plant or animal and is available on a farm operation (i.e. deadstock or composting material) and
- **Agricultural Exempted Biomass.**

A renewable energy approval (REA) is a single approval that integrates environmental, health and safety considerations. Large renewable energy projects (wind, ground mounted solar and bioenergy) are subject to the REA process (Ontario Regulation 359/09 under the Environmental Protection Act, RSO 1990[52]). The REA process includes: consultation with public, aboriginal communities, municipalities and agencies; assessment of site-specific issues (e.g. noise, air, flora, fauna) and mitigation at all project stages (construction, operation and decommissioning). No assessment/comparison of alternative sites is required.

An REA is either approved, denied or approved with conditions by the MOE Director. The process can be appealed to the provincial Environmental Review Tribunal.

11.3 Environmental Compliance Approval (ECA)

An ECA is a relatively new regulatory instrument developed by MOE over several years to streamline environmental approvals and shorten the time required for approvals. All new environmental approvals in Ontario are granted as ECA's. An ECA is required for facilities that:

- Discharge contaminants to air, ground and surface water, or
- Transport, manage and dispose of waste.

Should the AD facility be co-located at an existing Region of Durham waste management or water pollution control facility site, all existing Certificates of Approval for the site will be re-opened and updated when the new ECA is granted. This is considered a regulatory risk to co-locating at another site, but should not be considered a reason not to co-locate an AD facility at an appropriate existing Regional site.

The ECA for a greenfield AD facility could potentially require approvals under the following Acts:

- Environmental Assessment Act (EAA) and/or
- Environmental Protection Act (EPA)

Environmental Assessment Act

No approvals are anticipated for the AD facility under the EAA. Approvals would be required if the AD facility:

[52] www.ene.gov.on.ca/environment/en/subject/renewable energy/ from 19th June, 2013 OPA/IESO presentation on Stakeholder Engagement on Siting of Large Energy Infrastructure

- transfers more than 1,000 tonnes/day of residual waste per day for final disposal on an annual basis or
- The AD facility produces 10MW or more of electricity (the AD facility will not produce this amount of energy).

A 70,000 tonnes/yr AD facility (the largest capacity reviewed for this study) receives less than 300 tonnes/day. Only a percentage of the incoming tonnage will be transferred off site for additional composting and stabilization, or for residual disposal, therefore the total quantity of residual waste transferred would only be in the order of 150 tonnes/day or less therefore EAA approval is not required.

Environmental Protection Act

The Region of Durham AD facility will require an Environmental Compliance Approval (ECA) for Waste Processing under Section 27 of the EPA and an ECA (Air and Noise) under Section 9 of the EPA.

Applications for these amendments/approvals must be accompanied with a Design and Operations report, an Environmental Study report (including a hydrogeological assessment and drainage study) and, in the case of the ECA (Air and Noise) an Emission Summary and Dispersion Modeling (ESDM) report. The latter would include an Odour Impact Assessment to demonstrate the AD facility will meet the Ministry's requirement for one odour unit (1 OU) at the property boundary.

11.4 Ontario Water Resources Act (OWRA)

The Durham AD facility will require approval under the OWRA for sewage works and the storm water management plan, depending on the location.

The amount and quality of wastewater produced by the AD facility will depend on the system design (wet AD or dry AD). The requirement for wastewater treatment prior to discharge will depend on the AD facility location. Should the AD facility be located with access to the sewer system, the wastewater will need to be treated to meet sewer use by-law requirements.

Should the AD facility be located at some distance from the sewer system, approval will be required to discharge treated wastewater to the nearest suitable water course.

In either case, AD vendors typically supply on-site wastewater treatment packages as part of the system design.

11.5 Recent Experience With Environmental Approvals for Municipal AD Facilities In Ontario

The approvals approach for AD facilities handling residential SSO has only been used for a few facilities in Ontario to date, as few facilities of this nature have been constructed in Ontario. The most recent facilities to start construction are the Harvest Power Digester in London, Ontario and the City of Toronto digester at Disco Transfer Station.

The City of Toronto Disco AD project (currently under construction at the Disco Transfer Station) is a typical example. Because an ECA was required, all Certificates of Approval for the transfer station, some going back 30 years, were re-opened and updated. All approvals were issued over a period of about 18 months. In this instance, the ECA was a new process, and the Disco AD facility was one of the first projects to be approved through the new ECA approach.

Discussions with proponents seeking ECAs for various waste related projects indicate that the new ECA process is significantly better than the old EA process and that obtaining environmental approvals for waste management facilities is significantly quicker and more efficient than in the past.

11.6 Municipal Approvals For An AD Facility

Standard municipal approvals such as a building permit and Site Plan approval would be required for any planned AD facility. Both of these approvals and permits would likely be secured by the design team possibly with the Region's assistance. The Planning Act establishes land use by means of official plans and zoning by-laws. The new rules for siting of large energy infrastructure in Ontario announced on on 19th June, 2013 changed the rules on siting of renewable energy projects (which received efficient approval under the Green Energy Act, but sometimes were not supported by the community) to a new process which gives municipalities "a stronger voice, more options and new tools when it comes to renewable energy". The new process has not been fully described to date but will be designed to ensure that all renewable energy projects are sited and constructed based on need and that they have the support and approval of the municipality and the local community.

11.7 Approvals Related to Gas Handing

An AD facility would need to be designed in accordance with various codes which ensure facility safety when handling gas. The most notable for AD is the need to design digesters and the gas trane in accordance with the *CGA Code for Digester Gas and Landfill Gas Installations*. The *Fire Code* and *Building Code* are also relevant to gas handling.

11.8 Ontario Composting Guideline

The Ontario Composting Guideline is only relevant if the Region chooses to aerobically compost and cure the digestate from the AD process on site.

The new Ontario Compost Framework implemented in September, 2012, replaces a framework which had been in place for 20 years which needed updating for some time. It is intended to improve the operation of composting facilities by providing comprehensive and technically sound guidance on facility siting, design, operation and maintenance to reduce potential impacts off-site. The new Compost Framework also sets out guidance for municipal waste managers on organics collection program design which is aimed at improving facility operation. The Guideline is also relevant in the siting work as it recommends setbacks to sensitive receptors.

The New Ontario Composting Guideline issued in late September, 2012 has been divided into two new documents:

- Ontario Compost Quality Standards (Standards) and
- Guideline for the Production of Compost in Ontario (Guideline).

Details on the new Guideline are presented in Appendix B.

11.9 Municipal Sewer Use By-laws

Region of Durham by-laws deal with the quantity and composition of discharges into their sewers. A discharge from an AD facility could exceed sewer use by-laws quality or quantity limits depending on the type of process used (e.g. wet AD) and the size of the facility. Newer AD facilities often treat the wastewater on-site using sequential batch reactors (SBR tanks) to ensure that the discharge meets the sewer use discharge requirements in the local area.

12. Siting and Site Size for AD Facility

12.1 Introduction

This section identifies the area required for a "greenfield" site for the AD facility. Should the AD facility be co-located with other waste management of wastewater treatment facilities, an assessment would be needed in each case of the specific space requirements, as many of the facilities required for an AD facility (administration building, scale house, gas storage, etc) could possibly be shared with other facilities depending on the location.

12.2 Site Size Required for AD Facility

One of the benefits of AD technology is that it has a small footprint compared to composting. Table 27 presents a number of facilities which were reviewed to identify the site size for different sizes of AD facility.

Table 27: Site Size For Different AD Facility Design Capacities and Curing Arrangements

Vendor & Location	Location	Plant Capacity Tonnes/year	Area	Finished Compost Management
Kompogas (dry, single stage, thermophilic)	General	50,000 tonnes	12,000 m^2 3 acres	Not applicable
Valorga (dry, single stage, mesophilic)	Tilburg, Netherlands	52,000 tonnes	16,000 m^2 4 acres	Not applicable
BTA (wet, single stage thermophilic/mesophilic)	Ypres, Belgium	55,000 tonnes	40,500 m^2 11 acres	Not applicable
Linde (dry/wet, single/two stage, thermophilic/mesophilic)	Lemo, Germany	40,000 tonnes	50,000 m^2 12 acres	Not applicable
Harvest Power (high solid dry, multi stage, batch)	Sample layout	(27,000 tonnes)	2 acres for the facility 3-10 acres	20,000 tons (18,000 tonnes)
Harvest Power (low solid, wet, continuous)	Sample Layout	54-72,000 tonnes	10 acres	Not applicable
Harvest Power Fraser Richmond Soil & Fibre	Richmond, BC	27,000 tonnes	2 acres	20,000 tons (18,000 tonnes)
Harvest Power	London, ON	60,000 tonnes	5 acres	Not applicable
Eggersmann's Kompoferm technology (dry, single stage, batch)	San Jose, CA	3 phases each 75,000 tonnes (225,000 tonnes total)	41 acreas set aside for 3 AD buildings	each AD building requires 1.4 acres
Columbia Biogas using BDI's Farmatic Inc. (wet, two stage)	Portland, OR	100,00 tonnes	11 acres	Not applicable
Bekon (high solid, dry, batch)	Santa Barbara, CA	60,000 ton (54,000 tonnes)	AD facility 1.5 acres + curing of digestate 4-6 acres. AD + MRF = 6 acres	17,000 tons (15,000 tonnes)
Eisenmann's Biogas Green Waste technology) (high solid, dry, batch)	Columbia, SC	48,000 tonnes	AD facility is 4 acres and total site is 6 acres	Not applicable

European facilities do not typically employ the large site buffer that the Ontario MOE requires and are not typically required to meet the “one odour unit” requirement. MOE requires 250 meter buffer to the nearest sensitive receptor and 100m buffer on all sides.

For a 60,000 to 70,000 tonne/year AD facility an area of about 13 acres is required for the AD facilities and 35 acres is required for an AD facility with on-site composting/curing of the digestate produced during the AD process.

Both of these site sizes are based on 100m buffers all sides.

12.3 Siting Considerations For An AD Facility

Siting considerations for AD facilities depend to some extent on the end markets or buyers for the biogas from the AD operation. If electricity is produced, the AD facility should ideally be located close to transmission lines where the grid connection is easiest and cheapest to establish. If a steam/heat customer can be found for steam generated by burning biogas, a simple arrangement is to locate the AD facility adjacent to the steam/heat customer. If the steam/heat customer goes out of business, the AD facility loses revenues related to the steam/heat generation and needs to re-evaluate markets for the end product – this is one of the risks of the AD facility.

The Region of Durham could locate the AD facility:

- at a greenfield site or
- at an existing Regional site (either waste management or wastewater related).

Considerations for Greenfield AD Facility Locations

If the AD facility is located at a greenfield site (referring to a newly developed site), it is important to have a large, rural site to mitigate potential odour issues. Other good locations for the AD facility would be:

- adjacent to a steam host who could purchase heat or biogas/RNG from the AD facility.
- adjacent to a natural gas pipeline which could be used as a market for RNG produced at the AD facility;
- adjacent to a trucking operation where a fueling station could be established to use LNG (liquid natural gas) or CNG (compressed natural gas) produced from the biogas or RNG from the AD facility;
- adjacent to an electricity distribution line to reduce the connection costs to sell energy from the AD facility to the Ontario electricity grid.

Co-Location at An Existing Regional Wastewater or Waste Management Site

Existing or planned waste management related locations such as an existing or planned transfer station, landfill, composting facility, EFW facility or other waste management location are good locations for the AD facility. It could also be located at wastewater treatment facilities that have extra space available. Benefits of co-locating the AD facility with other Regional operations include:

- If the AD facility is located at a waste management site, local residents are used to a certain amount of truck traffic already. The additional truck traffic related to the AD facility will create less of an incremental impact than if the AD facility is located at a new site.
- If the AD facility is located at the Clarington EFW site, the site has already been developed with electrical power and on-site infrastructure such as roads, sewers, water supply, etc. Facilities such as the administration building and scale house could potentially be shared, as well as

possibly some of the energy related equipment. This will save considerably on the incremental capital cost of the AD facility.

- There will be some capital cost savings related to sharing overhead expenses or existing operations (with some expansion) and possibly staff at an existing site which is expanded to include an AD facility.
- If the AD facility is co-located at a composting facility, considerable cost savings would be achieved in trucking digestate to another site for composting and curing. The best cost savings would be achieved if the existing site would have sufficient capacity to process digestate from the AD facility.
- Existing waste management facilities such as transfer stations already have a scale house and administration building which can be expanded if necessary to accommodate the needs of the AD facility.
- If located at a wastewater treatment plant (WWTP), the wastewater from the AD facility can be discharged into the headworks of the wastewater treatment facility. It may be necessary to carry out some pre-treatment prior to discharge. This requirement would depend on the loading levels at the existing WWTP and the quality of the wastewater produced by the AD facility.
- If located at a wastewater treatment plant, gas handling facilities and infrastructure will already be in place. It may be possible to share some of these facilities and infrastructure. A technical assessment would be required as part of the preliminary design stage.

13. Public and Private Partnerships

13.1 Introduction

There are many aspects of an AD facility project which lend themselves to the formation of partnerships, either with local businesses, other municipalities, financing entities, waste management companies and others. Various possible partnerships are discussed in this section.

13.2 Ownership and Operation of the AD Facility

AD facility ownership options for the Region of Durham include:

- public ownership (the Region or the Region jointly with municipal neighbours);
- private ownership or
- some type of shared public/private ownership partnership.

A decision regarding ownership of the AD facility relates directly to the degree of risk, financially or otherwise, the Region is willing to assume. Some level of risk is associated with any undertaking; the absence of an ownership stake does not equate to the absence of risk. Various risk factors associated with the AD facility project are discussed in Section 14.

There are a number of ways in which the Region of Durham can implement the AD facility project. These include:

- Fully contract out to a private sector waste management company who will take on the financial and operational risk for the AD facility;
- Traditional design, bid, build (DBB);
- Engineering, procurement & construction (EPC);
- Design, build, operate & maintain (DBOM);
- Design, finance, build, operate (DFBO);
- Design, finance, build, own, operate (DFBOO); and
- Design, finance, build, own, operate and transfer ownership to the Region at the end of an agreed period. (DFBOOT).

Each of these approaches has been used by municipalities across Ontario for the provision of various waste management and other municipal services. Each approach involves different levels of risk. Each municipality has preferred methods of operating, so that many of these models would not be of interest. The Region of Durham should explore each of these models as part of the Business Case which should follow this Pre-Feasibility Study.

AD processing technology is more complex than composting or other operations which are better understood in Ontario. It is very important to have a good AD facility operator, particularly in the early years of the AD facility operation. Therefore a partnership involving an expert AD company to operate the facility is considered essential to the success of the AD project.

Partnerships related to siting depend on the AD facility design and ultimate markets for the end products.

13.3 Synergies with Regional Facilities and Operations

While the Regional Waste Management department will be responsible for the AD facility (either directly or through contracting with an outside vendor), it is possible to consider forming a number of partnerships with other Regional departments or Regionally owned facilities (operated by private contractors), or even with contractors providing services to the Region to share costs, infrastructure and equipment. These potential synergies and partnerships include:

- The possible co-location of the AD facility at a Regional WPCP and sharing of infrastructure such as gas handling and wastewater treatment. Locations with facilities which handle biosolids offer promising AD facility siting partnership opportunities as some of the material handling equipment (gas storage, wastewater treatment, etc) could be shared thus reducing the cost of the AD facility.
- The possible co-location of the AD facility at the Clarington EFW site so that the benefits of an existing fully developed site are realized, and a new site does not have to be developed for the AD facility. Some existing infrastructure such as power lines, the scale house, administration building and possibly staffing could be shared between the AD and EFW facilities
- Biogas from the AD facility could be sent to the EFW facility, and the EFW facility could provide heat to maintain temperature control for the AD process where required.
- Locating the AD facility between the EFW site and the WPCP would provide the possibility of a three way beneficial relationship. Heat from the EFW could be sent to the AD and WPCP facilities, AD leachate could be treated at the WPCP (saving costs of on-site treatment), biogas from the AD facility could be sent to the EFW. This would be particularly viable if the Region owned all three facilities;
- A partnership with Fleet Services to use some of the RNG from the AD facility to fuel some of the Regional truck fleet;
- The Region may have a partnership opportunity to use the biogas in the natural gas system. This option is dependent on the location of the AD facility and the interest of the local utility in green and renewable sources of natural gas.
- Durham could initiate discussions with their current contractors and fleet managers to assess the level of interest in fuelling trucks with natural gas. The City of Surrey in British Columbia has recently awarded a ten year collection contract which required natural gas powered vehicles.

13.4 Partnerships For Additional Input Materials

Partnerships for additional input materials are not required if the Region chooses to send all of its Green Bin material to an AD facility; however, the cost per tonne would be lower if the tonnage processed was higher. Adding materials from outside sources brings with it a number of risks:

- Contamination
- Unreliable supply
- Logistics

Neighbouring Municipalities

Neighbouring GTA municipalities were contacted as part of the study to determine the status of their SSO planning and assess their potential level of interest in co-owning, co-operating or in providing materials to a potential AD facility in Region of Durham. The status identified in these discussions is summarized below.

- Halton, Peel and York are all actively evaluating options for SSO processing at this time. Halton has decided to continue to use the Hamilton composting facility;
- Peel is running some pilot studies and will not make a decision on pursuing composting and AD capacity themselves until late 2013, after the pilots are completed;
- York cancelled an SSO RFP in 2012 process and continues to look for processing options,
- Simcoe County is currently exploring SSO processing options.

The Region should further explore partnership opportunities as part of a business case.

13.5 Partnerships For Energy Markets

AD facilities can produce a range of energy products. The final decision on which energy product to produce depends on the partnerships which can be formed to secure revenues for the energy products. The options are:

- Burn biogas with minimal clean-up to produce steam – this option works if a steam/heat customer is available within the Region and steam/heat from the AD facility can be transported to the steam/heat customer in pipelines. Location of the AD facility adjacent to the steam/heat customer is essential for success of this option;
- Biogas can be upgraded and burned in generators to produce electricity (or in co-generation plants to generate electricity and steam). In Ontario this electricity will be purchased by the OPA if the AD facility owner can secure a FIT contract. Risks related to FIT contracts are discussed in Section 14.5 of this report;
- Biogas can be upgraded to RNG standards and can be used to generate CNG (compressed natural gas) for use as a fuel in either Regional or other fleets. The Regional fleet is the most secure end market.
- A waste management company might be interested in running their fleet on CNG;
- RNG could be sold into the natural gas pipeline grid, requiring a partnership with Union Gas or Enbridge.

13.6 Partnerships For Compost Markets

The AD facility will produce digestate which needs to be stabilized, and will produce compost. Approximately, 30 tonnes of compost should be produced for each 100 tonnes of input material. Two options are available to the Region:

- Compost the digestate at the AD facility, and be responsible for marketing of the compost, or
- Contract with a composting facility operator who will take the digestate for a tipping fee, and keep revenues (this is the approach used by Toronto).

If the Region determines the scenario whereby they are in control of marketing the compost product themselves, partnerships will need to be explored with soil blenders and landscapers which are the main buyers of finished compost.

14 AD Facility Risks for Region of Durham

14.1 Introduction

AD brings many benefits to the Region, such as energy production, and also involves a number of risks. The Region needs to be aware of the risks, and to take appropriate actions to mitigate and minimize the risks that can be identified at the pre-feasibility level. The Region will need to weigh risks against benefits as the project progresses through the business case, feasibility and later stages of development. This section identifies the risks of the AD project.

14.2 Risks Related To Collecting Pet Waste, Diapers and Sanitary Products

Section 5 of this report concluded that pet waste is a potential addition to the Region's program, if the processor can handle pet wastes, but that diapers and sanitary products are not suitable for the SSO program. Should the Region choose to add pet waste or diapers and sanitary products to their diversion programs, there are two options for collection. The materials could be added to the Green Bin program, or collected separately. Separate collection poses risks of low participation, low recovery and low diversion because of householder confusion.[53] No community has been identified in North America that currently collects pet waste or diapers and sanitary products as a separate stream. The City of Seattle plans to pilot this approach in 2018 but no details have been worked out at this time.

Pet waste can likely be added to the existing Green Bin as long as the processor is approved to process pet waste along with the current SSO list of materials. Should the AD project be pursued, discussions with AD vendors need to explore the extent to which the addition of pet waste complicates their process and increases the costs of AD. The answer will vary by vendor, with some likely to be able to handle some pet wastes, and others not able to process pet wastes.

Separate collection of pet waste, diapers and sanitary products is not recommended as an estimated $3.8 million (assumes $20 per bin) excluding distribution costs would be required to provide each stop with a separate container for pet waste, diapers and sanitary products. Additional collection costs would need to be identified by the collection contractor. The approach has not been implemented elsewhere to date, and there is a concern that this approach would confuse residents and result in diapers and sanitary products going into the Green Bin and contaminating the SSO stream.

14.3 Technical and AD Technology Risks

There are a number of technical risks associated with the AD project.

There is almost no operational experience with AD of residential SSO in North America. AD has not penetrated the North American market to date mostly because it is a more costly technology than aerobic

[53] Conversation with Derek Sawyer, Supervisor Processing Operations, City of Toronto, July 3, 2012

composting, which is traditionally used for processing residential SSO in Ontario. However, cost factors are changing, therefore there has been a renewed interest in AD in the last few years. The City of Toronto Dufferin AD facility (and soon the Disco AD Facility) remain the only AD facilities processing residential SSO in North America. Other AD facilities are expected to come on line in BC and Quebec soon.

Problems that have afflicted AD operations in the past have been addressed with newer designs and upgrades in technology. While technical and operational risks still exist, mitigation measures are helping to reassure new customers.

Technical and operational risks associated with AD are listed below:

- Risks associated with inclusion of pet wastes, diapers and sanitary products, etc. There is a risk that inclusion of these materials limits the potential vendors to those who offer a wet pre-processing system (dry AD vendors may not bid).
  - Mitigation: Meet with MOE early on in the AD facility planning process to gain MOE perspective on conditions they will impose in order to gain approval.
- Facility components break down leading to facility shutdown and it is difficult to access spare parts (such as those from Europe).
  - Mitigation: establish high risk components and provide stand-by.
- The facility capacity exceeded leading to the need to export SSO.
  - Mitigation: use conservative design capacity based on 20-year horizon capacity. Require an expansion plan in the RFP. Acquire large enough site for expansion.
- Numerous risks are associated with selecting the best design/build/operator at the RFP stage.
  - Mitigation: Write the RFP with due diligence requirements that factor into the proposal evaluation (examples: require a list of reference facilities operating on a similar scale and feedstock for extensive period, DBO experience (corporate and individuals) demonstrated, good design drawings, financing plan, operating plan, products marketing plan, etc).
- Odours at facility causing complaints or shutdown.
  - Mitigation: conservative design with odour control features written into the RFP requirements (examples: fast acting truck doors, negative pressure, biofilter and possibly scrubber, segregated building rooms preventing cross-drafts). Using a large site is a major benefit to meeting MOE property line requirements for odour. Require DBO contractor to adhere to ESDM findings even if this means changes to the proposal.
- Reliance on other parties for digestate curing is a risk if the processor of digestate no longer accepts material.
  - Mitigation: Process digestate through aerobic composting on-site (note, this requires a much larger site than an AD only facility).
- Risks associated with performance issues – the AD facility does not divert the amount of material expected.
  - Mitigation: set appropriate bonding requirements in RFP.
- Risks associated with variations in feedstock.
  - Mitigation: conduct seasonal audits to gain a good understanding of feedstock composition.

14.4 Regulatory Risks

There are two main regulatory risks associated with constructing the AD facility and obtaining the necessary approvals to construct and operate the AD facility:

ECA (Environmental Compliance Approval) Risk: Should the AD facility be co-located at an existing Region of Durham waste management or water pollution control facility site, all existing Certificates of

Approval for the site will need to be re-opened and updated. This should not be considered a reason not to co-locate an AD facility at an appropriate existing Regional site.

MOE Reluctant to Approve Sites Which Process Diapers and Sanitary Products: The MOE has been reluctant to approve the inclusion of diapers and sanitary products as well as plastic bags at existing composting facilities in Ontario because of the belief that these products in particular lead to odour problems. Some of the issues related to this topic are addressed in the new Composting Guidelines released in late September, 2012, and are summarized in Appendix B. There is on-going discussion and research by RPWCO (Regional Public Works Commissioners of Ontario) to identify best practices at organics processing facilities that will minimize odour generation.

14.5 Economic and Market Risks

There are a number of economic and market risks associated with construction and operation of an AD facility in Ontario, and in the Region of Durham. Risks are associated with the location of the AD facility as well as selling the steam, heat and electricity or other energy products created from the biogas. These risks are listed below.

Electricity Revenue Risk: Until mid-2013, electricity produced by the Region of Durham AD facility could be sold into the Ontario electricity grid for 14.7 cents per kilowatt-hour if a FIT contract was obtained from OPA. This program was cancelled (except for small projects under 500kW) in summer, 2013. In the future, OPA will continue to purchase electricity from renewable sources, but decisions will be made on the basis of community needs, and a public procurement process. The prices to be paid in the future are not known at this time.

Electricity Grid Connection Risk: Producing green electricity from biogas from the AD facility requires the electricity to be fed into the Ontario electricity grid. Some parts of the province are constrained by the fact that there is no capacity to add more electricity into the grid, particularly rural locations in the province. In some instances green energy producers (such as an AD facility owner, or particularly small solar installations) are unable to access the electricity grid due to grid capacity constraints. This issue cannot be clarified further until the location of the AD facility is identified.

Steam/heat Customer Risk: If a steam/heat customer can be found for the biogas from the AD facility, a simple arrangement is to locate the AD facility adjacent to the steam/heat customer. However, the AD facility is then completely dependent on the steam/heat customer for revenues from biogas generation. If the steam/heat customer no longer requires steam/heat, the AD facility loses revenues related to the steam/heat generation and needs to re-evaluate markets for the biogas.

Renewable Natural Gas (RNG) Revenue Risk: There is an increased interest in purchasing renewable natural gas (RNG) from biogas facilities and injecting this gas into the natural gas grid or using it as a fleet fuel. Future revenues for this commodity are now known at this time. The viability of this option depends on the AD facility location which is not known at this time.

14.6 Summary and Conclusions

This section has identified economic, technical, regulatory and other risks associated with the AD project. Many of these risks can be mitigated or minimized through best practices and due diligence in design and management of the procurement process; others are out of the control of the Region.

One of the keys to mitigating risk related to construction and operation of the AD facility is to structure the contract so that it allows maximum flexibility for AD vendors to share their ideas with the Region.

15. Conclusions and Recommendations

The overall conclusions and recommendations resulting from this study are:

1. AD facilities reach economies of scale, and become cost competitive at capacities of greater than 50,000 tonnes/year. Option 2, with a required AD facility capacity of 60,000 to 70,000 tonnes/year is considered the only viable option worth pursuing. There is sufficient SSO in the Region to consider AD if all SSO is processed in an AD facility.

2. If the Region pursues an AD option where they own the AD facility, partnerships should be considered to augment the amount of material brought to the AD facility in order to reduce capital and operating costs.

16. References

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Appendix A

Information On Selected AD Technology Vendors and Capabilities

The AD facility developed by the Region or for the Region will be supplied by an AD system vendor.

Over the last decade, the AD industry has experienced significant changes in the number of players in the market. In the early 2000's fewer than 15 companies were involved in the AD market. Today, the list includes over 100 companies already in the AD market or trying to break into the AD market.[54]

This Appendix describes the current range of AD vendors in the marketplace. While not considered an exhaustive description of the AD players in the marketplace today, this appendix illustrates that AD technology provision is a very dynamic marketplace with vendors entering all the time as the economics of AD in Ontario improve.

AD Vendors Established in the 1980's and 1990's

In the early 2000's a handful of well-established European based companies dominated the SSO AD market, with the leaders shown in Table 28. Most of these companies were established in the 1980's and have been in the AD market for over 30 years. These companies have a strong record of success throughout Europe in constructing and operating AD facilities to process SSO. These companies have designed and operated 11 to 38 AD facilities processing SSO.

Table 28: AD Technology Vendors In Market For More Than Fifteen Years

AD Technology Vendors in Business For At Least 15 Years	Established	Headquarters	Facilities Processing SSO (2009)	North America experience
Valorga Int.	1982	France	22	No
Kompogas,	1991	Switzerland	38	No
BTA	1984	Germany	23	Yes - Toronto
OWS/Dranco	1988	Belgium	17	No
Strabag/Linde	1973	Germany	11	No
Ros Roca	1968	Germany	>15	No

[54] Anaerobic Digestion Technology for Biomass Projects. June 2007. Juniper for Renewables East

A description of the companies and their AD technologies is summarized below:

- **BTA** - BTA (Biotechnische Abfallverwetung) GmbH International was founded in 1984 and is based in Munich, Germany. It is represented in North America by CCI (Canada Composting Inc). The AD technology was adapted from treating wastewater to processing SSO using a wet system approach. SSO is fed into a hydropulper with water added to make a slurry. Plastic contaminates are skimmed off the top and heavy fractions (glass, stones, bones) sink to the bottom and are removed. Grit is removed during the hydro-cyclone process. The slurry is then fed into the methanization digester for processing. The finished digestate is dewatered by a centrifuge. BTA technology is used at City of Toronto's Dufferin AD facility (25,000 tonnes/year) and will be used at Toronto's new AD facility located at the Disco Transfer Station (75,000 tonnes/year).

- **OWS/DRANCO** - Organic Waste Systems (OWS) developed the DRANCO process (Dry Anaerobic Composting). The company was established in 1988 and is based in Gent, Belgium. Dranco technology is represented in the US and Canada by Organic Waste Systems based in Dayton, Ohio. The company has a well established track record with 21 commercial facilities located in Europe and Asia that process SSO and residual municipal solid waste. The sizes range from 10,000 tonnes/year to 120,000 tonnes/year.

- **Strabag/Linde** - Linde-KCA-Dresden GmbH has been operating since 1973 and opened its first manure processing AD facility in 1985. In 1999, Linde-KCA merged with Linde BRV Biowaste Technologies and changed its name to Strabag after being acquired by the company in January 2007. The company's headquarters are in Dresden, Germany. In Canada, Strabag/Linde technology is represented by Sustainable Energy Holdings (EnerMac Consultants). The company has a well established track record for AD processing capabilities with 38 commercial scale facilities in Europe and Asia of which 11 process strictly SSO and 19 process SSO with other feedstocks (e.g. manure, sewage sludge). Capacities for AD facilities processing strictly SSO range from 18,000 tonnes/year to 150,000 tonnes/year.

- **Valorga** – Valorga AD is a patent of Valorga International SAS founded in 1982 and based in Montpellier, France. The North American representative is Waste Recovery Systems Inc. The technology is a dry, plug flow continuous system. The company has a well established track record for AD processing capabilities with 27 commercial facilities constructed in Europe and Asia that process SSO and residual municipal solid waste. The sizes range from 13,000 tonnes/year to 240,000 tonnes/year.

- **Kompogas** – Kompogas was founded in 1991 and later partnered with Axpo in 2006, which acquired 100% of the share capital of Axpo Kompogas in 2011. Axpo Kompogas has its headquarters in Glattbrugg, Switzerland. Kompogas is a dry, continuous plug flow horizontal digester. The company has over 35 commercial facilities operating in Europe, which process SSO, generally ranging from 5,000 to 25,000 tonnes/year.

- **Ros Roca** – Ros Roca was founded in 1968 as a leader in supplying waste management equipment. During the 1980's the company started to diversify into the area of composting and formed Ros Roca Envirotech in 1994 to pursue anaerobic digestion. The company offers both wet and dry anaerobic digestion technology depending on the needs of the client. The company has over 25 AD facilities in operation or under construction processing SSO.

AD Vendors Established Since Year 2000

A number of companies have entered the AD market since the year 2000, many of which have been operating for only a decade or less, as shown in Table 29. These companies have secured agreements with municipalities recently to construct AD facilities in Canada and the US. These companies have a shorter, less established record in constructing and operating AD facilities processing SSO. Most of the newer AD companies have less than 10 facilities in operation throughout Europe.

Table 29: AD Vendors Established After Year 2000

Technology	Established	Headquarters	Facilities Processing SSO (2009)	North America experience
GICON	2006	Germany	n.a.	Under construction Fraser Richmond Soil & Fibre,BC Renovations under way, Energy Garden Facility, London, ON
BEKON	2002	Germany	16	Agreement reached Santa Barbara, CA
Kompoferm	n.a.	Germany	7	Agreement reached San Jose, CA
FITEC (represented by Yield Energy)	2001	Germany	7	Construction to begin fall 2012 for Renew Earth Facility, Delta BC
Farmatic (Biotech Energy)	2001	Austria	3	Final design stage Portland, OR
Biogas GW (Green Waste)	2008	Germany	<5	AD facility in Columbia, SC Under construction

*Biowaste includes residential and restaurant SSO

A description of the companies and their AD technologies is summarized below:

- **GICON** – GICON Bioenergie GmbH was founded in 2006 (as an independent firm within the GICON group) and is headquartered in Dresden, Germany. The North American representative is Harvest Power. The company has past experience in constructing AD technology for the agricultural sector but has adapted AD technology to accommodate SSO using single stage, dry, batch technology and currently has eight facilities in Europe produce 11 MW of power and process 171,000 tonnes/year of SSO and other organic material.

- **BEKON** – Bekon Energy Technologies was founded in 2002 with headquarters in Munich, Germany. The company has partnered with the North American consortium Mustang Renewable Power Venture. The AD technology is designed for high solid feedstock (handling dry matter up to 50%) and is well suited to SSO. The company has 16 commercial scale facilities in Europe of which 11 process SSO (the first plant opening in 2008). The AD facility sizes range from 8,300 t/y – 44,000 tonnes/year.

- **FITEC** – The Fitec system was introduced in 2001 by Finsterwalder Umwelttechnik GMbH based in Berlin, Germany. The North American representative is Yield Energy. The AD technology is unique as it acts like a wet system but can handle high solids and uses only the liquid generated by the SSO, with minimal water input. The company has ten commercial scale facilities in Europe of which seven process SSO. The first plant opened in 2008. The facility sizes range from 4,000 – 15,000 tonnes/year.

- **Farmatic** (Biotech Energy) – Farmatic AD technology was engineered by Enbasys (part of the BDI group based in Graz, Austria) in 2001. The company has partnered with the North American consortium Columbia Biogas. Farmatic is a two stage, wet AD technology. The company transitioned from AD targeting farm waste to AD targeting SSO in the early 2000's and has four facilities processing SSO (with other waste) throughout the world, with facility sizes ranging from 60,000 t/y to 146,000 tonnes/year.

- **Kompoferm** – The Kompoferm AD system was developed by Eggersmann Anlugenbau GmbH, with headquarters in Dessau, Germany. The company has partnered with Zero Waste Energy in North America. Kompoferm is a dry AD technology capable of handing a high solid feedstock using a batch processing system. The company has seven Kompoferm facilities in operation or under construction that process SSO. AD facility sizes range from12,000 - 35,000 tonnes/year.

- **Biogas GW** (Green Waste) – The Biogas Green Waste (GW) technology was introduced in 2008 by Eisenmann Anlagenbau Gmbh, with headquarters in Boeblingen, Germany. The company has partnered with North American consortium W2E Organic Power. The technology is designed to process dry (high solid) feedstock using a continuous, plug flow horizontal approach, a second digester is used to further increase biogas yield. The company has less than five facilities in operation or under construction that process SSO. The most recent facility is in South Carolina.

Minimal AD Facility Capacity To Reach Economies of Scale

Economies of scale come into play when evaluating an AD strategy. Some AD designs can handle smaller quantities of feedstock economically, while other designs are better suited to larger quantities of feedstock. Each AD vendor will have a range where their plants typically operate. In many cases, the smallest viable AD facility is bigger than the amount of SSO available in some of the Durham AD Options. The only way to truly find the answer to what is viable for Durham is to issue some kind of invitation to AD vendors in the marketplace and evaluate their responses.

Many AD vendors can supply systems to process the different feedstocks under consideration by the Region in an AD system. An RFQ, REOI or RFP will need to be issued to identify those AD vendors who are interested in supplying the AD technology to the Region and discover what blend of technologies and pre-processing they will propose.

Each AD vendor uses a different proprietary AD system, and will design the pre-processing system which best prepares the input materials to remove contaminants and make the input material suitable for their particular AD technology and approach. Each vendor designs the pre-treatment system to remove contaminants and prepare the input materials in a way which does not compromise gas production or reduce the potential for energy generation. This is a balancing act, and each vendor has developed their own unique approach.

Appendix B

Ontario's Compost Quality Guideline, September 2012

Ontario's former compost Guideline only had one compost standard whereas nine other provinces had compost standards similar to those endorsed by the Canadian Council of Ministers of the Environment (CCME). This inconsistency across provinces on compost standards resulted in an unlevel playing field and competitive barriers for the Ontario compost industry for cross-provincial boundary sales.

The new Compost Framework is intended to improve the operation of composting facilities by providing comprehensive and technically sound guidance on facility siting, design, operation and maintenance to reduce potential impacts off-site. The new Compost Framework also sets out guidance for municipal waste managers on organics collection program design which is aimed at improving facility operation.

In order to support the new Compost Framework, amendments to Regulation 347 under the Environmental Protection Act (EPA) and O. Reg. 267/03 under the Nutrient Management Act, 2002 (NMA) were filed on September 24, 2012, to support the proposed compost quality standards. The links to the regulations will be included in this notice once the final regulations are posted on e-laws.

The New Guideline issued in late September, 2012 has been divided into two new documents:

- Ontario Compost Quality Standards (Standards) and
- Guideline for the Production of Compost in Ontario (Guideline).

Summary of Ontario Compost Quality Standards ("Standards")

The Standards document includes three new compost standards – AA, A and B, as outlined below:

Category AA

Standards:

- Highest quality standards; similar to former Ontario standards but with some modifications.
- May not contain sewage biosolids, pulp & paper biosolids or septage as feedstock.
- Continues the use of former zinc and copper standards, which are more stringent than Category A.

Restrictions on Use:

Category AA may be used without restrictions or approvals (both on and off farm).

Category A

Standards:

- Consistent with the CCME Category A quality guidelines.
- Category A allows for slightly higher concentration of zinc and copper.

- May use biosolids as feedstock (maximum 25% of total feedstock), but must meet the metals standards on input feedstock.

Restrictions on Use:

Category A must include the following labelling information:

- maximum application rates;
- identification of any biosolids and domestic septage used as feedstock;
- warning that product should not be used on soils with elevated copper or zinc concentrations.

Category A compost may be used without an Environmental Compliance Approval (ECA) (both on and off farm).

Category B

Standards:

- Meet the CCME Category B quality guidelines plus Ontario's Cadmium and Copper standards; less restrictive metals and foreign matter standards than Category AA and A.

- May use biosolids, but must meet the same metals standards for feedstock as Category A.

Restrictions on Use:

Category B compost would continue to require government approval for use and transportation (i.e., ECA off-farm or an approved NASM Plan on-farm).

The standards document also includes:

- Quality standards (for metals, pathogens, maturity and foreign matter) for each category of compost that reflect the quality of the compost and a risk-based approach to public health and environmental protection.
- New feedstock standards for metals concentrations (i.e., input materials) for each category

Key revisions to the compost standards include:

- A restriction has been added to Category A feedstock for a 25% maximum concentration of sewage biosolids, pulp and paper biosolids and domestic septage (on a dry weight basis).
- Labelling requirements for Category A have been revised, to allow some information to be included on the back of the bag, and more flexibility in presenting the information. A new option allows producer calculation of an alternative application rate.
- The sharp foreign matter standard for AA and A has been revised to "compost shall contain no material of a size or shape that can reasonably cause human or animal injury", which is consistent with Ontario's previous standard for sharp foreign matter.
- The list of acceptable maturity tests has been revised, including removal of the "re-heat" test.

Summary of Regulatory Amendments

Amendments to Regulation 347 under the EPA

The amendments to Regulation 347 give legal effect to the new compost quality standards set out in the Standards, by providing exemptions from the ministry's approval requirements. The amended Regulation 347 exempts:

- Category AA compost that meets the quality standards is exempt from the ministry's approval requirements for use and transport.
- Category A compost that meets both the quality standards and labelling requirements is exempt from the ministry's approval requirements for use and transport. Labelling requirements for Category A compost ensure that generators inform end-users about proper compost application, and notify them if biosolids and/or domestic septage were used to make the compost.
- Category B compost is not exempt from the ministry's approval requirements under the EPA, and is subject to all ministry approval requirements for transportation and use.

Subject to approvals, Category B compost may be used in a variety of regulated applications, such as on agricultural land as a 'nutrient' pursuant to O. Reg. 267/03, or as a soil conditioner on non-agricultural land (e.g., for land reclamation, mining rehabilitation, reforestation, etc.), pursuant to an organic soil conditioning site environmental compliance approval.

Regulation 347 amendments also exclude compost from the retail exemption in s. 3(2)1 of Regulation 347.

***Amendments to O. Reg. 267/03 under the NMA** (Nutrient Management Act)*

Complementary amendments have been made to O. Reg. 267/03 and to documents referenced by the regulation, specifically the Nutrient Management Protocol, Nutrient Management Tables, NASM Odour Guide and Sampling and Analysis Protocol. The amendments ensure consistency with the Standards and the amendments to Regulation 347 and include:

There is a new definition of "Compost Standards" to reflect the revised name of the document containing the standards – Ontario Compost Quality Standards.

Amended definitions of "non-agricultural source material" (NASM) and "agricultural source material" (ASM) to exclude compost that meets the "Category AA" or "Category A" compost quality standards set out in the Standards. The definitions have been amended to reflect the new expanded categories of compost.

As compost is strictly managed under the Compost Framework, and as both Category AA and A compost are required to meet stringent metal, pathogen, maturity and foreign matter content requirements under the compost regulatory regime, these materials are excluded from testing requirements and application restrictions under the NMA.

Category B compost created from leaf and yard waste only would be classified as a "Category 2 NASM".

Category B compost created from all other materials (e.g., biosolids) would be classified as a "Category 3 NASM".

Amendments exempt Category B compost made with sewage biosolids or septage from testing for two of the four pathogens, the testing is not necessary because the composting process provides strong assurance of pathogen reduction.

Inclusion of Category B Compost under the NASM table for odour categories as an "OC1", which represents materials with the lowest level of odour. All compost that meets the maturity requirements set out in the Standards would be a low-odour material.

Summary of Guideline for the Production of Compost in Ontario (Guideline)

Most of the key concepts in the revised Guideline are consistent with the original proposed Guideline that was posted on the Environmental Registry in November 2009. The Guideline includes best practices guidance for composting facilities in the following areas:

- Land use planning and site selection
- Site and facility design considerations
- Operating procedures during each stage of material handling
- Feedstock management
- Operational flexibility and optimization
- Operational controls such as compost recipe development and composting process monitoring
- Prevention and control of potential adverse effects, such as odour.

Key revisions to the Guideline since consultation include re-organization and streamlining of the document, and the addition of more detailed guidance on a number of topics including:

- Odour prevention and management in all aspects of siting, design and operation
- Minimum separation distance from sensitive receptors and buffer zones
- Considerations related to feedstock, such as the use of plastic bags, compostable plastic bags and the inclusion of disposable diapers and sanitary items
- Objectives and considerations of each stage of material handling
- Record keeping.

Additionally, provisions that were considered onerous by facility operators were made more flexible where it was possible to do so without increasing environmental, health and community risks. In some cases, provisions were strengthened to decrease these risks.

Appendix C

Locations Where Composting Guidelines Refer to Diapers, Sanitary Products, Pet Waste and Plastic Bags

Guideline for the Production of Compost in Ontario Companion to the Ontario Compost Quality Standards. last update: July 2012

Website source:
http://www.ene.gov.on.ca/stdprodconsume/groups/lr/@ene/@resources/documents/resource/stdprod_099823.pdf

From this document, the following instances were found:

Page 11.

Table 3.1 Additional Factors that Affect Required Separation Distance

Factors that Reduce the Need for Separation Distance	Factors that Increase the Need for Separation Distance
Sensitive receptors located upwind from facility, relative to prevailing winds	Sensitive receptors located downwind from facility, relative to prevailing winds
Favourable topography and vegetative buffer	Unfavourable topography and vegetation
Receipt of lower-odour feedstock (e.g., higher carbon materials like leaf and yard waste)	Receipt of feedstock with greater odour-generating potential (e.g., higher nitrogen materials like diapers, green grass) or material that has undergone longer storage and shipping times

Page 42.

5.1 FEEDSTOCK QUALITY

“Facilities will be granted approval to accept certain materials, on a site-specific basis, depending on the capabilities of the processing and odour control technology. Examples of feedstocks that may be acceptable include:

- leaf and yard wastes
- food wastes
- food processing wastes
- non-recyclable paper wastes
- wood (natural wood only - excluding pressure treated, painted, or composite wood)
- pulp and paper biosolids *
- domestic septage *
- sewage biosolids *

- agricultural manures
- crop residues
- pet waste
- soiled paper such as tissues and paper towels
- diapers and sanitary products

Page 42.

5.1 FEEDSTOCK QUALITY

Some wastes received at a composting facility may contain micro-organisms that are human pathogens. These wastes include food wastes, diapers, domestic septage, manure, and biosolids. Workers should take precautions (e.g., practice good hygiene) to ensure that they are not exposed to pathogens.

Page 44.

5.2.2 Other Quality Considerations

Composting facilities should not accept diapers or sanitary products as feedstock, unless the facility has implemented special management techniques, odour control systems and processing technologies capable of dealing with these materials (e.g., feedstock preparation and adequate screening for compost quality). Without appropriate mechanical processes, diapers and sanitary products often remain mostly intact in the compost, and the uncomposted fibre portion and residual plastic need to be removed and disposed as waste.

Page 50.

PART IV – ODOUR PREVENTION AND CONTROL

Odour control is of critical importance to the success of a composting facility for the following reasons:

- All composting feedstocks contain some amount of odorous compounds when they are received at the facility; some material (e.g., residential food waste and diapers) is more odorous than others (e.g., leaf and yard materials). Normal composting operations, such as handling and aeration, tend to promote the volatilization of odorous compounds

Page 56.

Key factors that *increase* the risk of odours at composting facilities:

accepting materials with higher potential for odours, such as food waste, animal feces and materials that are not delivered the same day as they are collected from the source and/or are in an anaerobic condition

Page 65.

6.4.2 Assessing Feedstock Odour Potential

Odours released during feedstock receiving and pre-processing operations can be stronger and more offensive than odours released during the composting process.

Feedstock materials received in plastic bags, or in certified compostable bags, can be a particularly troublesome source of odours at compost facilities. The collection of organic wastes in plastic bags or sealed bins or carts may interfere with oxygen flow and create uncontrolled anaerobic digestion of the materials, which can create significant odours, often before the materials even arrive at the facility. The potential for odours is especially great where there is a long travel time between the collection point and the composting facility. It is essential that materials are collected and delivered to the composting facility in a timely manner.

Facilities that receive materials with a high potential for odours (e.g., food waste, animal waste and organic materials that are not delivered the same day they are collected and/or are in an anaerobic condition) require suitable management techniques and/or odour control systems to minimize the risk of off-site odour impacts

Page 72.

Glossary

Organic Waste - Waste containing carbon-based compounds. In the context of composting, the term is often used in a more restrictive sense to refer specifically to biodegradable, compostable wastes of plant or animal origin, such as food scraps, grass clippings, yard wastes, etc. but excluding lumber, plastic, rubber, oils and other hydrocarbons, and other organic chemicals.

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Appendix 3: **OTHER RELEVANT REGULATIONS AND STANDARDS**

Federal Fertilizers Act

The Fertilizers Act is the legislative authority under which the Canadian Food Inspection Agency regulates and monitors fertilizers and supplements sold or imported into Canada. This protects the farmer and the general public against potential health hazards and fraud in marketing as well as ensuring a fair marketplace. It therefore regulates compost when sold either as an amendment to soil, or as a fertilizer with plant nutrient claims.

Some fertilizers and supplements are exempt from the Act and its Regulations, such as animal and vegetable manures sold in their natural condition, fertilizers and supplements intended and labelled for export, potting soils (unless they claim a nutrient/supplement value) and supplements intended for experimental purposes.

plastic bags.

4.1.2.1.1 Pre-processing and Contaminant Removal

If the feedstock arrives in bags of any kind, it will need to be processed to remove the compostable material from the bags, to ensure that the material can be properly blended.

Experience at compost facilities that accept organic materials in non-compostable plastic bags has demonstrated that non-compostable plastic bags are difficult to remove. Depending on the processing equipment, it can be challenging to fully remove the organic material from the bags. If the bags are screened out prior to processing, then desirable organic materials can remain trapped in the bags and sent to landfill as residual waste. Also, non-compostable plastic bags can remain in the compost as a contaminant, even if there is a pre-processing screening step.

The use of plastic bags for organics collection, and the acceptance of material collected in plastic bags at composting facilities, should only be considered where appropriate provisions have been incorporated into the facility design (see Part III, section 5.2 of this Guideline for additional guidance on plastic bag use).

4.1.4.1.3 Finishing

One of the final activities on a composting site is the preparation of the compost for delivery to market. The extent of the activity will depend on the end market requirements, and may include screening, blending, bagging, and loading material for shipment. To minimize potential off-site dust impacts, these activities should be undertaken during favourable wind conditions. Wetting Moistening dry compost may be required to prevent off-site dust impacts. If the feedstock was collected in plastic bags, care must be taken to ensure that the screening operations do not generate litter.

5.2.1 Plastic Bags and Compostable Plastic Bags

An important consideration for collection programs, in particular municipal "green bin" programs, is whether plastic or compostable plastic bags will be used. Where bags are used, it is necessary for the receiving composting facility to have the proper processing technology in place to handle this material.

As noted above, inorganic materials, such as plastic bags, are undesirable in the compost feedstock. Organic material collected in plastic bags can be challenging to manage. The degree of difficulty varies, depending on the number and types of bags used, and the transport and storage times.

Generally, while plastic bag use should be limited, it may be suitable in some situations. The acceptance of materials collected in plastic and/or compostable plastic bags would be discussed as part of the facility's approval process. Proponents would need to demonstrate to the ministry that the facility has been designed to adequately manage these materials, including providing sufficient odour control measures to manage the higher odour-generating potential of the feedstock.

The use of certified compostable bags and paper bags may be suitable, but should also be thoughtfully considered with regard to processing capabilities. For example, the facility should be equipped with adequate processing technology (e.g., to break apart the bags) and adequate composting conditions and material retention time so that the bags, and their contents, fully decompose.

6.4.2 Assessing Feedstock Odour Potential

Odours released during feedstock receiving and pre-processing operations can be stronger and more offensive than odours released during the composting process.

Feedstock materials received in plastic bags, or in certified compostable bags, can be a particularly troublesome source of odours at compost facilities. The collection of organic wastes in plastic bags or sealed bins or carts may interfere with oxygen flow and create uncontrolled anaerobic digestion of the materials, which can create significant odours, often before the materials even arrive at the facility. The potential for odours is especially great where there is a long travel time between the collection point and the composting facility. It is essential that materials are collected and delivered to the composting facility in a timely manner.

Ontario Compost Quality Standards. Last update: July 2012

Website Source:
http://www.ene.gov.on.ca/stdprodconsume/groups/lr/@ene/@resources/documents/resource/stdprod_099819.pdf

There is no mention of "pet waste" in this document.

There is no mention of "sanitary products" in this document.

There is one mention of "diapers" in this document on Page 37, in the Glossary.

Glossary

Human Body Waste Feedstock - Human body waste feedstock means feedstock materials derived from or containing wastes from the human body, including sewage biosolids, domestic septage and diapers.

There are two instances of "plastic bags" in this document, but only in the case of compost sampling techniques.

1. **APPENDIX 1 (In the Compost Quality Standards): FEEDSTOCK AND COMPOST SAMPLING**

   A1.0 SAMPLING PREPARATION
   The following equipment is recommended for compost and feedstock sampling:

   clean hand shovel

   clean plastic bag, bucket or pail large enough to contain 10 grab samples of 1-3 litres each

   clean tarp at least 2m x 3m

   implement handle that can be cleaned and disinfected between samples to split sample on tarp

   clean sample containers (new plastic bags)

   marker to uniquely identify sample (e.g. date, location, lot#, etc.)

   shovel to remove rejected materials from tarp

2. **A1.4.1 Sample Containers**

   Plastic "zip-lock" bags or other clean plastic or glass containers with no metal contact should suffice for most compost sampling activities.

   Analysis for some parameters may require containers other than clean plastic bags. For example pre-sterilized and sealed containers may be required for pathogen analyses, and glass sample containers with specially lined lids may be required for selected chemicals, such as mercury.